



Upper Columbia Basin Network Integrated Water Quality Annual Report 2015

Big Hole National Battlefield (BIHO)

Natural Resource Report NPS/UCBN/NRR—2016/1273



ON THE COVER

North Fork Big Hole River, September 2015, Big Hole National Battlefield
Photograph courtesy of the National Park Service

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Contents

	Page
Figures.....	iv
Tables.....	v
Appendices.....	vi
Executive Summary	vii
Acknowledgments.....	ix
Introduction and Background.....	1
Objectives	2
Study Area	5
North Fork Big Hole River- Big Hole National Battlefield (BIHO).....	5
Methods.....	9
Water Chemistry.....	9
Quality Assurance/Quality Control (QA/QC):	9
Discharge.....	10
Macroinvertebrates	10
Results.....	11
North Fork Big Hole River.....	11
Water Chemistry.....	11
Macroinvertebrates	23
Literature Cited	25

Figures

	Page
Figure 1. North Fork Big Hole River looking upstream towards water quality monitoring station #01.....	6
Figure 2. Big Hole National Battlefield regional map	7
Figure 3. Water quality monitoring location in North Fork Big Hole River 2015.	8
Figure 4. July 2015 cross section survey of North Fork Big Hole River, box plot of specific conductance and plot of 95% family-wise confidence level	12
Figure 5. September 2014 cross section survey of North Fork Big Hole River, box plot of specific conductance and plot of 95% family-wise confidence level	12
Figure 6. North Fork Big Hole River, water quality monitoring results box-plot 2009-2015.....	15
Figure 7. Daily maximum and mean water temperature in North Fork Big Hole River, BIHO, 2015.....	16
Figure 8. Corrected daily mean specific conductance North Fork Big Hole River, BIHO, 2015.....	18
Figure 9. Corrected daily minimum dissolved oxygen and daily maximum temperature in North Fork Big Hole River, BIHO, 2015.....	20
Figure 10. Corrected daily maximum, minimum, and median pH in North Fork Big Hole River, BIHO, 2015.....	21
Figure 11. Corrected daily mean turbidity in North Fork Big Hole River, BIHO, 2015.....	22

Tables

	Page
Table ES-1. North Fork Big Hole River Water Chemistry Summary 2015	viii
Table 1. Vital sign summary table for water chemistry in North Fork Big Hole River June-October, 2015.	13
Table 2. Vital sign summary table for water chemistry in North Fork Big Hole River June-October, 2012.	14
Table 3. Water temperature summary table for North Fork Big Hole River 2009-2015.	16
Table 4. Data grade/rating for water temperature each deployment period June-October 2015 in North Fork Big Hole River, BIHO.	17
Table 5. Data grade/rating for specific conductance each deployment period June- October 2015 in North Fork Big Hole River, BIHO.....	18
Table 6a. Spawning times of fishes that may occur in the North Fork Big Hole River within BIHO. ^a	19
Table 6b. Dissolved oxygen standards for early and other life stages that may occur in the North Fork Big Hole River within BIHO. ^a	19
Table 7. Data grade/rating for dissolved oxygen each deployment period June-October 2015 in North Fork Big Hole River, BIHO.	20
Table 8. Data grade/rating for pH each deployment period June-October 2015 in North Fork Big Hole River, BIHO.....	21
Table 9. Data grade/rating for turbidity each deployment period June-October 2015 in North Fork Big Hole River, BIHO.....	22
Table 10. Vital sign summary table for benthic macroinvertebrates in North Fork Big Hole River, 2015. ^a	24

Appendices

	Page
Appendix A. 2015 Water Quality Monitoring Locations	Appendix A-1
Appendix B. BIHO Hydrologic Unit Code Boundaries	Appendix B-1
Appendix C. Sample Locations for Water Quality Monitoring at BIHO	Appendix C-1
Appendix D. Quality Control (QC) Indicators.....	Appendix D-1
Appendix E. Macroinvertebrate Metrics.....	Appendix E-1
Appendix F. Macroinvertebrate Taxa List.....	Appendix F-1

Executive Summary

The mission of the National Park Service 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 uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks. The Upper Columbia Basin Network (UCBN) is comprised of 8 national park sites located in Idaho, Montana, Oregon, and Washington.

The UCBN has identified 14 priority park vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent of the network is to monitor a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Water quality is a particularly high priority vital sign for six of the nine UCBN parks. The UCBN contains more than 34 rivers, streams, ponds, and reservoirs. Unlike many National Parks that are large and often encompass entire watersheds, most UCBN parks and water bodies are small and embedded in large watersheds with diverse land use.

This annual report details the status of key indicators of water quality obtained from monitoring in Big Hole National Battlefield (BIHO), June-October 2015. Monitoring occurred in the North Fork Big Hole River, which was previously sampled in 2012 (see Starkey 2013). Data from the 2015 field sampling effort was collected following methods detailed in the UCBN integrated water quality monitoring protocol (Starkey et al. 2008). The UCBN Integrated Water Quality Monitoring Protocol was formally peer-reviewed and approved for implementation in August 2009. A revised version has recently been published (Starkey et al. 2016a) and can be found on the UCBN website at: <http://science.nature.nps.gov/im/units/ucbn/publications.cfm?tab=3>. This protocol can be found on the UCBN website at: <http://science.nature.nps.gov/im/units/ucbn/publications.cfm?tab=3>. Benthic macroinvertebrates were collected by the United States Forest Service- PACFISH/INFISH Biological Opinion (PIBO) according to their peer reviewed protocol during the UCBN’s monitoring of stream channel characteristics and riparian condition in 2014. The UCBN’s peer reviewed stream channel characteristics and riparian condition protocols can also be found on the UCBN’s website listed above.

Water chemistry and macroinvertebrate results indicate that the North Fork Big Hole River is in fair to good condition, with the primary concerns being dissolved oxygen levels below established thresholds and elevated water temperatures. The status of water quality for North Fork Big Hole River relative to state regulatory thresholds is given in the summary table on the following page. UCBN water quality monitoring is conducted on a 3 year rotating panel. As a result, conditions in North Fork Big Hole River will be re-evaluated in 2018.

Note that several of the appendices in this report are primarily intended for UCBN internal reference. In addition, some appendices serve as hard copies of quality assurance/quality control procedures performed during data processing.

Table ES-1. North Fork Big Hole River Water Chemistry Summary 2015

Measure	Current Condition (June-October, 2015)	State DEQ Thresholds ^a	% Exceedance ^b
Temperature (MDMT ^c , MDAT ^d)	MDMT ^c = 19.59 °C MDAT ^d = 17.57 °C	"A 1 °F [0.56 °C] maximum increase above naturally occurring water temperature is allowed"	--
		<18 °C threshold to protect against stress or lethal conditions for arctic grayling ^e	3.57%
Specific conductance (mean)	58.80 µS/cm	N/A	N/A
Dissolved oxygen (mean daily min)	6.91 mg/l	Daily minimum > 8.0 mg/L; 7-d mean > 9.5 mg/L (Early life stage- applicable 16 July to 30 Sept.)	96% 100%
		1-day minimum >4.0 mg/L; 7-d mean minimum > 5.0 mg/L; 30 day mean >6.5 mg/L (Other life stages applicable to data collected 17 June to 15 July and 1 Oct. to 21 Oct.)	0% 0% 0%
pH (mean daily max)	7.34 pH Units	6.5-8.5; < 0.5 unit human induced change; Maintain >7.0 if naturally > 7.0	0%
pH (mean daily min)	7.13 pH Units		0%
Turbidity (mean daily max)	7.07 NTU ^d	"No increase above natural turbidity is allowed"	--

^a MT DEQ water quality standards for North Fork Big Hole River planning area

^b Proportion of samples above water quality standard (Note that the % exceedance indicated is based on 24 hours of data). Exceedance values 0% - 5% indicates good water quality (also highlighted in green), 5% - 25% indicates fair water quality (also highlighted in yellow), and > 25% indicates poor water quality (also highlighted in red).

^c MDMT – Maximum Daily Maximum Temperature

^d MDAT – Maximum Daily Average Temperature

Acknowledgments

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Servicewide Inventory and Monitoring Program. The UCBN would also like to thank BIHO staff for their assistance in the field, accommodations during field work, and for the review of this report.

Introduction and Background

Water resources have been identified as a high priority vital sign for the Upper Columbia Basin Network (UCBN). These resources are used by many riparian, migratory, and terrestrial organisms in the Network, and have intrinsic value as places of natural beauty and recreation (Garrett et al. 2007). Reflecting this priority, the Water Resources Division (WRD) of the NPS provides a separate source of funding each fiscal year to the UCBN to accomplish water quality monitoring. In June 2015 the UCBN began its third year of integrated water quality monitoring in the North Fork Big Hole River at Big Hole National Battlefield (BIHO).

Water resources in the semi-arid West have been strongly affected by human activity, and many UCBN streams and rivers are listed by states as impaired for one or more parameters. Most UCBN water bodies and many aquatic resources such as migratory fish are strongly influenced by activities in the larger watersheds outside park boundaries. Understanding the current status of freshwater ecosystems will help guide management and restoration efforts, and provide insight into ecosystem change in a landscape with a shifting climate and dynamic human influences.

During the process of prioritizing vital signs to monitor in UCBN parks in 2005, water quality was identified as a high priority vital sign (Garrett et al. 2007). When asked what aspects of water quality were important to monitor, resource managers identified the sampling of macroinvertebrate assemblages within UCBN water bodies as the top monitoring priority. Secondary priorities included baseline sampling of water chemistry parameters, characterization of channel morphology, and information on water quantity. Channel morphology and riparian vegetation are addressed in separate monitoring protocols which were also implemented at BIHO in 2015.

The objectives of the UCBN Integrated Water Quality Monitoring Protocol are documenting the aquatic macroinvertebrate assemblage composition and baseline water chemistry parameters. Aquatic macroinvertebrate assemblages have strong effects on freshwater ecosystem processes and represent an important trophic linkage between primary producers and fishes. Measures of macroinvertebrate assemblage composition and structure have been frequently used as water quality indicators because these assemblages integrate the effects of point and non-point source pollutants over spatial-temporal scales and can be used to answer many management questions. Also, macroinvertebrates are more cost-effective to sample than other biota or many water chemistry parameters.

Water chemistry and temperature have strong effects on aquatic biota. Consequently, direct and indirect human alteration of stream water quality is associated with altered biotic communities and ecosystem processes. Because of the direct relationship between water chemistry and biota, water chemistry is typically a central component of any water quality monitoring program. More recently, monitoring of stream water temperatures has increased in the Pacific Northwest, because of concerns over cold-water fish habitat (primarily salmonid fishes), the recognized influence of land- and water-use on stream temperature regime, and the need for baseline temperature information to monitor the effects of climate change. National Park Service (NPS) Water Resource Division (WRD) has identified a suite of four “core water quality parameters”: temperature, specific conductance, pH, and dissolved oxygen, which are critical to understanding baseline conditions in aquatic habitats. The

UCBN added turbidity as a parameter to measure because it is listed as a source of impairment in several UCBN park streams.

Well-articulated desired future condition statements have not yet been developed for water quality in UCBN parks. However, the mission statements for the NPS as a whole and for the individual parks clearly state the intent “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). Water quality is a particularly important resource with nationally recognized merit. It is assumed that desired future conditions for all UCBN parks will include clean streams, rivers, and lakes free of human health concerns that provide visitors with recreational and scenic experiences. Monitoring macroinvertebrate assemblage composition and structure, and core water quality parameters will directly measure the water characteristics most important to park mission, visitor experience, and desired future conditions.

Objectives

The overarching programmatic goal of the UCBN integrated water quality monitoring program is to obtain information that will aid in informed management decisions pertaining to improved water quality within UCBN parks. Park managers have committed to improving the water quality of impaired waters by adopting the NPS Government Performance Results Act (GPRA) goal (Ia4) that streams and rivers managed by NPS will meet State and Federal water quality standards (NPS 2000).

Given this goal, it should be noted that in 2014 North Fork Big Hole River was listed as a category 4A or impaired water according to the state of Montana. Meaning that sufficient data shows the stream is failing to achieve compliance with applicable water quality standards (i.e., nonsupport or partial support of beneficial uses). Designated state beneficial uses are agricultural, aquatic life, drinking water, and primary contact recreation. Of which, aquatic life and primary contact recreation uses were not supported. Probable causes of impairment include; low flow alterations, sedimentation/siltation, and alteration in stream-side or littoral vegetative covers (MT DEQ 2014). A category 4A water also means that the stream has total maximum daily loads (TMDL) being actively implemented to remedy issues.

Given the lack of available data on water quality in UCBN parks, the following fundamental questions drive much of the UCBN’s inquiry into water quality:

- Are the core water quality parameters of streams in the UCBN with established Total Maximum Daily Loads (TMDLs) selected for sampling improving over time?
- What is the status and long-term trend of core water quality parameters (temperature, pH, conductivity, dissolved oxygen, and turbidity) in UCBN streams selected for sampling?
- What is the status and long term trend in aquatic macroinvertebrate abundance and assemblage composition in selected UCBN streams?
- Do aquatic macroinvertebrate assemblages sampled within UCBN streams indicate polluted or otherwise impaired water quality?

- Do aquatic macroinvertebrate assemblages sampled within UCBN streams indicate “pristine” or “reference” conditions according to regional criteria established by the (Environmental Protection Agency (EPA) and the states of Idaho, Oregon, Montana, and Washington?

In light of these questions and the broader goals outlined above, water quality monitoring in the UCBN addresses the following specific measurable monitoring objectives:

- Determine status and long term trend in key water quality parameters for selected streams within UCBN park units.
- Determine status and trend in aquatic macroinvertebrate abundance, assemblage composition, and functional feeding group composition in wadeable streams within the UCBN.

Study Area

North Fork Big Hole River- Big Hole National Battlefield (BIHO)

Big Hole National Battlefield is in the North Fork Big Hole River subwatershed, in Hydrologic Unit Code (HUC 12) 100200040509 (United States Geologic Survey [USGS]), Big Hole subbasin (HUC 8) 1002004, in Beaverhead County, Montana (Figures 1 and 2 Appendix B). The drainage area above the park is approximately 241 square km (150 square miles) (NPS 1997). According to Corrao and Erixson 2011, the Big Hole watershed is dominated by the following cover types: closed tree canopy (44%), herbaceous-grassland/shrub-steppe (23%), open tree canopy (17%), and shrubland (15%).

North Fork Big Hole River is classified as an A-1 surface water (Admin. Rules of MT 2015, 17.30.610 [through 5/09/2008]). As such, designated beneficial uses for North Fork Big Hole River include: agricultural, aquatic life, drinking water, and primary contact recreation (MT DEQ 2009, Admin. Rules of MT 2015, 17.30.622 [through 8/08/2014]). In 2006, the North Fork Big Hole River was identified as impaired and was placed on the 303(d) list (MT DEQ 2006). Probable causes of impairment included: “sediment-related listings (siltation, suspended solids, turbidity, bank erosion), metals (cadmium, copper, lead, mercury, and zinc), thermal modification, nutrients, riparian and fish habitat degradation, habitat alteration, habitat modification, channel incisement, and flow alteration (dewatering)” (MT DEQ 2009). Since that time, MT DEQ has developed total maximum daily loads (TMDLs) that address temperature, sediment, nutrients, and metal pollution (see MT DEQ 2009). In 2012 and 2014, North Fork Big Hole River was listed as a category 4A water, meaning that it has a pollution problem, but has total maximum daily loads (TMDL) being actively implemented to reduce pollution (MT DEQ 2012 and MT DEQ 2014). The probable causes of impairment are listed as alteration in stream-side or littoral vegetative covers, low flow alterations, and sedimentation/siltation.

Additional information about water quality in North Fork Big Hole River can be found in Natural Resource Condition Assessment: Big Hole and Bear Paw National Battlefields of the Nez Perce National Historical Park (Corrao and Erixson 2011) and Upper Big Hole River Watershed Assessment Report (BLM 2009).

The continuous water quality data logger (Hydrolab) was deployed within the park, approximately 100 meters upstream from the bridge over the North Fork Big Hole River and 40m west of the lower parking lot. This location was chosen due to logistical considerations and adequate water depth (Figures 1-3 and Appendix A). In addition, the Hydrolab deployment location was chosen to avoid placement of equipment near the culturally significant encampment area. The macroinvertebrate sample reaches coincide with the stream channel characteristics and riparian condition monitoring reaches (see Appendix C for GPS waypoints).



Figure 1. North Fork Big Hole River looking upstream towards water quality monitoring station #01.

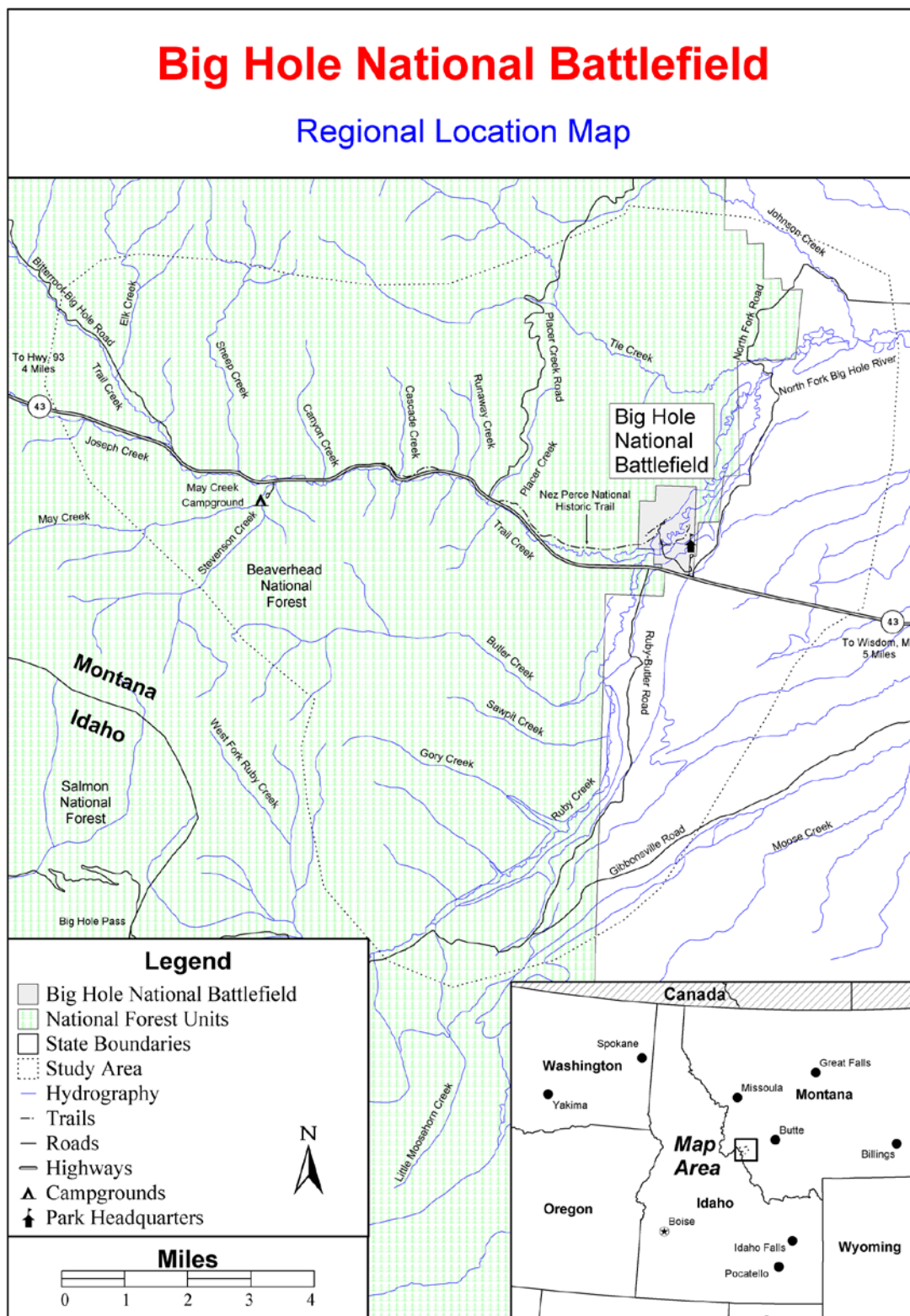


Figure 2. Big Hole National Battlefield regional map (NPS 1997).

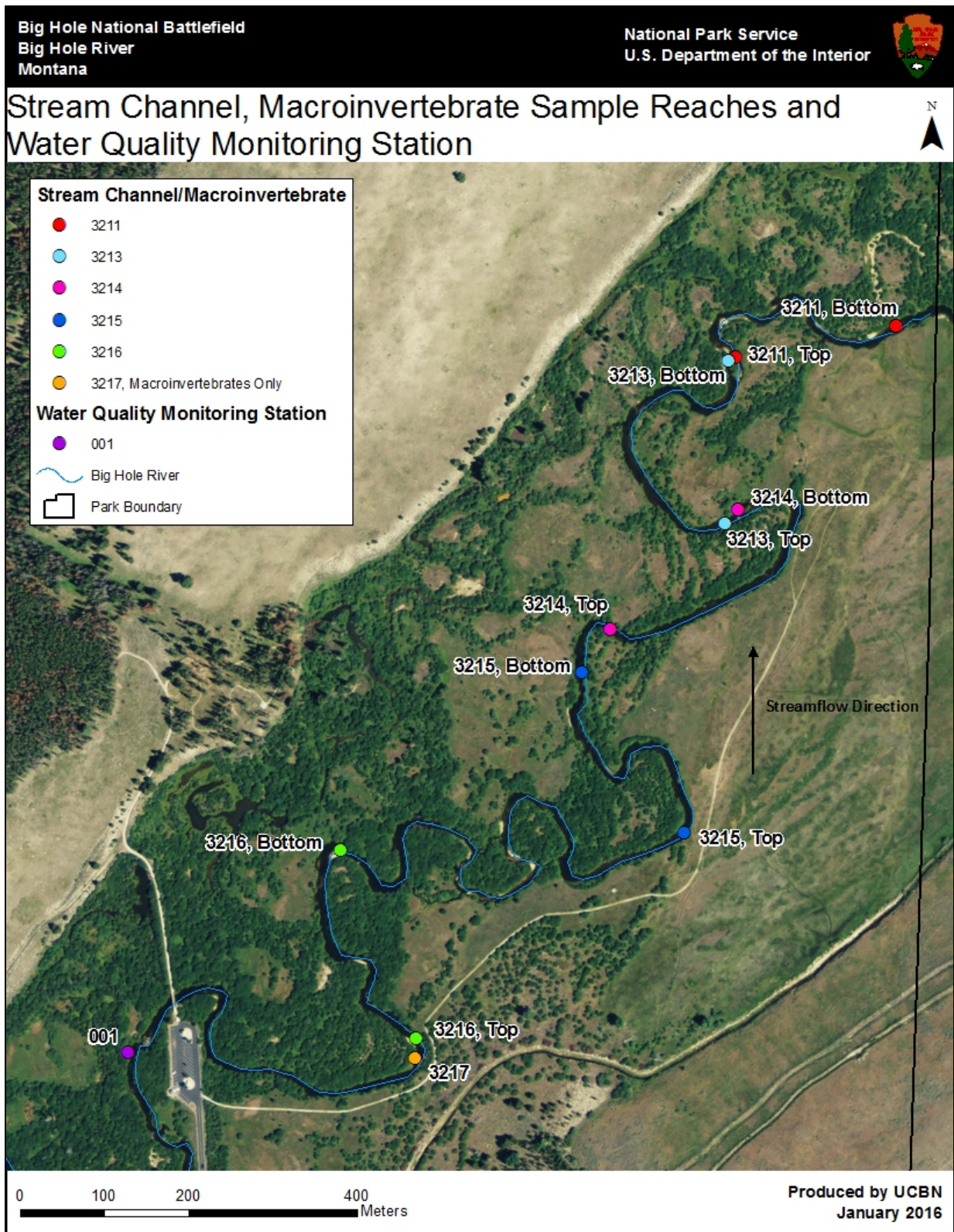


Figure 3. Water quality monitoring location in North Fork Big Hole River 2015. Macroinvertebrate sample locations correspond with UCBN stream channel characteristics and riparian condition monitoring sites 3211-3217.

Methods

Water Chemistry

A continuous water quality monitor (HACH, MS5 Hydrolab) was deployed from June 17th to October 21th in North Fork Big Hole River at an index site to estimate the status, variability, and long-term trends in core parameters. The core parameters measured were water temperature, dissolved oxygen, pH, specific conductance, and turbidity. These core parameters were measured hourly and the instrument serviced monthly throughout the deployment period. Data quality ratings were determined by the degree of sensor drift and other factors discussed in the results section. Any corrections to the data, including outlier removal and drift corrections are documented in AQUARIUS Time-Series software/database. For more information on the UCBN water chemistry sampling design and data quality ratings see Starkey et al. (2016a) and Wagner et al. (2006). The monitor was deployed in the same location as in both 2009 and 2012. This location (station # 01) was relatively representative of conditions in the park, logistically feasible to access, and secure from vandalism and high flows. A cross-section survey was conducted to aid in the determination of Hydrolab site selection. For more information on the UCBN water chemistry sampling design see Starkey et al. (2016a).

During the years the UCBN is not conducting the full suite of monitoring, temperature loggers (HOBO, Pro v2) are deployed in North Fork Big Hole River. Additional water temperature monitoring occurred in 2010, 2011, 2013 and 2014.

Quality Assurance/Quality Control (QA/QC):

Quality assurance and quality control for multiprobe data collection are covered in detail in SOP #10 (Starkey et al. 2016b). Basic procedures adhere to the guidelines established in Part B lite (Irwin 2008); the National Coastal Assessment Quality Assurance Project Plan 2001-2004 (U.S. EPA 2001); the Laboratory Methods Manual-Estuarines, Volume 1: Biological and Physical Analyses (U.S. EPA 1995); and Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et al. 1999).

General quality assurance and quality control methods for UCBN water quality multiprobe calibration and data downloads include the following:

- Representative multiprobe sample locations are determined by using a cross-section and stream segment survey. Each site is re-assessed for representativeness at the start and end each sample year.
- The UCBN follows pre-established maximum acceptable differences for field instrument calibration and QC checks. If the multiprobe readings are outside of the maximum acceptable differences, the multiprobe is removed for non-routine maintenance.
- When calibrating the multiprobe, values of known standard solutions are measured pre and post calibration, to help determine if the instrument's measurements have "drifted." In addition, repeated measures of these solutions are used to determine the repeatability of multiprobe measures.

- All multiprobe data is visually checked for outliers and QC issues immediately following the download of data. QC issues indicated by the data may include: wiper parking, defective sensors, power supply problems, and other anomalies affecting data quality.
- Quantitative and qualitative terms that describe how accurate data need to be in order to meet project objectives are discussed in detail in SOP #10 Starkey et al. (2016b) and Appendix D in this report. NPS WRD lists the following data quality objectives as necessary for water chemistry data: target population, representativeness, completeness, data comparability, measurement sensitivity and detection limits, measurement precision as repeatability, and measurement systematic error/bias.

More detailed QA/QC for water quality multiprobes is contained in SOP #10, Starkey et al. (2016b).

Discharge

No USGS gaging station exists on the North Fork Big Hole River or its tributaries. The closest gage is on the Big Hole River near Wisdom MT (USGS 06024540 Big Hole River bl Mudd Cr nr Wisdom MT) and is marginally useful for determining flow in north fork. As a result, no discharge data or results are presented in this report.

Macroinvertebrates

Macroinvertebrates were collected at 6 designated sample reaches by the United States Forest Service- PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Program during the assessment of stream channel characteristics. This assessment was completed as part of the UCBN stream channel characteristics monitoring protocol. Macroinvertebrates were collected from 8 fast water habitats (riffles, runs) in each sample reach. These 8 samples were combined for a single composite sample per reach. For more information on the PIBO macroinvertebrate sampling design, see Heitke et al. (2008).

Results

North Fork Big Hole River

Water Chemistry

Cross Section Survey:

A cross section survey was conducted at the proposed multiprobe deployment location to evaluate if the site was reasonably representative of stream conditions throughout the park. As suggested by the water resource division the UCBN judges overall representativeness primarily on the basis of specific conductance (Starkey et al. 2016a).

As indicated in Starkey 2013, a series of beaver dams near the confluence of Trail and Ruby Creeks created a pond just upstream of the monitoring station. These dams and associated ponds/discharge persisted in 2015. As a result, a new potential monitoring location was evaluated; however, it was found to be less representative of conditions in the North Fork Big Hole River than the original location (Starkey 2010). For this reason, the monitoring station remained in the same pool as in 2009 and 2012, albeit shifted downstream 3 m to accommodate changes to the stream channel. The 2015 deployment location provided adequate water depth throughout the field season, was easily accessible, and was away from heavily trafficked access points. The following results are focused on the established monitoring station #001.

A one way analysis of variance (ANOVA) test was conducted to evaluate representativeness (R v3.1.2). Results of the ANOVA showed that there was no significant difference for specific conductance among the transects and the deployment location in July $F(4,44)=1.428$, $p > 0.05$, but that there was a significant difference in September $F(4,45)= 7.443$, $p < 0.05$ (Figures 4 and 5).

To determine where the difference in representativeness occurred, a post hoc Tukey's test was conducted (R v3.1.2). Relative to specific conductance, results of the Tukey's test for the cross section conducted in September indicates that the deployment location was significantly different from transect 4 (Figure 5).

Both cross section surveys indicate that the current monitoring station is relatively representative of downstream conditions. For this reason, it is advisable to maintain the monitoring station in its current location. Future cross section surveys should continue because they offer interesting insight into stream flow and water quality dynamics that might not otherwise be apparent.

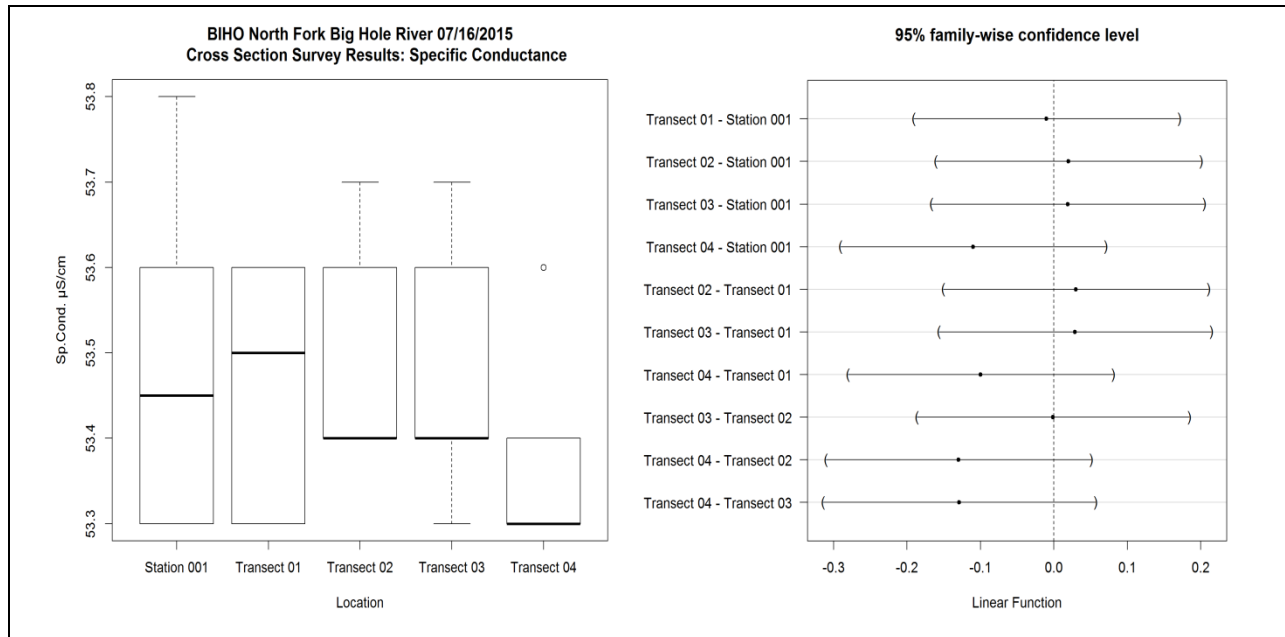


Figure 4. July 2015 cross section survey of North Fork Big Hole River, box plot of specific conductance and plot of 95% family-wise confidence level. Note that “Station 01” is the location of multiprobe deployment and transects progress downstream (1-4).

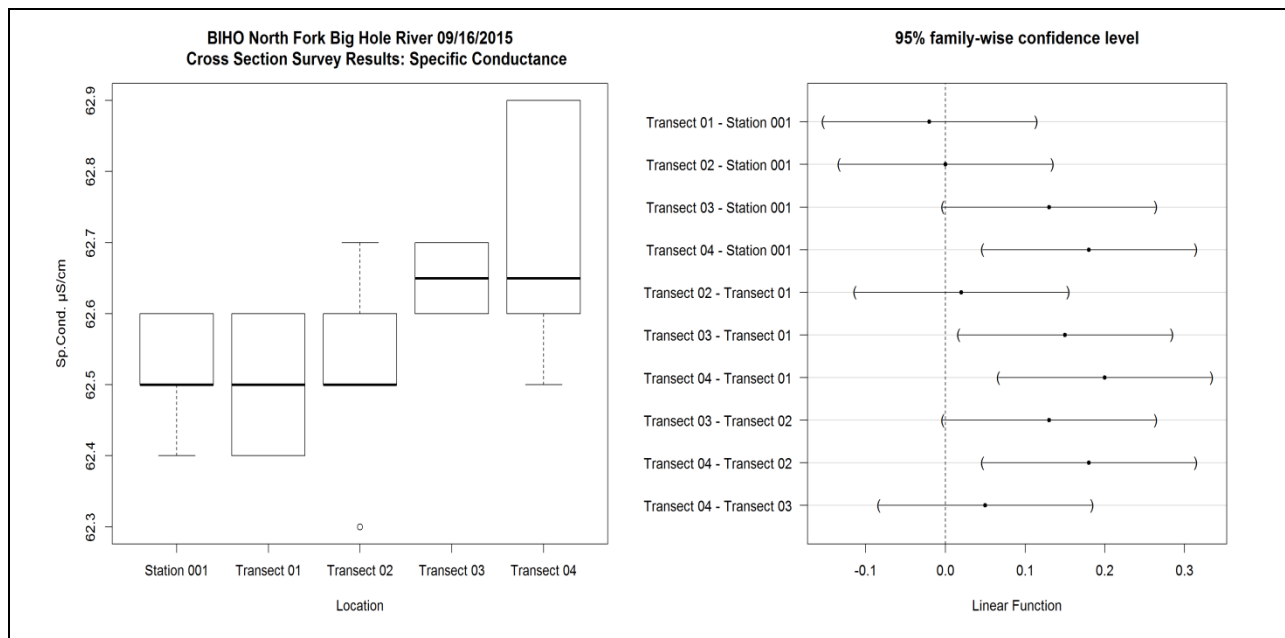


Figure 5. September 2014 cross section survey of North Fork Big Hole River, box plot of specific conductance and plot of 95% family-wise confidence level. Note that “Station 01” is the location of multiprobe deployment and transects progress downstream (1-4).

Status:

Condition of core water quality parameters (2015) along with the corresponding Montana DEQ regulatory threshold are given in Table 1. For comparison, the condition of core water quality parameters as observed in 2012 are given in Table 2 and Figure 6. The primary concerns are low dissolved oxygen concentrations and elevated water temperatures and their effects on native cold water biota. Each parameter is discussed in further detail below.

Table 1. Vital sign summary table for water chemistry in North Fork Big Hole River June-October, 2015.

Measure	Current Condition (June-October, 2015)	State DEQ Thresholds ^a	% Exceedance ^b
Temperature (MDMT ^c , MDAT ^d)	MDMT ^c = 19.59 °C MDAT ^d = 17.57 °C	"A 1 °F [0.56 °C] maximum increase above naturally occurring water temperature is allowed"	--
		<18 °C threshold to protect against stress or lethal conditions for arctic grayling ^e	3.57%
Specific conductance (mean)	58.80 µS/cm	N/A	N/A
Dissolved oxygen (mean daily min)	6.91 mg/l	Daily minimum > 8.0 mg/L; 7-d mean > 9.5 mg/L (Early life stage- applicable 16 July to 30 Sept.)	96% 100%
		1-day minimum >4.0 mg/L; 7-d mean minimum > 5.0 mg/L; 30 day mean >6.5 mg/L (Other life stages applicable to data collected 17 June to 15 July and 1 Oct. to 21 Oct.)	0% 0% 0%
pH (mean daily max)	7.34 pH Units	6.5-8.5; < 0.5 unit human induced change; Maintain >7.0 if naturally > 7.0	0%
pH (mean daily min)	7.13 pH Units		0%
Turbidity (mean daily max)	7.07 NTU ^d	"No increase above natural turbidity is allowed"	--

^a MT DEQ water quality standards for North Fork Big Hole River planning area

^b Proportion of samples above water quality standard (Note that the % exceedance indicated is based on 24 hours of data). Exceedance values 0% - 5% indicates good water quality (also highlighted in green), 5% - 25% indicates fair water quality (also highlighted in yellow), and > 25% indicates poor water quality (also highlighted in red).

^c MDMT – Maximum Daily Maximum Temperature

^d MDAT – Maximum Daily Average Temperature

Table 2. Vital sign summary table for water chemistry in North Fork Big Hole River June-October, 2012.

Measure	Current Condition (June-October, 2015)	State DEQ Thresholds ^a	% Exceedance ^b
Temperature (MDMT ^c , MDAT ^d)	MDMT ^c = 8.78 °C MDAT ^d = 17.24 °C	"A 1 °F [0.56 °C] maximum increase above naturally occurring water temperature is allowed"	--
		<18 °C threshold to protect against stress or lethal conditions for arctic grayling ^b	1.2%
Specific conductance (mean)	57.8 µS/cm	N/A	N/A
Dissolved oxygen (mean daily min)	6.38 mg/l	Daily minimum > 8.0 mg/L; 7-d mean > 9.5 mg/L (Early life stage- applicable 16 July to 30 Sept.)	100% 100%
		1-day minimum >4.0 mg/L; 7-d mean minimum > 5.0 mg/L; 30 day mean >6.5 mg/L (Other life stages applicable to data collected 20 June to 15 July and 1 Oct. to 17 Oct.)	0% 0% 0%
pH (mean daily max)	7.30 pH Units	6.5-8.5; < 0.5 unit human induced change; Maintain >7.0 if naturally > 7.0	0%
pH (mean daily min)	7.15 pH Units		0%
Turbidity (mean daily max)	2.46NTU ^d	"No increase above natural turbidity is allowed"	--

^a MT DEQ water quality standards for North Fork Big Hole River planning area

^b Proportion of samples above water quality standard (Note that the % exceedance indicated is based on 24 hours of data). Exceedance values 0% - 5% indicates good water quality (also highlighted in green), 5% - 25% indicates fair water quality (also highlighted in yellow), and > 25% indicates poor water quality (also highlighted in red).

^c MDMT – Maximum Daily Maximum Temperature

^d MDAT – Maximum Daily Average Temperature

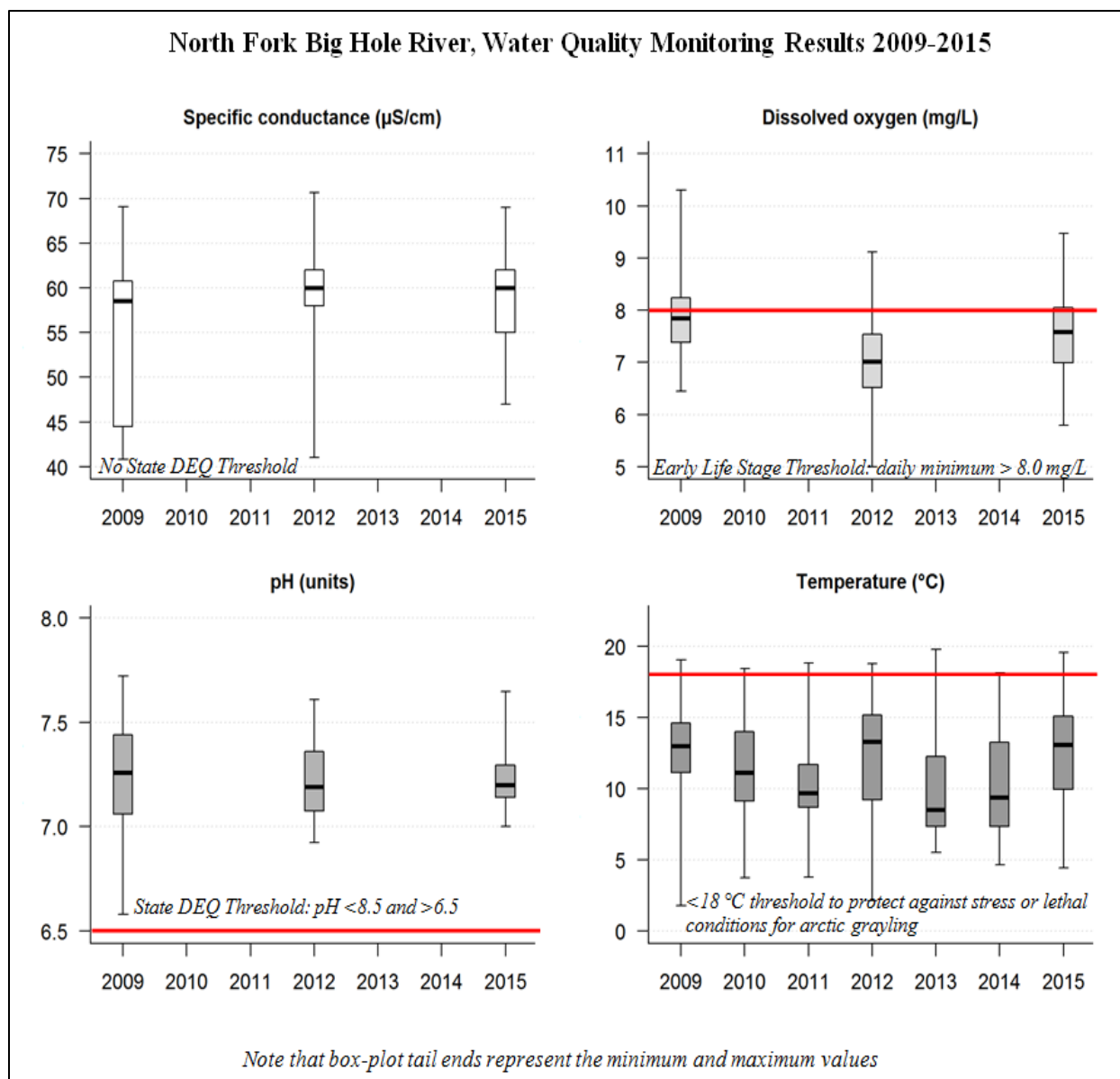


Figure 6. North Fork Big Hole River, water quality monitoring results box-plot 2009-2015. The red line indicates the state threshold shown in italics.

Temperature:

In 2015, the maximum daily maximum temperature (MDMT) was 19.59 $^{\circ}\text{C}$ and the maximum daily average temperature (MDAT) was 17.57 $^{\circ}\text{C}$. The 18 $^{\circ}\text{C}$ threshold to protect against stress or lethal conditions for arctic grayling (see MT DEQ 2009) was exceeded in 3.57% of observations. Data from 2015 is consistent with that collected during water temperature monitoring 2009-2014 (Table 3).

Figure 7 shows the daily maximum and mean daily temperatures in North Fork Big Hole River from June-October 2015. Table 4 lists the data rating/grade for each deployment period (monthly interval). These standard USGS ratings are based on the degree of sensor fouling and drift encountered during

each deployment period (Wagner et al. 2006; Starkey et al. 2016b). Data ratings less than “excellent” were due to a combination of sensor fouling and effect of environmental change during evaluation of fouling.

Table 3. Water temperature summary table for North Fork Big Hole River 2009-2015.

Monitoring Dates	MDMT °C ^a	MDAT °C ^b
06/17/2015-10/21/2015 ^c	19.59	17.57
06/22/2014-10/22/2014 ^d	18.15	16.25
06/01/2013-10/03/2013 ^d	19.81	17.98
06/20/2012-10/16/2012 ^c	18.78	17.24
11/01/2010-10/03/2011 ^d	18.84	15.34
05/28/2010-10/20/2010 ^d	18.46	16.29
06/22/2009-10/06/2009 ^c	19.06	17.10

^a MDMT – Maximum Daily Maximum Temperature

^b MDAT – Maximum Daily Average Temperature

^c Collected with Hydrolab,

^d Collected with HOBO Pro v2.0 temperature logger, MDMT – Maximum Daily Maximum Temperature, MDAT – Maximum Daily Average Temperature

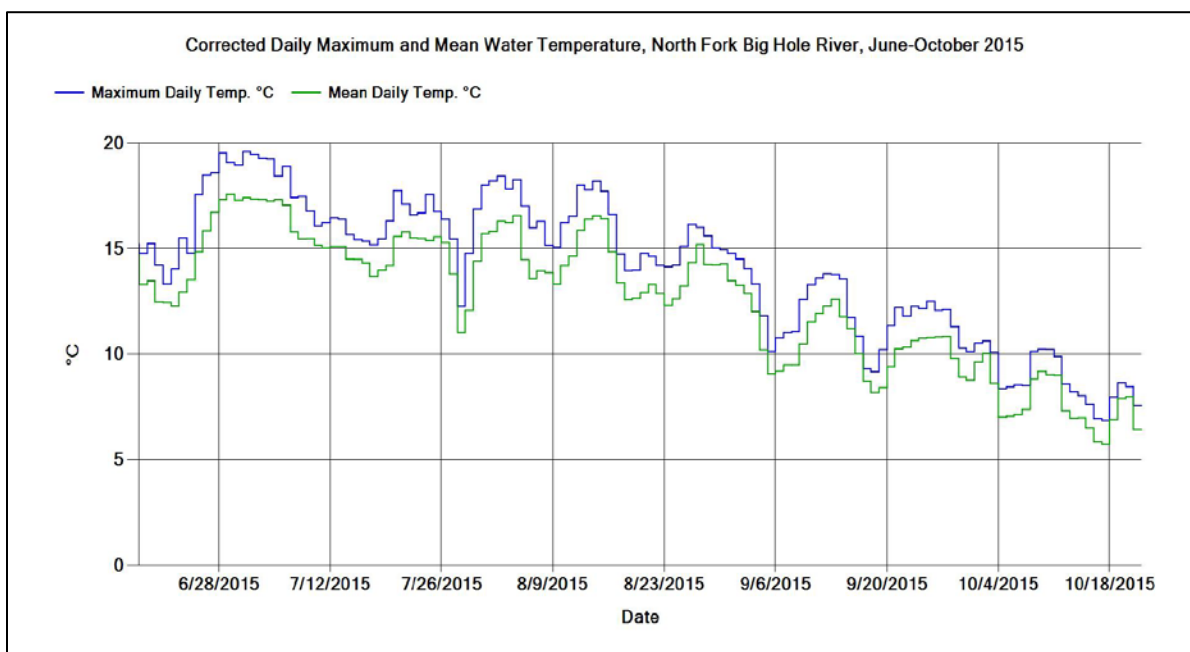


Figure 7. Daily maximum and mean water temperature in North Fork Big Hole River, BIHO, 2015.

While 18 °C is not a state regulatory threshold, the park has opted to use it as a benchmark to gauge resource condition and because “this temperature has the potential to physiologically impact [fluvial arctic] grayling (*Thymallus arcticus*) in a short time frame” and temperatures <18 °C “protect against extreme physiological stress or lethal conditions” (MT DEQ 2009).

“Arctic grayling is a freshwater fish in the same family (Salmonidae) as salmon, trout, and whitefish. A distinctive morphological characteristic of this fish is its large, sail-like dorsal fin. Arctic grayling is an obligate cool- or cold-water species. Individual fish can range widely, moving tens of miles on a seasonal or annual basis between spawning, rearing, and sheltering habitats”

(<http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=E03Q> Accessed 12/08/2015). While the most recent observations of grayling in the North Fork Big Hole River are near its confluence with the Big Hole River, BIHO would like to maintain favorable temperatures for this species (Rens and Magee 2007, Magee and McCullough 2008, Cayer et al. 2010, USFWS 2010). Arctic grayling populations in Montana are currently considered a candidate for listing as an endangered species (see USFWS 2010 and http://ecos.fws.gov/docs/candidate/assessments/2013/r6/E03Q_V01.pdf Accessed 12/08/2015). However, listing has been precluded due the need to complete other listing priorities.

Table 4. Data grade/rating for water temperature each deployment period June-October 2015 in North Fork Big Hole River, BIHO.

Temperature Data Grade/Rating	From UTC-06:00	To UTC-06:00
EXCELLENT	06/17/2015 16:00	07/16/2015 08:00
EXCELLENT	07/16/2015 18:00	08/19/2015 08:00
GOOD	08/19/2015 11:00	09/16/2015 08:00
GOOD	09/16/2015 15:00	10/21/2015 09:00

Additional implications of elevated water temperatures may include decreased salmonid recruitment, decreased salmonid health, and potential shifts in fish and benthic macroinvertebrate communities (Vannote and Sweeney 1980; McCullough 1999). It is also important to note that elevated water temperatures have the capacity to reduce the total concentration of dissolved oxygen (i.e., there is an inverse relationship between water temperature and dissolved oxygen; Figure 9), thereby impacting aquatic biota.

Maintaining water temperatures suitable for naturally occurring species will depend on riparian, stream channel, and stream-flow conditions basin-wide. For this reason cooperation with other agencies, stakeholders, and adjacent landowners will be critical for improving water temperature.

For additional details about TMDLs specific to water temperature, see MT DEQ 2009.

Specific Conductance:

Specific conductance ranged from 47.0 to 69.0 $\mu\text{S}/\text{cm}$, with an average specific conductance of 58.8 $\mu\text{S}/\text{cm}$. The steady increase in specific conductance shown in Figure 8 reflects decreased surface flow and subsequent drop in water level associated with evaporation throughout the summer. Table 5 shows the data rating/grade for each deployment period (monthly interval). These standard USGS ratings are based on the degree of sensor fouling and drift encountered during each deployment period (Wagner et al. 2006; Starkey et al. 2016b).

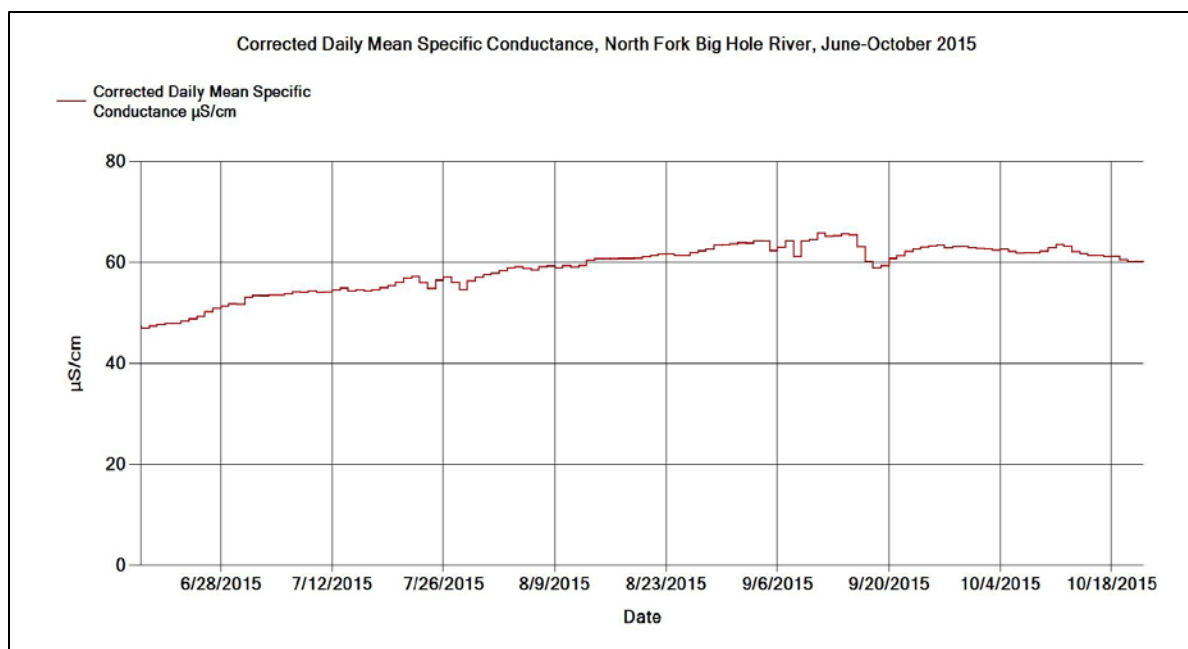


Figure 8. Corrected daily mean specific conductance North Fork Big Hole River, BIHO, 2015.

Table 5. Data grade/rating for specific conductance each deployment period June-October 2015 in North Fork Big Hole River, BIHO.

Specific Conductance Data Grade/Rating	From UTC-06:00	To UTC-06:00
EXCELLENT	06/17/2015 16:00	07/16/2015 08:00
EXCELLENT	07/16/2015 18:00	08/19/2015 08:00
EXCELLENT	08/19/2015 11:00	09/16/2015 08:00
EXCELLENT	09/16/2015 15:00	10/21/2015 09:00

Dissolved Oxygen:

Prior to discussion about dissolved oxygen (DO) monitoring results, it is important to understand what and when DO standards are applicable to the North Fork Big Hole River. Upon review of Montana water quality standards as stated in MT DEQ 2009 and 2010 “early life stage” and “other life stage” DO standards dictated by fish spawning times (Table 6a and Table 6b) are applicable to data collected at BIHO. The “early life stage” standard (daily minimum > 8.0 mg/L and 7-day mean > 9.5 mg/L) is applicable 16 July to 30 September. The “other life stage” standard (daily minimum > 4.0 mg/L, 7-day mean minimum > 5.0 mg/L, 30-day mean > 6.5 mg/L) is applicable to data collected 17 June to 15 July and 1 October to 21 October.

In 2015, mean daily minimum dissolved oxygen was 6.91 mg/L and dipped below the “early life stage” threshold of “daily minimum > 8.0 mg/L” during 96% of observations. In addition, dissolved oxygen was below the “early life stage” threshold of “7-day mean > 9.5 mg/L” during 100% of observations between July 16th and September 30th. No “other life stage” exceedances occurred.

Table 6a. Spawning times of fishes that may occur in the North Fork Big Hole River within BIHO. ^a

Species	Month Increment ^b																							
	J1	J2	F1	F2	M1	M2	A1	A2	M1	M2	J1 ^c	J2 ^c	J1 ^c	J2 ^c	A1 ^c	A2 ^c	S1 ^c	S2 ^c	O1 ^c	O2 ^c	N1	N2	D1	D2
Mountain whitefish	I	I	I	I	I	I	--	--	--	--	--	--	--	--	--	--	--	S	S	S	S	S	I	I
Rainbow trout	--	--	--	--	S	S	S	S	S	S	S	S	I	I	E	--	--	--	--	--	--	--	--	--
Brook trout	I	I	I	I	E	E	E	E	E	--	--	--	--	--	--	--	S	S	S	S	I	I	I	I
Arctic grayling	--	--	--	--	--	--	--	S	S	S	S	S	SI	--	--	--	--	--	--	--	--	--	--	--
Longnose dace	--	--	--	--	--	--	--	--	S	S	S	S	S	S	S	--	--	--	--	--	--	--	--	--
Longnose sucker	--	--	--	--	--	S	S	S	S	S	S	S	S	--	--	--	--	--	--	--	--	--	--	--
White sucker	--	--	--	--	--	--	S	S	S	S	S	S	--	--	--	--	--	--	--	--	--	--	--	--
Burbot	--	--	S	S	S	S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mottled sculpin	--	--	--	--	--	--	--	--	S	S	S	S	--	--	--	--	--	--	--	--	--	--	--	--

Table 6b. Dissolved oxygen standards for early and other life stages that may occur in the North Fork Big Hole River within BIHO. ^a

Applicable DO standard ^d	Month Increment ^b																							
	J1	J2	F1	F2	M1	M2	A1	A2	M1	M2	J1 ^c	J2 ^c	J1 ^c	J2 ^c	A1 ^c	A2 ^c	S1 ^c	S2 ^c	O1 ^c	O2 ^c	N1	N2	D1	D2
Early Life Stage	--	--	--	--	--	--	X	X	X	--			X	X	X	X	X	X	--	--	--	--	--	--
Other Life Stage	X	X	X	X	X	X	--	--	--	X	X	X	--	--	--	--	--	--	X	X	X	X	X	X

^a This table helps identify periods when “early life stages” of fish may be present. The EPA definition of “early life stage” for salmonids is 30 days after emergence/swim-up; for all other species it is 34 days after spawning. This information is necessary when applying the dissolved oxygen standard to the North Fork Big Hole River.

^b The code for the table is as follows: J1,J2, F1, F2 refer to the half month increments of January 1-15, January 16-31, February 1-14, February 15-29, and so on. In the table S=spawning period, I = incubation period for eggs of salmonids, E=time period in which salmonid sac-fry are in the gravels.

^c Dark gray shading indicates timing of UCBN integrated water quality monitoring. This table has been adapted from the original, which can be found at www.deq.mt.gov/wqinfo/Standards/PDF/SpawningTimesFWP.pdf (Accessed 12/10/2015).

^d The applicable DO standard is based on the stated and assumed presence of “early life stage” fish (30 or 34 days after spawning).

Low dissolved oxygen levels in North Fork Big Hole River may be having an impact on cold water fish development (early life stages) and recruitment. Maintaining dissolved oxygen levels suitable for cold water biota will depend on upland, riparian, stream channel, and stream-flow conditions basin-wide. For this reason cooperation with other agencies, stakeholders, and adjacent landowners will be critical for improving dissolved oxygen.

As expected, minimum dissolved oxygen levels generally corresponded to maximum water temperatures. Figure 9 shows the daily minimum dissolved oxygen and maximum temperatures in North Fork Big Hole River from June-October 2015. Table 7 shows the data rating/grade for each deployment period (monthly interval). These standard USGS ratings are based on the degree of sensor fouling and drift encountered during each deployment period (Wagner et al. 2006; Starkey et al. 2016b). Data grades of “good” were due to a combination of fouling and sensor drift.

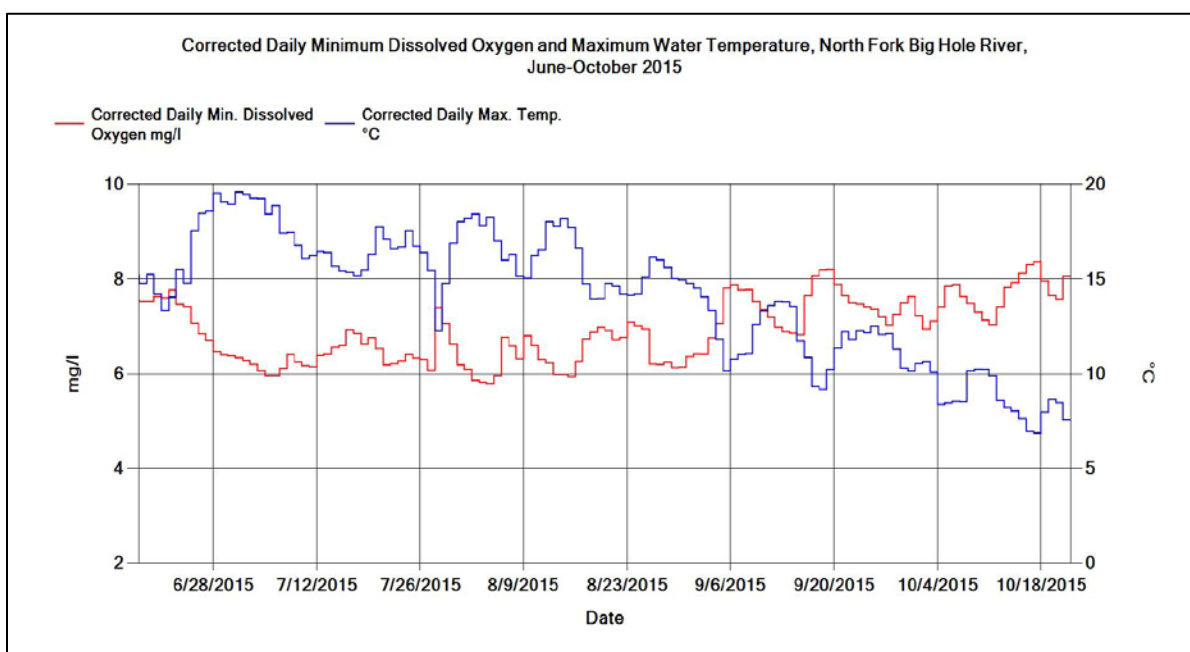


Figure 9. Corrected daily minimum dissolved oxygen and daily maximum temperature in North Fork Big Hole River, BIHO, 2015.

Table 7. Data grade/rating for dissolved oxygen each deployment period June-October 2015 in North Fork Big Hole River, BIHO.

Dissolved Oxygen Data Grade/Rating	From UTC-06:00	To UTC-06:00
EXCELLENT	06/17/2015 16:00	07/16/2015 08:00
EXCELLENT	07/16/2015 18:00	08/19/2015 08:00
GOOD	08/19/2015 11:00	09/16/2015 08:00
GOOD	09/16/2015 15:00	10/21/2015 09:00

pH:

The minimum and maximum pH (7.0 and 7.7, respectively) were never outside the acceptable regulatory thresholds of 6.5-8.5 pH units and the median (7.2 pH units) was well within this range. Figure 10 shows the daily maximum, minimum, and median pH in North Fork Big Hole River from June-October 2015. Table 8 shows the data rating/grade for each deployment period (monthly interval). These standard USGS ratings are based on the degree of sensor fouling and drift encountered during each deployment period (Wagner et al. 2006; Starkey et al. 2016b). Data grades less than “excellent” were due to a combination of sensor fouling and drift.

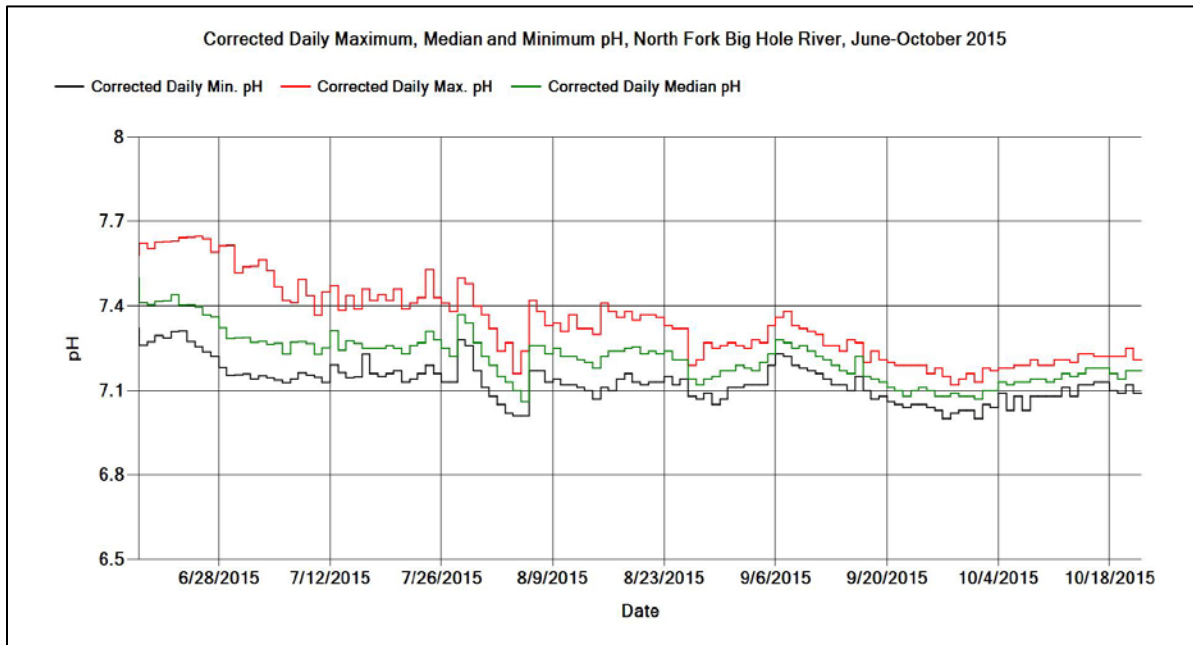


Figure 10. Corrected daily maximum, minimum, and median pH in North Fork Big Hole River, BIHO, 2015.

Table 8. Data grade/rating for pH each deployment period June-October 2015 in North Fork Big Hole River, BIHO.

pH Data Grade/Rating	From UTC-06:00	To UTC-06:00
GOOD	06/17/2015 16:00	07/16/2015 08:00
EXCELLENT	07/16/2015 18:00	08/19/2015 08:00
GOOD	08/19/2015 11:00	09/16/2015 08:00
EXCELLENT	09/16/2015 15:00	10/21/2015 09:00

Turbidity:

Prior to discussion about turbidity in North Fork Big Hole River, it should be noted that conclusions based on this data are limited due to unusable data quality 6/17/2015 to 8/19/2015 (Table 9). Sensor fouling due to sediment and sensor drift were the primary factors influencing data quality. It is

important to note that the method detection limit (MDL) for the turbidity sensor on Hydrolab 095 was 0.5 NTU and the minimum level of quantitation (ML) was 1.59 NTU (Appendix D). Figure 11 shows the corrected daily mean turbidity in North Fork Big Hole River from June-October 2015. Note that data graded “unusable” has been omitted from the graph.

Table 9. Data grade/rating for turbidity each deployment period June-October 2015 in North Fork Big Hole River, BIHO.

pH Data Grade/Rating	From UTC-06:00	To UTC-06:00
UNUSABLE	06/17/2015 16:00	07/16/2015 08:00
UNUSABLE	07/16/2015 18:00	08/19/2015 08:00
GOOD	08/19/2015 11:00	09/16/2015 08:00
GOOD	09/16/2015 15:00	10/21/2015 09:00

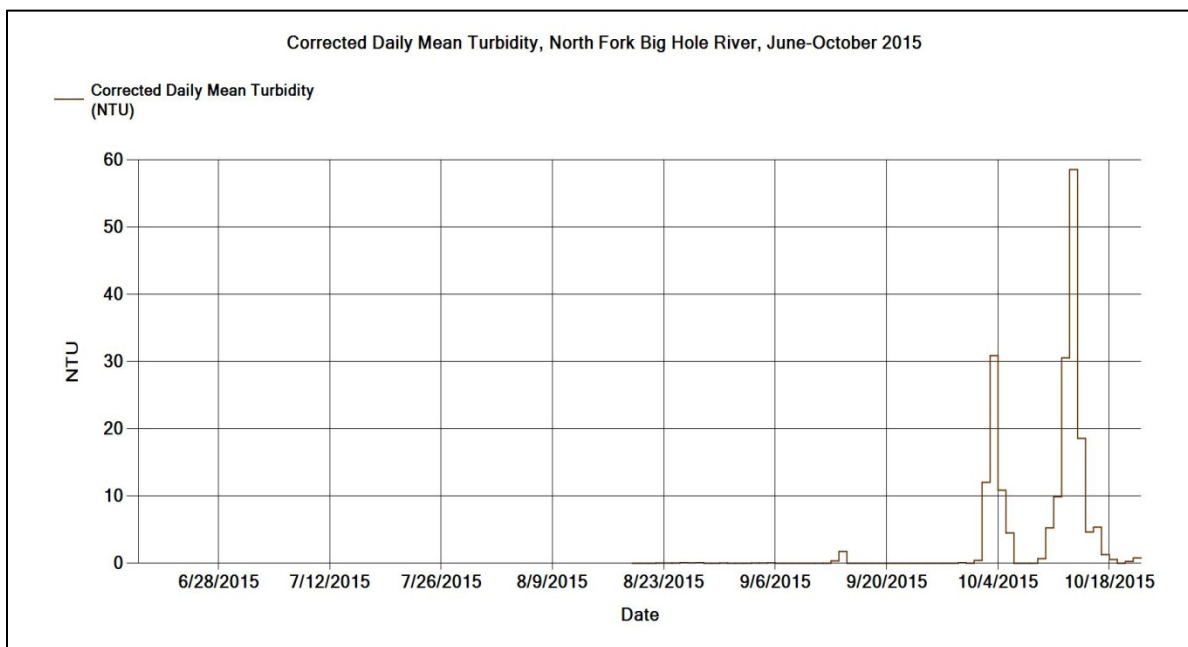


Figure 11. Corrected daily mean turbidity in North Fork Big Hole River, BIHO, 2015.

Data indicates that turbidity ranged from <0.5 to 86.4 NTU, with the most pronounced spikes in turbidity occurring during deployments with “good” data quality. However, due to less than desirable data quality and lack of historic data for this site the UCBN is unable to determine if conditions exceeded the state standard. Regulatory thresholds for turbidity state that “no increase above natural turbidity is allowed”. Although conclusions are limited based on the quality of data collected in 2015 it is likely that North Fork Big Hole River does experience pulses of turbidity in part due to historic/current land use within the Trail and Ruby Creek drainages. Turbidity levels are tied to sediment and erosion issues, both of which have established TMDLs (MT DEQ 2006 and 2009).

Macroinvertebrates

Status:

The Hilsenhoff Biotic Index (HBI), which summarizes pollution tolerances of the macroinvertebrate taxa within the sample, ranged from 2.33 to 3.67 and the mean HBI was 2.93. Values indicate that on average, water quality is excellent with “organic pollution unlikely” (Hilsenhoff 1988). HBI values generally increase (HBI ranges from 0.0 to 10.0) as nutrient enrichment increases. While HBI is most sensitive to organic pollution, it may also respond to sediment loading, low dissolved oxygen and elevated water temperatures. Note that the mean HBI value from monitoring conducted in 2012 (3.07) also indicated excellent water quality with “organic pollution unlikely” (Starkey 2013).

The mean US Forest Service (USFS) community tolerance quotient was 66 and ranged from 62 to 71. Community tolerance quotient values vary from 20 to just over 100, with lower values indicating better water quality. The observed-to-expected ratio (OE) or River Invertebrate Prediction and Classification System (RIVPACS) score ranged from 0.41 to 0.65 and indicated poorer quality habitat. Note that a condition of poor indicates additional sampling should be conducted prior to designating the site “impaired.” Although observed-to-expected ratio results were lower than anticipated, Bollman and Bowman (2008) reported that for the Middle Rockies ecoregion as many as 40% of the evaluated streams were impaired and that sedimentation and temperature may be causative factors. See Table 10 and Appendix E for additional summary metrics.

In a single sample reach, the maximum number of Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa was 15; and there were a maximum of 6 long lived taxa. In 3 samples, the dominate family was Chironomidae (non-biting midges). In the remaining 3 samples, the dominate family was Brachycentridae (humpless case maker caddisflies).

As in 2012, these data along with the tolerance indices listed above suggest that macroinvertebrate assemblage in the North Fork Big Hole River may be suboptimal. Suboptimal does not necessarily imply “impaired” but rather indicates cause for some concern and continued monitoring. Elevated water temperatures, sedimentation, or other factors may be contributing to these results.

Table 10. Vital sign summary table for benthic macroinvertebrates in North Fork Big Hole River, 2015. ^a

Parameter	PIBO Abbreviation ^b	PIBO Station (Sample ID)					
		3211 (155505)	3213 (155506)	3214 (155507)	3215 (155508)	3216 (155509)	3217 (155510)
Richness ^c	RICH	21	24	16	23	26	26
Shannon's Diversity ^c	SHDIVER	2.01	2.24	1.83	2.23	2.73	2.52
Simpson's Diversity ^c	SIDIVER	0.77	0.82	0.73	0.81	0.92	0.89
Evenness ^c	Evenness	0.66	0.70	0.66	0.71	0.84	0.77
# of EPT Taxa ^c	EPTT	12	16	10	15	14	15
Dominant Family	DFAMILY	Chironomidae	Brachycentridae	Brachycentridae	Chironomidae	Chironomidae	Brachycentridae
Dominant Taxa	dtaxonomy	Orthocladiinae	Brachycentrus americanus	Brachycentrus occidentalis	Orthocladiinae	Orthocladiinae	Brachycentrus occidentalis
Hilsenhoff Biotic Index ^c	tv1	3.67	2.62	2.33	3.65	2.68	2.63
# of Intolerant Taxa ^c	HBIINT1	7	9	8	9	9	9
# of Tolerant Taxa ^c	HBITOL1	0	0	0	1	1	0
USFS Community Tolerance Quotient (d) ^c	ctqd	70	66	66	65	71	62
# of shredder taxa ^c	sht	3	3	3	3	3	3
# of scraper taxa ^c	sct	1	1	2	1	3	3
# of collector-filterer taxa ^c	cft	4	2	2	2	3	2
# of collector-gatherer taxa ^c	cgt	6	9	5	9	9	8
# of predator taxa ^c	prt	3	5	1	4	4	6
# of clinger taxa ^c	clinger	10	10	7	10	8	12
Long-lived Taxa ^c	LLTaxa	6	5	4	6	4	5
RIVPACS	--	0.47	0.47	0.41	0.47	0.49	0.65

^a The entire macroinvertebrate taxa and metrics lists can be found in Appendix E and F.

^b The abbreviations are those found in the PIBO MS-Access database.

^c Standardized to operational taxonomic units (OTU) and fixed count

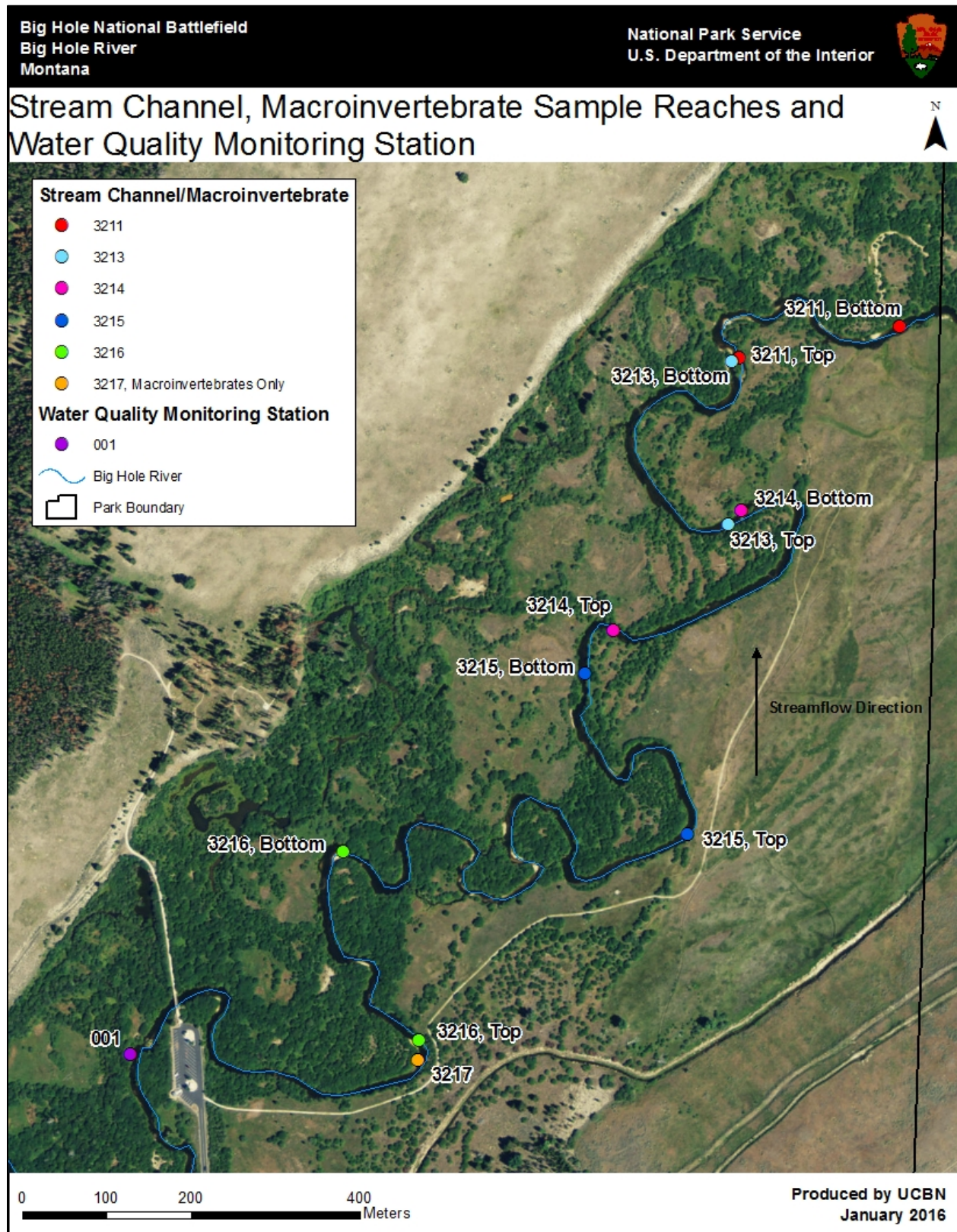
Literature Cited

- Administrative Rules of Montana. 2015. Environmental quality-water quality, Surface water quality standards and procedures. 17.30.601-17.30.670. Montana Department of Environmental Quality, Helena, MT. (<http://www.mtrules.org/gateway/Subchapterhome.asp?scn=17.30.6>). Accessed 04 December 2015.
- Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency.
- Bollman, W. A. and J. A. Bowman. 2008. An assessment of the ecological conditions of the streams and rivers of Montana using the Environmental Monitoring and Assessment Program (EMAP) Method. Montana Department of Environmental Quality. Helena, MT.
- Bureau of Land Management (BLM). 2009. Upper Big Hole River watershed assessment report. Dillon, MT.
- Cayer, E., A. McCullough, J. Magee. 2010. Candidate conservation agreement with assurances for fluvial arctic grayling in the Upper Big Hole River- 2010 annual report. Montana Fish, Wildlife and Parks. Dillon, MT. (<http://fwp.mt.gov/fwpDoc.html?id=49817>). Accessed 11 December 2015.
- Corrao, M. V. and J.A. Erixson. 2011. Natural resource condition assessment: Big Hole National Battlefield. Natural Resource Report NPS/UCBN/NRR-2011/471. National Park Service, Fort Collins, CO.
- Garrett, L. K., T. J. Rodhouse, G. H. Dicus, C. C. Caudill, and M. R. Shardlow. 2007. Vitals Signs Monitoring Plan, Upper Columbia Basin Network. Natural Resource Report NPS/PWR/UCBN/NRR—2007/002. National Park Service, Fort Collins, CO.
- Heitke, J. D., E. J. Archer, D. D. Dugaw, B. A. Bouwes, E. A. Archer, R. C. Henderson, J. L. Kershner. 2008. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. PACFISH/INFISH- Biological Opinion Effectiveness Monitoring Program (PIBO-EM). Logan, UT.
- Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist **20**:31-39.
- Hilsenhoff, W. L. 1988. Rapid field assessment of organic pollution with a family-level biotic index. Journal of the North American Benthological Society. **7**:65-68.
- Irwin, R. J. 2008. Draft Part B lite QA/QC review checklist for aquatic vital sign monitoring protocols and SOPs, National Park Service, Water Resources Division. Fort Collins, CO. (<http://www.nature.nps.gov/water/vitalsigns/assets/docs/PartBLite.pdf>). Accessed 11 December 2015.

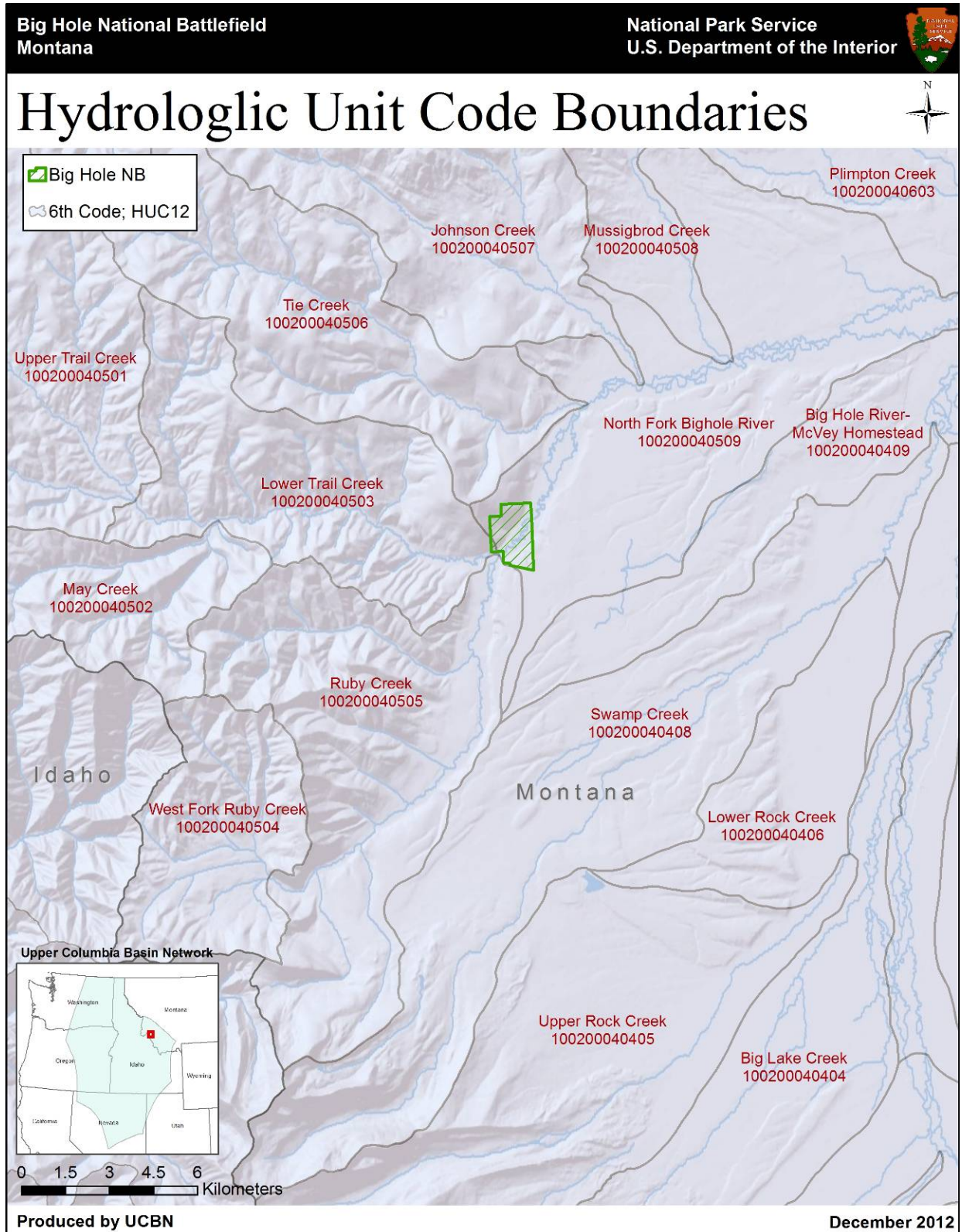
- Montana Department of Environmental Quality (DEQ). 2006. 2006 Integrated 303(d)/305(b) water quality report for Montana. Helena, MT.
- Montana Department of Environmental Quality (DEQ). 2009. Upper and North Fork Big Hole River planning area TMDLs and framework water quality restoration approach. MO3-TMDL-01A. Helena, MT.
- Montana Department of Environmental Quality (DEQ). 2010. Circular DEQ-7, Montana numerical water quality standards. Helena, MT.
- Montana Department of Environmental Quality (DEQ). 2012. Montana 2012 final water quality integrated report. Helena, MT.
- Montana Department of Environmental Quality (DEQ). 2014. Montana 2014 final water quality integrated report. Helena, MT.
- McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to chinook salmon. EPA 910-R-99-010. U.S. Environmental Protection Agency, Washington, DC.
- National Park Service (NPS) 1997. Baseline water quality data inventory and analysis: Big Hole National Battlefield and Bear Paw Battlefield. NPS/NRWRD/NRTR-97/115. Fort Collins, CO.
- National Park Service (NPS). 1999. Natural resource challenge: the National Park Service's action plan for preserving natural resources. US Department of the Interior National Park Service, Washington D.C.
- National Park Service (NPS). 2000. Strategic plan FY 2001-2005. NPS D-1383. US Department of the Interior National Park Service, Washington D.C.
- Rens, E. and Magee J. 2007. Arctic grayling recovery program- Montana arctic grayling monitoring report 2006. Montana Fish, Wildlife and Parks. Dillon, MT.
(<http://fwp.mt.gov/fwDoc.html?id=28962>). Accessed 11 December 2015.
- Starkey, E. N. 2010. Upper Columbia Basin Network integrated water quality annual report 2009: Big Hole National Battlefield (BIHO). Natural Resource Technical Report NPS/UCBN/NRTR—2010/291. National Park Service, Fort Collins, CO.
(<https://irma.nps.gov/App/Reference/Profile/664164>). Accessed 11 December 2015.
- Starkey, E. N. 2013. Upper Columbia Basin Network integrated water quality annual report 2012: Big Hole National Battlefield (BIHO). Natural Resource Technical Report NPS/UCBN/NRTR—2013/808. National Park Service, Fort Collins, CO.
(<https://irma.nps.gov/App/Reference/Profile/2204066>). Accessed 11 December 2015.

- Starkey, E. N., L. K. Garrett, T. J. Rodhouse, G. H. Dicus, and R. K. Steinhorst. 2008. Upper Columbia Basin Network integrated water quality monitoring protocol: Narrative version 1.0. Natural Resource Report NPS/UCBN/NRR—2008/026. National Park Service, Fort Collins, CO. (<https://irma.nps.gov/App/Reference/Profile/662633>). Accessed 11 December 2015.
- Starkey, E. N., G. H. Dicus, L. K. Garrett, M. K. Lonneker, T. J. Rodhouse, K. R. Sherrill, and R. K. Steinhorst. 2016a. Upper Columbia Basin Network integrated water quality monitoring protocol: Narrative version 1.9. Natural Resource Report NPS/UCBN/NRR—2016/1231. National Park Service, Fort Collins, Colorado.
- Starkey, E. N., G. H. Dicus, L. K. Garrett, M. K. Lonneker, T. J. Rodhouse, K. R. Sherrill, and R. K. Steinhorst. 2016b. Upper Columbia Basin Network integrated water quality monitoring protocol: Standard operating procedures version 1.9. Natural Resource Report NPS/UCBN/NRR—2016/1231.1. National Park Service, Fort Collins, Colorado.
- United States EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan 2001-2004. United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002.
- United States EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008.
- United States Fish and Wildlife Service (USFWS). 2010. Endangered and Threatened Wildlife and Plants; Revised 12-Month Finding to List the Upper Missouri River Distinct Population Segment of Arctic Grayling as Endangered or Threatened; Proposed Rule. Federal Register 75 (8 September 2010): 54708–54753.
- Vannote, R. L., and B. W. Sweeney. 1980. Geographic analysis of thermal equilibria: a conceptual model for evaluating the effect of natural and modified thermal regimes on aquatic insect communities. *The American Naturalist* **115**: 667–695.
- Wagner, R. J., R. W. Boulger Jr., C. J. Oblinger, and B. A. Smith. 2006. Guidelines and Standard procedures for continuous water-quality monitors: station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Appendix A. 2015 Water Quality Monitoring Locations



Appendix B. BIHO Hydrologic Unit Code Boundaries



Appendix C. Sample Locations for Water Quality Monitoring at BIHO

Park	Stream	Monitoring Type	Station #	Lat.	Long.	Y ^a	X ^a
BIHO	North Fork Big Hole River	Water Chemistry	001	45.65166414	-113.64428200	5058747.22112554	293967.64787458
BIHO	North Fork Big Hole River	Macroinvertebrate	3211	45.6515284028425	-113.642758646643	5058733	294086
BIHO	North Fork Big Hole River	Macroinvertebrate	3213	45.6510639458218	-113.645316504799	5058688	293885
BIHO	North Fork Big Hole River	Macroinvertebrate	3214	45.6493456648691	-113.644889042235	5058496	293912
BIHO	North Fork Big Hole River	Macroinvertebrate	3215	45.6477809496476	-113.647536085331	5058329	293700
BIHO	North Fork Big Hole River	Macroinvertebrate	3216	45.6457316184628	-113.65089160712	5058110	293431

^a X and Y have been projected in NAD 83, UTM Zone 12. These locations were recorded by the field crew with a handheld GPS unit.

Appendix D. Quality Control (QC) Indicators

Table D-1. QC data quality indicators for 2015 season at BIHO, North Fork Big Hole River, Hydrolab #095, Station ID: BIHO #001

STORET Name	Units	Detection Range Description From Manufacture	Method Detection Limit (MDL)	Minimum Level of Quantitation (ML)	Alternative Measurement Sensitivity Plus (AMS+) Beginning of Season	Alternative Measurement Sensitivity Plus (AMS+) End of Season	Precision+ (RPD) Beginning of Season	Precision+ (RPD) End of Season
Temperature, water	deg C	-5 to 50°C	N/A	N/A	0.04	0.1	0	0.11
Specific Conductance	µS/cm	0 to 100,000 µS/cm	N/A	N/A	0.74	0.26	0.37	0.16
Dissolved Oxygen	mg/L	0-20 mg/L	N/A	N/A	0.09	0.12	0.25	1.09
pH	pH units	0-14 Units	N/A	N/A	0.07	0.07	0.27	0
Turbidity	NTU	0-3000 NTU	0.5	1.59	21.9	0	0	0

Appendix E. Macroinvertebrate Metrics

Table E-1. NPS Upper Columbia Basin Benthos 2015 – BIHO.

Parameter	Sample ID					
	155505	155506	155507	155508	155509	155510
Station	PIBO:3211	PIBO:3213	PIBO:3214	PIBO:3215	PIBO:3216	PIBO:3217
ReachID	8834	8835	8836	8837	8838	8839
Waterbody	N.F. Big Hole 1	N.F. Big Hole 2	N.F. Big Hole 3	N.F. Big Hole 4	N.F. Big Hole 5	N.F. Big Hole 6
County	Beaverhead	Beaverhead	Beaverhead	Beaverhead	Beaverhead	Beaverhead
State	MT	MT	MT	MT	MT	MT
Latitude	45.65155278	45.65096111	45.6494694	45.64773611	45.64572222	45.64347778
Longitude	-113.642842	-113.644967	-113.645075	-113.647136	-113.650928	-113.649597
Collection Date	8/13/2015	8/13/2015	8/14/2015	8/15/2015	8/16/2015	8/17/2015
Habitat Sampled	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle
Collection Method	Surber Net	Surber Net	Surber Net	Surber Net	Surber Net	Surber Net
Field Notes	NULL	NULL	NULL	NULL	NULL	NULL
Lab Notes	NULL	NULL	NULL	NULL	NULL	NULL
Area sampled (m^2)	0.74	0.74	0.74	0.74	0.74	0.74
Field Split	100	100	100	100	100	100
Lab Split	6.25	25	25	12.5	6.25	6.25
Split Count	591	671	672	633	673	743
Fixed Count	300	300	300	300	300	300
Big Rare Count	6	18	4	9	12	11
Richness ^a	21	24	16	23	26	26
Abundance	12786	3651	3638	6855	14568	16080
Shannon's Diversity ^a	2.009784	2.240164	1.828322	2.234259	2.73305	2.520742

^a Standardized to OTU and fixed count

Table E-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO.

Parameter	Sample ID					
	155505	155506	155507	155508	155509	155510
Simpson's Diversity ^a	0.768071	0.818082	0.732308	0.810635	0.921672	0.893668
Evenness ^a	0.660131	0.704886	0.659428	0.71257	0.838849	0.773685
# of EPT Taxa ^a	12	16	10	15	14	15
EPT Taxa Abundance	5953	2374	2186	3150	7320	9601
Dominant Family	Chironomidae	Brachycentridae	Brachycentridae	Chironomidae	Chironomidae	Brachycentridae
Abundance of Dominant Family	4951	1211	1465	2589	2703	3459
Dominant Taxa	Orthocladiinae	<i>Brachycentrus americanus</i>	<i>Brachycentrus occidentalis</i>	Orthocladiinae	Orthocladiinae	<i>Brachycentrus occidentalis</i>
Abundance of Dominant Taxa	4692	1173	1438	2438	1838	3178
Hilsenhoff Biotic Index ^a	3.673333	2.623333	2.33	3.646667	2.68	2.626667
# of Intolerant Taxa ^a	7	9	8	9	9	9
Intolerant Taxa abundance	4828	1753	2057	2651	5484	8381
# of Tolerant Taxa ^a	0	0	0	1	1	0
Tolerant Taxa abundance	0	0	0	0	0	0
USFS Community Tolerance Quotient (d) ^a	70	66	66	65	71	62
# of shredder taxa ^a	3	3	3	3	3	3
Shredder Abundance	1278	238	141	888	1039	2616
# of scraper taxa ^a	1	1	2	1	3	3
Scraper abundance	778	368	292	486	1691	1751
# of collector-filterer taxa ^a	4	2	2	2	3	2
Collector-filterer abundance	2878	1265	1486	897	2989	3200
# of collector-gatherer taxa ^a	6	9	5	9	9	8
Collector-gatherer abundance	6011	854	1003	3270	5408	5320
# of predator taxa ^a	3	5	1	4	4	6
Predator abundance	630	353	381	532	1776	1116

^a Standardized to OTU and fixed count

Table E-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO.

Parameter	Sample ID					
	155505	155506	155507	155508	155509	155510
# of clinger taxa ^a	10	10	7	10	8	12
Long-lived Taxa ^a	6	5	4	6	4	5
# of Ephemeroptera taxa ^a	4	6	4	6	5	6
Ephemeroptera abundance	1362	584	341	778	2965	2465
# of Plecoptera taxa ^a	2	3	2	3	3	2
Plecoptera abundance	846	423	203	878	826	1362
# of Trichoptera taxa ^a	6	7	4	6	6	7
Trichoptera abundance	3745	1368	1643	1493	3530	5774
# of Coleoptera taxa ^a	4	3	2	3	2	3
Coleoptera abundance	1492	666	741	953	1884	2876
# of Elmidæ Taxa ^a	3	3	2	3	2	3
Elmidæ abundance	757	330	259	497	800	1016
# of Megaloptera taxa ^a	0	0	0	0	0	0
Megaloptera abundance	0	0	0	0	0	0
# of Diptera taxa ^a	3	3	2	4	6	7
Diptera abundance	5018	519	603	2677	3028	3127
# of Chironomidae taxa ^a	2	2	2	3	3	3
Chironomidae abundance	4951	465	586	2589	2703	2854
# of Crustacea taxa ^a	0	0	0	0	0	0
Crustacea abundance	0	0	0	0	0	0
# of Oligochaete taxa ^a	0	0	0	0	0	0
Oligochaete abundance	0	5	0	0	22	0
# of Mollusca taxa ^a	1	0	1	0	3	0
Mollusca abundance	130	5	49	0	1903	0
# of Insect taxa ^a	19	22	14	22	22	25

^a Standardized to OTU and fixed count

Table E-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO.

Parameter	Sample ID					
	155505	155506	155507	155508	155509	155510
Insect abundance	12462	3559	3530	6780	12232	15604
# of Non-insect taxa ^a	2	2	2	1	4	1
Non-insect abundance	324	92	108	76	2335	476

^a Standardized to OTU and fixed count

Appendix F. Macroinvertebrate Taxa List

Table F-1. NPS Upper Columbia Basin Benthos 2015 – BIHO.^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	146	Zaitzevia parvulus	2	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	146	Zaitzevia parvulus	2	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	182	Chironominae	12	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	184	Orthoclaadiinae	217	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	59	Hygrobatidae	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	63	Lebertia	4	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	65	Protzia	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	135	Optioservus	31	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	223	Simulium	2	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	236	Antocha monticola	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	241	Hexatoma	0	1
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	280	Epeorus	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	250	Baetis	3	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	262	Ephemerellidae	14	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	285	Rhithrogena	5	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	419	Sweltsa	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	499	Hydropsyche	6	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	506	Hydroptilidae	3	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	509	Hydroptila	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	515	Oxyethira	7	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	519	Lepidostoma	17	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	520	Leptoceridae	2	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	263	Attenella	1	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	276	Heptageniidae	4	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	292	Paraleptophlebia	7	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	303	Ameletus	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	484	Micrasema	13	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	521	Ceraclea	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	584	Rhyacophila	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	646	Pisidiidae	6	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	834	Dipheter hageni	11	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	970	Drunella grandis	16	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	1076	Optioservus quadrimaculatus	20	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	1461	Pteronarcys dorsata	0	1
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	1743	Cleptelmis addenda	13	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	2180	Liodessus obscurellus	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	799	Pteronarcys californica	0	1
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	800	Pteronarcella badia	29	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	838	Hesperoperla pacifica	1	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	932	Brachycentrus occidentalis	119	2
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	1199	Amiocentrus aspilus	3	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	1206	Rhyacophila brunnea/vemna group	0	1
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	2172	Torrenticola	3	0
155505	8834	N.F. Big Hole 1	8/13/2015	6.25	100	0.74	5757	Chloroperlinae	8	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	5846	Ephemerella tibialis	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	4017	Paraleptophlebia with tusks	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	5757	Chloroperlinae	12	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	1199	Amiocentrus aspilus	5	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	2172	Torrenticola	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	800	Pteronarcella badia	30	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	58	Trombidiformes	3	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	184	Orthoclaadiinae	64	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	19	Oligochaeta	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	182	Chironominae	13	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	180	Chironomidae	9	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	146	Zaitzevia parvulus	11	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	146	Zaitzevia parvulus	12	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	838	Hesperoperla pacifica	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	2253	Neoplasta	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	1743	Cleptelmis addenda	3	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	1743	Cleptelmis addenda	4	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	970	Drunella grandis	8	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	1076	Optioservus quadrimaculatus	61	1
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	809	Brachycentrus americanus	214	12
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	834	Diphetero hageni	15	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	647	Pisidium	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	521	Ceraclea	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	444	Perlidae	5	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	455	Perlodidae	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	484	Micrasema	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	276	Heptageniidae	36	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	292	Paraleptophlebia	8	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	519	Lepidostoma	12	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	509	Hydroptila	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	515	Oxyethira	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	499	Hydropsyche	13	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	469	Skwala	2	1
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	419	Sweltsa	26	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	285	Rhithrogena	28	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	262	Ephemerellidae	3	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	250	Baetis	3	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	210	Muscidae	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	252	Centroptilum	4	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	236	Antocha monticola	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	241	Hexatoma	1	4
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	206	Wiedemannia	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	221	Simuliidae	1	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	223	Simulium	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	135	Optioservus	32	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	63	Lebertia	7	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	65	Protzia	2	0
155506	8835	N.F. Big Hole 2	8/13/2015	25	100	0.74	67	Sperchon	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	182	Chironominae	31	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	146	Zaitzevia parvulus	11	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	146	Zaitzevia parvulus	3	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	66	Sperchonidae	3	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	65	Protzia	2	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	63	Lebertia	3	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	135	Optioservus	48	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	121	Elmidae	39	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	184	Orthocladinae	77	2
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	201	Chelifera	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	203	Hemerodromia	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	241	Hexatoma	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	262	Ephemerellidae	21	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	419	Sweltsa	30	2
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	480	Trichoptera	7	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	506	Hydroptilidae	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	515	Oxyethira	4	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	519	Lepidostoma	14	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	276	Heptageniidae	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	484	Micrasema	5	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	303	Ameletus	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	292	Paraleptophlebia	9	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	531	Apatania	4	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	521	Ceraclea	3	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	647	Pisidium	9	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	834	Diphetor hageni	4	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	1031	Timpanoga hecuba	1	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	1076	Optioservus quadrimaculatus	36	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	1281	Drunella grandis/spinifera	26	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	800	Pteronarcella badia	7	0
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	932	Brachycentrus occidentalis	266	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155507	8836	N.F. Big Hole 3	8/14/2015	25	100	0.74	2172	Torrenticola	3	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	2172	Torrenticola	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	5757	Chloroperlinae	15	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	5845	Ephemerella dorothea/excrucians	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	932	Brachycentrus occidentalis	80	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	1199	Amiocentrus aspilus	8	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	838	Hesperoperla pacifica	2	1
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	799	Pteronarcys californica	0	1
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	800	Pteronarcella badia	46	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	1461	Pteronarcys dorsata	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	1742	Optioservus pecosensis	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	1743	Cleptelmis addenda	18	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	1743	Cleptelmis addenda	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	1076	Optioservus quadrimaculatus	15	1
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	970	Drunella grandis	19	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	834	Dipheter hageni	8	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	292	Paraleptophlebia	24	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	484	Micrasema	17	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	444	Perlidae	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	455	Perlodidae	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	515	Oxyethira	12	1
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	519	Lepidostoma	18	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	509	Hydroptila	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	499	Hydropsyche	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	419	Sweltsa	14	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	262	Ephemerellidae	12	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	285	Rhithrogena	4	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	252	Centroptilum	3	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	236	Antocha monticola	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	187	Tanypodinae	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	216	Pericoma	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	237	Dicranota	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	250	Baetis	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	241	Hexatoma	1	1
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	223	Simulium	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	135	Optioservus	44	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	65	Protzia	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	67	Sperchon	1	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	63	Lebertia	3	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	182	Chironominae	12	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	146	Zaitzevia parvulus	6	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	146	Zaitzevia parvulus	2	0
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	184	Orthocladiinae	225	4
155508	8837	N.F. Big Hole 4	8/15/2015	12.5	100	0.74	58	Trombidiformes	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	58	Trombidiformes	6	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	63	Lebertia	2	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	19	Oligochaeta	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	184	Orthocladiinae	85	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	146	Zaitzevia parvulus	6	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	182	Chironominae	33	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	180	Chironomidae	4	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	223	Simulium	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	201	Chelifera	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	241	Hexatoma	2	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	243	Limnophila	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	236	Antocha monticola	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	262	Ephemerellidae	57	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	216	Pericoma	2	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	187	Tanypodinae	3	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	135	Optioservus	61	2
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	252	Centroptilum	15	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	404	Capniidae	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	419	Sweltsa	20	1
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	480	Trichoptera	3	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	509	Hydroptila	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	520	Leptoceridae	3	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	519	Lepidostoma	41	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	515	Oxyethira	37	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	292	Paraleptophlebia	21	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	444	Perlidae	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	484	Micrasema	3	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	303	Ameletus	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	307	Tricorythodes	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	834	Dipheter hageni	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	647	Pisidium	78	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	610	Physa	9	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	531	Apatania	13	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	521	Ceraclea	3	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	1194	Diura knowltoni	3	1
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	1076	Optioservus quadrimaculatus	13	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	970	Drunella grandis	28	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	1743	Cleptelmis addenda	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	1743	Cleptelmis addenda	6	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	800	Pteronarca badia	3	1
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	2195	Atherix pachypus	2	1
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	2253	Neoplasia	3	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	2150	Mideopsis	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	908	Probezzia	2	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	927	Lymnaea	1	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	932	Brachycentrus occidentalis	59	4
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	5846	Ephemerella tibialis	11	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	4017	Paraleptophlebia with tusks	2	2
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	5757	Chloroperlinae	10	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	2162	Sperchonopsis	2	0
155509	8838	N.F Big Hole 5	8/16/2015	6.25	100	0.74	2172	Torrenticola	8	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	2172	Torrenticola	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	2162	Sperchonopsis	3	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	5757	Chloroperlinae	39	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	4017	Paraleptophlebia with tusks	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	800	Pteronarca badia	18	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	1199	Amiocentrus aspilus	2	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	932	Brachycentrus occidentalis	147	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	2195	Atherix pachypus	5	10
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	1743	Cleptelmis addenda	19	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	1076	Optioservus quadrimaculatus	15	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	970	Drunella grandis	13	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	521	Ceraclea	3	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	531	Apatania	9	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	555	Psychoglypha	0	1
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	834	Dipheter hageni	2	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	655	Turbellaria	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	455	Perlodidae	4	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	484	Micrasema	10	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	484	Micrasema	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	292	Paraleptophlebia	37	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	267	Drunella doddsii	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	276	Heptageniidae	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	262	Ephemerellidae	55	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	515	Oxyethira	2	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	519	Lepidostoma	91	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	499	Hydropsyche	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	509	Hydroptila	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	419	Sweltsa	2	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	285	Rhithrogena	2	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	135	Optioservus	70	0

^a All samples were from targeted riffles and sampled using Surber nets.

Table F-1 (continued). NPS Upper Columbia Basin Benthos 2015 – BIHO. ^a

Sample ID	Reach ID	Name	Sample Date	Lab Split	Field Split	Area	Code	Taxon	Split Count	Big Rare Count
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	187	Tanypodinae	4	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	234	Tipulidae	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	216	Pericoma	3	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	250	Baetis	2	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	241	Hexatoma	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	236	Antocha monticola	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	201	Chelifera	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	184	Orthocladiinae	101	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	65	Protzia	5	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	121	Elmidae	9	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	146	Zaitzevia parvulus	2	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	180	Chironomidae	10	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	182	Chironominae	17	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	146	Zaitzevia parvulus	18	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	59	Hygrobatidae	1	0
155510	8839	N.F. Big Hole 6	8/17/2015	6.25	100	0.74	63	Lebertia	11	0

^a All samples were from targeted riffles and sampled using Surber nets.

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