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Wadeable Stream Monitoring in the Eastern Rivers and Mountains Network

2009–2010 Summary Report

Natural Resource Data Series NPS/ERMN/NRDS—2011/151

ON THE COVER
Vancampens Brook in Delaware Water Gap National Recreation Area.
Photograph by: Caleb Tzilkowski.

Wadeable Stream Monitoring in the Eastern Rivers and Mountains Network

2009–2010 Summary Report

Natural Resource Data Series NPS/ERMN/NRDS—2011/151

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Acronyms

ALPO	Allegheny Portage Railroad National Historic Site
BCP	Boundary control point
BLUE	Bluestone National Scenic River
BMI	Benthic macroinvertebrate
DEWA	Delaware Water Gap National Recreational Area
DO	Dissolved oxygen
ERMN	Eastern Rivers and Mountains Network
FONE	Fort Necessity National Battlefield
FRHI	Friendship Hill National Historic Site
GARI	Gauley River National Recreation Area
IDAS	Invertebrate Data Analysis System
JOFL	Johnstown Flood National Memorial
MAHR	Mid-Atlantic Highlands Region
MBII	Macroinvertebrate Biotic Integrity Index
MTI	Macroinvertebrate Tolerance Index
NERI	New River Gorge National River
NPS	National Park Service
RTH	Richest targeted habitat
SRMP	Scenic Rivers Monitoring Program
UNT	Unnamed tributary
UPDE	Upper Delaware Scenic and Recreational River
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Executive Summary

The mission of the National Park Service (NPS) is “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). To achieve that goal, and as a result of the Natural Resource Challenge, 270 parks in the national park system were organized into 32 Inventory and Monitoring (I&M) Networks. One of those networks, the Eastern Rivers and Mountains Network (ERMN), includes nine parks in New Jersey, New York, Pennsylvania, and West Virginia.

The NPS’ purpose for natural resource monitoring is to determine the status and trends in the condition of selected park resources (Fancy et al. 2009). Monitoring 13 ecological “vital signs” throughout the ERMN provides the ability to assess the efficacy of management and restoration efforts (Marshall and Piekielek 2007). Furthermore, vital signs are expected to provide early warning of impending threats and provide a basis for understanding and identifying meaningful change in natural systems characterized by complexity, variability, and surprises (NPS 2008). During 2008, the ERMN began collecting data using the Wadeable Streams Monitoring Protocol, which addressed the benthic macroinvertebrate (BMI) and water quality vital signs.

This report summarizes the status of BMI communities and water quality in selected wadeable streams throughout ERMN parks. Data collected since 2008, particularly data collected during 2009 and 2010, are presented and discussed. All data were collected following methods detailed in the Wadeable Stream Monitoring Protocol (Tzilkowski et al. 2009).

The broad gradient of ecological conditions across the 60,000 hectares of the ERMN is reflected by the status of BMI communities in network streams. In addition to historical human impacts on ERMN parks and water resources, ongoing human activities (e.g., point and non-point source pollution) continue to affect many streams throughout the network. Nonetheless, many streams were at, or above, “reference” (i.e., relatively pristine) condition based on Macroinvertebrate Biotic Integrity Index (MBII) scores established by previous studies. Average MBII scores were considerably greater at “northern” parks (MBII = 53.6) than “southern” parks (45.3). Among “northern” parks, the average MBII score was greatest (66.7$\pm$3.1) at Ten Mile River, which flows to the Upper Delaware Scenic and Recreational River; conversely, the lowest MBII (23.7$\pm$0.1) was at the Un-named tributary to South Fork of the Little Conemaugh River, which is at Johnstown Flood National Memorial. In “southern” parks, Laurel Creek (New River Gorge National River) had the greatest (66.8$\pm$9.7) MBII whereas the lowest MBII (14.3$\pm$0.1) was at Ice Pond Run which is located at Friendship Hill National Historic Site.

Some, although few, obvious water quality issues were apparent among ERMN streams based on point-in-time measurement of core water quality parameters — that result was not surprising, given the infrequency (at most, two data points) and timing (i.e., spring or fall) of measurements. Deployment of continuous monitoring water quality “multiprobes” is planned for 2011 at six ERMN streams (four parks).

Acknowledgments

The Eastern Rivers and Mountains Network (ERMN) is grateful for the cooperation and support from all parks in the network. Without the logistical support, housing, and knowledge provided by the parks, the ERMN could not sustain Vital Signs monitoring at the current level.

Introduction

The National Park Service's (NPS) purpose for natural resource monitoring is to determine the status and trends in the condition of selected park resources (NPS 2008). Monitoring 13 vital signs throughout the Eastern Rivers and Mountains Network (ERMN) of the NPS, including benthic macroinvertebrates (BMI) and water quality, provides the ability to assess the efficacy of management and restoration efforts. Furthermore, vital signs are expected to provide early warning of impending threats and provide a basis for understanding and identifying meaningful change in natural systems characterized by complexity, variability, and surprises (Fancy et al. 2009). This report summarizes monitoring results of two vital signs (BMI and stream chemistry) during 2009 and 2010 (Oct. 1, 2009–Sept. 31, 2010) throughout the ERMN; additionally, data collected during 2008 and 2009 were incorporated into this report for averages of BMI metrics and stream chemistry parameters.

The ERMN includes nine national parks in four states (New Jersey, New York, Pennsylvania, and West Virginia) that range in size and the extent of natural resources (Figure 1). One of the primary objectives of the ecological monitoring program in the ERMN is to evaluate status and trends in the condition of tributary watersheds flowing into and through member parks. Watershed condition is evaluated using measures of ecosystem integrity, including streamside bird species and communities (Mattsson and Marshall 2009), forest structure and composition (Perles et al. 2009), BMI and water quality (Tzilkowski et al. 2009), and watershed land use, type, and configuration (Marshall and Piekielek 2007).

Because BMI are important biological components of all functioning stream ecosystems, they are often used as indicators of ecosystem integrity. BMI are instrumental to nutrient and carbon dynamics and are an important link in stream food webs (groups that are commonly used for water quality assessment include arthropods [insects, arachnids, and crustaceans], worms, clams, and snails). Given the thorough understanding of BMI and their importance to aquatic ecosystems, they are frequently studied with regard to their responsiveness to human-induced environmental perturbations. BMI are the most frequently used organisms in water quality assessment (Carter and Resh 2001) because: 1) they are relatively easy to collect; 2) many taxa can be identified to taxonomic level of family in the field (Barbour et al. 1999); and 3) several BMI life history traits (e.g., relatively sedentary) make them uniquely advantageous for monitoring condition of aquatic ecosystems.

Water chemistry and temperature strongly influence the character of aquatic ecosystems. When water quality is naturally or unnaturally (i.e., human induced) altered, biotic communities and ecosystem processes are changed. Because aquatic biota are tightly linked to the physical and chemical characteristics of waters they inhabit, water quality monitoring is part of most biomonitoring programs. Surface waters throughout ERMN properties are analyzed for chemical and physical constituents, termed "core parameters," including temperature, pH, dissolved oxygen (DO), and conductivity. Monitoring BMI assemblage composition and core water quality parameters will enable the ERMN to directly measure the characteristics of wadeable streams that are most important to the NPS mission "to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations" (NPS 1999).

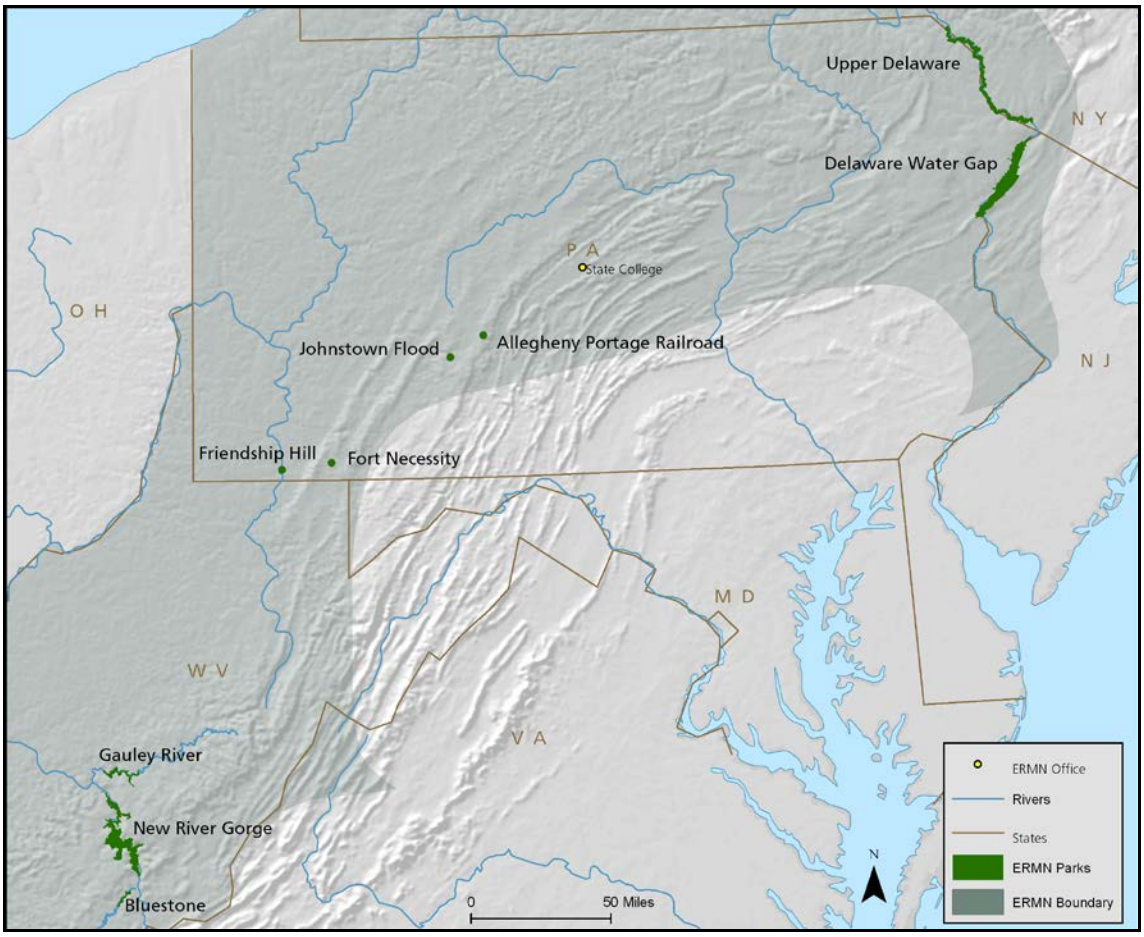


Figure 1. Map of national parks in the Eastern Rivers and Mountains Network (ERMN).

Objectives

The primary goal of the ERMN stream monitoring program is to collect, analyze, and report data that will help park management maintain or improve the ecological condition of wadeable streams (and rivers they are tributary to) throughout the network.

The following questions drive much of the ERMN wadeable streams monitoring program:

- What is the status and long-term trend of core water quality parameters (temperature, pH, conductivity, dissolved oxygen) in selected ERMN streams?
- What is the status and long-term trend in BMI abundance and assemblage composition in selected ERMN streams?
- Do BMI assemblages sampled within ERMN streams indicate polluted or otherwise impaired water quality?

Methods

Although a brief overview of the BMI and water quality monitoring methods is provided here, a detailed rationale of the sampling design and methods, in addition to Standard Operating Procedures, are provided in the Wadeable Stream Monitoring Protocol (Tzilkowski et al. 2009; hereafter, stream protocol).

Stream Reach Selection

The sampling unit or "site" for the stream protocol is a stream reach, which is a length of stream chosen to represent a uniform set of physical, chemical, and biological conditions. Reach length is proportional to (40×) stream width and therefore varies among streams.

Two methods were used to select sampling reaches in the stream protocol—probabilistic (i.e., stratified-random) and targeted (i.e., non-random) approaches. The probability-based design was developed by Mattsson and Marshall (2009) for the ERMN Streamside Bird Monitoring Protocol and defined the majority of the sampling reaches. However, it was not used to select reaches at two parks, Johnstown Flood National Memorial (JOFL) and Upper Delaware Scenic and Recreational River (UPDE), primarily because all streams in these parks did not meet the requirement of having >1 km of their length within the authorized park boundary. For these parks, and for additional reaches in the remaining parks, a variety of factors were considered when choosing targeted sampling reaches (Tzilkowski et al. 2009). In total, 54 probabilistic reaches and 26 targeted reaches were selected for monitoring (Table 1, Appendix A).

Table 1. Number of probabilistic and targeted sampling reaches throughout Eastern Rivers and Mountains Network parks.

Park	Probabilistic	Targeted
Allegheny Portage Railroad National Historic Site	2	1
Bluestone National Scenic River	2	2
Delaware Water Gap National Recreation Area	20	6
Fort Necessity National Battlefield	2	1
Friendship Hill National Historic Site	2	0
Gauley River National Recreation Area	3	1
Johnstown Flood National Memorial	0	1
New River Gorge National River	23	2
Upper Delaware Scenic and Recreational River	0	12
Total	54	26

Sampling Schedule

Due to a variety of factors, including the geographic distribution of network parks, associated weather, and hydrologic patterns, and a field crew of two people, the northern-most parks were sampled during fall 2008 and 2009; whereas the streams in the southern-most parks were sampled during spring 2009 and 2010 (Table 2). An exception was the two Bluestone River reaches, which were sampled in fall 2009 and 2010 due to high streamflows in the spring, making them inaccessible at that time.

Table 2. Distribution of parks throughout northern and southern portions of the Eastern Rivers and Mountains Network.

Northern Parks[1]	Southern Parks[2]
Allegheny Portage Railroad National Historic Site	Bluestone National Scenic River
Delaware Water Gap National Recreation Area	Fort Necessity National Battlefield
Johnstown Flood National Memorial	Friendship Hill National Historic Site
Upper Delaware Scenic and Recreational River	Gauley River National Recreation Area
	New River Gorge National River

[1]Sampled October/November 2008 and 2009
[2]Sampled March/April 2009 and 2010

Field Methods

Benthic macroinvertebrates were sampled using methods based on USGS protocols (Moulton et al. 2002) and are summarized in the stream protocol (Tzilkowski et al. 2009). BMI samples were collected from five different riffles within each reach using disturbance sampling and a slack sampler (500 µm mesh). The five discrete samples were then combined to form a composite sample for each reach which yielded 1.25 m^2 of sampled area at each reach. Physical conditions (i.e., depth, flow, and substrate) were recorded at each sampling location and were as similar as possible among samples. Samples were composited into one sample for each reach, preserved in 95% ethanol, and transported to the laboratory.

Concurrent with BMI sampling, core water quality parameters (i.e., dissolved oxygen, pH, specific conductance, and temperature) were measured at all reaches. YSI Model 556 water quality meters and reach-scale habitat conditions were assessed using U.S. Environmental Protection Agency (USEPA) methods (Barbour et al. 1999).

Beginning in March 2011, multiprobes (i.e., continuous water quality monitors) will be collocated with BMI sampling reaches in six streams at four ERMN parks (Table 3). Multiprobe reach selection was done in consultation with park staff to distribute reaches across a latitudinal gradient among streams with otherwise similar characteristics (e.g., catchment size, dominant land cover in the watershed, MBII score). Eureka (Manta 2) and Hach (Hydrolab DS5X) multiprobes will be deployed from March through October (as conditions permit) and will be maintained monthly by ERMN staff. Deployment and maintenance methods will follow well-established protocols (Wagner et al. 2006, Starkey et al. 2008) that are summarized in the stream monitoring protocol (Tzilkowski et al. 2009). Core parameters and turbidity will be measured continuously (i.e., hourly) and will be summarized annually.

Table 3. Continuous water quality monitoring locations in the Eastern Rivers and Mountains Network.

Park	Stream
Allegheny Portage Railroad National Historic Site	Millstone Run
Delaware Water Gap National Recreation Area	Adams Creek
	Vancampens Brook
New River Gorge National River	Ephraim Creek
	Fall Branch
Upper Delaware Scenic and Recreational River	Hankins Creek

Laboratory Methods

Laboratory methods for processing BMI samples were based on procedures developed by the USGS (Moulton et al. 2000). A fixed-count subsample of 300±20% individuals are sorted and identified from each sample. Generally, BMI were identified to genus using standard dichotomous keys, but some groups (e.g., Chironomidae, Oligochaeta) were identified to coarser taxonomic levels. Microsoft Access 2007 is the primary software used for storing and managing ERMN BMI and stream habitat data, whereas the Invertebrate Data Analysis System (IDAS *version 5*, U.S. Geological Survey, Raleigh, NC) was used for resolving taxonomic ambiguity issues and calculating metrics that describe the structure and diversity of BMI communities.

Data Analysis

We calculated BMI community metrics with IDAS and calculated the Macroinvertebrate Biotic Integrity Index (MBII; Klemm et al. 2003) using Microsoft Excel 2010. The MBII was developed by the (USEPA) Environmental Monitoring and Assessment Program and was ultimately used for the USEPA Wadeable Stream Assessment (USEPA 2006, Herlihy et al. 2008).

The MBII was developed for upland and lowland streams dominated by riffle habitat in the Mid-Atlantic Highlands Region (Klemm et al. 2003) which encompasses the ERMN. Moreover, the MBII was based on a large dataset of 574 wadeable stream reaches throughout this region and was thoroughly tested. The MBII uses seven metrics selected from the 100 that are commonly used by governmental agencies and academia. The metrics chosen were those that performed best in terms of range, precision, responsiveness to various human-induced disturbances, relationship to catchment area, and redundancy (Table 4; Klemm et al. 2003). Most MBII metrics are counts or proportions of taxa in the community that are characterized as tolerant or intolerant to human perturbations. One of the metrics, the Macroinvertebrate Tolerance Index (MTI), is more complex because it incorporates values (0–10) for each taxon with respect to pollution tolerance, weighted by taxon abundance, and results in higher scores as the proportion of taxa tolerant to general pollution increases (Klemm et al. 2003). Pollution Tolerance Values (PTV) incorporated in the MTI were average tolerances to "various types of stressors" (Klemm et al. 2002).

Table 4. Macroinvertebrate Biotic Integrity Index metric descriptions and their directions of response to increasing human perturbation (Response) from Klemm et al. (2003).

Metric	Description	Response
Ephemeroptera richness	Number of Ephemeroptera (mayfly) taxa	Decrease
Plecoptera richness	Number of Plecoptera (stonefly) taxa	Decrease
Trichoptera richness	Number of Trichoptera (caddisfly) taxa	Decrease
Collector-filterer richness	Number of taxa with a collecting or filtering-feeding strategy	Decrease
Percent non-insect individuals	Percentage of individuals that are not insects	Increase
Macroinvertebrate Tolerance Index	$\sum_i p_i t_i$, where p_i is the proportion of individuals in taxon *i* and t_i is the pollution tolerance value (PTV) for general pollution	Increase
Percent five dominant taxa	Percentage of individuals in the five numerically dominant taxa	Increase

Results and Discussion

The broad gradient of ecological conditions across the 60,000 hectares of the ERMN is reflected by the condition of BMI communities in network streams (Figures 2 and 3). In addition to historical human impacts on ERMN parks and water resources, ongoing human activities (e.g., point and non-point source pollution) continue to affect many aquatic ecosystems throughout the network. Nonetheless, many streams were at, or above, "reference" condition for their respective ecoregion based on MBII scores established by previous studies (e.g., Klemm et al. 2003, Herlihy et al. 2008). There have been, at most, only two years of sampling at ERMN reaches; consequently, there was considerable annual variability in point-in-time water quality measurements and estimates of BMI community condition. After several years, when estimates of natural variability can be calculated, baseline water quality and BMI status will be established. These estimates of current condition will serve as benchmarks to which long-term trends can be compared.

The average MBII among all reaches and years was considerably greater at "northern" parks (MBII=53.6) than "southern" parks (45.3). This is consistent with the EPA Wadeable Stream Assessment (Herlihy et al. 2008) which reported greater biological integrity index scores for BMI in Northern Appalachian streams than in Southern Appalachian streams. Among "northern" parks, the average MBII score was greatest (66.7±3.1) at Ten Mile River (UPDE) and lowest (23.7±0.1) at UNT to South Fork of the Little Conemaugh River (JOFL). In "southern" parks, Laurel Creek (NERI) had the MBII greatest (66.8±9.7), whereas the lowest MBII (14.3±0.1) was at Ice Pond Run (FRHI).

Individual park summaries of the 2009–2010 sampling seasons, along with figures that summarize both years of data collection, are presented in the following sections.

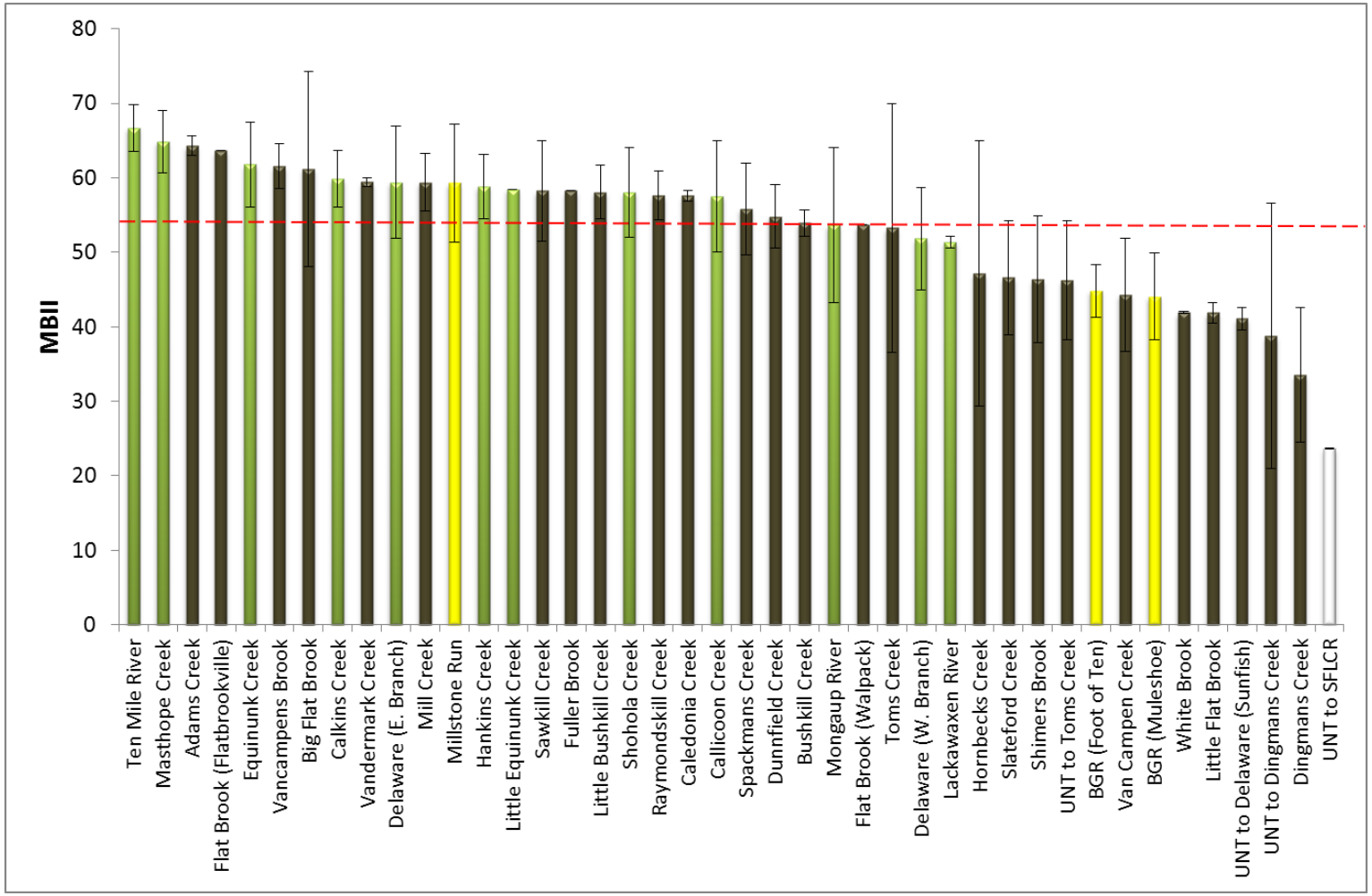


Figure 2. Average Macroinvertebrate Biotic Integrity Index (MBII) scores from the fall 2008 and 2009 sampling seasons from 42 stream reaches in four "northern" parks in the Eastern and Rivers Mountains Network. Bars are color-coded as: Allegheny Portage Railroad National Historic Site = yellow; Delaware Water Gap National Recreation Area = black; Johnstown Flood National Memorial = white; Upper Delaware Scenic and Recreational River = green. Dashed line depicts the mean MBII (53.6) from these stream reaches whereas error bars represent standard deviation.

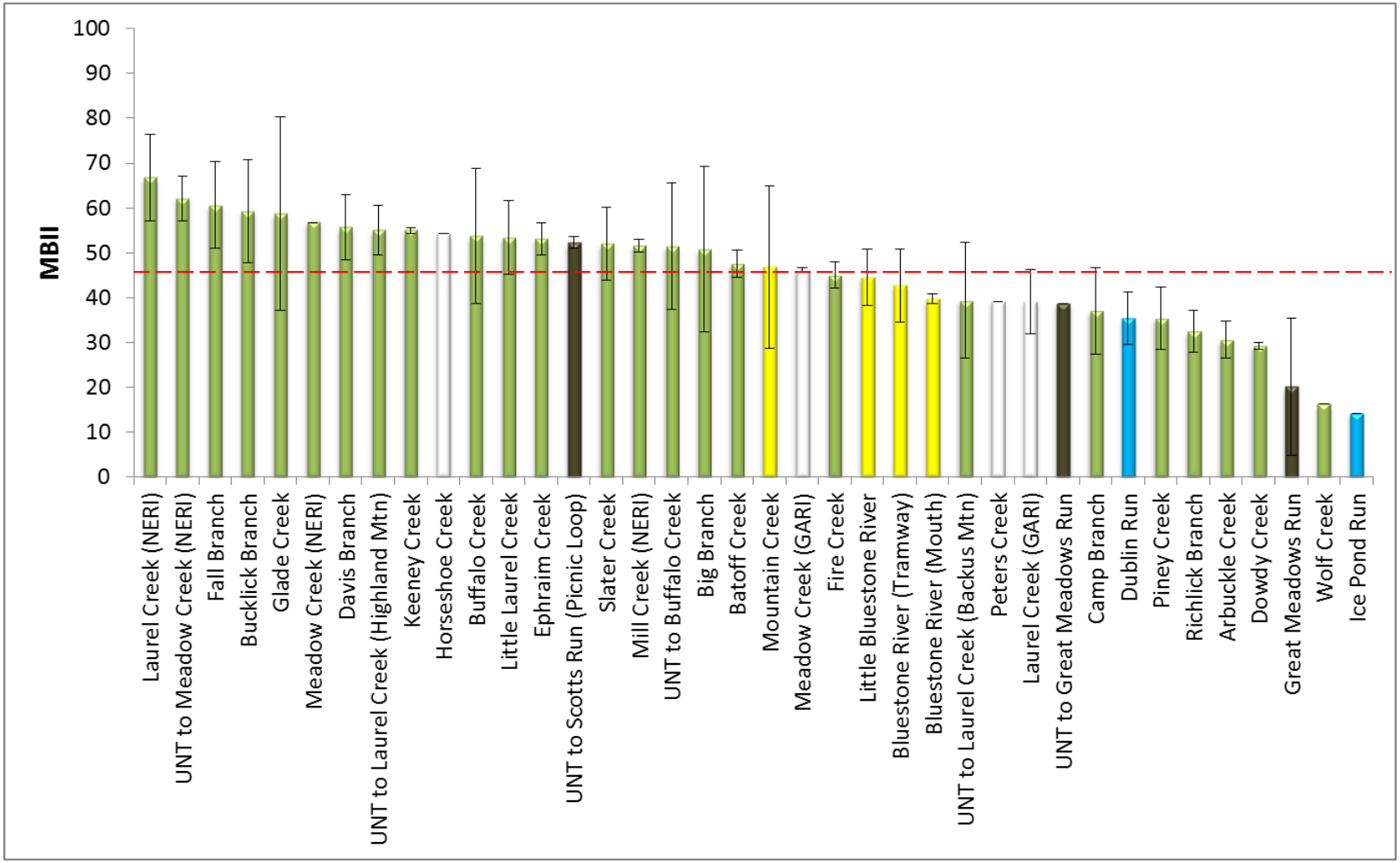


Figure 3. Average Macroinvertebrate Biotic Integrity Index (MBII) scores from the spring 2009 and spring 2010 sampling season from 38 reaches (stream reaches) in five "southern" parks in the Eastern and Rivers Mountains Network. Bars are color-coded as: Bluestone National Scenic River = yellow; Fort Necessity National Battlefield = black; Friendship Hill National Historic Site = blue; Gauley River National Recreation Area = white; New River Gorge National River = green. Dashed line depicts the mean MBII (45.3) from these stream reaches whereas error bars represent standard deviation.

Allegheny Portage Railroad National Historic Site and Johnstown Flood National Memorial

2009 Field Season Summary

All ALPO reaches (Figure 4) and the JOFL reach (Figure 5) were sampled on October 21, 2009. Aquatic organisms, including BMI, are affected by weather conditions during their life span, which for most species is one year. According to Knight et al. (2010 a), calendar year 2009 was cooler and drier than average for the ALPO and JOFL region, with maximum temperatures averaging between 1–2 degrees Fahrenheit (°F) (0.6–1.2 degrees Celsius [°C]) below normal and precipitation approximately 6 in (155 mm) below normal for the calendar year. Summer months can pose particularly stressful environmental conditions (e.g., drought) to BMI. Based on 115 years of record, the summer (Jul–Sept) of 2009 ranked as the 100th coldest and 75th driest summer. Thus, the summer was cooler and drier than normal but probably not an abnormally stressful year for BMI because actual drought conditions only occurred in May due to the timing of precipitation events (Knight et al. 2010 a).

Water Quality

The unnamed tributary to South Fork Little Conemaugh River (UNT to SFLCR) at JOFL had considerably greater specific conductance (241.2$\pm$2.5 µS/cm) than ALPO reaches (Figure 6; Appendix B), which likely reflected historical mining activity near JOFL. Within ALPO, the difference in specific conductance among reaches was also probably attributable to human activities. The Blair Gap Run (Foot of Ten) reach had the greatest specific conductance (136.3$\pm$5.2µS/cm), which was likely related to the fact that it is downstream and adjacent to numerous roadways and houses alongside Old Route 22 and Foot of Ten Road. Many human activities (e.g., road salt, malfunctioning septic systems) can contribute to elevated measures of conductivity.

Other core water quality parameters (pH, temperature, DO) were similar among ALPO and JOFL reaches (Figures 6 and 7). These measures vary daily and are related to each other; consequently, the wide range of pH, temperature, and DO values was not surprising, given that there have been only two visits to each reach. Generally, sunlight during the day increases water temperature and biological activity, which in turn, affects measures of pH and DO concentrations.

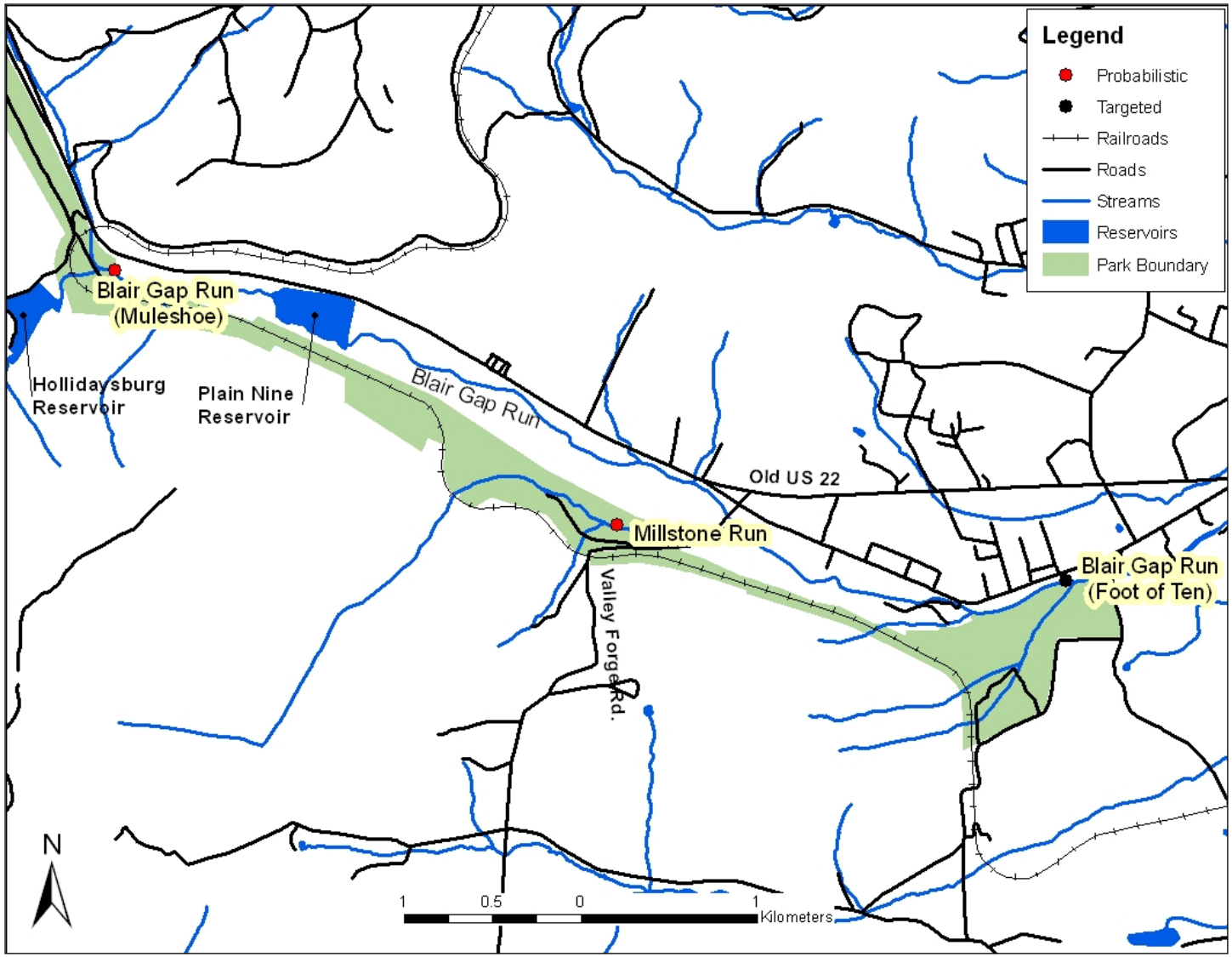


Figure 4. Locations of stream monitoring reaches at Allegheny Portage Railroad National Historic Site.

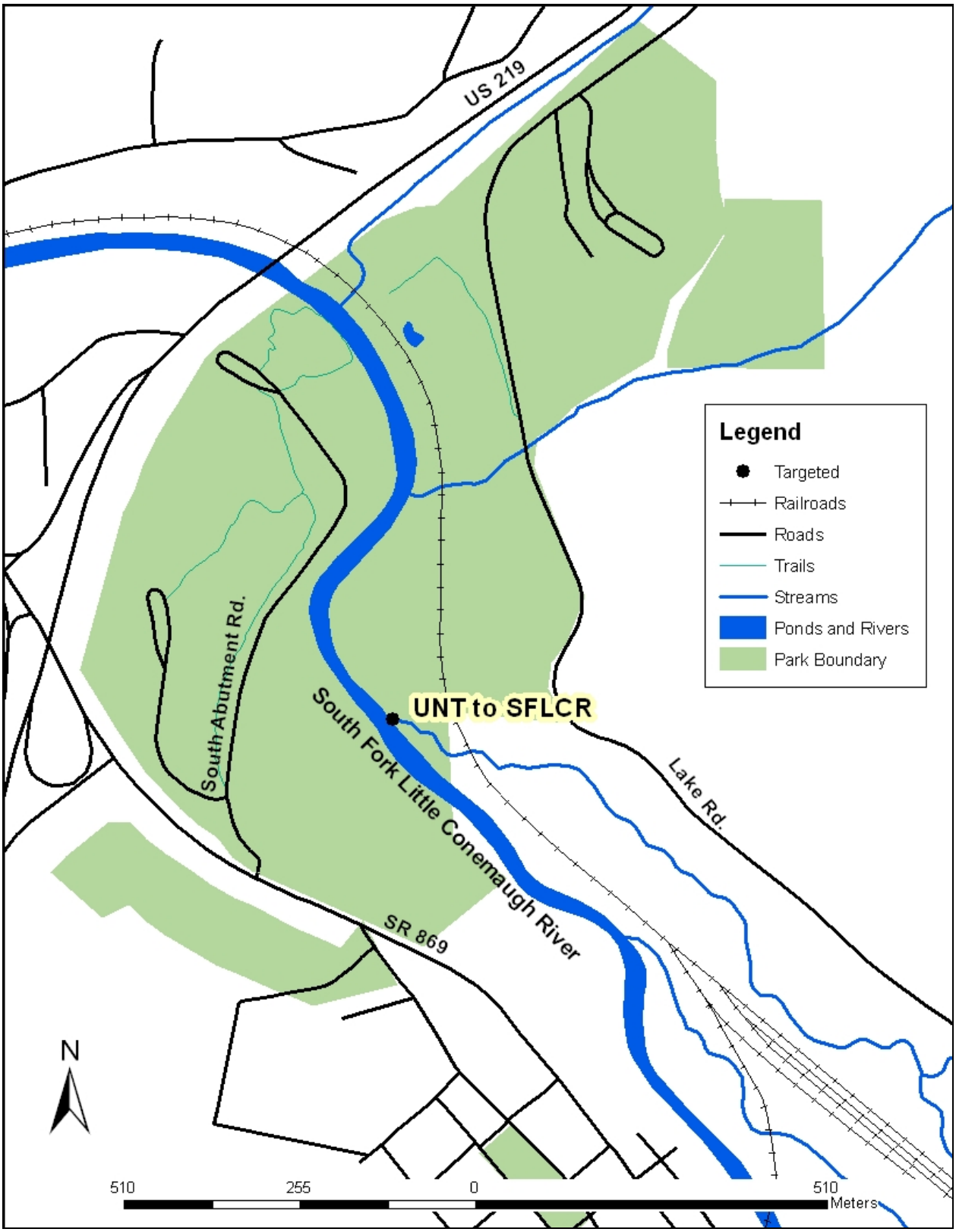
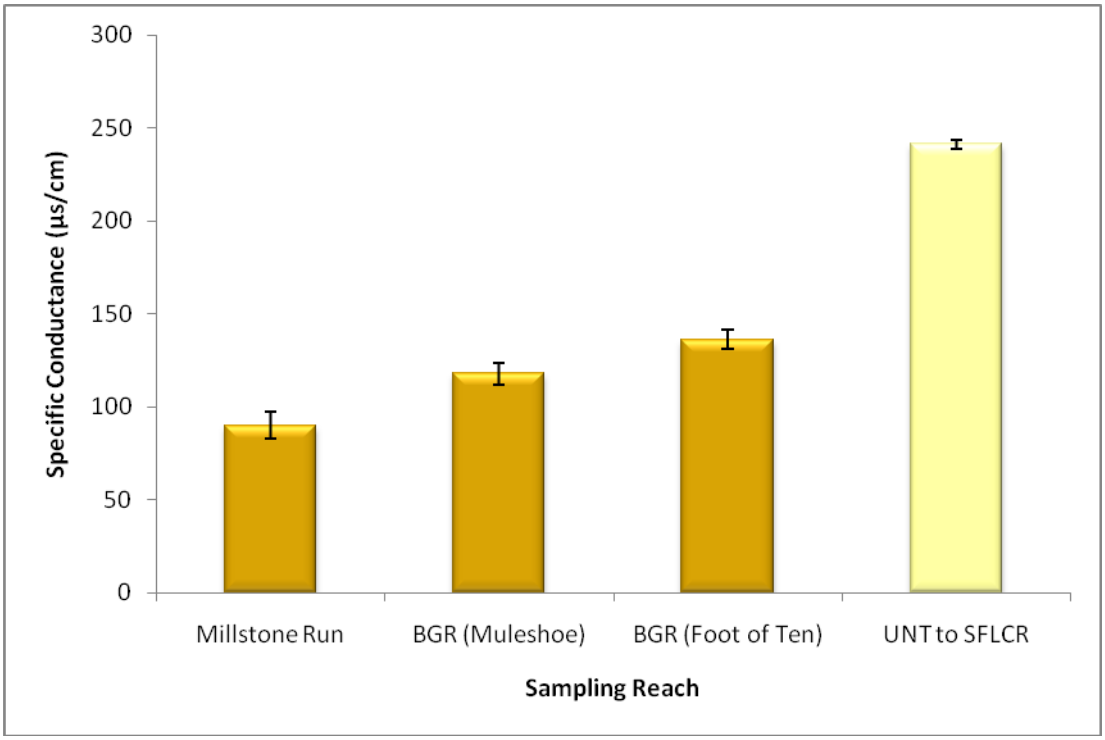


Figure 5. Location of the stream monitoring reach at Johnstown Flood National Memorial.



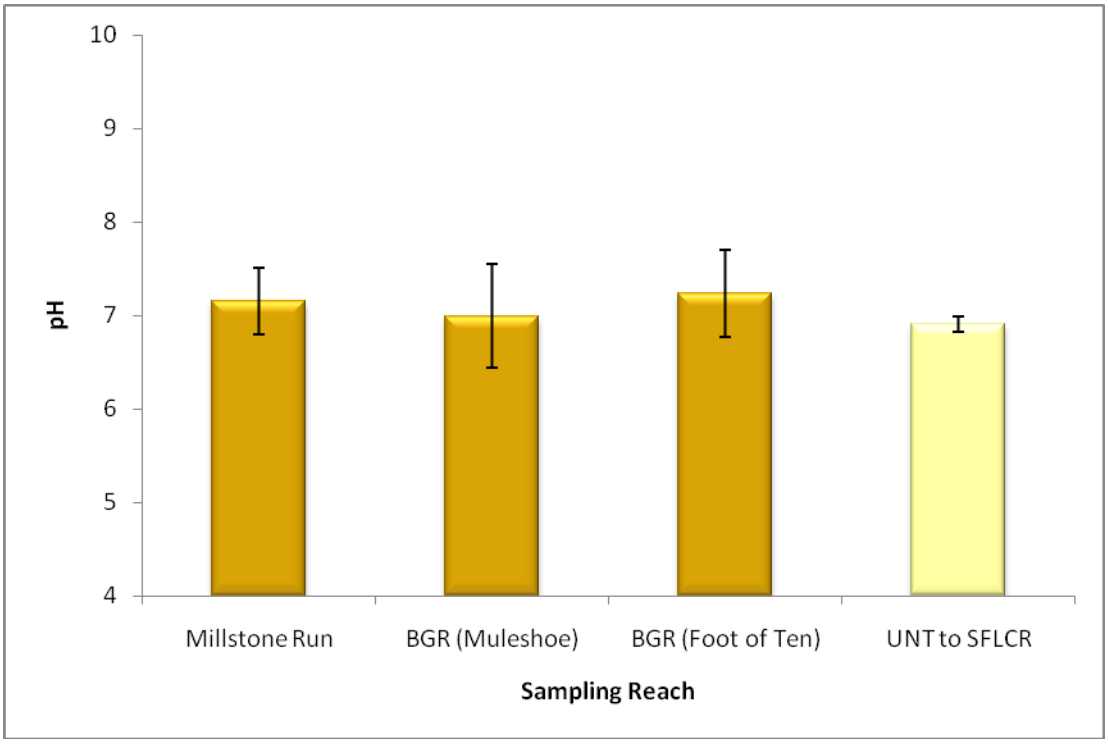
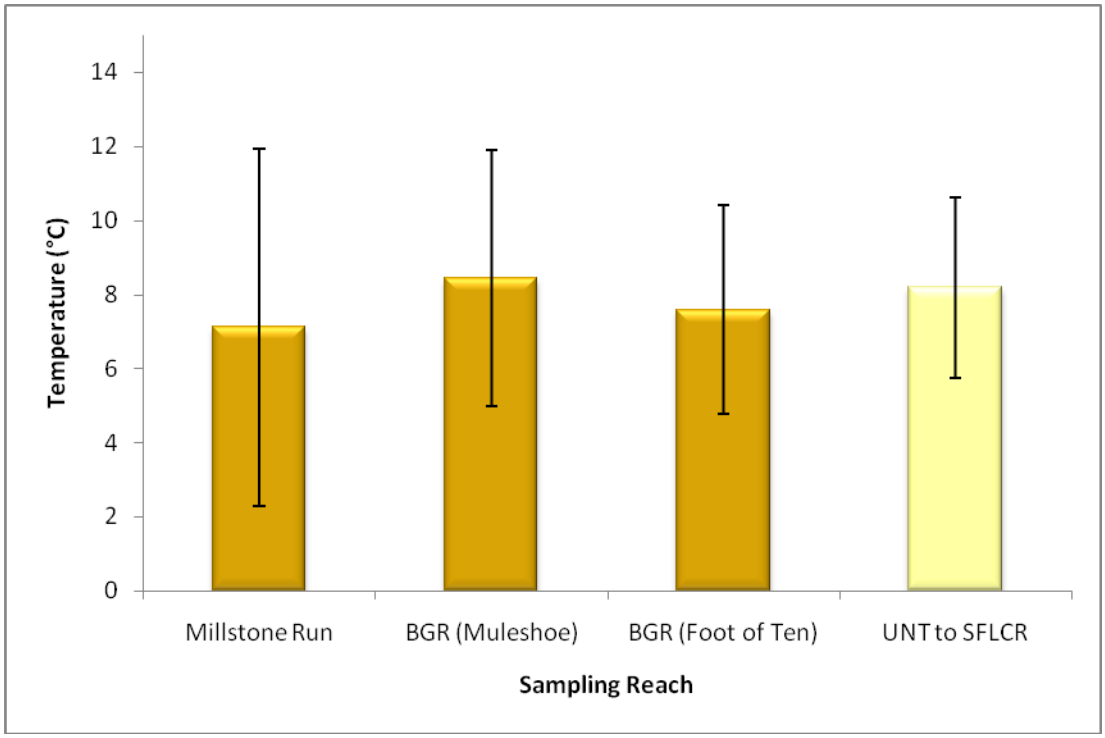


Figure 6. Average specific conductance (top) and pH (bottom) of water at sampling reaches throughout Allegheny Portage Railroad National Historic Site (dark bars) and Johnstown Flood National Memorial (light bars) in October 2008 and 2009. Error bars represent standard deviation. BGR = Blair Gap Run; UNT to SFLCR = Unnamed tributary to South Fork Little Conemaugh River.



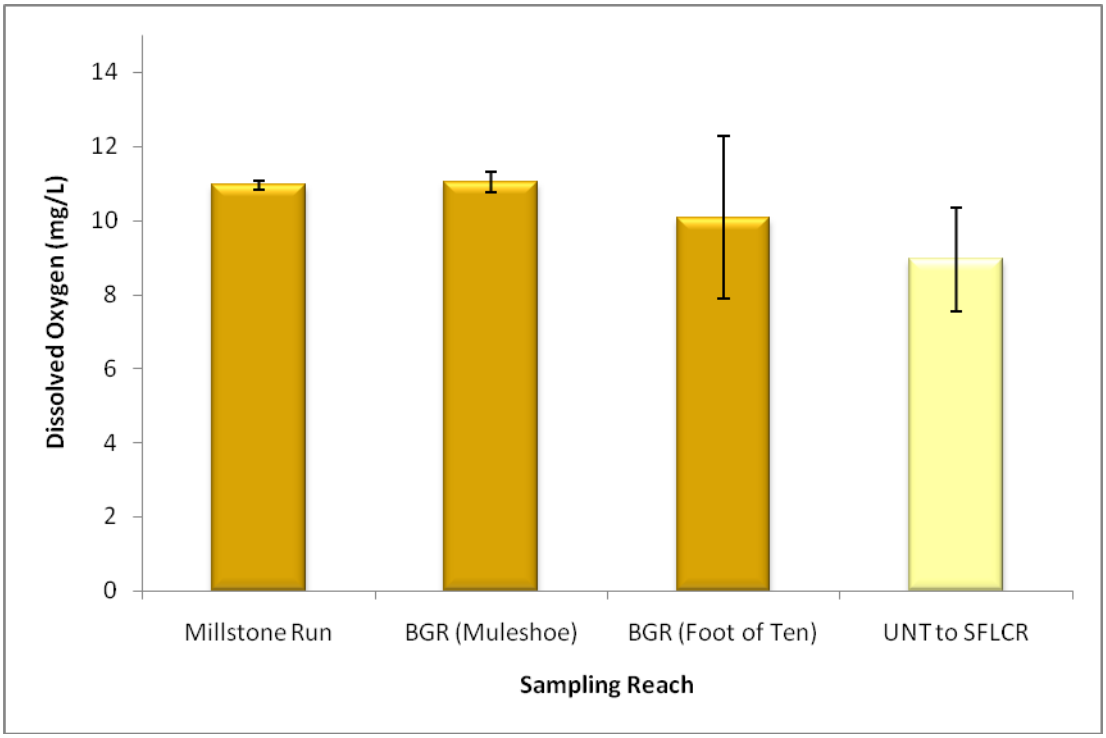


Figure 7. Average temperature (top) and dissolved oxygen concentration (bottom) of water at sampling reaches throughout Allegheny Portage Railroad National Historic Site (dark bars) and Johnstown Flood National Memorial (light bars) in October 2008 and 2009. Error bars represent standard deviation. BGR = Blair Gap Run; UNT to SFLCR = Unnamed tributary to South Fork Little Conemaugh River.

Benthic Macroinvertebrate Communities

Compared to many other reaches in the network, BMI communities were similar between 2008 and 2009 at ALPO and JOFL (Figure 8). In both years, MBII scores ranked the reaches in the same order, with Millstone Run ranking highest and the UNT to SFLCR ranking last—the two Blair Gap Run Reaches were very similar based on MBII scores. The MBII scores were greater during 2009 than 2008 at all ALPO reaches, whereas MBII scores at the JOFL reach were virtually identical between 2008 (MBII=23.6) and 2009 (23.7; Appendix C). There are many possible explanations of why MBII scores were consistently greater during 2009 (Appendix D), but all differences were within the range of what could be expected from combined environmental (e.g., weather) and sampling (e.g., sample date) variability.

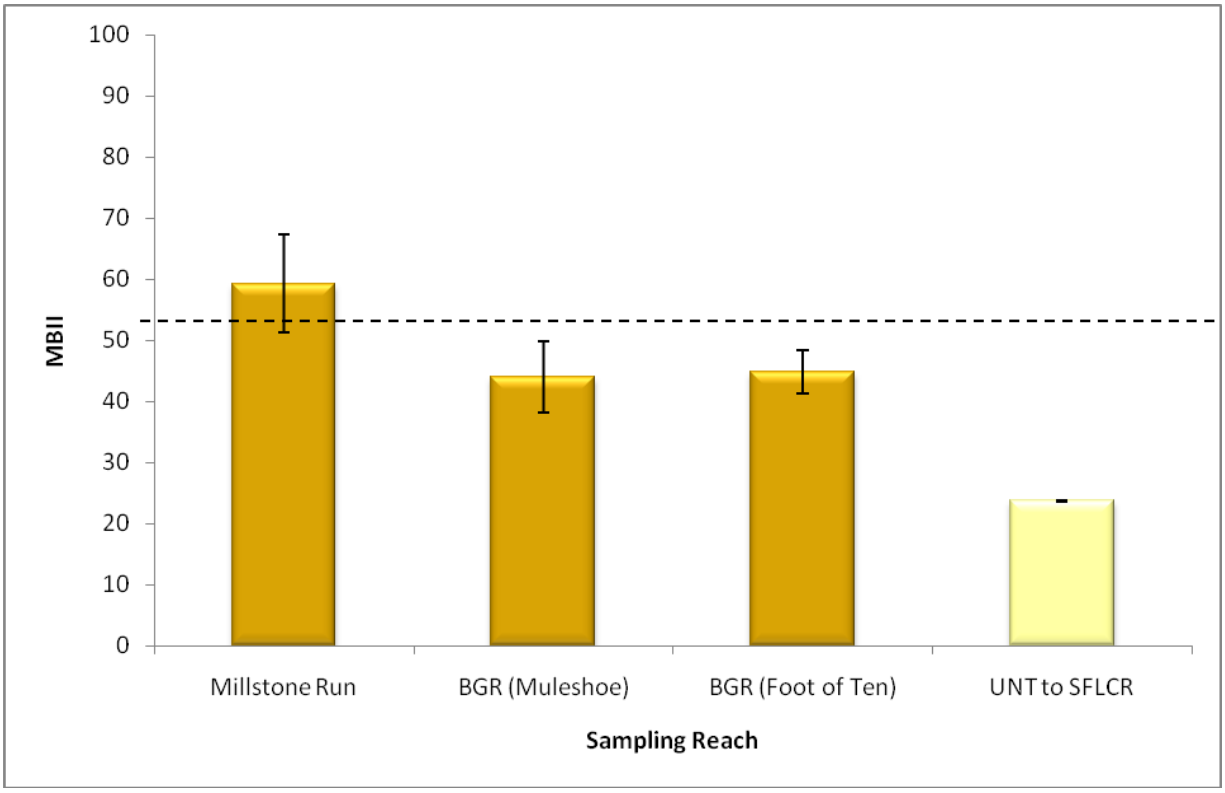


Figure 8. Macroinvertebrate Biotic Integrity Index (MBII) scores for benthic macroinvertebrate samples collected throughout Allegheny Portage Railroad National Historic Site (dark bars) and Johnstown Flood National Memorial (light bars) in October 2008 and 2009. Error bars represent standard deviation, whereas dashed line depicts the mean MBII (53.6) from "northern" Eastern Rivers and Mountains Network streams. BGR = Blair Gap Run; UNT to SFLCR = Unnamed tributary to South Fork Little Conemaugh River.

Bluestone National Scenic River and Gauley River National Recreation Area

2010 Field Season Summary

Although weather conditions were typical during 2009, heavy precipitation during March 2010 (5.24" at PIRW2 - Pipestem) and subsequent high stream flows caused most BLUE and GARI reaches (Figures 9 and 10) to be sampled approximately one week later during 2010 (4/5/2010–4/7/2010) than during 2009 (3/30/09–04/01/09). Due to the relatively large size of the Bluestone River, the two reaches there were not sampled in the spring, and were instead sampled during the fall (9/14/2010), when water levels were low enough to sample BMI. Those reaches will continue to be sampled during September in the future.

Aquatic organisms, including BMI, are affected by weather conditions during their life span, which for most species is one year. The 2009 calendar year averaged near normal compared with the long-term mean for temperature, though not as warm as earlier years in this decade Knight et al. (2010 b). Annual precipitation, conversely, was 3%–29% greater than the 30-year average, which was the seventh time in the past eight years that annual precipitation was greater than the long-term mean (Knight et al. 2010 b). Summer months can pose particularly stressful environmental conditions (e.g., drought and high temperatures) to aquatic animals. The summer months of July–September (2009) were much cooler than average due to lower-than-normal maximum readings and ranked as the 14th coolest summer in 115 years of record. Due to ample precipitation and near-normal temperatures, there were no drought conditions near either park during the growing season of 2009.

The Horseshoe Creek (GARI) reach could not be sampled in 2010 due to consistently high stream flows; moreover, the reach that had been established there previously was severely scoured and lacked habitat (riffles) typically sampled by the ERMN. It is likely that a different BMI sampling approach (i.e., woody debris sampling) will be necessary at Horseshoe Creek in the future due to the near-absence of riffles—most of the downstream portions of Horseshoe Creek have either sand or very large boulders as substrate. A new sampling reach was established and sampled on Peters Creek in 2010. The reach is located where Peters Creek intersects the GARI boundary and extends 310 m to just upstream of the first railroad bridge downstream of the park boundary.

Sampling at BLUE went well, although there was evidence of significant scouring at the Mountain Creek and Little Bluestone River sampling reaches.

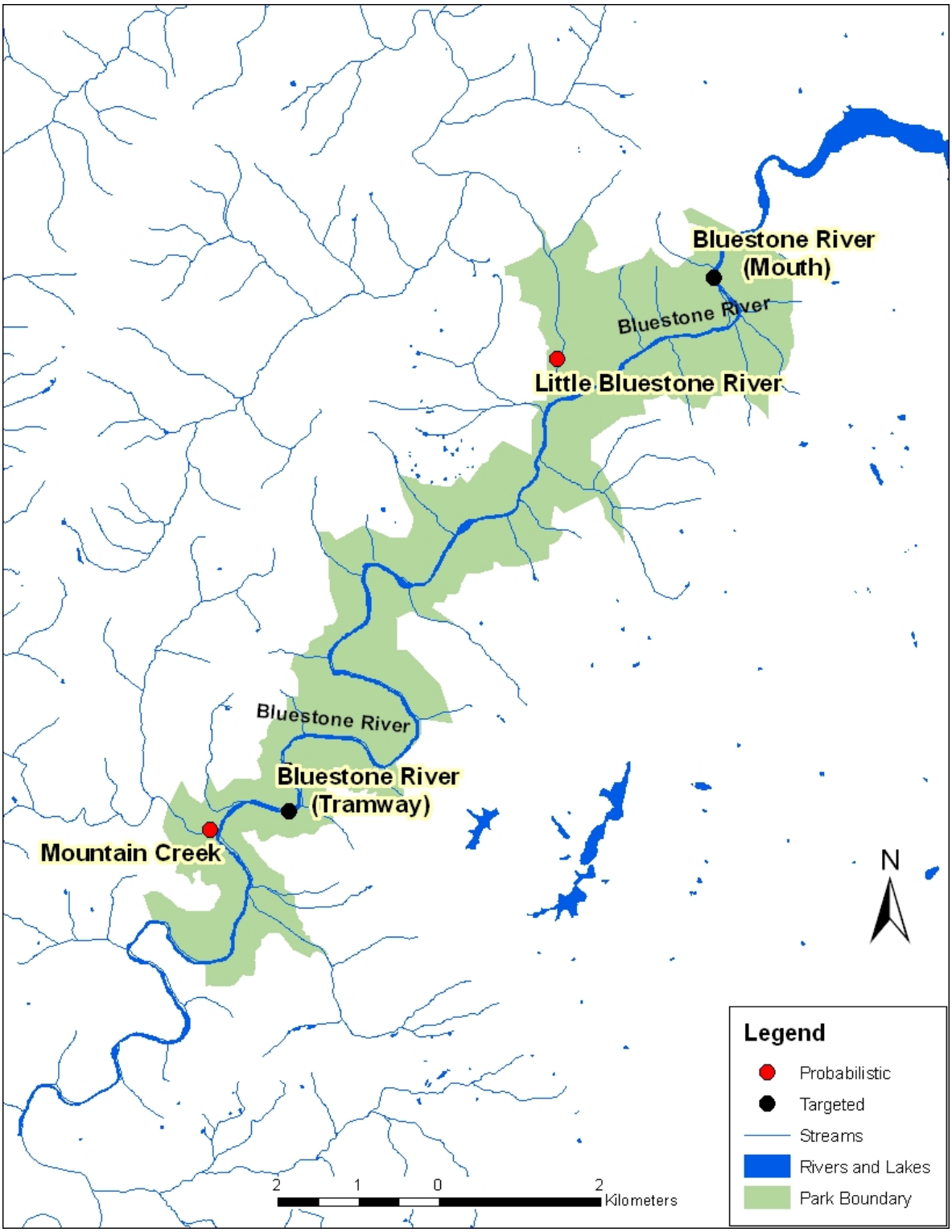


Figure 9. Locations of stream monitoring reaches at Bluestone National Scenic River.

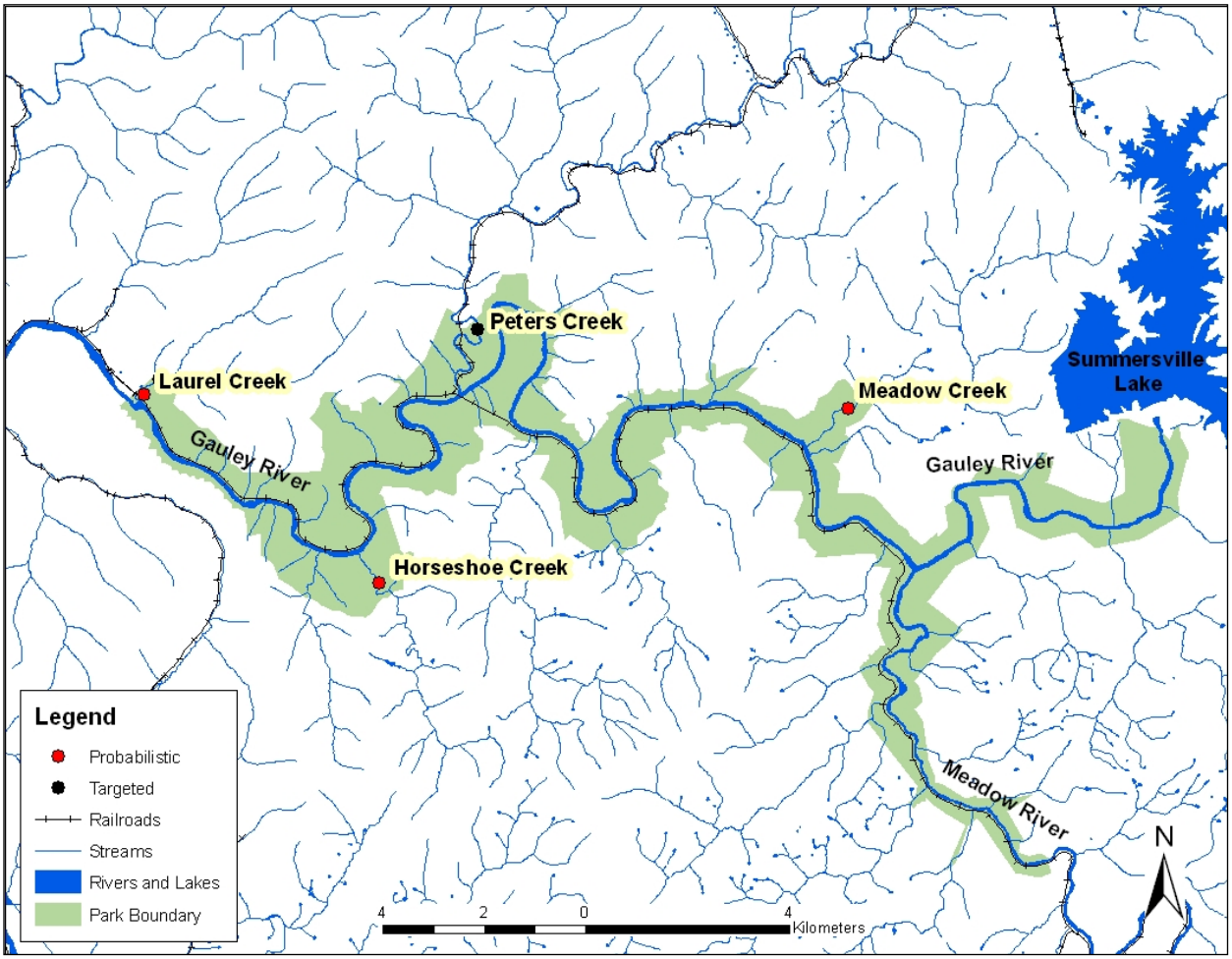


Figure 10. Locations of stream monitoring reaches at Gauley River National Recreation Area.

Water Quality

Physical and chemical characteristics of stream water can vary markedly, both daily and annually. Although there are limitations to point-in-time characterizations of core water quality parameters, these measures can be helpful when evaluating patterns in biological data; moreover, extreme changes to these parameters can sometimes be detected with point-in-time samples.

Larger streams and rivers generally had greater specific conductance than smaller streams at BLUE and GARI (Figure 11; Appendix B), which was likely a result of a combination of underlying geology and anthropogenic stressors (e.g., road salts, septic system effluent) that are often present in valley floodplains where large rivers occur. Other core parameters (i.e., pH, DO, water temperature) were variable among and within reaches (Figure 12), which was almost certainly due to different sampling dates and times.

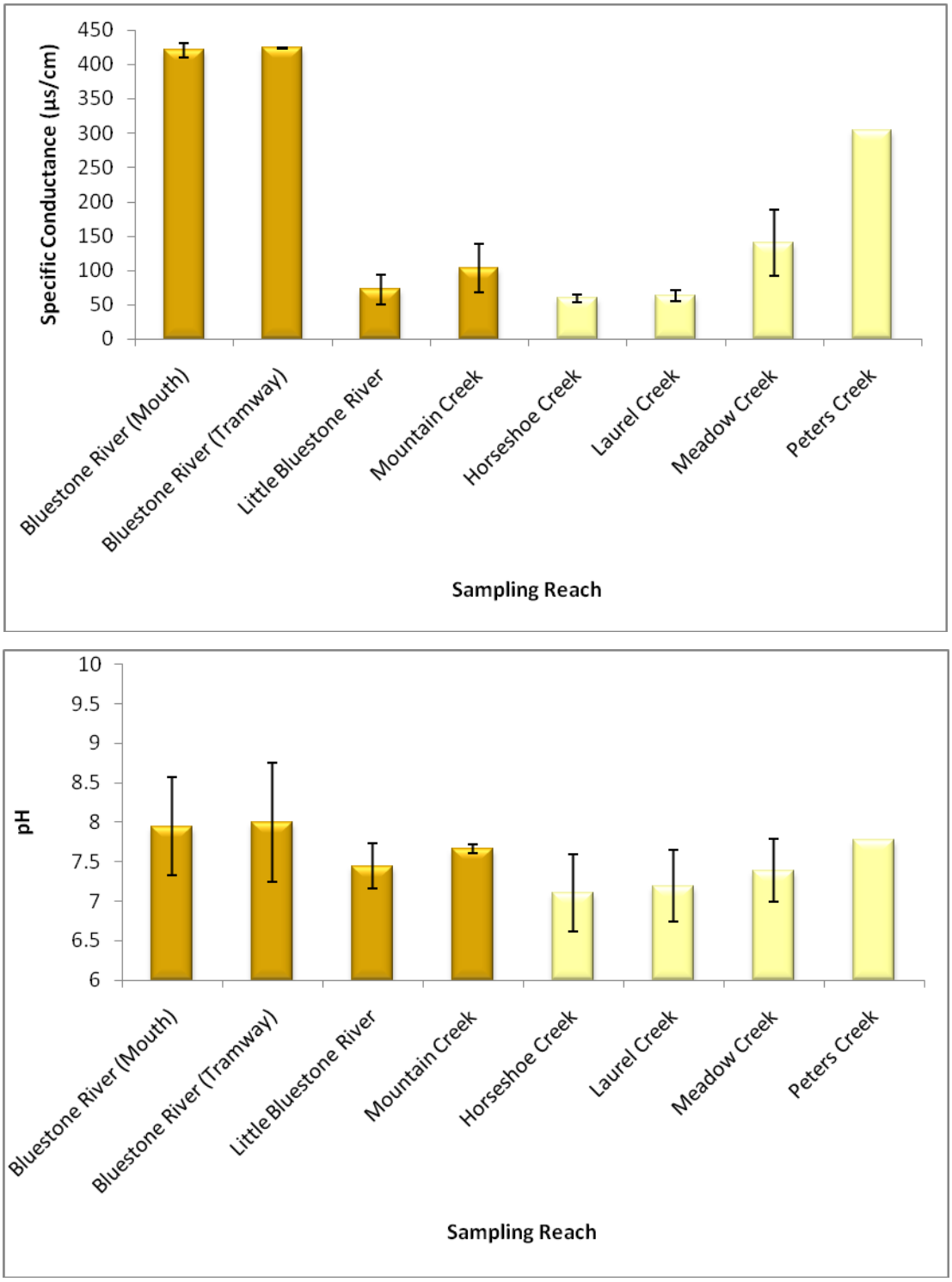
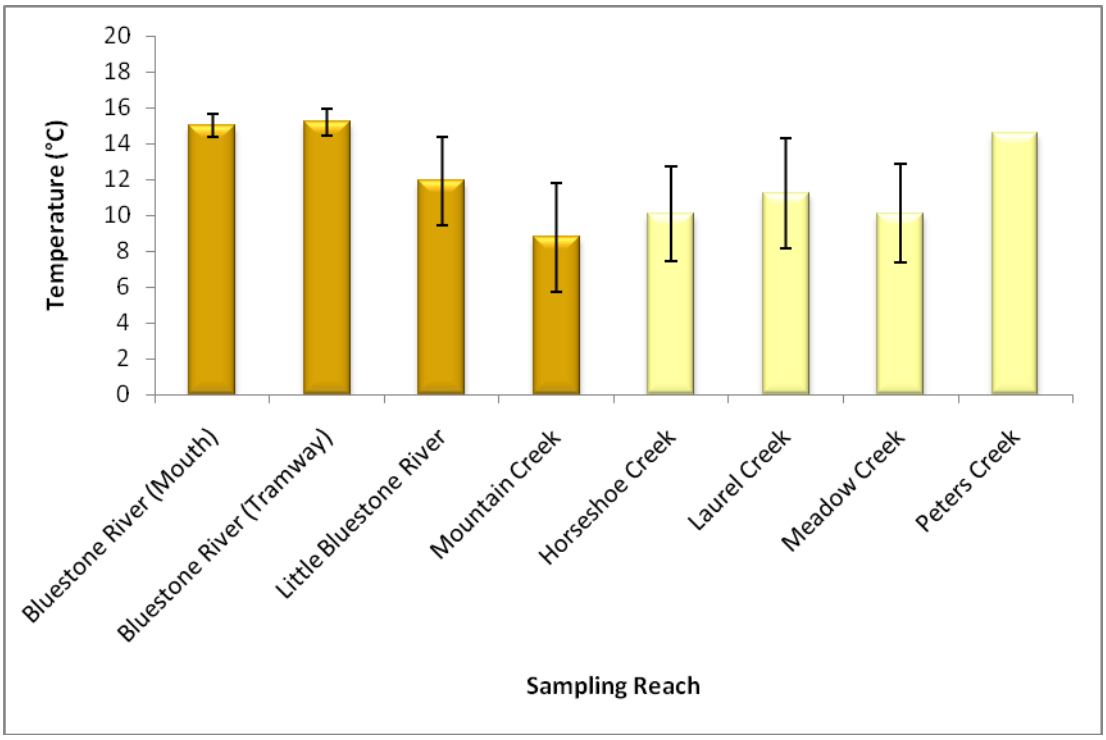


Figure 11. Average specific conductance (top) and pH (bottom) of water at sampling reaches throughout Bluestone National Scenic River (dark bars) and Gauley River National Recreation Area (light bars) in March 2009 and 2010. Error bars represent standard deviation.



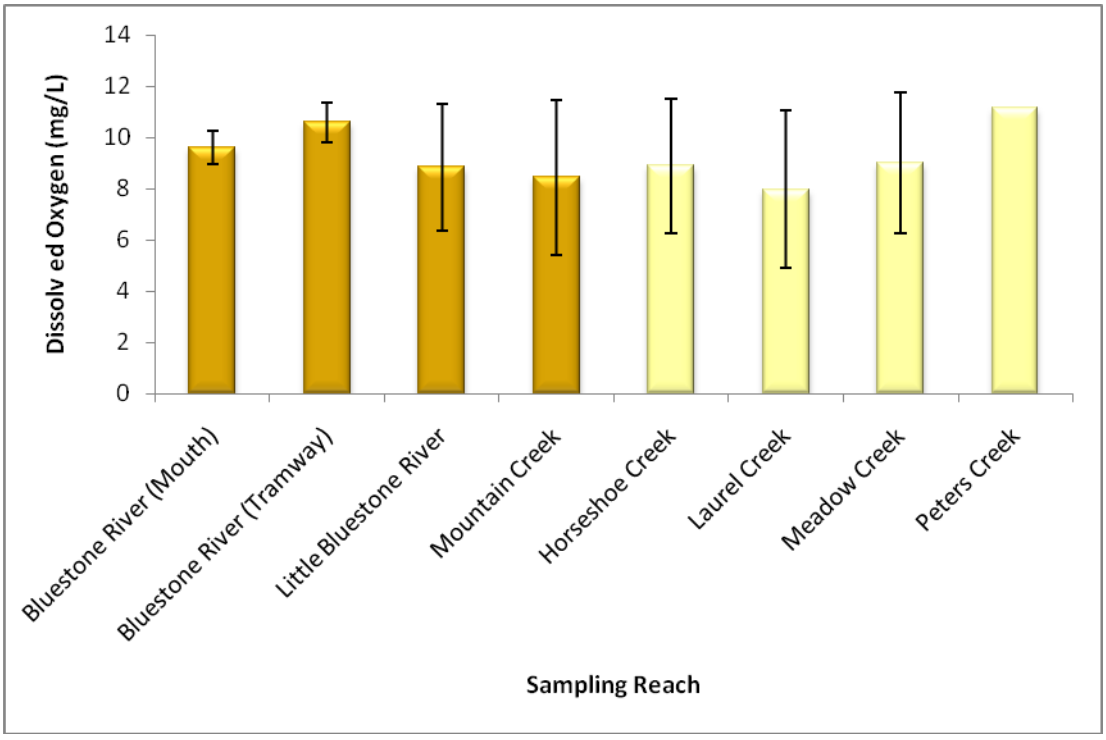


Figure 12. Average temperature (top) and dissolved oxygen concentration (bottom) of water at sampling reaches throughout Bluestone National Scenic River (dark bars) and Gauley River National Recreation Area (light bars) during March 2009 and 2010. Error bars represent standard deviation.

Benthic Macroinvertebrate Communities

In addition to slightly delaying the 2010 sampling season, high stream flows during March caused significant scouring in many streams, which may have decreased BMI densities in many BLUE and GARI streams (Figure 13). In streams that were sampled during March of both 2009 and 2010, Meadow Creek (GARI) was the only stream where BMI densities were greater in 2010 than 2009. Interestingly, the substrate at the Meadow Creek (GARI) reach was comprised of more bedrock than other sampled reaches, which, in some way, may have minimized the impact of high flow events on BMI communities.

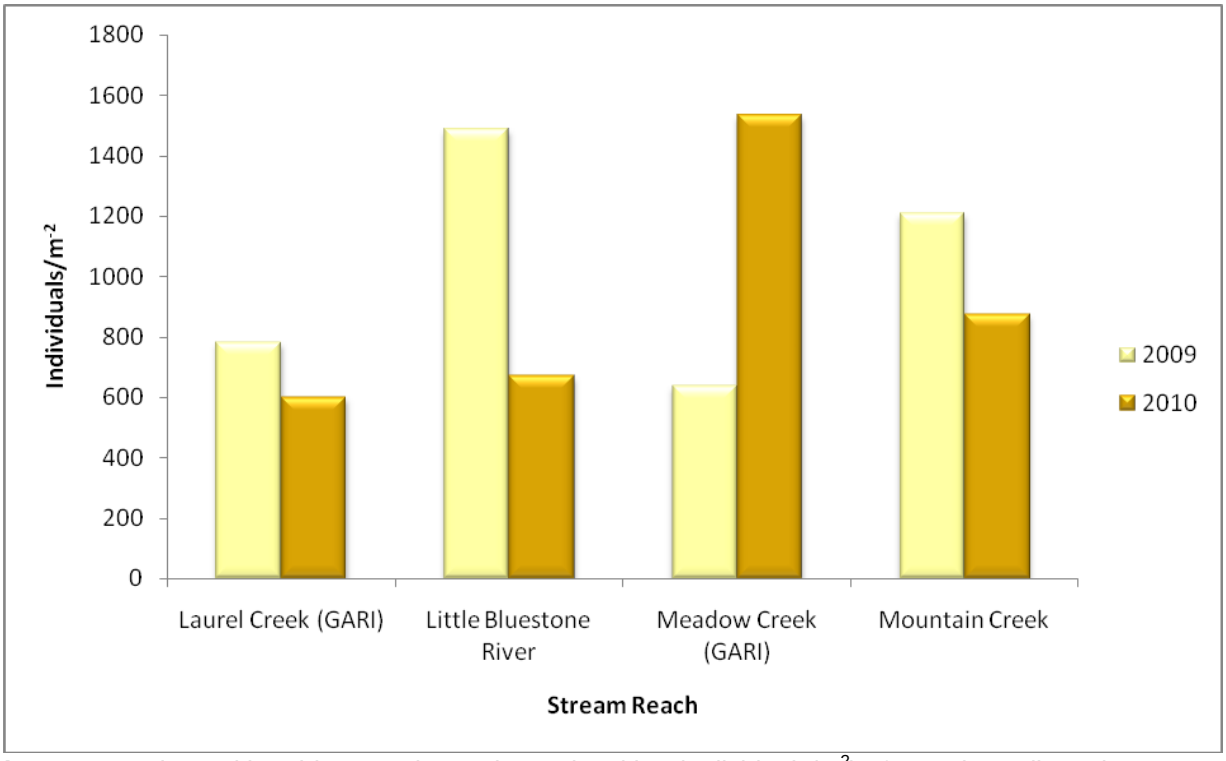


Figure 13. Estimated benthic macroinvertebrate densities (Individuals/m^2) of samples collected throughout Gauley River National Recreation Area and Bluestone National Scenic River in March 2009 (light bars) and 2010 (dark bars).

Although BMI densities were often lower in 2010 than during 2009, MBII scores were generally slightly higher during 2010 than in previous years (Figure 14; Appendix C)—note that Bluestone River reaches were sampled during the fall of 2008 but not in 2009. Mountain Creek at BLUE had a MBII score (59.7) in 2010 that was nearly twice that (34.1) of 2009. which was counterintuitive, based on very high stream flows during 2010. Other reaches were less variable in terms of MBII scores between years at other BLUE and GARI reaches—MBII scores at Meadow Creek (GARI) were nearly identical between 2009 (46.5) and 2010 (45.7).

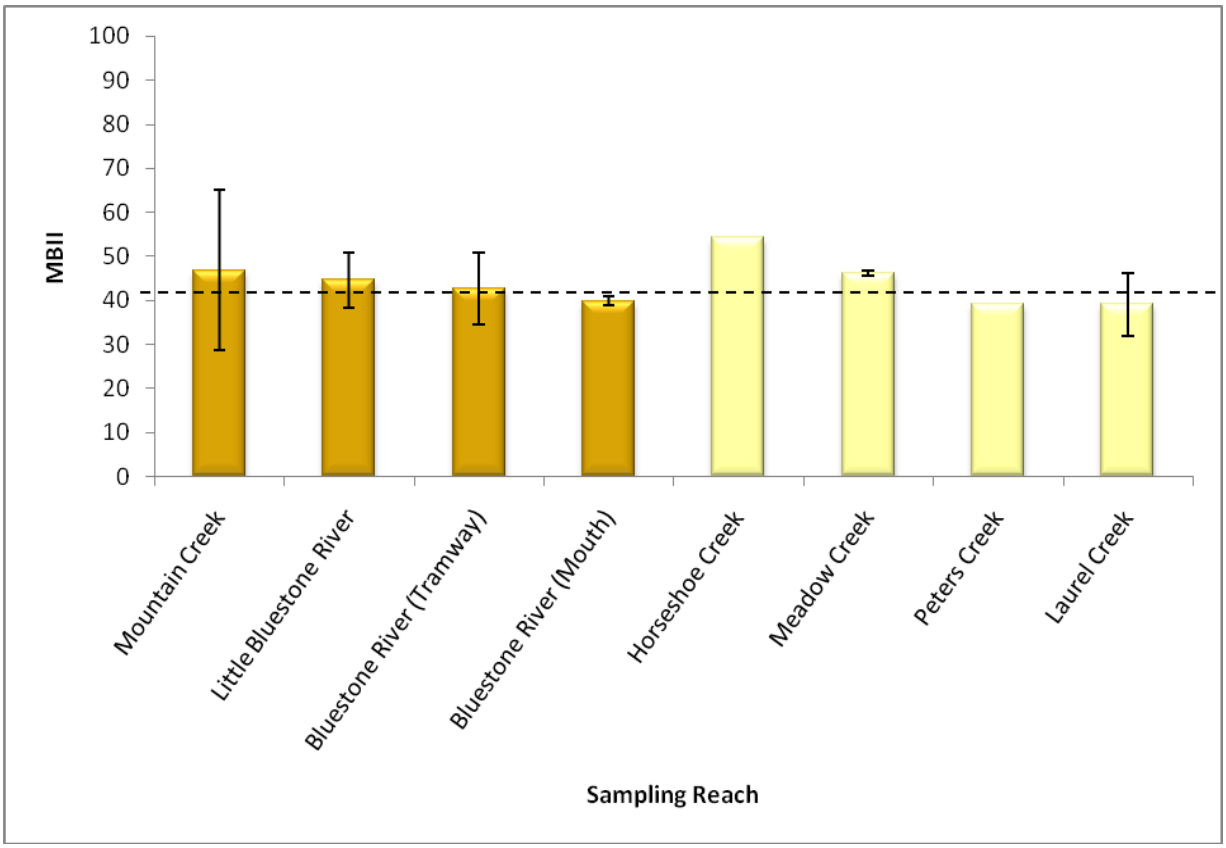


Figure 14. Macroinvertebrate Biotic Integrity Index (MBII) scores for benthic macroinvertebrate samples collected throughout Bluestone National Scenic River (dark bars) and Gauley River National Recreation Area (light bars) in March 2009 and 2010. Error bars represent standard deviation whereas dashed line depicts the mean MBII (45.3) from "southern" Eastern Rivers and Mountains Network streams.

Delaware Water Gap National Recreation Area

2009 Field Season Summary

All DEWA reaches (Figure 15), except for Fuller Brook, were sampled between October 1 and October 9, 2009. Fuller Brook could not be sampled in 2009 because there was not surface flow in the sampling reach; there were small isolated pools downstream of the reach but no surface flow. Two targeted reaches were added during 2009 on Flat Brook, one reach near Walpack and another near Flatbrookville. Those reaches were selected in consultation with park staff because of the high ecological and recreational value of that stream.

Aquatic organisms, including BMI, are affected by weather conditions during their life spans, which for most BMI taxa is one year. The 2009 calendar year was cooler than usual near DEWA—maximum temperatures for the year averaged between 0.5 and 2.3°F (0.2–1.2°C) below the long-term mean temperature (Knight et al. 2010 c). Total growing season length (days between last spring freeze and first fall freeze) ranged from 124–170 days in 2009, near the long-term average. The summer period was cooler than average and no record maximums were recorded during July, August, or September (Knight et al. 2010c). For the ninth consecutive year, annual precipitation for 2009 averaged above the long-term mean and the summer brought above-average rainfall, with two of the three months tallying more than 150% of normal. The combination of moderate temperatures and ample precipitation led to abnormally dry conditions only during the beginning of May.

Water Quality

Physical and chemical characteristics of streamwater can vary markedly, both daily and annually. Although there are limitations to point-in-time characterizations of core water quality parameters, these measures can be helpful when evaluating patterns in biological data; moreover, extreme changes to these parameters can sometimes be detected with point-in-time samples.

Specific conductance, a measure of the ability of a substance to conduct electricity, was generally between 50 and 300 µs/cm (Figure 16; Appendix B). Three DEWA streams (Little Flat Brook, Shimers Brook, and White Brook) that could be characterized as “limestone” streams had specific conductance values that were much higher (>300 µs/cm). As ion concentration increases in water, specific conductance increases. Underlying geology of streams is a primary factor that affects ion concentrations and DEWA streams with high conductance typically flow through limestone valleys. Human activities (e.g., road salts, effluent) can also raise specific conductance. For example, it is possible that White Brook had the highest conductance measures, due, in part, to its downstream proximity to the intersection of several major roads, in addition to its “limestone” geology.

Other core water quality parameters (pH, temperature, DO) were similar (but variable between years) among DEWA reaches (Figures 16 and 17). These measures fluctuate daily and are related to each other; consequently, the range of pH, temperature, and DO values was not surprising, given that there have been only two visits to each reach. Generally, sunlight during the day increases water temperature and biological activity, which, in turn, affects measures of pH and DO concentration. The UNT to Delaware River (Sunfish Pond) had pH that was considerably lower (4.95 ± 0.34) than other DEWA streams, whereas Little Flat Brook generally had the greatest pH (8.55 ± 0.16). Most DEWA streams were circumneutral (i.e., pH between 6.50 and 7.50) and DO concentrations were near or above saturation levels in all sampling reaches.

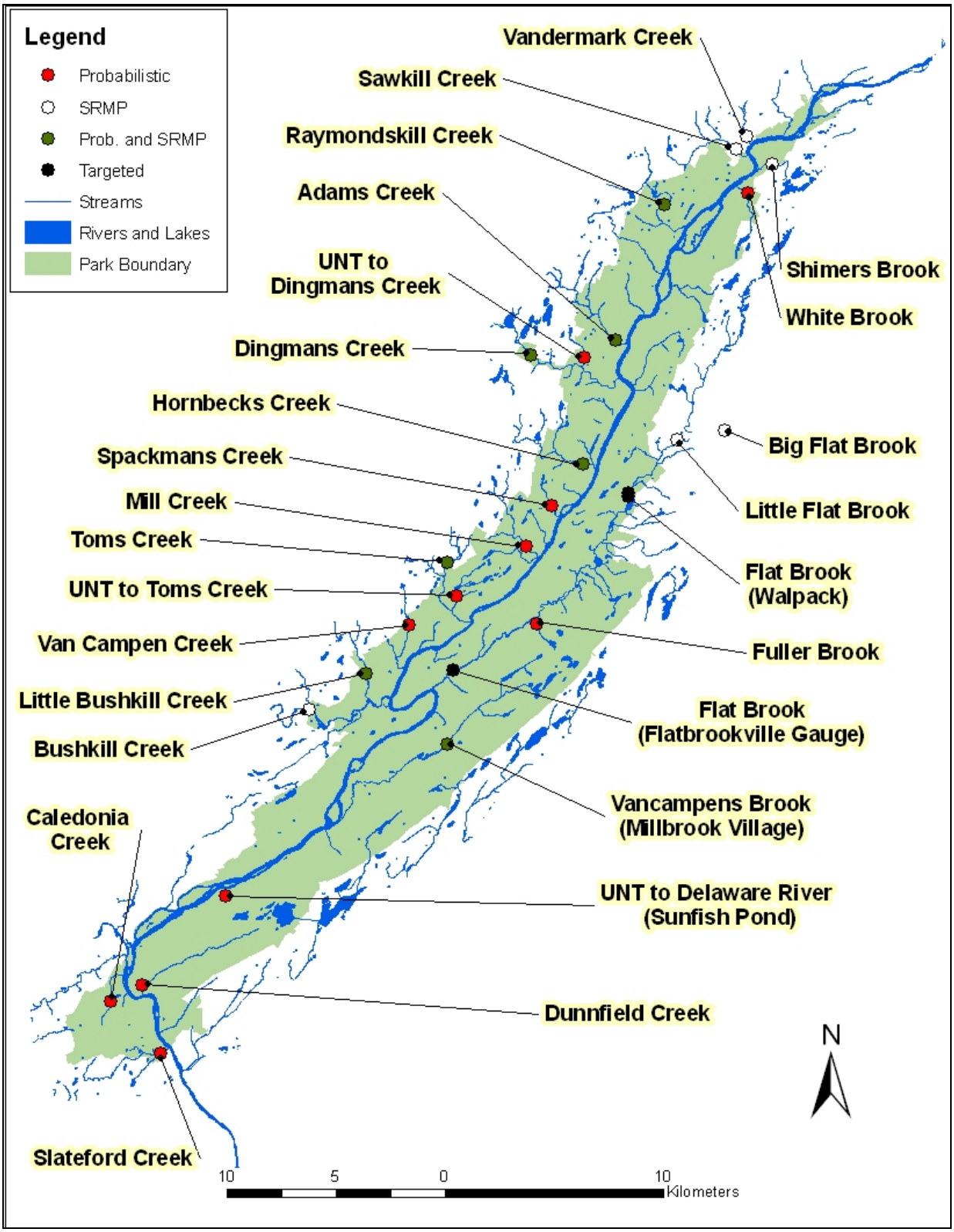


Figure 15. Locations of stream monitoring reaches at Delaware Water Gap National Recreation Area. "SRMP" reaches are targeted reaches that are collocated with Scenic Rivers (water quality) Monitoring Program reaches. UNT = Unnamed Tributary.

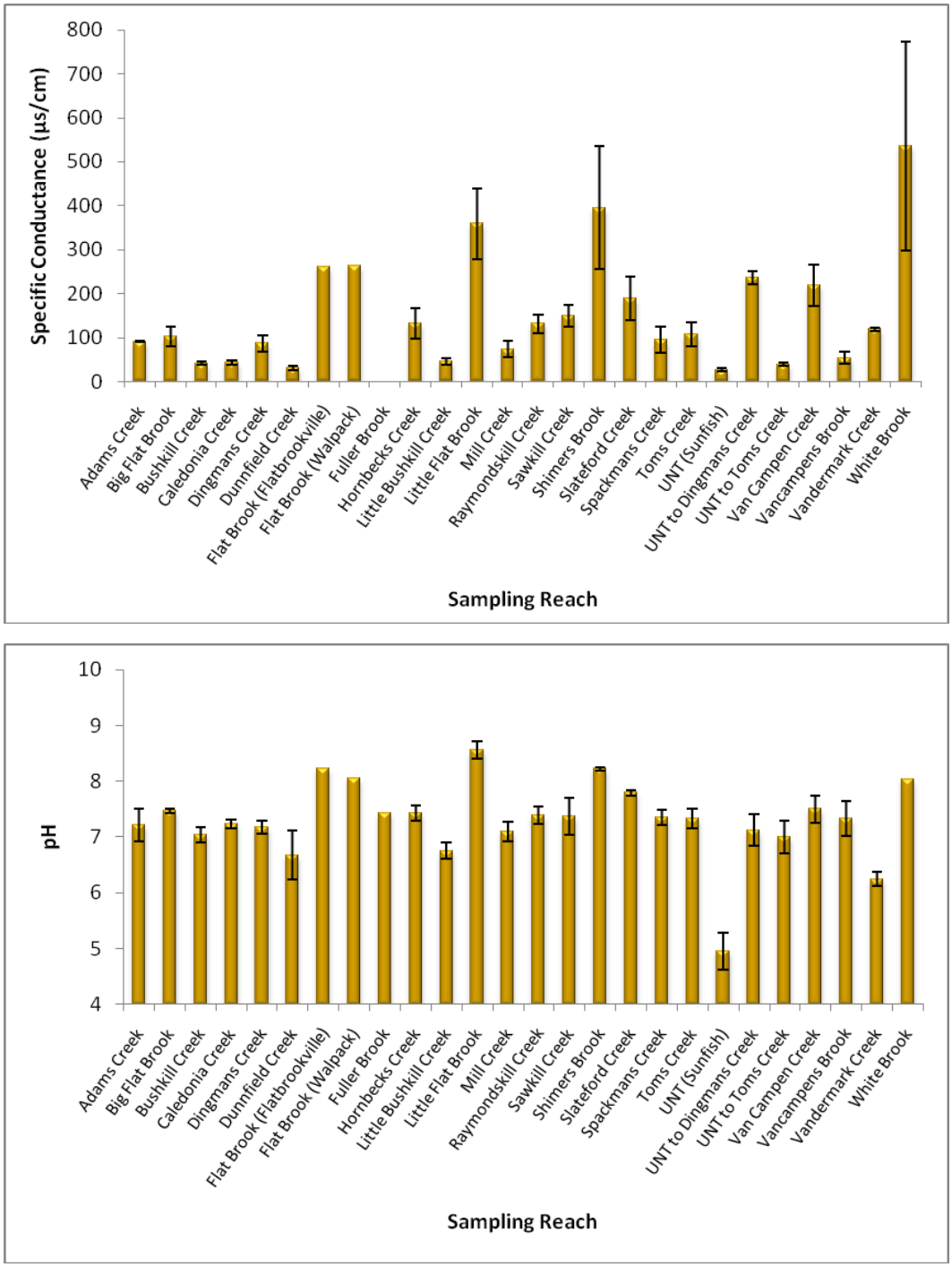


Figure 16. Average specific conductance (top) and pH (bottom) of water at sampling reaches throughout Delaware Water Gap National Recreation Area in October 2008 and 2009. Missing specific conductance data for Fuller Brook were a result of malfunctioning equipment during 2008 when there was surface flow —that stream could not be sampled during 2009 due to lack of surface flow. Error bars reflect standard deviation.

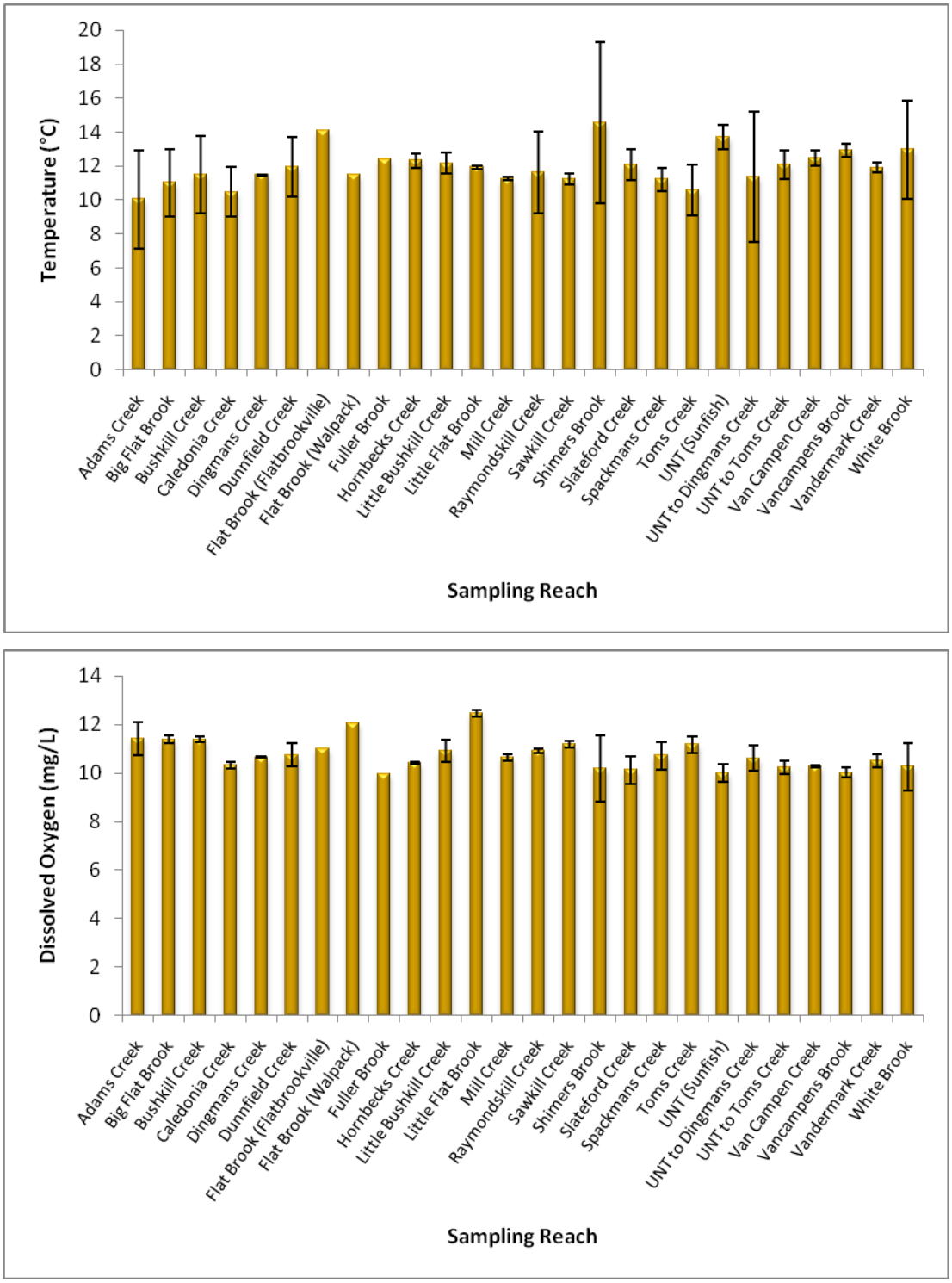


Figure 17. Average temperature (top) and dissolved oxygen concentration (bottom) of water at sampling reaches throughout Delaware Water Gap National Recreation Area in October 2008 and 2009. Error bars represent standard deviation.

Benthic Macroinvertebrate Communities

Based on MBII scores and constituent metrics, ecological integrity of DEWA streams ranged throughout the distribution of stream conditions observed in northern ERMN parks (see Figure 18). For example, MBII scores from Adams Creek and UNT to Dingmans Creek ranked third and second-to-last, respectively, among northern ERMN streams. MBII scores at several reaches (e.g., Big Flat Brook, Hornbecks Creek) were quite different between years, but most reaches had similar MBII scores between 2008 and 2009 (Figure 18; Appendix C). It is likely that much of the observed difference between years was due to environmental variability (e.g., weather patterns). It is expected that with several years of data, a baseline condition (with greater statistical precision) will be established to which future ecological status and trends can be compared.

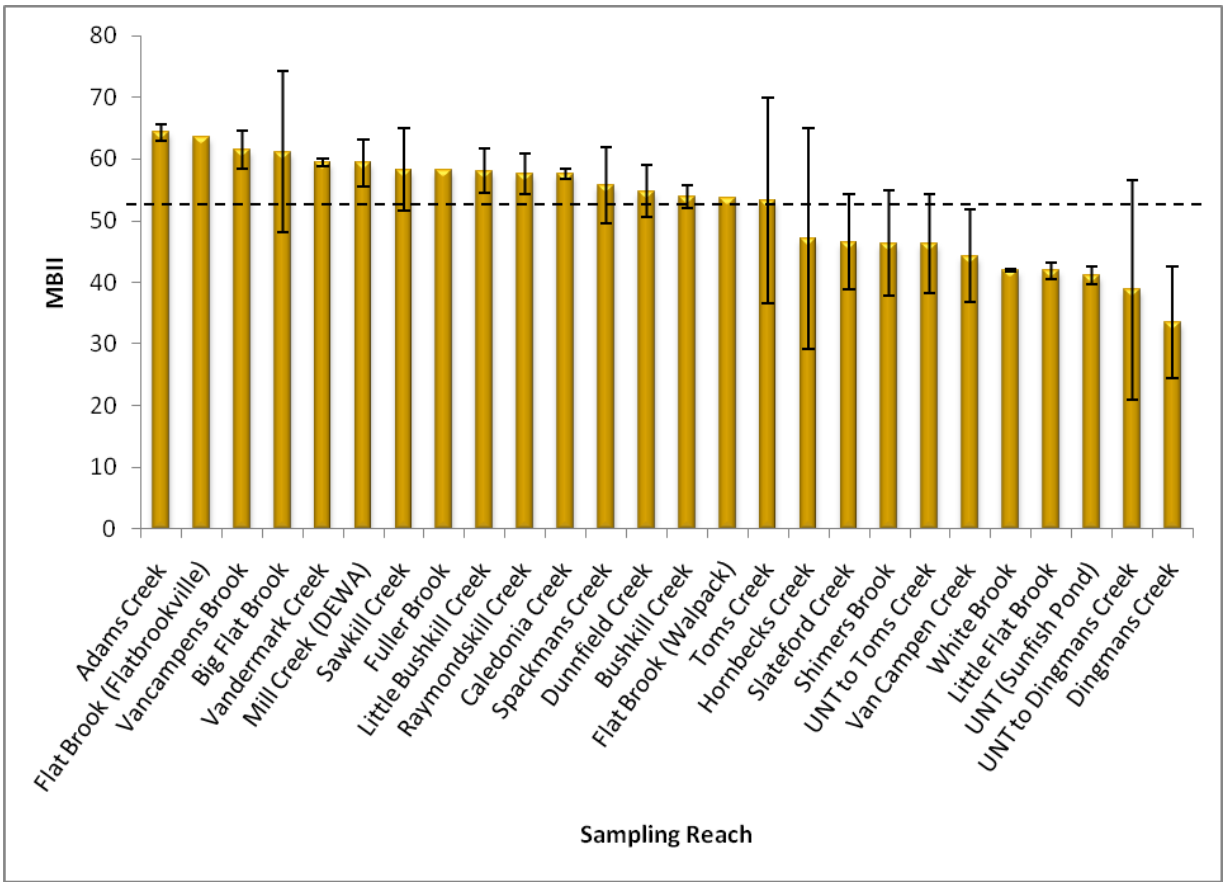


Figure 18. Macroinvertebrate Biotic Integrity Index (MBII) scores for benthic macroinvertebrate samples collected throughout Delaware Water Gap National Recreation Area in October 2008 and 2009. Error bars represent standard deviation whereas dashed line depicts the mean MBII (53.6) from "northern" Eastern Rivers and Mountains Network streams.

Fort Necessity National Battlefield and Friendship Hill National Historic Site

2010 Field Season Summary

All FONE reaches (Figure 19) were sampled on April 1, 2010, whereas both FRHI reaches (Figure 20) were sampled on April 2, 2010. Aquatic organisms, including BMI, are affected by weather conditions during their life span, which for most species is one year. According to Knight et al. (2010 d), temperatures near FONE and FRHI averaged lower (45.9°F) than normal (48.4°F), and summer of 2009 was much cooler than normal, ranking as the 11th coldest in 115 years of record (Knight et al. 2010 d). Precipitation varied during 2009 at FONE and FRHI and was above normal in five months, below normal in five months, and near normal in two months. Oddly, this was the same distribution as in 2008. In summary, weather conditions during 2009 were probably not abnormally stressful for BMI and other aquatic organisms.

The UNT to Great Meadows Run was sampled for the first time by the ERMN in 2010. We attempted to sample that stream in prior years but surface flow was insufficient. Similarly, Great Meadows Run could not be sampled during 2009 due to low flow conditions, but we were able to sample that stream during 2010. All other FONE and FRHI reaches were sampled successfully in 2010. Ice Pond Run (FRHI) was sampled again in 2010, but will likely not be sampled during 2011 because of the stably degraded condition of that stream and the BMI community that inhabits it. Ice Pond Run will be sampled again when either (a) significant mine drainage mitigation actions are implemented or (b) in five years, to validate no change in BMI community condition.

Water Quality

Physical and chemical characteristics of stream water can vary markedly, both daily and annually. Although there are limitations to point-in-time characterizations of core water quality parameters, these measures can be helpful when evaluating patterns in biological data; moreover, extreme changes to these parameters can sometimes be detected with point-in-time samples.

Ice Pond Run (FRHI) was, by far, the most impaired stream at FONE and FRHI and throughout sampled streams in the ERMN, as reflected by the measures of specific conductance (1,505$\pm$500 µs/cm) and pH (2.64$\pm$0.04; Figure 21; Appendix B). Other core water quality parameters (temperature and DO) were similar among FONE and FRHI reaches (Figure 22). These measures vary daily and are related to each other; consequently, the wide range of pH, temperature, and DO values was not surprising, given that there have been only two visits to each reach. Generally, sunlight during the day increases water temperature and biological activity, which, in turn, affects measures of pH and DO concentrations.

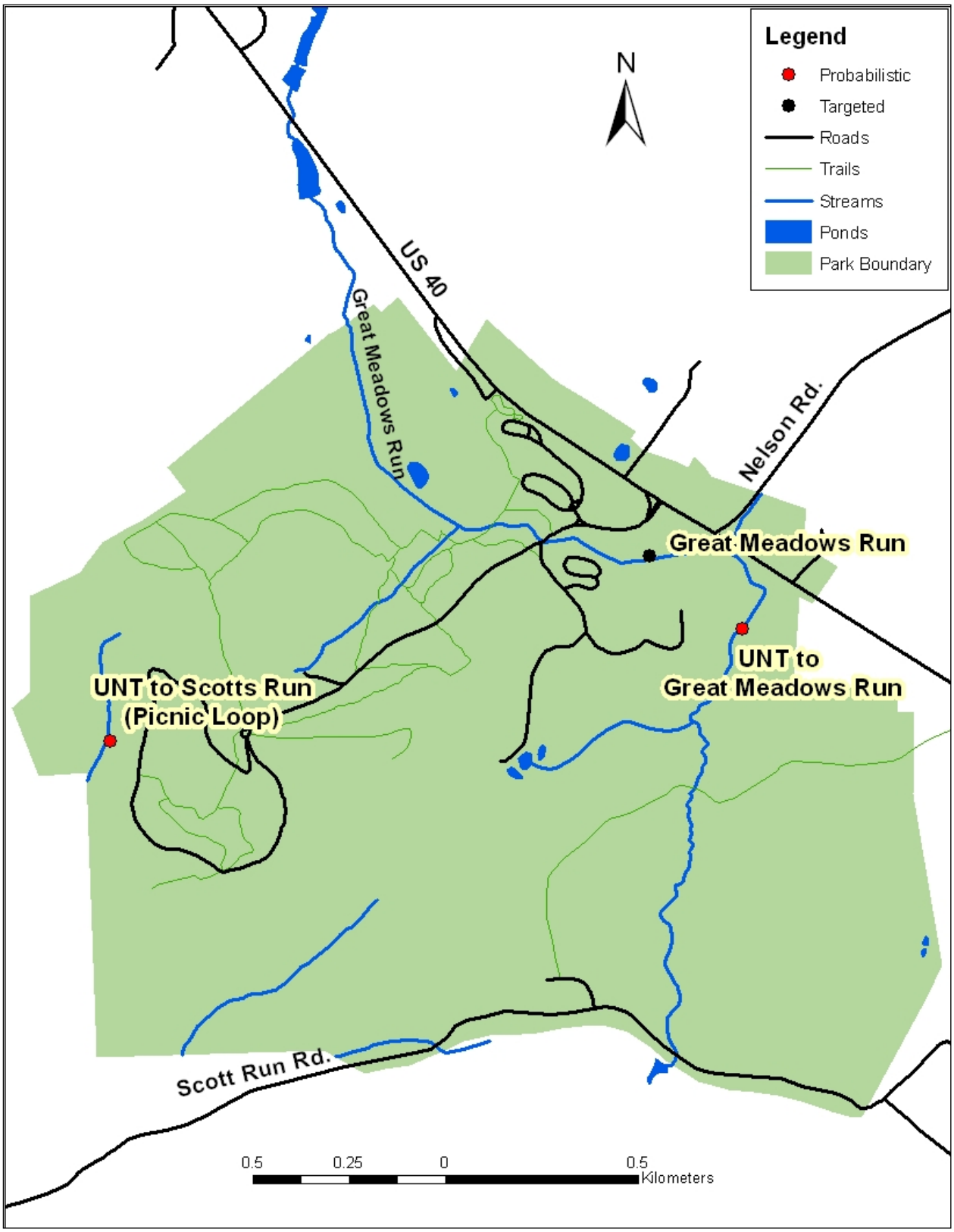


Figure 19. Locations of stream monitoring reaches at Fort Necessity National Battlefield. UNT = Unnamed tributary.

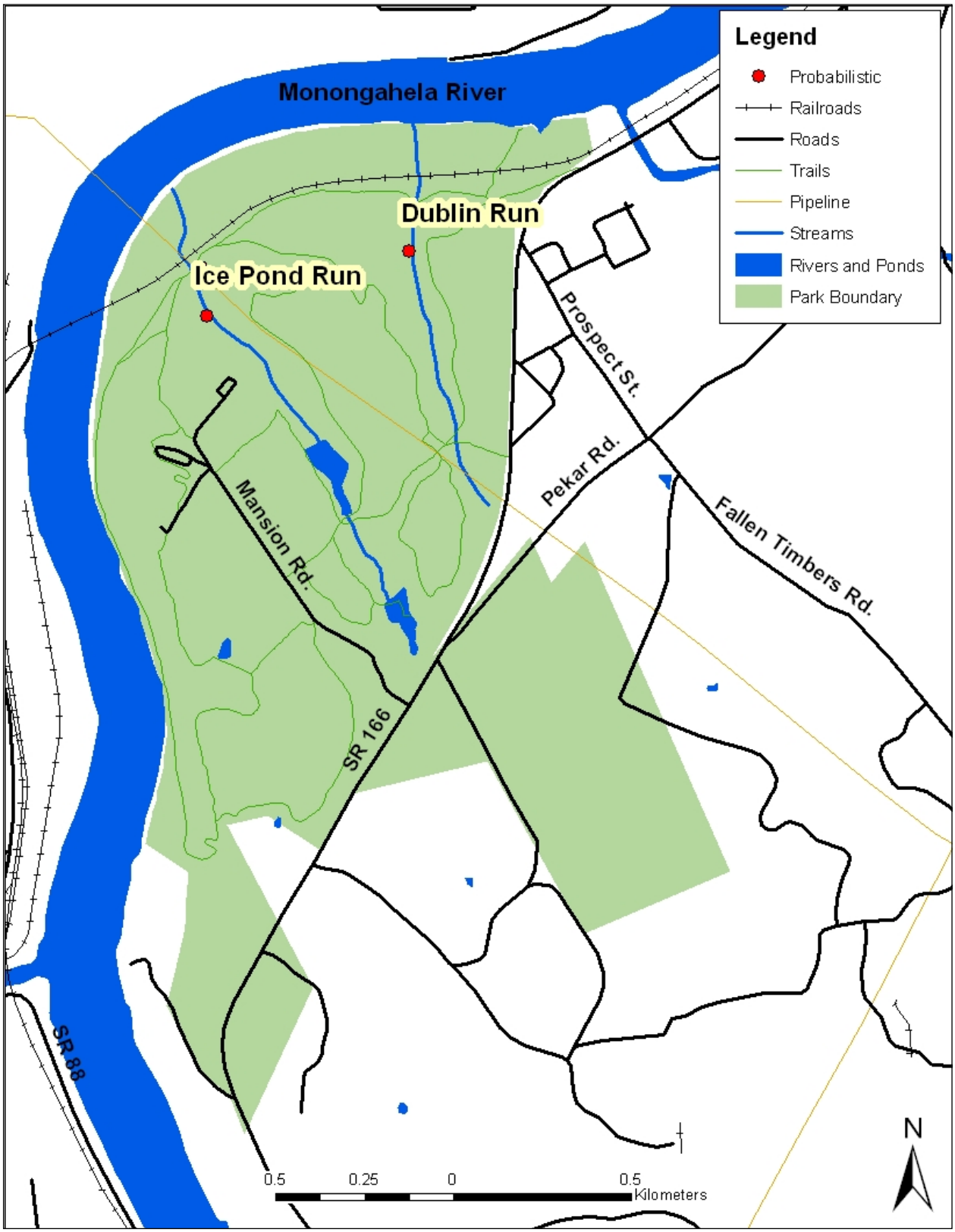


Figure 20. Locations of stream monitoring reaches at Friendship Hill National Historic Site.

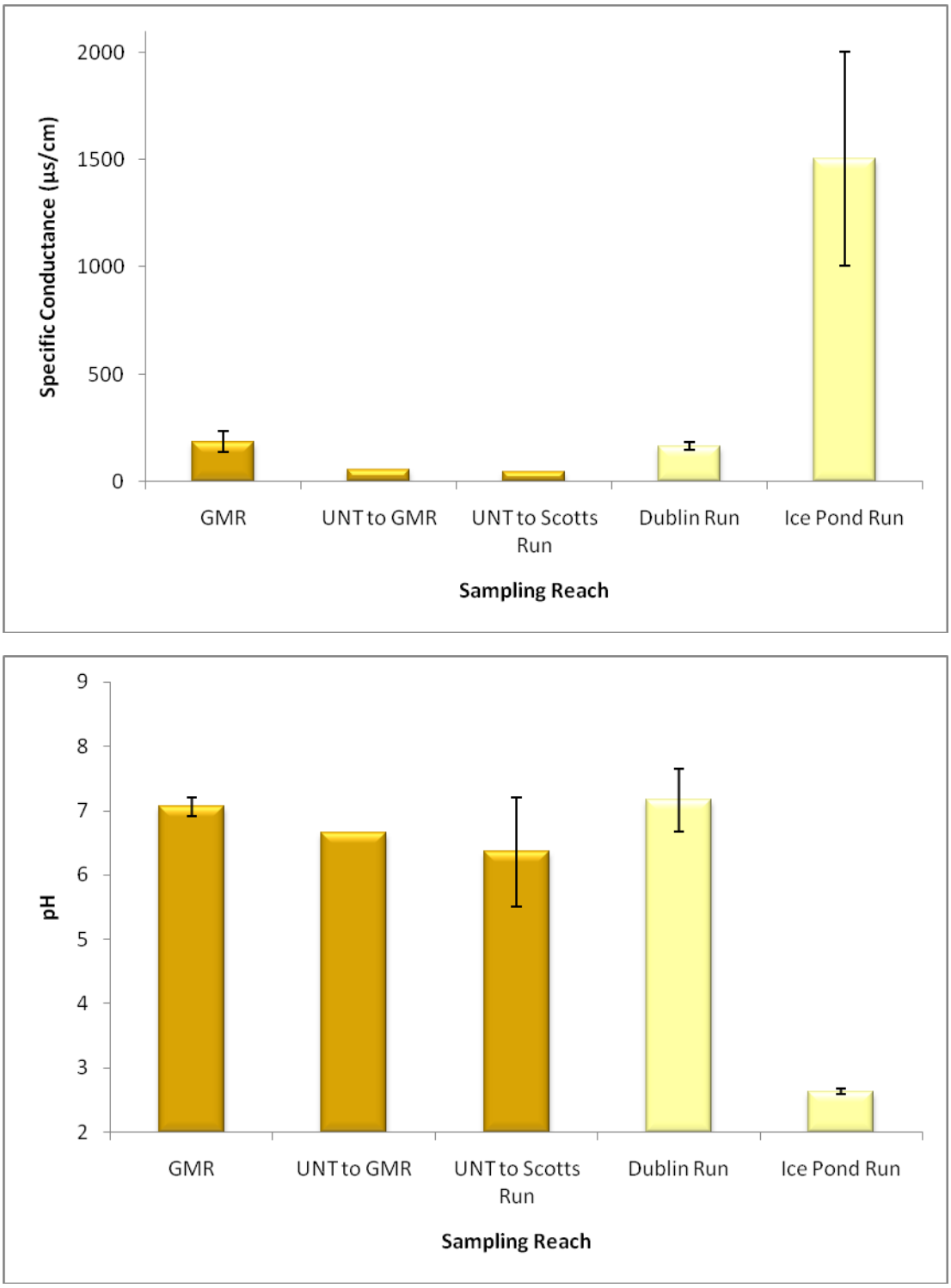


Figure 21. Average specific conductance (top) and pH (bottom) of water at sampling reaches throughout Fort Necessity National Battlefield (dark bars) and Friendship Hill National Historic Site (light bars) in March 2009 and 2010. Error bars represent standard deviation. GMR = Great Meadows Run; UNT = Unnamed tributary.

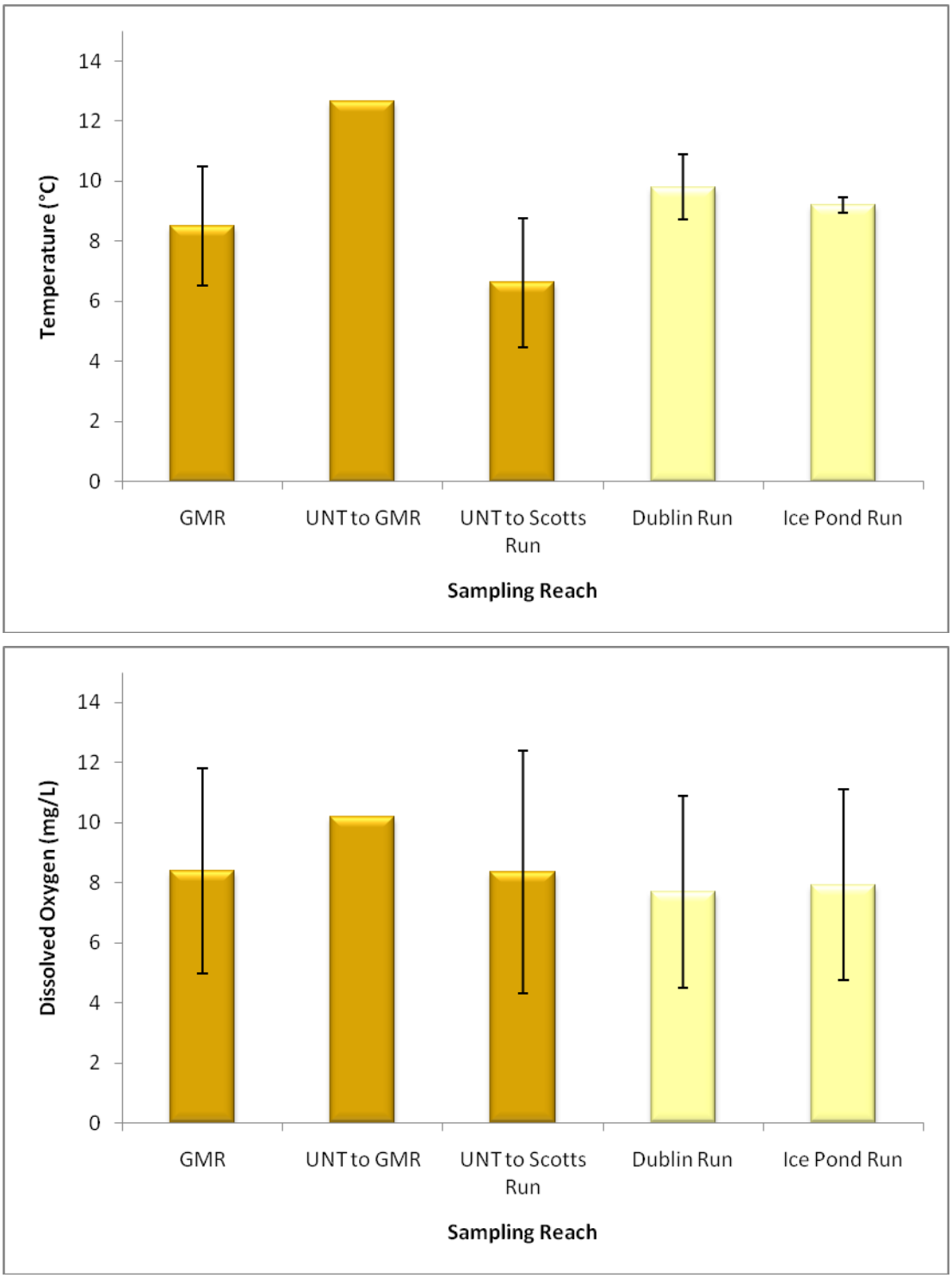


Figure 22. Average temperature (top) and dissolved oxygen concentration (bottom) of water at sampling reaches throughout Fort Necessity National Battlefield (dark bars) and Friendship Hill National Historic Site (light bars) in March 2009 and 2010. Error bars represent standard deviation. GMR = Great Meadows Run; UNT = Unnamed tributary.

Benthic Macroinvertebrate Communities

As expected, and as a result of the mine drainage problems at Ice Pond Run, that stream had the lowest MBII score (14.3+0.0) of FONE and FRHI streams (Figure 23; Appendix C). The UNT to Scotts Run (Picnic Loop) had the highest MBII score (52.3+1.3) and was the only stream that had a MBII score that was above the average (45.3) of southern ERMN streams. The MBII scores from Dublin Run were more variable than the other reaches. That variability was most likely due (in part) to sampling difficulties associated with low stream flows during 2010 sampling.

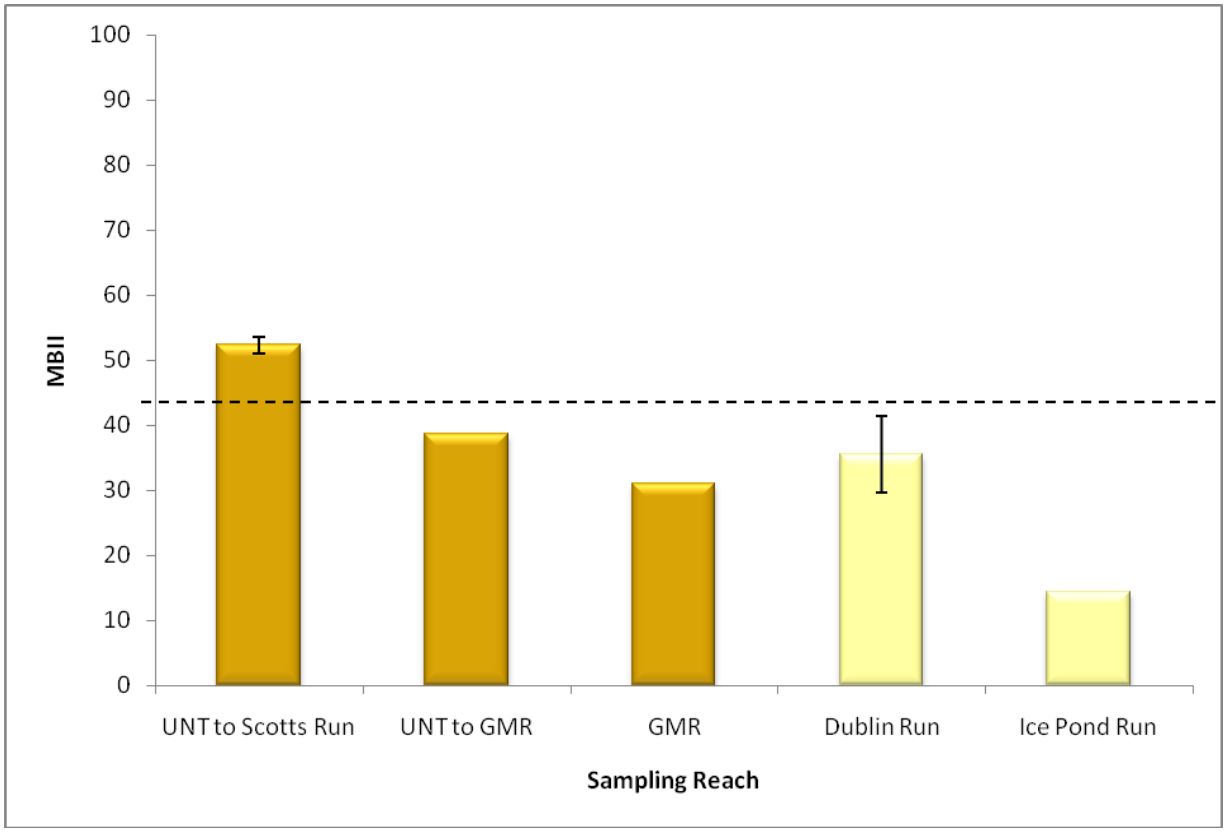


Figure 23. Macroinvertebrate Biotic Integrity Index (MBII) scores for benthic macroinvertebrate samples collected throughout Fort Necessity National Battlefield (dark bars) and Friendship Hill National Historic Site (light bars) in March 2009 and 2010. Error bars represent standard deviation whereas dashed line depicts the mean MBII (45.3) from "southern" Eastern Rivers and Mountains Network streams.

New River Gorge National River

2010 Field Season Summary

Aquatic organisms, including BMI, are affected by weather conditions during their life span, which for most species is one year. The 2009 calendar year averaged close to normal compared with the long-term mean for temperature near NERI, though not as warm as earlier years in this decade (Knight et al. 2010 b). Annual precipitation, conversely, was 3%–29% greater than the 30-year average, which was the seventh time in the past eight years that annual precipitation was greater than the long-term mean (Knight et al. 2010 b). Summer months can pose particularly stressful environmental conditions (e.g., drought) to aquatic animals. The summer months of July–September (2009) were much cooler than average due to lower than normal maximum readings. No record maximums were recorded during the period, and the summer ranked as the 14th to 20th coolest in 115 years of record. Due to ample precipitation and near-normal temperatures, there were no drought conditions near NERI during the growing season of 2009.

Although weather conditions were typical during 2009, heavy precipitation during March 2010 led to sampling difficulties at NERI. Twelve NERI streams were sampled between March 19 and March 21, 2010, but heavy rains caused the remaining sampling to be delayed. The remaining 11 reaches (Figure 24) sampled during 2010 were sampled between April 6 and April 9. Unfortunately, the Meadow Creek reach, near its confluence with the New River, could not be sampled for the second consecutive year due to high stream flows and unsafe conditions. If that reach cannot be sampled during 2011, it is possible that it will be replaced with a reach farther upstream in the Meadow Creek watershed; the specific location of that reach will be chosen in consultation with NERI staff. Similarly, the reach originally chosen at Wolf Creek may be replaced with another NERI reach due to lack of appropriate habitat (i.e., riffles) and consistently difficult access conditions (i.e., deep runs with steep banks). In 2011, the Pinch Creek reach, which was in the population of potential sampling reaches, will be visited. If the Pinch Creek reach can be sampled consistently and effectively, it will likely replace the Wolf Creek reach.

Water Quality

Physical and chemical characteristics of stream water can vary markedly, both daily and annually. Although there are limitations to point-in-time characterizations of core water quality parameters, these measures can be helpful when evaluating patterns in biological data; moreover, extreme changes to these parameters can sometimes be detected with point-in-time samples.

Larger streams and rivers generally had greater specific conductance and pH than smaller streams at NERI (Figure 25; Appendix B), which was likely a result of anthropogenic stressors (e.g., wastewater treatment plants, road salts, septic system effluent) that are often present in valley floodplains where large streams occur. For example, the three relatively large streams, Arbuckle Creek, Piney Creek, and Wolf Creek, generally had the highest specific conductance and pH among sampled NERI streams—all of these streams drain relatively populated areas in and around NERI. Most streams had pH values that were circumneutral; however, three reaches had pH lower than 6.0, which was probably a consequence of historical mining activity in those watersheds. Other core parameters (i.e., DO, water temperature) were variable among and within reaches (Figure 26), which was almost certainly due to different sampling dates and times.

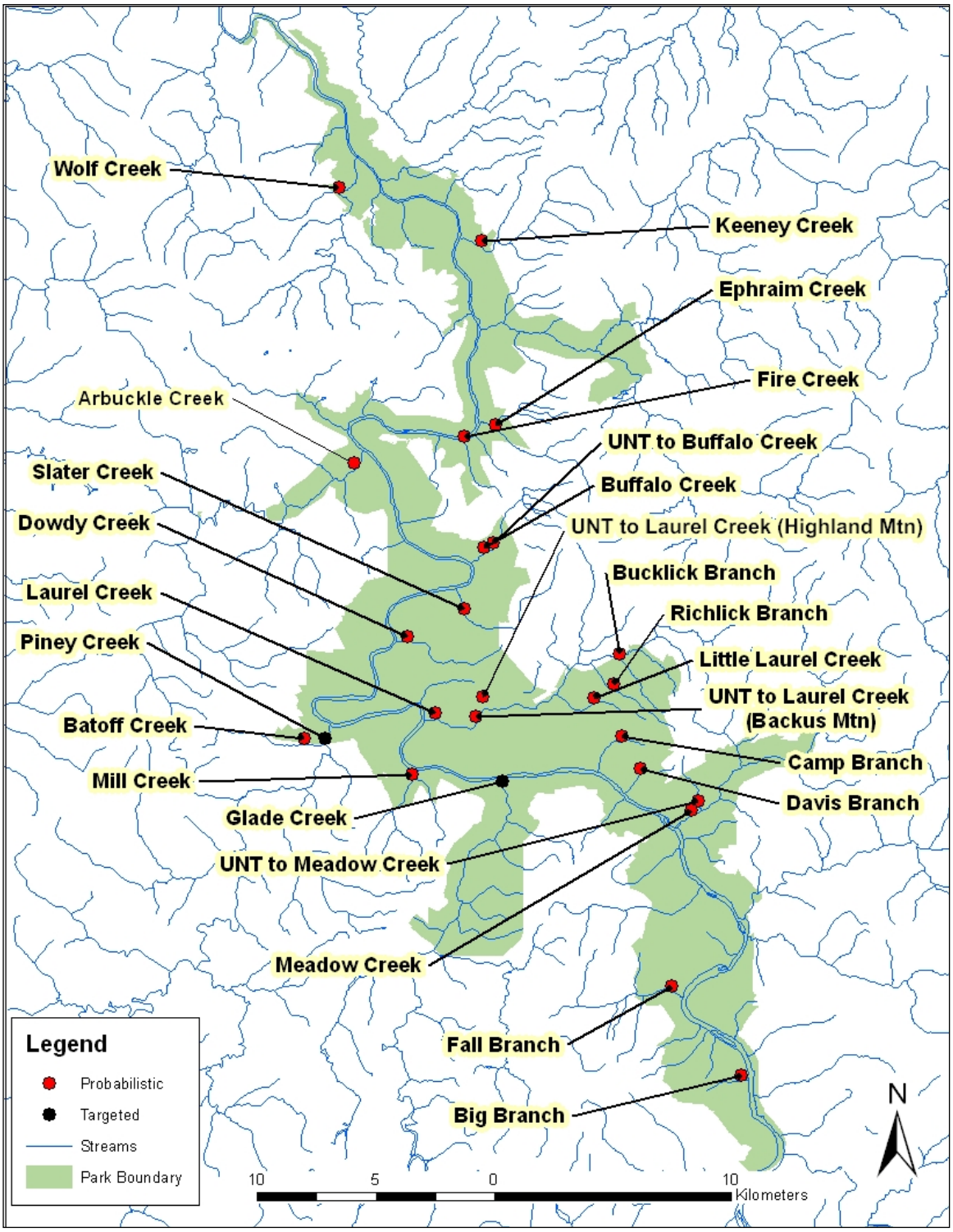


Figure 24. Locations of stream monitoring reaches at New River Gorge National River (NERI). UNT = Unnamed tributary.

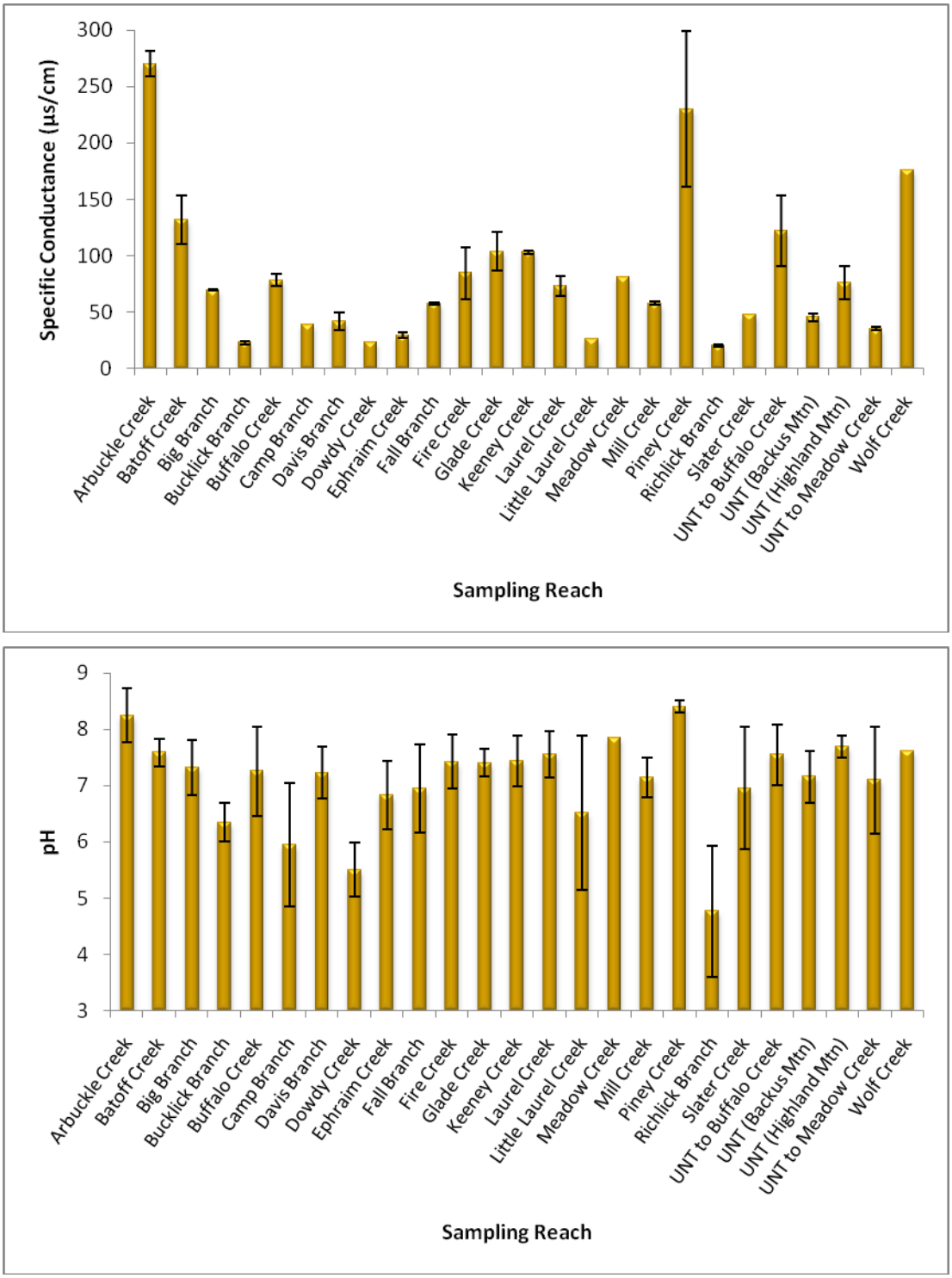


Figure 25. Average specific conductance (top) and pH (bottom) of water at sampling reaches throughout New River Gorge National River in March 2009 and 2010. Error bars represent standard deviation. UNT = Unnamed tributary.

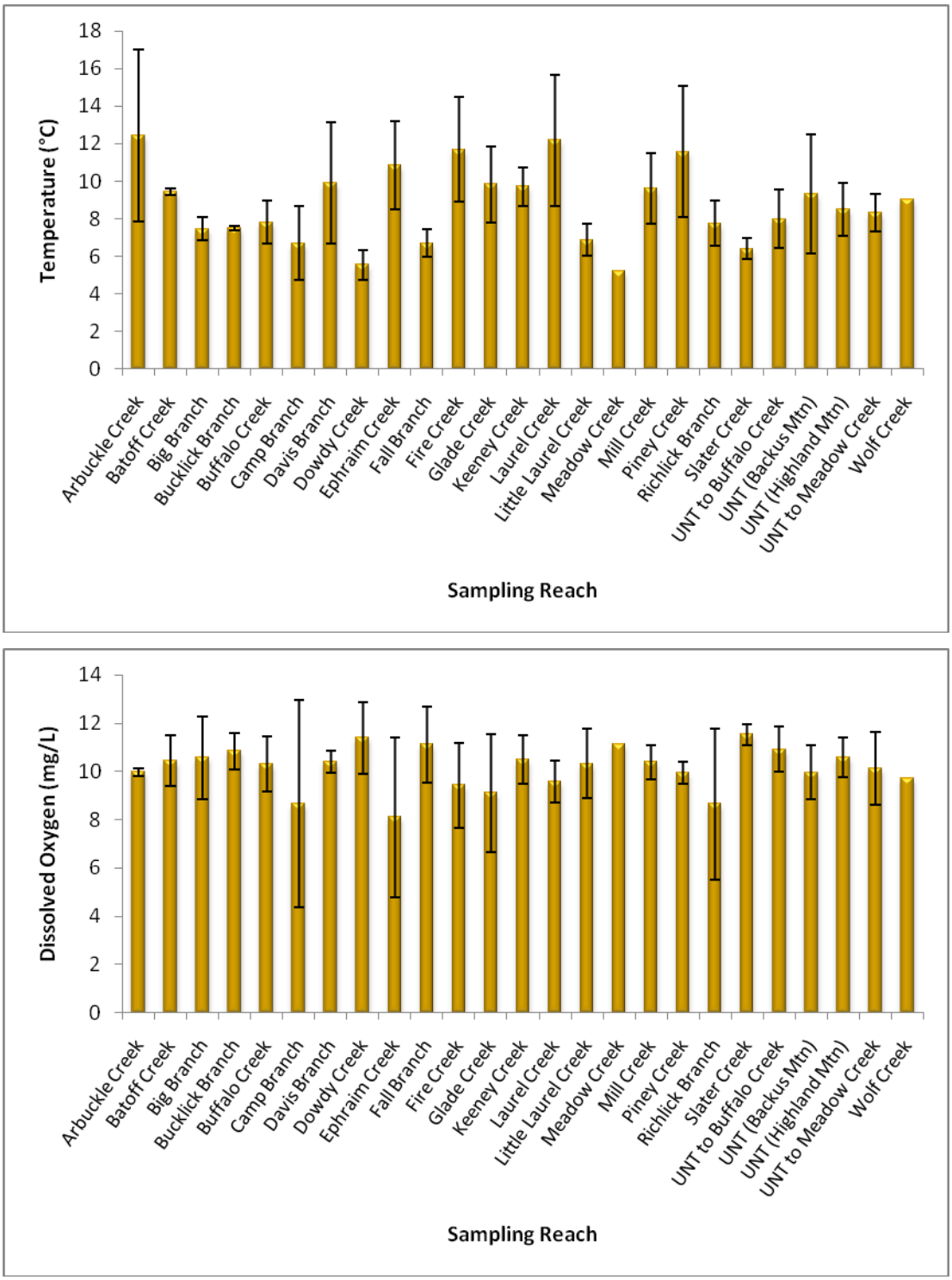


Figure 26. Average temperature (top) and dissolved oxygen concentration (bottom) of water at sampling reaches throughout New River Gorge National River in March 2009 and 2010. Error bars represent standard deviation. UNT = Unnamed tributary.

Benthic Macroinvertebrate Communities

Laurel Creek had the greatest MBII score (66.8±9.7) at NERI, whereas Wolf Creek had the lowest MBII (16.3; Figure 27; Appendix C). The inter-annual differences between estimates of ecological integrity also varied among reaches—BMI communities at some reaches were very similar between 2009 and 2010 (e.g., Dowdy Creek, SD=0.8), whereas others were considerably different (e.g., Glade Creek; SD=21.5). It is likely that much of the observed difference was due to environmental variability (e.g., weather patterns). It is expected that with several years of data, a baseline condition (with greater statistical precision) will be established, to which future ecological status and trends can be compared.

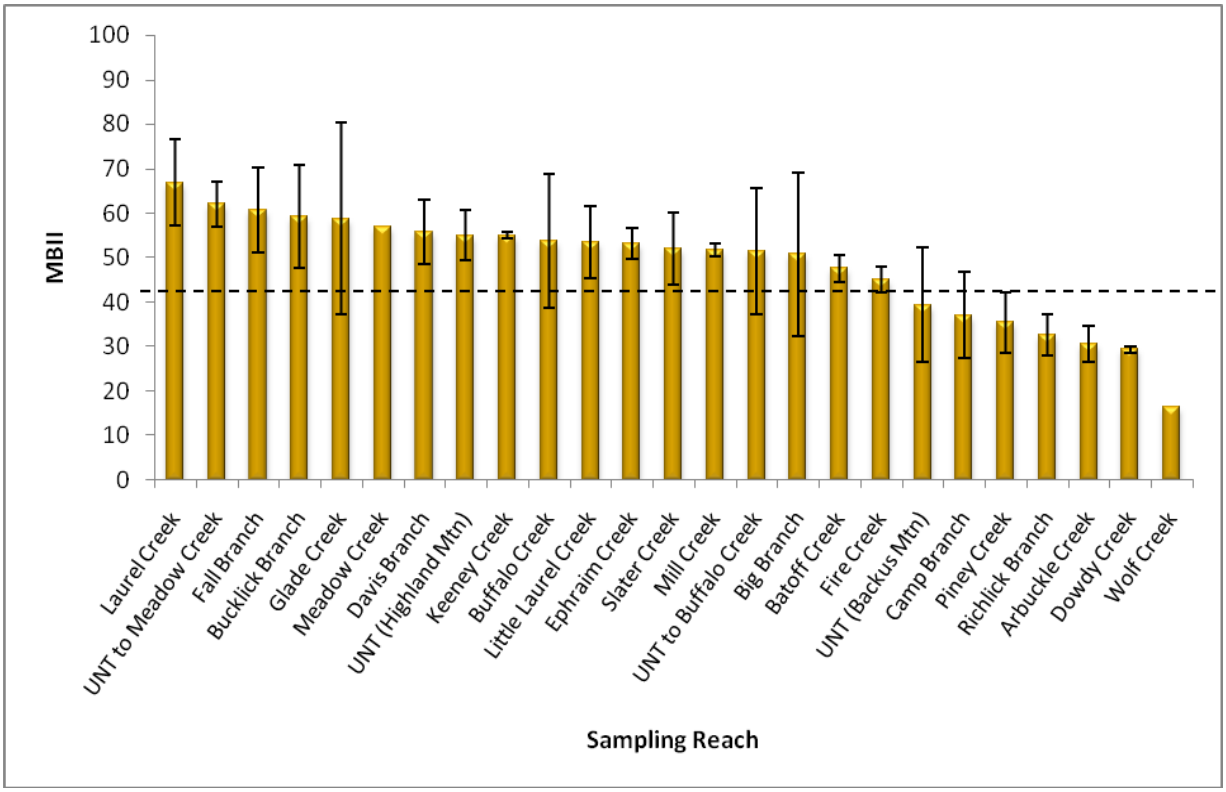


Figure 27. Macroinvertebrate Biotic Integrity Index (MBII) scores for benthic macroinvertebrate samples collected throughout New River Gorge National River in March 2009 and 2010. Error bars represent standard deviation whereas dashed line depicts the mean MBII (45.3) from "southern" Eastern Rivers and Mountains Network streams. UNT = Unnamed tributary.

Upper Delaware Scenic and Recreational River

2009 Field Season Summary

All UPDE reaches (Figure 28), except for the West Branch Delaware River, were sampled between October 12 and October 14, 2009. The West Branch Delaware River reach could not be sampled until November 19, 2009 because of high water flows that were a result of reservoir releases during October and early November.

Aquatic organisms, including BMI, are affected by weather conditions during their life spans, which for most BMI taxa is one year. The 2009 calendar year was cooler than usual near UPDE—maximum temperatures for the year averaged between 0.5 and 2.3°F (0.2 and 1.2°C) below the long-term mean temperature (Knight et al. 2010c). The total growing season length (days between last spring freeze and first fall freeze) ranged from 124–170 days in 2009, near the long-term average. The summer period was cooler than average and no record maximums were recorded during July, August, and September (Knight et al. 2010c). For the ninth consecutive year, annual precipitation for 2009 averaged above the long-term mean and the summer brought above-average rainfall, with two of the three months tallying more than 150% of normal. The combination of moderate temperatures and ample precipitation led to abnormally dry conditions only during the beginning of May.

Water Quality

Physical and chemical characteristics of stream water can vary markedly, both daily and annually. Although there are limitations to point-in-time characterizations of core water quality parameters, these measures can be helpful when evaluating patterns in biological data; moreover, extreme changes to these parameters can sometimes be detected with point-in-time samples.

In comparison to streams in most other ERMN parks, the specific conductance and pH of UPDE streams were very consistent between 2008 and 2009 (Figure 29; Appendix B). All UPDE streams had specific conductance values that were <140 µS/cm, which was indicative of generally unperturbed conditions. Similarly, the only stream with a pH <6.50 was Ten Mile River (6.45±0.58); many other ERMN streams had comparatively low pH, due, in large part, to atmospheric deposition, coal mining (both historical and ongoing), and other anthropogenic stressors. Although temperature and dissolved oxygen of UPDE streams were less variable than at other ERMN parks (Figure 30), they were likely influenced by the differing times (date and time of day) that they were sampled. That said, most UPDE streams were relatively cool (10–12 °C) and all were at, or above, oxygen saturation.

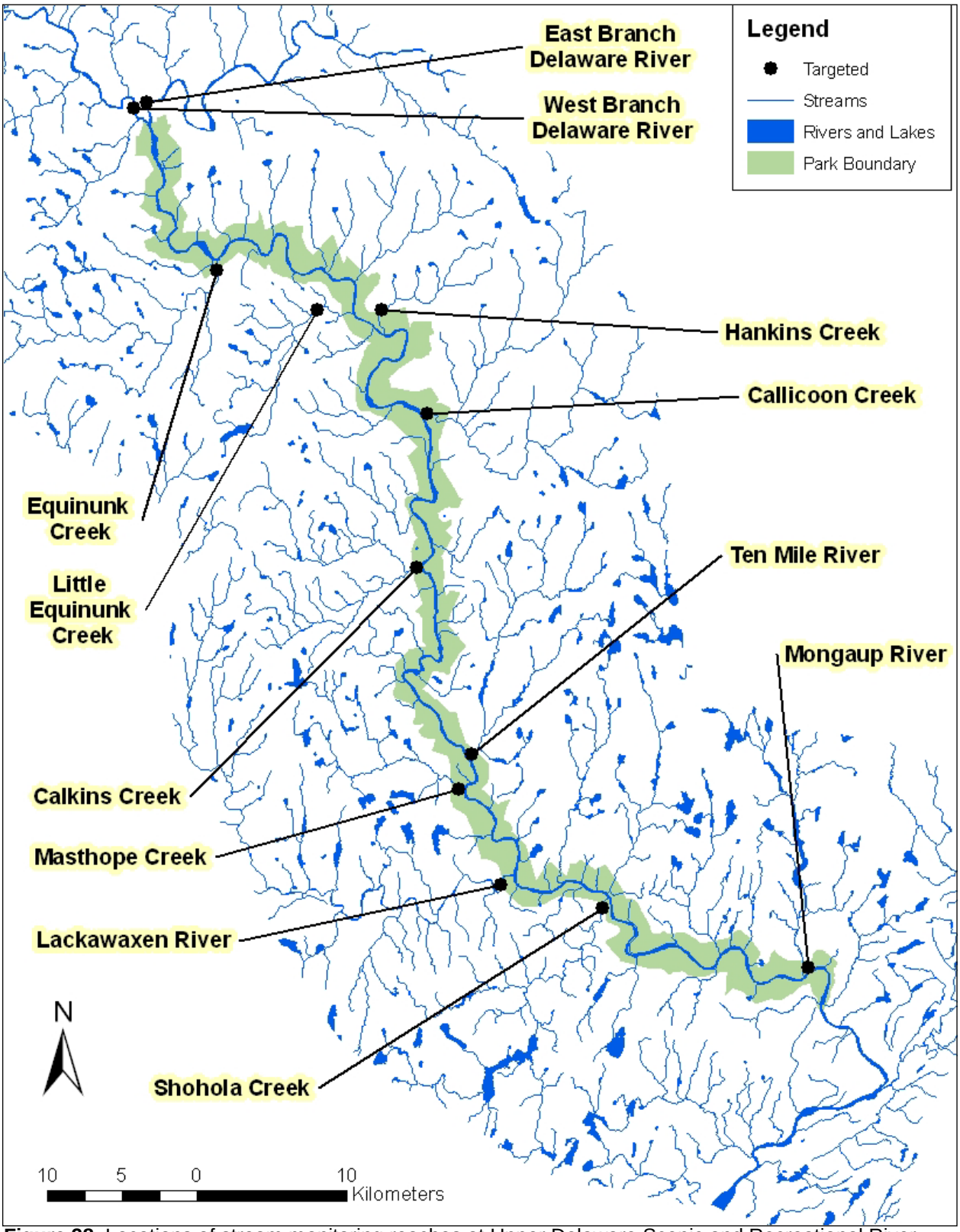
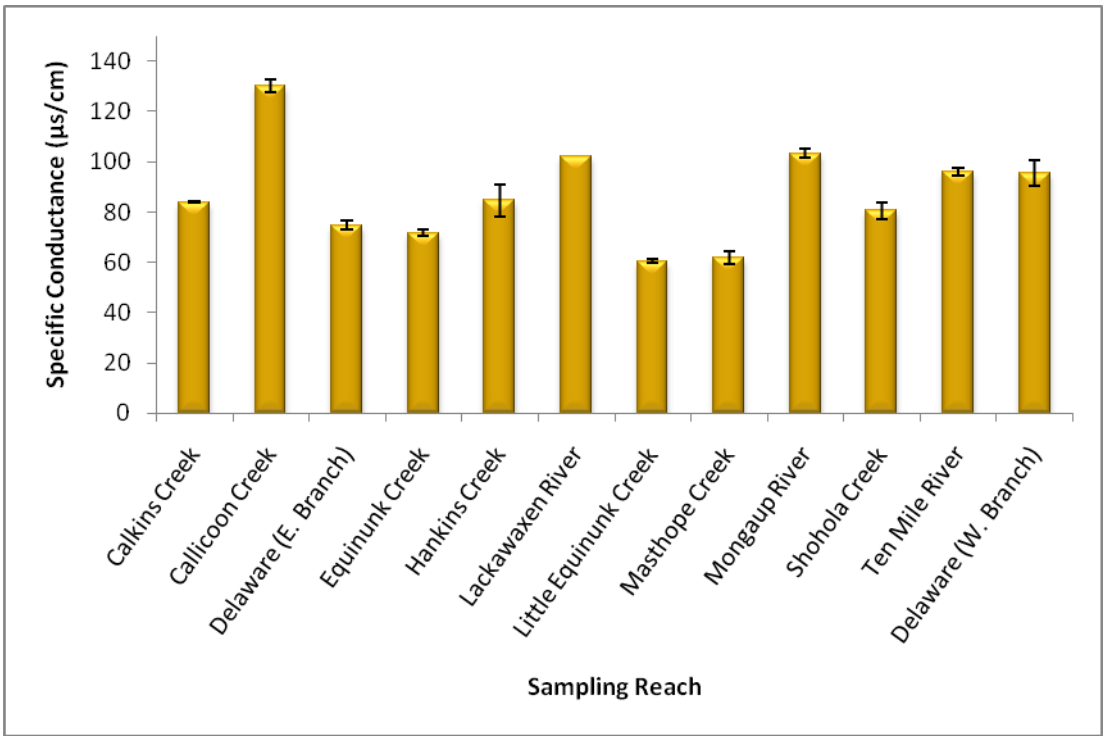


Figure 28. Locations of stream monitoring reaches at Upper Delaware Scenic and Recreational River.



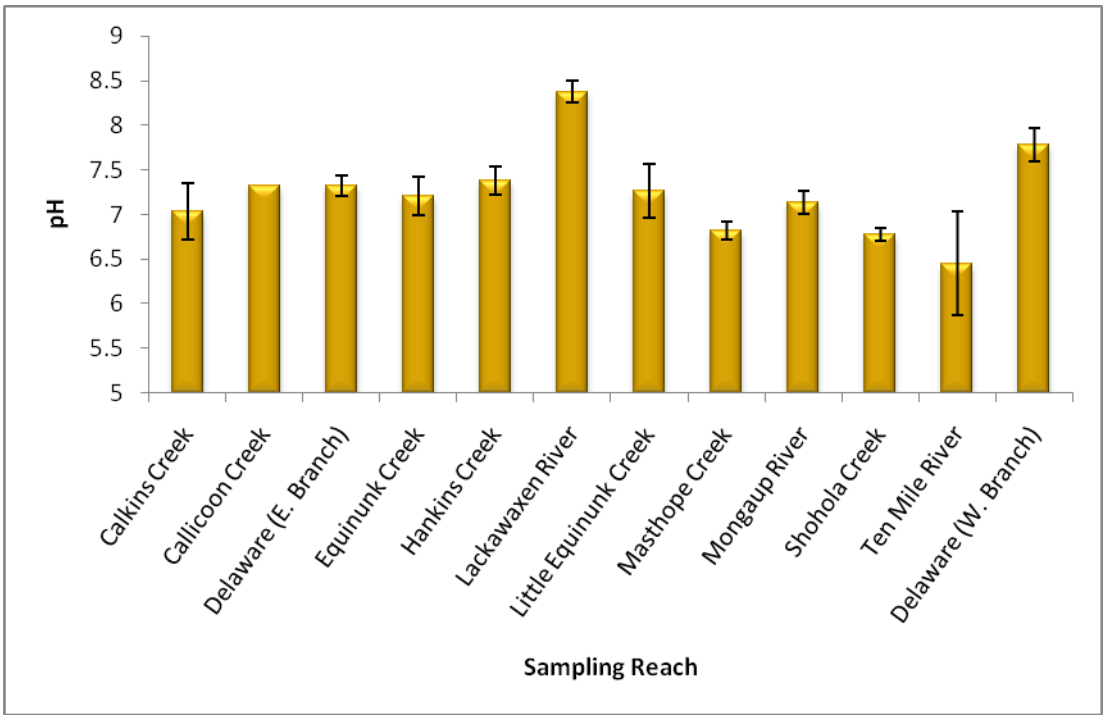


Figure 29. Average specific conductance (top) and pH (bottom) of water at sampling reaches throughout Upper Delaware Scenic and Recreational River in October 2008 and 2009. Error bars represent standard deviation.

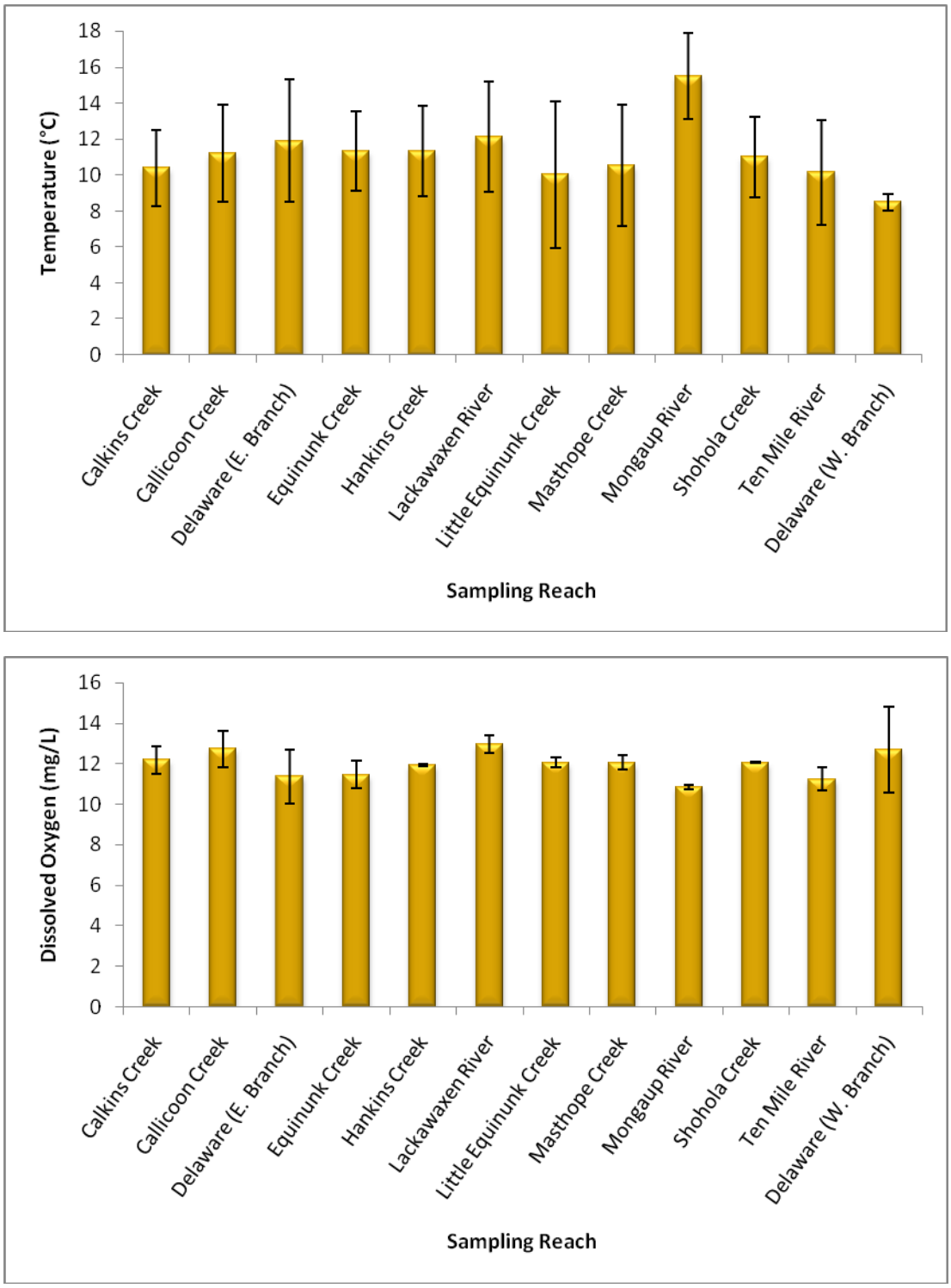


Figure 30. Average temperature (top) and dissolved oxygen concentration (bottom) of water at sampling reaches throughout Upper Delaware Scenic and Recreational River in October 2008 and 2009. Error bars represent standard deviation.

Benthic Macroinvertebrate Communities

Based on MBII scores and constituent metrics, ecological integrity of UPDE streams was generally above the average of northern ERMN parks (see Figure 2). Furthermore, three UPDE streams (Ten Mile River, Masthope Creek, and Equinunk Creek) ranked in the five highest MBII scores in northern ERMN parks. Although annual differences were observed at UPDE streams (Figure 31), the magnitude of those differences was relatively modest compared to some other large streams throughout the network (e.g., Big Flat Brook at DEWA, Glade Creek at NERI). It is expected that with several years of data, a baseline condition (with greater statistical precision) will be established to which future ecological status and trends can be compared.

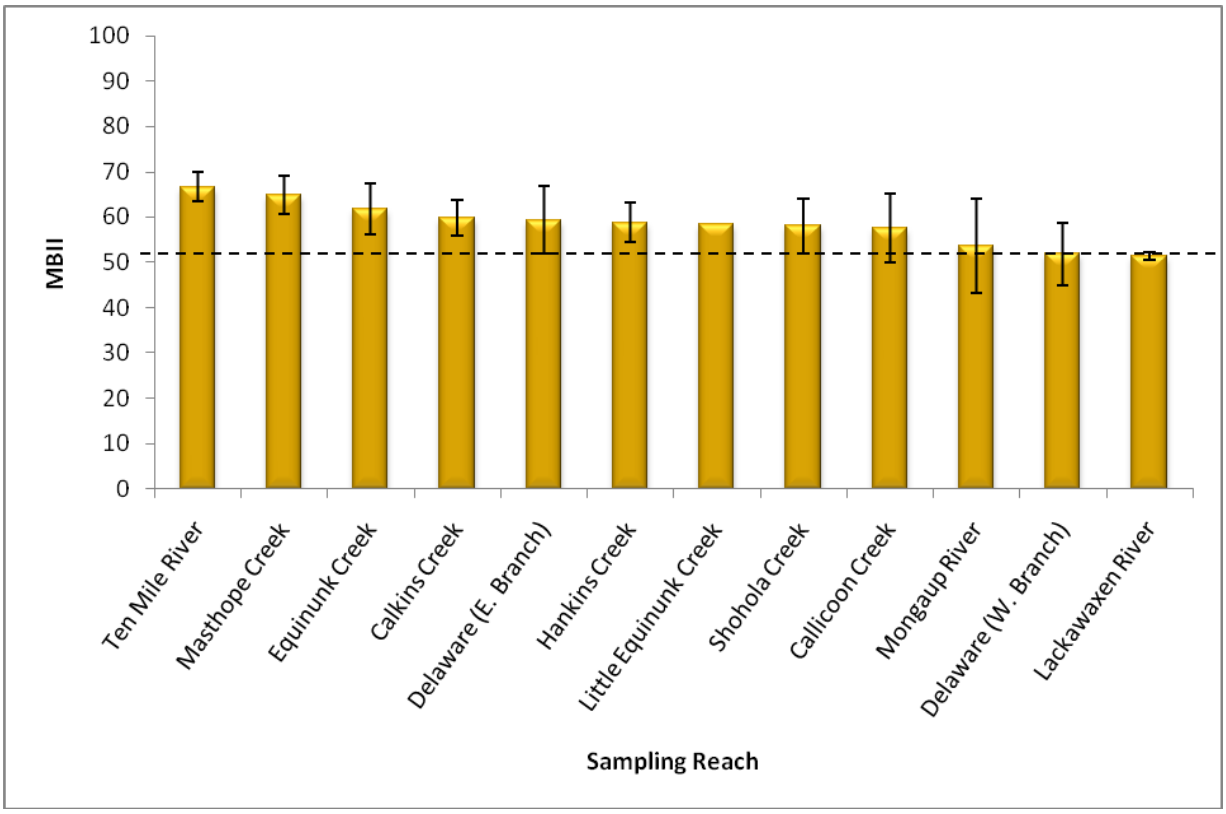


Figure 31. Macroinvertebrate Biotic Integrity Index (MBII) scores for benthic macroinvertebrate samples collected throughout Upper Delaware Scenic and Recreational River in October 2008 and 2009. Error bars represent standard deviation, whereas the dashed line depicts the mean MBII (53.6) from "northern" Eastern Rivers and Mountains Network streams.

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Appendix A. Universal Transverse Mercator (UTM) coordinates of Eastern Rivers and Mountains Network wadeable stream sampling locations.

Reach ID[1]	Reach Name	UTM Zone	X	Y
ALPO.1001	Millstone Run	17	713450	4477269
ALPO.1003	Blair Gap Run (Muleshoe)	17	710619	4478639
ALPO.2001	Blair Gap Run (Foot of Ten)	17	716143	4477044
BLUE.1002	Mountain Creek	17	498184	4154206
BLUE.1003	Little Bluestone River	17	502506	4159734
BLUE.2001	Bluestone River (Mouth)	17	504544	4161507
BLUE.2002	Bluestone River (Tramway)	17	499151	4154931
DEWA.1001	White Brook	18	517003	4572359
DEWA.1002	Dunnfield Creek	18	489349	4535863
DEWA.1003	UNT to Delaware River (Sunfish Pond)	18	493131	4540045
DEWA.1004	Vancampens Brook (Millbrook Village)	18	503300	4546948
DEWA.1005	Slateford Creek	18	490243	4532769
DEWA.1006	Caledonia Creek	18	487933	4535223
DEWA.1007	Fuller Brook	18	507316	4552548
DEWA.1008	Van Campen Creek	18	501529	4552321
DEWA.1009	Little Bushkill Creek	18	499572	4549936
DEWA.1010	UNT to Dingmans Creek	18	509549	4564567
DEWA.1011	Toms Creek	18	503199	4555119
DEWA.1012	UNT to Toms Creek	18	503653	4553598
DEWA.1013	Mill Creek (DEWA)	18	506946	4555900
DEWA.1014	Hornbecks Creek	18	509659	4559783
DEWA.1015	Dingmans Creek	18	507400	4564621
DEWA.1016	Adams Creek	18	511162	4565359
DEWA.1017	Raymondskill Creek	18	513253	4571704
DEWA.1018	Spackmans Creek	18	508179	4557869
DEWA.2001	Big Flat Brook	18	515664	4561148
DEWA.2002	Shimers Brook	18	518123	4573634
DEWA.2003	Stony Brook	18	491780	4533326
DEWA.2004	Little Flat Brook	18	513763	4560845
DEWA.2005	Sawkill Creek	18	516740	4574045
DEWA.2006	Bushkill Creek	18	497249	4548245
DEWA.2007	Vandermark Creek	18	517046	4574752
DEWA.2008	Flat Brook (Walpack)	18	511594	4558302
DEWA.2009	Flat Brook (Flatbrookville)	18	515664	4561148
FONE.1001	UNT to Scotts Run (Picnic Loop)	17	619861	4407623
FONE.1002	UNT to Great Meadows Run	17	621413	4408131
FONE.2001	Great Meadows Run	17	621413	4408131
FRHI.1001	Ice Pond Run	17	591604	4404162
FRHI.1002	Dublin Run	17	592181	4404330
GARI.1001	Laurel Creek (GARI)	17	489737	4230696
GARI.1002	Horseshoe Creek	17	494381	4227009
GARI.1003	Meadow Creek (GARI)	17	503602	4230413
GARI.2001	Peters Creek	17	495890	4232121
JOFL.2001	UNT to South Fork Little Conemaugh River	17	689010	4468236
NERI.1001	Batoff Creek	17	490735	4188377
NERI.1002	Mill Creek (NERI)	17	495309	4186828

Reach ID[1]	Reach Name	UTM Zone	X	Y
NERI.1003	Meadow Creek (NERI)	17	507074	4185333
NERI.1004	UNT to Meadow Creek (NERI)	17	507385	4185743
NERI.1005	Fall Branch	17	506265	4177887
NERI.1006	Big Branch	17	509199	4174121
NERI.1007	Laurel Creek (NERI)	17	496261	4189449
NERI.1008	Dowdy Creek	17	495086	4192678
NERI.1009	Slater Creek	17	497477	4193822
NERI.1010	Buffalo Creek	17	498337	4196445
NERI.1011	UNT to Buffalo Creek	17	498721	4196617
NERI.1012	Arbuckle Creek	17	492448	4201662
NERI.1013	UNT to Laurel Creek (Highland Mtn)	17	498286	4190116
NERI.1014	UNT to Laurel Creek (Backus Mtn)	17	497989	4189279
NERI.1015	Davis Branch	17	504907	4187081
NERI.1016	Little Laurel Creek	17	502953	4190099
NERI.1017	Richlick Branch	17	503776	4190647
NERI.1018	Wolf Creek	17	492209	4211624
NERI.1019	Keeney Creek	17	498222	4209397
NERI.1020	Camp Branch	17	504156	4188463
NERI.1021	Ephraim Creek	17	498829	4201617
NERI.1022	Fire Creek	17	497506	4201106
NERI.1023	Bucklick Branch	17	504047	4191913
NERI.2001	Piney Creek	17	491637	4188357
NERI.2002	Glade Creek	17	499128	4186544
UPDE.2001	Shohola Creek	18	507171	4590951
UPDE.2002	Lackawaxen River	18	500350	4592554
UPDE.2003	Masthope Creek	18	497651	4598476
UPDE.2004	Mongaup River	18	520377	4586212
UPDE.2005	Ten Mile River	18	498433	4600580
UPDE.2006	Calkins Creek	18	494929	4613425
UPDE.2007	Callicoon Creek	18	495117	4623677
UPDE.2008	Hankins Creek	18	492155	4630373
UPDE.2009	Little Equinunk Creek	18	488298	4630717
UPDE.2010	East Branch Delaware River	18	476689	4644452
UPDE.2011	Equinunk Creek	18	481344	4633473
UPDE.2012	West Branch Delaware River	18	475824	4644592

Reaches with identification numbers in the 1000 range were randomly chosen reaches, whereas those in the 2000 range are “targeted” non-random sampling reaches.

Appendix B. Core water quality parameter measurements throughout Eastern Rivers and Mountains Network wadeable streams during 2008–2010 field seasons.

Reach ID	Reach Name	*n*	Temp[1]	SD[2]	pH	SD	DO[3]	SD	DO%[4]	SD	SpC[5]	SD
ALPO.1001	Millstone Run	2	7.11	(4.82)	7.15	(0.35)	10.95	(0.12)	91.05	(11.53)	90.05	(7.00)
ALPO.1003	Blair Gap Run (Muleshoe)	2	8.44	(3.45)	7.00	(0.56)	11.03	(0.28)	94.40	(10.18)	117.90	(5.80)
ALPO.2001	Blair Gap Run (Foot of Ten)	2	7.59	(2.81)	7.24	(0.46)	10.08	(2.18)	85.10	(24.18)	136.30	(5.23)
BLUE.1002	Mountain Creek	2	8.77	(5.32)	7.67	(0.06)	8.45	(3.03)	74.55	(35.28)	103.20	(35.07)
BLUE.1003	Little Bluestone River	2	11.93	(4.94)	7.45	(0.29)	8.84	(2.46)	87.90	(25.60)	71.95	(21.28)
BLUE.2001	Bluestone River (Mouth)	2	15.03	(8.81)	7.95	(0.62)	9.62	(0.65)	95.15	(11.67)	420.70	(10.89)
BLUE.2002	Bluestone River (Tramway)	2	15.22	(9.64)	8.00	(0.75)	10.59	(0.76)	104.95	(14.35)	424.45	(0.78)
DEWA.1001	White Brook	2	12.97	(2.88)	8.04	(0.00)	10.26	(0.98)	99.40	*	535.40	(238.44)
DEWA.1002	Dunnfield Creek	2	11.96	(1.75)	6.68	(0.43)	10.75	(0.49)	99.45	(0.64)	30.75	(6.01)
DEWA.1003	UNT to Delaware River (Sunfish Pond)	2	13.71	(0.70)	4.95	(0.34)	10.01	(0.37)	97.15	(0.92)	26.50	(3.54)
DEWA.1004	Vancampens Brook (Millbrook Village)	2	12.93	(0.38)	7.33	(0.31)	10.02	(0.21)	95.15	(1.20)	53.20	(13.86)
DEWA.1005	Slateford Creek	2	12.07	(0.90)	7.79	(0.04)	10.13	(0.57)	94.75	(2.47)	188.70	(49.92)
DEWA.1006	Caledonia Creek	2	10.48	(1.45)	7.23	(0.08)	10.31	(0.13)	92.25	(1.77)	43.15	(4.03)
DEWA.1007	Fuller Brook	1	12.40	*	7.43	*	9.97	*	94.50	*	*	*
DEWA.1008	Van Campen Creek	2	12.49	(0.45)	7.50	(0.24)	10.29	(0.05)	96.65	(0.49)	218.30	(47.66)
DEWA.1009	Little Bushkill Creek	2	12.17	(0.62)	6.75	(0.14)	10.92	(0.46)	101.80	(2.97)	45.20	(8.20)
DEWA.1010	UNT to Dingmans Creek	2	11.38	(3.85)	7.13	(0.28)	10.61	(0.51)	96.75	(3.61)	235.80	(14.42)
DEWA.1011	Toms Creek	2	10.58	(1.53)	7.33	(0.17)	11.18	(0.35)	100.35	(0.49)	107.75	(27.22)
DEWA.1012	UNT to Toms Creek	2	12.10	(0.85)	7.01	(0.29)	10.22	(0.27)	95.20	(0.85)	39.10	(4.10)
DEWA.1013	Mill Creek (DEWA)	2	11.26	(0.08)	7.10	(0.18)	10.63	(0.14)	96.85	(0.64)	73.90	(18.53)
DEWA.1014	Hornbecks Creek	2	12.31	(0.44)	7.43	(0.14)	10.42	(0.06)	97.40	(1.27)	132.35	(34.86)
DEWA.1015	Dingmans Creek	2	11.46	(0.06)	7.18	(0.12)	10.66	(0.03)	97.70	(0.42)	86.50	(19.09)
DEWA.1016	Adams Creek	2	10.05	(2.89)	7.21	(0.30)	11.42	(0.68)	101.35	(0.21)	90.30	(0.99)
DEWA.1017	Raymondskill Creek	2	11.62	(2.43)	7.39	(0.16)	10.91	(0.11)	100.35	(4.45)	131.15	(21.00)
DEWA.1018	Spackmans Creek	2	11.21	(0.69)	7.35	(0.13)	10.73	(0.57)	97.50	(3.96)	95.20	(29.42)
DEWA.2001	Big Flat Brook	2	11.02	(2.00)	7.47	(0.04)	11.38	(0.17)	103.55	(5.73)	103.25	(22.27)
DEWA.2002	Shimers Brook	2	14.55	(4.74)	8.22	(0.03)	10.19	(1.38)	101.70	*	395.65	(139.09)
DEWA.2004	Little Flat Brook	2	11.93	(0.11)	8.55	(0.16)	12.46	(0.15)	115.55	(1.63)	359.25	(80.26)
DEWA.2005	Sawkill Creek	2	11.23	(0.33)	7.37	(0.33)	11.17	(0.14)	101.15	(3.18)	149.25	(25.10)
DEWA.2006	Bushkill Creek	2	11.51	(2.27)	7.04	(0.14)	11.38	(0.11)	104.35	(4.31)	41.75	(3.18)
DEWA.2007	Vandermark Creek	2	11.91	(0.28)	6.24	(0.13)	10.50	(0.26)	97.20	(2.83)	118.55	(3.46)
DEWA.2008	Flat Brook (Walpack)	1	11.50	*	8.05	*	12.07	*	110.90	*	263.00	*
DEWA.2009	Flat Brook (Flatbrookville)	1	14.06	*	8.22	*	10.98	*	106.80	*	260.00	*

Reach ID	Reach Name	*n*	Temp[1]	SD[2]	pH	SD	DO[3]	SD	DO%[4]	SD	SpC[5]	SD
FONE.1001	UNT to Scotts Run (Picnic Loop)	2	6.62	(2.15)	6.36	(0.85)	8.35	(4.04)	69.00	(36.20)	46.55	(0.64)
FONE.1002	UNT to Great Meadows Run	1	12.65	*	6.65	*	10.21	*	96.20	*	55.00	*
FONE.2001	Great Meadows Run	2	8.50	(1.98)	7.06	(0.14)	8.40	(3.42)	72.55	(32.74)	185.90	(50.77)
FRHI.1001	Ice Pond Run	3	9.21	(0.26)	2.64	(0.04)	7.92	(3.17)	68.97	(27.61)	1505.33	(500.07)
FRHI.1002	Dublin Run	3	9.80	(1.08)	7.16	(0.49)	7.69	(3.20)	67.40	(26.95)	164.20	(17.99)
GARI.1001	Laurel Creek (GARI)	2	11.22	(5.97)	7.20	(0.46)	7.97	(3.08)	74.80	(37.90)	63.15	(8.27)
GARI.1002	Horseshoe Creek	2	10.10	(2.55)	7.11	(0.49)	8.90	(2.63)	79.85	(28.07)	58.95	(5.73)
GARI.1003	Meadow Creek (GARI)	2	10.10	(1.69)	7.39	(0.40)	9.01	(2.74)	80.65	(27.37)	139.95	(48.15)
GARI.2001	Peters Creek	1	14.60	*	7.78	*	11.15	*	109.70	*	304.00	*
JOFL.2001	UNT to South Fork Little Conemaugh River	2	8.18	(2.43)	6.91	(0.08)	8.94	(1.40)	75.75	(7.14)	241.20	(2.55)
NERI.1001	Batoff Creek	2	9.43	(0.18)	7.59	(0.25)	10.45	(1.04)	90.95	(9.97)	131.80	(21.50)
NERI.1002	Mill Creek (NERI)	2	9.62	(1.87)	7.15	(0.35)	10.38	(0.71)	91.10	(10.61)	57.75	(1.77)
NERI.1003	Meadow Creek (NERI)	1	5.20	*	7.84	*	11.15	*	88.30	*	81.20	*
NERI.1004	UNT to Meadow Creek (NERI)	2	8.30	(0.99)	7.10	(0.95)	10.11	(1.51)	86.50	(14.42)	35.10	(1.56)
NERI.1005	Fall Branch	2	6.69	(0.73)	6.95	(0.78)	11.12	(1.57)	90.60	(11.17)	57.25	(1.06)
NERI.1006	Big Branch	2	7.46	(0.63)	7.32	(0.49)	10.57	(1.71)	89.25	(11.10)	69.60	(0.57)
NERI.1007	Laurel Creek (NERI)	2	12.18	(3.50)	7.56	(0.42)	9.59	(0.88)	89.85	(14.92)	73.25	(8.84)
NERI.1008	Dowdy Creek	2	5.55	(0.78)	5.51	(0.49)	11.40	(1.49)	90.70	(9.48)	23.10	(0.14)
NERI.1009	Slater Creek	2	6.40	(0.57)	6.95	(1.09)	11.53	(0.42)	93.60	(4.95)	47.80	(0.28)
NERI.1010	Buffalo Creek	2	7.82	(1.15)	7.25	(0.79)	10.30	(1.14)	89.40	(15.13)	78.45	(5.02)
NERI.1011	UNT to Buffalo Creek	2	7.99	(1.54)	7.55	(0.53)	10.92	(0.92)	93.70	(13.15)	121.75	(31.47)
NERI.1012	Arbuckle Creek	2	12.44	(4.57)	8.25	(0.47)	9.98	(0.16)	93.65	(11.10)	269.90	(11.17)
NERI.1013	UNT to Laurel Creek (Highland Mtn)	2	8.50	(1.41)	7.69	(0.20)	10.58	(0.83)	90.95	(9.55)	75.75	(14.50)
NERI.1014	UNT to Laurel Creek (Backus Mtn)	2	9.34	(3.16)	7.16	(0.46)	9.96	(1.11)	87.35	(16.05)	45.45	(3.61)
NERI.1015	Davis Branch	2	9.90	(3.25)	7.23	(0.45)	10.40	(0.46)	91.80	(2.97)	41.65	(7.99)
NERI.1016	Little Laurel Creek	2	6.88	(0.88)	6.51	(1.37)	10.33	(1.45)	84.95	(9.69)	25.90	(0.14)
NERI.1017	Richlick Branch	2	7.76	(1.22)	4.77	(1.17)	8.65	(3.13)	73.15	(28.07)	20.45	(0.78)
NERI.1018	Wolf Creek	1	9.00	*	7.61	*	9.71	*	84.10	*	175.50	*
NERI.1019	Keeney Creek	2	9.73	(1.03)	7.43	(0.45)	10.51	(1.01)	95.00	(14.14)	103.15	(1.63)
NERI.1020	Camp Branch	2	6.71	(1.97	5.96	(1.10)	8.67	(4.29)	70.05	(31.47)	39.10	(0.14)
NERI.1021	Ephraim Creek	2	10.85	(2.33)	6.83	(0.60)	8.11	(3.32)	74.05	(33.87)	29.50	(2.12)
NERI.1022	Fire Creek	2	11.67	(2.79)	7.42	(0.48)	9.42	(1.75)	87.20	(21.92)	84.60	(23.19)
NERI.1023	Bucklick Branch	2	7.52	(0.11)	6.35	(0.35)	10.84	(0.76)	90.40	(6.08)	22.85	(1.63)
NERI.2001	Piney Creek	2	11.57	(3.49)	8.41	(0.11)	9.96	(0.46)	92.00	(11.31)	230.10	(69.16)
NERI.2002	Glade Creek	2	9.83	(2.02)	7.41	(0.25)	9.12	(2.44)	81.05	(25.24)	103.90	(17.11)
UPDE.2001	Shohola Creek	2	11.02	(2.23)	6.78	(0.07)	12.06	(0.04)	109.50	(5.37)	80.55	(3.46)

Reach ID	Reach Name	*n*	Temp[1]	SD[2]	pH	SD	DO[3]	SD	DO%[4]	SD	SpC[5]	SD
UPDE.2002	Lackawaxen River	2	12.13	(3.07)	8.38	(0.12)	12.96	(0.45)	120.60	(4.24)	102.05	(0.07)
UPDE.2003	Masthope Creek	2	10.54	(3.34)	6.82	(0.10)	12.07	(0.35)	108.50	(5.66)	61.85	(2.62)
UPDE.2004	Mongaup River	2	15.51	(2.39)	7.14	(0.13)	10.85	(0.09)	108.60	(5.94)	103.25	(1.77)
UPDE.2005	Ten Mile River	2	10.15	(2.90)	6.45	(0.58)	11.24	(0.58)	100.05	(2.05)	96.05	(1.48)
UPDE.2006	Calkins Creek	2	10.41	(2.11)	7.04	(0.32)	12.19	(0.67)	109.10	(11.31)	83.90	(0.14)
UPDE.2007	Callicoon Creek	2	11.21	(2.67)	7.32	*	12.72	(0.91)	116.20	(15.27)	130.25	(2.47)
UPDE.2008	Hankins Creek	2	11.32	(2.52)	7.38	(0.16)	11.92	(0.07)	109.20	(5.94)	84.55	(6.43)
UPDE.2009	Little Equinunk Creek	2	10.03	(4.07)	7.27	(0.30)	12.07	(0.23)	107.00	(8.06)	60.50	(0.71)
UPDE.2010	East Branch Delaware River	2	11.90	(3.39)	7.32	(0.11)	11.37	(1.34)	105.05	(4.03)	74.75	(1.77)
UPDE.2011	Equinunk Creek	2	11.34	(2.21)	7.21	(0.21)	11.46	(0.67)	104.75	(0.64)	71.75	(1.06)
UPDE.2012	West Branch Delaware River	2	8.49	(0.44)	7.78	(0.18)	12.70	(2.12)	108.20	(17.25)	95.50	(4.95)

[1]Temperature
[2]Standard deviation
[3]Dissolved oxygen
[4]Dissolved oxygen percent concentration
[5]Specific conductance
*No standard deviation for these measures because there was only one data point

Appendix C. Benthic macroinvertebrate community metrics and indices from wadeable streams throughout the Eastern Rivers and Mountains Network (2008–2010).

Park	Stream	Taxa[1]	SD[2]	E[3]	SD	P[4]	SD	T[5]	SD	C-F[6]		%Non-insects[7]		%5 dominant[8]		MTI (-)[9]		MBII (+)[10]	
ALPO	Blair Gap Run (Foot of Ten)	27.5	(0.7)	4.0	(0.0)	2.5	(0.7)	8.0	(1.4)	7.5	(0.7)	8.1	(3.9)	69.1	(6.4)	4.10	(0.15)	44.8	3.5
ALPO	Blair Gap Run (Muleshoe)	27.5	(3.5)	7.0	(0.0)	4.0	(0.0)	7.5	(0.7)	6.0	(0.0)	20.4	(11.4)	57.7	(2.4)	4.26	(0.22)	44.1	5.9
ALPO	Millstone Run	34.5	(9.2)	6.5	(0.7)	6.5	(0.7)	6.5	(2.1)	4.0	(0.0)	1.2	(1.)	56.4	(2.9)	3.30	(0.07)	59.3	8.0
BLUE	Bluestone River (Mouth)	25.0	(1.4)	5.0	(0.0)	3.0	(1.4)	6.0	(1.4)	6.0	(0.0)	7.3	(0.2)	62.5	(3.7)	4.60	(0.23)	39.8	1.0
BLUE	Bluestone River (Tramway)	27.0	(2.8)	6.0	(0.0)	2.0	(1.4)	6.5	(0.7)	7.0	(1.4)	15.8	(2.8)	48.7	(0.8)	4.58	(0.10)	42.7	8.1
BLUE	Little Bluestone River	27.5	(2.1)	9.0	(1.4)	6.0	(1.4)	4.0	(0.0)	3.5	(0.7)	1.3	(0.3)	71.8	(8.7)	4.41	(1.02)	44.6	6.3
BLUE	Mountain Creek	28.0	(4.2)	6.5	(2.1)	6.0	(1.4)	5.0	(1.4)	4.0	(1.4)	3.4	(3.1)	70.1	(0.2)	3.99	(0.47)	46.9	18.1
DEWA	Adams Creek	32.0	(4.2)	8.0	(1.4)	5.0	(0.0)	9.5	(2.1)	6.5	(2.1)	0.7	(0.5)	61.2	(2.4)	3.54	(0.07)	64.3	1.3
DEWA	Big Flat Brook	36.0	(4.2)	7.0	(1.4)	4.0	(2.8)	9.5	(2.1)	8.0	(1.4)	4.1	(2.1)	61.2	(7.9)	3.86	(0.11)	61.2	13.1
DEWA	Bushkill Creek	32.5	(3.5)	8.5	(0.7)	2.5	(0.7)	9.0	(1.4)	6.0	(1.4)	9.9	(7.6)	54.8	(3.8)	3.84	(0.15)	53.9	1.8
DEWA	Caledonia Creek	32.5	(2.1)	6.0	(0.0)	6.0	(0.0)	7.5	(0.7)	3.5	(0.7)	1.4	(1.5)	61.4	(0.7)	3.34	(0.10)	57.6	0.7
DEWA	Dingmans Creek	26.5	(3.5)	4.5	(0.7)	2.0	(0.0)	8.0	(1.4)	7.5	(0.7)	36.7	(29.)	71.4	(13.7)	4.59	(0.46)	33.5	9.1
DEWA	Dunnfield Creek	30.5	(3.5)	6.0	(1.4)	5.0	(0.0)	8.5	(0.7)	3.0	(0.0)	3.3	(0.6)	55.6	(2.4)	3.75	(0.11)	54.8	4.3
DEWA	Flat Brook (Flatbrookville)	38.0	(0.0)	8.0	(0.0)	2.0	(0.0)	14.0	(0.0)	9.0	(0.0)	2.2	(0.0)	63.7	(0.0)	3.72	(0.00)	63.6	0.0
DEWA	Flat Brook (Walpack)	28.0	(0.0)	4.0	(0.0)	0.0	(0.0)	11.0	(0.0)	6.0	(0.0)	5.8	(0.0)	48.5	(0.0)	3.80	(0.00)	53.6	0.0
DEWA	Fuller Brook	29.0	(0.0)	4.0	(0.0)	6.0	(0.0)	8.0	(0.0)	3.0	(0.0)	0.1	(0.0)	54.9	(0.0)	3.57	(0.00)	58.2	0.0
DEWA	Hornbecks Creek	31.0	(2.8)	7.5	(3.5)	3.5	(0.7)	8.5	(2.1)	5.0	(0.0)	18.4	(19.2)	59.3	(11.9)	3.93	(0.20)	47.1	17.8
DEWA	Little Bushkill Creek	37.0	(0.0)	8.5	(0.7)	3.0	(1.4)	10.5	(0.7)	6.0	(2.8)	8.8	(1.9)	51.3	(2.4)	3.64	(0.06)	58.1	3.6
DEWA	Little Flat Brook	27.0	(4.2)	4.5	(0.7)	2.5	(0.7)	8.5	(2.1)	4.5	(0.7)	3.7	(2.1)	70.9	(3.4)	4.05	(0.64)	41.9	1.4
DEWA	Mill Creek (DEWA)	30.5	(3.5)	7.0	(0.0)	4.5	(2.1)	8.0	(1.4)	5.5	(0.7)	2.1	(0.5)	60.2	(6.)	3.62	(0.04)	59.4	3.9
DEWA	Raymondskill Creek	35.5	(2.1)	7.5	(0.7)	3.5	(0.7)	9.5	(3.5)	8.0	(1.4)	7.7	(4.1)	48.2	(8.3)	4.32	(0.03)	57.6	3.3
DEWA	Sawkill Creek	34.0	(4.2)	7.0	(0.0)	5.5	(0.7)	9.0	(1.4)	5.0	(1.4)	0.6	(0.8)	68.0	(6.8)	3.46	(0.19)	58.3	6.7
DEWA	Shimers Brook	25.5	(0.7)	2.5	(0.7)	2.0	(0.0)	8.5	(0.7)	6.5	(0.7)	1.1	(0.3)	72.5	(14.4)	4.22	(0.22)	46.4	8.5
DEWA	Slateford Creek	28.5	(0.7)	4.0	(1.4)	4.0	(0.0)	7.5	(2.1)	3.5	(0.7)	5.5	(5.2)	60.5	(3.2)	3.31	(0.12)	46.6	7.7
DEWA	Spackmans Creek	32.0	(1.4)	8.0	(0.0)	5.5	(2.1)	7.5	(0.7)	3.5	(0.7)	6.9	(3.9)	54.7	(7.4)	3.84	(0.11)	55.8	6.2
DEWA	Toms Creek	31.0	(2.8)	6.5	(2.1)	5.5	(0.7)	9.5	(2.1)	5.0	(0.0)	13.9	(9.1)	47.9	(9.1)	3.90	(0.34)	53.2	16.7
DEWA	UNT (Sunfish Pond)	21.0	(2.8)	0.5	(0.7)	4.5	(0.7)	7.0	(2.8)	2.0	(0.0)	3.9	(1.4)	71.2	(4.1)	3.87	(0.35)	41.1	1.5
DEWA	UNT to Dingmans Creek	28.0	(5.7)	3.5	(3.5)	3.5	(2.1)	7.5	(2.1)	7.0	(1.4)	24.8	(13.5)	58.5	(8.9)	4.59	(0.46)	38.8	17.8
DEWA	UNT to Toms Creek	29.0	(1.4)	5.5	(2.1)	3.5	(0.7)	9.5	(2.1)	5.5	(0.7)	5.4	(1.)	62.1	(13.6)	4.29	(0.32)	46.2	8.0
DEWA	Van Campen Creek	32.0	(2.8)	5.5	(0.7)	3.5	(0.7)	10.0	(1.4)	5.0	(0.0)	9.3	(5.2)	60.1	(1.9)	4.09	(0.11)	44.3	7.6
DEWA	Vancampens Brook	32.5	(0.7)	7.0	(1.4)	5.5	(0.7)	10.0	(1.4)	4.0	(0.0)	1.1	(1.)	52.6	(0.2)	3.48	(0.00)	61.5	3.0
DEWA	Vandermark Creek	31.5	(2.1)	5.5	(0.7)	6.0	(0.0)	8.5	(0.7)	4.0	(1.4)	3.8	(2.4)	51.8	(2.5)	3.48	(0.32)	59.4	0.6
DEWA	White Brook	22.5	(3.5)	2.0	(0.0)	3.5	(0.7)	5.5	(0.7)	3.0	(0.0)	1.1	(0.5)	72.5	(7.1)	3.35	(0.15)	41.9	0.2
FONE	Great Meadows Run	40.0	(0.0)	4.0	(0.0)	3.0	(0.0)	6.0	(0.0)	4.0	(0.0)	3.3	(0.0)	69.6	(0.0)	4.98	(0.00)	31.0	0.0
FONE	UNT to Great Meadows Run	34.0	(0.0)	7.0	(0.0)	5.0	(0.0)	6.0	(0.0)	4.0	(0.0)	22.3	(0.0)	50.2	(0.0)	4.46	(0.00)	38.7	0.0
FONE	UNT to Scotts Run	38.5	(0.7)	8.5	(0.7)	6.0	(0.0)	6.0	(0.0)	4.0	(0.0)	4.5	(1.1)	58.4	(3.9)	4.28	(0.00)	52.3	1.3
FRHI	Dublin Run	25.7	(2.3)	3.7	(0.6)	3.7	(1.5)	5.3	(0.6)	2.0	(1.)	4.4	(0.9)	72.3	(7.)	4.19	(0.29)	35.5	5.9

Park	Stream	Taxa[1]	SD[2]	E[3]	SD	P[4]	SD	T[5]	SD	C-F[6]		%Non-insects[7]		%5 dominant[8]		MTI (-)[9]		MBII (+)[10]	
FRHI	Ice Pond Run	5.7	(1.5)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.3	(0.6)	0.0	(0.0)	99.8	(0.2)	6.02	(0.02)	14.3	0.0
GARI	Horseshoe Creek	37.0	(0.0)	7.0	(0.0)	4.0	(0.0)	8.0	(0.0)	5.0	(0.0)	4.3	(0.0)	51.3	(0.0)	4.10	(0.00)	54.2	0.0
GARI	Laurel Creek	25.0	(1.4)	7.0	(0.0)	6.0	(0.0)	4.0	(1.4)	2.5	(0.7)	2.6	(2.8)	80.2	(5.)	4.16	(1.04)	39.1	7.2
GARI	Meadow Creek	29.5	(3.5)	6.0	(1.4)	4.5	(2.1)	6.5	(0.7)	5.5	(2.1)	2.6	(2.7)	67.0	(5.3)	4.57	(0.02)	46.1	0.5
GARI	Peters Creek	30.0	(0.0)	9.0	(0.0)	3.0	(0.0)	5.0	(0.0)	5.0	(0.0)	2.3	(0.0)	76.5	(0.0)	4.60	(0.00)	39.2	0.0
JOFL	UNT to SFLCR	21.0	(4.2)	1.0	(0.0)	2.0	(1.4)	4.5	(0.7)	4.5	(0.7)	1.7	(1.6)	84.1	(1.3)	5.24	(0.20)	23.7	0.1
NERI	Arbuckle Creek	12.5	(3.5)	1.0	(0.0)	0.0	(0.0)	3.0	(1.4)	4.5	(3.5)	5.5	(2.2)	92.9	(7.9)	3.62	(0.62)	30.7	4.0
NERI	Batoff Creek	24.0	(0.0)	4.5	(0.7)	7.0	(1.4)	5.5	(2.1)	4.5	(0.7)	0.3	(0.5)	77.5	(9.5)	4.07	(0.38)	47.6	3.0
NERI	Big Branch	27.5	(3.5)	6.5	(0.7)	7.0	(1.4)	4.5	(3.5)	3.5	(2.1)	1.2	(1.3)	72.5	(10.1)	3.77	(0.12)	50.8	18.4
NERI	Bucklick Branch	39.5	(2.1)	6.0	(0.0)	8.5	(3.5)	9.0	(2.8)	4.5	(0.7)	2.9	(0.2)	53.5	(8.7)	4.30	(0.08)	59.3	11.6
NERI	Buffalo Creek	28.5	(7.8)	7.0	(1.4)	7.0	(1.4)	5.0	(1.4)	3.5	(0.7)	1.2	(0.4)	67.4	(13.2)	3.73	(0.10)	53.8	15.1
NERI	Camp Branch	21.0	(4.2)	3.0	(0.0)	4.5	(0.7)	4.0	(1.4)	2.5	(0.7)	2.9	(3.1)	68.7	(3.4)	3.98	(0.55)	37.1	9.6
NERI	Davis Branch	33.0	(5.7)	6.0	(1.4)	7.5	(0.7)	7.5	(2.1)	4.0	(0.0)	1.1	(0.5)	66.4	(8.4)	3.98	(0.29)	55.7	7.2
NERI	Dowdy Creek	22.5	(0.7)	1.0	(0.0)	4.0	(0.0)	6.0	(0.0)	4.0	(1.4)	8.2	(3.7)	78.3	(4.9)	4.60	(0.48)	29.3	0.8
NERI	Ephraim Creek	29.0	(1.4)	6.5	(0.7)	7.0	(0.0)	6.0	(0.0)	3.5	(0.7)	1.6	(2.)	72.4	(0.7)	3.69	(0.26)	53.1	3.5
NERI	Fall Branch	32.0	(2.8)	8.0	(0.0)	6.5	(0.7)	5.5	(2.1)	4.5	(2.1)	1.2	(0.8)	61.0	(2.8)	3.52	(0.16)	60.6	9.6
NERI	Fire Creek	24.0	(2.8)	5.0	(1.4)	6.5	(0.7)	5.0	(1.4)	3.0	(0.0)	1.1	(1.)	80.5	(2.7)	3.74	(0.22)	45.0	2.9
NERI	Glade Creek	32.5	(6.4)	9.5	(2.1)	6.0	(1.4)	6.5	(0.7)	5.0	(1.4)	5.5	(5.6)	60.4	(7.5)	3.85	(0.42)	58.8	21.5
NERI	Keeney Creek	32.5	(0.7)	6.5	(0.7)	7.0	(1.4)	6.5	(0.7)	4.0	(0.0)	3.1	(2.3)	64.5	(2.7)	3.90	(0.07)	55.0	0.6
NERI	Laurel Creek	32.5	(7.8)	10.0	(1.4)	6.5	(2.1)	6.5	(2.1)	6.0	(1.4)	2.7	(2.8)	55.1	(10.9)	3.68	(0.37)	66.8	9.7
NERI	Little Laurel Creek	39.0	(1.4)	7.5	(0.7)	7.0	(0.0)	6.0	(1.4)	4.5	(0.7)	3.9	(0.1)	63.6	(10.7)	4.21	(0.03)	53.4	8.2
NERI	Meadow Creek	30.0	(0.0)	9.0	(0.0)	7.0	(0.0)	5.0	(0.0)	4.0	(0.0)	3.1	(0.0)	56.2	(0.0)	4.07	(0.00)	56.8	0.0
NERI	Mill Creek	31.0	(0.0)	7.0	(1.4)	6.5	(2.1)	4.5	(0.7)	4.0	(1.4)	1.7	(0.9)	63.2	(0.5)	3.98	(0.10)	51.7	1.4
NERI	Piney Creek	17.0	(5.7)	1.5	(0.7)	2.0	(1.4)	6.0	(1.4)	6.0	(1.4)	3.2	(4.1)	94.3	(1.3)	4.41	(1.61)	35.4	6.9
NERI	Richlick Branch	25.0	(4.2)	4.0	(0.0)	5.0	(1.4)	3.5	(0.7)	3.5	(0.7)	3.1	(1.2)	80.2	(4.9)	4.10	(0.04)	32.5	4.6
NERI	Slater Creek	24.5	(2.1)	6.0	(1.4)	7.5	(0.7)	5.0	(0.0)	3.5	(0.7)	1.5	(0.3)	73.0	(10.8)	3.58	(0.02)	52.0	8.2
NERI	UNT (Backus Mtn)	23.5	(4.9)	3.5	(0.7)	6.0	(1.4)	4.5	(0.7)	2.0	(0.0)	3.9	(0.7)	71.1	(9.1)	4.10	(0.46)	39.4	12.9
NERI	UNT (Highland Mtn)	32.5	(3.5)	7.5	(0.7)	6.5	(0.7)	7.5	(0.7)	3.0	(0.0)	3.2	(0.2)	64.5	(4.7)	4.03	(0.14)	55.0	5.6
NERI	UNT to Buffalo Creek	27.5	(0.7)	6.0	(0.0)	7.0	(1.4)	5.0	(2.8)	3.5	(0.7)	1.8	(0.2)	65.4	(3.5)	3.88	(0.31)	51.4	14.1
NERI	UNT to Meadow Creek	35.0	(2.8)	7.5	(0.7)	6.5	(0.7)	6.0	(1.4)	2.5	(0.7)	1.9	(0.3)	49.7	(4.5)	3.61	(0.17)	62.1	5.0
NERI	Wolf Creek	11.0	(0.0)	1.0	(0.0)	1.0	(0.0)	2.0	(0.0)	1.0	(0.0)	1.1	(0.0)	99.9	(0.0)	5.30	(0.00)	16.3	0.0
UPDE	Calkins Creek	31.5	(2.1)	9.0	(1.4)	3.5	(0.7)	9.5	(0.7)	5.0	(0.0)	1.3	(1.4)	57.2	(2.4)	3.68	(0.19)	59.8	3.8
UPDE	Callicoon Creek	27.0	(7.1)	9.0	(0.0)	4.0	(0.0)	8.5	(2.1)	5.5	(0.7)	0.2	(0.2)	71.5	(14.9)	3.69	(0.09)	57.5	7.5
UPDE	East Branch Delaware River	29.5	(7.8)	7.5	(0.7)	3.0	(1.4)	10.5	(2.1)	8.5	(2.1)	2.2	(1.4)	71.8	(5.6)	3.71	(0.01)	59.4	7.5
UPDE	Equinunk Creek	31.5	(4.9)	8.5	(0.7)	5.0	(1.4)	8.5	(0.7)	5.0	(1.4)	0.6	(0.8)	59.8	(4.5)	3.69	(0.14)	61.8	5.7
UPDE	Hankins Creek	29.0	(1.4)	9.0	(0.0)	6.0	(1.4)	7.0	(0.0)	3.5	(0.7)	0.2	(0.2)	72.2	(1.4)	3.25	(0.07)	58.8	4.3
UPDE	Lackawaxen River	33.5	(2.1)	7.0	(1.4)	3.5	(2.1)	9.5	(2.1)	7.5	(0.7)	6.7	(3.4)	67.5	(0.4)	4.22	(0.03)	51.4	0.8
UPDE	Little Equinunk Creek	32.5	(0.7)	7.0	(0.0)	5.0	(0.0)	10.5	(2.1)	6.0	(0.0)	1.0	(0.3)	69.5	(0.7)	3.43	(0.08)	58.4	0.0
UPDE	Masthope Creek	34.0	(4.2)	8.5	(0.7)	3.5	(0.7)	12.0	(0.0)	7.5	(0.7)	1.9	(0.3)	57.0	(2.9)	3.54	(0.04)	64.9	4.2
UPDE	Mongaup River	37.5	(0.7)	6.5	(0.7)	2.0	(1.4)	16.0	(2.8)	10.0	(1.4)	14.9	(9.3)	60.1	(4.7)	3.92	(0.48)	53.7	10.4

Park	Stream	Taxa[1]	SD[2]	E[3]	SD	P[4]	SD	T[5]	SD	C-F[6]		%Non-insects[7]		%5 dominant[8]		MTI (-)[9]		MBII (+)[10]	
UPDE	Shohola Creek	36.0	(4.2)	6.0	(1.4)	3.5	(0.7)	13.0	(0.0)	9.0	(0.0)	3.0	(0.0)	68.7	(7.1)	3.80	(0.06)	58.1	6.0
UPDE	Ten Mile River	34.0	(0.0)	7.0	(1.4)	3.5	(0.7)	14.5	(0.7)	9.5	(0.7)	2.3	(0.6)	54.7	(8.4)	3.77	(0.09)	66.7	3.1
UPDE	West Branch Delaware River	25.5	(3.5)	7.0	(0.0)	1.5	(0.7)	7.0	(1.4)	7.0	(1.4)	3.2	(0.7)	69.0	(1.2)	3.95	(0.24)	51.8	6.9

[1]Total number of distinct taxa
[2]Standard deviation
[3]Ephemeroptera taxa
[4]Plecoptera taxa
[5]Trichoptera taxa
[6]Collector-Filterer Richness
[7]Percentage of individuals that were non-insects
[8]Percentage of individuals comprised by the 5 dominant taxa
[9]Macroinvertebrate Tolerance Index; responds negatively with ecological integrity
[10]Macroinvertebrate Biotic Integrity Index responds positively with ecological integrity

Appendix D. Benthic macroinvertebrate community metrics and indices from wadeable streams throughout the Eastern Rivers and Mountains Network (2009–2010).

Park	Stream	Date	Taxa	E	P	T	C-F	%Non-insects	%5 dominant	MTI (-)	MBII (+)
ALPO	Blair Gap Run (Foot of Ten)	10/21/2009	28	4	2	9	8	5.4	73.6	3.99	47.33
ALPO	Blair Gap Run (Muleshoe)	10/21/2009	30	7	4	8	6	12.3	56.0	4.11	48.20
ALPO	Millstone Run	10/21/2009	41	7	7	8	4	0.5	54.4	3.24	64.92
BLUE	Bluestone River (Mouth)	9/14/2010	24	5	2	5	6	7.5	59.9	4.45	39.04
BLUE	Bluestone River (Tramway)	9/14/2010	25	6	1	6	6	17.7	49.3	4.65	37.01
BLUE	Little Bluestone River	4/7/2010	26	8	5	4	4	1.5	65.7	3.69	49.00
BLUE	Mountain Creek	4/7/2010	31	8	7	6	5	1.2	70.0	3.66	59.68
DEWA	Adams Creek	10/5/2009	29	9	5	8	5	0.3	59.5	3.59	63.38
DEWA	Big Flat Brook	10/6/2009	39	8	6	11	9	2.6	55.6	3.93	70.42
DEWA	Bushkill Creek	10/8/2009	35	9	3	10	7	15.3	52.1	3.95	52.63
DEWA	Caledonia Creek	10/2/2009	31	6	6	8	3	0.3	61.9	3.41	58.11
DEWA	Dingmans Creek	10/6/2009	29	5	2	9	7	16.2	61.7	4.26	39.91
DEWA	Dunnfield Creek	10/2/2009	28	7	5	9	3	2.9	53.9	3.68	57.85
DEWA	Flat Brook (Flatbrookville Gauge)	10/7/2009	38	8	2	14	9	2.2	63.7	3.72	63.63
DEWA	Flat Brook (Walpack)	10/1/2009	28	4	0	11	6	5.8	48.5	3.80	53.65
DEWA	Hornbecks Creek	10/5/2009	33	10	3	10	5	4.9	50.9	3.80	59.74
DEWA	Little Bushkill Creek	10/8/2009	37	9	4	10	4	7.5	53.0	3.59	55.52
DEWA	Little Flat Brook	10/1/2009	30	4	3	10	5	2.2	68.5	4.51	40.86
DEWA	Mill Creek (DEWA)	10/6/2009	33	7	6	9	6	1.8	64.5	3.59	62.08
DEWA	Raymondskill Creek	10/5/2009	37	7	4	12	9	4.8	54.1	4.30	59.92
DEWA	Sawkill Creek	10/9/2009	37	7	6	10	6	1.2	63.2	3.60	63.04
DEWA	Shimers Brook	10/1/2009	25	3	2	9	7	0.9	62.3	4.07	52.35
DEWA	Slateford Creek	10/2/2009	29	5	4	9	3	1.8	58.3	3.23	52.02
DEWA	Spackmans Creek	10/6/2009	31	8	7	7	3	4.1	59.9	3.76	60.17
DEWA	Toms Creek	10/8/2009	33	8	6	11	5	7.5	41.4	3.65	65.03
DEWA	UNT to Delaware River (Sunfish Pond)	10/7/2009	23	0	4	9	2	2.9	74.1	4.12	40.06
DEWA	UNT to Dingmans Creek	10/6/2009	32	6	5	9	8	15.2	52.2	4.26	51.37
DEWA	UNT to Toms Creek	10/8/2009	30	4	4	11	6	4.7	52.5	4.07	51.87
DEWA	Van Campen Creek	10/9/2009	34	6	4	11	5	5.6	58.8	4.02	49.67
DEWA	Vancampens Brook (Millbrook Village)	10/7/2009	32	8	6	9	4	1.8	52.5	3.48	63.63
DEWA	Vandermark Creek	10/5/2009	33	6	6	8	3	2.1	53.5	3.25	59.85
DEWA	White Brook	10/1/2009	25	2	4	6	3	0.7	77.5	3.24	42.02
FONE	Great Meadows Run	4/1/2010	40	4	3	6	4	3.3	69.6	4.98	31.01

Park	Stream	Date	Taxa	E	P	T	C-F	%Non-insects	%5 dominant	MTI (-)	MBII (+)
FONE	UNT to Great Meadows Run	4/1/2010	34	7	5	6	4	22.3	50.2	4.46	38.67
FONE	UNT to Scotts Run (Picnic Loop)	4/1/2010	38	8	6	6	4	3.7	55.7	4.28	53.24
FRHI	Dublin Run	4/2/2010	27	4	5	5	1	4.1	64.8	3.89	42.14
FRHI	Ice Pond Run	4/2/2010	6	0	0	0	0	0.0	99.5	6.02	14.29
GARI	Laurel Creek (GARI)	4/5/2010	24	7	6	3	2	0.7	76.7	3.43	44.19
GARI	Meadow Creek (GARI)	4/5/2010	27	5	6	7	4	0.7	70.8	4.56	45.71
GARI	Peters Creek	4/5/2010	30	9	3	5	5	2.3	76.5	4.60	39.17
JOFL	UNT to South Fork Little Conemaugh River	10/21/2009	24	1	3	4	5	2.9	83.1	5.10	23.75
NERI	Arbuckle Creek	4/6/2010	10	1	0	2	2	3.9	98.5	3.18	27.83
NERI	Batoff Creek	3/21/2010	24	5	8	4	4	0.7	70.8	3.80	49.79
NERI	Big Branch	3/21/2010	30	6	8	7	5	0.3	65.4	3.69	63.82
NERI	Bucklick Branch	4/9/2010	38	6	11	7	5	2.8	47.4	4.24	67.48
NERI	Buffalo Creek	3/20/2010	34	8	8	6	4	1.0	58.1	3.67	64.50
NERI	Camp Branch	3/19/2010	18	3	5	3	2	5.0	71.1	4.37	30.25
NERI	Davis Branch	4/8/2010	29	5	8	6	4	0.8	72.3	4.19	50.58
NERI	Dowdy Creek	3/20/2010	23	1	4	6	5	5.5	81.7	4.94	28.77
NERI	Ephraim Creek	4/6/2010	30	7	7	6	3	0.1	72.9	3.51	55.59
NERI	Fall Branch	3/21/2010	34	8	7	7	6	0.6	63.0	3.40	67.42
NERI	Fire Creek	4/6/2010	26	6	7	4	3	0.4	78.6	3.58	47.06
NERI	Glade Creek	4/8/2010	37	11	7	7	6	1.5	55.1	3.56	74.00
NERI	Keeney Creek	4/7/2010	33	7	6	7	4	1.5	66.4	3.85	55.47
NERI	Laurel Creek (NERI)	4/7/2010	27	11	5	5	5	0.7	62.8	3.42	59.98
NERI	Little Laurel Creek	3/19/2010	40	7	7	7	5	4.0	56.0	4.19	59.22
NERI	Mill Creek (NERI)	4/9/2010	31	6	8	4	5	2.3	63.6	4.06	52.64
NERI	Piney Creek	4/8/2010	13	1	1	5	5	0.3	95.2	3.28	40.28
NERI	Richlick Branch	3/19/2010	28	4	6	4	3	4.0	76.7	4.13	35.80
NERI	Slater Creek	3/20/2010	26	7	8	5	4	1.3	65.4	3.57	57.80
NERI	UNT to Buffalo Creek	3/20/2010	28	6	8	7	4	1.9	62.9	3.66	61.42
NERI	UNT to Laurel Creek (Backus Mtn)	4/8/2010	27	4	7	5	2	3.4	64.7	3.77	48.55
NERI	UNT to Laurel Creek (Highland Mtn)	3/19/2010	30	7	6	7	3	3.1	67.8	4.13	51.10
NERI	UNT to Meadow Creek (NERI)	3/21/2010	37	7	7	7	3	2.2	46.6	3.73	65.64
UPDE	Calkins Creek	10/13/2009	33	10	4	10	5	0.4	55.5	3.82	62.50
UPDE	Callicoon Creek	10/13/2009	22	9	4	7	5	0.3	82.1	3.75	52.24
UPDE	East Branch Delaware River	10/13/2009	35	8	4	12	10	3.2	67.9	3.70	64.70
UPDE	Equinunk Creek	10/14/2009	28	9	4	8	4	0.0	63.0	3.58	57.70
UPDE	Hankins Creek	10/13/2009	28	9	5	7	3	0.3	73.2	3.20	55.75

Park	Stream	Date	Taxa	E	P	T	C-F	%Non-insects	%5 dominant	MTI (-)	MBII (+)
UPDE	Lackawaxen River	10/12/2009	32	8	2	8	7	4.3	67.8	4.20	51.95
UPDE	Little Equinunk Creek	10/14/2009	33	7	5	12	6	0.7	70.0	3.48	58.43
UPDE	Masthope Creek	10/12/2009	37	9	4	12	8	2.2	54.9	3.51	67.83
UPDE	Mongaup River	10/12/2009	37	6	1	14	9	21.4	56.7	4.26	46.30
UPDE	Shohola Creek	10/12/2009	39	7	4	13	9	2.9	63.7	3.75	62.33
UPDE	Ten Mile River	10/12/2009	34	8	3	15	9	2.7	48.8	3.71	68.90
UPDE	West Branch Delaware River	11/19/2009	28	7	1	8	8	2.6	69.9	3.79	56.70

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