National Park Service
U.S. Department of the Interior

Natural Resource Program Center

National Capital Region Network Biological Stream Survey Protocol Version 2.0

Physical Habitat, Fish, and Aquatic Macroinvertebrate Vital Signs

Natural Resource Report NPS/NCRN/NRR—2009/116



ON THE COVER
Field crew collecting samples in a stream in Rock Creek Park
Photograph by: Contractor Field Crew

National Capital Region Network Biological Stream Survey Protocol Version 2.0

Physical Habitat, Fish, and Aquatic Macroinvertebrate Vital Signs

Natural Resource Report NPS/NCRN/NRR—2009/116

Version 2.0 Revised and Edited by
Marian E. Norris
Water Resources Specialist

And

Geoffrey Sanders
Data Manager
NCRN Inventory and Monitoring Program
4598 MacArthur Blvd., NW
Washington, DC 20007

June 2009

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, CO

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

Natural Resource Reports are the designated medium for disseminating high priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability. Examples of the diverse array of reports published in this series include vital signs monitoring plans; "how to" resource management papers; proceedings of resource management workshops or conferences; annual reports of resource programs or divisions of the Natural Resource Program Center; resource action plans; fact sheets; and regularly-published newsletters.

Views and conclusions in this report are those of the authors and do not necessarily reflect policies of the National Park Service. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Printed copies of reports in these series may be produced in a limited quantity and they are only available as long as the supply lasts. This report is also available from the National Capital Region I&M Network website (http://www.nature.nps.gov/im/units/ncrn/index.cfm) and the National Park Service Natural Resource Program Center (http://www.nature.nps.gov/publications/NRPM/) on the internet.

Please cite this publication as:

Norris, M. E., and G. Sanders. 2009. National Capital Region Network biological stream survey protocol: Physical habitat, fish, and aquatic macroinvertebrate vital signs. Natural Resource Report NPS/NCRN/NRR—2009/116. National Park Service, Fort Collins, Colorado.

NPS 800/100122, June 2009

Contents

Page

Figures v

Tables vi

Executive Summary vii

Acknowledgements viii

Background and Objectives 1

Background and History 1
Rationale for Monitoring this Resource 2
Measurable Objectives 5

Sampling Design 6

Study Area 6
Site Selection and Justification 6
Population Being Monitored 6
Sampling Frequency and Replication 7

Field and Laboratory Methods 11

Field Season Preparations, Field Schedule, and Equipment Setup 11
Sampling Methods 11
Water Chemistry 13
Biological Sampling 13
Benthic Macroinvertebrates *14*
Fish *15*
Physical Habitat 15

Data Management 16

Data Analysis and Reporting 16

Revising the Protocol and Archiving Previous Versions of the Protocol *17*

Literature Cited 18

Appendix A: Data Sheets and Sampling Forms 23

APPENDIX B MASTER FISH SPECIES LIST FOR THE STATE OF MARYLAND 40

APPENDIX C MASTER BENTHIC TAXA LIST FOR THE STATE OF MARYLAND..... 43

Standard Operating Procedures..... 55

Figures

Page

Figure 1. Locations of the National Parks (red) in the National Capital Region within the Potomac River Watershed..... 1

Tables

Table 1: Site characteristics for streams to be sampled during a six year rotation. 8

Executive Summary

The vital sign selection process of the NPS Inventory and Monitoring Program (I&M) identified fish, macroinvertebrates, and physical habitat characteristics as a critical need for the parks of the National Capital Region Network (NCRN). In 2005, the National Capital Region Inventory and Monitoring Network (NCRN) initiated a long-term water quality and quantity monitoring program, funded in part by the National Park Service Water Resources Division. The Biological monitoring portion of the program is carried out every 6 years at 37 sites within 10 of the NCRN parks. The data collected using this protocol will provide much needed baseline information on the stream biological resources in the NCRN, particularly in terms of community structure and composition. The information will also be used to determine long term trends in community composition, as well as trends in the abundance and distribution of individual species.

Parks monitored with this protocol include Antietam National Battlefield, Catoctin Mountain Park, Harpers Ferry National Historical Park, George Washington Memorial Parkway, Manassas National Battlefield Park, Monocacy National Battlefield, National Capital Parks - East, Prince William Forest Park, Rock Creek Park, and Wolf Trap National Park for the Performing Arts. The streams monitored are all part of the Potomac River Watershed. The Potomac is the second largest drainage of the nine river basins that form the 64,000 square mile Chesapeake Bay watershed.

This protocol includes monitoring of three related vital signs: fish, macroinvertebrates, and physical habitat. The protocol is based on the Maryland Department of Natural Resources (MD-DNR) Maryland Biological Stream Survey (MBSS). 23 standard operating procedures (SOPs) document the methods used to collect the relevant data. The protocol was developed in 2005 by Robert H. Hilderbrand, Richard L Raesly, and Daniel M. Boward, of the University of Maryland Center for Environmental Sciences – Appalachian Laboratory (UMCES-AL) and Maryland Department of Natural Resources (MD DNR) who perform sampling and data analysis as part of the MBSS, so that data collected will be compatible with that from the rest of the state to provide a wider context for trends in the NCRN parks.

The Protocol was revised and expanded (Version 2 by Norris and Sanders) in 2009 to include revisions to the MBSS program made by MD DNR for the State's Round three sampling as well as revisions to the I&M Water Program sampling design and clarifications for NPS contractors.

Acknowledgements

Additional assistance in preparing this document was provided by J. Patrick Campbell, Shawn Carter, Doug Curtis, Rick Inglis, Roy Irwin, Pete Penoyer, James Marcel Pieper, Jr., John Paul Schmit, and Scott Stranko.

Background and Objectives

Background and History

Almost all of the parks in the National Capital Region Inventory and Monitoring Network (NCRN) lie within the Potomac River watershed (Figure 1) with the exception of parts of Suitland Parkway and Baltimore and Washington Parkway of NACE, which are located in the Patuxent River watershed.

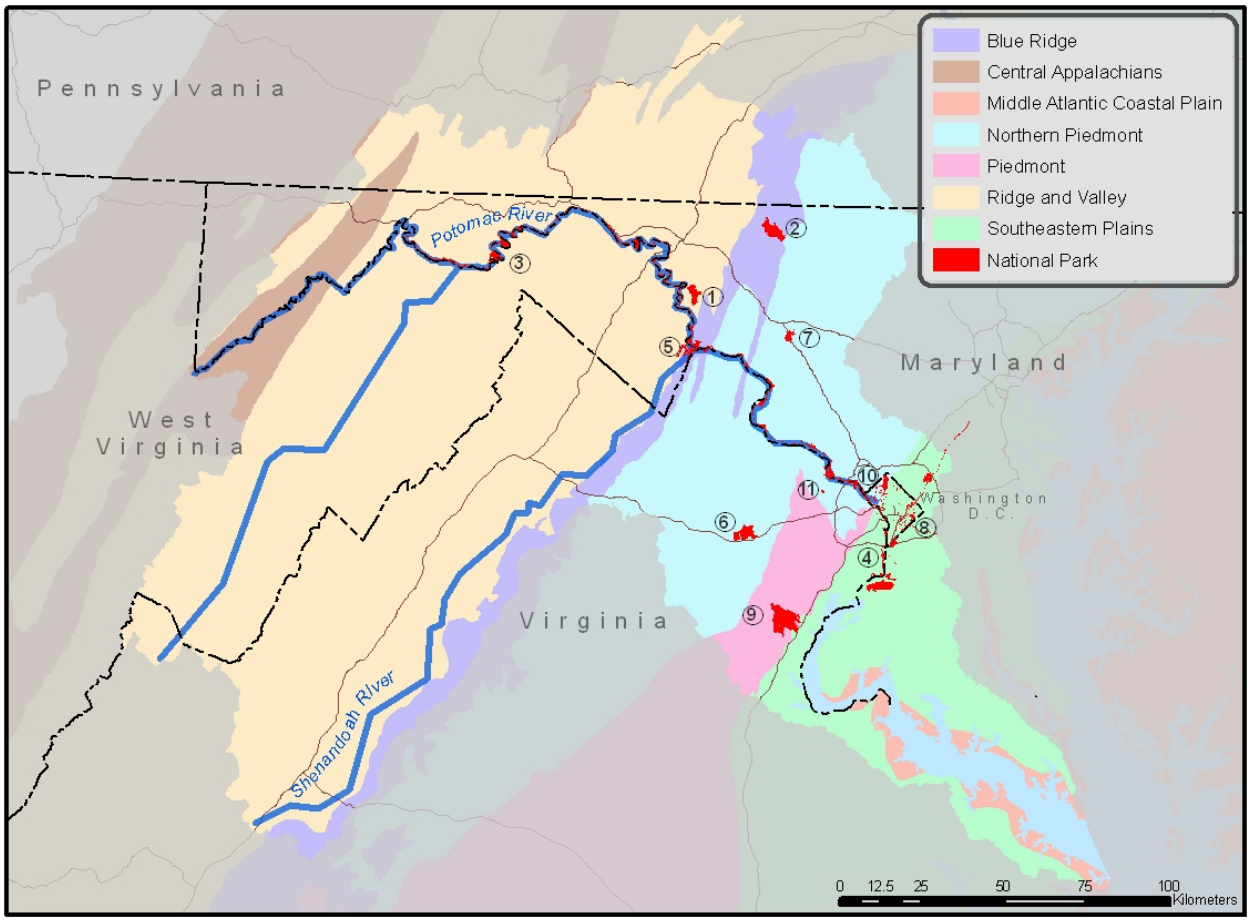


Figure 1. Locations of the National Parks (red) in the National Capital Region within the Potomac River Watershed

1. Antietam National Battlefield
2. Catoctin Mountain Park
3. Chesapeake & Ohio Canal National Historical Park
4. George Washington Memorial Parkway
5. Harpers Ferry National Historical Park
6. Manassas National Battlefield Park
7. Monocacy National Battlefield
8. National Capital Parks–East
9. Prince William Forest Park
10. Rock Creek Park
11. Wolf Trap National Park for the Performing Arts

The Potomac River Watershed covers 6 Physiographic Regions within 4 states and the District of Columbia. Nearly sixty percent of the stream reaches in the watershed are classified as first order by the Strahler system(Strahler 1957), with the rest classified as second order or higher. Though several national parks are adjacent to the river, the parks do not manage the waters of the Potomac. The waters of the Potomac River are owned by the state of Maryland. The river bottom running through the District of Columbia is owned by the National Park Service (NPS).

The Potomac is the second largest drainage of the nine river basins that form the 64,000 square mile Chesapeake Bay watershed. The Chesapeake Bay is the largest estuary in the United States, providing habitat for abundant and diverse wildlife populations and supporting an economy that includes fishing, shipping, and recreation. Currently, 13.6 million people live in the Chesapeake Bay watershed, which is challenged with unprecedented development (Burke *et al*. 1999).

Parks with natural water resources in the Region include Antietam National Battlefield, Catoctin Mountain Park, Chesapeake and Ohio Canal National Historical Park, Harpers Ferry National Historical Park, George Washington Memorial Parkway, Manassas National Battlefield Park, Monocacy National Battlefield, National Capital Parks - East, Prince William Forest Park, Rock Creek Park, and Wolf Trap National Park for the Performing Arts. It should be noted that National Capital Parks – East is not an individual park, but rather an administrative unit that manages a variety of small parks (Greenbelt Park, Suitland Parkway, Piscataway Park, etc.) not all of which are included in this monitoring protocol.

The NCRN long-term water monitoring program, funded in part by the Water Resources Division, is designed to ensure the National Capital Region's parks possess science-based information needed for effective resource management. To achieve this, program staff collects data for the following vital signs: water chemistry, nutrient dynamics, surface water dynamics, physical habitat index, aquatic macroinvertebrates, and fishes.

This protocol is designed for monitoring 1st to 4th order streams in 10 parks within the NCRN in the Washington, DC, metropolitan area.

Rationale for Monitoring this Resource

Water resources are a vital component of NPS lands in the National Capital Region (NCR). In parks such as Rock Creek Park, water resources are a dominant landscape feature, and the quality of the visitor experience largely depends on the quality of the resource. On other NCRN lands, aquatic resources play an important role in the visitor experience. The condition of water resources also has direct bearing on public health and safety when waters are degraded or contaminated. A significant number of NCRN park streams contribute to public drinking water supplies. To this end, the Clean Water Act and other regulatory mandates set minimum water quality standards; standards which are increasingly assessed using aquatic organisms.

In addition to the human element, NCRN water resources are significant because biotic communities within this region are unique: the geographic ranges of several fish species reach their limits in the Potomac River drainage. Extirpations of several fishes have occurred in the region (Kazyak, Kilian et al. 2005), and NCRN lands can play a central role in maintaining and conserving biodiversity because anthropogenic actions can be better controlled and detrimental

actions elsewhere balanced by NCRN practices. This is very important given increasing urbanization and development around NCRN parks.

The Mid-Atlantic region has experienced a long history of European settlement and landscape modification, resulting in the loss of undisturbed catchments. Although catchment modifications predate biological samples by decades or even centuries so that there are no benchmark data, ample evidence indicates that many streams within the region are degraded (Starnes 2002). Stream degradation is often expressed as either a loss of integrity or poor health, where integrity is based on the naturalness of the biotic community when compared to the pristine state (Karr 1981). The concept and use of the term "health" regarding streams has been discussed extensively and sometimes maligned (Calow 1992; Suter 1993; Scrimgeour and Wicklum 1996), but the notion is that a healthy stream is one not physically or chemically degraded. Ecosystem health is a very powerful concept when relating information to the public because it is readily interpretable in a social context (Boulton 1999).

There is an intimate link between a watershed and its stream (Allan and Johnson 1997) a degraded watershed creates a degraded stream (Norris and Thoms 1999) because streams receive their inputs from the surrounding landscape. Thus, a stream's appearance and condition is a reflection of the condition of the land, and, directly or indirectly, a reflection on the stewards. Unfortunately, many threats to aquatic resources (development, fertilizers and pesticides from agriculture, timber harvest, sediments, acidic precipitation) originate outside NCRN park boundaries and have the potential to degrade water quality, physical habitat, and biological communities within the parks. This threat exists because NCRN parks are all small (<8,000 ha, with most <1,500 ha), highly fragmented, and bisected by numerous streams often originating on non-Park lands. The Maryland Biological Stream Survey (MBSS) has determined that between one-third and three-quarters of streams in watersheds near the C&O Canal, Antietam National Battlefield, and Monocacy National Battlefield are in poor to very poor (Hilderbrand, Raesly et al. 2005). With a regional population growth rate of over 10% (and some areas adjacent to NCRN parks growing in excess of 30%), human caused landscape changes will substantially alter the existing aquatic resources unless much attention is focused on these resources. This underscores the need for long-term monitoring of water resources in the region.

Stream health should reflect the health of the entire food web, not just one component, yet most assessment methods use either fish or benthic macroinvertebrates and assume that this component represents overall system condition. However, different components may not equally reflect the presence or magnitude of stressors in the system (e.g., Berkman *et al*. 1986). Therefore a number of measures should be employed to obtain a more comprehensive assessment.

Information on water chemistry, physical habitat, and the aquatic community indicate much about the condition of a stream and its watershed, and an impressive body of literature covering a wide variety of stream types and geographic areas supports the link between environmental degradation and fish (Karr 1981; Fausch *et al*. 1984; Berkman *et al*. 1986; Leonard and Orth 1986; Fausch *et al*. 1990; Osborne *et al*. 1992; Lyons *et al*. 1996; Paller *et al*. 1996; Roth *et al*. 1996) and benthic macroinvertebrate community composition (Berkman *et al*. 1986; Kerans and Karr 1994; Wallace *et al*. 1996; Reynoldson *et al*. 1997; Turak *et al*. 1999). This is the basis of monitoring techniques such as the Index of Biotic Integrity (IBI; Karr 1991). IBIs have been very

successful at assessing the condition of aquatic resources and have been developed for the region's fish and benthic macroinvertebrate assemblages (Roth *et al*. 1998; Stribling *et al*. 1998) to assess current ecological conditions throughout the Potomac River watershed (Roth *et al*. 1999). Sedimentation, high nitrate levels, altered hydrologic regimes, and degradation of physical habitat have all been documented in watersheds containing the region's national parks.

Impacts to water quality are so diverse and variable in duration that chemical monitoring alone may fail to detect many of them (Karr 1981, 1991). Effective monitoring of NPS-NCRN water resources should address several vital signs for a more comprehensive assessment than can be gained from any single measure. The vital signs that most accurately reflect the condition of water resources are (1) water quality; (2) physical habitat structure; (3) benthic macroinvertebrate community structure; and (4) fish community structure. Our objectives are to provide tested, repeatable monitoring procedures for assessing water resources of parks in the NCRN and provide baseline data for 37 sites in NCRN parks.

Water quality consists of physical and chemical properties of the waters sampled and can be directly measured to identify specific pollutants or stressors at a site. Water quality includes measures such as dissolved oxygen, temperature, specific conductance, pH, and measures of pollution such as nitrate.

Physical habitat measures are useful for assessing site condition and also reflect conditions in the watershed above a site. The physical habitat structure and water quality both serve as the abiotic habitat template under which fish and benthic macroinvertebrates must live.

Resident biota (fish and benthic macroinvertebrates) are sensitive to low-level chemical, physical, and biological disturbances and therefore function as continuous monitors of system integrity (Berkman *et al*. 1986). Quantitative assessment of biotic assemblages based on ecological principles is more likely to identify human impacts than chemical or physical habitat monitoring alone because aquatic organisms integrate more anthropogenic factors that potentially influence aquatic systems (e.g., Paller *et al*. 1983; Karr *et al*. 1985; Reash and Berra 1987; Weaver and Garman 1994; Lyons *et al*. 1996).

The water resources monitoring protocols in this document use methods developed by the Maryland Biological Stream Survey (Heimbuch *et al*. 1997; Roth *et al*. 1998, 1999, 2001; Hall *et al*. 1999; Kazyak 2001; (Southerland 2007; Southerland, Franks et al. 2007). The MBSS was developed and tested to provide estimates of the condition of non-tidal first through fourth order streams and rivers of Maryland on a watershed as well as a statewide scale.

The MBSS program is based on a probabilistic stream sampling approach—random selections are made from all sections of streams in the state which can physically be sampled. While the approach works well for inventory purposes, long-term monitoring should adopt a fixed-station approach to be able to determine temporal changes in condition.

Biological sampling has always been the primary focus of the MBSS. During Rounds One and Two, MBSS focused primarily on fish and benthic macroinvertebrates. Indices of Biological Integrity (IBIs) for these groups were developed using Round One and Round Two MBSS data. These IBIs are now the basis of biocriteria in Maryland and have been extensively used to

represent the ecological condition of streams and rivers. A stream salamander IBI was also developed using MBSS sampling data along with supplemental sampling. In addition to providing IBI scores, the MBSS is well known for providing the best information on fish, benthic macroinvertebrates and stream salamanders in Maryland. New distributional records for many species (including rare, threatened, and endangered taxa) have been documented by MBSS. MBSS species specific data have also been used to determine biodiversity priority areas so that effective conservation measures can be implemented. Threats and stressors to biota have also been determined from MBSS data and can be used to implement restoration and protection.

Measurable Objectives

The monitoring objectives for water resources are to:

Determine current conditions and track long-term trends in water resource condition as measured by physical habit;
Determine current conditions and track long-term trends in water resource condition as measured by benthic invertebrates;
Determine current conditions and track long-term trends in water resource condition as measured by fishes;
Determine trends in species composition and functional groups of benthic invertebrates;
Determine trends in species composition and functional groups of fishes;
Use monitoring data to detect invasions of nonnative aquatic species;

Biological data are used in conjunction with physical habitat information to evaluate the overall condition of aquatic resources. In conjunction, all mentioned measures provide a fairly comprehensive assessment of site quality. The standard outputs also allow comparison of NPS-NCRN sites against numerous other sites that are using the same protocols within the state of Maryland and puts NCRN sites within a regional context for greater understanding of large-scale patterns of stream conditions. Although the George Washington Memorial Parkway, parts of Harpers Ferry National Historical Park, Manassas National Battlefield, parts of National Capital Parks-East, Prince William Forest Park, and Wolf Trap Farm Park are not located in Maryland, and there is no MBSS sampling program equivalent in Virginia, the streams are sufficiently close to Maryland that biological, chemical, and physical attributes will be comparable to streams in the existing MBSS sampling universe. All streams are within the Potomac River watershed, a single hydrographic system.

Sampling Design

Study Area

The sample frame for Biological Stream Sampling consists of perennial wadeable streams (Strahler stream orders 1-4) in 10 NCRN parks: Antietam National Battlefield, Catoctin Mountain Park, George Washington Memorial Parkway, Harpers Ferry National Historical Park, Manassas National Battlefield, Monocacy National Battlefield, National Capital Parks-East, Prince William Forest Park, Rock Creek Park, and Wolf Trap National Park for the Performing Arts. Streams in these parks are influenced by agriculture, urban development and light industry.

Site Selection and Justification

Monitoring sites for biological sampling were chosen from those sampled monthly for stream chemistry and nutrient sampling (Norris, Pieper et al. 2008). This includes every first to fourth order stream in the NCRN parks, except for those in the C&O Canal National Historical Park. The C&O canal occupies a narrow strip on the north bank of the Potomac. A large number of wadeable streams cross the park, but are only on park property for a few hundred meters at most. As a consequence, the park has little influence over any stream, and each stream influences only a small portion of the park. The NCRN staff decided not to monitor these streams. Instead monitoring carried out by the state of Maryland and relevant to the C&O Canal will be summarized.

Of the 39 streams that are monitored for nutrients and water chemistry, 37 will be monitored for benthic macroinvertebrates and fish. The two streams not monitored under this protocol are Sow Run and South Fork Quantico. These streams are already sampled annually by Fairfax County [see (Astin 2006) regarding data synthesis across Fairfax County and State of Maryland sampling methods)].

Selection of sites for either inventory or monitoring was based on the 1:24,000 scale National Hydrography Dataset (NHD) digital stream reach file. Site locations are provided in SOP #4 Sampling Site Documentation and Table 1. The specific area for sampling may be adjusted slightly up- or downstream if necessary once arriving at the site in order to ensure a sampleable reach for long-term measurements.

Population Being Monitored

The water resources monitoring protocols are sampling several distinct populations:

- The sampling population for benthic invertebrates is benthic macroinvertebrates residing in first- through fourth-order streams on park properties during March and April.
- The sampling population for fishes consists of those residing in first- through fourth-order streams on park properties between June and September.
- The sampling population for water quality consists of those analytes measured in first- through fourth-order park streams during March and April at the same time as the benthos are being sampled.

- The sampling population for physical habitat consists of in-stream and near-stream habitat measures of first- through fourth-order streams recorded between June and September at the same time as the fish are being sampled.

Sampling Frequency and Replication

To provide a synoptic view of the current ecological status of National Capital Region streams and provide water quality data pertinent to characterization of acidification effects, sampling will take place during two index periods, spring and summer. The spring index period was defined by degree-day limits for specific parts of the state. The spring index period was between March 1 and about May 1, with the end of the index period determined by degree-day accumulation as specified in Hilsenhoff (1987). The summer index period extends from 1 June to 30 September each year. The duration of index periods was selected to be as broad as possible to accommodate logistical constraints without introducing excessive intra-period variability.

The index periods were selected to (1) obtain water quality data at a time period most pertinent to acidification impacts; (2) sample benthic communities at a time of year when community structure provides useful information about environmental stresses at a site; (3) sample fish communities during low flow conditions and at a time when major spawning migrations are not in progress; (4) and evaluate habitat conditions during the period which is typically most limiting to the abundance of lotic fishes. Fish community composition tends to be stable during summer, and low flow is advantageous for electrofishing. While it is recognized that several different index periods may be used for benthic sampling, the MBSS chose the spring index period for logistical purposes.

Each site is sampled twice annually. Water chemistry analytes and aquatic invertebrates are sampled in the spring index period. Physical habitat and the fish community are sampled during the summer index period along with the *in situ* water chemistry variables pH, water temperature, dissolved oxygen, and specific conductance.

Table 1: Site characteristics for streams to be sampled during a six year rotation.

Streams are listed in proposed sampling order. Longitude and Latitude are given in Decimal Degrees from NAD83 UTM Zone 18N, North American 1983 datum.

Site_ID	Site_Name	PARK	Longitude	Latitude	Catchment Area (Acres)	B-IBI REGION	F-IBI REGION	State	County
ROCK-103-N-2008	Pinehurst Branch	ROCR	-77.0438112	38.9715562	663.250	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-104-N-2008	Luzon Branch	ROCR	-77.0417639	38.9610886	647.068	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-106-N-2008	Soapstone Valley Stream	ROCR	-77.0517722	38.9453248	505.528	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-107-N-2008	Hazen Creek	ROCR	-77.0524537	38.9382722	231.611	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-202-N-2008	Fenwick Branch	ROCR	-77.0422100	38.9842786	734.410	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-205-N-2008	Broad Branch	ROCR	-77.0503378	38.9449774	1172.872	Eastern Piedmont	Eastern Piedmont	DC	Washington
COCA-217-N-2009	Minnehaha Creek	GWMP	-77.1387376	38.9681932	881.019	Eastern Piedmont	Eastern Piedmont	MD	Montgomery
POTO-118-N-2009	Palisades Creek (Battery Kemble / Maddox Branch)	ROCR	-77.0994776	38.9204346	172.538	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-108-N-2009	Piney Branch	ROCR	-77.0468051	38.9356142	2381.811	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-109-N-2009	Dumbarton	ROCR	-77.0591555	38.915898324	203.342	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-111-N-2009	Normanstone	ROCR	-77.0560782	38.919224602	243.309	Eastern Piedmont	Eastern Piedmont	DC	Washington
ROCK-405-N-2009	Rock Creek at Dumbarton Oaks	ROCR			41727.020	Eastern Piedmont	Eastern Piedmont	DC	Washington
MONO-230-N-2010	Big Hunting Creek	CATO	-77.4404774	39.6261814	5126.050	Eastern Piedmont	Eastern Piedmont	MD	Frederick
MONO-133-N-2010	Owens Creek	CATO	-77.4819558	39.6605487	1252.025	Eastern Piedmont	Eastern Piedmont	MD	Frederick
MONO-134-N-2010	Whiskey Still Creek	CATO	-77.4504364	39.6333986	414.287	Eastern Piedmont	Eastern Piedmont	MD	Frederick
BULL-018-N-2010	Youngs Branch	MANA	-77.5105512	38.8177712	4380.723	Eastern Piedmont	Eastern Piedmont	VA	Prince William
MONO-217-N-2010	UT Monocacy River (Visitors Center / Gambrill Mill	MONO	-77.3883215	39.3686687	674.752	Eastern Piedmont	Eastern Piedmont	MD	Frederick

Site_ID	Site_Name	PARK	Longitude	Latitude	Catchment Area (Acres)	B-IBI REGION	F-IBI REGION	State	County
	Creek)								
MONO-316-N-2010	Bush Creek	MONO	-77.3854308	39.3690646	20450.977	Eastern Piedmont	Eastern Piedmont	MD	Frederick
CHOP-102-N-2011	North Branch of Chopawamsic Creek	PRWI	-77.4257624	38.5650806	3716.109	Eastern Piedmont	Eastern Piedmont	VA	Prince William
CHOP-103-N-2011	Middle Branch of Chopawamsic Creek	PRWI	-77.4237374	38.5577363	2872.522	Eastern Piedmont	Eastern Piedmont	VA	Stafford
QUAN-104- N-2011	Carters Run	PRWI	-77.3653335	38.5656461	84.222	Coastal Plain	Coastal Plain	VA	Prince William
QUAN-101-N-2011	Mawavi Run	PRWI			122.629	Eastern Piedmont	Eastern Piedmont	VA	Prince William
QUAN-201-N-2011	North Fork Quantico Creek	PRWI	-77.3470214	38.5728770	4404.703	Eastern Piedmont	Eastern Piedmont	VA	Prince William
QUAN-102-N-2011	Orenda Run	PRWI			127.893	Eastern Piedmont	Eastern Piedmont		
QUAN-103-N-2011	Taylor Run	PRWI	-77.3750684	38.5757525	293.023	Eastern Piedmont	Eastern Piedmont	VA	Prince William
QUAN-206-N-2011	Mary Bird Branch	PRWI	-77.3606892	38.5681686	502.019	Coastal Plain	Coastal Plain	VA	Prince William
POTO-309-N-2012	Pimmit Run	GWMP	-77.1192875	38.9304884	7732.454	Eastern Piedmont	Eastern Piedmont	VA	Fairfax
POTO-112-N-2012	Turkey Run	GWMP	-77.1569436	38.9656496	660.910	Eastern Piedmont	Eastern Piedmont	VA	Fairfax
POTO-211-N-2012	Mine Run	GWMP	-77.2565161	38.9997962	1599.442	Eastern Piedmont	Eastern Piedmont	VA	Fairfax
DIFF-202-N-2012	Courthouse Creek	WOTR	-77.2626874	38.9396672	1000.138	Coastal Plain	Coastal Plain	VA	Fairfax
DIFF-201-N-2012	Wolftrap Creek	WOTR	-77.2674253	38.9409876	2534.854	Coastal Plain	Coastal Plain	VA	Fairfax
ANTI-101-N-2013	Sharpsburg Creek	ANTI	-77.7377730	39.4550044	788.608	Highlands	Warmwater Highlands	MD	Washington
SHEN-110-N-2013	Flowing Springs Run	HAFE	-77.7903512	39.2948482	5521.232	Highlands	Warmwater Highlands	WV	Jefferson
PRUT-201-N-2013	Henson Creek	NACE	-76.9006632	38.8346874	2486.309	Coastal Plain	Coastal Plain	MD	Prince Georges

Site_ID	Site_Name	PARK	Longitude	Latitude	Catchment Area (Acres)	B-IBI REGION	F-IBI REGION	State	County
ACCO-214-N-2013	Accokeek Creek	NACE	-77.0540143	38.6905656	138.811	Coastal Plain	Coastal Plain	MD	Prince Georges
ANAC-113-N-2013	Still Creek	NACE	-76.9141393	38.9725011	2378.302	Eastern Piedmont	Eastern Piedmont	MD	Prince Georges
OXON-301-N-2013	Oxon Run	NACE	-77.0095181	38.8105563	8564.538	Coastal Plain	Coastal Plain	MD	Prince Georges

Field and Laboratory Methods

Field Season Preparations, Field Schedule, and Equipment Setup

Before the field season begins in March, all field personnel should review this document and the associated SOPs. Field personnel should pay close attention to the tasks described in:

NCRN BSS SOP #1 Roles and Responsibilities

NCRN BSS SOP #2 Training Field Personnel

NCRN BSS SOP #3 Field Safety

NCRN BSS SOP #4 Preparations and Equipment Setup Prior to Field Season and Sampling

Review of fish identification is particularly important since many species look similar to the untrained eye and incorrect identifications pose serious threats to the validity of the inventory and monitoring results. All equipment and supplies listed in Tables 4-1 and 4-2 of SOP#4 should be organized and working properly and field data sheets (Appendix) for the respective index period should be available on waterproof paper.

A timetable of sample dates should be constructed prior to each index period in the field season and flexibility should be built in to allow for inclement weather or other delays.

Sampling Methods

The purpose of this section is to outline procedures that must be followed during the sampling of water resources in the National Capital Region for water quality, benthic macroinvertebrate, fish, reptile, amphibian, crayfish, mussel, invasive plant, and physical habitat sampling. Sections on site location, sampleability determination, photo- documentation, and temperature logger deployment and retrieval are also included. Strict adherence to these protocols is necessary to ensure that 1) data from the monitoring effort is of known and acceptable quality, and 2) the monitoring can be readily repeated in the future.. Of particular importance is diligence in completing and verifying the complete and accurate recording of data sheet information while still in the field and completing sampling during the appropriate Index Period. The data sheets for the NCRN water resources monitoring are patterned after the Maryland Biological Stream Survey datasheets which were designed to ensure that all necessary information is recorded in a standardized manner; only spaces provided for data entry should be used and all spaces should be completed.

To provide a synoptic view of the current ecological status of Maryland streams, MBSS sampling takes place during two index periods, spring and summer. The Spring Index Period extends from 1 March to 30 April, and the Summer Index Period extends from 1 June to 30 September each year. Four primary activities are conducted during the Spring Index Period: benthic macroinvertebrate, water chemistry for laboratory analysis, select physical habitat variable sampling, and vernal pool searches. During the Summer Index Period, seven primary activities are conducted: fish, reptile and amphibian, mussel, crayfish, invasive plant, in situ water chemistry, and select physical habitat variable sampling. It is imperative that sampling for these variables be performed during the appropriate index period. Although focused sampling for

reptiles and amphibians, crayfishes, and mussels are conducted during the summer index period, incidental observations of any of these taxa should be recorded during any visit to the site, during any time of the year. If no specific place for recording the incidental observation of a particular species is available on data sheets, it should be recorded in the comments section of an available data sheet.

The time period for the Spring Index Period is based on sample degree-day accumulations of mean air temperatures above 4.5°C. This time period was chosen because studies in Maryland have demonstrated that sampling in spring can estimate the degree of acidification in a stream, within acceptable limits, and also provide benthic macroinvertebrate data most suited for identifying anthropogenic stressors at a site.

Based on the results of benthic macroinvertebrate studies, degree day accumulations above certain thresholds (440°C for Coastal Plain and 1050°C for the rest of Maryland) were used as a basis for determining when MBSS Spring Index Period sampling should be completed. Since degree day accumulations rarely approached these thresholds during March and April, the Spring Index Period for Round Three includes all days within these two months. Degree days do not need to be taken into consideration.

The sampling crew for the Spring Index Period (benthic macroinvertebrate and water quality sampling) should consist of at least two people. Both persons on the spring sampling crew must be trained in water quality sampling, and at least one person must be experienced with field sampling techniques for benthos. Because the water quality/benthic sampling crew will also determine whether electrofishing can be conducted in the sample segment, at least one person on the crew must also be experienced in stream electrofishing.

To promote consistency, completeness, and data quality, sampling activities should follow a consistent and defined pattern, as outlined in the following SOPS:

NCRN BSS SOP #5 Sampling Site Documentation

NCRN BSS SOP #6 Spring Index Period Water Quality Sampling

NCRN BSS SOP #7 Spring Index Period Benthic Macroinvertebrate Sampling

NCRN BSS SOP #8 Spring Index Period Physical Habitat Sampling

The MBSS Summer Index Period was selected to occur during the low flow period, which is most limiting to fishes. Sampling during this period is also advantageous because spawning effects are minimized, temperatures are conducive to wading and water contact, and capture efficiency using electro-fishing is typically best when streams are relatively low and warm. Most of the other taxa, for which MBSS summer sampling occurs, are most active and/or most easily observed/captured (crayfishes, mussels, stream salamanders, invasive plants) during this time period.

Since water levels are typically at their lowest in Maryland streams during the summer, the Summer Index Period is also the time during which physical habitat is most limiting to many stream dwelling organisms (including fishes, mussels, stream salamanders, and crayfishes). Physical habitat evaluation measurements taken during this time, therefore, represent limiting conditions for these organisms. The sampling crew for the Summer Index Period will consist of

three or more persons, including at least one person designated by the MBSS Training Officer as qualified to assess habitat and identify fish.

To promote consistency, completeness, and data quality, sampling activities should follow a consistent and defined pattern, as outlined in the following SOPS:

NCRN BSS SOP #9 Summer Index Period *In Situ* Water Quality

NCRN BSS SOP #10 Summer Index Period Fish Sampling

NCRN BSS SOP #11 Summer Index Period Physical Habitat Evaluation

NCRN BSS SOP #12 Summer Index Period Crayfish Sampling

NCRN BSS SOP #13 Summer Index Period Mussel Sampling

NCRN BSS SOP #14 Summer Index Period Invasive Plant Sampling

Water Chemistry

Selected water quality variables (pH, acid neutralizing capacity, sulfate, nitrite, nitrate, ammonia, total nitrogen (dissolved and particulate), ortho-phosphate, total phosphorous (dissolved and particulate), chloride, conductivity, and dissolved organic carbon) are measured based on grab samples taken during the Spring Index Period (1 March to 30 April). These analytes provide information about the state of acidification and degree of organic loading in the reaches being sampled. Approximately 1.5 L of water and at least 50 ml in a closed syringe are needed to provide data for all of the MBSS laboratory water chemistry parameters. Grab samples are collected in 0.5 and 1-liter bottles for analysis of all analytes except pH. Water samples for pH were collected with 60 ml syringes, which allow purging of air bubbles to minimize changes in carbon dioxide content (EPA 1987). Samples are stored on wet ice and shipped on wet ice to the analytical laboratory within 48 hours.

Chemical analyses of water samples follow standard methods as listed in Table 6-1 of SOP#6. Routine daily quality control (QC) checks include processing duplicate, blank, and calibration samples according to EPA guidelines for each analyte. Field duplicates are taken at 5% of all sites. Routine QC checks help to identify and correct errors in sampling routines or instrumentation at the earliest possible stage. The internal QA/QC protocols follow guidelines outlined in EPA (1987). A complete QA/QC report for 2003 MBSS laboratory analysis can be found in Kline and Morgan (2003).

During the summer index period, *in situ* measurements of dissolved oxygen (DO), pH, temperature, and conductivity are collected at each site to further characterize existing water quality conditions that might influence biological communities. Measurements are made at an undisturbed section of the segment, usually in the middle of the stream channel and at the upstream segment boundary, using electrode probes. Instruments are calibrated daily and calibration logbooks are maintained to document instrument performance.

Biological Sampling

The key to the successes that the MBSS has had with biological data has been the consistency that comes from strict adherence to established sampling protocols and the quality control

program which ensures (and documents) that those personnel collecting biological data in the field and laboratory are proficient with taxonomic identification.

Nationally, freshwater mussels and crayfishes are the most imperiled animal groups (Rahel 2002). A great deal of information is needed on these two groups in Maryland. To help meet this need crayfish and mussel information will be collected during Round Three. The sampling of stream salamanders has also been expanded to allow more rigorous examinations of salamander information collected at MBSS sites. The information collected on these taxa will supplement our knowledge of Maryland's biological integrity and biodiversity and will continue to provide much needed information to plan and implement effective restoration and protection measures for aquatic biota in the state.

Benthic Macroinvertebrates

Benthic macroinvertebrates are collected to provide a semi-quantitative description of the community composition at each sampling site. Sampling is conducted during the spring index period. Benthic community data are collected primarily for the purpose of calculating Maryland DNR's Benthic Index of Biotic Integrity (BIBI) for Maryland streams (Stribling *et al.* 1998) although the component metrics that make up the index are also valuable for assessing temporal trends. Recognizing that National Capital Region streams vary from high-gradient riffle habitat with abundant cobble substrate to low-gradient Coastal Plain streams with sandy or silty bottoms, sampling employs a "D" net suitable for sampling a wide variety of habitats. This multi-habitat approach is consistent with the recommendations of the Mid-Atlantic Coastal Streams Workgroup (MACS 1996) and the EPA's most recent Rapid Bioassessment Protocols (Barbour *et al*. 1999).

At each segment, a 600-micron mesh "D" net is used to collect organisms from habitats likely to support the greatest taxonomic diversity. This habitat often includes a riffle area when present. Other habitats, in order of preference, include gravel, broken peat, or clay lumps in a run area; snags or logs that create a partial dam or are in run habitat; undercut banks and associated root mats; and SAV and detrital/sand areas in moving water. In riffles and most other habitats, sampling involves placing the net downstream, gently rubbing surficial substrates by hand to dislodge organisms, and disrupting deeper substrates using vigorous foot action. Each dip of the net covers one-two square feet, and a total of approximately 2.0 m^2 (20 square feet) of combined substrates is sampled; samples are preserved in 70% ethanol. Duplicate benthic samples may be taken at some sites to assess the replicability of the field methods.

In the laboratory, the preserved sample is transferred to a gridded pan and organisms are picked from randomly selected grid cells until the cell that contains the 100th individual (if possible) is completely picked; some samples will have fewer than 100 individuals. The benthic macroinvertebrates are identified to genus, or lowest practicable taxon, in the laboratory. To aid in identification, oligochaete and chironomid taxa are slide-mounted and identified under a microscope. Laboratory QC procedures include the re-subsampling and identifying of every 20th sample. This second sample is identified according to standard procedures, and comparisons are made between the two duplicates. The MBSS voucher specimen collection is currently maintained at the Maryland DNR Field Office in Annapolis, Maryland. A complete description of laboratory protocols can be found in SOP #7 and in Boward and Friedman (2000), and results

of the QC analysis for the MBSS sampling technique in 2002 can be found in Rogers *et al*. (2003).

In macroinvertebrate monitoring, the decision to employ a particular subsample size (100 vs. 200 or greater) reflects a balance of how to best use program effort. While a larger subsample may improve precision in characterizing individual sites, each sample then requires additional effort for laboratory identification. At the outset of the MBSS monitoring program, a decision was made that 100-organism subsamples would provide acceptable precision at the single site level, and that, within a given total cost, effort would instead be focused on maximizing the total number of sites that could be sampled.

Fish

Fish are sampled during the summer index period using two-pass electrofishing within 75-meter stream segments (Heimbuch *et al*. 1997). Block nets are placed at each end of the segment and direct current backpack electrofishing units are used to sample the entire segment. An attempt is made to thoroughly fish each segment on each pass, sampling all habitat within the entire stream segment. A consistent effort is applied over the two passes. The sampling is detailed in SOP #10. This sampling approach allows calculation of several metrics constituting the biological index (see SOP #20) and can be used to produce estimates of fish species abundance.

In small streams, a single electrofishing unit is used. In larger streams, two or more are employed to effectively sample the site. Captured fish from each pass are identified to species, weighed in aggregate, counted, and released. Any individuals that cannot be identified to species are retained for laboratory confirmation, and a voucher series of about 10 individuals should be retained for each park. For each pass, all individuals of each gamefish species (defined as trout, bass, walleye, northern pike, chain pickerel, and striped bass) are measured for total length. For each species, unusual occurrences of visible external pathologies or anomalies are noted.

All voucher specimens and fish retained for positive identification in the laboratory are examined and verified by esperts. All MBSS collections are archived in the fish museum at Frostburg State University.

Physical Habitat

Habitat assessments (SOP #8 for spring sampling and SOP #11 for summer sampling) are conducted at all stream segments as a means of assessing the importance of physical habitat to the biological integrity and fishability of freshwater streams in National Capital Region parks. Procedures for habitat assessment (Kazyak 2001) were derived from two commonly used methodologies: EPA's Rapid Bioassessment Protocols (RBPs) (Plafkin *et al*. 1989), as modified by Barbour and Stribling (1991), and the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI) (Ohio EPA 1987, Rankin 1989).

During spring sampling, riparian zone vegetation type and width on each bank is estimated to the nearest meter (up to 50 meters from stream). Severity and type of buffer breaks are noted. Local land use type and the extent and type of stream channelization are recorded and stream gradient is measured. Crews also record distance from the nearest road and assign a trash rating (based on visible signs of human refuse at a site) to characterize human presence.

During summer sampling, several habitat characteristics (instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, and riffle/run quality) are assessed qualitatively on a 0–20 scale, based on visual observations within each segment. The percentage of embededdness of the stream channel and the percentage of shading of the stream site are estimated. Also recorded are the extent and severity of bank erosion and bar formation, number of woody debris and rootwads within the stream channel, and the presence of various stream features such as substrate types, various morphological characteristics, and beaver ponds. Maximum depth within the segment is measured. Wetted width, thalweg depth, and thalweg velocity are recorded at four transects. A complete velocity/depth profile is taken at one transect to compute discharge (streamflow); for sites with extremely low flow, the speed of a floating object is substituted to allow calculation of discharge.

Data Management

Having a suitable database to store monitoring information about many sites across many years is important to data retrieval, assessment, and trend detection. The NCRN I&M program has constructed an MS Access database and data entry system as described in:

NCRN BSS SOP #15 Data Management

NCRN BSS SOP #16 Database Design and Data Entry

NCRN BSS SOP #17 Metadata

NCRN BSS SOP #18 Network Data Storage

Throughout Data collection, management and analysis it is important to maintain the quality of the data. Guidance can be found in NCRN BSS SOP #19 QA/QC.

Data Analysis and Reporting

Three indices are calculated from the data collected at each site: the Fish Index of Biotic Integrity, the Benthic Macroinvertebrates Index of Biotic Integrity (BIBI), and the Physical Habitat Index (PHI). The process for each is described in NCRN BSS SOP #20 Data Analysis.

These indices, as well as details of the annual sampling effort and any unique circumstances of the annual sampling are reported by the contractor each year as described in NCRN BSS SOP#21 Contractor Reporting Specs. Since these reports cannot include any results or conclusions from the sampling effort, since they only cover 1/6 of the data at any time, they do not follow the Natural Resource Reporting standards.

At the end of each 6 year round, I&M staff will produce a detailed report of findings, including long-term trend analyses when applicable, following the guidelines described in NCRN BSS SOP#23 6 Year Reporting Requirements.

Revising the Protocol and Archiving Previous Versions of the Protocol

Over time, revisions to both the Protocol Narrative and to specific Standard Operating Procedures (SOPs) are to be expected. Careful documentation of changes to the protocol, and a library of previous protocol versions are essential for maintaining consistency in data collection, and for appropriate treatment of the data during data summary and analysis. The MS Access database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected.

The rationale for dividing a sampling protocol into a Protocol Narrative with supporting SOPs is based on the following:

The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol.

The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.

When an SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.

All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

The steps for changing the protocol (either the Protocol Narrative or the SOPs) are outlined in SOP #21, "Revising the Protocol". Each SOP contains a Revision History Log that should be filled out each time a SOP is revised to explain why the change was made, and to assign a new Version Number to the revised SOP. The new version of the SOP and/or Protocol Narrative should then be archived.

This protocol includes monitoring of three related vital signs: fish, macroinvertebrates, and physical habitat. The protocol is based on the Maryland Department of Natural Resources (MD-DNR) Maryland Biological Stream Survey (MBSS). 23 standard operating procedures (SOPs) document the methods used to collect the relevant data. The protocol was developed in 2005 by Robert H. Hilderbrand, Richard L Raesly, and Daniel M. Boward, of the University of Maryland Center for Environmental Sciences – Appalachian Laboratory (UMCES-AL) and Maryland Department of Natural Resources (MD DNR) who perform sampling and data analysis as part of the MBSS, so that data collected will be compatible with that from the rest of the state to provide a wider context for trends in the NCRN parks.

The Protocol was revised and expanded (Version 2 by Norris and Sanders) in 2009 to include revisions to the MBSS program made by MD DNR for the State's Round three sampling as well as revisions to the I&M Water Program sampling design and clarifications for NPS contractors. The February 2009 version of the protocol as written by Hilderbrand *et al*. was revised to incorporate changes to the MBSS manuals for Round 3 (Southerland 2007).

Literature Cited

Allan, J.D., and L. B. Johnson. 1997. Catchment-scale analysis of aquatic ecosystems. Freshwater Biology 37:107-111.

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 2005. Standard Methods for the Examination of Water and Wastewater : 21st Edition. American Public Health Association, Washington, D.C.

Astin, L. E., 2006. Data synthesis and bioindicator development for nontidal streams in the interstate Potomac River basin, USA. Ecological Indicators 6:664-685.

Barbour, M.T., and J.B. Stribling. 1991. Use of habitat assessment in evaluating the biological integrity of stream communities. In: Biological Criteria: Research and Regulation. U.S. Environmental Protection Agency, Washington, DC. EPA 440/5-91-005.

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. United States Environmental Protection Agency, Office of Water, Washington, DC. EPA 841/B/99-002.

Berkman, H.E., C.F. Rabeni, and T.P. Boyle. 1986. Biomonitors of stream quality in agricultural areas: fish vs. invertebrates. Environmental Management 10:413-419.

Boulton, A.J. 1999. An overview of river health assessment: philosophies, practice, problems, and prognosis. Freshwater Biology 41:469-479.

Boward, D., and E. Friedman. 2001. Maryland Biological Stream Survey: laboratory methods for benthic macroinvertebrate processing and taxonomy. Prepared by Maryland Department of Natural Resources (CBWP-MANTA-EA-00-6).

Calow, P. 1992. Can ecosystems be healthy? Critical consideration of concepts. Journal of Aquatic Ecosystem Health 1:1-5.

EPA (U.S. Environmental Protection Agency). 1987. Handbook of methods for acid deposition studies: Laboratory analysis for surface water chemistry. EPA-600/4-87/026.

Fausch, K.D., J. Lyons, J.R. Karr, and P.L. Angermeier. 1990. Fish communities as indicators of environmental degradation. American Fisheries Society Symposium 8:123-144.

Fausch, K.D., J.R. Karr, and P.R. Yant. 1984. Regional application of an index of biotic integrity based on stream fish communities. Transactions of the American Fisheries Society 113:39-55.

Heimbuch, D.G., H.T. Wilson, S.B. Weisberg, J.H. Volstad, and P.F. Kazyak. 1997. Estimating fish abundance in stream surveys using double-pass removal sampling. Transactions of the American Fisheries Society 126:795-803.

Hilderbrand, R. H., R. L. Raesly and D. M. Boward, 2005. Sampling Results for Inventory and Monitoring Protocols for Water Resources of National Capital Region Parks, Final Report. In, Editor (Editor)^(Editors). National Park Service, Washington, DC.

Hilsenhoff, W.L. 1987. An improved biotic index or organic stream pollution. Great Lakes Entomologist 20:31-39.

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. On Internet at http://www.nature.nps.gov/water/Vital_Signs_Guidance/Guidance_Documents/PartBLite.pdf.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

Karr, J.R. 1991. Biological integrity: a long-neglected aspect of resource management. Ecological Applications 1:66-84.

Karr, J.R. and D.R. Dudley. 1981. Ecological perspectives on water quality goals. Environmental Management 5:55-68.

Karr, J.R. and E.W. Chu. 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington, D.C.

Karr, J.R., R.C. Heidinger, and E.H. Helmer. 1985. Sensitivity of the index of biotic integrity to changes in ammonia and chlorine levels from wastewater treatment facilities. Journal of the Water Pollution Control Federation 57:912-915.

Kazyak, P. F., J. V. Kilian, S. A. Stranko, M. K. Hurd, D. M. Boward, C. J. Millard and A. Schenk, 2005. Maryland Biological Stream Survey 2000-2004 Volume 9: Stream and Riverine Biodiversity. In: Maryland Biological Stream Survey 2000-2004, Editor (Editor)^(Editors). Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division Report EA-05-6, Annapolis, Maryland.

Kazyak, P.F. 2001. Maryland Biological Stream Survey sampling manual. Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division, Annapolis, Maryland.

Kerans, B.L., and J.R. Karr. 1994. A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. Ecological Applications 4:768-785.

Kline, K.M. and R.P. Morgan. 2002. Summary of Quality Assurance/Quality Control Results from Spring 2002 Water Chemistry Analysis of the Maryland Biological Stream Survey. University of Maryland Center for Environmental Science Appalachian Laboratory.

Leonard, P.M. and D.J. Orth. 1986. Application and testing of an index of biotic integrity in small coolwater streams. Transactions of the American Fisheries Society 115:401-415.

Lyons, J., L. Wang, and T.D. Simonson. 1996. Development and validation of an index of biotic integrity for coldwater streams in Wisconsin. North American Journal of Fisheries Management 16:241-256.

Mid-Atlantic Coastal Stream Workgroup (MACS). 1996. Standard operating procedures and technical basis: Macroinvertebrate collection and habitat assessment for low-gradient nontidal streams. Delaware Department of Natural Resources and Environmental Conservation, Dover, Delaware.

Norris, M. E., J. M. Pieper and A. Cattani, 2008. National Capital Region Network Inventory & Monitoring Program Water Chemistry Monitoring Protocol. National Park Service, Washington, District of Columbia.

Norris, R.H., and M.C. Thoms. 1999. What is river health? Freshwater Biology 41:197-209.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31(4):1000–1003.

Ohio Environmental Protection Agency. (Ohio EPA) 1987. Biological criteria for the protection of aquatic life. Volumes I-III. Ohio EPA, Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Osborne, L.L., S.L. Kohler, P.B. Bayley, D.M. Day, W.A. Bertrand, M.J. Wiley, and R. Sauer. 1992. Influence of stream location in a drainage network on the index of biotic integrity. Transactions of the American Fisheries Society 121:635-643.

Paller, M.H., W.M. Lewis, R.C. Heidinger, and L.W. Wawronowicz. 1983. Effects of ammonia and chlorine in streams receiving secondary discharges. Journal of the Water Pollution Control Federation 55:1087-1097.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA 440-4-89-001.

Rahel, F. J., 2002. Homogenization of freshwater faunas. Annual Review of Ecology and Systematics 33:291-315.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Ohio EPA, Division of Water Quality Planning and Assessment, Ecological Analysis Section, Columbus Ohio.

Reash, R.J. and T.M. Berra. 1987. Comparison of fish communities in a clean water and an adjacent polluted stream. American Midland Naturalist 118:301-322.

Reynoldson, T.B., R.H. Norris, V.H. Resh, K..E. Day, and D. Rosenberg. 1997. The reference condition: a comparison of multimetric and multivariate approaches to assess water-quality impairment using benthic macroinvertebrates. Journal of the North American

Benthological Society 16:833-852.

Rogers, G., D. Baxter, J. Volstad, and N. Roth. 2003. Maryland Biological Stream Survey Quality Assurance Report. 2002. Prepared by Versar, Inc., Columbia, MD for the Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division.

Roth, N..E.., M.T. Southerland, G. Mercurio, J.C. Chaillou, P.F. Kazyak, S.S. Stranko, A.P. Prochaska, D.G. Heimbuch, and J.C. Seibel. 1999. State of the Streams: 1995-1997 Maryland Biological Stream Survey Results. Prepared by Versar, Inc., Columbia, MD and Post, Buckley, Schuh, and Jernigan, Inc., Bowie, MD and Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. CBWP-MANTA-EA-99-6.

Roth, N.E, , M.T. Southerland, G. Mercurio, and J.H. Volstad. 2001. Maryland Biological Stream Survey 2000-2004 Volume 1: ecological assessment of watersheds sampled in 2000. Report submitted to Maryland Department of Natural Resources (CBWP-MANTA-EA-01-5).

Roth, N.E., J.D. Allan, and D.L. Erickson. 1996. Landscape influences on stream biotic integrity assessed at multiple spatial scales. Landscape Ecology 11:141-156.

Roth, N.E., M.T. Southerland, J.C. Chaillou, P.F. Kazyak, and S.A. Stranko. 2000. Refinement and validation of a fish Index of Biotic Integrity for Maryland streams. Prepared by Versar, Inc., Columbia, MD, with Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. CBWP-MANTA-EA-00-2.

Roth, N.E., M.T. Southerland, J.C. Chaillou, R.J. Klauda, P.F. Kazyak, S.A. Stranko, S.B. Weisberg, L.W. Hall, Jr., and R.P. Morgan II. 1998. Maryland Biological Stream Survey: Development of a Fish Index of Biotic Integrity. Environmental Management and Assessment 51:89-106.

Scrimgeour, G.J., and D. Wicklum. 1996. Aquatic ecosystem health and integrity: problems and potential solutions. Journal of the North American Benthological Society 15:254-261.

Southerland, M., 2007. Round 3 Design Section for MBSS manual - unpublished draft. Versar, Inc.

Southerland, M., B. Franks and G. Rogers, 2007. Round 3 MBSS manual – IBI section. Versar, Inc.

Starnes, W.C. 2002. Current diversity, historical analysis, and biotic integrity of fishes in the lower Potomac drainage in the vicinity of Plummers Island, Maryland. Proc. Biol. Soc. Wash. 115:273-320.

Strahler, A. N., 1957. Quantitative analysis of watershed geomorphology. *Transactions of the American Geophysical Union* 38:913-920.

Stribling, J.B., B.K. Jessup, J.S. White, D. Boward, and M. Hurd. 1998. Development of a Benthic Index of Biotic Integrity for Maryland Streams. Prepared by Tetra Tech, Inc., Owings Mills, MD and Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Program. CBWP-MANTA-EA-98-3.

Suter, G. W. 1993. A critique of ecosystem health concepts and indexes. Environmental Toxicology and Chemistry 12:1533-1539.

Turak, E., L.K. Flack, R. H. Norris, J. Simpson, and N. Waddell. 1999. Assessment of river condition at a large spatial scale using predictive models. Freshwater Biology 41:283-298.

Wallace, J.B., J.W. Grubaugh, and M.R. Whiles. 1996. Biotic indices and stream ecosystem processes: results from an experimental study. Ecological Applications 6:140-151.

Weaver, L.A. and G.C. Garman. 1994. Urbanization of a watershed and historical changes in a stream fish assemblage. Transactions of the American Fisheries Society 123:162-172.

Wiley, M.J., L.L. Osborne, and R.W. Larimore. 1990. Longitudinal structure of an agricultural prairie river system and its relationship to current stream ecosystem theory. Canadian Journal of Fisheries and Aquatic Sciences 47:373-384.

Appendix A: Data Sheets and Sampling Forms

MBSS SPRING INDEX PERIOD DATA SHEET

SITE Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year ☐☐☐☐

BASIN ☐☐

DATE Year ☐☐ Month ☐☐ Day ☐☐

TIME ☐☐☐☐ (Military)

Reviewed By: _____

2nd Reviewer: _____

CREW: _____

STREAM: _____

LOCALITY: _____

SITE ACCESS ROUTE _____

SAMPLEABILITY

- ☐ Benthos
- ☐ Habitat Assessment
- ☐ Water Quality

TEMP. LOGGER ☐ (Y/N) **NUM.** ☐☐☐☐☐☐

AIR LOGGER ☐ (Y/N) **NUM.** ☐☐☐☐☐☐

LOCATION _____

SAMPLE LABELS

1L Bottle Label Verified by: _____

500 mL Bottle Label Verified by: _____

Syringe Label Verified by: _____

Benthos Label Verified by: _____

Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year ☐☐☐☐

1L Bottle Label Verified by: _____

500 mL Bottle Label Verified by: _____

Syringe Label Verified by: _____

Benthos Label Verified by: _____

Duplicate (D) or Blank (B): ☐

PHOTODOCUMENTATION

Time	#	Title
☐☐☐☐	☐	_____
☐☐☐☐	☐	_____
☐☐☐☐	☐	_____
☐☐☐☐	☐	_____
☐☐☐☐	☐	_____

BENTHIC HABITAT SAMPLED

- ☐☐☐ Riffle
- ☐☐☐ Rootwad/Woody Debris
- ☐☐☐ Leaf Pack
- ☐☐☐ Macrophytes
- ☐☐☐ Undercut Banks
- ☐☐☐ Other (specify)_____

HERPTOFAUNA

Seen (Y/N)	Heard (Y/N)	Retained	
☐	☐	☐	_____
☐	☐	☐	_____
☐	☐	☐	_____
☐	☐	☐	_____
☐	☐	☐	_____

COMMENTS/SAMPLING CONSID.: (☐ NUM. ANODES) _____

Information Codes for Spring Index Sampling

Drainage Basin Codes
NO = North Branch Potomac River
UP = Upper Potomac River
MP = Middle Potomac River
PW = Potomac Washington Metro
LP = Lower Potomac River

Watershed	Abbreviation
Anacostia River	ANAC
Antietam Creek	ANTI
Cabin John Creek	CABJ
Catoctin Creek	CATO
Conococheague	CONO
Evitts Creek	EVIT
Fifteen Mile Creek	FIMI
Little Conococheague	LCON
Licking Creek	LIKG
Lower Monocacy River	LMON
Little Tonoloway	LTON
Marsh Run	MARS
Oxon Creek	OXON
Piscataway Creek	PISC
Potomac AL Co	PRAL
Potomac River FR Co	PRFR
Pot. River Lower North Br	PRLN
Potomac Lower Tidal	PRLT
Potomac River MO Co	PRMO
Potomac River Middle Tidal	PRMT
Pot. River Upper North Br	PRUN
Potomac Upper Tidal	PRUT
Potomac WA Co	PRWA
Rock Creek	ROCK
Seneca Creek	SENE
Sideling Hill Creek	SIDE
Tonoloway	TONO
Town Creek	TOWN
Wills Creek	WILL

Park Codes

Antietam Nat. Bat.	ANTI
C&O Canal	CHOC
Catoctin Mountain Park	CATO
George Wash. Mem. Parkway	GWMP
Harper's Ferry	HAFE
Manassas Nat. Bat.	MANA
Monocacy Nat. Bat	MONO
National Capital Parks East	NACE
Rock Creek Park	ROCR
Prince William Forest Park	PRWI
Wolf Trap	WOTR

VEGETATION TYPES
G= Grasses /Forbes
R= Regen Deciduous /Shrubs (<4"DBH)
Y= Young Deciduous (4-12" DBH)
M= Mature Deciduous (12-24" DBH)
O= Old Deciduous (>24" DBH)
A= Regen Coniferous (<4" DBH)
B= Young Coniferous (4-12" DBH)
C= Mature Coniferous (12-24" DBH)
D= Old Coniferous (>24" DBH)
L= Lawn

Riparian Buffer Zone/ Adjacent Land Cover Types

FR = Forest
OF = Old Field
EM = Emergent Vegetation
LN = Mowed Lawn
TG = Tall Grass
LO = Logged Area
SL = Bare Soil
RR = Railroad
PV = Paved Road
PK = Parking Lot/ Industrial/ Commercial
GR = Gravel Road
DI = Dirt Road
PA = Pasture
OR = Orchard
CP = Cropland
HO = Housing

Site Type
R = Random (Inventory)
M = Monitoring (Long-term)
S = Sentinel

INSTREAM BLOCKAGE CODES

DM = Dam
PC = Pipe Culvert
F = Fishway
GW =Gaging Station Weir
G = Gabion
PX = Pipeline Crossing
AC = Arch Culvert
BC = Box Culvert
TG = Tide Gate

(Note: Height is measured in meters from stream surface to water surface above structure)

Sampleability Codes
s = Sampleable
1 = Dry Stream bed
2 = Too Deep
3 = Marsh, no defined channel
4 = Excessive Riparian Vegetation
5 = Impoundment
6 = Tidally Influenced
7 = Permission Denied
8 = Unsafe (Describe in Comments)
9 = Beaver
10 = Other

VEGETATION TYPES
G= Grasses/Forbes
R= Regen Deciduous/Shrubs (<4"dbh)
Y= Young Deciduous (4-12" DBH)
M= Mature Deciduous (12-24" DBH
O= Old Deciduous (>24" DBH)
A= Regen Coniferous (<4" DBH)
B= Young Coniferous (4-12" DBH)
C= Mature Coniferous (12-24" DBH
D= Old Coniferous (>24" DBH)
L= Lawn

Riparian Buffer Zone/ Adjacent Land Cover Types

FR = Forest
OF = Old Field
EM = Emergent Vegetation
LN = Mowed Lawn
TG = Tall Grass
LO = Logged Area
SL = Bare Soil
RR = Railroad
PV = Paved Road
PK = Parking Lot/ Industrial/ Commerical
GR = Gravel Road
DI = Dirt Road
PA = Pasture
OR = Orchard
CP = Cropland
HO = Housing

MBSS SPRING HABITAT DATA SHEET

Page ☐ of ☐

SITE Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year ☐☐☐☐

Reviewed By: _____

DATE Year ☐☐ Month ☐☐ Day ☐☐

2nd Reviewer: _____

☐☐☐☐ Dist. to Nearest Road (m)

☐☐ Trash Rating 0 - 20

STREAM WIDTH (m)

0 m ☐☐☐.☐

75 m ☐☐☐.☐

STRAIGHT LINE DIST.

(m) ☐☐

RIPARIAN VEGETATION

(facing upstream)

LEFT BANK	RIGHT BANK	
☐☐	☐☐	Width (50m max)
☐☐	☐☐	Adjacent Land Cover
☐☐☐☐	☐☐☐☐	Vegetation Type
☐	☐	Buffer Breaks (Y/N)

Buffer Break Types
(M = minor; S = severe)

☒	☒	Storm Drain
☒	☒	Tile Drain
☒	☒	Impervious Drainage
☒	☒	Gully
☒	☒	Orchard
☒	☒	Crop
☒	☒	Pasture
☒	☒	New Construction
☒	☒	Dirt Road
☒	☒	Gravel Road
☒	☒	Raw Sewage
☒	☒	Railroad

ROAD CULVERT

Present in Segment? (Y/N) ☐

Sampleable? (Y/N) ☐

Width of Culvert? (m) ☐☐

Length of Culvert? (m) ☐☐

Location (m)	Height (m)
☐☐	☐☐.☐
☐☐	☐☐.☐
☐☐	☐☐.☐
☐☐	☐☐.☐
☐☐	☐☐.☐
☐☐	☐☐.☐

LANDUSE (Y/N)

☐ Old Field	☐ Residentia
☐ Deciduous Forest	☐ Commercial/Industria
☐ Coniferous Forest	☐ Cropland
☐ Wetland	☐ Pasture
☐ Surface Mine	☐ Orchard/Vineyard/Nursery
☐ Landfil	☐ Golf Course

CHANNELIZATION

☐ Evidence of Channel Straightening or Dredging (Y/N)

TYPE	EXTENT (m) LEFT BANK	BOTTOM	RIGHT BANK
Concrete	☐☐	☐☐	☐☐
Gabion	☐☐	☐☐	☐☐
Rip-Rap	☐☐	☐☐	☐☐
Earthen Berm	☐☐	N/A	☐☐
Dredge Spoil Off Channel	☐☐	N/A	☐☐
Pipe Culvert	☐☐	☐☐	☐☐

Actual Coordinates
(If >30m distance between origina coordinates and stream)

	deg	min	sec
	☐☐	☐☐	☐☐
	☐☐	☐☐	☐☐

Stream Block Ht. (M) ☐☐.☐

Stream Block Type ☐☐

Photo Y/N ☐

	deg	min	sec
Lat	☐☐	☐☐	☐☐.☐
Lon	☐☐	☐☐	☐☐.☐

Summer Index Data Sheet 1

MBSS SUMMER INDEX PERIOD DATA SHEET

MBSS FISH DATA SHEET

Page ____ of ____

Page ____ of ____

SITE

Watershed Code | Segment | Type | Year

BASIN

Reviewed By: _____

2nd Reviewer: _____

DATE (Year / Month / Day) (Y/N)

CREW

COMMENT

Fish Move. During Net Install.?

Bottom Visible in all Areas of Seg.?

TIME (Military)

Same Water Clarity - 2nd Pass?

Begin 1st p.

Begin 2nd p.

Volt. | Waveform

End 2nd p.

Len. of Seg. Actually Samp. (m)

PHOTODOCUMENTATION (Optional)

Fish Captured? (Y/N)

Gamefish (Y/N)

Unit | Time | Number | Title

Unit | Time | Number | Title

Unit | Time | Number | Title

Unit | Time | Number | Title

SPECIES

SAMPLEABILITY

Number Retained? or Photo

1st Pass Catch (Total)

2nd Pass Catch (Total)

Anomalies (Y/N)

AQUATIC VEGETATION

Comments

(A, P, or E)

s = Sampleable
1 = Dry Streambed
2 = Too Deep
3 = Marsh, no defined channel
4 = Excessive Riparian Vegetation
5 = Impoundment
6 = Tidally Influenced
7 = Permission Denied
8 = Unsafe (describe in comments)
9 = Beaver
10 = Other

Electrofishing

Habitat Assessment

Water Quality

Herpetofauna

Mussels

Aquatic Plants

Submerged Aquatic Vegetation

Emergent Aquatic Vegetation

Floating Aquatic Vegetation

(Absent, Present, Extensive)

HERPETOFAUNA

Taxa Observed

Number retained or Photo

WATER QUALITY

Temp (C)

DO (ppm)

pH

Cond (umho/cm)

Turbidity (NTU)

Meter Calibrations by:

MUSSELS

Taxa Observed

(N,O,R, or L)

Retained? (Y/N)

Unionids

Corbicula

None Old Shell, Recent Shell, Live

Aggregate Fish Biomass (g)

MBSS GAME FISH LENGTH DATA SHEET

Page ____ of ____

SITE Watershed Code ____ Segment ____ Type ____ Year ____

Reviewed By: _____

2nd Reviewer: _____

SPECIES	LENGTH (TL; mm)	SPECIES	LENGTH (TL; mm)
1.		31.	
2.		32.	
3.		33.	
4.		34.	
5.		35.	
6.		36.	
7.		37.	
8.		38.	
9.		39.	
10.		40.	
11.		41.	
12.		42.	
13.		43.	
14.		44.	
15.		45.	
16.		46.	
17.		47.	
18.		48.	
19.		49.	
20.		50.	
21.		51.	
22.		52.	
23.		53.	
24.		54.	
25.		55.	
26.		56.	
27.		57.	
28.		58.	
29.		59.	
30.		60.	

MBSS GAME FISH LENGTH DATA SHEET (continued)

Page ____ Of ____

SITE Watershed Code ____ Segment ____ Type ____ Year ____

Reviewed By: _____

2nd Reviewer: _____

SPECIES	LENGTH (TL; mm)	SPECIES	LENGTH (TL; mm)

MBSS FISH DATA SHEET

Page ____ of ____

SITE Watershed Code ____ Segment ____ Type ____ Year ____

Reviewed By: _____

2nd Reviewer: _____

	(Y/N)
Fish Move. During Net Install.?	
Bottom Visible in all Areas of Seg.?	
Same Water Clarity - 2nd Pass?	
Volt. ____ Waveform ____	
Len. of Seg. Actually Samp. (m) ____	

Anodes/Un	Unit ____	Unit ____	Unit ____	Unit ____	Unit ____
Begin 1st p.					
Begin 2nd p.					
End 2nd p.					

SPECIES	Fish Captured? (Y/N) / Gamefish (Y/N)	Number Retained? or Photo	1st Pass Catch (Total)	2nd Pass Catch (Total)	Anomalies (Y/N)	Comments

Aggregate Fish Biomass ____ ____ (g)

MBSS SUMMER HABITAT DATA SHEET

Page ____ of ____

SITE BASIN

Watershed Code ____ Segment ____ Type ____ Year ____

Reviewed By: _____

2nd Reviewer: _____

BANK EROSION

	Left Bank	Right Bank
Extent (m)		
Severity (0=none, 1=min, 2=mod, 3=severe)		
Average Height (m)		
Eroded Area (m^2) x 10		

BAR FORMATION & SUBSTRATE

- ☐ None
- ☐ Minor
- ☐ Moderate
- ☐ Extensive
- ☐ Cobble
- ☐ Gravel
- ☐ Sand
- ☐ Silt/Clay

EXOTIC PLANTS Relative Abundance

(A, P, E)

- ☐ Multiflora Rose
- ☐ Mile-a-Minute
- ☐ Japanese Honeysuckle
- ☐ Phragmites
- ☐ Thistle
- ☐ Japanese Stilt Grass
- ☐ _____

- ☐☐ No. of Instream Woody Debris
- ☐☐ No. of Dewatered Woody Debris
- ☐☐ No. of Instream Rootwads
- ☐☐ No. of dewatered Rootwads

HABITAT ASSESSMENT

1. Instream Habitat (0-20) ☐☐
2. Epifaunal Substrate (0-20) ☐☐
3. Velocity/Depth Diversity (0-20) ☐☐
4. Pool/Glide/Eddy Quality (0-20) ☐☐
   - Extent (m) ☐☐
5. Riffle/Run Quality (0-20) ☐☐
   - Extent (m) ☐☐
6. Embeddedness (%) ☐☐☐
7. Shading (%) ☐☐☐

STREAM

- ☐ Braided
- ☐ Riffle
- ☐ Run/Glide
- ☐ Deep Pool(>= .5m)
- ☐ Shallow Pool(< .5m)
- ☐ Boulder >2m
- ☐ Boulder <2m
- ☐ Cobble
- ☐ Bedrock
- ☐ Gravel
- ☐ Sand
- ☐ Silt/Clay
- ☐ Undercut Bank
- ☐ Overhead Cover
- ☐ Beaver Pond

A = Absent
P = Present
E = Extensive

Maximum Depth (cm) ☐☐☐

	Wetted Width (m)	Thalweg Depth (cm)	Thalweg Velocity (m/s)
0 m			
25 m			
50 m			
75 m			

FLOW

Lat Loc (m)	Depth (cm)	Velocity (m/s)
0 0 0 0	0 0 0	0 0 0

Alternative Flow Measurements

- Distance (cm) ☐☐☐
- Depth (cm) ☐
- Width (cm) ☐☐
- Time (sec) 1. ☐☐☐ 2. ☐☐☐ 3. ☐☐☐

COMMENTS _____

Sampling Label for Water Samples and Benthic Invertebrate Samples

_ _ _ _- _ _ _ - _ - _ _ _ _	BASIN:_ _
DATE: _ _ / _ _ / _ _ _ _	TIME: _ _ : _ _
SAMPLER: _____	NPS NCR

Explanation:

Park Code - Segment - Type - Year Basin: (use codes)

Date: Day/ Month/ Year Time: (military)

Sampler: NPS NCR

Benthic Macroinvertebrate Chain of Custody Sheet

Site ID	Collector (print)	Collection Date (DD/MM/YY)	Date Delivered to Field Office (DD/MM/YY)	Relinquished By (print)	Received by (print)	Field Office Log Number

Comments

Guidance for Benthic Macroinvertebrate Sample Chain-of-Custody Sheet

General

This sheet provides a means of tracking the transfer of benthic macroinvertebrate samples between field collecting crews and DNR field office personnel responsible for processing the samples. If multiple sample containers are delivered for a single site, enter each container on a separate row. If entries are repeated down a row, it is not necessary to enter the information in each cell. Simply use an arrow or quote marks to indicate the information is repeated down the row. Please write as legibly as possible following the guidelines below. The entry of a printed name indicates responsibility of the individual for relinquishing or receiving each sample.

1.	***Site ID***	Enter the site ID just as it appears on the field data form.
2.	***Collector (print)***	Print the name of the person who collected the benthic sample.
3.	***Collection Date***	Enter the date the sample was collected (using DD/MM/YY format) just as it appears on the field data form.
4.	***Date Delivered to Field Office***	Enter the date the sample was delivered to the field office using DD/MM/YY format.
5.	***Relinquished By (print)***	Enter the printed name of the person relinquishing the sample to the appropriate field office staff member.
7.	***Received By (print)***	Enter the printed name of the person receiving the sample at the field office.
8.	***Field Office Log-In Number***	(Done by field office personnel) Enter the Benthic Sample Log-in number.
9.	***Comments***	Place any pertinent comments regarding the delivered samples, including unusual circumstances, here. Examples include “label for sample from site HA-P-056-312 fell off - see label in container” or “some of sample for site HA-P-056-312 spilled while in transport”.

If you have questions regarding the use of this sheet or the benthic sample chain-of-custody procedure, call Dan Boward at 410-974-3767.

Chain of Custody Form for Water Samples

UMCES - Appalachian Laboratory
301 Braddock Road
Frostburg, MD 21532

Chain of Custody Record
Maryland Biological Stream Survey
Spring Index Period

Date of Shipment	Cooler Temperature on Receipt	Analyze For:
YYMMDD _____	_____ °C	1-L Grab: DOC, TDP, TDN, Cl, NO_2, NO_3, PO_4, SO_4, NH3, PP, PN 0.5-L Grab: Specific conductance, ANC Syringe: closed pH

Sample Identification

Site ID	Date YYMMDD	Time Military	Site ID	Date YYMMDD	Time Military
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Field Comments:

Cooler Contents
Total Number of:

Syringes _____
1-L Bottles _____
0.5-L Bottles _____

Cooler relinquished by: _____
(print name)
_____
(signature)

Cooler received by: _____
(print name)
_____
(signature)

Date and Time of Receipt at Laboratory:
YYMMDD _____ Time (24hr) _____

Lab Comments:

Page ____ of ____

Voucher Label for Fish

Maryland Biological Stream Survey

SITE ID_____
Cat. No._____ Family:_____
Species:_____
Basin: _____ Date: _____
State: _____ County:_____
Locality: _____
Lat: _____ Lon:_____
Col. By: _____
Det. By: _____No.Specimens:_____

MBSS Benthic Macroinvertebrate
Laboratory Bench Sheet

Office Use Only			
E1D___	Init___	E2D___	Init___

Site: _____-____-_____-_____ Collection Date _____ Date IDed _____
Log No. _____ Subsampler _____ Taxonomist _____
Collector _____ No. of Grids _____

NEMATOMORPHA		**GAMMARIDAE**		**ODONATA**		**TAENIOPTERYGIDAE**	
GORDIIDAE		*Gammarus sp.*		**AESHNIDAE**		*Oemopteryx sp.*	
				Basiaeschna sp.		*Strophopteryx sp.*	
TURBELLARIA		**TALITRIDAE**		*Boyeria sp.*		*Taeniopteryx sp.*	
Cura sp.		Hyalella sp.					
Dugesia sp.				**CALOPTERYGIDAE**		**HEMIPTERA**	
		PALEMONIDAE		*Calopteryx sp.*		**BELOSTOMATIDAE**	
OLIGOCHAETA		*Palaemonetes sp.*				*Belostoma sp.*	
ENCHYTRAEIDAE				**COENAGRIONIDAE**			
		ISOPODA		*Argia sp.*		**CORIXIDAE**	
LUMBRICULIDAE		**ASELLIDAE**		*Enallagma sp.*		*Palmacorixia sp.*	
		Caecidotea sp.				*Trichocorixa sp.*	
NAIDIDAE		*Lirceus sp.*		**CORDULAGASTRIDAE**			
				Cordulagaster sp.		**GERRIDAE**	
TUBIFICIDAE		**CAMBARIDAE**		**CORDULIIDAE**		*Gerris sp.*	
Limnodrilus sp.		*Cambarus sp.*		*Macromia sp.*		*Trepobates sp.*	
Spirosperma sp.		*Orconectes sp.*		*Somatochlora sp.*		*Limnoporus sp.*	
		Procambarus sp.				*Metrobates sp.*	
HIRUDINEA				**GOMPHIDAE**			
ERPOBDELLIDAE		**INSECTA**		*Arigomphus sp.*		**NOTONECTIDAE**	
		COLLEMBOLA		*Gomphus sp.*		*Bueno sp.*	
PISCICOLIDAE		**ISOTOMIDAE**		*Lanthus sp.*		*Notonecta sp.*	
Piscicola sp.		*Isotomurus sp.*		*Progomphus sp.*			
				Stylogomphus sp.		**VELLIDAE**	
GASTROPODA		**EPHEMEROPTERA**		*Hagenius sp.*		*Microvelia sp.*	
VIVIPARIDAE		**AMELETIDAE**		*Dromogomphus sp.*		*Rhagovelia sp.*	
Campeloma sp.		*Ameletus sp.*					
Viviparus sp.				**LIBELLULIDAE**		**MEGALOPTERA**	
		LEPTOPHLEBIIDAE		*Leucorrhinia sp.*		**CORYDALIDAE**	
		Habrophlebia sp.		*Libellula sp.*		*Chauliodes sp.*	
LYMNAEIDAE		*Leptophlebia sp.*		*Erythemis sp.*		*Corydalus sp.*	
Pseudosuccinea sp.		*Paraleptophlebia sp.*				*Nigronia sp.*	
Radix sp.				**PLECOPTERA**			
Stagnicola sp.		**EPHEMERIDAE**		**CAPNIDAE**		**SIALIDAE**	
		Ephemera sp.		*Allocapnia sp.*		*Sialis sp.*	
				Paracapnia sp.			
PLANORBIDAE						**NEUROPTERA**	
Gyraulus sp.		**EPHEMERELLIDAE**		**CHLOROPERLIDAE**			
Helisoma sp.		*Drunella sp.*		*Alloperla sp.*		**TRICHOPTERA**	
Menetus sp.		*Eurylophella sp.*		*Haploperla sp.*		**BRACHYCENTRIDAE**	
Planorbella sp.		*Ephemerella sp.*		*Sweltsa sp.*		*Brachycentrus sp.*	
Promenetus sp.		*Serratella sp.*				*Micrasema sp.*	
				LEUCTRIDAE			
		HEPTAGENIIDAE		*Leuctra sp.*		**DIPSEUDOPSIDAE**	
PLEUROCERIDAE		*Cinygmula sp.*		*Paraleuctra sp.*		*Phylocentropus sp.*	
Goniobasis sp.		*Epeorus sp.*					
Leptoxis sp.		*Heptagenia sp.*		**NEMOURIDAE**		**GLOSSOSOMATIDAE**	
		Leucrocuta sp.		*Amphinemura sp.*		*Agapetus sp.*	
		Nixe sp.		*Ostrocerca sp.*		*Glossosoma sp.*	
ANCYLIDAE		*Stenacron sp.*		*Prostoia sp.*			
Ferrissia sp.		*Stenonema sp.*		*Shipsa sp.*		**HYDROPSYCHIDAE**	
				Soyedina sp.		*Cheumatopsyche sp.*	

APPENDIX B MASTER FISH SPECIES LIST FOR THE STATE OF MARYLAND

Ecological characteristics of fish species for use in IBI metrics (Southerland, Franks et al. 2007). Tolerance: I = intolerant, T = tolerant; Native/introduced status: N = native statewide, IC = introduced to Chesapeake drainage, IY = introduced to Youghiogheny, I = introduced statewide; Trophic groups: FF = filter feeder, TP = top predator, GE = generalist, IV = invertivore, IS = insectivore, OM = omnivore, AL = algivore, HE = herbivore; NOTYPE = no category assigned.

Common Name	Tolerance (Based on Data)	Native or Introduced	Trophic Status	Lithophilic Spawner
LAMPREY (UNKNOWN)	NOTYPE	N	FF	N
LAMPREY SP.	NOTYPE	N	FF	N
AMERICAN BROOK LAMPREY	NOTYPE	N	FF	N
LEAST BROOK LAMPREY	NOTYPE	N	FF	N
SEA LAMPREY	I	N	FF	N
LONGNOSE GAR	NOTYPE	N	TP	N
AMERICAN EEL	NOTYPE	N	GE	N
BLUEBACK HERRING	NOTYPE	N	IV	N
GIZZARD SHAD	NOTYPE	N	FF	N
CHAIN PICKEREL	NOTYPE	IY	TP	N
NORTHERN PIKE	NOTYPE	IC	TP	N
REDFIN PICKEREL	T	IY	TP	N
EASTERN MUDMINNOW	T	N	IV	N
CYPRINID HYBRID	NOTYPE	NOTYPE	NOTYPE	NOTYPE
CYPRINID (UNKNOWN)	NOTYPE	NOTYPE	NOTYPE	NOTYPE
BLACKNOSE DACE	T	N	OM	N
BLUNTNOSE MINNOW	T	N	OM	N
CENTRAL STONEROLLER	I	N	AL	Y
COMELY SHINER	I	N	IV	Y
COMMON CARP	NOTYPE	I	OM	N
COMMON SHINER	I	N	OM	Y
CREEK CHUB	T	N	GE	Y
CUTLIPS MINNOW	NOTYPE	N	IV	Y
CYPRINELLA SP.	I	N	IV	N
EASTERN SILVERY MINNOW	NOTYPE	N	AL	N
FALLFISH	I	N	GE	Y
FATHEAD MINNOW	NOTYPE	I	OM	N
GOLDEN SHINER	T	N	OM	N
GOLDFISH	NOTYPE	I	OM	N
IRONCOLOR SHINER	I	N	IS	Y
LONGNOSE DACE	NOTYPE	N	OM	N
LUXILUS SP.	NOTYPE	N	OM	Y
NOTROPIS SP.	NOTYPE	NOTYPE	NOTYPE	NOTYPE
PEARL DACE	NOTYPE	N	IV	Y
RIVER CHUB	I	N	OM	Y
ROSYFACE SHINER	NOTYPE	N	IV	Y

Appendix B. MASTER FISH SPECIES LIST FOR THE STATE OF MARYLAND

(Continued)

Common Name	Tolerance (Based on Data)	Native or Introduced	Trophic Status	Lithophilic Spawner
ROSYSIDE DACE	NOTYPE	N	IV	Y
SATINFIN SHINER	I	N	IV	N
SILVERJAW MINNOW	NOTYPE	N	OM	Y
SPOTFIN SHINER	I	N	IV	N
SPOTTAIL SHINER	I	N	OM	Y
STRIPED SHINER	I	N	OM	Y
SWALLOWTAIL SHINER	NOTYPE	N	IV	Y
CREEK CHUBSUCKER	NOTYPE	N	IV	N
GOLDEN REDHORSE	NOTYPE	N	OM	Y
NORTHERN HOGSUCKER	I	N	IV	Y
SHORTHEAD REDHORSE	NOTYPE	N	OM	Y
WHITE SUCKER	T	N	OM	Y
BULLHEAD (UNKNOWN)	NOTYPE	N	OM	N
BROWN BULLHEAD	T	N	OM	N
CHANNEL CATFISH	NOTYPE	IC	OM	N
MARGINED MADTOM	I	IY	IV	N
TADPOLE MADTOM	NOTYPE	N	IV	N
WHITE CATFISH	NOTYPE	IY	OM	N
YELLOW BULLHEAD	NOTYPE	N	OM	N
BROOK TROUT	I	N	GE	Y
BROWN TROUT	NOTYPE	I	TP	Y
CUTTHROAT TROUT	NOTYPE	I	TP	Y
RAINBOW TROUT	NOTYPE	I	TP	Y
PIRATE PERCH	T	N	IV	N
BANDED KILLIFISH	NOTYPE	N	IV	N
MUMMICHOG	NOTYPE	N	IV	N
RAINWATER KILLIFISH	NOTYPE	N	IV	N
MOSQUITOFISH	NOTYPE	N	IV	N
SCULPIN (UNKNOWN)	NOTYPE	N	IS	Y
CHECKERED SCULPIN	NOTYPE	N	IS	Y
MOTTLED SCULPIN	I	N	IS	Y
POTOMAC SCULPIN	NOTYPE	N	IS	Y
STRIPED BASS	NOTYPE	N	TP	N
WHITE PERCH	NOTYPE	N	IV	N
SUNFISH (UNKNOWN)	NOTYPE	NOTYPE	NOTYPE	NOTYPE
BANDED SUNFISH	NOTYPE	N	IV	N
BLACK CRAPPIE	NOTYPE	IC	GE	N
BLUEGILL	T	IC	IV	N
BLUESPOTTED SUNFISH	NOTYPE	N	IV	N
FLIER	I	N	IV	N
GREEN SUNFISH	T	IC	GE	N
LARGEMOUTH BASS	T	IC	TP	N

Appendix B. MASTER FISH SPECIES LIST FOR THE STATE OF MARYLAND (Continued)

Common Name	Tolerance (Based on Data)	Native or Introduced	Trophic Status	Lithophilic Spawner
LONGEAR SUNFISH	NOTYPE	IC	IV	Y
MUD SUNFISH	NOTYPE	N	IV	N
PUMPKINSEED	T	IY	IV	N
REDBREAST SUNFISH	NOTYPE	IY	GE	N
ROCK BASS	NOTYPE	IC	GE	Y
SMALLMOUTH BASS	NOTYPE	IC	TP	N
WARMOUTH	NOTYPE	N	GE	N
LEPOMIS HYBRID	NOTYPE	NOTYPE	NOTYPE	NOTYPE
DARTER (UNKNOWN)	NOTYPE	N	NOTYPE	Y
BANDED DARTER	NOTYPE	I	IS	Y
FANTAIL DARTER	NOTYPE	N	IS	Y
GLASSY DARTER	NOTYPE	N	IS	Y
GREENSIDE DARTER	NOTYPE	N	IS	N
JOHNNY DARTER	NOTYPE	N	IV	N
LOGPERCH	NOTYPE	N	IV	Y
RAINBOW DARTER	NOTYPE	N	IS	Y
SHIELD DARTER	I	N	IS	Y
STRIPEBACK DARTER	NOTYPE	N	IV	N
SWAMP DARTER	NOTYPE	N	IV	N
TESSELLATED DARTER	T	N	IV	N
YELLOW PERCH	NOTYPE	IY	GE	N
SPOT	NOTYPE	N	IV	N

APPENDIX C MASTER BENTHIC TAXA LIST FOR THE STATE OF MARYLAND

Master taxa list for benthic macroinvertebrates with designated tolerance value (Tol/Val), functional feeding group (FFG), and habitat. Abbreviations of habits are as follow: bu – borrower, cn – clinger, cb – climber, sp- sprawler, dv - diver, and sk – skater. Notes are keyed to comments at end of table (Southerland, Franks et al. 2007).

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
Nematomorpha						bu	1
Enopla	Hoplonemertea	Tetrastemmatidae		7.3	Predator		
			Prostoma	7.3	Predator		
Turbellaria				4	Predator	sp	
	Tricladida	Planariidae		8.4	Predator	sp	
			Cura	6.5		sp	
			Dugesia	9.3	Predator	sp	
			Phagocata	8.4	Predator		
Oligochaeta				10	Collector	bu	
	Haplotaxida	Enchytraeidae		9.1	Collector	bu	
		Naididae		8.5	Collector	bu	2
	Lumbricina				Collector	bu	
	Lumbriculida	Lumbriculidae		6.6	Collector	bu	2
	Tubificida	Haplotaxidae					
		Naididae	Chaetogaster				
		Tubificidae		8.4	Collector	cn	2
			Branchiura				
			Limnodrilus	8.6	Collector	cn	
			Spirosperma	6.6	Collector	cn	
Hirudinea		Hirudinea			Predator	sp	
	Pharyngobdellida	Erpobdellidae		10	Predator	sp	
			Mooreobdella	8	Predator	sp	
	Rhynchobdellida	Glossiphoniidae		6	Predator	sp	
			Alboglossiphonia	6	Predator		
			Batracobdella	6	Predator		
			Helobdella	6	Predator	sp	
			Placobdella	6	Predator		
		Piscicolidae					
Gastropoda							
	Basommatophora	Ancylidae		7	Scraper	cb	
		Lymnaeidae		6.9	Scraper	cb	
			Fossaria	6.9	Scraper	cb	
			Lymnaea	6.9	Scraper	cb	
			Pseudosuccinea	6.3	Collector	cb	
			Radix	6.9	Collector	cb	
			Stagnicola	7.8	Scraper	cb	
		Physidae		7	Scraper	cb	
			Physella	7	Scraper	cb	
		Planorbidae		7.6	Scraper	cb	
			Gyraulus	7.6	Scraper	cb	
			Helisoma	7.6	Scraper	cb	
			Menetus	7.6	Scraper	cb	
			Planorbella	7.6	Scraper	cb	
			Promenetus	7.6	Scraper	cb	
	Bivalvia	ORDER					

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
	Limnophila	Ancylidae	Ferrissia	7	Scraper	cb	
	Mesogastropoda	Bithyniidae					
			Bithynia	9	Scraper	cb	
		Hydrobiidae		8	Scraper	cb	
			Amnicola	8	Scraper	cb	
			Hydrobia	8	Scraper	cb	
		Pleuroceridae					
			Goniobasis	10	Scraper	cb	
			Leptoxis	10	Scraper	cb	
		Valvatidae					
			Valvata	9			
		Viviparidae					
			Campeloma	6	Scraper	cb	
			Viviparus	1	Scraper	cb	
Pelecypoda	Unionoida	Unionidae		6	Filterer	bu	3
	Veneroida	Corbiculidae			Filterer		
			Corbicula	6	Filterer	bu	
		Sphaeriidae		6.5	Filterer	bu	
			Pisidium	5.7	Filterer	bu	
			Sphaerium	5.5	Filterer	bu	
		Piscicolidae	Piscicola		Predator	sp	
Malacostraca	Amphipoda			6		sp	
		Crangonyctidae		6.5	Collector	sp	
			Crangonyx	6.7	Collector	sp	
		Gammaridae					
			Gammarus	6.7	Shredder	sp	
			Stygonectes	9.3	Shredder	sp	
		Hyalellidae			Shredder		
			Hyalella	4.2	Shredder	sp	
		Taltridae					
	Cladocera	ORDER					
	Decapoda	Cambaridae		2.8	Shredder	sp	
			Cambarus	0.4	Collector	sp	
			Orconectes	2.8	Shredder	sp	
			Procambarus	2.8	Collector		
		Palaemonidae					
			Palaemonetes	7		sp	
	Isopoda			3.3	Collector		
		Asellidae		3.3			
			Caecidotea	2.6	Collector	sp	
			Lirceus	3.3	Collector	sp	
	Gordioidea	GORDIIDAE		6.8	Predator		
Insecta	Amphipoda	Crangonyctidae	Synurella	0.4			
	Coleoptera			4.1			
		Carabidae					
			Chlaenius			-	
		Chrysomelidae			Shredder	cn	
		Curculionidae			Shredder	cn	
		Dryopidae					
			Helichus	6.4	Scraper	cn	
		Dytiscidae		5.4	Predator	sw, dv	
			Acilius	5.4			
			Agabetes	5.4	Predator		
			Agabus	5.4	Predator	sw, dv	
			Copelatus		Predator	sw	

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Coptotomus				
			Cybister	5.4	Predator	sw, dv	
			Deronectes	5.4	Predator	sw	
			Derovatellus	5.4	Predator	sw, dv	
			Helocombus	4.1			
			Hydaticus		Predator	sw	
			Hydroporus	4.6	Predator	sw, cb	
			Laccophilus	5.4	Predator	sw, dv	
			Laccornis	5.4		sw	
			Matus	5.4			
			Rhantus	5.4	Predator	sw	
			Uvarus	5.4	Predator	sw, cb	
		Elmidae		4.8	Collector	cn	
			Ancyronyx	7.8	Scraper	cn, sp	
			Dubiraphia	5.7	Scraper	cn, cb	
			Macronychus	6.8	Scraper	cn	
			Microcylloepus	4.8	Collector		
			Optioservus	5.4	Scraper	cn	
			Oulimnius	2.7	Scraper	cn	
			Promoresia	0	Scraper	cn	
			Stenelmis	7.1	Scraper	cn	
		Gyrinidae			Predator		
			Dineutus	4	Predator	sw, dv	
			Gyrinus	4	Predator	sw, dv	
		Haliplidae					
			Haliplus	9	Shredder	cb	
			Peltodytes	8.9	Shredder	cb, cn	
		Helophoridae			Shredder	cl	
			Helophorus	4.1	Shredder		
		Hydrochidae					
		Hydrophilidae	Berosus	4.1	Collector	sw, dv, cb	
			Cymbiodyta	4.1	Collector	bu	
			Enochrus	4.1	Collector	bu, sp	
			Helochares				
			Hydrobius	4.1	Collector	cb, cn, sp	
			Hydrochara	4.1			
			Hydrochus	4.1	Shredder	cb	
			Hydrophilus	4.1	Collector	sw, dv, cb	
			Sperchopsis	4.1	Collector	cn	
			Tropisternus	4.1	Collector	cb	
		Psephenidae					
			Ectopria	2.2	Scraper	cn	
			Psephenus	4.4	Scraper	cn	
		Ptilodactylidae					
			Anchytarsus	3.1	Shredder	cn	
		Scirtidae		4	Collector	cb, sp	
			Cyphon	7	Scraper	cb	
	Collembola			6			
		Isotomidae		4.8			
			Isotomurus	4.8			
		Sminthuridae					
	Diptera			6			
		Athericidae				sp, bu	
			Atherix	2	Predator	sp, bu	
		Blephariceridae					
			Blepharicera	4	Scraper	cn	

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
		Ceratopogonidae		3.6	Predator	sp, bu	
			Alluaudomyia	3.6	Predator	bu	
			Atrichopogon	3.6	Predator		
			Bezzia	3.3	Predator	bu	
			Ceratopogon	2.7	Predator	sp, bu	
			Culicoides	5.9	Predator	bu	
			Dasyhelea	3.6	Collector	sp	
			Helius	3.6	Predator	sp, bu	
			Mallochohelea	3.6	Predator	bu	
			Probezzia	3	Predator	bu	
			Sphaeromias	3.6	Predator	bu	
			Stilobezzia	3.6	Predator	sp	
		Chaoboridae					
			Chaoborus	4	Predator	sp, sw	
		Chironomidae		6.6			
				6.6	Collector		
				7.1	Collector		
				7.6	Collector		
				7.5	Predator		
				3.5	Collector		
			Ablabesmyia	8.1	Predator	sp	
			Alotanypus	6.6			
			Apsectrotanypus	6.6	Predator	bu, sp	
			Brillia	7.4	Shredder	bu, sp	
			Brundiniella	6.6	Predator	bu, sp	
			Cardiocladius	10	Predator	bu, cn	
			Chaetocladius	7	Collector	sp	
			Chironomini	5.9			
			Chironomus	4.6	Collector	bu	
			Cladopelma	6.6	Collector	bu	
			Cladotanytarsus	6.6	Filterer	-	
			Clinotanypus	6.6	Predator	bu	
			Conchapelopia	6.1	Predator	sp	
			Constempellina	6.6	Collector		
			Corynoneura	4.1	Collector	sp	
			Cricotopus	9.6	Shredder	cn, bu	
			Cricotopus/Orthocladius	7.7	Shredder		
			Cryptochironomus	7.6	Predator	sp, bu	
			Cryptotendipes	6.6	Collector	sp	
			Diamesa	8.5	Collector	sp	
			Dicrotendipes	9	Collector	bu	
			Diplocladius	5.9	Collector	sp	
			Einfeldia	6.6	Collector		
			Endochironomus	6.2	Shredder	cn	
			Eukiefferiella	6.1	Collector	sp	
			Georthocladius			sp	
			Glyptotendipes	6.6	Filterer	bu, cn	
			Guttipelopia	6.6	Predator		
			Heleniella	0.9	Predator	sp	
			Heterotrissocladius	2	Collector	sp, bu	
			Hydrobaenus	7.2	Scraper	sp	
			Kiefferulus	6.6	Collector	bu	
			Krenopelopia	6.6	Predator	sp	
			Labrundinia	6.6	Predator	sp	
			Larsia	8.5	Predator	sp	
			Limnophyes	8.6	Collector	sp	

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Lopescladius	6.6	Collector	sp	
			Macropelopia	6.6	Predator	sp	
			Meropelopia	6.8			
			Mesocricotopus	6.6			
			Mesosmittia	6.6		sp	
			Metriocnemus				
			Micropsectra	2.1	Collector	cb, sp	
			Microtendipes	4.9	Filterer	cn	
			Nanocladius	7.6	Collector	sp	
			Natarsia	6.6	Predator	sp	
			Nilotanypus	6.6	Predator	sp	
			Nilothauma	6.6		lotic	
			Odontomesa	6.6	Collector	sp	
			Omisus	6.6			
			Orthocladiinae A	8.4	Collector		
			Orthocladiinae B	6.6	Collector		
			Orthocladius	9.2	Collector	sp, bu	
			Pagastia	6.6	Collector	-	
			Pagastiella		Collector	sp	
			Parachaetocladius	3.3	Collector	sp	
			Parachironomus	6.6	Predator	sp	
			Paracladopelma	6.6	Collector	sp	
			Parakiefferiella	2.1	Collector	sp	
			Paralauterborniella	6.6	Collector	cn	
			Paramerina	6.6	Predator	sp	
			Parametriocnemus	4.6	Collector	sp	
			Paraphaenocladius	4	Collector	sp	
			Parasmittia	6.6			
			Paratanytarsus	7.7	Collector	sp	
			Paratendipes	6.6	Collector	bu	
			Paratrichocladius	6.6	Collector	sp	
			Pentaneura	6.6	Predator	sp	
			Phaenopsectra	8.7	Collector	cn	
			Platysmittia	6.6			
			Polypedilum	6.3	Shredder	cb, cn	
			Potthastia	0	Collector	sp	
			Procladius	1.2	Predator	sp	
			Prodiamesa	6.6	Collector	bu, sp	
			Psectrocladius	6.6	Shredder	sp, bu	
			Psectrotanypus	6.6	Predator	bu	
			Pseudochironomus	6.6	Collector		
			Pseudorthocladius	6	Collector	sp	
			Pseudosmittia	6.6	Collector	sp	
			Psilometriocnemus	6.6	Collector	sp	
			Rheocricotopus	6.2	Collector	sp	
			Rheopelopia	6.6	Predator	sp	
			Rheosmittia	6.6			
			Rheotanytarsus	7.2	Filterer	cn	
			Robackia		Collector		
			Saetheria	6.6	Collector	bu	
			Smittia	6.6	Collector	lentic	
			Stempellina	6.6	Collector	cb	
			Stempellinella	4.2	Collector	cb, sp, cn	
			Stenochironomus	7.9	Shredder	bu	
			Stictochironomus	9.2	Collector	bu	
			Stilocladius	6.6	Collector	sp	

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Sublettea	10	Collector	-	
			Symposiocladius	4.8	Predator	sp	
			Sympotthastia	8.2	Collector	sp	
			Syndiamesa	6.6		sp	
			Synorthocladius	6.6	Collector		
			Tanypus	6.6	Predator		
			Tanytarsus	4.9	Filterer	cb, cn	
			Thienemanniella	5.1	Collector	sp	
			Thienemannimyia	6.7	Predator	sp	
			Thienemannimyia group	8.2	Predator	sp	
			Tribelos	7	Collector	bu	
			Trissopelopia	4.1	Predator	sp	
			Tvetenia	5.1	Collector	sp	
			Unniella	6.6	Collector	-	
			Xenochironomus				
			Xylotopus	6.6	Shredder	bu	
			Zalutschia	6.6	Shredder		
			Zavrelia	6.6	Collector	cb, sp, cn	
			Zavreliella			bu	
			Zavrelimyia	5.3	Predator	sp	
			Demicryptochironomus				
		Culicidae			Collector	sw	
				8			
			Aedes	8	Filterer	sw	
			Culex		Collector	sw	
		Dixidae		5.8			
			Dixa	5.8	Predator	sw, cb	
			Dixella	5.8	Collector		
		Dolichopodidae		7.5	Predator	sp, bu	
		Empididae		7.5	Predator	sp, bu	
			Chelifera	7.1	Predator	sp, bu	
			Clinocera	7.4	Predator	cn	
			Hemerodromia	7.9	Predator	sp, bu	
		Ephydridae			Collector	bu, sp	
		Muscidae		7	Predator	sp	
			Limnophora	7	Predator	bu	
		Pelechorhynchidae			Predator		
		Psychodidae		4			
			Pericoma	4	Collector		
			Psychoda	4	Collector	bu	
		Ptychopteridae					
			Bittacomorpha	4	Collector	bu	
			Ptychoptera	4	Collector		
		Sarcophagidae					
		Sciomyzidae		6	Predator	bu	
		Simuliidae		3.2	Filterer	cn	
			Cnephia	3.2	Filterer	cn	
			Greniera	3.2	Filterer		
			Prosimulium	2.4	Filterer	cn	
			Simulium	5.7	Filterer	cn	
			Stegopterna	2.4	Filterer	cn	
		Stratiomyidae			Collector		
			Stratiomys	2.8	Collector	sp, bu	
		Syrphidae			Collector		
			Chrysogaster		Collector	bu	
		Tabanidae		2.8	Predator		

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Chrysops	2.9	Predator	sp, bu	
			Tabanus	2.8	Predator	sp, bu	
		Tanyderidae	Protoplasa		Collector		
		Tipulidae		4.8	Predator	bu, sp	
			Antocha	8	Collector	cn	
			Cryptolabis	4.8		bu	
			Dicranota	1.1	Predator	sp, bu	
			Erioptera	4.8	Collector	bu	
			Hexatoma	1.5	Predator	bu, sp	
			Limnophila	4.8	Predator	bu	
			Limonia	4.8	Shredder	bu, sp	
			Liogma	4.8			
			Molophilus	4.8		bu	
			Ormosia	6.3	Collector	bu	
			Pedicia	4.8	Predator	bu	
			Pilaria	4.8	Predator	bu	
			Pseudolimnophila	2.8	Predator	bu	
			Rhabdomastix	4.8		bu	
			Tipula	6.7	Shredder	bu	
	Ephemeroptera			2.9	Collector		
		Ameletidae		2.6			
			Ameletus	2.6	Collector	sw, cb	
		Baetidae		2.3	Collector	sw, cn	
			Acentrella	4.9	Collector	sw, cn	
			Acerpenna	2.6	Collector	sw, cn	
			Baetis	3.9	Collector	sw, cb, cn	
			Barbaetis	2.3	Collector		
			Callibaetis	2.3	Collector	sw, cn	
			Centroptilum	2.3	Collector	sw, cn	
			Cloeon				
			Diphetor	2.3	Collector	sw, cn	
			Fallceon	2.3			
			Procloeon	2.3	Collector		
		Baetiscidae				sp	
			Baetisca	4	Collector	sp	
		Caenidae					
			Caenis	2.1	Collector	sp	
		Ephemerellidae		2.6		cn, sp, sw	
			Attenella	2.6	Collector		
			Drunella	1.9	Scraper	cn, sp	
			Ephemerella	2.3	Collector	cn, sw	
			Eurylophella	4.5	Scraper	cn, sp	
			Serratella	2.8	Collector	cn	
			Timpanoga	2.6	Collector	sp	
		Ephemeridae					
			Ephemera	3	Collector	bu	
			Hexagenia	6	Collector	bu	
			Litobrancha				
			Pentagenia	3	Collector		
		Heptageniidae		2.6	Scraper	cn	
			Cinygmula	1.6	Scraper	cn	
			Epeorus	1.7	Scraper	cn	
			Heptagenia	2.6	Scraper	cn, sw	
			Leucrocuta	1.8	Scraper	cn	
			Nixe	2.6	Scraper	cn	
			Stenacron	2	Collector	cn	

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Stenonema	4.6	Scraper	cn	
		Isonychiidae					
			Isonychia	2.5	Filterer	sw, cn	
		Leptophlebiidae		1.7	Collector	sw, cn	
			Habrophlebia	1.7	Collector	sw, cn, sp	
			Leptophlebia	1.8	Collector	sw, cn, sp	
			Paraleptophlebia	2	Collector	sw, cn, sp	
		Metretopodidae					
			Siphloplecton	2	Predator	sw, cn	
		Polymitarcyidae			Collector	bu	
		Potamanthidae					
			Anthopotamus	3			
		Siphlonuridae		7	Collector	sw, cb	
			Siphlonurus	7	Collector	sw, cb	
		Tricorythidae			Collector	cn, sp	
	HYMENOPTERA	ORDER					
	Hemiptera	Belostomatidae					
			Belostoma	10	Predator	cb, sw	6
		Corixidae		5.6	Predator	sw	
			Hesperocorixa	5.6	Piercer	sw	
			Palmacorixa	5.6	Predator	-	
			Trichocorixa	5.6	Predator	sw, cb	
		Gerridae					
			Aquarius				
			Gerris	6	Predator	skater	
			Limnoporus	6	Predator	skater	
			Metrobates		Predator	skater	
			Trepobates	6	Predator	skater	
		Mesoveliidae			Predator	cn	
		Naucoridae			Predator	cb, sw	
		Nepidae			Predator		
			Ranatra	5.6	Predator		
		Noteridae	Hydrocanthus				
		Notonectidae					
			Bueno	5.6			
			Notonecta	10	Predator	sw, cb	
		SALDIDAE		6	Predator		
		Veliidae					
			Microvelia	6	Predator	skater	
			Rhagovelia		Predator	skater	
	Hymenoptera	BRACONIDAE			Parasite		
	Lepidoptera			6.7			
		Cosmopterygidae			Shredder		
			Pyroderces	6.7	Shredder	bu	
		Noctuidae		6.7	Shredder	bu	
		Pyralidae		6.7	Shredder	cb	
			Crambus	5			
		Tortricidae		6.7	Shredder	bu, cb	
	Megaloptera	Corydalidae		1.4	Predator		
			Chauliodes	1.4	Predator	cn, cb	
			Corydalus	1.4	Predator	cn, cb	
			Nigronia	1.4	Predator	cn, cb	
		ORDER					
		Sialidae		1.9	Predator	bu, cb, cn	
			Sialis	1.9	Predator	bu, cb, cn	
	Neuroptera	Sisyridae					

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Climacia		Predator	cb	7
	Odonata			6.6	Predator		
		Aeshnidae		6.2	Predator	cb	
			Aeshna				
			Anax		Predator		
			Basiaeschna	6.2	Predator	cb, sp, cn	
			Boyeria	6.3	Predator	cb, sp	
			Nasiaeschna				
		Calopterygidae			Predator		
			Calopteryx	8.3	Predator	cb	
		Coenagrionidae		9	Predator	cb	
			Argia	9.3	Predator	cn, cb, sp	
			Enallagma	9	Predator	cb	
			Ischnura	9	Predator	cb	
			Nehalennia	9	Predator	cb	
		Cordulegastridae			Predator		
			Cordulegaster	2.4	Predator	bu	
		Corduliidae		2	Predator	sp, cb	
			Helocordulia				
			Macromia	3	Predator	sp	
			Somatochlora	1	Predator	sp	
		Gomphidae		2.2	Predator	bu	
			Arigomphus	2.2	Predator	bu	
			Dromogomphus	2.2	Predator	bu	
			Erpetogomphus	2.2	Predator	bu	
			Gomphus	2.2	Predator	bu	
			Hagenius	2.2	Predator	sp	
			Lanthus	1.1	Predator	bu	
			Progomphus	2.2	Predator	bu	
			Stylogomphus	2.2	Predator	bu	
		Lestidae			Predator		
			Lestes	9	Predator	cb	
		Libellulidae		9	Predator		
			Erythemis	7	Predator	sp	
			Leucorrhinia	7	Predator	cb	
			Libellula	7	Predator	sp	
			Pachydiplax	8	Predator		
			Plathemis	3	Predator		
	Plecoptera			2.4			
		Capniidae		3.7	Shredder	sp, cn	
			Allocapnia	4.2	Shredder	cn	
			Capnia	3.7	Shredder	sp, cn	
			Paracapnia	2.8	Shredder	-	
		Chloroperlidae		1.6	Predator	cn	
			Alloperla	1.6	Predator	cn	
			Haploperla	1.6	Predator	cn	
			Perlinella	1.6	Predator	cn	
			Sweltsa	1.9	Predator	cn	
		Leuctridae		0.8	Shredder	sp, cn	
			Leuctra	0.4	Shredder	cn	
			Paraleuctra	0.8	Shredder	sp, cn	
		Nemouridae		2.9	Shredder	sp, cn	
			Amphinemura	3	Shredder	sp, cn	
			Nemoura	2.9	Shredder	sp, cn	
			Ostrocerca	1.7	Shredder	sp, cn	
			Paranemoura	2.9			

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Prostoia	4.5	Shredder	sp, cn	
			Shipsa	2.9	Shredder	sp, cn	
			Soyedina	2.9	Shredder	sp, cn	
		Peltoperlidae		1.3	Shredder	cn, sp	
			Peltoperla	1.1	Shredder	cn, sp	
			Tallaperla	1.5	Shredder	cn, sp	
		Perlidae		2.2	Predator	cn	
			Acroneuria	2.5	Predator	cn	
			Eccoptura	0.6	Predator	cn	
			Neoperla	2.2	Predator	cn	
			Paragnetina	2.2	Predator	cn	
			Perlesta	1.6	Predator	cn	4
			Phasganophora	2.2	Predator	cn	5
		Perlodidae		2.2	Predator	cn	
			Clioperla	1.7	Predator	cn	
			Cultus	2.2	Predator	cn	
			Diploperla	2.2	Predator	cn	
			Helopicus				
			Isoperla	2.4	Predator	cn, sp	
			Malirekus	2.2	Predator	cn	
			Yugus		Predator	cn	
		Pteronarcyidae					
			Pteronarcys	1.1	Shredder	cn, sp	
		Taeniopterygidae		3.1	Shredder		
			Oemopteryx	1.8	Shredder	sp, cn	
			Strophopteryx	3.3	Shredder	sp, cn	
			Taeniopteryx	4.8	Shredder	sp, cn	
	TRICHOPTERA			4.6			
	Trichoptera	Brachycentridae		2.3	Filterer		
			Brachycentrus	2.3	Filterer	cn	
			Micrasema	2.3	Shredder	cn, sp	
		Calamoceratidae					
			Anisocentropus				
			Heteroplectron	3	Shredder	sp	
		Dipseudopsidae					
			Phylocentropus	5	Collector	bu	8
		Glossosomatidae		1	Scraper	cn	
			Agapetus	2	Scraper	cn	
			Glossosoma	0	Scraper	cn	
		Goeridae			Scraper	cn	
			Goera	3.4	Scraper	cn	
		Helicopsychidae	Helicopsyche		Scraper	cn	
		Hydropsychidae		5.7	Filterer	cn	
			Cheumatopsyche	6.5	Filterer	cn	
			Diplectrona	2.7	Filterer	cn	
			Homoplectra	5.7	Filterer	cn	
			Hydropsyche	7.5	Filterer	cn	
			Parapsyche	5.7	Filterer	cn	
			Potamyia	5.7	Filterer	cn	
		Hydroptilidae		4			
			Hydroptila	6	Scraper	cn	
		Hydroptilidae	Leucotrichia	5	Scraper	cn	
			Ochrotrichia	4	Scraper	cn	
			Orthotrichia	5	Piercer		
			Oxyethira	3	Collector	cb	
		Lepidostomatidae					

Class	Order	Family	Genus	TolVal	FFG	Habit	Note
			Lepidostoma	0	Shredder	cb, sp, cn	
		Leptoceridae		4.1	Collector		
			Ceraclea	4.1	Collector	sp, cb	
			Mystacides	4.1	Collector	sp, cb	
			Nectopsyche	4.1	Shredder	cb, sw	
			Oecetis	4.7	Predator	cn, sp, cb	
			Triaenodes	5	Shredder	sw, cb	
		Limnephilidae		3.4	Shredder	cb, sp, cn	
			Hydatophylax	3.4	Shredder	sp, cb	
			Ironoquia	4.9	Shredder	sp	
			Limnephilus	3.4	Shredder	cb, sp, cn	
			Limnophilus				
			Platycentropus	3.4	Shredder	cb	
			Pycnopsyche	3.1	Shredder	sp, cb, cn	
		Molannidae					
			Molanna	6	Scraper	sp, cn	
			Molannodes	6			
		Odontoceridae					
			Psilotreta	0.9	Scraper	sp	
		Philopotamidae		2.6	Filterer	cn	
			Chimarra	4.4	Filterer	cn	
			Dolophilodes	1.7	Filterer	cn	
			Wormaldia	1.8	Filterer	cn	
		Phryganeidae		4.3	Shredder		
			Oligostomis	2			
			Ptilostomis	4.3	Shredder	cb	
		Polycentropodidae		0.2		cn	
			Neureclipsis	0.2	Filterer	cn	
			Nyctiophylax	0.2	Filterer	cn	
			Polycentropus	1.1	Filterer	cn	
		Psychomyiidae		4.9			
			Lype	4.7	Scraper	cn	
			Psychomyia	4.9	Collector	cn	
		Rhyacophilidae					
			Rhyacophila	2.1	Predator	cn	
		Sericostomatidae					
			Agarodes	3	Shredder	sp	
		Uenoidae		2.7		cn	
			Neophylax	2.7	Scraper	cn	9
BRANCHIOBDELLIDA							
Crustacea	Bivalvia	Sphaeriidae	Musculium	5.5	Filterer		
	Cladocera			8	Filterer		
	Copepoda			8	Collector		
	Ostracoda			8	Collector		

1. Nematomorpha is a phylum level identification. No class level identification was made.
2. Brinkhurst (1986). ITIS (1998) places the family in the order Haplotaxida.
3. Margulis and Schwartz (1988). ITIS (1998) uses the class name Bivalvia.
4. Merritt and Cummins (1996). ITIS (1998) places *Perlesta* in the family Chloroperlidae.
5. Merritt and Cummins (1996). ITIS (1998) uses the genus name *Agnetina*.
6. Merritt and Cummins (1996). ITIS (1998) uses the order name Heteroptera.
7. Merritt and Cummins (1996). ITIS (1998) places Sisyridae in the order Megaloptera.
8. Merritt and Cummins (1996). ITIS (1998) places *Phylocentropus* in the family

Psychomyiidae.
9. Merritt and Cummins (1996). ITIS (1998) places *Neophylax* in the family Limnephilidae.
10. Use the leftmost Habit when calculating the % Climbers, % Clingers and % Swimmers metrics.
SF Subfamily
TR Tribe

Standard Operating Procedures

NCRN Biological Stream Survey – Roles and Responsibilities Standard Operating Procedure #1

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, renaming, rewording	Updating protocol for use by any contractor	1.1

Purpose

This Standard Operating Procedure (SOP) was drafted to provide cooperators, field crews and network staff with information on who is responsible for performing project tasks.

Scope and Applicability

This document applies to all personnel involved in the biological stream monitoring protocol including field crews, cooperators, and network personnel.

Reference Documents

NCRN Biological Stream Survey Monitoring Protocol

NCRN Data Management Plan

Personnel and Tasks

Successfully coordinating environmental monitoring projects requires coordination, communication and cooperation among all those involved. Therefore, the responsibility for tasks cannot be placed on a single individual but distributed and shared among many involved in the project. The primary responsibility for certain tasks will obviously reside with certain individuals more than others but all will share the responsibility of making sure that the task is completed properly. For instance, the project manager may not be directly involved with field season preparation but should ensure that co-operators or staff are taking the necessary steps to prepare for the upcoming field season.

The following two tables list those personnel involved in the project and their associated role (Table 1) and the tasks for which each individual is responsible (Table 2).

NCRN Biological Stream Survey – Roles and Responsibilities
Standard Operating Procedure #1

Personnel

Table 1-1. List of personnel involved in the NCRN Biological Stream Survey project

Title	Name	Role
NPS Lead	**Marian Norris**	**NPS Lead**
Ecologist	**John Paul Schmit**	**ECO**
Data Manager	**Geoff Sanders**	**DM**
GIS Specialist	**Mark Lehman**	**GIS**
Project Manager	**If contracted, TBD each year**	**PM**
Crew Leader	**If contracted, TBD each year**	**CL**
Field Crew	**If contracted, TBD each year**	**FC**

Responsibilities

- **NPS Lead** – Responsible for overseeing the entire project. This does not mean that he/she will play an active role in each task but have they must have knowledge of the task and assure that it is being handled by the appropriate party. May also serve as key official on contracts and agreements.

- **Ecologist** – Plays an integral role in protocol review/revision, sampling design and data analysis. Can assist in other areas but these are the primary areas of responsibility.

- **Data Manager** – Responsible for coordinating data management throughout the lifespan of the project. Develops data management guidance for the project, develops the proper database application for data storage and ensures that the field crews are properly trained on using the application. Makes sure that all personnel are well versed in the data management guidance and are aware of their role.

- **GIS Specialist** – Supports the projects GIS needs especially during the sampling design and site selection stage.

- **Project Manager** – May be NPS staff, contractor or co-operator. Responsible for identifying field crews and securing necessary permits from the Parks (see SOP#21 for more information on the Research Permit and Reporting System (RPRS)). Must be able to provide the field team with a vehicle and provide them with guidance through out the field season. Must work closely with NPS Lead and ecologist to coordinate budget, protocol review and revision, data analysis and reporting.

NCRN Biological Stream Survey – Roles and Responsibilities Standard Operating Procedure #1

- **Crew Leader** – May be NPS staff, contractor or co-operator. Responsible for all aspects of field work from coordinating the technicians, training them and ensuring that the data is collected properly. Also must ensure that the data is properly entered into the project database, thoroughly checked and validated and transferred to NPS offices in accordance with data transfer guidance. Must also work with the Project Manager and NPS Lead to assist with reporting, analysis and supply information on field methodologies.

- **Field Crew** – May be NPS staff, contractor or co-operator. Responsible for field data collection, data entry and data QA/QC.

Tasks

Protocol revision and review: This is an on-going task that should take place at least annually. Review should involve input from all of those involved in the project.

- **Database development:** Entails creating a project database based on the I&M database template that meets the needs of the project. The development process depends on coordination between NPS and co-operators, if applicable, to ensure that the database functions properly and meets the needs of the field crew.

- **Field Season Preparation:** Ensure that field crews are hired and trained and assemble all field equipment and data, such as maps. Obtain all necessary permits from the Parks.

- **Data Collection:** Those responsible must ensure that all field data is collected in line with the field protocols.

- **Data Entry:** Data is entered into the project database in accordance with the specific project data entry requirements (see Database Design SOP). This task primarily falls on the field crew but NCRN staff must ensure that the field crew is properly trained in using the project database.

- **Data QA/QC:** Data is verified and validated in accordance with NCRN QA/QC requirements (see Data Management SOP and QA/QC SOP).

- **Metadata:** All data sets (both spatial and non-spatial) must be fully and completely documented with Federal Geographic Data Committee compliant metadata. This requires completing the proper metadata forms in accordance with NCRN metadata standards. Cooperators must complete the metadata but NCRN staff must review and ensure that metadata is received and completed properly.

- **Data Analysis:** Prepare the proper summaries and conduct the necessary analyses as recommended by the protocol.

- **Reporting:** Prepare and provide annual reports summarizing the results of field work from the previous field season and illustrating interesting findings and analysis results. Reports should be prepared based on the NCRN reporting requirements (see NCRN Reporting SOP). Submit an Investigator Annual Report in RPRS.

NCRN Biological Stream Survey – Roles and Responsibilities Standard Operating Procedure #1

- **Budget Tracking:** Review project budget to make sure that the project has not exceeded cost expectations. NCRN staff and cooperators must work together to agree on a reasonable and sustainable annual project budget.

- **Data Transfer:** If applicable, responsible parties ensure that data is transferred from cooperators to NCRN office on the agreed upon transfer schedule. Cooperators must transfer deliverables in a timely manner and NCRN staff must ensure that deliverables are received and that they meet the required standards.

- **Data Archiving:** Ensure that data that have been completely verified and validated are stored safely and securely on NCRN servers. Data archiving should take place at least annually once all of the field data have been received.

Task Matrix

Table 1-2. Task matrix illustrating the list of project tasks and those responsible for each task. Personnel can bear the primary responsibility (P) for a task or play a supporting role (S).

	Personnel						
	NPS Lead	ECO	DM	GIS	PM	CL	FC
Tasks							
Database Development			P			S	
Protocol Review and Revision	P	P	S		S	S	
Field Season Prep.	S		S	S	P	P	S
Data Collection						P	P
Data Entry						P	P
Data QA/QC			S			P	P
Metadata	S		S			P	P
Data Analysis		S			P	S	S
Reporting	S		S		P	S	
Budget Tracking	P				P		
Data Transfer	P		S		P	S	
Data Archiving			P				

NCRN Biological Stream Survey
Training Field Personnel
Standard Operating Procedure #2

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Contact information & approximate dates of training	Clarification of how to arrange for training	1.1

Purpose

The purpose of this section is to outline procedures and provide guidance for training crew members prior to the field sampling season.

Scope and Applicability

This SOP applies to the NCRN Biological Stream Survey protocol when applied to NCRN parks.

Reference Documents

Kazyak, P.F. 2001. Maryland Biological Stream Survey sampling manual. Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division, Annapolis, Maryland.

Procedures and General Requirements

An important aspect of the water resources monitoring for the National Capital Region is the mandatory training of field personnel that is conducted prior to sampling. The goal of the training is to ensure consistent implementation of required procedures and attainment of a minimum level of technical competency by each crew member. Standardized training helps to maximize the comparability of data among field crews, among years, and among other agencies in the region using the same methodologies. In addition to crew training, Crew Leaders are given additional instruction and guidance to maximize consistency in decision making. To meet the program's QA objectives for training, crew leaders must successfully pass examinations administered during annual training provided by the Maryland Biological Stream Survey (MBSS) program. The annual training is open to all private and state agencies that use MBSS methods in the region.

For personnel involved in sampling during the spring index period, training includes water quality and benthic macroinvertebrate sampling using MBSS procedures (Kazyak 2001). For personnel involved in sampling during the summer index period, training includes fish sampling, habitat assessment, and a laboratory examination concerning the identification of regional fishes and herpetofauna. These taxonomy tests involve the identification of preserved fish and may underestimate the ability of the individual to identify live specimens.

NCRN Biological Stream Survey
Training Field Personnel
Standard Operating Procedure #2

To ensure consistent implementation of sampling procedures and a high level of technical competency, experienced field biologists are assigned to each crew and all field personnel complete program training before participating in field sampling. Training topics include MBSS program orientation, stream segment location using global positioning system (GPS) equipment, sampling protocols, operation and maintenance of sampling equipment, data transcription, quality assurance/quality control, and safety. The spring field crews receive additional training in sampling protocols for water quality and benthic macroinvertebrates. The summer field crews receive additional training in habitat assessment methods, taxonomy, and *in situ* water chemistry assessment. Training includes classroom, laboratory, and field activities. Instructors emphasize the objectives of the Survey and the importance of strict adherence to the sampling protocols. The QC Officer conducts proficiency examinations to evaluate the effectiveness of the training program and ensure that the participants have detailed knowledge of the sampling protocols. Members of the spring sampling crew are required to demonstrate proficiency in techniques for collecting samples for water chemistry and benthic macroinvertebrates. At least one member of each summer sampling crew is required to pass a comprehensive fish taxonomy examination. Each crew must also demonstrate proficiency in locating pre-selected stream segments using the GPS receiver and determining if the segment is acceptable for sampling. Comprehensive "dry runs" are conducted to simulate actual field conditions and evaluate classroom instruction.

Training occurs in February for the Spring Index and May for the Summer Index.

For training schedule and registration contact:

Tiffany Adams
(410) 260-8611
tadams@dnr.state.md.us.

or

Scott Stranko
410-260-8603
sstranko@dnr.state.md.us

NCRN Biological Stream Survey - Field Safety Standard Operating Procedures #3

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Purpose

To present the guidelines for Field Safety during water monitoring in the National Capital Region Network (NCRN).

Scope and Applicability

This Standard Operating Procedure (SOP) applies to all fieldwork performed following the NCRN BSS Protocol.

Reference Documents

Spaulding , S., and L. Elwell. 2007. Increase in nuisance blooms and geographic expansion of the freshwater diatom *Didymosphenia geminata*: Recommendations for response.

Procedures and General Requirements

Health and Safety

The purpose of this SOP is to provide recommendations for health and safety aspects to persons involved in BSS field collections. Suggested training and qualifications are described, along with general safety procedures, sampling hazards, provision of first aid, and emergency situations. The recommendations in this chapter are non-binding; the ultimate responsibility for health and safety of field crews lies with the parent organization for each field crew.

Training and Qualifications

To minimize any potential health and safety risks related to field sampling conducted as part of the BSS, survey personnel need to be physically able to conduct fieldwork under demanding conditions and be well prepared to handle contingencies or emergencies. The following are suggested requirements for all field survey personnel:

a) Recent (within 1 year) physician's approval to conduct rigorous physical work
b) Recent (within 1 year) CPR certification
c) Recent (within 1 year) Red Cross First Aid Training

d) Complete a satisfactory interview about health and safety aspects of the MBSS with the field crew supervisor, including routine safety precautions and a discussion of actions to be taken in an emergency.
In addition to the recommendations identified for all survey personnel, Crew Leaders should have adequate field sampling experience under rigorous conditions.

Duties and Responsibilities

This section outlines the health and safety responsibilities of persons involved with field activities of the MBSS.

Project Manager

The Project Manager for each organization involved in sampling has overall responsibility for health and safety aspects of the portion of the BSS for which that organization is responsible.

Crew Leader

Crew Leaders are responsible for ensuring that day-to-day activities of the field crew are conducted in as safe a manner as possible. Recommended health and safety responsibilities of the Crew Leader include:

- instruction and supervision of the survey team such that sampling and travel at a given site are done in a manner which minimizes health and safety risks;

- reporting to the Field Crew Supervisor or his/her designee any unusual health and safety conditions, emergencies, or accidents encountered during the deployment of the crew. In the case of accidents or emergencies, the Crew Leader should, as soon as the situation permits, notify the Field Crew Supervisor or his/her designee by direct phone contact;

- ensuring that vehicles and sampling equipment are in safe operating condition prior to and during field deployments;

- ensuring that all members of the survey team are fully aware of any potentially hazardous materials used as part of sampling. Examples include preservatives for biological and chemical samples;

- determining whether sampling conditions are safe and appropriate;

- informing the survey team of any situation-specific dangers involved at a given site;

- ensuring that vehicles are operated in a safe manner; and

- ensuring that samples and sampling equipment are safely stored prior to vehicle operations.

Field Crew Members

All personnel involved in field sampling or field observations (e.g., QA/QC inspections) should be aware of the risks involved with the routine aspects of BSS. When unsafe or hazardous conditions are observed, crew members should inform the Crew Leader at the earliest opportunity. In addition, crew members should notify the Crew Leader if, for any reason, they cannot perform an assigned task in a safe manner.
Examples include sickness, physical limitations, or uncertainty about proper operation of the sampling equipment.

Sampling Hazards and Procedures for Minimizing Risk

There are a number of potential health and safety considerations specific to the BSS. A number of these hazards are common to all sampling sites, while others may be site- or region-specific. This section lists a number of hazards likely to be encountered during the BSS as well as measures to minimize the health and safety risks associated with them.

Vehicle Accident

As with nearly all other field sampling programs, there is a risk of a vehicular accident. To minimize this risk, the following measures should be taken:

- an inspection of the sampling vehicle should be performed by the Crew Leader or a designee prior to departure. This inspection should include tire condition and operability of wipers, defroster, etc.;

- during sampling activities, any potentially unsafe vehicle condition should be reported to the Field Crew Supervisor and corrected as soon as is practical;

- if, in the judgment of the Crew Leader, the sampling vehicle is not safe to operate, the vehicle should not be operated until the condition is rectified; and

- vehicles should not be operated by crew members who are incapable of safely operating them. No sampling vehicle should be operated by a person not holding a valid drivers license.

NCRN Biological Stream Survey - Field Safety Standard Operating Procedures #3

Electric Shock

Failure to observe appropriate safety precautions when using backpack electrofishing gear could result in electric shock. Under worst case conditions, this shock could result in cardiac arrest and loss of life. To minimize risks associated with electrofishing during the BSS, the following measures shall be taken:

- only personnel designated by Crew Leaders should operate the backpack electrofishing unit;

- to minimize the amount of body surface area potentially exposed to electric shock, normal wading gear for the BSS should be chest waders. Only non-leaking wading gear should be used during electrofishing-- if a leak is discovered, wading gear should be changed and the leaking gear repaired or replaced prior to the next use;

- bare wire portion of the cathode (rattail) or the anode should never be touched while the unit is in operation;

- electrofishing should only be conducted when a minimum of three persons are present at a site. In the event of electric shock, this provides for one person to administer CPR while another seeks medical assistance. Use of a portable phone is also recommended as an effective means to summon emergency medical care if necessary;

- if the Crew Leader determines that stream conditions at the time of the site visit present an abnormal risk of electric shock, he or she will determine that the site is not sampleable and sampling will be conducted at an alternate site or canceled in that reach;

- prior to each use, electrofishing gear should be verified to be in safe working condition by the Crew Leader. This verification should include an examination of external wiring and electrical connections;

- in cases where two electrofishing units are used or barge shocking is employed at a site, extra care should be taken to ensure that unit operators maintain an awareness of all personnel in the water. In addition, unit operators should maintain adequate spacing between units to minimize the risks of shock from both electric fields in the event a crew member slips or falls into the water, or the discharge of one anode completing the switch circuit for another unit.

NCRN Biological Stream Survey - Field Safety Standard Operating Procedures #3

Hazardous Terrain

A routine part of sampling during the BSS is traveling over rough terrain to access the sample site. One of the risks arising from this aspect of the BSS is the possibility of injury from falling. To minimize this risk, the following preventive actions are recommended:

- when necessary, the Crew Leader will make a determination that access to the sampling site is not possible and the site will be deemed unsampleable;
- when traveling over any extensive distance, appropriate footwear should be worn instead of waders or hip boots;
- equipment should be distributed equitably among crew members for transport from the vehicle to the site; if determined to be necessary by the Crew Leader, more than one trip to transport equipment should be made;
- to the greatest extent possible, travel between the vehicle and the sample site should occur during daylight hours; and
- only in unusual circumstances (as determined by the Crew Leader) should a crew member travel alone over hazardous terrain.

Fast or Deep Water

During the BSS, some sampling sites may be visited which have fast and/or deep water in them. Sampling in locations which are too deep or too fast for wading could result in injury or drowning. It should be noted that sampling fast and/or deep waters also increases the likelihood of electrical shock; thus a high degree of caution is imperative for safe operations. To minimize health and safety risks associated with sampling in fast and/or deep waters, the following steps should be taken:

- prior to sampling, the Crew Leader should ensure that all crew members who are to enter the stream are physically fit to do so and are aware of any specific sampling risks at the site;
- prior to sampling, the Crew Leader should make a determination as to whether the site can be sampled by wading without undue risks. If a negative determination is reached, the site should be revisited at another time or not sampled;
- all field crew members should wear chest waders outfitted with waist belts and felt soles or cleats should be used in rocky areas.

NCRN Biological Stream Survey - Field Safety Standard Operating Procedures #3

Slippery Substrate

During the BSS, sampling at some sites will be hazardous due to slippery substrate. Examples of stream types which may have treacherous substrates include those affected by acid mine drainage and streams with high silt loads. To minimize the risks associated with slippery substrates, the Crew Leader should factor the degree of slipperiness of the substrate into decisions as to whether a site can be sampled and any extra precautions to be taken by the field crew; and all wading gear should have felt soles and/or cleats.

Dangerous Animals or Plants.

Sampling at some sites during the BSS will include risks associated with dangerous animals and/or plants. Poison ivy is likely to be common along many travel routes used by the sampling crew, as well as in riparian vegetation. Poison ivy roots on tree trunks offer particular risks since they are often unnoticed. Another plant which occurs in boggy areas and should be avoided is poison sumac. Contact with bees, wasps, and certain caterpillars can cause allergic reactions and should also be avoided. A number of other animals also present serious risks including: northern copperheads, timber rattlesnakes, free-ranging domestic dogs, rabid animals of any species, and ticks. To minimize the risks associated with dangerous animals and plants during the BSS, the following measures are recommended:

- all field survey personnel should receive training in field identification, avoidance of, and first aid for dangerous plants and animals which may be encountered during the BSS;

- crew members should inform their Crew Leader of any known allergies and keep appropriate medical relief in the field first aid kit (at a minimum, each crew should keep an emergency supply of benadryl – gel caps or liquid are preferred because they enter the bloodstream more quickly than tablet form, Crew leader should also be aware of proper procedures for administering injectable drugs if necessary. This would only come up if a team member had an allergy and carried an epi-pen. The crew leader should be aware of this and the person should show the crew leader how to admister if the person is unable.);

- the Crew Leader should make all crew members aware of site- or situation-specific dangers as they are noted. Similarly, field crew members should inform the Crew Leader as soon as they are discovered; and

- All crew members should be informed of the risks of lyme disease and should check each after conducting field work for ticks that may have become attached to the body.

NCRN Biological Stream Survey - Field Safety Standard Operating Procedures #3

High Bacterial Levels

When sampling in areas downstream of sewage or other organic waste sources, potentially dangerous bacterial levels may exist. In urban areas, the presence of such inputs may be clearly evident by smell, observation of solids and floatables, and/or the presence of sewage fungus on bottom substrates. However, in some areas, potentially dangerous bacterial levels could be present in a stream without any obvious evidence. To minimize the health risks associated with high bacterial levels in streams, the following measures should be incorporated into field surveys:

- during development of the itinerary, the Crew Leader should examine the list of National Pollution Discharge Elimination System (NPDES) permits and investigate through the state environmental office any known pollution problems in the watershed being sampled. Using this information, a determination should be made as to whether special safety precautions are necessary;

- prior to entering the stream, the Crew Leader should make note of any evidence of high bacterial levels and inform the field crew;

- the use of gloves should be maximized during the sampling process;

- open wounds should not be exposed to contact with stream water; and

- after exposure to stream water, all crew members should wash their hands in isopropyl alcohol and clean water prior to consuming any food or drink.

Hazardous Waste

Because of historical disposal practices, hazardous wastes may be present at an unknown number of sites to be sampled during the BSS. Risks of relatively brief exposure (such as sampling during the MBSS) to hazardous wastes are likely to be low, but precautions still need to be taken to minimize exposure probabilities. These include:

- prior to commencement of field sampling, existing information (through MDE and EPA) about known or probable hazardous waste sites in the NCRN in relation to BSS sample sites should be reviewed. After review of available hazardous site information, the crew should be informed of any hazardous waste sites in areas designated to be sampled. Any such areas identified will be sampled by a crew that has received OSHA hazardous waste safety training (as specified in 29 CFR 1910.120);

- all sampling at hazardous waste sites will be conducted in accordance with site health and safety plans and only after proper advance notice has been given to authorities on site;

- if sampling is to be conducted in an area where hazardous waste is known to be present, personnel who participate in sampling should participate in a Medical Monitoring Plan established by NPS or the Contractor for the hazardous site sampling crew. Medical Monitoring should include baseline, yearly, and exit examinations;

- after sampling at or in the vicinity of hazardous waste sites, all exposed equipment should be thoroughly rinsed, including waders and any exposed personal equipment and;

- no food should be consumed at known hazardous waste sites and following sampling, food will only be consumed after thorough hand washing.

Hypothermia

Many of the sites sampled during the BSS will be in remote locations. At these locations, the potential for stranding and prolonged exposure to extreme weather conditions is of concern, especially when sampling is conducted during cold weather. There is also a potential for prolonged exposure to cold water in the case of accidents, emergencies or other unusual conditions. Recommended precautions to reduce the possibility of hypothermia or related illnesses include:

- each field crew should carry several space blankets at all times when in the field during the Spring Index Period;

- Crew Leaders should be responsible for monitoring weather conditions and adjusting or postponing sampling plans as appropriate; and

- prior to leaving the vehicle for a sampling site, the Crew Leader should ensure that crew members are properly clothed and that emergency supplies are taken to the site.

Lightning Strike

As sampling during the BSS will occur over relatively long periods of time in spring and summer, exposure of field crews to electrical storms is likely. To minimize risks associated with a lightning strike the following measures should be taken:

- Crew Leaders should be responsible for monitoring weather conditions, adjusting sampling schedules as appropriate to minimize the chance of a field crew being exposed to an electrical storm while in a remote location; and

- in the event of an electrical storm while sampling, sampling activities should be halted and the Crew Leader should determine whether to return to the vehicle or seek local shelter.

Dehydration and Hyperthermia

The most prevalent risk to BSS sampling crews is the risk of dehydration. Freshwater should be kept with sampling crews at all times and crew members should be encouraged to drink plenty of water. In the event that a crew member suffers from dehydration or heat related illness, all possible attempts should be made to cool and hydrate the person. Make sure to have plenty of fresh drinking water readily available.

First Aid

During any field sampling activity such as the BSS, there is a possibility that first aid will need to be administered. To meet this need, all personnel should be trained in first aid. In addition, each field crew should maintain a stocked first aid kit in both field sampling equipment and in the sampling vehicle.

Emergencies

In the event of a medical or other emergency, the Crew Leader or qualified crew member should take all appropriate immediate actions and should send for appropriate assistance using the fastest available means.
In the event the emergency occurs at a remote location, all necessary information to guide assistance personnel should be provided, including map coordinates if known and appropriate.

Precautions for Minimizing Ecological Risk

An increasing potential exists for transferring non-native and invasive organisms (including those that cause serious diseases to native stream dwelling fauna) from one stream to another while conducting monitoring.
Whirling disease (a protist , *Myxobolus cerebralis*), rock snot (an alga , *Didymospenia geminata*), and amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) are examples of such organisms. In addition, avian influenza can be transferred among farms simply by walking in the chicken litter that came from infected individuals and then walking in another area with chickens. It is important to properly clean all footwear or other equipment that may have contacted disease-containing litter.
The risks described above require that field crews conducting BSS sampling take precautions to minimize, to the greatest extent possible, the transfer of any disease organisms from one place to another.
Beginning in June 2007, all BSS field crews will be required to disinfect all field equipment and waders that come in contact with stream or wetland (e.g. vernal pool) water following sampling at each stream site. This procedure should also be applied to all equipment that comes in contact with chicken litter.

NCRN Biological Stream Survey - Field Safety Standard Operating Procedures #3

The disinfection procedure consists of soaking or rinsing all equipment that has come in contact with water (or chicken litter) in a 10% bleach solution for at least one minute. Equipment with a smooth surface (e.g. buckets, sides – but not soles - of waders) can be scrubbed with a scrub brush using a 10% bleach solution. After soaking and scrubbing have been completed, all equipment must be rinsed with freshwater to remove the bleach solution.
Avoid skin and eye contact with bleach solution as it can be severely irritating. Thoroughly rinsing all equipment with freshwater also minimizes risk of skin and eye irritation.

NCRN Biological Stream Survey Preparations and Equipment Setup Prior to Field Season and Sampling Standard Operating Procedure #4

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbered, Training sections moved to training SOP, other text moved to appropriate sections	Clarification of purpose and scope of the SOP	1.1

Purpose

The purpose of this section is to outline procedures and provide guidance for pre-deployment activities to be completed prior to the field sampling season and prior to each field sampling trip.

Scope and Applicability

This SOP applies to the NCRN Biological Stream Survey protocol when applied to NCRN parks.

Reference Documents

None.

Procedures and General Requirements

Protocol Review

Each year before the field season begins, all crew members should review the entire protocol and Standard Operating Procedures (SOP).

Equipment

Prior to beginning sampling efforts for the respective index period, all equipment in Tables 1-1 and 1-2 should be obtained and checked to be in proper working condition. Preventative maintenance and calibration must be performed on all sampling equipment used as part of the BSS. Maintenance and calibration procedures should be implemented as per manufacturer's instructions. Unless otherwise specified, calibration must be performed daily prior to equipment use and anytime equipment problems are suspected. Preventative maintenance must be performed at intervals not to exceed the frequency recommended by the manufacturer. **All equipment malfunctions must be fully corrected prior to reuse.** For weighing scales, weekly checks must be conducted during field sampling using NIST standards or other accepted

standards to demonstrate that instrument error is within limits specified by the manufacturer. For each piece of equipment used as part of the BSS, record for calibration and maintenance must be maintained. Entries in the record must be made for all calibration and maintenance activities. Documentation includes detailed descriptions of all calibrations, adjustments, and replacement of parts, and each entry must be signed and dated.

Prior to each field sampling trip, the Crew Leader should check that all necessary sampling equipment, site lists, and QC site lists are loaded into the sampling vehicle, including spare or back-up equipment, extra data sheets, etc. A list of equipment for sampling during the Spring Index Period is shown in Table 4-1, and equipment for the Summer Index Period is listed in Table 4-2. **The Project Manager should be informed as soon as practicable of any equipment problems which develop during sampling; in no case should faulty equipment continue to be used for sampling.**

The Crew Leader will be responsible for ensuring that all necessary equipment and supplies are loaded into the vehicle. **The crew will depart for sampling only after the Crew Leader has verified the equipment inventory.** During or shortly after completion of the sampling trip, the Crew Leader will inform the Project Manager of any equipment needs, repairs, etc., and make arrangements for replacements prior to the next sampling trip.

At the end of each sampling day, the Crew Leader will ensure that all sampling equipment is properly stored and that gear, data sheets, preservatives, sample bottles, etc., needed for the next day are identified. When conducting water quality sampling, the Crew Leader should ensure that water quality instruments are in working order and calibrated prior to use.

To provide access to unimproved roads and thereby reduce travel time to numerous sample segments, four-wheel drive vehicles should be used when possible for BSS sampling. Prior to use each day, the Crew Leader will visually inspect the sampling vehicle for any evidence of safety or mechanical problems.

NCRN Biological Stream Survey
Preparations and Equipment Setup
Prior to Field Season and Sampling
Standard Operating Procedure #4

TABLE 4-1. LIST OF ITEMS FOR STREAM SAMPLING DURING THE SPRING INDEX PERIOD.

Spring Index Period Equipment List	
MBSS Sampling Manual, NPS NCRN SOPs	G.P.S. Unit, battery packs, chargers
Road Maps, Itinerary	G.P.S. instruction book, spare batteries, NiCad charger
Site List/Maps	Coolers, Ice, Ziplock Bags, Chain-of-Custody forms
QC Sample List	Bubble Wrap, Packing Material, Tape
Spring Index Period Data Sheets	Fed-X Forms
No. 1 Pencils, Permanent Markers	Label Tape (clear, 2" wide)
Crew Leader Field Notebook, Quad Map	Chest Waders (1 pair/person)
Pre-printed Adhesive Outside Labels, Inside Labels	First Aid Kit
Digital Camera, Extra Batteries, & Accessories	Water Quality Sample Bottles- 1 liter
Pruning Tool	Water Quality Sample Bottles- 500 mL
1 Liter Squirt Bottle	Syringes and valves
Mace	Tripod, Level, Stadia
Rangefinder	
Flagging, Spray Paint	
100 m Tape	
600 micron Mesh D-net	
Spare Net Bag for D-net	
EtOH (2 liters per site)	
Foul Weather Gear	**Reserve Equipment** (to be kept in sampling vehicle)
Pack Basket/ Backpack/ small cooler	Data sheets, Markers, Pencils
	DI Water for blanks
	Spare Squirt Bottle, Funnel
	Spare Sample Bottles, Syringes
	Spare D-net, silicone for net repairs
	Spare Sample Jars, EtOH
	Wader Repair Kit

NCRN Biological Stream Survey
Preparations and Equipment Setup
Prior to Field Season and Sampling
Standard Operating Procedure #4

TABLE 4-2. LIST OF ITEMS FOR STREAM SAMPLING DURING THE SUMMER INDEX PERIOD.

Summer Period Equipment List	
MBSS Sampling Manual	Flowmeter/Staff Gauge/extra batteries/Meter Stick
Road Maps, Itinerary	Spring or Electronic Scale
Site List and Site Maps	DO, temp.,pH, conductivity meter (Hydrolab or equivalent)
Summer Index Period Data Sheets	1 liter Buffered Formalin/site
Fish Data Sheets	Backpack Electrofishing Unit(s) (site dependent)
Summer Habitat Data Sheets	Anode Ring Probe(s) (site dependent, fitted with 3/16" mesh);
Gamefish Length Data Sheets	"Y" connection and extra probe
Qualitative Electrofishing Sheets	Cathode Tail (1 per electrofishing unit)
Habitat Guidance Sheet- Laminated	Gasoline for Electrofishing (model dependent)
No. 1 Pencils, Permanent Markers	Dipnets, 3/16" mesh
Crew Leader Field Notebook, Quad Maps	Blocknets (2)- 2m, 6 m, 15 m & 40 m sizes
Pre-printed Voucher Labels; Sample Jars; ziplocks	Labeled Livecars
Taxonomic Keys--Reptiles and Amphibians; Fish, Freshwater Mussels	Livecar Net (1)
Voucher List for Each Drainage Basin	25 liter buckets; floating live car
Mace	Electrofishing Gloves (1pr/person)
Rangefinder, 100m tape	Wader Repair Kit
Flagging	
Digital Camera, Extra Batteries, & Accessories	**Reserve Equipment**
G.P.S. Unit and Spare, Battery Packs, NiCad Charger G.P.S. instruction book, Spare Batteries	Spare Generator(s)/Electrofishing Batteries
Compass	Spare Gas and Oil for Generators
Turbidimeter, extra batteries	Tool Box
Turbidity Standards	Spare Netting/Cable Ties for Anode Ring Nets
Disinfectant Lotion	Spare Voucher Jars and Formalin
Freshwater for Crew Consumption	Spare Data Sheets/Markers/Pencils/Labels
First Aid Kit	Extra Blocknets
Foul Weather Gear	Spare WQ Instruments/Flowmeter/Scale
Wader Repair Kit	Calibration Kits, Spare DO Membrane Kit
Pruning Tool	Waders
Machete	Calibration Weights
Measuring Board	
Pack Baskets/Backpacks	
Portable Cellular Phone	

NCRN Biological Stream Survey Preparations and Equipment Setup Prior to Field Season and Sampling Standard Operating Procedure #4

Sampling Schedule

Crew Leaders should develop a generalized sampling itinerary. In cases where major exceptions or changes to the generalized schedule must be made due to equipment failure, inclement weather, or other problems, the Crew Leader should notify the respective Project Manager who will in turn notify the NPS Lead.

Site Visit Notification

Prior to sampling, the Crew Leader should provide the Park Service Police and Natural Resources Specialists with notification of the tentative dates and locations in which sampling is scheduled. Phone numbers for each Park are provided in Table 4-3.

TABLE 4-3. CONTACT INFORMATION FOR EACH PARK AND PARK POLICE. PARKS SHOULD BE CONTACTED PRIOR TO SAMPLING.

Contact	Telephone number
Antietam National Battlefield	
Resource Management	301-432-2243
Park Police	301-714-2235 (NCR Dispatch)
Catoctin Mountain Park	
Resource Management	301-416-0536
C&O Canal National Historic Park	
Resource Management	301-714-2225
Park Police	301-714-2235 (NCR Dispatch)
George Washington Memorial Parkway	
Resource Management	703-289-2542
Park Police	301-714-2235 (NCR Dispatch)
Ft. Hunt substation	703-557-1763
Turkey Run substation	703-285-1000
Great Falls substation	703-759-7135
Harper's Ferry National Historic Park	
Resource Management	304-535-6038; 304-535-6770
Park Police	301-714-2235 (NCR Dispatch)
Manassas National Battlefield	
Resource Management	703-754-1859
Park Police	703-754-8694
Monocacy National Battlefield	
Resource Management	301-662-3515
Park Police	301-714-2235 (NCR Dispatch)
National Capital Parks - East	
Resource Management	220-690-5160
Park Police (Greenbelt)	301-344-4250
Park Police (non-emergency communications)	202-619-7105

NCRN Biological Stream Survey
Preparations and Equipment Setup
Prior to Field Season and Sampling
Standard Operating Procedure #4

Contact	Telephone number
Prince William Forest Park	
Resource Management	703-221-2176
Park Police	301-714-2235 (NCR Dispatch)
Rock Creek Park	
Resource Management	202-895-6077
Park Police	202-619-7310
Rock Creek substation	202-426-7716/7717
Wolf Trap National Park for the Performing Arts	
Resource Management	703-255-1892
Park Police	202-619-7310

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, renaming of SOP, rewording, revision of sampling design	Updating protocol for use by any contractor, revision of sampling design	2.0

Purpose

The Standard Operating Procedures (SOP) detail how to select, establish, and mark permanent survey sections for long-term monitoring of water resources in National Capital Region parks.

Scope and Applicability

This SOP applies to the Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

NCRN BSS Protocol

Procedures and General Requirements

Site Selection

Selection of sites was based on the 1:24,000 high resolution National Hydrography Dataset (NHD) digital stream reach file. Sites have been groundtruthed to determine which are ephemeral and therefore dry in the summer months. All stream reach coordinates are listed in Maryland State Plane (FIPS = 1900), datum = NAD 1983 meters or other coordinate system specified *a priori* by the NCRN.

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

Table 5-2: Site characteristics for streams to be sampled during a six year rotation.

Streams are listed in proposed sampling order. Longitude and Latitude are given in Decimal Degrees from NAD83 UTM Zone 18N, North American 1983 datum.

Site_ID	Site_Name	Reach Code	PARK	Longitude	Latitude	State	County
ROCK-103-N-2008	Pinehurst Branch	2070010001805	ROCR	-77.0438112	38.9715562	DC	Washington
ROCK-104-N-2008	Luzon Branch	2070010001817	ROCR	-77.0417639	38.9610886	DC	Washington
ROCK-106-N-2008	Soapstone Valley Stream	2070010001047	ROCR	-77.0517722	38.9453248	DC	Washington
ROCK-107-N-2008	Hazen Creek	2070010001829	ROCR	-77.0524537	38.9382722	DC	Washington
ROCK-202-N-2008	Fenwick Branch	2070010001799	ROCR	-77.0422100	38.9842786	DC	Washington
ROCK-205-N-2008	Broad Branch	2070010001047	ROCR	-77.0503378	38.9449774	DC	Washington
COCA-217-N-2009	Minnehaha Creek	2070080001351	GWMP	-77.1387376	38.9681932	MD	Montgomery
POTO-118-N-2009	Palisades Creek (Battery Kemble / Maddox Branch)	2070010001849	ROCR	-77.0994776	38.9204346	DC	Washington
ROCK-108-N-2009	Piney Branch	2070010001830	ROCR	-77.0468051	38.9356142	DC	Washington
ROCK-109-N-2009	Dumbarton	2070010001846	ROCR	-77.05915551	38.915898324	DC	Washington
ROCK-111-N-2009	Normanstone	2070010001841	ROCR	-77.05607815	38.919224602	DC	Washington
ROCK-405-N-2009	Rock Creek at Dumbarton Oaks	2070010000087	ROCR	-77.05915551	38.915898324	DC	Washington
MONO-230-N-2010	Big Hunting Creek	2070009001876	CATO	-77.4404774	39.6261814	MD	Frederick
MONO-133-N-2010	Owens Creek	207000900916	CATO	-77.4819558	39.6605487	MD	Frederick
MONO-134-N-2010	Whiskey Still Creek	2070009001847	CATO	-77.4504364	39.6333986	MD	Frederick
BULL-018-N-2010	Youngs Branch	2070010000869	MANA	-77.5105512	38.8177712	VA	Prince William
MONO-217-N-2010	UT Monocacy River (Visitors Center Creek / Gambrill Mill Creek)	2070009000510	MONO	-77.3883215	39.3686687	MD	Frederick
MONO-316-N-2010	Bush Creek	2070009000308	MONO	-77.3854308	39.3690646	MD	Frederick
CHOP-102-N-2011	North Branch of Chopawamsic Creek	2070011000296	PRWI	-77.4257624	38.5650806	VA	Prince William
CHOP-103-N-2011	Middle Branch of Chopawamsic Creek	2070011000904	PRWI	-77.4237374	38.5577363	VA	Stafford
QUAN-104- N-2011	Carters Run	2070011002768	PRWI	-77.3653335	38.5656461	VA	Prince William
QUAN-101-N-2011	Mawavi Run		PRWI			VA	Prince William

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

Site_ID	Site_Name	Reach Code	PARK	Longitude	Latitude	State	County
QUAN-201-N-2011	North Fork Quantico Creek	2070011000288	PRWI	-77.3470214	38.5728770	VA	Prince William
QUAN-102-N-2011	Orenda Run		PRWI			VA	Prince William
QUAN-103-N-2011	Taylor Run	2070011000925	PRWI	-77.3750684	38.5757525	VA	Prince William
QUAN-206-N-2011	Mary Bird Branch	2070011000924	PRWI	-77.3606892	38.5681686	VA	Prince William
POTO-309-N-2012	Pimmit Run	2070010001258	GWMP	-77.1192875	38.9304884	VA	Fairfax
POTO-112-N-2012	Turkey Run	2070008004639	GWMP	-77.1569436	38.9656496	VA	Fairfax
POTO-211-N-2012	Mine Run	2070008001412	GWMP	-77.2565161	38.9997962	VA	Fairfax
DIFF-202-N-2012	Courthouse Creek	2070008000561	WOTR	-77.2626874	38.9396672	VA	Fairfax
DIFF-201-N-2012	Wolf Trap Creek	2070008000560	WOTR	-77.2674253	38.9409876	VA	Fairfax
ANTI-101-N-2013	Sharpsburg Creek	2070004005066	ANTI	-77.7377730	39.4550044	MD	Washington
SHEN-110-N-2013	Flowing Springs Run	2070007000030	HAFE	-77.7903512	39.2948482	WV	Jefferson
PRUT-201-N-2013	Henson Creek	2070010001904	NACE	-76.9006632	38.8346874	MD	Prince Georges
ACCO-214-N-2013	Accokeek Creek	2070010001176	NACE	-77.0540143	38.6905656	MD	Prince Georges
ANAC-113-N-2013	Still Creek	2070010001070	NACE	-76.9141393	38.9725011	MD	Prince Georges
OXON-301-N-2013	Oxon Run	2070010001264	NACE	-77.0095181	38.8105563	MD	Prince Georges

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

It is important to note that because of map errors, locations on the NHD stream reach file used for site selection may at times be in conflict with the provided coordinates relative to the exact position of the actual stream. In cases where a conflict arises between the stream reach file and provided coordinates, the Crew Leader must exercise professional judgment as to the correct sampling location and provide written documentation to the QC officer. The specific area for sampling may be adjusted slightly up- or downstream if necessary once arriving at the site in order to ensure a sampleable reach for long-term measurements is fully located on park property. Landowner permission is not necessary since all sites are fully located on NPS property.

The GPS receiver should be used (in conjunction with a compass if necessary) to locate the sampling site. After the GPS unit acquires a position, observe and record on the Spring Habitat Data Sheet (Protocol Appendix) the straight line distance from the road to the site.

Use the GPS distance and directional functions to navigate to the site. Once the GPS receiver indicates arrival at the target coordinates, walk directly (shortest distance) to the point in the stream closest to your current position. This position is the midpoint of the sampling segment (37.5 m upstream from the downstream end).

If the point where the GPS unit indicates arrival at the site is more than 30 meters from the stream, determine and record on the Spring Habitat Data Sheet (Protocol Appendix) the latitude and longitude coordinates from the mid-point of the segment.

In cases where the midpoint of the segment is listed as being within 138 m from the downstream node (confluence with another stream), the segment can be located by measuring (not pacing) the required distance upstream from the confluence. However, the GPS should still be used as confirmation.

Site Location and Length

All sampling sites are 75 m long and are located only on non-tidal 1st – 4th order (Strahler) streams based on a 1:24,000 scale stream reach file. The geographical coordinates represent the mid-point of the 75 m long site (37.5 m from the downstream end of the site). Geographic coordinates are provided for all non-random sites at the mid-point of the site (37.5 m from either end). A hard copy map showing the location of the site must also be included with data sheets.

Determination of Sampleability

To ensure that a site can be safely and effectively sampled, the Crew Leader will examine the stream prior to the initiation of any sampling. General criteria for determining sampleability include: safety, ability to electrofish effectively, and non-tidal status. No sampling should take place under dangerous conditions. If the site has non-wadeable

areas that can be safely sampled using a combination of long-handled anodes and/or dipnets, the site should be considered sampleable. Examples of conditions which could deem a site unsampleable include: a dry stream bed, obvious tidal influence, , impoundments such as those produced by beaver dams that are too deep to sample, tidally influenced streams, areas where permission is denied, and unsafe velocities/depths. The determination of sampleability for benthic macroinvertebrates, spring physical habitat assessment, vernal pools, and spring water chemistry should be noted on the Spring Index Period Data Sheet. Sampleability for electrofishing, summer physical habitat assessment, water chemistry, herpetofauna, mussels, and crayfishes should be noted on the Summer Index Period Data Sheet. A description of how to determine sampleability for each of these is included with the description of sampling methods for each. A list of codes for sampleability are provided in the Protocol Appendix.

Effective BSS benthic macroinvertebrate sampling requires inspection of suitable habitats. Although turbidity or darkly stained water should not prohibit benthic macroinvertebrate sampling, streams that are so turbid that benthic macroinvertebrate habitat cannot be seen at all should not be sampled. Exceptions are sites with persistent and excessive turbidity problems (based on many return visits none of the stream bottom is ever visible). In these cases a note describing the turbidity problem should be made in the comments section of the spring data sheet.. The appropriate code for unsampleability (page 49) should be recorded on the Spring Index Period Data Sheet.

Prior to conducting electrofishing, the crew leader (with input from other crew members) must determine if the site can be sampled safely and effectively. Electrofishing can only be conducted safely if the site being sampled can be waded. If the depth or current velocity precludes safe wading, then the site should be considered unsafe for electrofishing. However, where the margins of deep areas can be safely waded and fish can be effectively captured (e.g. using long handled dip nets and anodes), as long as all other sampleability considerations are met, sampling should occur. The most predominant effective sampleability consideration is water visibility. Effective BSS electrofishing cannot occur in water that is turbid.

All areas of the stream bottom must be visible. The only exception to the visibility consideration is a stream that is stained dark from natural organic sources (tannins leached from leaves; blackwater streams). Although sampling can occur in blackwater streams when visibility is relatively limited due to a natural cause, sampling should not occur in a blackwater stream that is also turbid. Whether or not the entire stream bottom is clearly visible in all portions of the site is recorded on the BSS Fish Data Sheet.

In addition to turbidity and tannic water, overhanging vegetation (especially multiflora rose) may prohibit clear visibility of (and often access to) the stream and habitats that are to be sampled. Provided proper authorization from the Park Resource Manager has been acquired, vegetation that substantially limits electrofishing should be cleared prior to

electrofishing. Block nets should be put in place prior to commencing clearing (or as early as possible during the clearing process) so that fishes are not chased from the site during clearing. Note that when rating shading on the BSS Summer Habitat Assessment Data Sheet shading that was present before clearing should be recorded.

If a stream is unsampleable (typically due to depth, velocity, or turbidity) during the early part of the Summer Index Period or following rain, the stream should be visited later in the Index Period or during a dryer period to re-assess sampleability. If (upon return visits) the stream is found to be continuously too deep, fast, or turbid to sample, then the appropriate code for unsampleability (found on the BSS Summer Index Period Data Sheet) should be recorded on the Summer Index Period Data Sheet.

Culverts

It should be noted that some sites may still be sampleable even though they include underpasses, beaver dams, large culverts, and dry sections. In the case of small culverts which cannot be electrofished, the length of the culvert should be measured and recorded on the data sheet and the length added to the original 75 m site. If the culvert occurs in the first half of the site, the additional distance should be added to the downstream end of the site. Similarly, the additional distance should be added to the upstream end, if the culvert is within the upper half of the original site. If the culvert can be sampled completely, no change should be made to the original 75 m site.

Moving Sites

The location of a site can be changed to ensure that a sample is collected as close as possible to the location originally chosen for sampling. This may be important to avoid any bias that may come from sampling large numbers of replacement sites. However, the maximum distance that a site should be moved is 75 meters. Sites (especially randomly selected sites) should only be moved after every attempt has been made to sample the site in its originally chosen location.

Marking the Sampling Site Boundaries

If a site is determined to be sampleable, place a site marker/orange flagging at the upstream and downstream boundaries **and place labeled flagging at the 25 and 50 m locations**. The 25 m and 50 m locations need to be identified along with the 75 m and 0 m locations to complete Summer Index period habitat sampling. Marking of all four locations (0 m, 25 m, 50 m, and 75 m) during the spring index period is recommended. Although it is important to mark the segment well enough that it can be relocated in summer, markings should not be so conspicuous as to be eyesores. After marking the segment, record on the data sheet the stream width at the upstream and downstream boundaries. If electrofishing is not possible, other activities should still be conducted if

possible. To the full extent possible, all flagging or other material used for marking sites should be removed from the site following the last visit to the site.

Photodocumentation

All BSS sites require at least one photograph be taken of the stream being sampled. Typically, at least two photographs are taken from the mid-point of the site, one looking upstream and one looking downstream. These photographs are typically taken during the Spring Index Period and are used to depict the general appearance and conditions of the stream. Any unusual or unique conditions that exist at the site should be documented with a photograph. Examples of unusual or unique conditions include severely eroded stream banks or trash dumping, pipes or other point source discharges, unusual water coloration, abundant flocculent, large silt or sediment deposition, and riparian tree cutting. Many conditions may warrant taking a photograph to document observations. Crew Leader judgment should be used when deciding what conditions should be photographed. However, when in doubt, take a picture.

A unique number should be used to label each digital photograph on the camera. This number, along with a descriptive title, should be entered in the appropriate portion of the Spring or Summer Index period data sheet, depending on when the photograph(s) was taken. Digital photograph files should be stored with file names that include (at a minimum) the site identification and the unique photograph number. All files should be appropriately backed up.

After arrival at the sampling segment, the Crew Leader should determine whether unusual or unique conditions exist at the segment, and whether photographs should be taken to document these conditions. **In any event, digital photographs should be taken at every site visited to document conditions regardless of whether or not the site could be sampled.**

For each photograph taken, record the time and an appropriate title on the Spring Index Period Data Sheet (see Appendix 5-A). All photograph files should be named with the site label as it appears on the top of each data sheet. All photographic files should be backed up and then submitted to the Data Management Officer for archiving within two weeks after the Spring Index Period ends.

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

Appendix 5-A: Sampling Site Locations in the Parks

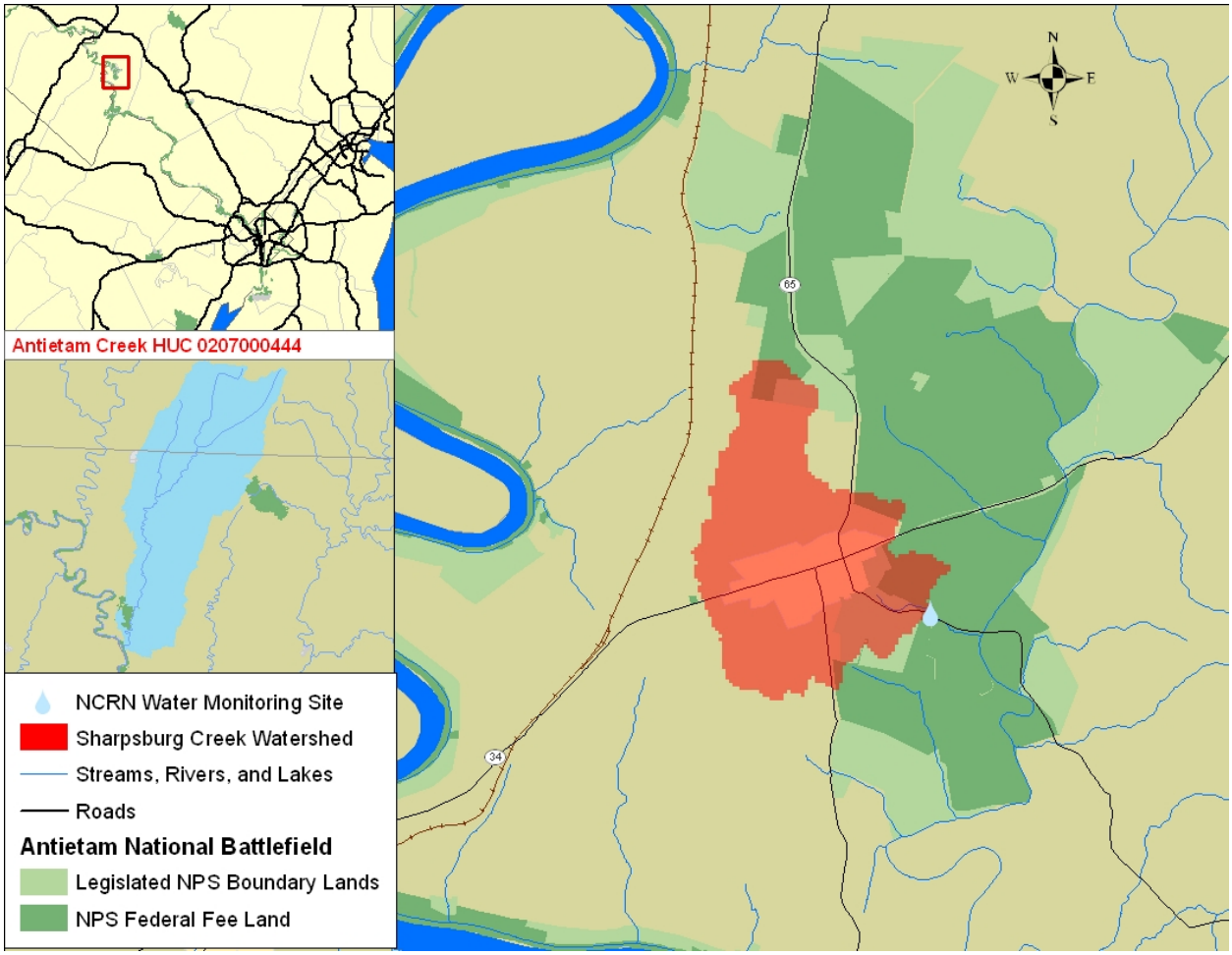


Figure 5-1: Sampling sites in Antietam National Battlefield (ANTI)

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

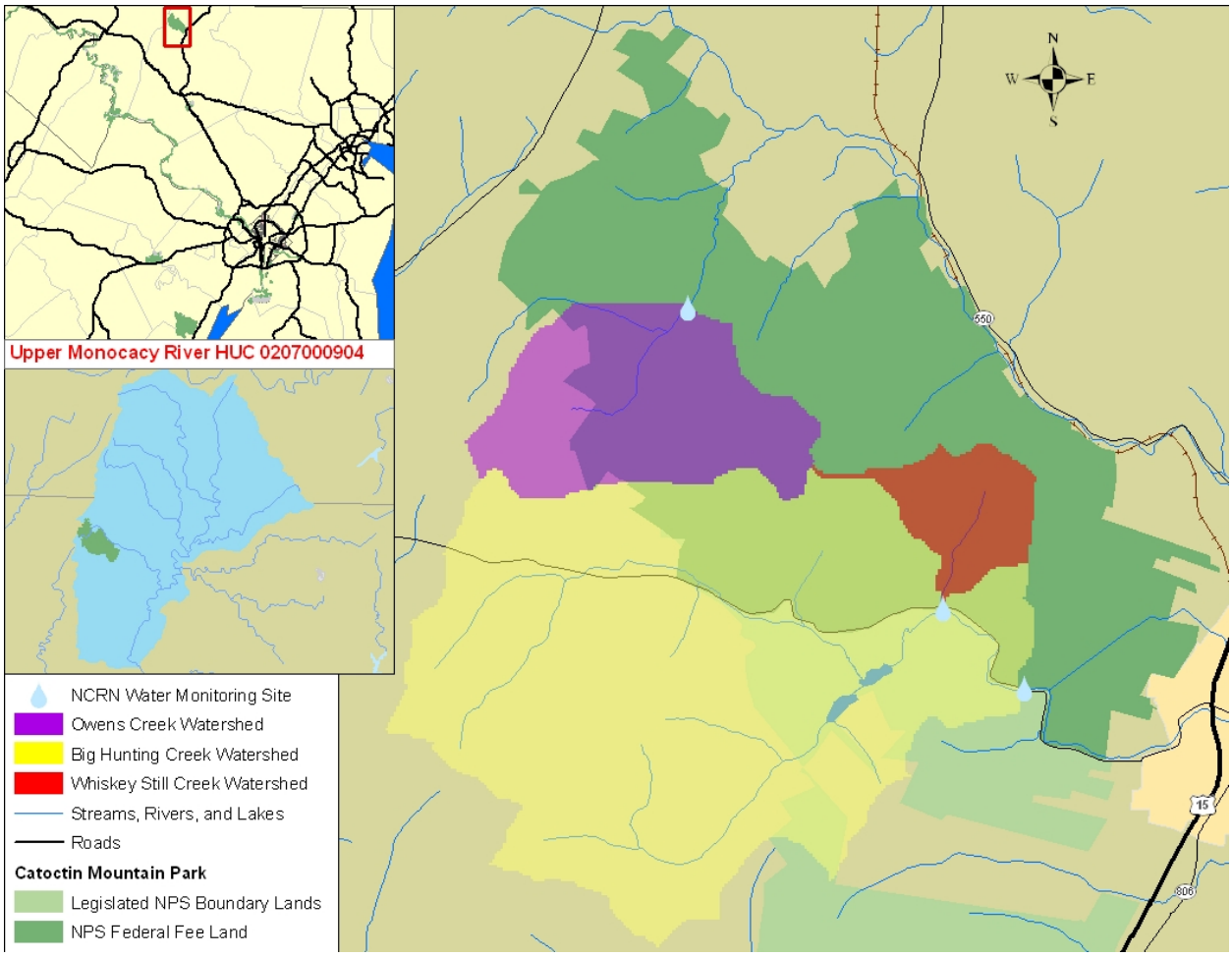


Figure 5-2: Sampling sites in Catoctin Mountain Park (CATO)

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

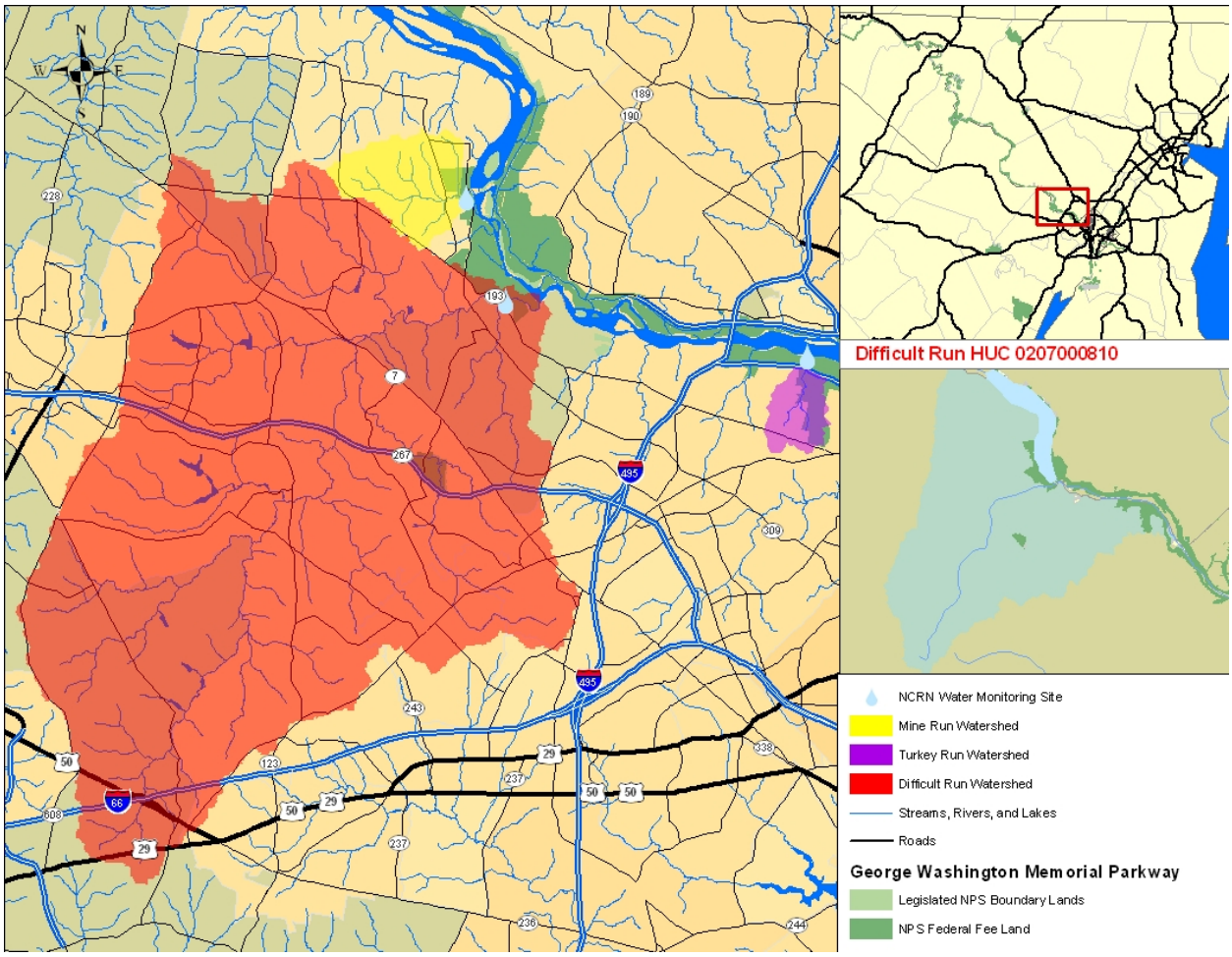


Figure 5-3a: Sampling sites in George Washington Memorial Parkway (GWMP): Mine Run, Turkey Run, and Difficult Run

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

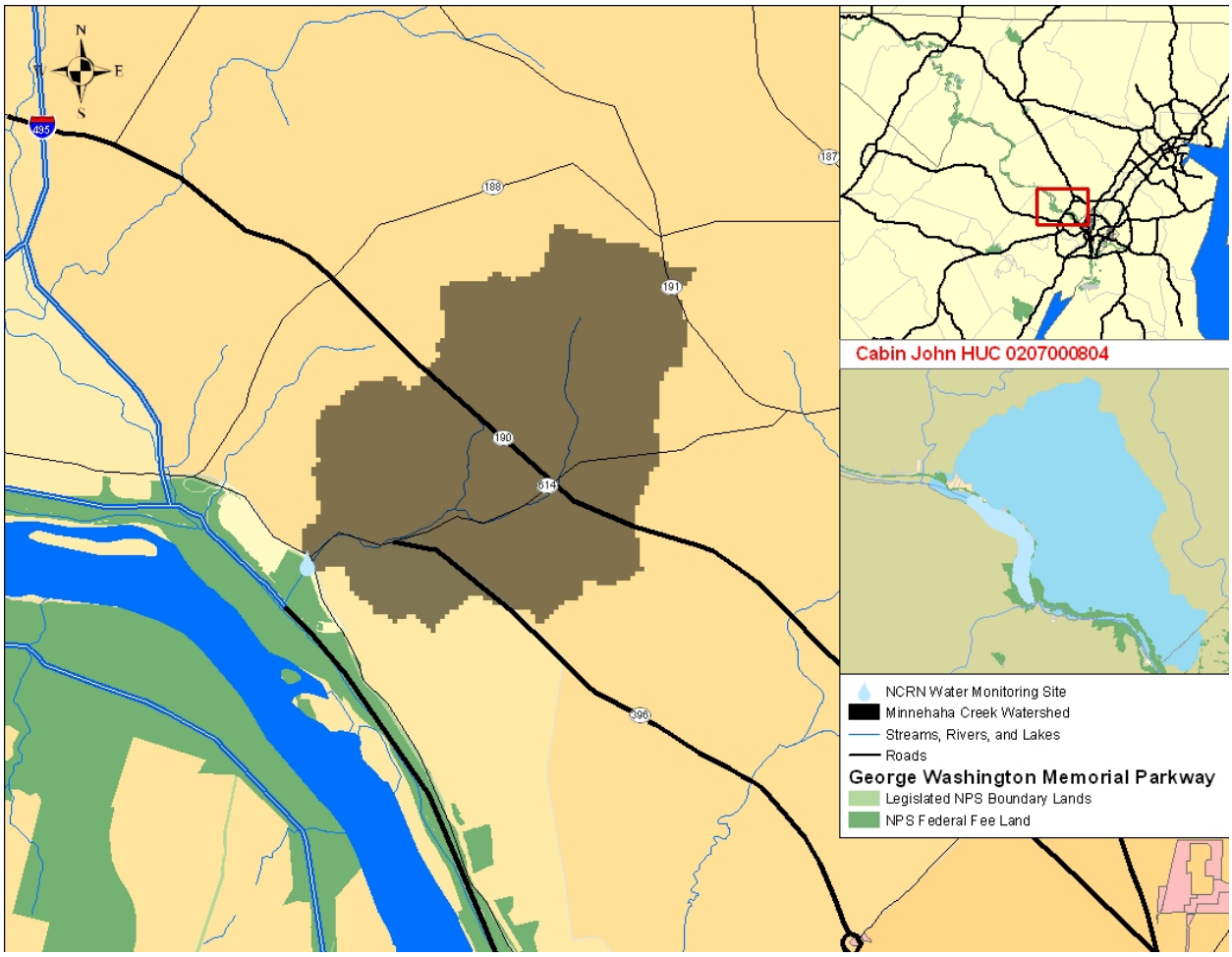


Figure 5-3b: Sampling sites in George Washington Memorial Parkway (GWMP): Minnehaha Creek

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

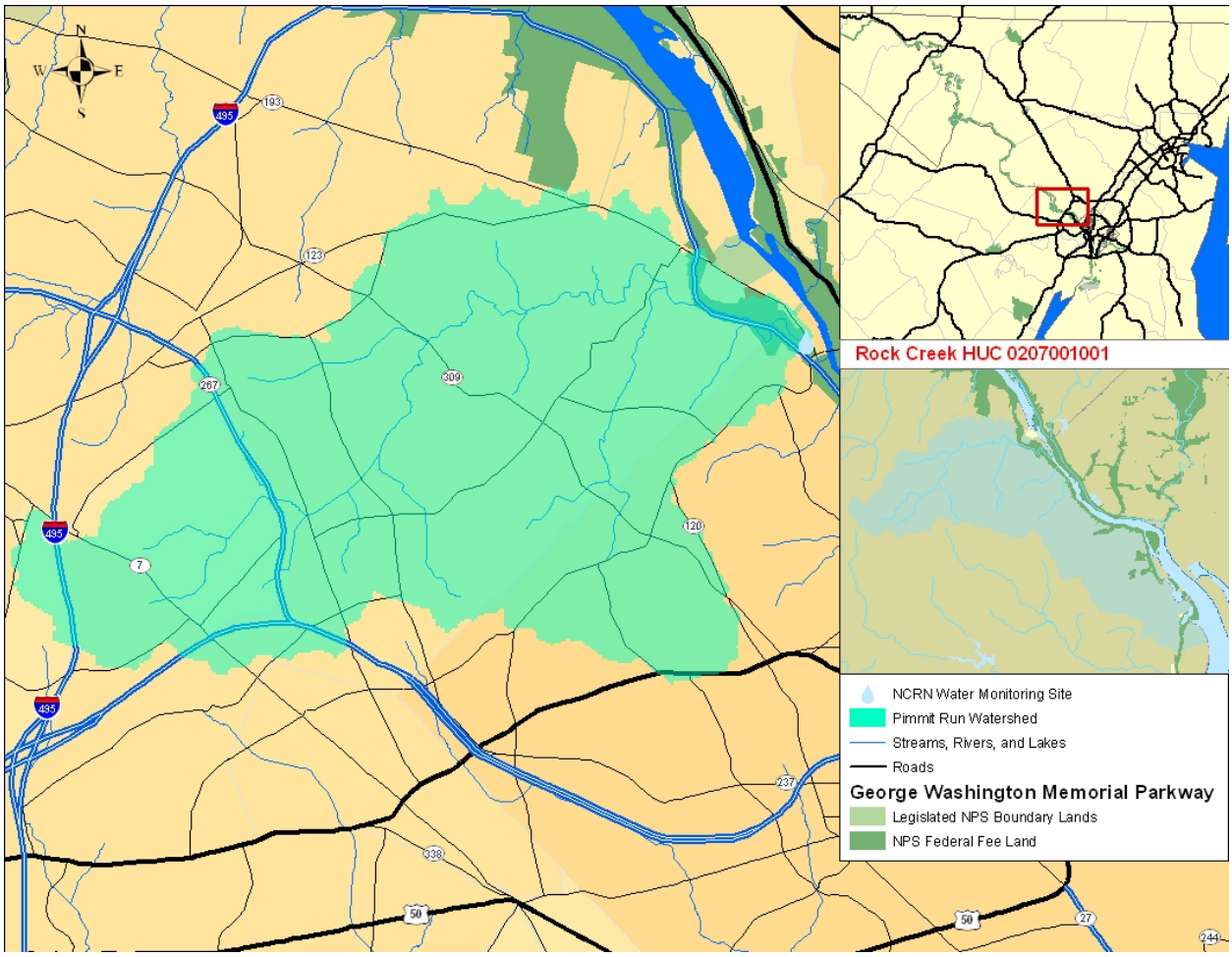


Figure 5-3c: Sampling sites in George Washington Memorial Parkway (GWMP): Pimmit Run

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

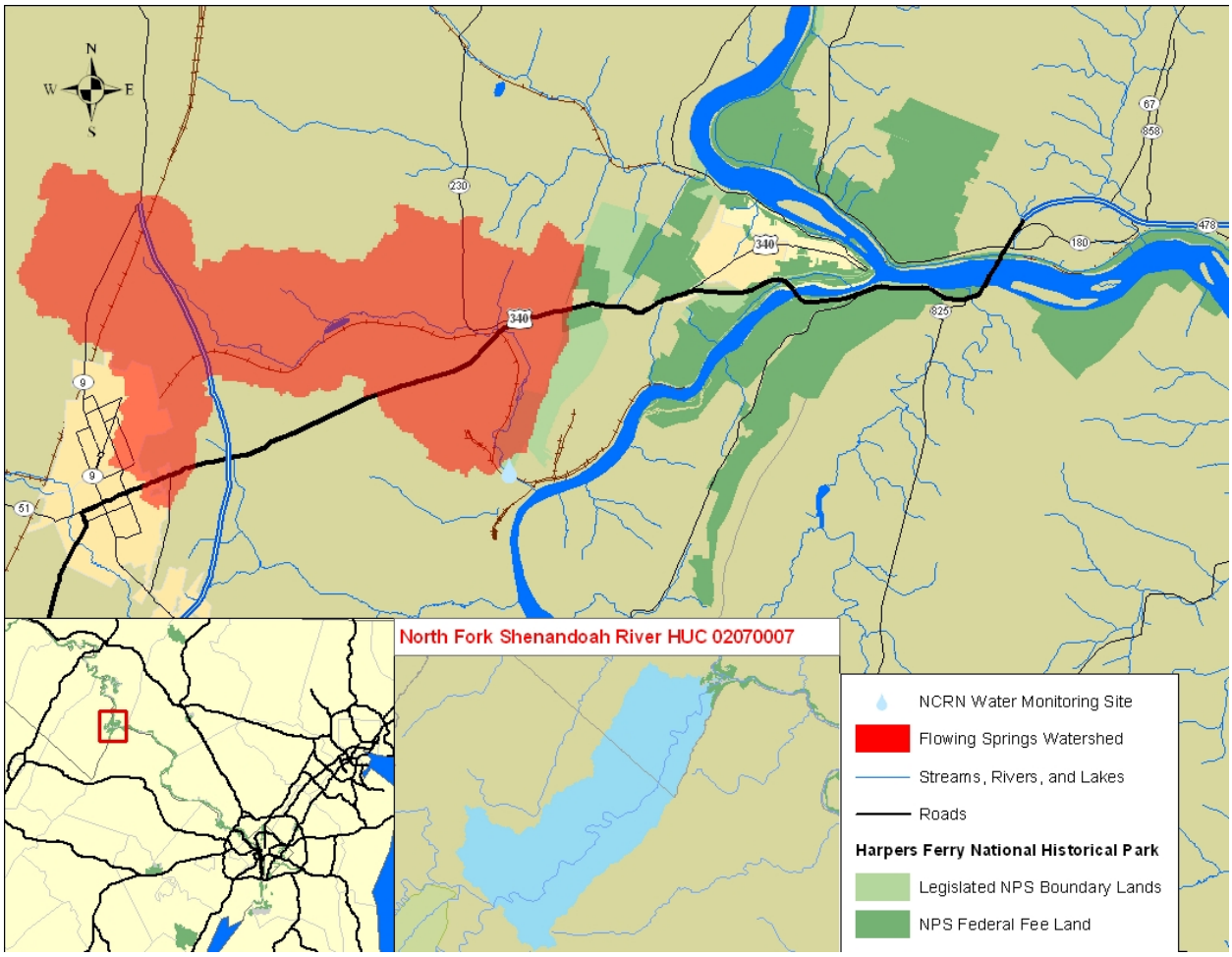


Figure 5-4: Sampling sites in Harpers Ferry National Historical Park (HAFE): Flowing Springs

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

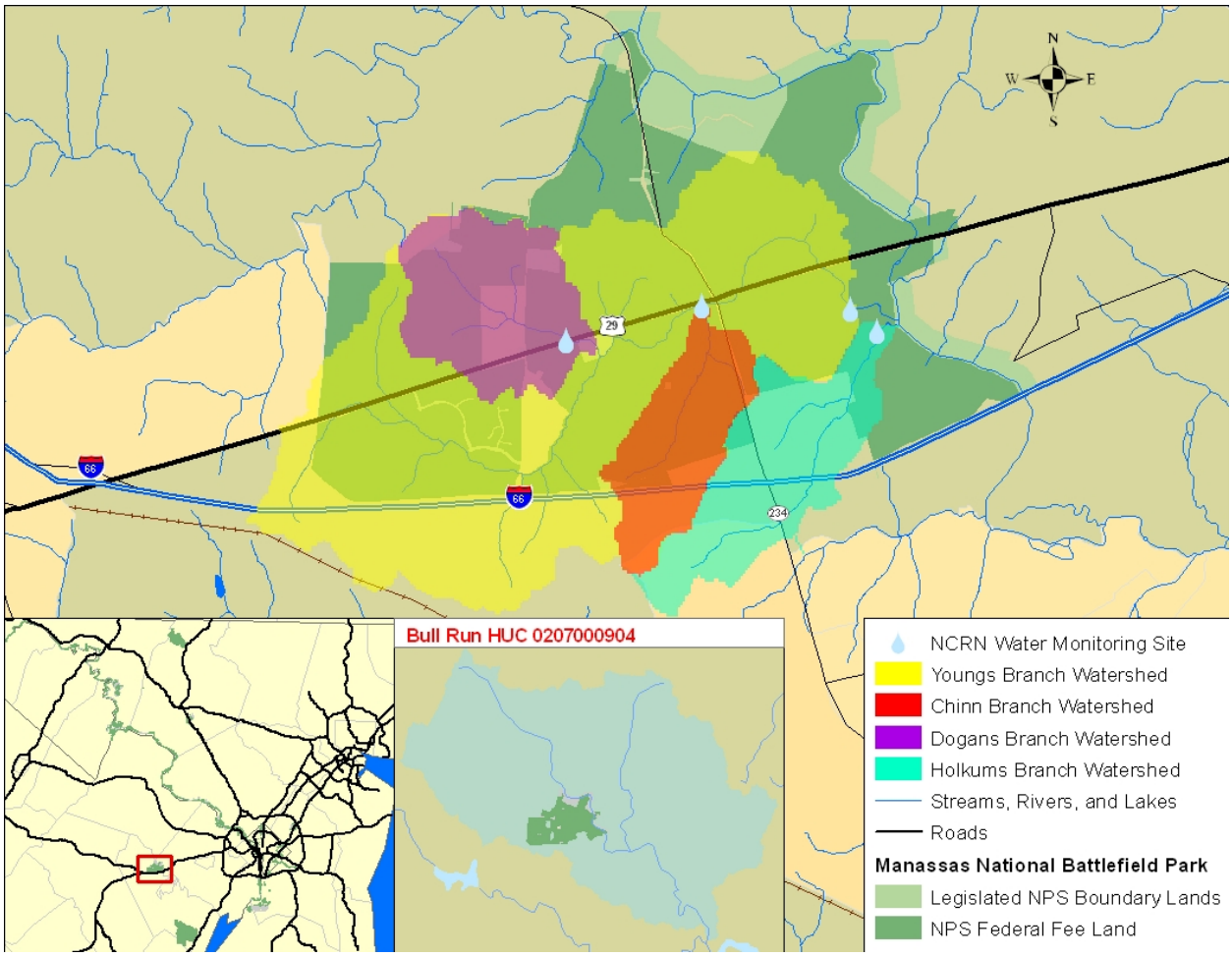


Figure 5-5: Sampling sites in Manassas National Battlefield Park (MANA): Youngs Branch

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

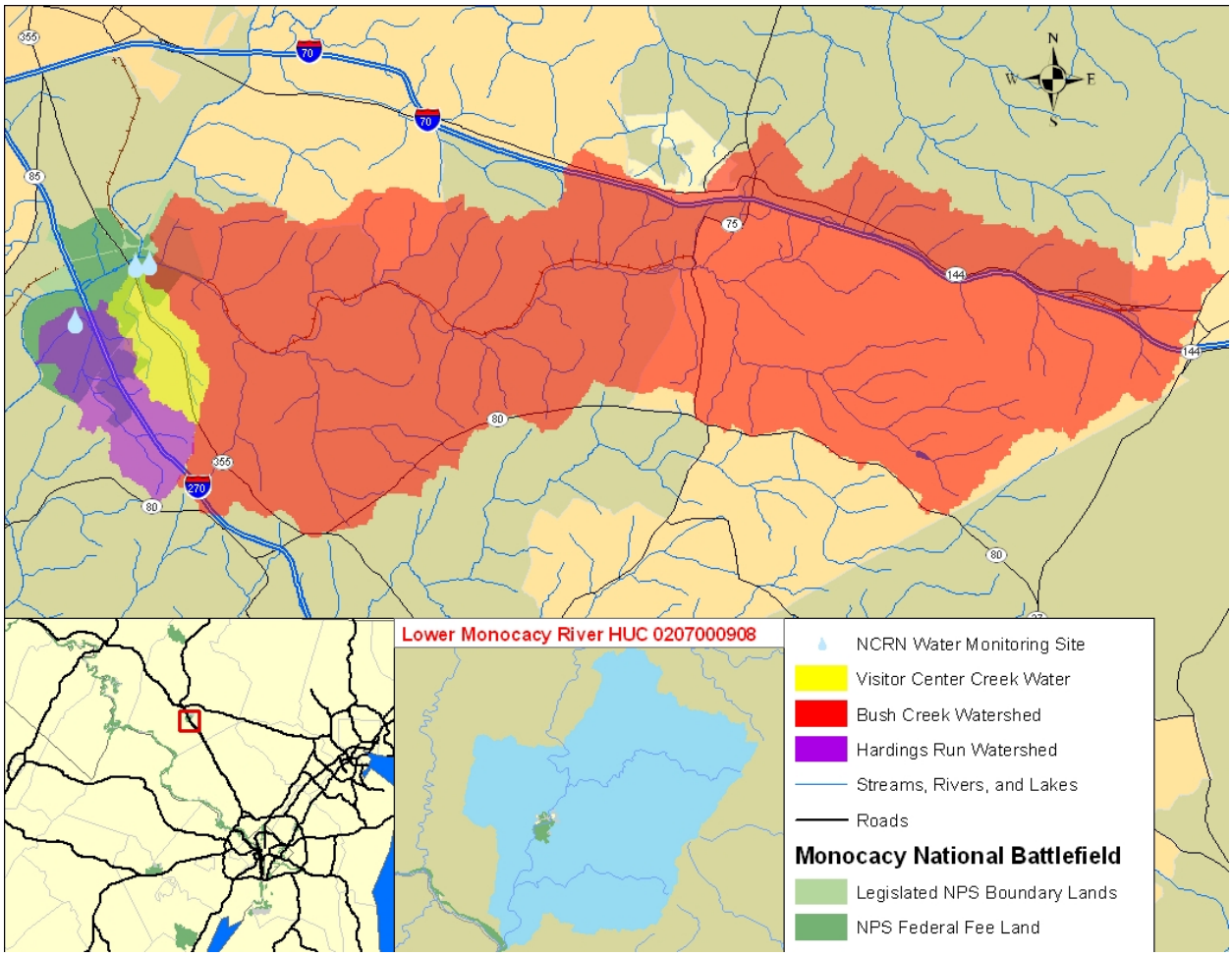


Figure 5-6: Sampling sites in Monocacy National Battlefield (MONO): Bush Creek, Visitors Center (Gambrill Mill) Creek

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

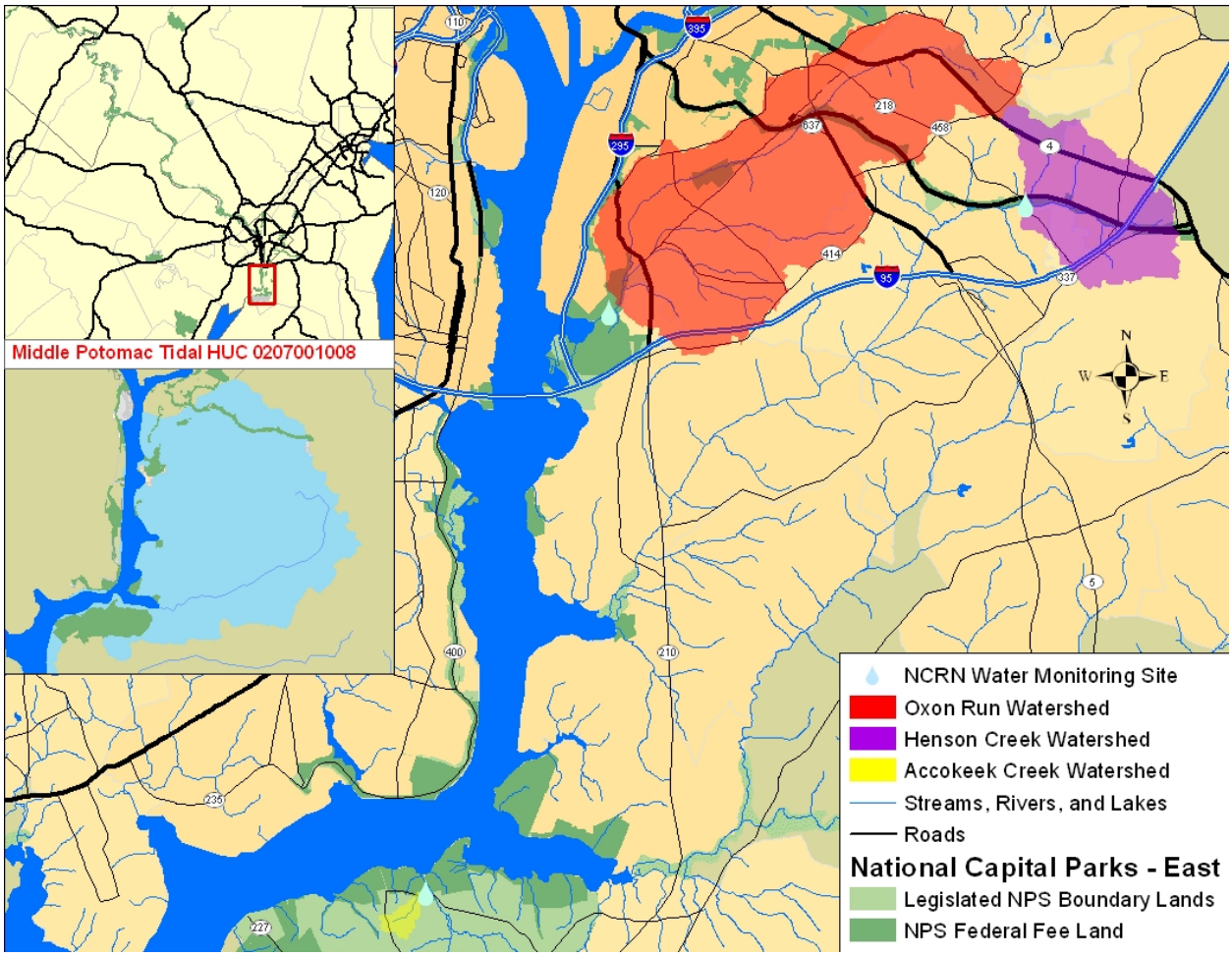


Figure 5-7b: Sampling sites in National Capital Parks–East (NACE): Oxon Run, Henson Creek, and Unnamed Tributary of Accokeek Creek

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

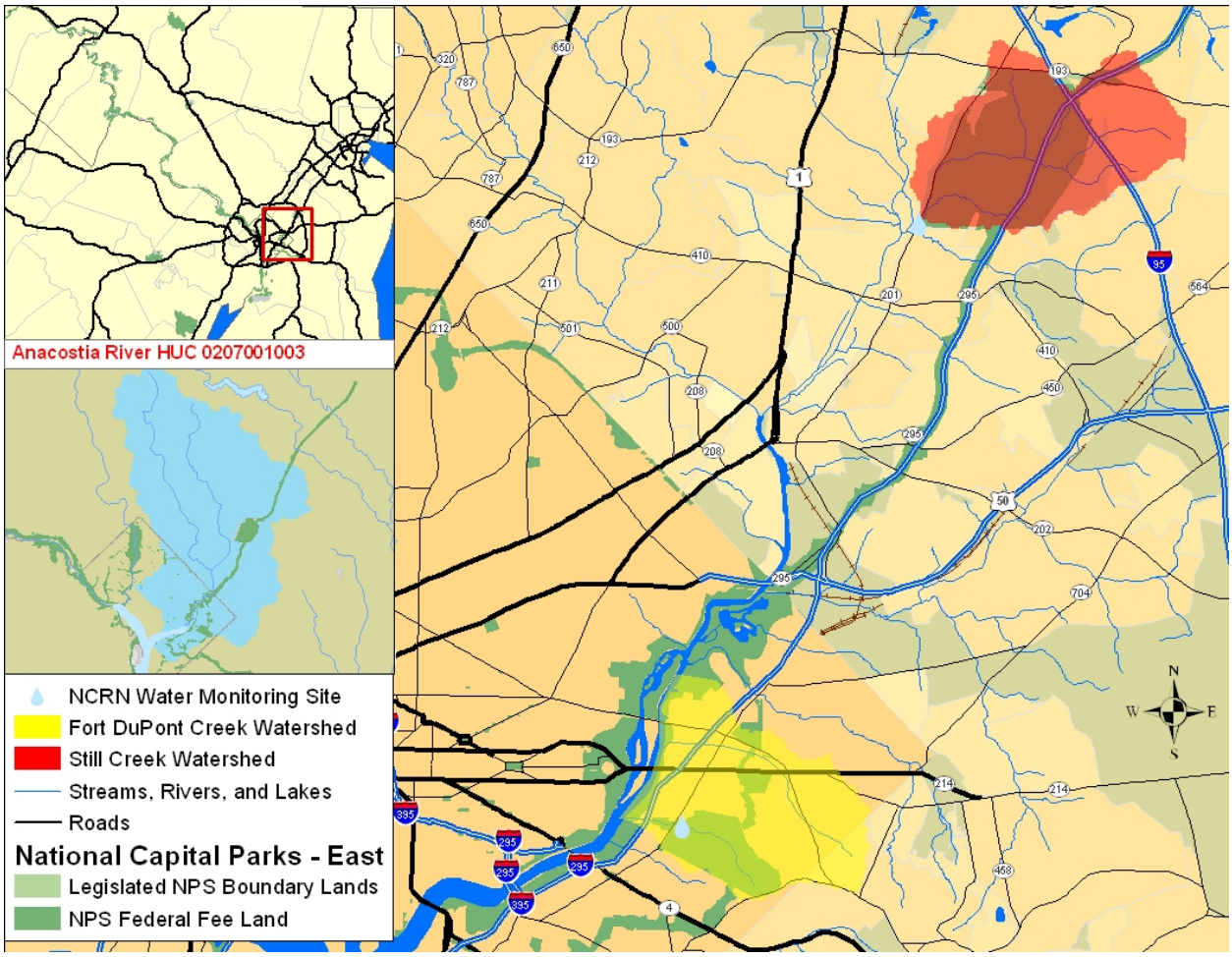


Figure 5-7b: Sampling sites in National Capital Parks–East (NACE): Fort Dupont and Still Creek

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

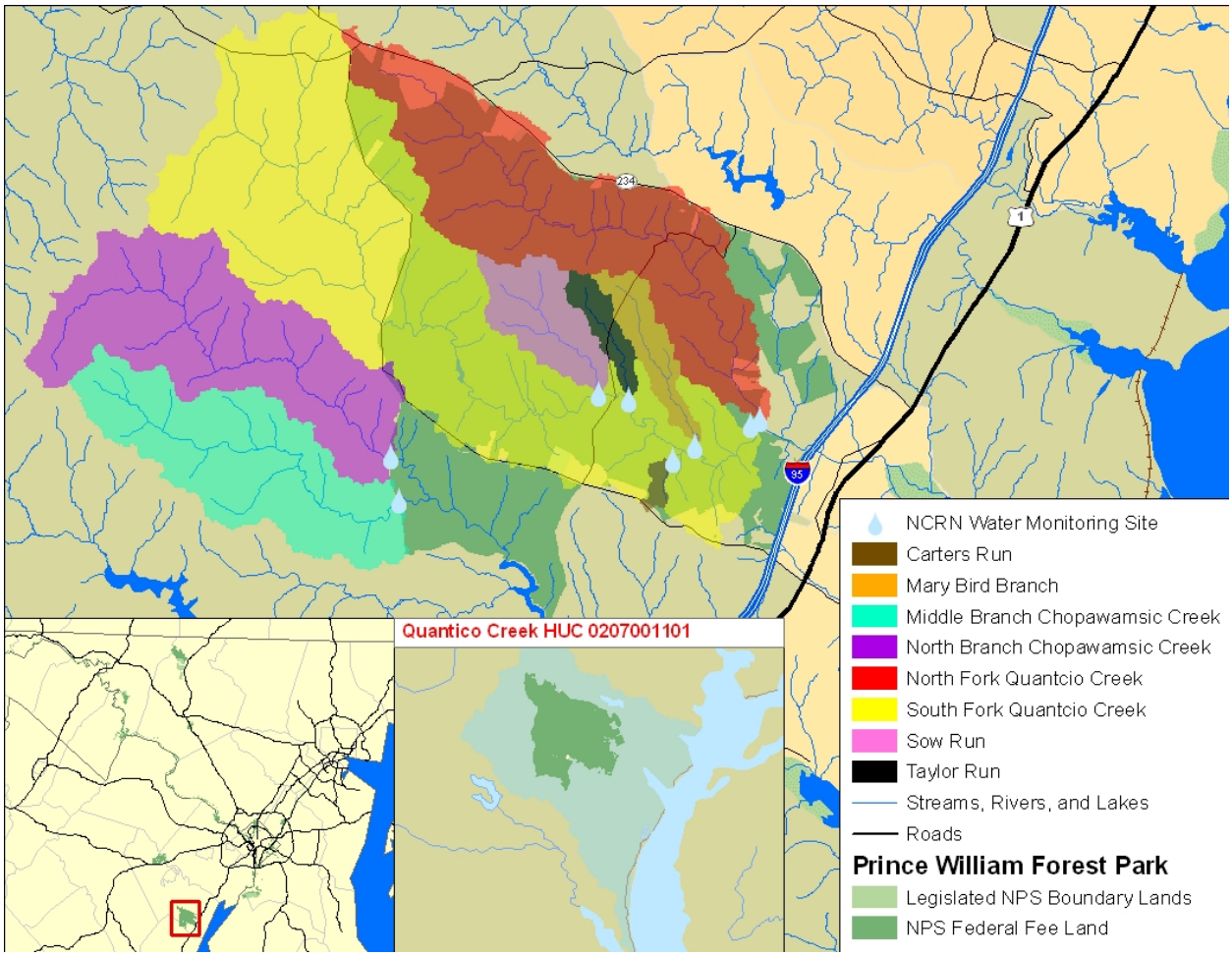


Figure 5-8: Sampling sites in Prince William Forest Park (PRWI):

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

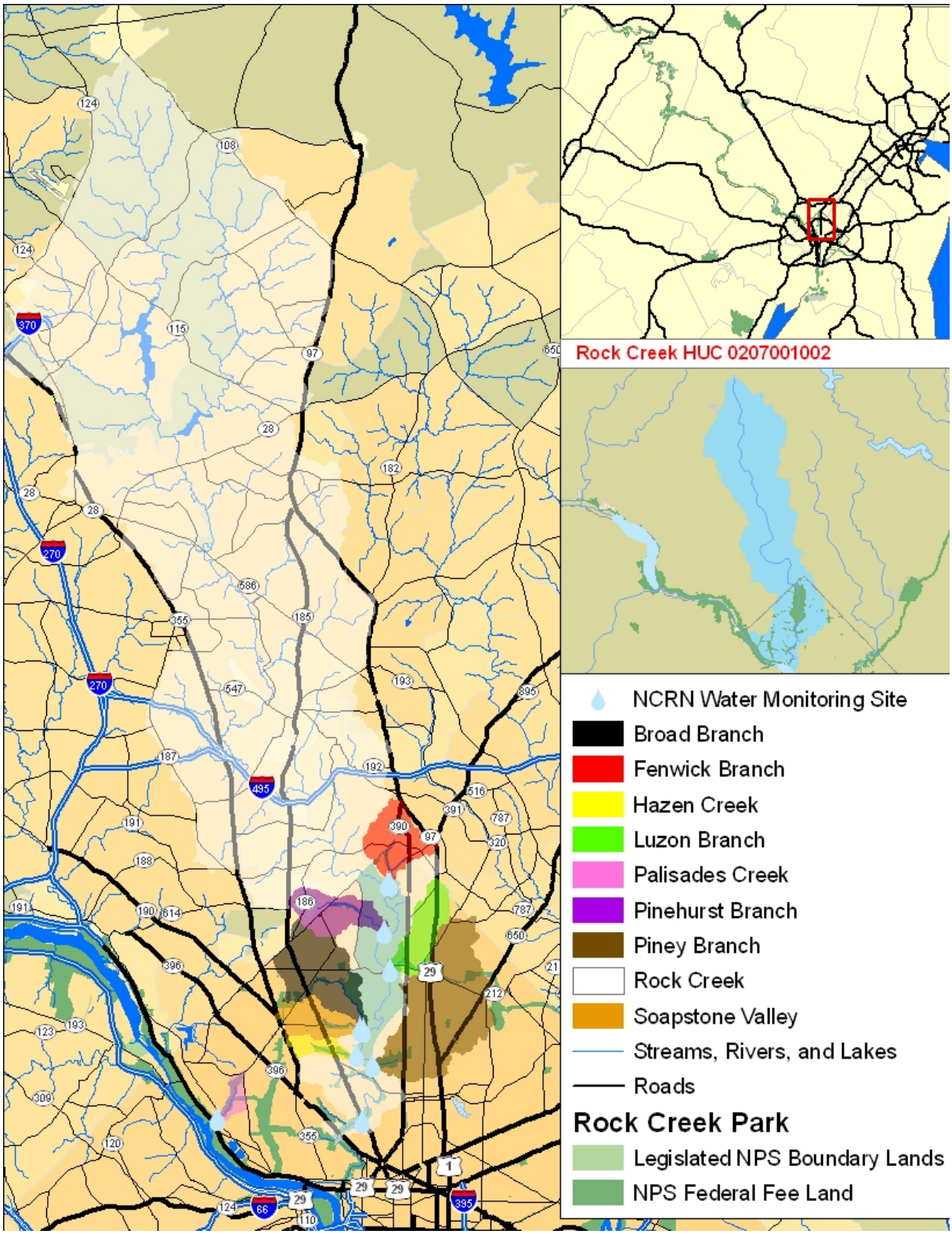


Figure 5-9: Sampling sites in Rock Creek Park (ROCR)

NCRN Biological Stream Survey
Sampling Site Location
Standard Operating Procedure #5

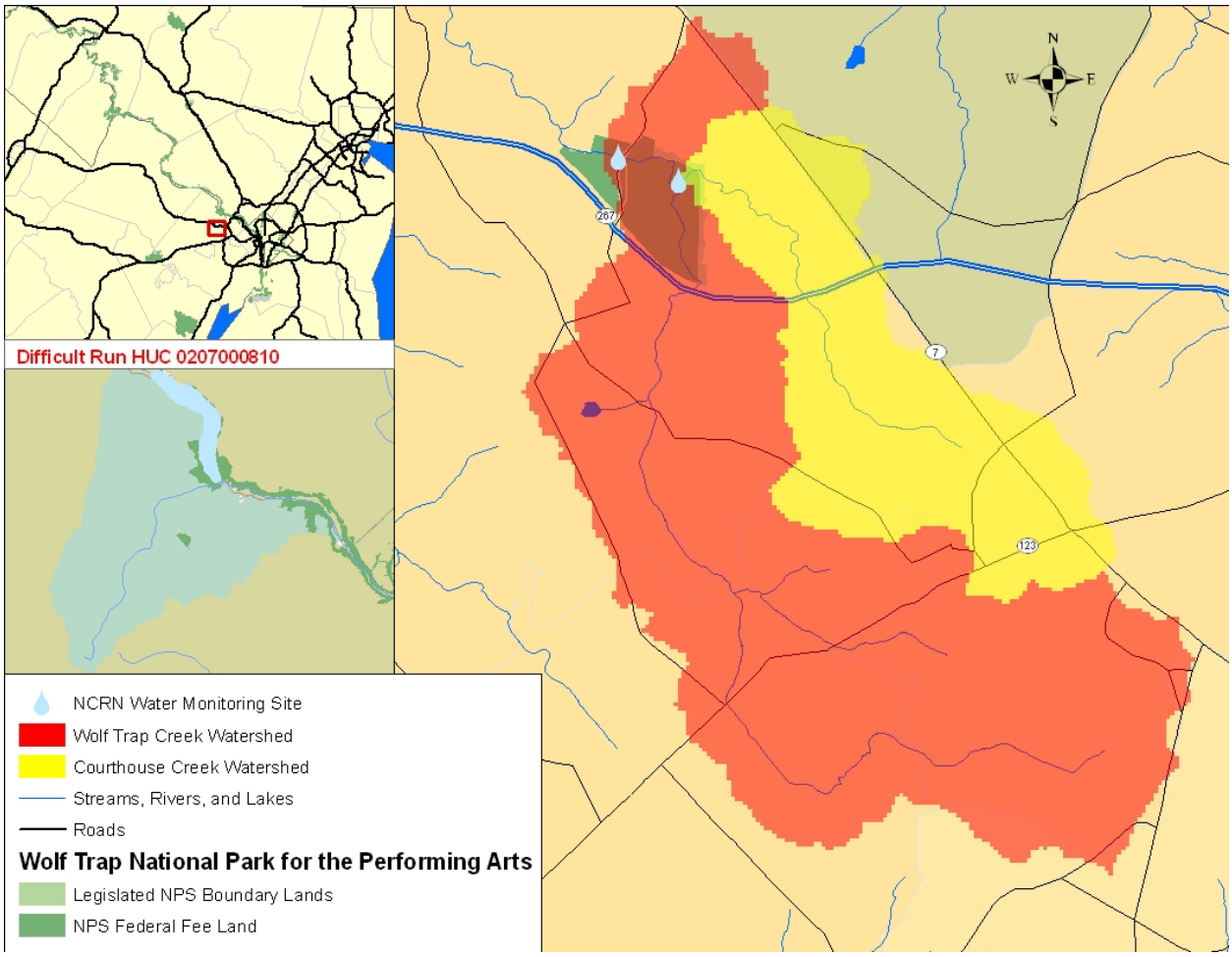


Figure 5-10: Sampling sites in Wolf Trap National Park for the Performing Arts (WOTR)

NCRN Biological Stream Survey
Spring Index Period Water Quality Sampling
Standard Operating Procedure #6

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, renaming, rewording	Updating protocol for use by any contractor	1.1

Purpose

The Standard Operating Procedures (SOP) detail how to collect water samples for laboratory analysis for water resources in National Capital Region parks.

Scope and Applicability

This SOP applies to the collection and processing of benthic macroinvertebrate samples during the Spring Index Period in NCRN parks.

Reference Documents

APHA. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association, Washington, DC.
EPA. 1987. Handbook of Methods for Acid Deposition Studies: Laboratory Analyses for Surface Water Chemistry. Office of Acid Deposition, Environmental Monitoring and Quality Assurance, U.S. Environmental Protection Agency, Washington, DC.
EPA. 1999. Methods and Guidance for Analysis of Water. EPA 821-C-99-004. Office of Water, U.S. Environmental Protection Agency, Washington, DC.

Procedures and General Requirements

Selected water quality variables (pH, ANC, sulfate, nitrite, nitrate, ammonia, total nitrogen (dissolved and particulate), ortho-phosphate, total phosphorous (dissolved and particulate), chloride, conductivity, and DOC) are measured under spring baseflow conditions as part of the BSS to provide information about the state of acidification and degree of organic loading in the reaches being sampled. In addition, *in situ* measurements of dissolved oxygen, temperature, pH, turbidity, and conductivity should be made during the Summer Index Period (see SOP #9). Table 4-1 has details on analysis methods and holding times for water chemistry samples.

NCRN Biological Stream Survey
Spring Index Period Water Quality Sampling
Standard Operating Procedure #6

Sample Period

Collection of samples for laboratory analyses for the BSS occurs during the Spring Index Period. The range of dates for the Spring Index Period will be 1 March to approximately 1 May, depending on the region being sampled. The ending date for the Spring Index Period is based on sample degree-day accumulations of mean air temperatures above 4.5 C. For Coastal Plain physiographic regions, spring sampling will be completed prior to degree-day accumulations reaching 440. For all other physiographic regions, spring sampling will be completed prior to degree-day accumulations reaching 1050. This approach was chosen because existing studies in Maryland have demonstrated that sampling in spring can estimate the degree of acidification in a stream within acceptable limits and also provide benthic macroinvertebrate data most suited to identifying anthropogenic stresses at a site.

In addition to laboratory water quality sampling in spring, *in situ* measurements of dissolved oxygen, temperature, pH, and conductivity will be made during the Summer Index Period. The Summer Index Period extends from 1 June to 30 September.

Water Sampling Protocols

Prior to departure for the sample segment, the Crew Leader must ensure that all equipment needed for water quality and benthic macroinvertebrate sampling is present, in working order, and calibrated. Necessary equipment for the Spring Index Period is listed in Table 1 (SOP4). The Crew Leader must also ensure that the list of sample blanks and duplicates to be collected (provided the by QC Officer) is present.

All bottles for water sampling should be leached in deionized water for at least 24 hours prior to field use, and syringes should be new and unopened. All sampling equipment should be carefully packed to eliminate potential contamination. If any contamination is suspected, spare sample bottles or syringes should be used.

Water samples should be collected without regard to: stream stage and the amount of precipitation or the time since the last precipitation--the only criteria that must be met are that the stream is safe and a representative benthic sample can be collected. However, sampling during turbid conditions or just after heavy rains should be avoided to ensure that benthic habitat can be properly evaluated.

After sampleability of a segment has been determined and the site markers installed, the crew member responsible for water quality sampling should move to the upstream boundary of the sample segment, carefully locating an undisturbed area for sampling. [By collecting water quality samples from the upstream boundary, any non-representative, temporary water quality changes caused by benthic macroinvertebrate sampling will be avoided.]
Label the 1 liter and 0.5 liter sample bottles and the syringe. The label (Appendix H) should include: the park code (e.g., MANA), the date, and segment identification as recorded on the top

NCRN Biological Stream Survey
Spring Index Period Water Quality Sampling
Standard Operating Procedure #6

of the Spring Index Period Data Sheet. Each syringe and sample bottle label must be verified by a member of the field crew for accuracy, with verification indicated on the data sheet (Appendix A). All labels on water quality samples should be covered with clear plastic tape to ensure the labels are not smudged or lost. [Labels for QC samples [see 7) below] should use letter characters in place of numbers in the 'segment' portion of the label (e.g, 1=A; 2=B, 3=C, etc.).]
Using care to avoid potential sample contamination from handling, fill the pre-leached 0.5 and 1 liter sample bottles to half-full, rinse, and discard. Repeat the process twice. Then fill the sample containers such that no or a minimum of air space exists in the neck of the bottle. These samples will be used for all analyses except pH.
Check to ensure that the seals on both sample bottles are tight.
Place a Luer Lock valve on the end of the syringe. Fill the syringe for pH three times, expelling the water each time. Fill the syringe a fourth time to the 60 ml mark. Hold the syringe in a vertical position and gently tap it until all bubbles are released. After all air is expelled from the syringe, use the plunger to release 5 to 10 ml of sample. When the volume in the syringe is 50 to 55 ml and while still discharging water, carefully close the Luer Lock valve. [Syringes should not contain more than 50–55 ml of sample to minimize the possibility of plunger dislodgement during shipping].
Place samples on wet or blue ice (e.g., Kool Paks) to maintain samples at 4° C until laboratory analysis is performed.
If a blank sample is designated to be taken at the segment being sampled, that sample should be taken before collecting a routine sample at the randomly selected stream reach. Blanks should be collected following collection procedures outlined in steps 2 to 7 above, except that water from the DI water container should be substituted for stream water. The letter "B" for "blank" should be written in the QC label portion of the Spring Data Sheet. The label for the QC sample should be the same as the original sample, EXCEPT THAT LETTERS SHOULD BE SUBSTITUTED FOR NUMBERS IN THE "SEGMENT" PORTION OF THE LABEL (e.g., A=1; B=2; C=3, etc.).
If a duplicate sample is to be taken, that duplicate sample should be collected immediately after the routine sample using steps 2 to 7 above. The letter "D" for "Duplicate" should be entered on the QC label portion of the data sheet.
After sample collections are completed, the field data and chain-of-custody forms (see Appendix J) should be completed and checked by the field crew for completeness and accuracy.
Sample bottles must be shipped to the analytical laboratory via overnight mail within 48 hours of collection. FedEx Standard Overnight must be used for weekday deliveries. However if samples are going to be shipped on a Friday, Saturday Delivery and Priority Overnight must be checked on the FedEx form. When a Saturday Delivery is expected, the analytical laboratory MUST be notified, either by phone or email to ensure that the shipment is received and processed. Special attention should be given to packing samples in such a way that they are unlikely to leak or break during transport. During the packing process, re-verify that data sheets, labels on samples, and chain-of-custody sheets are consistent, and that a complete sample has been taken. For consistency sake, MBSS uses the Appalachian Laboratory of the University of Maryland Center for Environmental Science (301 Braddock Rd, Frostburg, MD 21532).

NCRN Biological Stream Survey
Spring Index Period Water Quality Sampling
Standard Operating Procedure #6

Analytical laboratory analyses and the standard techniques are reported in Table 6-1.

TABLE 6-1. ANALYTICAL METHODS, INSTRUMENTS, DETECTION LIMITS, AND HOLDING TIMES FOR WATER QUALITY ANALYSES FOR LONG-TERM MONITORING OF WATER RESOURCES IN THE NATIONAL CAPITAL REGION.

Analyte (units)	Method	Instrument	MDL Approximation	PQL	Holding Time (days)
pH (standard units)	EPA (1987) Method 19	Orion pH meter	0.01	0.05	7
Acid neutralizing capacity (μeq/l)	EPA (1987) Method 5	Brinkmann Automated Titration System equipped with customized software	0.01	0.05	14
Sulfate (mg/l)*	APHA (1998) 4110-C	Dionex DX-500 Ion Chromatograph (AS-9 HC column)	0.020	0.10	14
Nitrite-nitrogen* (mg/l)	EPA (1999) Method 354.1	Lachat QuikChem Automated Flow Injection Analysis System	0.0004	0.0020	28 (frozen)
Nitrate-nitrogen* (mg/l)	APHA (1998) 4110-C	Dionex DX-500 Ion Chromatograph (AS-9 HC column)	0.001	0.005	14
Ammonia (mg/l)*	EPA (1999) Method 350.1	Lachat QuikChem Automated Flow Injection Analysis System	0.003	0.015	28 (frozen)
Total Nitrogen (mg/l)	APHA (1998) 4500-N (B)	Lachat QuikChem Automated Flow Injection Analysis System w/In-line Digestion Module	0.0980	0.490	28 (frozen)
Ortho-phosphate (mg/l)*	APHA (1998) 4500-P (G)	Lachat QuikChem Automated Flow Injection Analysis System	0.0007	0.0035	28 (frozen)
Total Phosphorus (mg/l)	APHA (1998) 4500-P (H)	Lachat QuikChem Automated Flow Injection Analysis System w/In-line Digestion Module	0.0037	0.0185	28 (frozen)
Chloride (mg/l)*	APHA (1998) 4110-C	Dionex DX-500 Ion Chromatograph (AS-9 HC column)	0.010	0.05	14
Specific conductance (mg/l)	APHA (1998) 2510-B	YSI Conductance Meter w/Cell	0.1	0.5	7
Dissolved organic carbon (mg/l)*	APHA (1998) 5310-C	Dohrmann Phoenix 8000 Organic Carbon Analyzer	0.14	0.7	28

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, renaming, rewording	Updating protocol for use by any contractor	1.1

NCRN Biological Stream Survey
Spring Index Period Benthic Macroinvertebrate Sampling
Standard Operating Procedure #7

Purpose

The Standard Operating Procedures (SOP) details how to collect benthic macroinvertebrate samples for assessing biological condition of water resources in National Capital Region parks.

Scope and Applicability

This SOP applies to the collection and processing of benthic macroinvertebrate samples during the Spring Index Period in NCRN parks.

Reference Documents

Boward, D.M. 2000. Maryland Stream Waders. Volunteer Stream Sampling Manual. Maryland Department of Natural Resources. Monitoring and Non-tidal Assessment Division. Annapolis, Maryland.

Boward, D., and E. Friedman. 2001. Maryland Biological Stream Survey: laboratory methods for benthic macroinvertebrate processing and taxonomy. Prepared by Maryland Department of Natural Resources (CBWP-MANTA-EA-00-6).

EPA 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. U.S. Environmental Protection Agency. EPA/600/4-90/030. Cincinnati, Ohio.

Kazyak, P.R. 2000. Maryland Biological Stream Survey Sampling Manual. Maryland Department of Natural Resources. Monitoring and Non-tidal Assessment Division. Annapolis, Maryland.

Stribling, J.B., B.K. Jessup, J.S. White, D.M. Boward, and M.K. Hurd. 1998. Development of a Benthic Index of Biotic Integrity for Maryland Streams. Report Number CBWP-EA-98-3. Prepared for Maryland Department of Natural Resources by Tetra Tech, Inc. Owings Mills, Maryland.

White, J. 1999. Ecological Application Data System (EDAS): A User's Manual. Tetra Tech, Inc. Owings Mills, Maryland.

Procedures and General Requirements

Overview of Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate sampling is conducted within the same 75 m segment established for fish, habitat, and water quality sampling. The intent of benthic sampling is to qualitatively describe the community composition and relative abundance in favorable habitat (habitats supporting the greatest benthic diversity) within the sampling segment. The sample collection

NCRN Biological Stream Survey
Spring Index Period Benthic Macroinvertebrate Sampling
Standard Operating Procedure #7

procedures described below allow for calculation of an Index of Biotic Integrity as described in Stribling et al. (1998).

Sample Period

As the usefulness of benthic data to describe environmental stresses (particularly effects of acid deposition) is thought to be reduced in summer, benthic sampling for the BSS is conducted concurrent with water quality sampling in spring (see SOP #6.

Habitats to be Sampled

A combination of habitats supporting the most diverse macroinvertebrate community within a sample segment is sampled qualitatively. This habitat includes a riffle area when one is present. Other habitats, in order of preference, include: root wads, root mats and woody debris and associated snag habitat; leaf packs; submerged macrophytes and associated substrate; and undercut banks. Other less preferred habitats include gravel, broken peat, clay lumps and detrital or sand areas in runs. Note that, among all the habitats listed above, those in moving water are preferred to those in still water.
Prior to departure for the site, the Crew Leader must ensure that all equipment needed for benthic macroinvertebrate sampling is present and in serviceable condition. Necessary equipment is listed in Table 1 in SOP #4.

After arrival at the sampling segment, ensure that there are no holes or remnants of prior samples in the D-net. If holes exist, they must be repaired before sampling is continued. Survey the segment to locate the most productive habitat. This may involve turning over some rocks, examining organic debris, etc. to locate macroinvertebrates. Fill out an internal and external label for the sample bucket (Appendix H) with the date, time, and site identification from the Spring Index Period Data Sheet (Appendix A). Verify the correctness of each label and indicate so on the data sheet. The external label should then be covered with clear plastic tape to prevent smudging and/or loss of the label. Benthic sample chain-of-custody forms (Attachment 8) should also be filled out at this time, including the name of the sampler, date, time, and sample site number.
In a riffle area, start at the downstream edge and place the net firmly in the substrate. Aggressively disturb the substrate with hand and/or foot down to the hardpan (usually 5 to 8 cm) in an area the width of the net and at most two net widths upstream. Rub by hand any large sticks and/or stones from the disturbed area to dislodge any organisms. Repeat this process near the upstream edge of the riffle. Repeat as necessary until 20 square feet of substrate has been sampled. As community composition is known to vary with stream velocity and substrate size, attempt to sample the range of substrate types and velocities found within the riffle.

- If only log and snag substrates are available, 20 square feet of surface area should be rubbed off by hand or with a small brush.

NCRN Biological Stream Survey
Spring Index Period Benthic Macroinvertebrate Sampling
Standard Operating Procedure #7

- When sampling habitats other than riffles or snags, the D-net should be used in a jabbing/sweeping motion to dislodge organisms from root mats, SAV, etc. Kicking of the habitat prior to jabbing may also be done as needed to dislodge organisms. A minimum of 20 square feet should be sampled, and the amount of each habitat type indicated on the Spring Index Period Data Sheet (Appendix A). In soft substrates the net motion should be more gentle to minimize the collection of detritus. Multiple habitats may be sampled to cover the best available substrates.

- When sampling in some large 3rd-4th order streams, sampleable habitat might not be present within the 75 m sample segment. If this is the case, moving out of the sample segment in an upstream direction to find habitat that can be sampled using a D-net is permissible. This should only be done if it is impossible to sample within the 75 m transect. This action should be noted in the comments section of the Spring Index Period Data Sheet.

When a 20 ft^2 sample has been obtained, or when the D-net becomes filled to the point that water does not pass easily through it, the net should be washed into a sieve bucket. While the sample is in the sieve bucket, all large stone, debris, leaves, etc., should be carefully washed, inspected for organisms, and discarded. If necessary, use forceps to remove any animals remaining on the net. Verify that the net is clean. All vertebrates (e.g., herpetofauna and fish) should be removed from the sieve bucket at this time. To remove fine sediments from the sample, the sieve bucket may be gently "slapped" against the stream water surface and very slowly rotated while the bottom of the bucket is submerged. Do not rotate the sieve bucket quickly during this process, as this action may damage many soft-bodied macroinvertebrates potentially rendering them unidentifiable. After processing the sample in the sieve bucket, the benthic net should be rinsed carefully in stream water to make sure that no benthic macroinvertebrates remain that may be transported to the next sample site. At each segment, sample collection should not exceed 15 minutes.

The sample should then be transferred to a labeled sample bucket and preserved in a 95% ethanol solution or equivalent. Prior to placing the lid on the sample bucket ensure that the lip of the bucket is clean to maximize the integrity of the seal. The lid to the sample bucket should be verified tight and the sample readied for transport.

Fill out the Chain of Custody Sheet (Appendix I) and transfer the sample bucket to the Benthic lab. The sample will be processed according to protocols in MBSS Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy (EA-00-6).

Laboratory Processing of Benthic Macroinvertebrates

Sample Check-In and Inspection

NCRN Biological Stream Survey
Spring Index Period Benthic Macroinvertebrate Sampling
Standard Operating Procedure #7

Benthic samples will be either shipped to the MD DNR field office for processing and assigned a unique sample number, or processed in-house by NCRN personnel.

Upon arrival at the laboratory, list each sample on the Benthic Macroinvertebrate Sample Chain of Custody Form (Appendix I).

Each sample bucket is given a unique "Log Number" by Field Office staff. The Log Number is sequential for each calendar year with the first two digits indicating the year of collection and the last four digits indicating the sequential number of each sample bucket in the order that it is received by the lab (e.g., 000487 is sample bucket number 487 in calendar year 2000). Log Numbers, which are kept in a separate notebook for each calendar year, are especially useful in avoiding confusion related to duplicate samples taken at the same site.

Check each sample bucket for an adequate quantity of preservative. Ideally, there should be about twice as much preservative as there is sample material (by volume). If preservative is low due to spillage or evaporation, add more. Check sample buckets for cracks and poorly-fitting lids. Correct these problems as needed.

Store samples in an area with good ventilation (ambient air temperature should not exceed 37 ° C) until processed.

Preparation and Subsampling

Fill out all information at the top of a blank BSS Benthic Macroinvertebrate Bench Sheet (Appendix L). Under a fume hood, remove the sample bucket lid and inspect the sample contents. Verify that sample numbers on both outside and inside labels are the same and complete. Note any instances of sample drying, dried organisms, mold, unusual color or odors, etc. in the comments section of the Bench Sheet.

Over a large and well-ventilated sink, pour the sample contents through a U.S. #30 (595 mesh) sieve, catching the Synasol in a clean bucket positioned beneath the sieve. Once most of the Synasol is poured through the sieve, remove it from the sink. Gently rinse the interior of the sample bucket with tap water (sides, bottom, and lid) into the sieve until the Synasol odor is undetectable. Check that all organisms are removed from the sample bucket. Save the Synasol in the original labeled sample bucket for sortate storage (only Synasol that is not degraded [i.e., without a pungent odor or without discoloration] is saved for reuse). Rinse the sample material on the sieve with tap water to remove fine sediments. Clean large objects such as stones, sticks, and large leaves with a scrub brush to remove organisms. Discard these large objects after inspection.

Position the subsampling tray (see Boward and Friedman 2001 for a description of the tray) on a flat and level surface in good light. Place about ½ to 1 inch of tap water in the tray (or enough to completely cover sample material). Rinse the contents of the sieve into the subsampling tray. Use

a squirt bottle to remove all sample material from the sieve. Spread the sample material evenly over the entire tray bottom. Allow sample material to hydrate for about 10 minutes. (Note: If the quantity of sample material is more than one sample bucket (about 86 ounces), the material may be split into (approximate) halves and the steps above repeated for each half).

Using a random numbers table or a similar method of choosing numbers, randomly choose a number between 1 and 100 (there are 100 5 cm grids in the subsampling tray). After positioning a Tensor lamp over the grid to be picked, begin removing organisms from the randomly chosen grid with forceps and place them in a watch glass containing preservative. It is advisable to sort major groups of organisms (e.g., to order plus family Chironomidae) into separate watch glasses upon removal from the subsampling tray. Keep a tally of the total number of organisms removed from the subsample tray.

If the total number of organisms removed from the first grid is equal to or greater than 120, subsampling is complete for the sample. If not, repeat the above process for another randomly-chosen grid. Continue this process until at least 120 organisms have been subsampled. The last grid chosen must be picked in it's entirety. For some samples, the total number of organisms may be less than 120, even after picking all grids in the subsample tray. Note: this process is normally referred to as "100 organism subsampling". The 120 organism target is used to allow for organisms that are missing parts needed for identification or non-organism material counted in the subsample.

Once the target number of organisms is tallied, note the number of grids required for the subsample on the Bench Sheet. If the sample was split and subsampled twice, make a note of the number of grids needed to get the first and second group of (approximately) 50 organisms. Make sure all watch glasses containing the subsampled organisms are securely covered and properly labeled, preferably with separate labels for each watch glass, written in pencil. These labels should contain the Station ID, date collected and log number. If the organisms in the subsample will not be identified for several days, cover the watch glasses with parafilm in addition to the cover or transfer the organisms to an 80 ml snap top vial.

After subsampling, pour the remaining sample material back into the laboratory sieve, allowing the water from the tray to go down the drain. Place the sample material back into the original sample bucket containing preservative and store as described in Section 6.0.

Make sure the subsample tray and laboratory sieve are rinsed well and free from remaining organisms prior to beginning another sample.

Identification

The following is a list of taxonomic keys used for the identification of BSS benthic macroinvertebrates:

NCRN Biological Stream Survey
Spring Index Period Benthic Macroinvertebrate Sampling
Standard Operating Procedure #7

Merritt, R.W. and K.W. Cummins. 1996. An Introduction to the Aquatic Insects of North America. Third Edition. Kendall/Hunt Publishing Company. Dubuque, Iowa.

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin, Jr. 1990. Freshwater Macroinvertebrates of Northeastern North America. Comstock Publishing Association. Ithaca, New York.

Pennak, R.W. 1989. Freshwater Invertebrates of the United States. Third Edition. John Wiley and Sons, Inc. New York, New York.

Wiggins, G.B. 1996. Larvae of the North American Caddisfly Genera (Trichoptera). Second Edition. University of Toronto Press. Toronto, Canada.

Most organisms are identified to genus, if possible, using stereo dissecting microscopes. Exceptions, and their corresponding target taxonomic level, include: Oligochaeta (family), Nematoda (phylum), Nematomorpha (family), etc. Those taxa not identifiable to genus (due to small size or damage) may be left at family or higher. These are noted on the bench sheet at the higher taxonomic level. Counts at levels higher than genus (except those noted above) are not assumed to be different from those identified to genus (see Data Entry below). Likewise, counts at levels higher than family are not assumed to be different from those identified to family.

Identifying Chironomid larvae

Divide Chironomid larvae into Subfamily (i.e., Chironominae, Orthocladiinae, Tanypodinae, Diamesinae) or Tribe (i.e., Tanytarsini, Chronomini) and count the total number in each group. Identify (using slide mounts,) approximately 20% of the individual larvae within each Subfamily or Tribe. Once all 20% subsamples are identified, multiply the counts of all genera by five and record the total extrapolated number of genera for the entire Chironomid group. Note: if either the total number of Chironomids or the total number of individuals within a Subfamily or Tribe is ten or less, all larvae are identified (no subsampling is performed).

Remove Chironomid larvae from the Synasol and place in deionized water for about 10 minutes. Ensure that the larvae are totally immersed in the water and not floating. Place the larvae in 10% KOH in a small heat-resistant crucible. Heat them on low heat using a hotplate until the internal tissues are clear. Place the larvae in deionized water again for about 5 minutes. Return the larvae to Synasol.

With a drop or two of Synasol on a microscope slide, place several cleared larvae in a row with all heads toward one edge of the slide and dorsum down (mouthparts upward). Do not allow the larvae to dry, as air bubbles within the integument may block essential structures from view. Add one or two drops of mounting media (CMCP 10/CMCP 9AF) next to the larvae. Carefully lower a cover slip (one edge down first) over the larvae. Try to prevent movement of the larvae and air bubbles from being trapped beneath the coverslip. Gently press on the coverslip with a pencil

eraser to spread mouthparts and extrude air. Identify the larvae using a compound microscope. After identification, place a bead of Sally Hanson Hard as Nails around the edge of the cover slip to render the mount permanent. Detailed procedures for the mounting and identification of Chrionomid larvae may be found in EPA (1990).

Store all slide mounted Chironomid larvae in a slide storage box with the corresponding box of subsamples from the same sampling year.

Chironomid pupae are identified to genus (if possible) without subsampling.

Mounting Oligochaeta

Place Oligochaetes in a drop of Synasol on a microscope slide. Place several drops of mounting medium (CMCP 10/CMCP 9AF) over the organisms. Carefully place a cover slip over the worms and gently press with a pencil eraser to remove bubbles. Place the slide in a drying oven on low heat for 5 to 10 minutes or until tissues clear.

Place counts of all organisms in the subsample on the Bench Sheet. Include comments on sample condition, etc. in the Comments section of the Bench Sheet. All identified non-Chironomid and non-Oligochaete organisms are placed into a glass snap cap vial and stored in numerical (Log Number) order.

Quality Assurance/Quality Control

Repeated Subsampling

Using sequential Log Numbers, every 20^{th} sample (if two buckets were required at a site, they should be treated as a single unit) is chosen for re-subsampling and identification according to the following procedure:

Subsample and identify the sample as usual EXCEPT - identify Chrionomids to Subfamily or Tribe (do not slide mount the larvae) and Oligochaetes to class.

Return the once-identified organisms to the original sample bucket containing the sortate and preservative, and re-subsample.

Identify the second subsample according to standard procedures (i.e., slide mount Chironomid larvae and Oligochaetes and identify them to genus and family, respectively, if possible).

QC comparisons are made on the two taxa lists and benthic Index of Biotic Integrity (BIBI; see Stribling et al. 1998) values generated from the two subsamples (of the same sample). Differences of less than 1 BIBI value are acceptable.

NCRN Biological Stream Survey
Spring Index Period Benthic Macroinvertebrate Sampling
Standard Operating Procedure #7

Questionable identifications are verified by consulting other DNR benthic taxonomists, regional experts, and regional keys for certain taxonomic groups.

Sample Storage and Disposal

All subsamples are archived indefinitely in 80 ml snap top vials containing Synasol. Pencil-written labels include Site ID, sample date, and log number. Vials are stored in cardboard boxes separated and labeled according to sampling year.

Sample sortate is kept in the original 86 ounce plastic bucket for 5 years (e.g., sortate from samples collected during spring 2000 are kept until spring 2005). Sortate is discarded by pouring the material in the 86 ounce bucket through a #30 sieve over a sink, flushing the Synasol down the drain, and discarding the sample material in an appropriate trash receptacle. Once sortate is discarded, sample buckets are washed and old labels are removed to prepare them for reuse, if possible.

NCRN Biological Stream Survey
Spring Index Period Physical Habitat Sampling
Standard Operating Procedure #8

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, Renaming, rewording	Updating protocol for use by any contractor	1.1

Purpose

This Standard Operating Procedure (SOP) details how to record and evaluate physical habitat attributes at sampling reaches during the spring index period visit. Although the majority of physical habitat attributes are measured in the summer index period, some attributes are easier to measure in the spring before the leaves come out.

Scope and Applicability

This SOP applies to The Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

None.

Procedures and General Requirements

Observations for all physical habitat variables are made within or from the 75 m site only, unless otherwise stated below.
In all cases where it is necessary to differentiate the left bank of the stream from the right bank, the left and right are determined while facing upstream.
Only persons who have attended MBSS training and have demonstrated proficiency with performing MBSS physical habitat assessments should conduct MBSS physical habitat assessments.
Most MBSS physical habitat assessment information is collected during the Summer Index Period. However, a number of important measures are rated during the Spring Index Period.

NCRN Biological Stream Survey
Spring Index Period Physical Habitat Sampling
Standard Operating Procedure #8

Physical Habitat Evaluation

The physical habitat assessment variables recorded during the Spring Index Period can be found on the MBSS Spring Habitat Data Sheet and should be recorded on this sheet. The methods used to determine exactly what should be recorded for each variable are described, by variable, below. Data sheet entries for all Spring Index Period physical habitat variables are based on observations within or from the 75 m site only.

If the stream cannot be sampled for spring physical habitat assessment, this should be noted on the Spring Index Period Data Sheet. Codes designating reasons that a stream could not be sampled are provided on page 49.

Trash Rating

Use the Stream Habitat Assessment Guidance Sheet (Appendix G) to evaluate and score the sample site for the abundance of trash and other human refuse.

The trash rating is scored on a 0-20 scale based on criteria found on the Stream Habitat Assessment Guidance Sheet (Page 50).

Distance of Nearest Road to Site

This variable should be measured when practical with a tape measure or GPS to the nearest meter. If it is not practical to measure this distance, it can be estimated to the nearest 10 m.

Riparian Buffer Width

Measure and record (in meters) the width of the vegetated riparian buffer on each side of the stream. (If the buffer is greater than or equal to 50 m, enter 50). Also record the dominant type of land cover adjacent to the buffer.

The riparian buffer width should be measured to the nearest meter on each side of the stream. The left and right banks of the stream are determined while facing upstream. The average width of the buffer should be recorded. Buffer breaks should not be considered when estimating the average buffer width as buffer breaks are recorded in a different portion of the data sheet (see number 6 below). If the average buffer width is greater than or equal to 50 meters, enter 50 for the buffer width.

Adjacent Land Cover

NCRN Biological Stream Survey
Spring Index Period Physical Habitat Sampling
Standard Operating Procedure #8

Using the codes for adjacent land cover types (page 49), the type of land cover immediately adjacent to the stream buffer should be recorded. If the buffer is 50 m or more, then the same code that was recorded for the buffer should be recorded for the adjacent land cover.

Riparian Vegetation

Using the codes for vegetation types (page 49) the dominant vegetation types present within the buffer of the 75 m site should be recorded. As many as four types can be recorded. The vegetation types are recorded in order of their dominance within the buffer, with the most dominant recorded first (in the left most box under the bank where the buffer is being recorded). Stem density and canopy density should both be taken into consideration for determining density. However, stem density should take precedence over canopy density.

Using the size categories on the back of the Spring Habitat Data Sheet (Appendix A), record the dominant stem sizes of riparian vegetation present.

Buffer Breaks

Note on the Spring Habitat Data Sheet whether there are any functional breaks in the riparian buffer on each side of the stream.

Both banks of the stream for the entire 75 m site should be examined for buffer breaks. For each bank of the stream, if any buffer breaks are observed, then a Y should be placed in the box on the MBSS Spring Habitat Data Sheet next to the words “Buffer Breaks (Y/N)”. If no buffer breaks are observed, write an N in the box.

Buffer Break Types

If a buffer break is observed while examining the stream banks, the severity of the buffer break should be noted and recorded as M (minor) or S (severe) in the box alongside the most appropriate buffer break type listed on the Spring Habitat Data Sheet.

Channelization

Survey the sample site for evidence of channel dredging or straightening and indicate presence (Y) or absence (N) on the Spring Habitat Data Sheet. If there is evidence, indicate the type and linear extent (in meters) for each bank and for the stream bottom itself.

The site should be inspected for any evidence of channel straightening or dredging. If evidence of channel straightening or dredging are observed anywhere within the 75 m site, the linear extent of the channelization should be measured to the nearest meter. Channelization along each bank and the stream bottom should be measured separately and recorded in the appropriate portion of the Spring Habitat Data Sheet, where the type of channelization is listed. If

channelization is observed at a site with a braided stream channel, the total extent of stream channel that is channelized should be recorded. It is possible (when multiple channels are present), using this method, for the total extent of left bank, right bank, or stream bottom channelized to be more than 75 m. Since the objective of this measure is to determine the total length of stream channel that is channelized, this is acceptable.

Land Use

Classify and record on the Spring Habitat Data Sheet (Appendix A) the presence (Y) or apparent absence (N) of land use types immediately visible from the sample segment. For each land use type listed on the Spring Habitat Data Sheet mark a Y or N indicating whether or not the land use type is present near the site. Any land use that can be observed while in or alongside the stream at the site should receive a Y and any that cannot be observed should receive an N.

Stream Gradient

While at the boundaries of the sample segment, use a rangefinder or measuring tape to obtain the straight-line distance between the 0 and 75 m points of the segment (this measurement will provide an accurate assessment of sinuosity). Record the straight-line distance in meters on the Spring Habitat Data Sheet (Appendix A).

Use the procedures outlined below to measure the stream gradient from the downstream boundary to the upstream boundary of the segment using a Levelometer. When backsiting, insure that siting is done relative to the water's edge. The intent is to measure water surface slope. Record this information on the Spring Habitat Data Sheet (Appendix A). When measuring gradient be sure to record % slope, not degrees.

The intent of this is to measure the slope of the stream over 75 m. This is achieved by recording the difference in water surface height from the 0 m to the 75 m locations of the BSS site as compared to a level plane. A levelometer was used during the Round Two BSS to measure stream gradient. Laser levels and other techniques may provide similar results, sometimes with increased precision. Any technique used to measure stream gradient should provide data accurate to at least the nearest 5 centimeters to be comparable to data collected during the Round Two BSS.

Measure the stream slope from the center of the stream according to the maufacuturere instructions. The calibration and proper functioning of the instrument that is used for determining stream gradient must be verified at least every two weeks while sampling is being conducted and documentation showing verification must be kept with the instrument.

Measurements of height should be taken from the water’s surface and NOT to the stream bottom or any bank locations. Measurements can be taken at a number of locations if the 0 m and 75 m locations cannot be seen at the same time, from the same location. However, if the level must be

relocated, height measurements must be taken again from the next closest location where a measurement was already taken.

If a culvert is present within the BSS site and the stream level drops below the culvert due to the presence of the culvert, then the stream gradient should be measured without considering the unnatural drop caused by the culvert. This requires two separate sets of height measurements, one downstream from the culvert and one upstream of the culvert. The height difference over the span of the culvert should not be measured in this case.

Record the height differences that will be used to calculate stream gradient on the Spring Habitat Data Sheet. [The difference in height between locations will be divided by the distance between the measurement points to arrive at a percent gradient. To calculate a gradient for the entire segment, it is important to include as much of the segment as possible and record this information on the data sheet].

Note on the Spring Habitat Assessment Data Sheet (Appendix A) the location (latitude and longitude) and height of any man-made instream blockages greater than 0.3 m in height in or near the sampling segment. Using the back of the data sheet as a reference, record the type of instream blockage. ***Note:*** *indicate any instream blockages found, whether they are in the segment to be sampled or not.*

Road Culvert

If a road culvert is present within the 75 m site, an assessment of whether or not the culvert will be sampleable for fish is conducted. The width and length of the culvert should also be measured and recorded on the Spring Habitat Data Sheet.

NCRN Biological Stream Survey
Summer Index Period *In Situ* Water Quality
Standard Operating Procedure #9

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, renaming, rewording	Updating protocol for use by any contractor	1.1

Purpose

This Standard Operating Procedure (SOP) details how to conduct *in situ* water quality measurements as supplemental data to the summer index sampling of fish and physical habitat. These data in themselves are probably not necessary for long-term monitoring, as laboratory analytes are more rigorously analyzed during the spring index sampling. However, the water quality attributes are valuable as companion data to the summer fish sampling.

Scope and Applicability

This SOP applies to the Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

Bain, M. B. and N. J. Stevenson, 1999. *Aquatic habitat assessment: common methods*, American Fisheries Society Bethesda, Maryland.

Procedures and General Requirements

A general description of *in situ* water quality variables measured during summer is provided at the end of this SOP. As the type of instruments may differ, manufacturer's instructions should be followed for summer water quality measurements. Prior to departure for the sample segment, the Crew Leader must ensure that all equipment needed for water quality measurements is present, in working order, calibrated, and signed for on the Summer Index Period Data Sheet as being calibrated. Necessary equipment for the Summer Index Period is listed in Table 2. An extra set of *in situ* water quality instruments should be on hand (in the field sampling vehicle) during the Summer Index Period.

In addition to laboratory water chemistry sampling during spring, *in situ* measurements of dissolved oxygen, pH, and specific conductance will be made during the Summer Index Period (1 June to 30 September). Although technically not a chemistry parameter, temperature is also

NCRN Biological Stream Survey
Summer Index Period *In Situ* Water Quality
Standard Operating Procedure #9

taken (typically using the same instrument used to measure the other parameters listed above) during the Summer Index Period.

Turbidity is another parameter that is technically not a chemical parameter, but is included in this section. In general, manufacturer's instructions should be followed for using equipment to collect summer water chemistry measurements. Prior to sampling, all equipment needed for water chemistry measurements must be calibrated and be in working order. The summer index period data sheet includes a section that is to be signed by the person who calibrated the instrument. An extra set of instruments should be on hand (in the field sampling vehicle) during the Summer Index Period as a backup in case of a malfunction of the primary instrument.

As with water collection for laboratory analysis, water must be collected prior to, or upstream of, any disturbance to the stream caused by site sampling or access. Stepping in the water upstream of the location where *in situ* chemistry measurements are being made should be avoided until after all measurements have been completed. Collecting water at the upstream end (75 m) of the site can ensure that other sampling can occur coincident with the collection of *in situ* water chemistry data. After sampleability of a segment has been determined and the blocknets installed (described in SOP #8), the crew member responsible for water quality sampling should move to the upstream boundary of the sample segment, carefully locating an undisturbed area for sampling. Where possible, the velocity of the selected area should be sufficient to allow a representative sample to be collected.

Being careful to avoid direct contact of probes with bottom substrates, instrument probes should be deployed at a representative location at or near mid-stream. If necessary to protect the probes, one crew member should hold the unit off of the bottom while another person records data. The units should be turned on and allowed to equilibrate according to manufacturers specifications.

After readings have stabilized, temperature, dissolved oxygen, pH, conductivity, and turbidity data should be recorded on the Summer Index Period Data Sheet (Appendix D). **IN NO CASE SHOULD WATER QUALITY INSTRUMENTS BE USED IF THEY HAVE NOT PASSED CALIBRATION OR ARE UNSTABLE.**

After *in situ* water quality measurements have been completed, necessary caps for probes should be replaced and the instruments disassembled and stored for transportation. Care should be taken to avoid storing instruments in a moist carrying case.

Description of water quality attributes measured during the summer index sample

Turbidity

(taken in large part from(Bain and Stevenson 1999)) — Turbidity is a measure of the extent that light penetration is reduced from suspended solids, and, to a lesser extent, pollution-derived color, optically active dissolved material, organic matter/detritus, and plankton/other microscopic

NCRN Biological Stream Survey
Summer Index Period *In Situ* Water Quality
Standard Operating Procedure #9

organisms. Therefore, data interpretation should factor in these other sources of light reduction. For the MBSS, turbidity is measured with a field nephelometric turbidity meter as NTU, or nephelometric turbidity units. Light transmission is measured by passing a beam of light through sample cuvettes containing sample material and recording the amount of light that reaches the other side. Calibration is easily accomplished using cuvettes with standards of known turbidity. The Maryland state water quality criterion for turbidity is 50 NTU monthly average or 150 NTU instantaneous. Readings for most streams during baseflow will be well below 5 NTU.

Dissolved oxygen

Dissolved oxygen (DO) is a term used to describe the concentration of the element oxygen in water. DO enters the water from one of two ways– photosynthesis of plants and directly from the atmosphere via diffusion or mechanical aeration (e.g., waves, waterfalls). DO it vital to respiration of both plants and animals. Because of its importance to biota, DO is frequently used as an indicator of water quality. DO in surface waters varies with temperature because the saturation level for DO decreases as temperature rises. In rocky, high gradient streams, mechanical aeration is often great enough that even streams with highly elevated oxygen demand are at or near saturation levels. In low gradient coastal plain systems, even moderate oxygen demand (referred to as BOD, or biochemical oxygen demand) can result in DO levels that are low enough to harm aquatic biota.

DO is measured with a probe outfitted with a thin plastic membrane stretched over a platinum or gold cathode. When a current is passed between the indicating electrode and a reference electrode (usually silver chloride), the oxygen in the solution being measured diffuses through the membrane and is reduced at the cathode. The measured current flow corresponds to a given oxygen concentration for the temperature of the sample. Calibration is performed by exposing the probe to a known concentration (usually water saturated air).

In streams, DO varies during the course of a day. In organically enriched streams, DO is often lowest just before sunrise because plants have not been photosynthesizing and only respiration has been occurring. Conversely, DO increases after sunrise until the sun's angle of incidence is greatest because the rate of photosynthesis is dependent on sunlight. In less enriched streams this pattern may be less apparent or absent because stream temperatures are lower at night and thus can contain more dissolved oxygen.

pH

In Webster's Dictionary, pH is described as being derived from the French phrase pouvoir hydrogene, or ‘hydrogen power' and is defined as a 'symbol for the degree of acidity or alkalinity of a solution'. More specifically, pH is a measure of the number of hydrogen ions in a given

NCRN Biological Stream Survey
Summer Index Period *In Situ* Water Quality
Standard Operating Procedure #9

solution that are available to react. The more ions available for reaction, the lower the pH. The concentration of these ions is measured on a log scale, so each pH unit change represents a 10X change in hydrogen ion concentration. Pure water has a pH of 7 (neutral), which means that it is equally able to accept or donate hydrogen ions. At pH<7, hydrogen ions are more readily donated.

pH is measured with a voltmeter attached electrically to a glass electrode– an electrode converts the voltage from a solution to a current which is amplified, read, and converted to a pH for that temperature. For samples with pH <7, hydrogen ions migrate from the solution being measured to the electrode, creating a measured positive charge (a negative charge is created when measuring a high pH sample). Calibration is accomplished using two, highly stable buffer solutions of known concentration. All samples must fall between the range of the buffer solutions being used (pH= 4 and 7 or pH = 7 and 10). The accuracy of a field pH meter is about 0.1 pH units.

Conductivity

Conductivity or specific conductance is a measure of the ability of water to conduct an electric current. Electric current is carried by dissolved inorganic solids such as chloride, carbonate, nitrate, sulfate and phosphate anions (negatively charged particles), as well as sodium, calcium, magnesium, potassium, iron and aluminum cations (positively charged particles). Organic materials such as oils, phenols, alcohols and sugars do not carry electric current.

Specific conductance is measured in units of micro siemens per centimeter (µS/cm) at 25°C using a probe employing from two to six electrodes to generate a voltage potential in a cell and measure the electric current that passes through the water sample in the cell. The higher the current, the higher the conductivity of the water. Calibration is accomplished by setting the zero point in air (or de-ionized water @ 1µS/cm) and setting the upper range slope using a solution of a known value. Usually the calibration standard is near, but above, the range expected to be seen in the waters sampled.

In the National Capital Region, stream conductivity ranges from less than 50 µS/cm in Western Maryland streams known to be affected by acid deposition to greater than 2,000 µS/cm in streams in urban watersheds affected by point source discharges, urban runoff, and raw sewage. Other human influences on conductivity in streams include agriculture (primarily from the liming of fields) and acid mine drainage (AMD) in coal-bearing regions. AMD streams may exceed 1,200 µS/cm because of high concentrations of sulfates, aluminum, iron, and manganese. In general, the Southern Coastal Plain has the lowest conductance waters, averaging less than 200 µS/cm, and the Valley and Ridge physiographic province has the highest average conductivities at about 400 µS/cm. In a given stream, conductivity usually increases in the downstream direction, but this pattern may be altered by the addition of acid deposition

influenced tributaries. An example might be a coastal plain stream which originates in a series of limed farm fields and then receives water from a forested watershed.

NCRN Biological Stream Survey
Summer Index Period - Fish Sampling
Standard Operating Procedure #10

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, renaming, rewording	Updating protocol for use by any contractor	1.1

Purpose

The Standard Operating Procedure (SOP) details how to conduct fish sampling during the Summer Index Period. Strict adherence to the procedures spelled out ensures a standardized and repeatable survey that allows comparisons among years and across parks.

Scope and Applicability

This SOP applies to the Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

Fish Identification Manual

Procedures and General Requirements

Prior to departure for the sample segment, the Crew Leader must ensure that all equipment needed for fish and habitat sampling is present and in working order, including nets and electrofishing gear. A list of necessary equipment is provided in Table 2.

Before departing from the sampling vehicle, the Crew Leader should refer to the spring index period data sheet to determine the previously measured stream width. The Crew Leader should then select appropriate block nets (repaired and in good condition) for the segment and determine the number of electrofishing units to be used, whether a "y" connection and 2 anodes are necessary, etc. In streams wider than 10 m, two or more electrofishing units are to be used, each with at least one dipnetter. In smaller streams, a single unit should be generally used, with one or two dipnetters, depending on conditions.

Exceptions include stream reaches with predominantly deep pool or run habitat, or other conditions where two units are necessary for effective electrofishing. In these cases, Crew Leaders should use professional judgment to determine the number of units to be used. In

cases such as beaver impoundments with broad expanses and no definable channel, the Crew Leader may decide not to sample fish at the site.

Locate the existing site marker from the spring index visit and/or flagging at the downstream boundary using G.P.S. and any notes compiled by the spring sampling crew. Determine whether the site is sampleable and record Sampleability on the Summer Index Period Data Sheet (Appendix D). If the marker cannot be located, re-verify the site location with GPS and if necessary place a new site marker and flagging at the downstream boundary. Note the replacement of the site marker in the field notebook. If a site is determined to be unsampleable by electrofishing, the Fish and Gamefish Data Sheets should not be filled out. However, all other sampling should be performed if possible.

Fill out all appropriate site information on the Summer Index Period Data Sheet (Appendix D), Fish Data Sheet (Appendix E) and Gamefish Length Data Sheet (Appendix F). Data sheets for a given segment should be labeled consecutively so that the number of data sheets completed for each site during each Index Period is known.

If the site is sampleable, place a single block net across each of the upstream and downstream boundaries of the sampling segment (in the case of a divided stream channel, two or more nets may need to be used). During placement of each block net, avoid any unnecessary disturbance of fish and work quickly to minimize any redistribution of fish into or out of the sample segment. Use available substrate where possible to anchor and seal gaps between the lead line and the bottom. Where appropriate, tie the ends of the net to a firm anchoring point on each bank, and check/clean the net as necessary to prevent ‘blowdown' from leaf accumulation.

Note: *The bottom line of each net should be perpendicular to stream flow at the 0 and 75 meter points of the segment (Tent stakes or large spikes should be used to anchor ends of block nets at sites where trees, roots, or other stable structures are not available). Any tributaries or seeps entering the site that will not be sampled must be blocked*

If the segment includes a culvert that is too small or too dark to sample in, block nets should be used to isolate the culvert from the sampling segment. The length of the culvert (not the width of the pipe) should then be added to the sample segment so that the sampled segment is 75-m long.

If one boundary of the segment cannot be relocated, re-measure the segment from the known boundary, deploy the measuring tape along the bank of the stream, avoiding disturbance to fish. If neither boundary can be relocated, use the GPS to locate the segment and remark the boundaries.

NCRN Biological Stream Survey
Summer Index Period - Fish Sampling
Standard Operating Procedure #10

Although block nets are typically outfitted with small lead weights on the bottom end, these weights are typically insufficient to keep fishes from swimming under the net (especially eels and small benthic species). Therefore, it is necessary to use rocks, stakes, or other objects to anchor the bottom of the net to the stream bottom. Like the lead weights on the bottom of the block net, the top of the block net is also typically outfitted with floats. These floats, however, are typically not sufficient to keep the entire top of the block net above the water's surface, which may permit the escape of small fishes or fishes that can readily jump out of the water. To prohibit the escape of these fishes, it is necessary to lift the top of the block net out of the water and prop it with sticks, rods, or other devices. In most streams, ropes will be needed to anchor the sides of the block nets so that they are not dislodged by the stream current or by floating debris during electrofishing.

Note on the Fish Data Sheet (Appendix E) any observed movement of fish to or from the upstream and downstream boundaries or the sampling segment. Also note whether the bottom is clearly visible in all portions of the segment.

Verify that the electrofishing unit is fueled (or sufficient battery capacity exists for battery-powered units), and adjust the output voltage of the electrofishing unit according to the conductivity.

In waters where conductivity is between 100 to 400 umho/cm, a voltage setting of 300 or 400 volts should be effective. In lower conductivity water, increase the output voltage, and decrease the output voltage in high conductivity water. In waters where conductivity is greater than 1,000 umho/cm, the lowest voltage and frequency settings should be used and any observed problems in capture efficiency should be noted on the datasheet. In streams sampled for the NPS National Capital Region, such high conductivities are most likely to be encountered in reaches impacted by acidic mine drainage or landfill runoff.

Gasoline is extremely flammable, and vapors readily ignite on contact with heat, spark, or flame. Always allow the generator to cool before refilling. Keep gasoline out of direct sunlight and store only in approved containers.

Prior to operating the electrofishing unit, ensure that members of the fish sampling crew all have:

- Polarized sunglasses to reduce glare and thereby improve capture efficiency. Under cloudy or lower light conditions, amber glasses should be worn, while green or brown glasses are appropriate under sunny conditions;
- Undamaged rubber gloves; and
- Watertight chest waders

NCRN Biological Stream Survey
Summer Index Period - Fish Sampling
Standard Operating Procedure #10

At the discretion of the Crew Leader, hip boots may be worn for comfort in small streams. In rocky streams, felt soles or boot chains must be used.
The use of gloves and waders/hip boots is MANDATORY for all NPS electrofishing surveys. Briefly test the effectiveness of the electrofishing unit in an area downstream of the lower block net. Adjust controls as necessary and record settings on the data sheet (Appendix E).

The unit voltage and waveform settings should be based on conductivity and any observed mortality during testing.

Time. The seconds of electrofishing for each unit being used for sampling should be monitored and recorded for each of the two electrofishing passes. On the BSS Fish Data Sheet the time in seconds is recorded as the time each unit reads at the beginning of the first electrofishing pass, at the beginning of the second electrofishing pass, and at the end of the second pass. Re-zero and record the electrofishing unit timer reading(s) and the number of anodes used for each electrofishing unit on the Fish Data Sheet (Appendix E). If more than four electrofishing units are used, use a second Fish data sheet to record electrofishing times.

Beginning at the downstream block net, thoroughly electrofish the entire segment length, bank to bank, including backwater areas, sloughs, and shallows, making an equal attempt to capture every fish observed. An exception is that Young of the Year (YOY) fish too small to be retained by dip nets (body length less than 30 mm) should not be collected. When necessary to ensure capture of fish, the operator of the electrofishing unit should use the net on the anode ring. Continuous rather than intermittent electrofishing should be used to avoid bias introduced by selective placement of the electrode and reduce sampling mortality. All captured fish are placed into 25 liter buckets and then into labeled, covered livecars deployed in the stream. All captured fish are placed into buckets, live cars, or other appropriate storage containers immediately upon capture to limit, as much as possible, stress to each individual fish that is captured. Using flow through live cars and bubblers will substantially increase survival of collected fishes compared to using closed systems without bubblers. Care should be taken to avoid electrofishing near any flow through containers as the fishes in these containers will be affected by the electricity.

In fast water areas or where visibility is reduced dip netters should place nets on the stream bottom to increase the probability of capturing bottom dwelling individuals that may be difficult to see. Particular attention should be paid to sighting small bottom fishes such as darters, sculpins, and madtoms.

In areas where the ability to see fish is reduced by turbidity, tannic acids, or fast water, dipnetters should deploy nets on the bottom downstream of the anode as much as possible to capture unseen fish. Particular attention should be paid to sighting bottom fishes such as darters, sculpins, and madtoms which are often undersampled.

NCRN Biological Stream Survey
Summer Index Period - Fish Sampling
Standard Operating Procedure #10

When the entire 75 m segment has been electrofished, turn off the unit and record the timer reading for each unit on the Fish Data Sheet (Appendix E).

Transport fish captured during the first pass to an area downstream of the sample segment and return to the downstream block net with as little disturbance as possible. Check the downstream blocknet for fish.

If water clarity in the sampling segment is reduced because of substrate disturbance during the 1st pass, 2nd pass electrofishing must be delayed up to 1 hour until visibility improves to the point that capture efficiency is similar to that achieved during the first pass. If 2nd pass visibility is poorer that 1st pass visibility, it should be noted on the Fish Data Sheet (Appendix E)

When the electrofishing crew is ready to commence the 2nd pass, fill out the 2nd pass information on the Fish Data Sheet (Appendix E), verify the timer reading on each unit and turn each unit on.

Commence 2nd pass electrofishing as with the 1st pass.

It is important to use the same effort on the 2nd pass as was expended for the 1st pass (i.e., cover all habitat equally on both passes). Therefore, the entire segment should be electrofished on the 2nd pass, and if two electrofishing units were used on the 1st pass, two units should be used on the 2nd pass.

After the 2nd pass has been completed, turn off each unit and record the timer reading on the data sheet. Check the downstream blocknet for fish.

Place all fish captured on the second pass into the livecar labeled "second pass".

After removing debris, crayfish, etc., from the sample, weigh in aggregate (nearest 10 g) the biomass of all fish captured on the 1st pass. Return fish to the livecar and record 1st pass total weight on the Fish Data Sheet (Appendix E). Repeat the weighing procedure for the 2nd pass.

If using spring scales, ensure that the tare feature of the scale is used to minimize the possibility of math errors on weights.

Identify and enumerate all first and second pass fish, retaining in labeled jars all individuals not clearly identifiable to species for laboratory analysis. Record the numbers of each fish species on the Fish Data Sheet (Appendix E) noting the number of unknown individuals under "Species A", "Species B", etc. For each species or unknown, the number of individuals retained should be indicated on the data sheet. RETENTION OF ALL SPECIMENS WHICH CANNOT BE POSITIVELY IDENTIFIED IS MANDATORY. Specimens for preservation should be promptly placed into plastic jars filled with a 10% buffered formalin solution (later transferable to 70% EtOH solution). Individuals >160 mm should be slit on the lower abdomen of the RIGHT side.

NCRN Biological Stream Survey
Summer Index Period - Fish Sampling
Standard Operating Procedure #10

Label all specimen jars with inside labels specifying the date, segment number, and name of collector (Appendix K). The MBSS fish key should be used as needed for positive verification during field identifications.

Formaldehyde is an extremely caustic agent and may cause severe irritation on contact of vapors or solution with skin, eyes, or mucus membranes. It is also a potential carcinogen. Always use in well ventilated area and in case of contact with skin or eyes, rinse immediately with copious amounts of fresh water.

Voucher Specimens

Each crew must maintain an ongoing voucher collection checklist of fish for each species taken or photographed in each park. Compare the list of species taken at the segment with the checklist of species currently retained for the park being sampled. If new species have been taken, retain 8-10 individuals of each new species (include a range of sizes if possible) in labeled plastic jars filled with buffered 10% formalin solution. For rare/uncommon species or gamefish (especially stocked fish), fewer specimens may be retained, at the discretion of the Crew Leader. Note on the Fish Data Sheet (Appendix E) species for which voucher specimens have been retained or photographed. For specimens too large to be preserved in available jars, or those Federally listed as threatened or endangered and positively identifiable in the field, photographs are acceptable, with labeling as shown in Appendix K. Each species photograph should include a label with the date and site identification.

Gamefish

During counting and identification of the fish sample for each pass, measure to the nearest mm (total length) and record on the Gamefish Lengths Data Sheet (Appendix F) all individuals of each gamefish species captured (bass, walleye, trout, or esocids). During measurement, if visual observations suggest that some individuals may be stocked fish (based on fin wear, fin size, etc.), indicate so in the comments section for that species on the Fish Data Sheet (Appendix E).

In addition, observe and record on the Fish Data Sheet (Appendix E) any unusual occurrence of anomalies for any of the species examined. Potential types of anomalies to note include excessive black spot or black spot on an atypical species, multiple skeletal deformities, lesions, or tumors, etc. All fish with skeletal deformities should be labeled, preserved and forwarded to the Project Manager.

Release all fish not retained as voucher specimens or for laboratory examination.

After fish sampling has been completed, record on the Summer Index Period Data Sheet (Appendix D) the relative abundance of aquatic plants and presence/condition of mussels present within the sampling segment. At the crew leader's discretion, vouchers of shell from rare species may be retained for identification by mussel experts.

NCRN Biological Stream Survey
Summer Index Period - Fish Sampling
Standard Operating Procedure #10

After or during the time period when field sampling is conducted in a park, additional qualitative electrofishing may be conducted at the discretion of the Project Manager or Crew Leader. At each site, all representative habitats should be surveyed, and a checklist of species captured and the latitude and longitude should be recorded on the BSS Qualitative Electrofishing Data Sheet (Appendix E). Elapsed time, elapsed distance, instream habitat and pool quality scores should also be recorded on the data sheet. As with quantitative sampling, any species not yet retained from previous segments should be retained as part of the voucher collection for that park, and any species not positively identifiable in the field should be retained for laboratory examination.

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, renaming, rewording	Updating protocol for use by any contractor	1.1

Purpose

The Standard Operating Procedure (SOP) details how to evaluate physical habitat during the summer index period.

Scope and Applicability

This SOP applies to The Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

None.

Procedures and General Requirements

Observations for all physical habitat variables are made within or from the 75 m site only, unless otherwise stated below.

In all cases where it is necessary to differentiate the left bank of the stream from the right bank, the left and right are determined while facing upstream.

Only persons who have attended MBSS training and have demonstrated proficiency with performing MBSS physical habitat assessments should conduct MBSS physical habitat assessments.

Most MBSS physical habitat assessment information is collected during the Summer Index Period. However, a number of important measures are rated during the Spring Index Period..

Sampling Period

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

Habitat evaluation will be conducted during the summer index period to provide a characterization of habitat during summer low flow conditions. Habitat availability during this time period is commonly thought to be a primary factor limiting standing stocks of fish in streams.

Sample Site Boundary for Habitat Evaluation

Instream habitat evaluations at a sample segment will be based only on the designated 75 m length of the stream. Adjacent landuse characterization will be based on features observable from the segment being sampled. However, any notable natural or anthropogenic features observed outside of the immediate zone of evaluation must also be noted on the data sheet in the comments section. Examples of such features include: beaver dams, waterfalls, recent logging, new construction, or point sources of pollution.

Habitat Evaluation Protocols

Habitat assessments during the summer visit should generally begin after electrofishing has been completed; however assessments may be done prior to electrofishing if the assessment can be done without reducing visibility for electrofishing. In general, the only time that habitat assessments should precede electrofishing is when it is likely that turbidity from the electrofishing crew will remain elevated for a long time after the first pass. If the habitat evaluation precedes electrofishing, block nets must be installed prior to habitat measurements. Only crew members approved by the MBSS Training Officer should conduct the evaluation.

Evaluate and record on the Summer Habitat Data Sheet (Appendix) the linear extent (in meters), severity, and approximate areal extent (in square meters) of bank erosion on the right and left banks. Note that the areal extent is recorded X10.

Evaluate and record on the Summer Habitat Data Sheet (Appendix) the extent and composition of bar formation within the sample segment.

Evaluate and record on the Summer Habitat Data Sheet (Appendix) the relative abundance of exotic plants within 5 meters of the stream on either bank.

Count and record on the Summer Habitat Data Sheet (Appendix) the number of Large Woody Debris (LWD) (>10 cm diameter and >1.5 m long) located within the wetted portion of the segment. Do the same for LWD located above the wetted portion of the segment.

Count and record on the Summer Habitat Data Sheet (Appendix) the number of rootwads with trunk diameter (at chest height) >15 cm that are functional habitat within the wetted portion of the stream. Also count and record the number of rootwads (>15 cm diameter) which form part of the stream bank but are not functional aquatic habitat within the wetted portion of the stream.

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

Using the BSS Habitat Assessment Guidance Sheet (Table 11-1), assign a score or percentage for each of the habitat metrics listed on the Summer Habitat Data Sheet (Appendix G).The evaluator should refer to the Guidance Sheet each time a metric is scored; scoring based on memory is unacceptable. During the assessment, the entire 75 m segment should be walked. Because of the probability of substrate disturbance during electrofishing, embeddedness should be evaluated within the thalweg of a riffle (preferred) or run during the first pass of electrofishing. If evaluation is unintentionally omitted during the 1st pass, the stream area immediately upstream of the sample segment should be evaluated and a notation made in the comments portion of the data sheet.

Classify the stream characteristics of the 75 m segment being sampled by checking one or more of the stream characterization choices shown on the Summer Habitat Data Sheet (Appendix G). Include only those features which appear to be functionally important within the segment.

Measure and record maximum depth in the segment to the nearest centimeter.

Measure and record the wetted width to the nearest 0.1 m and the thalweg depth (deepest portion of the lateral transect) and velocity at the 0, 25, 50, and 75 meter points of the sample segment and record on the data sheet. All width measurements must be made perpendicular to the direction of streamflow by stretching a meter tape across the entire distance in which water is found, including large exposed boulders and islands with permanent vegetation. Subtractions should then be made for islands or other non-wetted areas such as large boulders that are deterred under most conditions, but no subtractions should be made for exposed substrates that are submerged at higher baseflows.

After ensuring that the flowmeter is functional and within calibration limits, select a transect suitable for flow measurements (glides with "u" shaped channels are best—try to avoid cross sections with boulders or other irregularities that create backflows and cross flows) and make a series of 10 to 20 velocity measurements at regular intervals across the stream. Start on the left side facing downstream. Measure velocity to the nearest 0.1 m/s at a point 0.6 of the distance from the water surface to the bottom (measured from the surface), making sure to orient the sensor to face upstream and taking care to stand well downstream to avoid deflection of flows. At the same locations where velocity measurements are taken, measure depths with the staff gauge of the flowmeter to the nearest 1 cm (depth and velocity measurements should be made at the selected point on the transect even if the point has no water).

When using an electromagnetic current meter, use the lowest time constant scale setting on the meter that provides stable readings.

In some cases, it may be advantageous to temporarily constrict the flow patterns in the stream so that steady, laminar flows with adequate depths exist. If flows are so low that they can not be measured with a flow meter, constrict flow as much as possible in a 1 meter section of uniform

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

width and use the speed of a floated object as a substitute for velocity measured with the flow meter. Record on the data sheet the depth, width, and time (3 trials) for a floated object to move 1 m.

After electrofishing, water quality measurements, and habitat assessments are complete, the Crew Leader and another person should carefully review and initial all data sheets for the segment BEFORE LEAVING THE SITE.

Many of the summer physical habitat assessment measures require sufficiently clear water to observe the stream bottom throughout the majority of the 75 m site. If conditions do not allow sufficient visibility to see all of the features that must be observed, or if conditions are unsafe for wading, the site should be considered unsampleable for physical habitat. In many cases, the stream may be sampleable during a return visit when the water level is lower. However, if the stream cannot be sampled for summer physical habitat assessment, this should be noted on the Summer Index Period Data Sheet. Codes designating reasons that a stream could not be sampled are provided on page 49.

1. Habitat Assessment Metrics. Five metrics: instream habitat, epifaunal substrate, pool quality, riffle quality, and velocity depth diversity are rated on a scale of 0-20 using criteria provided on the Habitat Assessment Guidance Sheet (page 50). The scores for each of these metrics are meant to characterize a distinct aspect of stream habitat. The in-stream habitat metric primarily addresses habitat for fishes and epifaunal substrate is meant to rate the suitability of habitat for benthic macroinvertebrates. The general quality of riffle and pool habitats are rated based primarily on the prevalence of sufficient depth and extent of these habitats. Velocity/depth/diversity provides a measure of the how well fast, slow, deep, and shallow areas are represented in the stream.

2. Embeddedness. The percent of riffle substrates surrounded by fine substrates, such as sand and silt, is recorded based on visual observation. The riffle substrates that are examined should include the area with the fastest flow within riffle or run habitats. If no riffle is present within the75 m site, embeddedness can be rated based on the closest available riffle located in the same reach as the site (but should not be more than 75 m away from the upstream or downstream end of the site). Several substrates should be examined within the riffle to determine the approximate average condition within the fast part of the riffle. Substrates should be examined for embeddedness prior to disturbances (such as walking or netting) that are likely to dislodge fine materials from around larger materials.

3. Shading. The percent of the wetted area of the 75 m site that is shaded by overhanging vegetation or other structures is approximated based on a visual assessment. If clearing of vegetation was conducted to facilitate electrofishing, or for any other reason, shading should be rated based on the condition prior to clearing.

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

4. Woody Debris. For the BSS, large woody debris are defined as any natural woody structures (e.g. logs, snags, dead tree trunks), with the exception of live trees, that are at least 10cm in diameter and more than 1.5 m long. The number of pieces of large woody debris, located in the wetted portion of the 75 m stream site (in-stream woody debris), is counted. The number of pieces of large woody debris in the stream channel or immediate riparian area, but not in the wetted portion of the stream (dewatered woody debris) are counted separately from in-stream woody debris. Only those dewatered woody debris from the immediate riparian area that (in the opinion of the evaluator) are likely to become wetted during high flows, or fall into the stream channel should be counted.

5. Root Wads. For the BSS, root wads that are on live trees with a chest high trunk diameter(DBH) of at least 15 cm should be counted. These should be counted along both banks of the stream within the 75 m site. Those root wads that are in the water (in-stream) are counted separately from those not in the stream (dewatered). However, only those dewatered root wads that provide stability to the stream bank or that are likely to become wetted during high flows should be counted.

6. Stream Character. The Stream Character portion of the BSS Summer Habitat Data Sheet lists 15 stream features. For each feature, an A, P, or E should be recorded in the box next to the feature indicating whether the feature is absent, present, or extensive respectively in the 75 m stream site.

7. Maximum Depth. The maximum depth of the BSS site is considered the deepest area found anywhere within the 75 m. Maximum depth is recorded to the nearest cm.

8. Wetted Width, Thalweg Depth, and Thalweg Velocity. The wetted width, thalweg depth and thalweg velocity are measured at four transects within the 75 m BSS site. The four transects are located at the 0m, 25m, 50m, and 75m portions of the BSS site (beginning with 0m at the downstream-most end of the site). Wetted width is measured from bank to bank (perpendicular to the direction of the stream flow) to the nearest 0.1 m and includes only the wetted portion of the stream. Islands or other large features in the stream that would not be covered by water during higher base-flow should not be included in the measurement of wetted width. Features that would be covered by water (during higher base-flow should be included in the wetted width measurement. Thalweg depth is the depth (in cm) of the deepest part of the stream at each transect. Thalweg velocity is the stream current velocity (in m/sec) in the deepest part of the stream at each transect.

9. Flow. Measurements that can be used to calculate flow (often referred to as discharge) are recorded on the BSS Summer Habitat Data Sheet. A transect that is suitable for taking these measurements should be located. A suitable transect approximates a “U” shaped channel to the greatest extent possible. The most useful measurements are acquired by avoiding transects with boulders or other irregularities that create backflows and cross flows. The stream channel can be

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

modified to more closely approximate a “U” shaped channel and provide laminar flow with adequate depth for taking velocity measurements. Unless the stream is very small (less than 0.5 m wide), a minimum of 10 measurements should be taken. As many as 25 measurements can be recorded on the BSS Summer Habitat Data Sheet. In general, more measurements are required in larger streams, at least 1 measurement per meter. The measurements consist of depth (to the nearest 0.5 cm) and velocity (to the nearest 0.001 m/sec) and should be recorded at regular intervals. Velocity measurements should be taken at 0.6 of the distance from the water surface to the bottom (measured from the surface), making sure to orient the sensor to face upstream and taking care to stand well downstream to avoid deflection of flows. Depth and velocity measurements should be taken at the exact same locations. The Lat Loc on the BSS Summer Habitat Data Sheet refers to the distance from one stream bank (either left or right) where each depth and velocity measurement is taken.

10. Alternative Flow. If flows are so low that they cannot be measured with a flow meter, the stream should be constricted as much as possible in a 1 meter long section of uniform width and depth. The speed of a floated object should be recorded three times as a substitute for velocity measured with the flow meter. Record on the data sheet the depth, width, and time (3 trials) for the floated object.

11. Bank Erosion. The length and average height of erosion on both banks of the stream, within the 75 m site should be recorded along with the severity of erosion, on the BSS Summer Habitat Data Sheet. In braided streams it is possible to have the total extent of eroded bank add up to more than 75 m. Since the objective of this measure is to determine the total area of erosion present at the site, this is acceptable.

12. Bar Formation and Substrate. Boxes in this portion of the BSS Summer Habitat Data Sheet should be filled in completely to indicate if the bar formation is absent (fill in the box next to “None”), minor, moderate, or extensive; and the dominant substrate type(s) that make up the bars in the site. More than one substrate can be selected. However substrates comprising only a minor part of the substrate should not be selected.

Stream Blockages

Barriers to migration (such as stream blockages) often restrict the movements of resident, as well as diadromous, fishes. The Maryland Department of Natural Resources Fisheries Service keeps track of all known barriers to fish migration. The MBSS has provided the locations of many man-made barriers to fish migration to Fisheries Service to aid in documenting their locations so that the most effective possible plans to provide passage can be implemented.

To continue to provide this useful information, any man-made stream blockages either at the BSS site or en route to the BSS site, should have the height (to the nearest 0.1 m) and location (latitude and longitude in decimal degrees) recorded on the BSS Spring Habitat Data Sheet. The

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

type of blockages should also be recorded. Well known and obvious blockages such as dams on major rivers need not be recorded, but if there is any doubt about whether or not to record a blockage, recording the blockage is recommended.

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

TABLE 11-1. CRITERIA FOR EVALUATING STREAM HABITAT ATTRIBUTES.

MBSS Stream Habitat Assessment Guidance Sheet				
Habitat Parameter	**Optimal (16–20)**	**Sub-Optimal (11–15)**	**Marginal (6–10)**	**Poor (0–5)**
1. Instream Habitat[a]	**Greater than 50% of a variety of cobble, boulder, submerged logs, undercut banks, snags, rootwads, aquatic plants, or other stable habitat**	**30–50% of stable habitat. Adequate habitat**	**10–30% mix of stable habitat. Habitat availability less than desirable**	**Less than 10% stable habitat. Lack of habitat is obvious.**
2. Epifaunal Substrate[b]	**Preferred substrate abundant, stable, and at full colonization potential (riffles well developed and dominated by cobble; and/or woody debris prevalent, not new, and not transient)**	**Abundance of cobble with gravel &/or boulders common; or woody debris, aquatic veg., under-cut banks, or other productive surfaces common but not prevalent /suited for full colonization**	**Large boulders and/or bedrock prevalent; cobble, woody debris, or other preferred surfaces uncommon**	**Stable substrate lacking; or particles are over 75% surrounded by fine sediment or flocculent material**
3. Velocity/Depth Diversity[c]	**Slow (<0.3 m/s), deep (>0.5 m); slow, shallow (<0.5 m); fast (>0.3 m/s), deep; fast, shallow habitats all present**	**Only 3 of the 4 habitat categories present**	**Only 2 of the 4 habitat categories present**	**Dominated by 1 velocity/depth category (usually pools)**
4. Pool/Glide/Eddy Quality[d]	**Complex cover/&/or depth >1.5 m; both deep (>.5 m)/shallows (<.2 m) present**	**Deep (>0.5 m) areas present; but only moderate cover**	**Shallows (<0.2 m) prevalent in pool/glide/eddy habitat; little cover**	**Max depth <0.2 m in pool/glide/eddy habitat; or absent completely**
5. Riffle/Run Quality[e]	**Riffle/run depth generally >10 cm, with maximum depth greater than 50 cm (maximum score); substrate stable (e.g., cobble, boulder) & variety of current velocities**	**Riffle/run depth generally 5–10 cm, variety of current velocities**	**Riffle/run depth generally 1–5 cm; primarily a single current velocity**	**Riffle/run depth <1 cm; or riffle/run substrates concreted**
6. Embeddedness[f]	**Percentage that gravel, cobble, and boulder particles are surrounded by line sediment or flocculent material.**			
7. Shading[g]	**Percentage of segment that is shaded (duration is considered in scoring). 0% = fully exposed to sunlight all day in summer; 100% = fully and densely shaded all day in summer**			
8. Trash Rating[h]	**Little or no human refuse visible from stream channel or riparian zone**	**Refuse present in minor amounts**	**Refuse present in moderate amounts**	**Refuse abundant and unsightly**

NCRN Biological Stream Survey
Summer Index Period Physical Habitat Evaluation
Standard Operating Procedure #11

a. Instream Habitat – Rated based on perceived value of habitat to the fish community. Within each category, higher scores should be assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores should be assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where ferric hydroxide is present, instream habitat scores are not lowered unless the precipitate has changed the gross physical nature of the substrate. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

b. Epifaunal Substrate – Rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, floculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.

c. Velocity/Depth Diversity – Rated based on the variety of velocity/depth regimes present at a site (slow-shallow, slow-deep, fast-shallow, and fast-deep). As with embeddedness, this metric may result in lower scores in low-gradient streams but will provide a statewide information on the physical habitat found in Maryland streams.

d. Pool/Glide/Eddy Quality – Rated based on the variety and spatial complexity of slow- or still-water habitat within the sample segment. It should be noted that even in high-gradient segments, functionally important slow-water habitat may exist in the form of larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris or other types of cover for fish.

e. Riffle/Run Quality – Rated based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

f. Embeddedness – Rated as a percentage based on the fraction of surface area of larger particles that is surrounded by fine sediments on the stream bottom. In low gradient streams with substantial natural deposition, the correlation between embeddedness and fishability or ecological health may be weak or non-existent, but this metric is rated in all streams to provide similar information from all sites statewide.

g).Shading – Rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by landforms.

h. Trash Rating The scoring of this metric is based on the amount of human refuse in the stream and along the banks of the sample segment.

NCRN Biological Stream Survey
Summer Index Period - Crayfish Sampling
Standard Operating Procedure #12

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Purpose

The Standard Operating Procedure (SOP) details how to conduct crayfish sampling during the Summer Index Period. Strict adherence to the procedures spelled out ensures a standardized and repeatable survey that allows comparisons among years and across parks.

Scope and Applicability

This SOP applies to the Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

Crayfish Identification Manual

Procedures and General Requirements

Sampleability.

Sampling for crayfishes occurs during the Summer Index Period and coincides with stream fish sampling. Therefore, crayfish sampleability is determined following identical protocols used to determine sampleability of stream fishes.

Stream Crayfishes

An attempt should be made to capture all crayfishes encountered during each electrofishing pass. Most stream-dwelling crayfishes are primarily nocturnal and reside in shallow burrows under stream substrate (e.g. cobbles, boulders, woody debris) during the day. Effort should be made during each electrofishing pass to overturn or disturb these habitats to optimize the number crayfishes captured. All captured crayfishes are placed into buckets, live cars, or other appropriate storage containers immediately upon capture to limit, as much as possible, stress to each individual crayfish that is captured. Upon the completion of each pass, the downstream blocknet is checked for crayfishes. Identify and enumerate all adult (>15mm carapace length) crayfishes caught during the first and second electrofishing pass. The full scientific (Latin) name

NCRN Biological Stream Survey
Summer Index Period - Crayfish Sampling
Standard Operating Procedure #12

of each species and the number collected during each pass are recorded in the crayfish section of the Summer Index Period Data Sheet.

Burrows

The presence of crayfish burrows along stream banks or within the floodplain adjacent to the BSS site is recorded on the datasheet. The abundance of burrows is recorded as (P): Present, (A): Absent, or (E): Extensive. An attempt should be made to excavate crayfish burrows to identify the burrowing species.

Taxonomic Identification

Only those members of the field sampling crew who have passed the crayfish taxonomy test should perform crayfish identification for the crew. The Key to the Crayfishes of Maryland can be consulted to help with identifications.

Crayfish Vouchers

All specimens that could not be positively identified in the field should be retained for further inspection by a regional crayfish expert. Retention of all specimens which cannot be positively identified is mandatory. Specimens for preservation should be promptly placed into plastic jars filled with 70% ethanol solution. Label all specimen jars with an inside label specifying the date, site name, and name of collector. Release all crayfishes not retained for vouchers.

NCRN Biological Stream Survey
Spring & Summer Index Period - Mussel Sampling
Standard Operating Procedure #13

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Purpose

The Standard Operating Procedure (SOP) details how to conduct crayfish sampling during the Summer Index Period. Strict adherence to the procedures spelled out ensures a standardized and repeatable survey that allows comparisons among years and across parks.

Scope and Applicability

This SOP applies to the Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

Crayfish Identification Manual

Procedures and General Requirements

Any freshwater mussels of the family Unionidae or exotic Asian clams (Corbicula) that are observed while sampling BSS sites should be identified to species with species common names recorded.

During the Summer Index Period, suitable Unionidae habitats within the sampling segment should be searched for the presence of freshwater bivalves, with part of this effort focused on searching obvious, bank side animal middens for shells. This search can be conducted in conjunction with the herpetofauna search and can take as little as five to ten minutes. Live specimens that are found should be identified in the field, and then returned as closely as possible to where they were collected. A pin flag should be used to mark the location where a live specimen is removed from the substrate for identification. After identification, the specimen should be returned to the location from where it was collected. The mussel should be gently placed partway into the substrate with the anterior end pointing down. The species encountered and whether specimens of that species were live (L), recent shell (R), or old shell (O) will be noted on the Summer Index Period Data Sheet in the appropriate area. If no freshwater mussels or Corbicula are encountered, it will be noted on the data sheet as none (N).

NCRN Biological Stream Survey
Spring & Summer Index Period - Mussel Sampling
Standard Operating Procedure #13

Any Unionidae or Corbicula encountered during the spring index visit should be noted in the comments section of the Spring Index Period Data Sheet. The data sheet should list the species as well as if the specimen that was found was live or dead shell. If live Unionidae are collected in the d-net during benthic macroinvertebrate sampling, they should be replaced as closely as possible to where they were collected, or into the appropriate habitat if unsure where the specimen was collected. The mussel should be gently placed partway into the substrate with the anterior end pointing down.

No live Unionid mussels should be vouchered. Digital pictures should be taken of live specimens, for which the identification is uncertain provided that the photographs clearly show characters necessary to confirm the identification. At a minimum, photodocumentation will clearly show a lateral and a dorsal aspect of each specimen. Placing the specimen against a light-colored background for the picture may help produce a clear photograph. Pictures should be forwarded to a mussel expert for confirmation. Any empty shell for which the identification is uncertain should be retained. Empty shells collected from a single site can be collected in one zip-lock bag with a completed label containing site name, date, and collector.

NCRN Biological Stream Survey
Summer Index Period – Invasive Plant Sampling
Standard Operating Procedure #14

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Purpose

The Standard Operating Procedure (SOP) details how to conduct invasive plant sampling during the Summer Index Period. Strict adherence to the procedures spelled out ensures a standardized and repeatable survey that allows comparisons among years and across parks.

Scope and Applicability

This SOP applies to the Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

Invasive Plant Identification Manual

Procedures and General Requirements

The full common name of invasive plants observed at each BSS site is recorded during the Summer Index Period. The common names of any invasive plant species observed within view of the BSS site should be recorded. However, the riparian area within five meters of the stream on each bank should be thoroughly searched. The abundance of each invasive plant found is recorded as present (P) or Extensive (E). Only those members of the field sampling crew who have passed the exotic plant taxonomy test should perform invasive plant identification for the crew.

NCRN Biological Stream Survey - Data Management Standard Operating Procedure #15

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering, merging Geoff Sander's guidance w/ Bob Hilderbrand's	Updating protocol to current MBSS version and for any contractor to use	2.0

Purpose

This Standard Operating Procedure (SOP) details the data management guidelines and procedures that apply to all data collected under the National Capital Region Network's (NCRN) Biological Stream Survey (BSS) monitoring protocol.

Scope and Applicability

This standard operating procedure applies to how all data relating to the NCRN Biological Stream Survey monitoring protocol will be managed. More specific guidance may appear in other documents such as the steps to take when entering data into the project database. This document does not in any way dictate how data should be collected in the field. Those procedures are outlined in separate field methodology SOPs.

Reference Documents

NCRN Data Management Plan

NCRN BSS Protocol

NCRN BSS Database Design SOP

NCRN BSS Metadata SOP

Procedures and General Requirements

Field information Management

To facilitate data recording during inclement weather, data sheets should be printed on waterproof paper. Backup copies of all field data sheets are made prior to submittal to the Data Manager (DM)

NCRN Biological Stream Survey - Data Management Standard Operating Procedure #15

To ensure that all field data for the NPS are collected and recorded in a useable manner, data are recorded in the units specified on the data sheets. Recorded data are reviewed at the sampling site and the Crew Leader reviews and initials all data sheets prior to departure from the site. Legible copies of data sheets are provided to the DM on an approximately bi-weekly basis during sampling.

Field Data Verification

Once the Crew Leaders have submitted legible copies of data sheets to the DM officer, the QC officer examines the sheets and records potential errors, documents and corrects discrepancies, and periodically alerts Crew Leaders to prevent similar errors in the future. Common data entry errors include the following:

- Spelling errors for fish species
- Incorrect or misspelled stream names
- Smears on data sheets and illegible handwriting
- Inconsistencies in the listing of riparian buffer vegetation types
- Meter calibration not signed for
- Blank space on data sheets
- Page number not labeled on all pages
- Inconsistent labeling of photodocumentation
- Field crew leader failed to sign for verification of benthic bottle labels

Data Entry

Field data are collected on paper field forms that have been customized to meet the needs of the field crew and the project. Upon returning to the office from the field, data sheets should be copied. One copy should be maintained in the office and used for data entry while the other is archived in a safe (ideally off-site) location.

All data collected on field forms must be entered into the project database. Data entry should take place as soon as possible, ideally no longer than one week after the data are collected, and should be done by one of the field crew. Entering data in a timely manner and having one of the field crew enter the data increases the chances of identifying errors or questionable data. Refer to the BSS Database Design SOP for more details on using the database and entering the data.

A copy of the field data forms should be provided to the NCRN at the conclusion of the field season.

NCRN Biological Stream Survey - Data Management Standard Operating Procedure #15

Quality Assurance & Quality Control (QA/QC)

After the data are entered into the project database, all entered data must be reviewed for accuracy and correctness. This is a two step process involving data verification and data validation.

Data Verification

After the data have been entered into the project database it should be reviewed. The purpose of this step is to catch errors that were incorrectly entered into the database from the datasheets (e.g. species count is entered as 100 instead of 10).The data should be reviewed by someone other than the person who entered the data. If two people are involved in the data entry process (e.g. one person dictating the information from the data sheet and the second entering the data into the database), data verification can take place almost at the same time that the data is entered. Both parties must be involved in reviewing the data and it is still imperative that the two people involved review each record and compare it to the data sheet to ensure proper data entry.

It is essential that this review takes place in a timely manner, within a week of data collection and entry, so that the data is still fresh in the minds of the field crew.

The reviewer should check all records entered into the database for each event against those on the data sheet.

Once the data have been checked, the reviewer should indicate on the data sheet as well as in the database that the data has been verified and by whom.

Any data entry errors should be corrected in the database and the name of the person who made the correction as well as the date of the change should also be indicated. This information can be entered in the metadata fields on the main Event Information tab in the database under “Updated by”.

Data Validation

Data validation or identifying records that are unreasonably out of bounds (i.e. outliers) is an essential step to ensuring data quality. A good portion of data validation is built into the database structure such as limiting the data entry to pick lists or value ranges.

Data should be reviewed to identify validation errors but specific queries can be designed to catch validation errors that are not captured during the data entry process. These queries, which will evolve over time, are intended to summarize data fields and identify those data points that might be questionable. Development of these queries requires input from all those on the project team.

NCRN Biological Stream Survey - Data Management Standard Operating Procedure #15

It is important to note that simply because a record seems out of bounds or unusual does not mean that it is necessarily incorrect.

Data Documentation (Metadata)

Overview

Metadata is essential for data managers and data users to track and understand the content, quality and standards relating to each data set. All data sets, both spatial and non-spatial (e.g. tabular data sets) need to be fully documented with FGDC compliant metadata. A metadata template will be provided but the NCRN I&M Program may rely on cooperators and contractors to assist in the completion of metadata because of the knowledge they have regarding data collection and analysis. Please refer to the NCRN Metadata SOP for more details.

Data Transfer, Network Storage and Archiving

The following sections detail how data should be transferred between the cooperator and NPS.

Data Transfer

In order to ensure data security, data should be transferred to the NCRN periodically during the field season. A transfer schedule should be established. At the very least since the NCRN Biological Stream Survey protocol has a Spring and Summer sampling cycle a comprehensive data transfer should take place after each of these sampling cycles. A final, comprehensive data transfer will take place at the end of the field season. All final data products must have undergone complete QA/QC but this is less important for interim data transfers. More specific details about the data transfer milestones will need to be worked out between the project manager, data manager and the contractor.

Only the back-end data file associated with the project data base should be transferred. This file should be sent to the NPS project manager, Marian Norris (marian_norris@nps.gov). If the file is too large to e-mail (e.g greater than 6 MB) and compressing the data file into a ZIP format does not help, data can be posted to the NPS public FTP site.

Data and directories on this FTP site have a limited lifespan. To avoid the build-up of files and to preserve storage space, files and directories are removed after two weeks of inactivity. Therefore, please notify the project manager prior to posting to this site and after data are posted to ensure that 1) the directories are in place to post the data and 2) that the NPS project manager can retrieve the data in a timely manner prior to its removal from the site.

NCRN Biological Stream Survey - Data Management
Standard Operating Procedure #15

In addition to receiving the electronic data, field data sheets should be transferred to the NPS project manager at the end of every field season.

Roles and Responsibilities

Principle Investigator/Contractor

- Ensure that all members of the field crew are aware of the procedures outlining how data should be entered into the project database, verified and validated.
- Make sure that field crews are entering/uploading the field data in a timely fashion as outlined in this document.
- Ensure that data undergo the proper QA/QC procedures (QA/QC SOP).
- Maintain communications with NCRN project manager

Field Crews

- Follow all data collection and data management procedures.
- Enter data into project databases in a timely manner (within a week of entry).
- Document in the project database as well as on the data sheets who was involved in the data entry and QA/QC process and when each took place.
- Conduct data verification and validation checks.

NPS Data Manager

- Provide training and/or assistance with project databases.
- Develop database tools to assist with data entry and data QA/QC procedures.
- Develop data management guidance and ensure that all those involved in the project are aware of the standards required.
- Archive data files and data sheets.

NPS Project Manger

- Coordinate with contractor and act as liaison between contractor and NCRN I&M Staff.
- Coordinate data transfers with contractor.Page number code—do not delete or use this marker for anything else!

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	12/12/2008	G. Sanders	Updated with new Summer sampling guidance	Updated to correspond to changes made to the database	1.1
1.1	2/2009	M. Norris	Renumbered	Accuracy/Clarity	1.2
1.2	6/2009	G. Sanders	Updated SOP to reflect updates in database design	Updated to correspond to changes made to the database	1.3

Purpose

This purpose of this Standard Operating Procedure (SOP) is to provide an overview of the NCRN Biological Stream Monitoring database. It is intended to provide users with an understanding of the functional capabilities and requirements of the database application.

Scope and Applicability

This SOP applies to the structure and function of the NCRN Biological Stream Monitoring database. This document should be used as a reference for those using the database.

Reference Documents

Procedures and General Requirements

Database Design

The NCRN Biological Stream Monitoring Database is based on the Natural Resources Database Template (NRDT) Version 3.1 developed by WASO developers in Fort Collins, CO. The database consists of two Microsoft Access database files, a 'front-end' forms database and a 'back-end' database where all of the data is stored. The user will need both files to use the application but will only physically use the 'front-end' forms application. The 'back-end' database should not be altered by the user at any time. If any changes are necessary, the user should contact the NCRN Data Manager for assistance.

Back-End Application

The back-end database application is an MS Access database file that contains all of the data tables associated with this project. This is the file that contains the table designs and data structure for the project database. This file should never be used to edit data. In fact the user should not have a need to open this file for any reason.

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

Front-End Application

The 'front-end' application is an MS Access database consisting primarily of forms and linked database tables (the actual data tables exist in the 'back-end' file).

Establishing Database Links

Upon opening the database for the first time new users will have to establish the links to the 'back-end' data file. If the links need to be restored, the user will see a message indicating this (Figure 1), a form will open enabling the user to find the appropriate 'back-end' data file and re-establish the links (Figure 2). This link only needs to be established once as long as the 'back-end' data file is not moved.

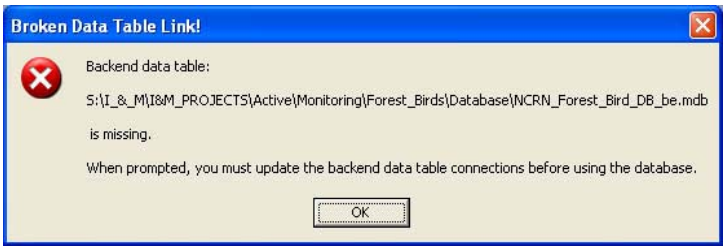


Figure 16-2. Error message displayed upon opening the database if the back-end data links are bad.

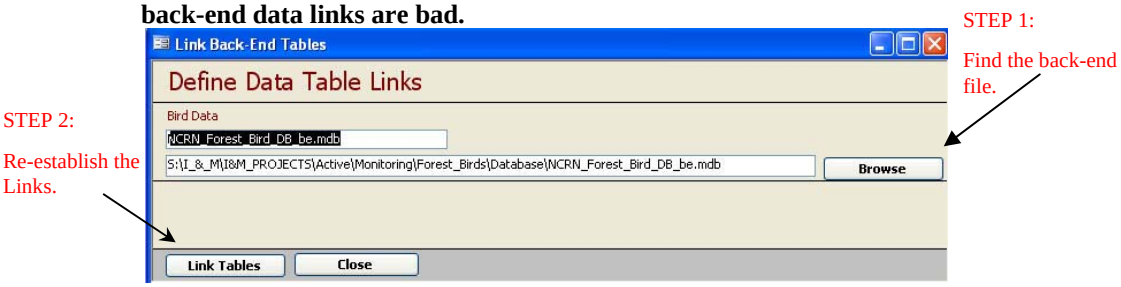
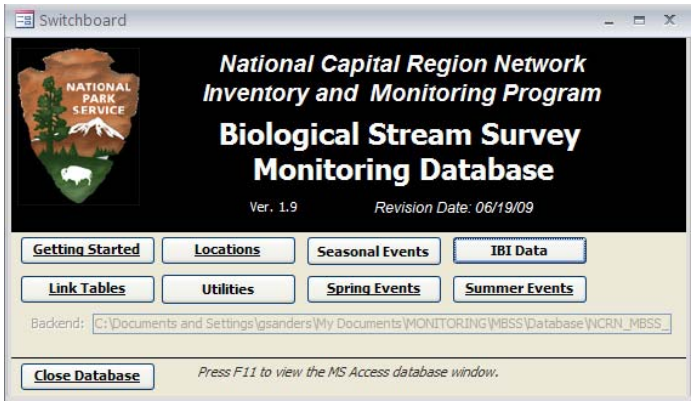


Figure 16-3. Form used to find the back-end table (Browse), select the file and re-establish the table links (Link Tables).

Data Entry

Once the back-end links are established the user is presented with a 'Switchboard' (Figure 3.) from which the user can select to do a number of different things.



NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

Figure 16-4. Application 'Switchboard' used to navigate through the application forms.

Data entry is based on sampling events and in the case of this protocol there are both Spring and Summer sampling events. To enter or edit field data the user must click either the Spring Events or Summer Events button on the Switchboard. This will open the appropriate sampling events form (Figure 4). From here the user can enter new data, view existing data, or edit existing data.

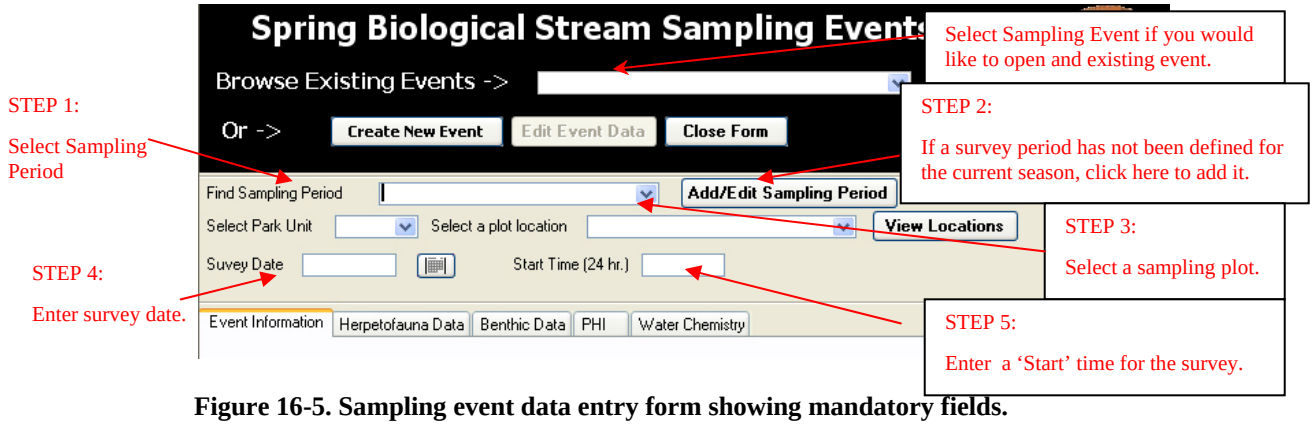


Figure 16-5. Sampling event data entry form showing mandatory fields.

Upon opening the form the user is presented with a blank data record ready to accept new data. If the user would like to find an existing sampling event in the database, select a record from the selection box at the top of the page. If entering new data all of the data fields above the 'tabbed' portion of the form are required fields and must be completed. If you attempt enter field data without completing all of these fields you will be prompted to do so by an error message (Figure 5).



Figure 16-6. Missing data error message.

New Data

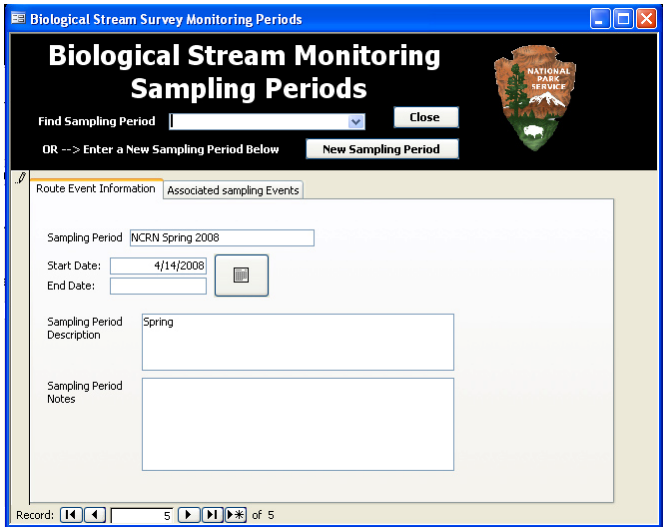
Step 1) Select a sampling period.

This sampling protocol has two sampling cycles, a Spring and Summer. Sampling events are grouped based on the cycle and year in which they occur (e.g. Spring 2007). You can access the sampling period from directly from the switchboard or from the data entry form.

Select a sampling period from the selection box. If a sampling period does not exist, click the button 'Add/Edit Sampling Period'. This will open the sampling period form where you will be able to add new sampling periods or edit existing ones (Figure 6a).

Once a number of survey events are associated with a 'sampling period' you can view the associated events in the 'Sampling Period' form (Figure 6b).

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16



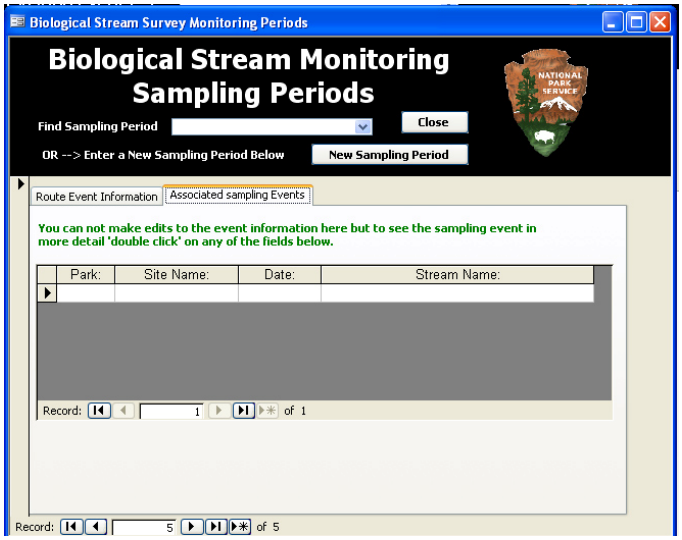


Figure 16-6a. Sampling Route form. ***Figure 16-7b. Survey events associated with routes.***

After adding the sampling period, close the form and return to the data entry form. The sampling period you added should now appear in the list. If you select an existing sampling period from the list and would like to see more information about the route, 'double click' on the selection box after the sampling period has been selected and the sampling period form will open to the proper record.

Step 2) Select a sampling location.

The user must select a park unit to filter the plot selection list. Select a plot from the list. If the user wants to view a specific sampling plot, select if from the list and 'double click' the selection box. The sampling locations form will open to the desired plot. The 'View Locations' button can also be used to open the 'Locations' form to a blank record.

Calendar tool:



Clicking on the calendar icon opens up the calendar tool. After selecting a date from the tool, click the calendar icon again to close the calendar tool.

Step 3) Enter the survey date.

Either type the date into the box or click the calendar icon to open the calendar tool. Note, you must select a sampling period prior to entering the date. Also, the survey date must fall within the dates of the sampling period or you will receive an error message.

Step 4) Enter Start Time.

Enter the start time of the survey (in 24 hr. time units).

Entering Spring Field Data

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

The NCRN Biological Stream Monitoring protocol calls for data to be collected during two field cycles. During the Spring sampling period, data collection focuses primarily on benthic habitats while the summer sampling period collects data on fish. The physical habitats of streams are evaluated during both the Spring and Summer sampling periods but the data collected are quite different. Due to the significant differences in the data being collected during the two sampling periods, different data forms were created for each.

Spring General Event Information

After entering all of the mandatory data in the first section, you can proceed to enter the field data. Start by entering the personnel involved in the field sampling effort. If you can not find the person in the list click 'Add New Contact' to open the contacts form and add the person to the database.

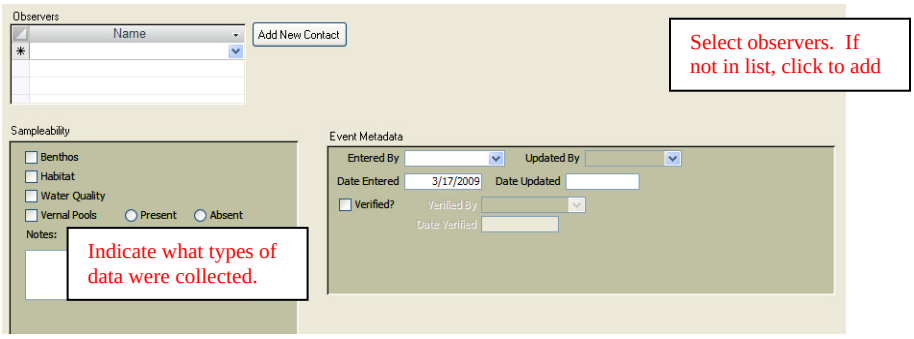


Figure 16-8. Spring event information form.

The remaining "Tabs" on the field forms are for entering the various types of field data including fauna data (Herps, Mussels and Crayfish), Benthic Macroinvertebrates (Figure 8), Physical Habitat Index (Figure 9), Vernal Pools data, and Water Chemistry. The data entry process is pretty straight forward but you should note that certain fields are inactive or locked until the user indicates that they should be filled. Examples of this are the data for buffer breaks and culvert measurements. On the Spring PHI data form if the check box indicating if buffer breaks are present *is not checked* then the buffer break type fields below remain inactive (Figure 8). They are only editable if the buffer break check box is checked.

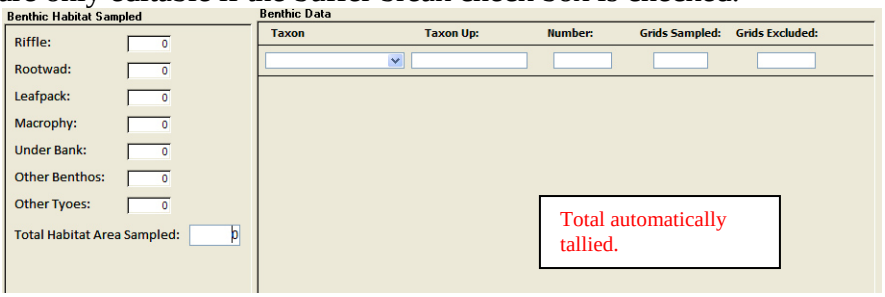
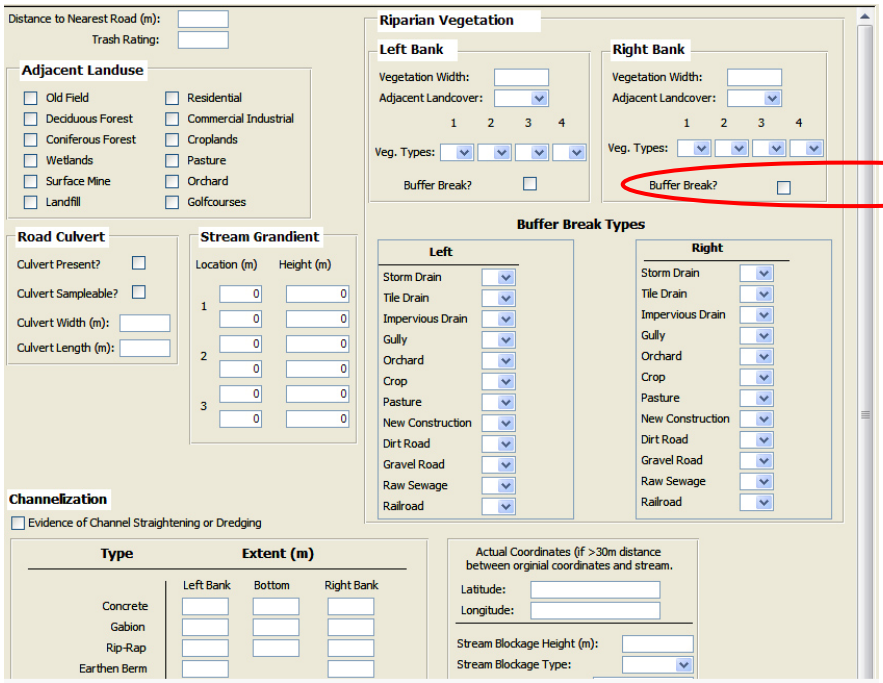


Figure 16-9. Spring benthic data form.

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16



Buffer Break boxes must be checked before you can enter details on Buffer Break Tyoes.

Figure 16-9. Spring PHI form indicating inactive fields.

Once you check these boxes, the selection boxes below become active and you can edit them. The same type of control is applied to other parts of the form including the road culvert information.

Entering Summer Field Data

Entering summer field data is very similar to entering Spring data except that the data collection in during the Summer focuses primarily on fish. All of the standard event information described in section 4.3.3.1 are still required. Additional data entry cannot take place until this information is entered.

Users must select what parameters were sampleable during the event. Figure 10 shows the Sampleability form for the summer sampling period. It is configured differently than the Spring in accordance with the MBSS sampling design. Unless a sampling parameter is selected as "Sampleable" ("s") the corresponding data entry forms will be disabled. Using the example in Figure 10, the only data that the user could enter would be fish. All other data entry forms would be disabled until the sampleability form is updated to reflect that the parameter was sampleable.



Figure 16-10. Summer Sampleability Form

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

Enter Summer Field Data

The tabbed sections of the main form are for entering the various types of field data. As was the case with the summer data forms, certain data entry fields will be rendered inactive if the user selects certain sampling characteristics. The Fauna Data form is almost identical to the form used during Spring sampling except that it includes space to record Salamander observations (Figure 11). If the user indicates that no salamanders or herps were observed using the check box to the left then the forms will be locked (even if data was already entered). Unchecking the boxes unlocks the forms. The same applies for Crayfish and Mussel forms.

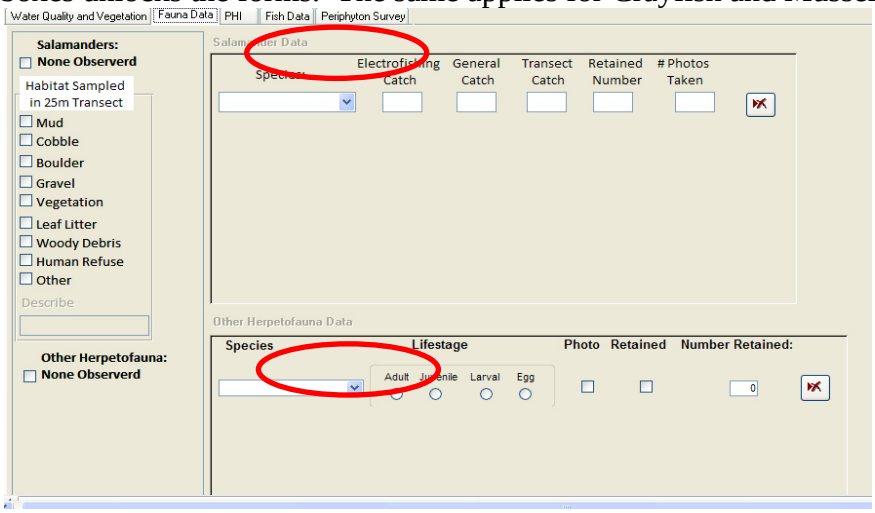


Figure 16-11. Summer fauna data entry form

Similarly, fish data cannot be entered until the user indicates that fish were captured. Once that has been done, the user is able to enter details about the sampling as well as enter species that were observed. The user can also indicate that Game Fish were found. If this box is checked then the corresponding sub form for game fish will be enabled and data can be entered there as well (Figure 12).

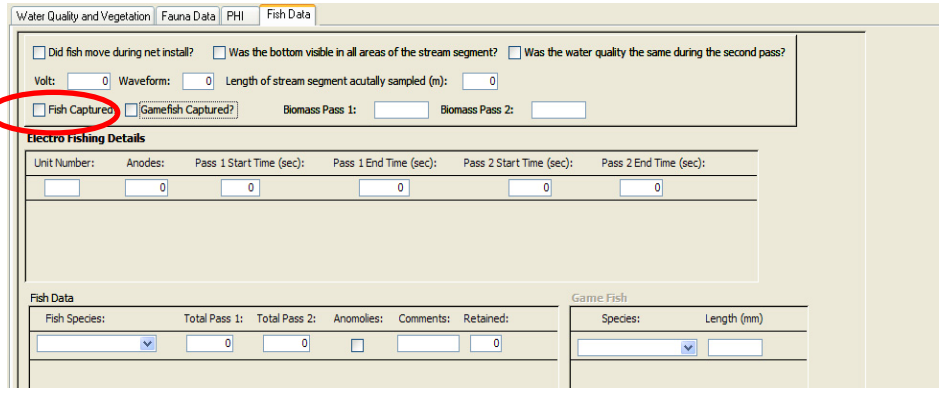


Figure 16-12. Fish data collection form.

Editing Existing Data

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

Existing data cannot be immediately altered in the database. A button at the top of the data entry form indicates the current status of the data record (Figure 13). When existing data is accessed the form defaults to "Browse Mode" and the user can review the data but not make changes. To edit data users must click the button after which a message box will appear requesting the user to confirm that data needs editing (Figure 14). After acknowledging this message the form will become editable and the button will update to indicate that the form is in "Edit Mode". When editing is complete either close the form or click the button again to return the form to "Browse Mode. This is a safeguard to prevent the inadvertent altering of existing data.



Figure 16-13. Users must click the 'Edit Event Data' button prior to editing existing data.

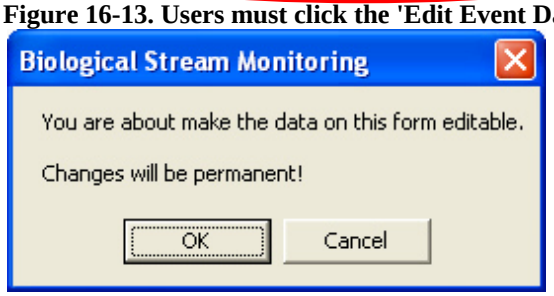


Figure16-14. Data edit warning message.

IBI/PHI Data

Fish IBI, Benthic IBI and PHI data can be entered by clicking the "IBI Data" button from the main Switchboard. Once the form opens the user must select a site from the list (Figure 15) and the site location will be populated and the PHI, FIBI, and BIBI data can be entered. No data can be entered until the sampling site information is chosen.

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

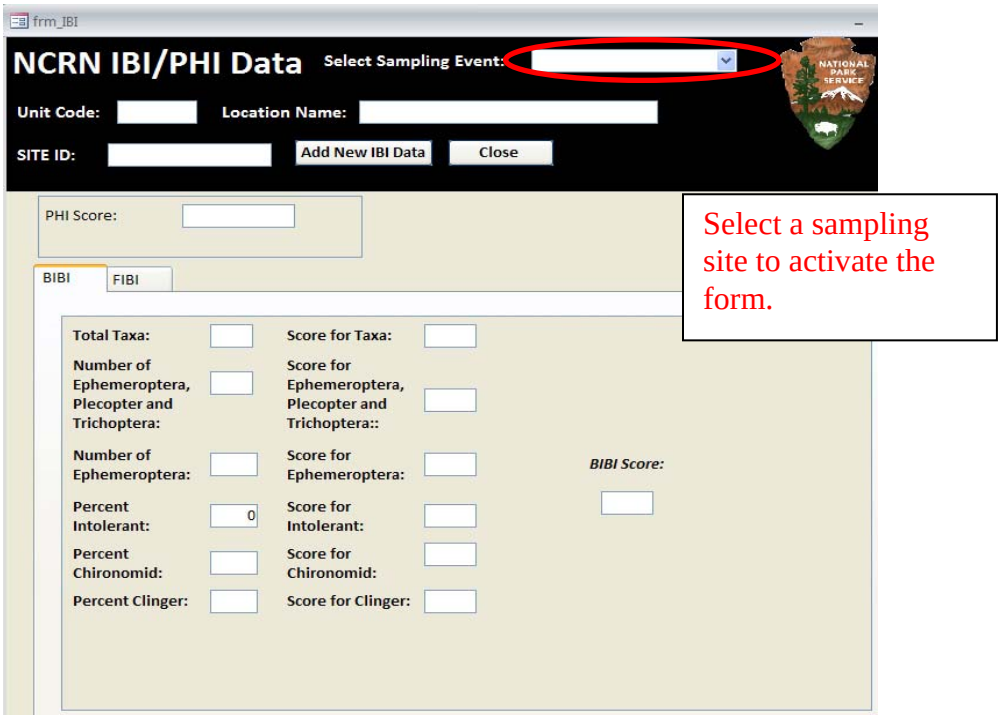


Figure 16-15. IBI/PHI data entry form.

Event Metadata

Once data has been entered for a specific survey event, the user should complete the 'Event Metadata' (Figure 16) fields at the bottom of the main 'Events' form



Figure 16-16. Event metadata form.

The person who entered the data should be indicated in the 'Entered By' box. The persons responsible of data verification (i.e. making sure the data was entered correctly from the data sheet) should 'check' the 'Verified?' box when this has been completed. The verifier should also input their information in the 'Verified By' box and indicate the date of verification.

If any mistakes are found in the data set and/or the data needs updating (at any time), the proper information should be indicated in the updated boxes.

Database Issues or Problems

If you encounter any problems or issues with the database please do not attempt to make any changes. Contact the NCRN Data Manager:

Geoffrey Sanders

NCRN Biological Stream Survey – Database Design & Data Entry
Standard Operating Procedure #16

202-342-1443 ext. 230
geoffrey_sanders@nps.gov

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/2009	Marian Norris	Renumbering,	Updating protocol to current MBSS version and for any contractor to use	2.0

Purpose

The purpose of this standard operating procedure is to familiarize NPS staff and cooperators with the requirements that the NCRN I&M Program has for dataset documentation. This document is also meant to serve as a guide to metadata generation.

Scope and Applicability

The NCRN requires that all datasets, both spatial and non-spatial, be accompanied by metadata that meets the Federal Geographic Data Committee (FGDC) metadata standards. Accordingly, any dataset (spatial or non-spatial) produced by or for the NCRN must be accompanied by FGDC compliant metadata.

This document is not intended to serve as step-by-step instructions for metadata generation, but should serve as an overview of metadata requirements and provide sources that can guide the reader through the process of generating FGDC compliant metadata.

Acronyms and Definitions

Arc Catalog	Module in ESRI's ArcGIS software within which metadata for spatial data sets can be created.
Biological Data Profile	Set of definitions for the documentation of biological data through the creation of extended elements to FGDC Content Standard.
CSDGM	Content Standard for Digital Geospatial Metadata.
ESRI	Environmental Systems Research Institute – GIS software company
FGDC	Federal Geographic Data Committee – Interagency committee that promotes the coordinated development, use, sharing, and dissemination of geographic data.
Metadata	Data about the content, quality, condition and other characteristics of a data set, documented in a standardized format.
NCRN	National Capital Region I&M Network
NPS Profile	The NPS Natural Resources Profile extends the FGDC CSDGM

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17

	to incorporate NPS-specific elements such as park unit.
NPS Data Store	Web-based clearinghouse for GIS and tabular datasets. All data sets posted to the Data Store must be accompanied by FGDC compliant metadata.
XML	Extensible Markup Language. A simple and flexible text format that facilitates large-scale electronic publishing and exchange of data.

Reference Documents

Code of Federal Regulations, Executive Order 12906 (1994) Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure. Document available online at http://www.fgdc.gov/publications/documents/geninfo/execord.html
OMB Circular No. A-16. Document online: http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html#5
Federal Geographic Data Committee (1998) Content standard for digital geospatial metadata. Document available online at: http://www.fgdc.gov/metadata/csdgm/.
National Spatial Data Infrastructure (2004) Metadata Factsheet. Document available online at http://www.fgdc.gov/publications/documents/metadata/metafact.pdf.
NPS Metadata Tools and Editor: Creating Non-Geospatial Metadata for the NPS Data Store. Document online: http://science.nature.nps.gov/nrdata/docs/metahelp/NPSDataStoreCreatingNGSMetadata.pdf
NPS Metadata Tools and Editor: Creating Simple Geospatial Metadata. Document online: http://science.nature.nps.gov/nrdata/docs/metahelp/NPSDataStoreCreatingGSMetadata.pdf
Biological Profile (National Biological Information Infrastructure – NBII) Metadata Guide. Document online: http://science.nature.nps.gov/nrdata/docs/metahelp/BiologicalProfileGuide.pdf
NPS Data Store: Metadata and Data Uploading Guidance. Document online: http://science.nature.nps.gov/nrdata/docs/metahelp/NPSDataStoreMetadataDataUploadGuidance.pdf
NPS Data Store: Parsing Metatdata with NPS Metadata Tools and Editor. Document online: http://science.nature.nps.gov/nrdata/docs/metahelp/NPSDataStoreMetadataParsingGuidance.pdf

Procedures and General Requirements

Overview

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which is defined as structured information about the content, quality, condition, and other characteristics of a data set. Basically speaking, the ‘who’, ‘what’, ‘when’, ‘where’, ‘why’ and ‘how’ of the data set. In addition, metadata include information about data

format, collection and analysis methods, access/use constraints, and distribution. Metadata provide the means to catalog data sets, within intranet and internet systems, making their associated data sets available to a broad range of potential users. While most frequently developed for geospatial data, metadata describing non-geospatial data sets are also needed. For example, water samples collected daily for an annual report to summarize water quality should be documented with complete protocols and metadata for the database in which the data are stored.

The general goal of the NPS metadata system is to catalog all data sets and to produce FGDC-compliant metadata for those data sets that require comprehensive documentation. The NPS Natural Resource, GIS and I&M Programs released the NPS Data Store in 2005 as an FGDC-structured database and data server system that provides a secure web interface and tools to import metadata records from desktop metadata authoring programs.

Tools for Metadata Generation

There is no single, standard software package used for metadata generation within the NPS I&M Program. The two programs that the NCRN strongly recommends are used are: the NPS Metadata Editor and ArcCatalog and they are described below. The functionality of the tools are outlined in Table 1.

- The I&M Program has developed a Metadata Editor for editing and managing metadata that can function as a stand alone application or as an extension of ArcCatalog. The NCRN I&M Program recommends using this tool for preparing and editing non-spatial metadata.

- ArcCatalog is part of ERSI's ArcGIS® software system. With ArcCatalog, you can browse, manage, create, and organize your geographic and tabular data. In addition, ArcCatalog comes with support for several popular metadata standards to allow you to create, edit, and view information about your data. There are editors to enter metadata, a storage schema, and property sheets to view the data. ArcCatalog may be used for metadata generation for all geospatial data.

NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Table 17-1. Comparison of the three main metadata generation tools.

Tool/Features	ArcCatalog	NPS Tools & Editor
Minimal Metadata	Y	Y
Comprehensive Metadata	Y	Y
Biological Metadata	N	Y
Create metadata templates?	Y	Y
FGDC Section 1	Y	Y
FGDC Section 2	Y	Y
FGDC Section 3	Y	Y
FGDC Section 4	Y	Y
FGDC Section 5	Y	Y
FGDC Section 6	Y	Y
FGDC Section 7	Y	Y
Import	.sgm, .txt, .xml	.sgm, .txt, .xml
Export	.txt, .xml	.txt, .xml, .sgm, .html
Parsing	N	Y

- *NPS Database Metadata Extractor:* The Metadata Extractor is Microsoft Access Add-in developed by the Natural Resource GIS Program. The tool is designed to harvest content information from MS Access database including information on database entities (tables), attributes (fields each table) and domains. The application allows the user to edit the harvested information (including batch edits) and export it as an FGDC compliant XML file. The XML file generated can be incorporated into an existing metadata template using the Metadata Tools & Editor to provide content for section 5 of the template. *http://science.nature.nps.gov/nrdata/tools/dme.cfm*

- *Metadata Questionnaire:* NCRN staff understands that not everyone is familiar with metadata or the two metadata generation tools previously mentioned. Metadata is still a programmatic requirement and it is very important to have the appropriate staff and/or cooperators involved in the data documentation process. Therefore, the NCRN has adapted a metadata questionnaire (KLMN 2007; NCCN 2006) for project staff to complete which will provide NCRN staff the information needed to update the electronic metadata file. A copy of the questionnaire can be found in Appendix A.

Metadata Generation

Metadata creation should begin during the planning phase of a project. During this time the Data Manager will create a metadata "template" for the project wherein much of the information found in Sections 0, 1, 2, 6 and 7 of the metadata file such as network contacts, associated parks, and keywords are added. The metadata record should continue to be updated during the data acquisition and data delivery phases of a project by the field crews, PI or cooperators.

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17

Additional data files created during the project such as geographic data sets must be fully documented by the field crew and/or principle investigator.

- Metadate must be created for every GIS datalayer as well as all tabular datasets.
- A metadata file (.xml) should be created at the beginning of every project and updated as the project progresses.
- When creating/editing metadata for non-spatial data files using the NPS Metadata Tools and Editor, use the BioProfile Style Sheet (NPS_BioProfile_Edit.xsl; see Figure 1 below). This style sheet will allow you to create/edit metadata for Section 2 (Data Quality).

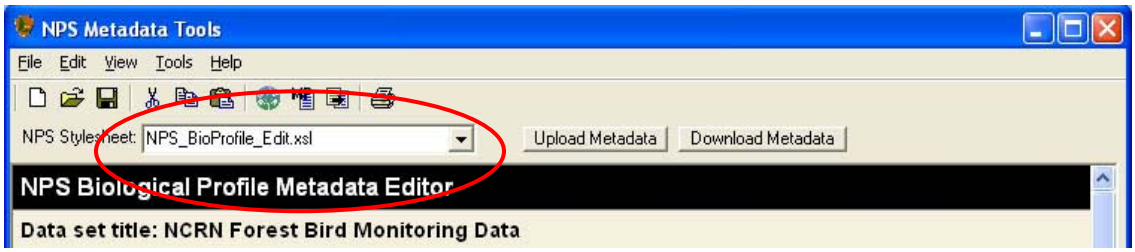


Figure 17-10. Screen capture from the NPS Metadata Tools & Editor illustrating the proper metadata sytle sheet to use.

Metadata Outlined (sections in bold are the minimally required sections)

- **Section 0: NPS Information:**

  This section is only found if using the NPS Metadata Tools and Editor application (either as stand alone or incorporated into ArcCatalog). This section identifies the park units associated with the data as well as specific keyword categories and contact information required by the NPS Data Store. This section has been completed by NCRN staff and included in the 'Template' metadata document provided to the cooperators. ***You need not edit this section further unless the areas in which you are working happen to change.*** See Appendix B for an illustration of this section.

- **Section 1: Identification Information:**

  This section contains mandatory information such as (Appendix C):

  - *Data set citation details* – Basic information relating to this section has been included. Please review this information and make any changes and additions necessary.

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17

- *Data set abstract and purpose statement* - Basic information relating to this section has been included. ***Please review this information and make any changes and additions necessary.***
- *Supplemental Information* – this field is optional but you are encouraged to enter additional information about the project here. ***This section would be a good spot to put information about the additional work you are doing for your masters project.***
- *Time period information for when the data was collected* – a range of dates was included in the metadata file based on what the field season might be. ***Please ensure that this date range is accurate and change if necessary. Please note that FGDC standard date format is YYYYMMDD***.
- *Keywords (both place and theme)* – numerous keywords have been added; however, many additional keywords may apply. ***Please add additional theme and place based keywords as you see fit.***

- **Section 2: Data Quality Information:**

Fields in this section allow for the input of very important information such as how final data products were generated and the analytical processes involved. This section will allow you to detail the methodologies used during your filed work as well as during the data analysis stage of the project.

Logistical Consistency

Please detail the steps taken to ensure that the data is consistent and accurate. This information will include the QA procedures used when entering and checking the data.

Completeness Report

If any information was omitted from the data set for any reason, please detail the criteria used for selecting the information to omit.

Methodology

Two Methodology sections have already been created for this project.

1. Field Work – Please detail the methods used during the field component of the project. Some of this information was already added to the methodology description. ***Please add additional details here regarding the field work here.***

2. Data Analysis – ***Please detail the methods used to analyze the data. Things like how the data was summarized, what software was used to analyze the data, and what statistical tests were performed.***

Process Steps

Additionally there are two Process Step sections (one for field data and one for data analysis) where you can add detailed information about the step-by-step processes used when collecting field data and performing data analysis. ***This section is not mandatory but it is helpful to include this information if specific steps were taken when collecting and process the data.***

When using the NPS Metadata Tools and Editor, Section 2 of the metadata record is only accessible using the **NPS_BioProfile_Edit.xsl** style sheet. See Appendix D for an illustration.

- Section 3: Spatial Data Organization Information:

  This section only applies to spatial data sets and contains information on the mechanism used to represent spatial information in the data set. ArcCatalog automatically harvests this information from spatial data sets.

- Section 4: Spatial Reference Information:

  This section only applies to spatial data sets and contains a description of the reference frame for, and means of encoding, coordinates in the data set. Examples include the name of and parameters for map projections or grid coordinate systems, horizontal and vertical datums, and the coordinate system resolution. This information is also automatically harvested from spatial data sets by ArcCatalog.

- Section 5: Entity and Attribute Information:

  This section contains information about the content of the data set, including the entity types and their attributes and the domains from which attribute values may be assigned. Examples include the names and definitions of features, attributes, and attribute values. The NPS Metadata Tools and Editor does not provide the capability to enter this information but it can be incorporated into a metadata file by using the 'Update with XML Template' tool.

  A metadata harvester 'Add In' was developed for MS Access which will harvest all the metadata from the tables and fields in an MS Access database and save the information to an XML file. This file can be incorporated into the main metadata record using the 'Update with XML Template' tool.

- **Section 6: Distribution Information:**

  This section provides information about obtaining the data set. Examples include contact information for the distributor, available formats, information about how to obtain data

sets online, and fees for the data. This section also contains the standard NPS Liability Statement included by default into every NCRN metadata record.

This section has been completed for you and you need not edit this information or add additional detail. See Appendix E for a detailed illustration of this section.

- **Section 7: Metadata Reference Information:**

This section deals specifically with information pertaining to the metadata record itself. It describes, who created it, when it was created, when it was updated and all of the contact information for the person responsible for the metadata. This section will be completed and distributed with the 'template' metadata file but as cooperators or staff update metadata records, they must indicate the date when the metadata record was updated (Appendix F). ***Please indicate the date when the metadata was updeated.***

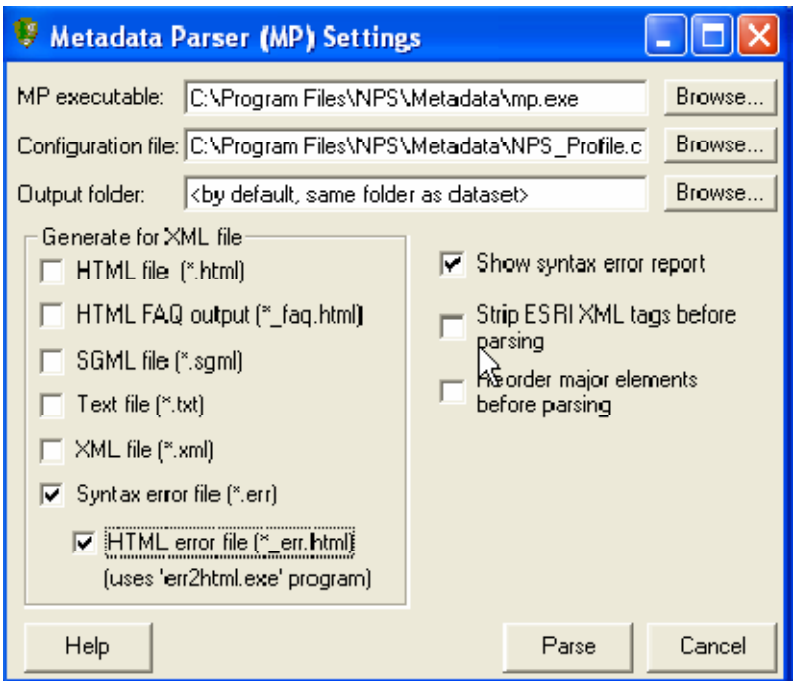
Metadata Completion

When the project is complete, or in the case of long-term monitoring datasets, when data set milestone is reached (e.g. annually), the metadata record should be finalized by reviewing for quality, FGDC- and NPS-compliance, and parsing for errors. The metadata and data set must also be reviewed by cooperators and/or NPS staff to determine if the data set or metadata contain any sensitive information. If the data set does contain sensitive information make sure that the Section 1 of the metadata record addresses this.

Parsing Metadata:

The metadata file must be parsed using the Meta Parser built into the NPS Metadata Tools and Editor. This will identify any incorrectly placed metadata elements or omissions in the metadata record. To parse a metadata record select the 'Parse with MP' tool from the Tools menu. The Metadata Parser dialog box will open and be sure to select the appropriate settings (Figure 2).

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17



NOTE:
It is always a good idea to save a copy of your metadata record prior to parsing it with the Metadata Parser.

Figure 17-2. Metadata Parser settings dialog box.

The Metadata Parser will produce a series of error reports. These errors should be addressed as best as possible. In some cases some errors will be unavoidable as is the case when a non-geospatial data set has errors due to missing spatial domain information. In such cases, errors should be ignored. Refer to the Metadata Parsing Guide for step-by-step instructions on parsing metadata.

Uploading Metadata and Data to the NPS Data Store

All non-sensitive data sets should be uploaded to the NPS Data Store for wider dissemination. If the data set contains sensitive information the data set cannot be posted to the NPS Data Store but the data manager can choose to post the metadata file alone to the data store and maintain the data set locally. Refer to the Uploading Data and Metadata guidance for step-be-step instructions. Currently only the NCRN Data Manager and GIS Specialist have the appropriate permissions to upload Network data to the Data Store.

Responsibilities

- Project Scientist (NPS staff or cooperator): The person creating or editing either geo or non-geospatial data is also responsible for FGDC compliant metadata development for any data set generated or modified as part of an NPS natural resource project. FGDC compliant metadata must accompany all geospatial datasets and is due when the final report and deliverables are submitted to the NCRN and parks included in the study. If you have not generated metadata in the past, or if you have any questions, please contact the data or project manager for assistance.

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17

- Project Manager: The project manager must ensure that FGDC compliant metadata is received for all geospatial data received from the project scientist (Cooperator or NPS staff). The project manager should provide guidance and assistance to staff and cooperators seeking assistance with metadata creation.

- Data Manager: The data manager meets with the cooperators and/or NPS staff at the onset of a project and will develop a metadata 'template' document which has much of the standard information completed already. The responsibility for updating the metadata record belongs to the cooperator or project manager. The data manager is also responsible for reviewing the metadata and working with either the project manager or cooperator to make any necessary changes. Once a metadata record has been finalized, the data manager is responsible for posting that record to the NPS Data Store.

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17

Appendix 17-A - NCRN Metadata Questionnaire

1. Select the all of the parks where the project took place:

☐ ANTI	☐ CATO	☐ CHOH	☐ GWMP
☐ HAFE	☐ MANA	☐ MONO	☐ NACE
☐ PRWI	☐ ROCR	☐ WOTR	

2. What is the title of the data set?

3. Who are the creators/owners of the data set (include addresses, phone numbers and e-mail)?

    a. If someone else should answer questions about the data, please list their name and contact information.

4. If the data set has been published please provide the citation information:

5. Please provide a brief description or abstract for the data set:

6. Please indicate the purpose behind the project and resulting data set:

7. Please indicate when the data was collected:
    a. Single date:
    b. Date range:
        i. Start Date
        ii. End Date

8. Status of the data set:
    a. Is the project complete, in progress or planned?
    b. Will the data set be updated?
        i. If so, how frequently?

9. Please indicate appropriate keywords for the following categories:
    a. Thematic
    b. Place
    c. Temporal

NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-A - NCRN Metadata Questionnaire

d. Taxonomic

10. List any related data sets that could be documented for cross-reference:

11. Does the data set contain biological information? If no, skip to question 12.
    a. What species or communities were studied?
    b. Was a taxonomic authority or field guide used for identification?
    c. Were voucher specimens collected?
        i. If so, were they herbarium specimens, animal specimens, or photographs?

12. Was the data set developed using an analytical tool or model?
    a. If yes, please reference the tool or model and provide a URL if one exists.

13. Describe the methodologies behind data collection and analysis:
    a. Summarize field methods (copy/paste from other documents):

        i. If existing protocols were used, provide the reference.

    b. Summarize laboratory methods (if any):

        i. If existing protocols were used, provide the reference.

14. Describe the quality assurance and quality control measures taken to ensure that the data are accurate:

15. Is this a GIS data set?
    a. If so, how was the data set created (e.g. GPS, digitizing)?
    b. Does the data set contain the proper projection information (e.g. projection, units, datum)
    c. Provide a brief description of the data set:

    d. List geo-processing steps:

16. Does the data set contain sensitive information? If so, describe:

NCRN Biological Stream Survey – Metadata
Standard Operating Procedure #17

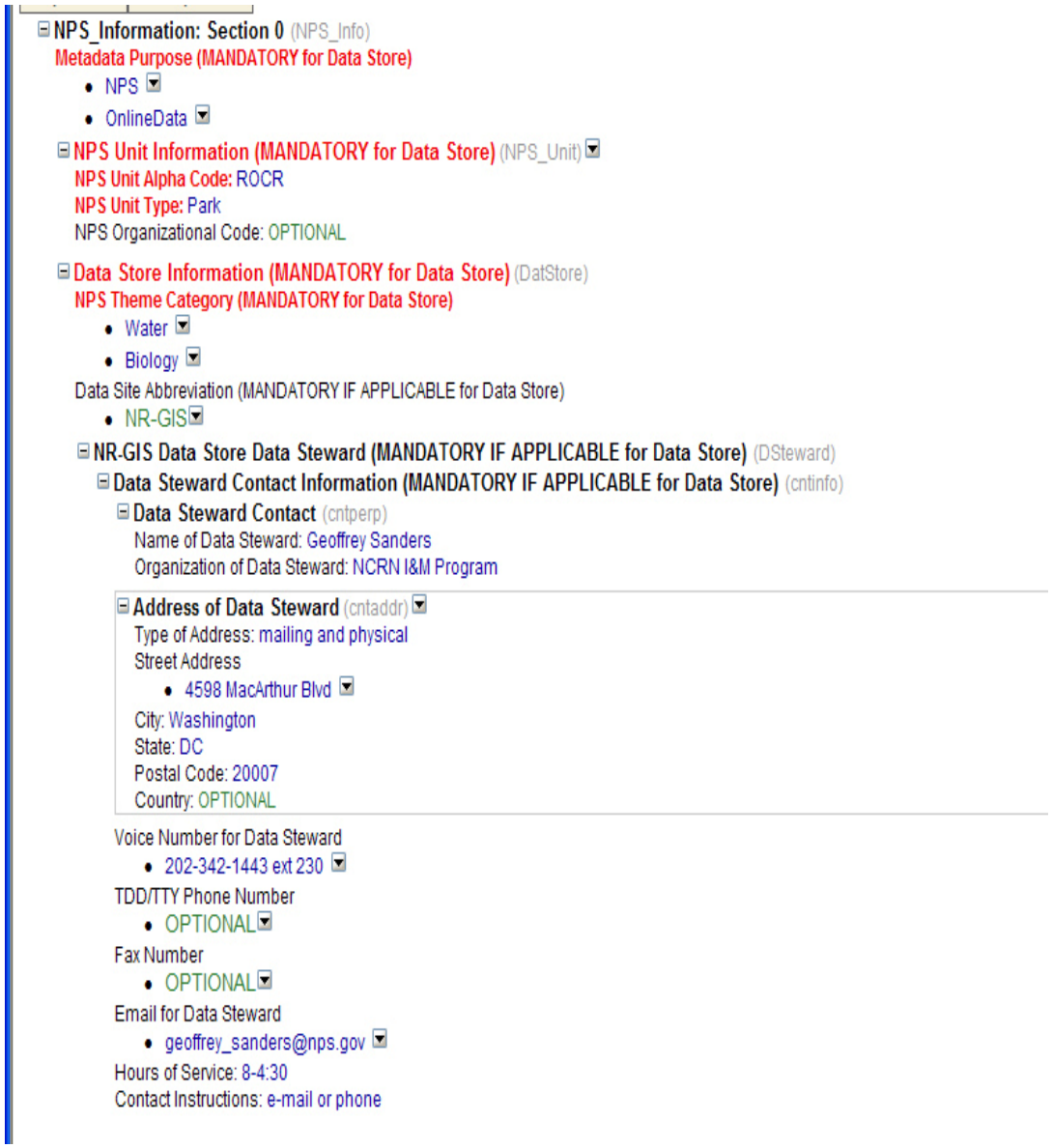
Appendix 17-A - NCRN Metadata Questionnaire

17. For all data sets: does the data set contain sensitive information? If so, describe:

18. Provide any advice/caveats for potential data users:

NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-B - NPS Metadata Section 0



NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-C - NPS Metadata Section 1

Identification_Information: Section 1 (idinfo)
- **Dataset Citation (MANDATORY for Data Store)** (citation)
  - **Dataset Citation Details (MANDATORY for Data Store)** (citeinfo)
    - Originator of Dataset
      - Versar, Inc
    - Publication Date: 20090301
    - Publication Time: OPTIONAL
    - Title of Dataset: 2008 National Capital Region Network Biological Stream Survey
    - Edition
      - OPTIONAL
    - Geospatial Data Presentation Form
      - OPTIONAL: Mode in which geospatial data are repre
    - **Series Information** (serinfo)
    - **Publication Information** (pubinfo)
    - Other Citation Details
      - OPTIONAL
    - Online Link to Dataset
      - http://science.nature.nps.gov/nrdata
    - NatureBib BibKeyID: OPTIONAL: NatureBib BibKeyID for Dataset Citation
- **Description of the Dataset (MANDATORY for FGDC)** (descript)
  - Abstract: The vital sign selection process of the NPS Inventory and Monitoring Program (I&M) identified fish, macroinvertebrates, and physical habitat characteristics as a critical need for the parks of the National Capital Region Network (NCRN). This protocol includes monitoring of three related vital signs: fish, macroinvertebrates, and physical habitat. The protocol is based on the Maryland Department of Natural Resources (MD-DNR) Maryland Biological Stream Survey (MBSS). XX standard Operating procedures (SOPs) document the methods used to collect the relevant data. The protocol was developed by Faculty and staff of UMCES-AL who perform sampling and data analysis as part of the MBSS, so that data collected will be compatible with that of the rest of the state to provide a wider context for trends in the NCRN park
  - Purpose: The data collected using this protocol will provide much needed baseline information on the stream biological resources in the NCRN, particularly in terms of community structure and composition. The information will also be used to determine long term trends in community composition, as well as trends in the abundance and distribution of individual species.
  - Supplemental Information: OPTIONAL: other descriptive information about the dataset
- **Time Period of Dataset (MANDATORY for FGDC)** (timeperd)
  - **Time Period Information** (timeinfo)
    - **Single Date/Time** (sngdate)
      - Calendar Date: YYYYMMDD - Populate EITHER Single Date, Range of Dates or Multiple Dates.
      - Time of Day: OPTIONAL
    - **Range of Dates** (rngdates)
      - Beginning Date: 20080301
      - Ending Date: 20080801
    - **Multiple Dates** (mdattim)
      - **Single Date/Time** (sngdate)
        - Calendar Date: YYYYMMDD - Populate EITHER Single Date, Range of Dates
        - Time of Day: OPTIONAL
      - **Single Date/Time** (sngdate)
        - Calendar Date: YYYYMMDD - Populate EITHER Single Date, Range of Dates or Multiple Dates.
        - Time of Day: OPTIONAL
    - **Geologic Age, if applicable** (geolage)
  - Currentness Reference: ground condition
- **Status of Dataset (MANDATORY for FGDC)** (status)
  - Progress (MANDATORY for FGDC): Complete
  - Update Frequency (MANDATORY for FGDC): Annually
- **Spatial Domain of Dataset, if applicable** (spdom)
  - Description of Geographic Extent: MANDATORY for BioProfile: Short description of the areal domain of the dataset
  - **Bounding Rectangle of Dataset** (bounding)
- **Keywords (MANDATORY for Data Store)** (keywords)
- **Taxonomy Information, if applicable** (taxonomy)

Access Constraints (MANDATORY for FGDC): None
Use Constraints (MANDATORY for FGDC): None

Enter additional Abstract and Purpose information here

Enter additional project information here

NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-C - NPS Metadata Section 1

- **Analytical Tool, if applicable** (tool)
  - Analytical Tool: MANDATORY IF APPLICABLE
  - **Tool Access Information** (toolacc)
    - Online Linkage
      - OPTIONAL
    - Tool Access Instructions: MANDATORY
    - Tool Computer and Operating System: OPTIONAL
  - **Tool Contact** (toolcont)
    - **Contact Information** (cntinfo)
      - **Person to Contact** (cntperp)
        - Name of Contact: MANDATORY: The person who is the contact
        - Organization of Contact: The organization of the contact
      - **Contact Address** (cntaddr)
        - Type of Address: default
        - Street Address
          - default
        - City: default
        - State: default
        - Postal Code: default
        - Country: OPTIONAL
      - Voice Number for Contact
        - MANDATORY
      - TDD/TTY Phone Number
        - OPTIONAL
      - Fax Number
        - OPTIONAL
      - Email for Contact
        - default
      - Hours of Service: OPTIONAL
      - Contact Instructions: OPTIONAL
  - **Tool Citation** (toolcite)
    - **Tool Citation Details** (citeinfo)
      - Originator
        - MANDATORY IF APPLICABLE: The originator of the classification system
      - Publication Date: MANDATORY IF APPLICABLE: The publication date of the classification system
      - Publication Time: Optional
      - Title: MANDATORY IF APPLICABLE: The title of the data being documented
      - Edition
        - OPTIONAL
      - Geospatial Data Presentation Form
        - OPTIONAL: Mode in which geospatial data are represented
      - **Series Information** (serinfo)
      - **Publication Information** (pubinfo)
      - Other Citation Details
        - OPTIONAL
      - Online Linkage
        - RECOMMENDED: The full URL if available
      - NatureBib BibKeyID: OPTIONAL: NatureBib BibKeyID for Citation

Provide details about specific analytical tools that were used to produce the data set

NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-D - NPS Metadata Section 2



NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-D - NPS Metadata Section 2

Process Step (procstep)
Process Description: MANDATORY
Source Used Citation Abbreviation
- OPTIONAL

Process Date: MANDATORY
Process Time: OPTIONAL
Source Produced Citation Abbreviation
- OPTIONAL

Process Contact (proccont)
Contact Information (cntinfo)
Person to Contact (cntperp)
Name of Contact: MANDATORY: The person who is the
Organization of Contact: The organization of the contact

Contact Address (cntaddr)

Voice Number for Contact
- MANDATORY

TDD/TTY Phone Number
- OPTIONAL

Fax Number
- OPTIONAL

Email for Contact
- default

Hours of Service: OPTIONAL
Contact Instructions: OPTIONAL

Process Step (procstep)
Process Description: MANDATORY
Source Used Citation Abbreviation
- OPTIONAL

Process Date: MANDATORY
Process Time: OPTIONAL
Source Produced Citation Abbreviation
- OPTIONAL

Process Contact (proccont)

Detail any processes used to summarize or create derived data products included in the data set. For instance, this section should be used to detail the processes used to create the various indexes of biotic integrity. Existing documents that provide

NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-E - NPS Metadata Section 6

Distribution_Information: Section 6 (distinfo)
- **Data Distributor (MANDATORY for FGDC)** (distrib)
  - **Data Distribution Contact Information (MANDATORY for FGDC)** (cntinfo)
    - **Distribution Contact - Primary** (cntperp)

Name of Data Distribution Contact: Geoffrey Sanders
Organization of Data Distribution Contact: NCRN

Contact Position: NCRN Data Manager

Address of Data Distribution Contact (cntaddr)

Type of Address: mailing and physical
Street Address
- 4598 MacArthur Blvd.

City: Washington
State: DC
Postal Code: 20007
Country: USA

Voice Number of Data Distribution Contact
- 202-342-1443 ext. 230

TDD/TTY Phone Number
- OPTIONAL

Fax Number
- OPTIONAL

Email of Data Distribution Contact
- geoffrey_sanders@nps.gov

Hours of Service: 8-4:30
Contact Instructions: Phone or e-mail

NPS Data Distribution Liability Statement (MANDATORY for Data Store): The National Park Service shall not be held liable for improper or incorrect use of the data described and/or contained herein. These data and related graphics (i.e. GIF or JPG format files) are not legal documents and are not intended to be used as such. The information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and consistent within the limitations of geospatial data in general and these data in particular. The related graphics are intended to aid the data user in acquiring relevant data; it is not appropriate to use the related graphics as data. The National Park Service gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. It is strongly recommended that these data are directly acquired from an NPS server and not indirectly through other sources which may have changed the data in some way. Although these data have been processed successfully on computer systems at the National Park Service, no warranty expressed or implied is made regarding the utility of the data on other systems for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data.

- **Data Ordering Information (MANDATORY IF APPLICABLE for Data Store)** (stdorder)
  - **Digital Form Ordering Information (MANDATORY IF APPLICABLE for Data Store)** (digform)
    - **Digital Transfer Information (MANDATORY IF APPLICABLE for FGDC)** (digtinfo)

Data Format Name: MDB
Data File Transfer Size (Mb): MANDATORY IF APPLICABLE for FGDC: The size of the data transfer file in Megabytes
Data File Size (Mb): OPTIONAL: The size of the uncompressed data file in Megabytes

- **Digital Transfer Option (MANDATORY IF APPLICABLE for Data Store)** (digtopt)
  - **Online Option Details (MANDATORY IF APPLICABLE for Data Store)** (onlinopt)
  - **Offline Option** (offoptn)

Fees for Data (MANDATORY IF APPLICABLE for FGDC): None

NCRN Biological Stream Survey – Metadata Standard Operating Procedure #17

Appendix 17-F - NPS Metadata Section 7



Please indicate the date when the Metadata was updated.

NCRN Biological Stream Survey - Network Data Storage Standard Operating Procedure #18

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	2/2009	Marian Norris	Renumbering	Update of protocol to new MBSS manuals	1.1

Purpose

This Standard Operating Procedure (SOP) details how all data collected under the National Capital Region Network's (NCRN) Biological Stream Survey (BSS) monitoring protocol should be stored on the network file server.

Scope and Applicability

This standard operating procedure applies to how all data relating to the NCRN Biological Stream Survey monitoring protocol will be stored. This procedure applies only to network staff.

Reference Documents

NCRN Data Management Plan

NCRN BSS Protocol

NCRN BSS Data Management SOP

Procedures and General Requirements

The following procedures describe how data collected under this protocol will be managed. More specific guidance may appear in other documents. This does not in any way dictate how data should be collected in the field. Those procedures are outlined in separate field methodology SOPs.

Network Storage and Archiving

This portion of the document outlines how and where data, as well as other project materials are stored on the NCRN file servers. All data and project materials will be maintained on the NCRN file server under a project specific directory.

NCRN Biological Stream Survey - Network Data Storage Standard Operating Procedure #18

Protocols and SOPs

All currently active protocols and SOPs will be maintained in the 'MBSS' Directory under the 'MONITORING\WaterQual&Quant' directory (Figure 1). Copies of the currently active protocol and SOPs will also be stored under the appropriate 'ARCHIVE' folder (Figure 2) in case the 'Active' files are inadvertently altered.

Field Data

All field data will remain under the 'MONITORING' data folder until the field season has been completed and the project manager certifies that all data products have been received and have undergone the proper level of QA/QC. Once the project manager is confident that the data are in good order, the data files should be archived under the project's ARCHIVE directory. The data should be appended to the master NCRN BSS database located in the ARCHIVE directory.

All data sheets will be archived in the NCRN archive fire cabinets. Copies will be maintained separately.

Reports

Annual reports are stored in under the project's MONITORING directory (Figure 1) until they have undergone review. Network staff should review reports for completeness and compliance with standards. The project manager should circulate the reports to network parks for review. All comments should be provided back to the contractor to be addressed. Once the report has been finalized and approved, a copy is archived and entered into NatureBib.

Archiving

Project materials should be archived periodically throughout the annual project cycle as a means of increasing data security. Project milestones that define the appropriate times to archive file materials in addition to the seasonal close-out milestone when all materials are received and finalized: at the completion of the Spring sampling data entry and the completion of the Summer sampling data entry. Once the data are sent to I&M and entered in the database, the data should be archived. The project manager should advise the data manager that materials are ready for archiving.

NCRN Biological Stream Survey - Network Data Storage
Standard Operating Procedure #18

Roles and Responsibilities

Principle Investigator/Contractor

- Ensure that all members of the field crew are aware of the procedures outlining how data should be entered into project database, verified and validated.
- Make sure that field crews are entering/uploading the field data in a timely fashion as outlined in this document.
- Ensure that data undergo the proper QA/QC procedures.

Field Crews

- Follow all data collection procedures.
- Enter/upload data into project databases in a timely fashion.
- Conduct data verification and validation checks.

NPS Data Manager

- Provide training and/or assistance with project databases.
- Develop database tools to assist with data entry and data QA/QC procedures.
- Develop data management guidance and ensure that all those involved in the project are aware of the standards required.
- Archive data files and data sheets.

NPS Project Manger

- Coordinate with contractor and act as liaison between contractor and NCRN I&M Staff
- Ensure that all QA/QC has been conducted properly.

Revision History Log:

Prev.	Revision	Author	Changes Made	Reason for Change	New Version

NCRN Biological Stream Survey
Quality Assurance / Quality Control
Standard Operating Procedure #19

Version #	Date				#

Purpose

The purpose of this Standard Operating Procedure (SOP) is to provide an overview of quality assurance and quality control (QA/QC) procedures for data collected using the NCRN BSS protocol. The SOP includes descriptions of documentation procedures, responsibility and accountability of project personnel, training requirements, facilities, and equipment. To achieve the objectives of the BSS, it is imperative that all project personnel follow the procedures and guidance provided in this SOP.

Scope and Applicability

This SOP applies to the quality assurance and quality control of data collected following the NCRN BSS protocol and associated SOPs. This SOP describes what will be done to assure adequate QA/QC for the data quality indicators: precision, bias, representativeness, comparability, completeness, and sensitivity.

Reference Documents

Kazyak, P., S. Stranko, D. Boward, J. Kilian, C. Millard, A. Becker, R. Gauza, A. Schenk, A. Roseberry-Lincoln and M. O'Connor, 2007. Maryland Biological Stream Survey Sampling Manual: Field Protocols. *In*, Maryland Department of Natural Resources, CHESAPEAKE BAY AND WATERSHED PROGRAMS, MONITORING AND NON-TIDAL ASSESSMENT Report CBWP-MANTA-EA-07-01, Anapolis, MD http://www.dnr.state.md.us/streams/pubs/ea-0seven-01b_fieldRevMay200seven.pdf

Procedures and General Requirements

Quality assurance and quality control (QA/QC) are integral parts of data collection and management activities. The field QA program was designed to: 1) ensure comparability of data collected by disparate sampling crews and to data collected previously by MBSS 2) ensure that data are of known and sufficient quality to meet the project objectives, and 3) provide estimates of various sources of variance associated with the individual variables being measured.

NCRN Biological Stream Survey
Quality Assurance / Quality Control
Standard Operating Procedure #19

A Quality Control Officer (QC Officer) experienced in all aspects of the Survey is appointed to administer the quality assurance program. Specific quality assurance activities administered by the QC Officer include preparing a field manual of standard sampling protocols, designing standard forms for recording field data, conducting field crew training and proficiency examinations, conducting field and laboratory audits, making independent habitat assessments, identifying taxa, reviewing all reports, and reporting errors.

Training

An important aspect of the QA program is the training program for field personnel, which will be conducted prior to sampling. Training ensures consistent implementation of required procedures and attainment by each person of a minimum level of technical competency. Along with having qualified persons in each of these positions**, all participants in field sampling must receive MBSS training.** Additionally, the field crew must be made up of persons who collectively passed all MBSS taxonomy tests for any taxonomic groups on which the crew plans to collect field data (e.g. the fish taxonomy test must be passed to collect fish data). Since benthic macroinvertebrates are identified in the laboratory, no one on the field crew is required to pass the benthic macroinvertebrate taxonomy test to collect benthic macroinvertebrates.

To ensure consistent implementation of sampling procedures and a high level of technical competency, experienced field biologists are assigned to each crew and all field personnel complete program training before participating in field sampling. Training includes classroom, laboratory, and field activities. Training topics include MBSS program orientation, stream segment location using global positioning system (GPS) equipment, sampling protocols, operation and maintenance of sampling equipment, data transcription, quality assurance/quality control, and safety. Instructors emphasize the objectives of the Survey and the importance of strict adherence to the sampling protocols. The spring field crews receive additional training in sampling protocols for water quality and benthic macroinvertebrates and are required to demonstrate proficiency in techniques for collecting samples for water chemistry and benthic macroinvertebrates. The summer field crews receive additional training in habitat assessment methods, taxonomy, and *in situ* water chemistry assessment.

The QC Officer conducts proficiency examinations to evaluate the effectiveness of the training program and ensure that the participants have detailed knowledge of the sampling protocols. At least one member of each summer sampling crew is required to pass a comprehensive fish taxonomy examination. Each crew must also demonstrate proficiency in locating pre-selected stream segments using the GPS receiver and determining if the segment is acceptable for sampling. Comprehensive "dry runs" are conducted to simulate actual field conditions and evaluate classroom instruction.

NCRN Biological Stream Survey
Quality Assurance / Quality Control
Standard Operating Procedure #19

Field

Equipment Preparation

Preventive maintenance and calibration must be performed on all sampling equipment used as part of the MBSS. Maintenance and calibration procedures should be implemented as per manufacturer instructions.
Unless otherwise specified, calibration must be performed daily prior to equipment use and anytime equipment problems are suspected. Preventative maintenance must be performed at intervals not to exceed the frequency recommended by the manufacturer. All equipment malfunctions must be fully corrected prior to the next use. For weighing scales, weekly checks must be conducted during field sampling using NIST standards or other accepted standards to demonstrate that instrument error is within limits specified by the manufacturer.
For each piece of equipment used as part of the MBSS, a bound logbook for calibration and maintenance must be maintained. Entries in the log must be made for all calibration and maintenance activities.
Documentation includes detailed descriptions of all calibrations, adjustments, and replacement of parts, and each entry must be signed and dated.
To ensure that equipment is operated within QA/QC requirements, the QC Officer should conduct periodic site equipment audits.

Documentation

To ensure scientific credibility, study repeatability and cost effectiveness, all field sampling activities need to be adequately documented. These activities include adherence to sampling protocols, equipment calibration, data sheet review, field notes, information management, and data quality assessment. To minimize the possibility that needed documentation or data are not recorded, standardized forms and on-site verification of form completions by supervisory personnel are included in the Protocol Appendix. Each of the activities listed above is described in other sections of this manual, including documentation procedures and requirements.

Field Audits

Field audits are conducted by the QC Officer during the field sampling to assess the adequacy of training, adherence to sampling protocols, and accuracy of data transcription. The audits include evaluation of the preparation and planning prior to field sampling, stream segment location using GPS equipment and assessment of acceptability for sampling, adherence to sampling protocols, data transcription,

NCRN Biological Stream Survey
Quality Assurance / Quality Control
Standard Operating Procedure #19

and equipment maintenance and calibration. Typically audits are performed at a minimum of two sites sampled by each crew. However, additional audits may be required depending on the experience of the crew, performance on previous audits, and intended use of collected data. The QC Officer makes an independent assessment of habitat at all segments where field audits are done (approximately 13% of the total number of sites sampled across MD in 2003). Field audits consist of checking for consistency and accuracy in taxonomic identification, site confirmation, calibration and maintenance of equipment, adherence to established protocols, record keeping, and prompt identification of necessary remedial or corrective actions.

For taxonomic identification, the QC officer may designate someone who is an expert in particular taxa to verify accurate taxonomic identification.

To ensure consistency in data collection, the QC officer is required to fill out an extra set of data sheets at sites sampled during QC visits. These data sheets are to be filled out independently from the data sheets filled out by the crew. Any decisions regarding safety, sampleability, number of persons involved with sampling at the site, use of equipment, or anything that may affect data quality, comparability, or completeness should be recorded on the extra data sheets or in a QC log book. The data recorded by the QC officer will be compared to the data recorded by each crew. Assuming the QC officer makes decisions and records data consistently, and since the QC officer visits all sampling crews, this provides a measure of comparability of data collection among sampling crews. In addition to field audits, the QC Officer will visit with each crew prior to the Summer Index Period to verify competency prior to initiating sampling. This visit typically consists of protocol review in the field while hypothetical sampling is conducted

Field Data Comparability and completeness

Comparability of data between field crews is maximized by providing standardized training in MBSS techniques prior to sampling. Training requirements are include in the Scope of Work for each organization involved in field sampling. Training is mandatory for all persons involved with data collection.

To utilize data from a given site during analyses, all data included on the data sheets, which pertains to the analysis being conducted, must be validated along with appropriate site location information.

Each MBSS site is assigned a unique identification code. The code is recorded at the top of all MBSS data sheets. The unique code is made up of four parts. 1) Watershed code. The appropriate four letter code indicating the eight digit watershed containing the site (watershed codes are found in SOP #5) 2) Segment. Three numbers are used to designate the segment. These three letters begin with the stream order and the next two letters refer to the order in which the site was

NCRN Biological Stream Survey
Quality Assurance / Quality Control
Standard Operating Procedure #19

selected. For random sites, the order in which the sites were collected can be important as sites lower in order being sampled indicate less probability of bias (i.e. in being representative of watershed conditions) compared to having many sites with higher order sampled. 3) Type. A one letter code is used to designate the site type. Site type codes that were used during the Round Two MBSS and are likely to be used during the Round Three MBSS include "R" for random sites, "S" for sentinel sites, "X" for special study sites and "T" for targeted sites. 4) Year. The last four digits in the site identification are the calendar year during which sampling occurred.

To facilitate data recording during inclement weather, data sheets should be printed on waterproof paper.

Backup copies of all field data sheets must be made. Digital photographs should be labeled appropriately with site identification and backed up.

To ensure that all field data for the MBSS are collected and recorded in a usable manner, all data should be printed in the units specified on the MBSS data sheets. No writeovers are permitted on data sheets. The incorrect entry should be lined out and the correct entry written in an obvious location next to the line out. Data sheets for a given site must be consecutively labeled so that the total number of data sheets generated for each site is known. Recorded data must be reviewed at the point of entry and the Crew Leader and one other member of the crew must review and initial all data sheets prior to departure from the site.

Duplicate Samples

Each sample collected as part of the MBSS will be assigned a sample number. The sample number will contain several unique identifiers to minimize the possibility of misidentification. In addition, chain-of custody forms should be maintained for all water sample, benthic macroinvertebrate, herpetofauna, crayfish, mussel, and fish collections. To aid evaluation of precision and bias, 5% of all sites will have replicate benthic macroinvertebrate and water chemistry samples collected. For water chemistry samples, one QC sample from each crew will be a blank (filled with deionized water in addition to other duplicate and blank samples analyzed as part of in-laboratory QA/QC protocols. An annual summary of QA/QC results for benthic macroinvertebrate and analytical chemistry sampling will be prepared and maintained on file. For precision, one duplicate measure of the same thing could be made every 20 samples, and the result could be reported as a relative % difference (RPD).

For bias, one invertebrate sample could be measured by a rookie and another by an expert every 20 samples or so, and the result could be reported as a % difference (PD).

Taxonomic Identification

The MBSS is recognized as providing high quality biological data. This is due primarily to the QC requirements for taxonomic identification. The following taxa are identified to

species (or subspecies in some cases) in the field: fishes, reptiles, amphibians, crayfishes, freshwater mussels, and select invasive plants. The crew conducting sampling must consist of members who, collectively, have passed tests for all of these taxonomic groups. Only the person(s) on each crew that has passed the test for the taxonomic group should conduct identification in the field.

Photographs of at least five specimens of each fish, herpetofauna, and crayfish species encountered (as long as five were collected) should be photographed. In addition, any rare, threatened, or endangered species encountered should be photographed, as long as the photograph can be taken without causing any harm to the specimen. Photographs must clearly show the appropriate features necessary for identifying the species. With the exception of rare, threatened, or endangered species, specimens that are too small to provide photographs that can be used to verify identifications should be preserved for verification.

Photographs will be reviewed by an expert in taxonomy for each taxonomic group and results will be kept on record.

Taxonomic experts (or a designee assigned by the taxonomic expert) will also audit field identification of organisms. Field audits will be conducted by taxonomic experts (or designee) at a minimum of two sites per crew.

Data Entry

All crews used standardized pre-printed data forms developed for the Survey to ensure that all data for each sampling segment were recorded and standard units of measure were used. Using standard data forms facilitates data entry and minimizes transcription error. The field crew leader and a second reviewer check all data sheets for completeness and legibility before leaving each sampling location. Original data sheets are sent to the Data Management Officer for further review, another signoff, and data entry, while copies were retained by the field crews.

After the data are entered into the project database, all entered data must be reviewed for accuracy and correctness. This is a two step process involving data verification and data validation.

Data Verification

After the data have been entered into the project database it should be reviewed. The purpose of this step is to catch errors that were incorrectly entered into the database from the datasheets (e.g. species count is entered as 100 instead of 10).The data should be reviewed by someone other than the person who entered the data. If two people are involved in the data entry process (e.g. one person dictating the information from the data sheet and the second entering the data into the database), data verification can take place almost at the same time that the data is entered. Both parties must be involved in reviewing the data and it is still imperative that the two people involved review each record and compare it to the data sheet to ensure proper data entry.

NCRN Biological Stream Survey
Quality Assurance / Quality Control
Standard Operating Procedure #19

It is essential that this review takes place in a timely manner, within a week of data collection and entry, so that the data is still fresh in the minds of the field crew.
The reviewer should check all records entered into the database for each event against those on the data sheet.
Once the data have been checked, the reviewer should indicate on the data sheet as well as in the database that the data has been verified and by whom.
Any data entry errors should be corrected in the database and the name of the person who made the correction as well as the date of the change should also be indicated. This information can be entered in the metadata fields on the main Event Information tab in the database under "Updated by".
Data Validation
Data validation or identifying records that are unreasonably out of bounds (i.e. outliers) is an essential step to ensuring data quality. A good portion of data validation is built into the database structure such as limiting the data entry to pick lists or value ranges.
Data should be reviewed to identify validation errors but specific queries can be designed to catch validation errors that are not captured during the data entry process. These queries, which will evolve over time, are intended to summarize data fields and identify those data points that might be questionable. Development of these queries requires input from all those on the project team.
It is important to note that simply because a record seems out of bounds or unusual does not mean that it is necessarily incorrect.

Data Analysis

Data Quality Assessment

Assessment of data quality against established data quality objectives will be conducted to determine the overall performance of the QA program, identify potential limitations to use and interpretation of the field collected data, and to provide information for other data users regarding usability of the data for other purposes.
Precision and bias associated with important elements of the sampling and measurement process for each variable measured will be evaluated using results from replicate sampling and performance evaluation studies. Information about precision, bias, and completeness will be used to determine the comparability of data acquired during each sampling year.
Inherent differences in data collected at independent sites are potentially confounded by differences in sampling efficiency, experience, knowledge of protocols, or sampling effort. Such crew differences can adversely affect data quality and interpretation of regional patterns, but logistics constrain the degree to which these potential limitations can be evaluated and/or corrected. In general, field crews will be assigned sampling sites within discrete geographic regions,

NCRN Biological Stream Survey
Quality Assurance / Quality Control
Standard Operating Procedure #19

and it is likely that sampling efficiency will not be uniform from the beginning to the end of the index period or between years. To minimize this effect, retaining consistent personnel should be a priority.

Archiving.

Benthic macroinvertebrate sample sortates are kept for five years. After this time, the sample material is discarded. Benthic macroinvertebrate subsamples are kept as archives in perpetuity.

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Purpose

The Standard Operating Procedure (SOP) details the analysis of water monitoring data for current status and for long-term trends. A number of point-in-time analyses as well as trend analyses can be conducted on the raw data and derived index scores.

Scope and Applicability

This SOP applies to The Biological Stream Survey Protocol when applied to NCRN parks.

Reference Documents

- Korn, E.L. and B.I. Gearbard. 1999. Analysis of Health Surveys. John Wiley and Sons. New York. 382 pp.
- Lenat, D.R. 1988. Water quality assessment of streams using qualitative collection methods for benthic macroinvertebrates. Journal of the North American Benthological Society 7:222-233.
- Paul, M.J., J.B. Stribling, R. Klauda, P. Kazyak, M. Southerland, and N. Roth. 2003. Further Development of a Physical Habitat Index for the Maryland Wadeable Freshwater Streams. Report to the Maryland Department of Natural Resources, Annapolis, MD.
- Resh, V.H. and G. Grodhaus. 1983. Aquatic insects in urban environments. In: G.W. Frankie and C.S. Koehler (editors). *Urban Entomology: Interdisciplinary Perspectives*. Praeger Publishers, New York. pp. 247-276.
- Roth, N.E., M.T. Southerland, J.C. Chaillou, P.F. Kazyak, and S.A. Stranko. 2000. Refinement and validation of a fish Index of Biotic Integrity for Maryland streams. Prepared by Versar, Inc., Columbia, MD, with Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division. CBWP-MANTA-EA-00-2.
- Schenker, N. and J.F. Gentleman. 2001. On judging the significant of differences by examining the overlap between confidence intervals. The American Statistician. 55(3): 182-186.
- Stribling J.B., B.K. Jessup, J.S. White, D. Boward, and M. Hurd. 1998. Development of a Benthic Index of Biotic Integrity for Maryland Streams. Prepared by Tetra Tech, Inc., Owings Mills, MD and Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Program. CBWP-MANTA-EA-98-3.

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Procedures and General Requirements

Analysis of Benthic Macroinvertebrate Data

A number of analyses can be conducted on these data. The standard approach is to aggregate the taxonomic information into variables called metrics (Table 5) that have been shown through previous analyses to relate to stream health and have ecological relevance. More details can be found in Stribling et al. (1998).

Table 20-3: Relevant parameters and threshold values considered as indicators of stress based on 539 sites with a fish or benthic IBI score rated poor or very poor.

Physical Habitat Index score	< 42
Urban land use	> 25% of catchment area
Agricultural land use	> 72% of catchment area
Spring pH	< 5
ANC	< 200 µeq/l
Nitrate-nitrogen	> 2 mg/l
DO	< 5 ppm
Sulfate	> 24 mg/l
DOC	> 8.0 ppm
Instream habitat score	< 11 (out of 20 points)
Epifaunal substrate score	< 11
Velocity/depth diversity score	< 11
Pool/glide/eddy quality score	< 11
Riffle/run quality score	< 11
Embeddedness	> 75%
Shading	< 30%
Riparian buffer width	< 15 m
Remoteness score	< 11
Aesthetic rating	< 11
Maximum depth	< 20 cm
Average thalweg depth	< 20 cm

Source: Roth et al. 1999; http://www.dnr.state.md.us/streams/pubs/ea-99-6.pdf).

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

The Index of Biotic Integrity (IBI) is a stream assessment tool that evaluates biological integrity based on characteristics of the fish or benthic assemblage at a site. Biological integrity is defined as *the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region* (Karr and Dudley (1981) as cited in Karr (1991)).

To develop an IBI, reference sites were selected to represent regional natural habitats, also referred to as "minimally impacted" conditions. No streams in the National Capital Region are entirely undisturbed by human activities. Atmospheric deposition of contaminants alone reaches all parts of the mid-Atlantic region, few streams have natural temperature regimes, and more than 1,000 man-made barriers to fish migration have been documented in Maryland alone. Therefore, reference conditions currently in use should not be viewed as completely natural or pristine (Southerland, Franks et al. 2007).

Reference conditions are, however, a representative sample of the best streams that currently exist in the surrounding region. Whether these conditions are the best attainable depends on future restoration activities and the goals of state and federal agencies and the public.

Multi-metric Indices of Biotic Integrity (IBIs), originally developed by Karr et al. (1986), are the most common indicators of stream condition in use today. The Maryland Biological Stream Survey developed the first fish (Roth et al. 1998) and benthic macroinvertebrates (Stribling et al. 1998) IBIs for Maryland in 1998. Subsequently, Roth et al. (2000) refined the Maryland fish IBI and Southerland et al. (2004) developed a stream salamander IBI for Maryland. In 2005, Southerland et al. (2005) developed new fish and benthic macroinvertebrate IBIs that perform better and apply to more stream classes. This section describes these new IBIs, including the information needed to apply them to any site in the National Capital Region. Details on how the new IBIs differ from the old IBIs and on how they perform can be found in Southerland et al. (2005).

Different IBIs for Different Regions

IBIs must balance capturing natural variability over as wide a region as possible with retaining an adequate ability to distinguish degrees of stream degradation from human activities. The MBSS IBIs accomplish this by using different IBIs in different geographic regions with approximately homogeneous natural conditions. Individual fish IBIs were developed for four geographic regions: Coastal Plain, Eastern Piedmont, Warmwater Highlands, and Coldwater Highlands. Individual benthic IBIs were developed for three geographic regions: Coastal Plain, Eastern Piedmont, and Coldwater Highlands. The boundary between the Coastal Plain and Eastern Piedmont is the Fall Line; the boundary between the Eastern Piedmont and Coldwater Highlands is the drainage divide beginning at Great Falls; and the Coldwater Highlands includes all streams west of the Evitts Creek drainage (Southerland, Franks et al. 2007).

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Table 20-4: Site characteristics for streams to be sampled during a six year rotation.
Streams are listed in proposed sampling order. RCH_CODE is the reach code in the National Hydrography Dataset for the reach of stream sampled. SP_East and SP_North are the site location coordinates in State Plane, meters, NAD83, FIPS 1900.

Site_ID	Site_Name	PARK	Catchment Area (Acres)	B-IBI REGION	F-IBI REGION
ROCK-103-N-2008	Pinehurst Branch	ROCR	663.250	Eastern Piedmont	Eastern Piedmont
ROCK-104-N-2008	Luzon Branch	ROCR	647.068	Eastern Piedmont	Eastern Piedmont
ROCK-106-N-2008	Soapstone Valley Stream	ROCR	505.528	Eastern Piedmont	Eastern Piedmont
ROCK-107-N-2008	Hazen Creek	ROCR	231.611	Eastern Piedmont	Eastern Piedmont
ROCK-202-N-2008	Fenwick Branch	ROCR	734.410	Eastern Piedmont	Eastern Piedmont
ROCK-205-N-2008	Broad Branch	ROCR	1172.872	Eastern Piedmont	Eastern Piedmont
COCA-217-N-2009	Minnehaha Creek	GWMP	881.019	Eastern Piedmont	Eastern Piedmont
POTO-118-N-2009	Palisades (Battery Kemble / Maddox Branch) Creek	ROCR	172.538	Eastern Piedmont	Eastern Piedmont
ROCK-108-N-2009	Piney Branch	ROCR	2381.811	Eastern Piedmont	Eastern Piedmont
ROCK-109-N-2009	Dumbarton	ROCR	203.342	Eastern Piedmont	Eastern Piedmont
ROCK-111-N-2009	Normanstone	ROCR	243.309	Eastern Piedmont	Eastern Piedmont
ROCK-405-N-2009	Rock Creek at Dumbarton Oaks	ROCR	41727.020	Eastern Piedmont	Eastern Piedmont
MONO-230-N-2010	Big Hunting Creek	CATO	5126.050	Eastern Piedmont	Eastern Piedmont
MONO-133-N-2010	Owens Creek	CATO	1252.025	Eastern Piedmont	Eastern Piedmont
MONO-134-N-2010	Whiskey Still Creek	CATO	414.287	Eastern Piedmont	Eastern Piedmont
BULL-018-N-2010	Youngs Branch	MANA	4380.723	Eastern Piedmont	Eastern Piedmont
MONO-217-N-2010	UT Monocacy River (Visitors Center / Gambrill Mill Creek)	MONO	674.752	Eastern Piedmont	Eastern Piedmont
MONO-316-N-2010	Bush Creek	MONO	20450.977	Eastern Piedmont	Eastern Piedmont
CHOP-102-N-2011	North Branch of Chopawamsic Creek	PRWI	3716.109	Eastern Piedmont	Eastern Piedmont
CHOP-103-N-2011	Middle Branch of Chopawamsic Creek	PRWI	2872.522	Eastern Piedmont	Eastern Piedmont
QUAN-104- N-2011	Carters Run	PRWI	84.222	Coastal Plain	Coastal Plain
QUAN-101-N-2011	Mawavi Run	PRWI	122.629	Eastern Piedmont	Eastern Piedmont

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Site_ID	Site_Name	PARK	Catchment Area (Acres)	B-IBI REGION	F-IBI REGION
QUAN-201-N-2011	North Fork Quantico Creek	PRWI	4404.703	Eastern Piedmont	Eastern Piedmont
QUAN-102-N-2011	Orenda Run	PRWI	127.893	Eastern Piedmont	Eastern Piedmont
QUAN-103-N-2011	Taylor Run	PRWI	293.023	Eastern Piedmont	Eastern Piedmont
QUAN-206-N-2011	Mary Bird Branch	PRWI	502.019	Coastal Plain	Coastal Plain
POTO-309-N-2012	Pimmit Run	GWMP	7732.454	Eastern Piedmont	Eastern Piedmont
POTO-112-N-2012	Turkey Run	GWMP	660.910	Eastern Piedmont	Eastern Piedmont
POTO-211-N-2012	Mine Run	GWMP	1599.442	Eastern Piedmont	Eastern Piedmont
DIFF-202-N-2012	Courthouse Creek	WOTR	1000.138	Coastal Plain	Coastal Plain
DIFF-201-N-2012	Wolftrap Creek	WOTR	2534.854	Coastal Plain	Coastal Plain
ANTI-101-N-2013	Sharpsburg Creek	ANTI	788.608	Highlands	Warmwater Highlands
SHEN-110-N-2013	Flowing Springs Run	HAFE	5521.232	Highlands	Warmwater Highlands
PRUT-201-N-2013	Henson Creek	NACE	2486.309	Coastal Plain	Coastal Plain
ACCO-214-N-2013	Accokeek Creek	NACE	138.811	Coastal Plain	Coastal Plain
ANAC-113-N-2013	Still Creek	NACE	2378.302	Eastern Piedmont	Eastern Piedmont
OXON-301-N-2013	Oxon Run	NACE	8564.538	Coastal Plain	Coastal Plain

NCRN Biological Stream Survey - Data Analysis Standard Operating Procedure #20

Fish IBIs

The fish IBIs are calculated using the numbers and species of fish sampled at a site. Depending on where the site is, a specific IBI is used. Each IBI has a unique combination of metrics and scoring thresholds (Southerland, Franks et al. 2007).

Fish IBI metrics

The Coastal Plain fish IBI comprises the following six metrics (Southerland, Franks et al. 2007):

1. Abundance per square meter: The number of fish caught at the site are summed. The area of the site is calculated by multiplying the length of stream sampled (measured in meters) by the average wetted width (measured in meters). The number of fish is then divided by the stream area.
2. Number of Benthic Species Adjusted: The number of species caught at each site that are identified as darter, sculpin, madtom, or lamprey (See Appendix A) are summed. This value is adjusted using a correction involving the catchment acreage as follows: Number of Benthic Species Adjusted = Number of Benthic Species divided by (($\log_{10}$ catchment acreage * 1.69) – 3.33).
3. Percent Tolerants: The percentage of the fish sample considered tolerant of disturbance (See Appendix A for tolerance designations).
4. Percent Generalists, Omnivores, and Invertivores: The percentage of the fish sample considered generalists, omnivores, or invertivores in their feeding (See Appendix A for feeding group designations).
5. Percent Non-tolerant Suckers: The percentage of the fish sample classified as suckers, excluding the white sucker.
6. Percent Abundance of Dominant Species: In the sample, the species that occurs the most often is considered the dominant species. To calculate this metric, the number of individuals of this dominant species is divided by the total number of individuals caught at the site and multiplied by 100 to convert to a percentage.

The Eastern Piedmont fish IBI comprises the following six metrics (Southerland, Franks et al. 2007):

1. Abundance per square meter: The number of fish caught at the site are summed. The area of the site is calculated by multiplying the length of stream (as measured in meters) sampled by the average wetted width (as measured in meters) of the site. The number of fish is then divided by the stream area.
2. Number of Benthic Species Adjusted: The number of species caught at each site that are identified as darter, sculpin, madtom, or lamprey (See Appendix A) are summed. This value is adjusted using a correction involving the catchment acreage as follows: Number of Benthic Species Adjusted = Number of Benthic Species divided by ((log10 catchment acreage * 1.25) – 2.36).
3. Percent Tolerants: The percentage of fish sample considered tolerant of disturbance (See Appendix A for tolerance designations).

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

4. Percent Generalists, Omnivores, and Invertivores: The percentage of fish sample considered generalists, omnivores, or invertivores in their feeding (See Appendix A for feeding group designations).
5. Biomass per square meter: The mass of all fish obtained in sampling is divided by the total area of the site. Total area of the site is found by multiplying the length of stream sampled (measured in meters) by the average wetted width (measured in meters).
6. Percent Lithophilic Spawners: The percentage of fish obtained in the sample that broadcast eggs over silt-free, rocky substrates to reproduce (See Appendix A for spawning designations).

The Warmwater Highlands fish IBI comprises the following six metrics (Southerland, Franks et al. 2007):

1. Abundance per square meter: The number of fish caught at the site are summed. The area of the site is calculated by multiplying the length of stream (measured in meters) sampled by the average wetted width (measured in meters). The number of fish is then divided by the stream area.
2. Number of Benthic Species Adjusted: The number of species caught at each site that are identified as darter, sculpin, madtom, or lamprey (See Appendix A) are summed. This value is adjusted using a correction involving the catchment acreage as follows: Number of Benthic Species Adjusted = Number of Benthic Species divided by ((log10 catchment acreage * 1.23) – 2.35).
3. Percent Tolerants: The percentage of fish sample considered tolerant of disturbance (See Appendix A for tolerance designations).
4. Percent Generalists, Omnivores, and Invertivores: The percentage of fish sample considered generalists, omnivores, or invertivores in their feeding (See Appendix A for feeding group designations).
5. Percent Insectivores: The percentage of fish sample considered insectivores in their feeding (See Appendix A for feeding group designations).
6. Percent Abundance of Dominant Species: In the sample, the species that occurs the most often is considered the dominant species. To calculate this metric, the number of individuals of this dominant species is divided by the total number of individuals caught at the site and multiplied by 100 to convert to a percentage.

The Coldwater Highlands fish IBI comprises the following four metrics (Southerland, Franks et al. 2007):

1. Abundance per square meter: The number of fish caught at the site are summed. The area of the site is calculated by multiplying the length of stream (measured in meters) sampled by the average wetted width (measured in meters). The number of fish is then divided by the stream area.
2. Percent Tolerants: The percentage of fish sample considered tolerant of disturbance (See Appendix A for tolerance designations).

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

3. Percent Brook Trout: The percentage of fish sample that are brook trout.
4. Percent Sculpins: The percentage of fish sample that are sculpins (See Appendix A for designations).

Scoring the fish IBI metrics

Once each metric has been calculated, the values obtained for each metric are scored as a 1, 3, or 5 depending on its value. These scores are assigned relative to the percentage of reference sites with those values (Figure 1). For variables that increase with higher quality, metric values less than the 10th percentile of reference sites were scored a 1, values between the 10th and 50th percentiles were scored a 3, and values greater than the 50th percentile were scored a 5. For variables that decrease with higher quality, the scoring was reversed (i.e., 1 greater than 90th, 3 between the 90th and 50th, and 5 less than the 50th). For example, the abundance of fish in coldwater streams declines with higher quality conditions. Scoring criteria for each metric used in the specific fish IBI for each geographic region are given in Table 3 (Southerland, Franks et al. 2007).

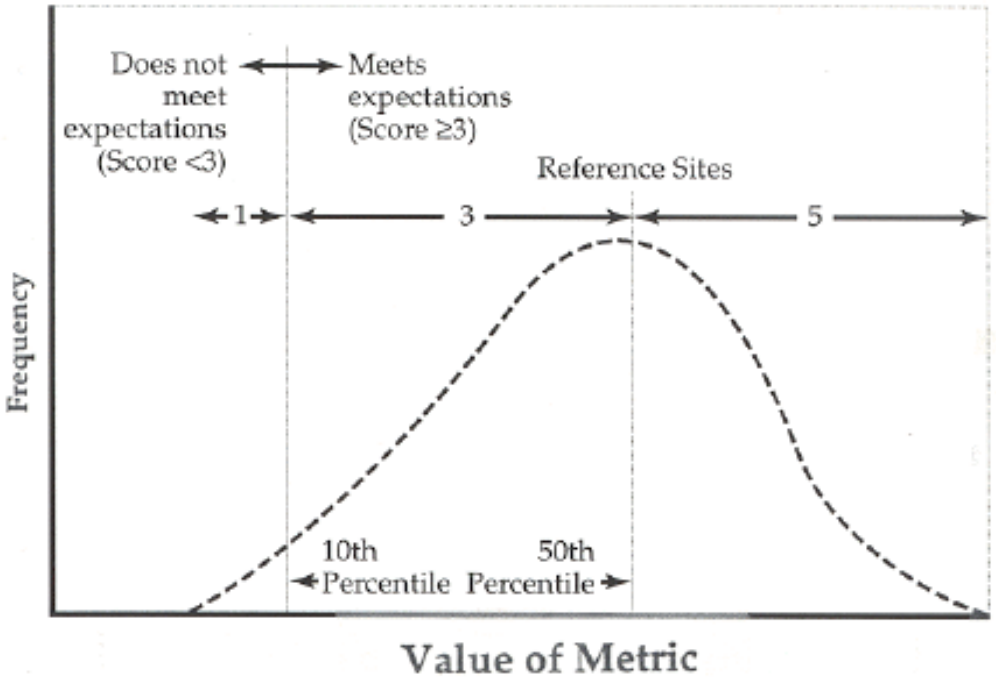


Figure 20-11: Method for scoring metrics relative to reference site values

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Table 20-5: Fish IBIs for Maryland by region with metric scoring thresholds.

	Thresholds		
	1	**3**	**5**
Coastal Plain			
Abundance per square meter	<0.45		>= 0.72
Number of Benthic Species Adjusted	0		>= 0.22
Percent Tolerants	> 97		<= 68
Percent Generalists, Omnivores, Invertivores	100		<= 92
Percent Non-tolerant Suckers (all suckers except white sucker)	0		>= 2
Percent Abundance of Dominant Species	> 69		<=40
Eastern Piedmont			
Abundance per square meter	< 0.25		>= 1.25
Number of Benthic Species Adjusted	< 0.09		>= 0.26
Percent Tolerants	> 68		<= 45
Percent Generalists, Omnivores, Invertivores	100		<= 80
Biomass per square meter	< 4.0		>= 8.6
Percent Lithophilic Spawners	< 32		>= 61
Warmwater Highlands			
Abundance per square meter	< 0.31		>=0.65
Number of Benthic Species Adjusted	<0.11		>=0.25
Percent Tolerants	> 80		<= 39
Percent Generalists, Omnivores, Invertivores	> 96		<= 61
Percent Insectivores	< 1		>= 33
Percent Abundance of Dominant Species	> 89		<= 38
Coldwater Highlands			
Abundance per square meter	>=2.24		<=0.88
Percent Tolerants	>=0.81		<=0.22
Percent Brook Trout	0		>=0.14
Percent Sculpins	0		>=0.44

Calculating the fish IBI

After each metric value is scored, a fish IBI score for each site is calculated by summing the individual metric scores for each site and dividing by the total number of metrics in the IBI. The range of fish IBI scores is 1.0 (worst) and 5.0 (best) (Southerland, Franks et al. 2007).

Benthic IBIs

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

The benthic macroinvertebrate IBIs are calculated using the numbers and taxa of macroinvertebrates collected at a site and subsampled in the laboratory. The macroinvertebrates identified approximate a 100-organism random subsample. Depending on where the site is, a specific IBI is used. Each IBI has a unique combination of metrics and scoring thresholds (Southerland, Franks et al. 2007).

The Coastal Plain benthic IBI comprises the following seven metrics (Southerland, Franks et al. 2007):

1. Number of Taxa: The number of taxa obtained in the sample.
2. Number of EPT Taxa: The number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (See Appendix B for insect orders).
3. Number of Ephemeroptera Taxa: The number of mayfly (order Ephemeroptera) taxa found in the sample (See Appendix B for insect orders).
4. Percent Intolerant Urban: The number of individuals obtained in the sample that are intolerant of urban conditions (See Appendix B for tolerance designations) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.
5. Percent Ephemeroptera: The number of individuals obtained in the sample that are in the order Ephemeroptera (See Appendix B for insect orders) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.
6. Number of Scraper Taxa: The number of taxa obtained in the sample that scrape food from the substrate to feed (See Appendix B for feeding group designations).
7. Percent Climbers: The number of taxa obtained in the sample that have a habitat designation of climber (See Appendix B for habitat designations) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.

The Eastern Piedmont benthic IBI comprises the following six metrics(Southerland, Franks et al. 2007):

1. Number of Taxa: The number of taxa obtained in the sample.
2. Number of EPT Taxa: The number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (See Appendix B for insect orders).
3. Number of Ephemeroptera Taxa: The number of mayfly (order Ephemeroptera) taxa found in the sample (See Appendix B for insect orders).
4. Percent Intolerant Urban: The number of individuals obtained in the sample that are intolerant of urban conditions (See Appendix B for tolerance designations) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.
5. Percent Chironomidae: The number of taxa obtained in the sample that are of the family Chironomidae (See Appendix B for insect families) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.

6. Percent Clingers: The number of taxa obtained in the sample that have a habitat designation of clinger (See Appendix B for habitat designations) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.

The Highlands benthic IBI comprises the following eight metrics (Southerland, Franks et al. 2007):

1. Number of Taxa: The number of taxa obtained in the sample.
2. Number of EPT Taxa: The number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (See Appendix B for insect orders).
3. Number of Ephemeroptera Taxa: The number of mayfly (order Ephemeroptera) taxa found in the sample (See Appendix B for insect orders).
4. Percent Intolerant Urban: The number of individuals obtained in the sample that are intolerant of urban conditions (See Appendix B for tolerance designations) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.
5. Percent Tanytarsini: The number of taxa obtained in the sample that are of the tribe Tanytarsini (See Appendix B for insect tribes) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.
6. Percent Scrapers: The number of taxa obtained in the sample that are in the scraper functional feeding group (See Appendix B for feeding group designations) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.
7. Percent Swimmers: The number of taxa obtained in the sample that have a habitat designation of swimmer (See Appendix B for habitat designations) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.
8. Percent Diptera: The number of taxa obtained in the sample that are of the order Diptera (See Appendix B for insect orders) divided by the total number of individuals obtained in the sample, and multiplied by 100 to convert to a percentage.

Scoring the benthic IBI metrics

Once each metric has been calculated, the values obtained for each metric are scored as a 1, 3, or 5 depending on its value. These scores are assigned relative to the percentage of reference sites with those values (Figure 1). For variables that increase with higher quality, metric values less than the 10^{th} percentile of reference sites were scored a 1, values between the 10^{th} and 50^{th} percentiles were scored a 3, and values greater than the 50^{th} percentile were scored a 5. For variables that decrease with higher quality, the scoring was reversed (i.e., 1 greater than 90^{th}, 3 between the 90^{th} and 50^{th}, and 5 less than the 50^{th}). For example, the abundance of fish in coldwater streams declines with higher quality conditions. Scoring criteria for each metric used in the specific benthic IBI for each geographic region are given in Table 4 (Southerland, Franks et al. 2007).

NCRN Biological Stream Survey - Data Analysis Standard Operating Procedure #20

Table 20-6: Benthic IBIs for Maryland by region with metric scoring thresholds.

	Thresholds		
	1	**3**	**5**
Coastal Plain			
Number of Taxa	< 14		>= 22
Number of EPT Taxa	< 2		>= 5
Number of Ephemeroptera Taxa	< 1		>= 2
Percent Intolerant to Urban	<10		>= 28
Percent Ephemeroptera	< 0.8		>= 11
Number of Scraper Taxa	< 1		>= 2
Percent Climbers	< 0.9		>= 8
Eastern Piedmont			
Number of Taxa	< 15		>= 25
Number of EPT Taxa	< 5		>= 11
Number of Ephemeroptera Taxa	< 2		>= 4
Percent Intolerant to Urban	< 12		>= 51
Percent Chironomidae	> 63		<= 24
Percent Clingers	< 31		>= 74
Combined Highlands			
Number of Taxa	< 15		>= 24
Number of EPT Taxa	< 8		>= 14
Number of Ephemeroptera Taxa	< 3		>= 5
Percent Intolerant to Urban	< 38		>= 80
Percent Tanytarsini	<0.1		>=4
Percent Scrapers	< 3		>= 13
Percent Swimmers	< 3		>= 18
Percent Diptera	> 50		<= 26

Calculating the benthic IBI

After each metric value is scored, a benthic IBI score for each site is calculated by summing the individual metric scores for each site and dividing by the total number of metrics in the IBI. The range of benthic IBI scores is 1.0 (worst) and 5.0 (best) (Southerland, Franks et al. 2007).

Assigning Condition Classes to IBI Scores

In addition to indicating relative stream condition (i.e., higher IBI scores mean higher quality), MBSS IBIs denote absolute condition as good, fair, poor, or very poor (Table 5). Integer ranges of IBI scores have been assigned to each of the four narrative descriptions shown in Table 5.

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Because an IBI score of 3 represents the threshold of reference condition, values less than 3 (i.e., poor or very poor) represent sites that are degraded. In contrast, values greater than or equal to 3 (i.e., fair or good) indicate that most attributes of the community are within the range of those at reference sites and therefore not degraded. The assignment of scores to narrative categories is a useful method for translating scores into a form that is easily communicated (Southerland, Franks et al. 2007).

Sites are evaluated using both the fish and benthic IBIs developed for the MBSS from indicators or metrics previously employed in evaluating results from the mid 1990s (Roth et al. 1999). For details about IBI development, see Roth et al. (2000) and Stribling et al. (1998). IBI scores for each site are determined by comparing the fish or benthic assemblage to those found at minimally impacted reference sites. Three separate formulations are employed for the fish IBI, one for each of three distinct geographic areas: Coastal Plain, Eastern Piedmont, and Highlands. Two different formulations of the benthic IBI are used in the Coastal Plain and non-Coastal Plain regions. IBIs were calibrated specifically for each ecological region during their development.

The MBSS method computes the IBI as the average of individual metric scores. Individual metric scores are based on comparison with the distribution of metric values at reference sites within each geographic stratum. Metrics are scored 1 (if < 10th percentile of reference value), 3 (10th to 50th percentile), or 5 (> 50th percentile). The final IBI scores are calculated as the average of three scores and therefore range from 1 to 5. An IBI > 3 indicates the presence of a biological community with attributes (metric values) comparable to those of reference sites, while an IBI < 3 means that, an average, metric values fall short of reference expectations. Table 3 contains narrative descriptions for each of the IBI categories developed for the Survey.

Because an IBI score of 3 represents the threshold of reference condition, values less than 3 (i.e., poor or very poor) represent sites suspected to be degraded. In contrast, values greater than or equal to 3 (i.e., fair or good) indicate that most attributes of the community are within the range of those at reference sites. High scores (IBI of 4 to 5) were designated as good, recognizing that available reference sites do not necessarily represent the highest attainable condition nor are these sites pristine or completely natural. The assignment of scores to narrative categories is a useful method for translating scores into a form that is easily communicated.

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Table 20-7: Narrative descriptions of stream biological integrity associated with each of the IBI categories.

Good	IBI score 4.0–5.0	Comparable to reference streams considered to be minimally impacted. On average, biological metrics fall within the upper 50% of reference site conditions.
Fair	IBI score 3.0–3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally impacted streams. On average, biological metrics fall within the lower portion of the range of reference sites (10th to 50th percentile).
Poor	IBI score 2.0–2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating degradation. On average, biological metrics fall below the 10th percentile of reference site values.
Very Poor	IBI score 1.0–1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating severe degradation. On average, biological metrics fall below the 10th percentile of reference site values; most or all metrics are below this level.

Physical Habitat

A revised Physical Habitat Index (PHI) was developed using MBSS data through 2000 (Paul et al. 2003). Because of underlying differences in stream types, separate PHIs are applied on each of three geographic strata: the Highland, Piedmont, and Coastal Plain. Four physical habitat variables (SOP #8 & 11) are common to all three indices: (1) bank stability, (2) epibenthic substrate, (3) shading, and (4) remoteness. Five additional variables are included in one of two indices: (1) riparian width, (2) riffle quality, (3) instream wood, (4) instream habitat quality, and (5) embeddedness.

Index scores (calculated based on table 20-6)are adjusted to a percentile scale that rates each sample segment as follows:

- Scores of 81 to 100 are rated minimally degraded
- Scores of 66 to 80 are rated partially degraded
- Scores of 51 to 65 are degraded
- Scores of 0 to 50 are rated severely degraded

NCRN Biological Stream Survey - Data Analysis Standard Operating Procedure #20

TABLE 20-6. RANGES OF BIBI METRICS AND ASSOCIATED IBI SCORES FOR COASTAL PLAIN AND NON-COASTAL PLAIN STREAMS.

	IBI Score		
Coastal Plain			
Metric	5	3	1
Total number of taxa	>24	11–24	<11
Number of EPT taxa	>6	3–6	<3
% Ephemeroptera	>11.4	2.0–11.4	<2.0
% Tanytarsini of Chiron.	>13.0	>0.0–13.0	0
Beck's Biotic Index	>12	4–12	<4
Number of scraper taxa	>4	1–4	<1
% clingers	>62.1	38.7–62.1	<38.7
Non-Coastal Plain			
Total number of taxa	>22	16–22	<16
Number of EPT taxa	>12	5–12	<5
Number of Ephemeroptera taxa	>4	2–4	<2
Number of Diptera taxa	>9	6–9	<6
% Ephemeroptera	>20.3	5.7–20.3	<5.7
% Tanytarsini	>4.8	>0.0–4.8	0.0
Number of intolerant taxa	>8	3–8	<3
% tolerant	<11.8	11.8–48.0	>48.0
% collectors	>31.0	13.5–31.0	<13.5

Ecological relevance of selected metrics

The initial compilation of candidate metrics and the process of metric selection and testing was in part driven by a goal of representing different categories of ecological information. Effort was made not only to maximize the effectiveness of detecting degradation, but also to communicate meaningful ecological information. The following provides a description of the ecological relevance of metrics that were selected and what changes in their values may mean.

Total number of taxa.

The richness of the community in terms of number of genera indicates biodiversity of ecosystems and is commonly used as a quantitative measure of stream water and habitat quality. Taxa richness generally decreases as a stream ecosystem degrades (Resh and Grodhaus 1983) and may be a factor of habitat elimination, competitive displacement by opportunistic taxa following disturbance, and/or local extirpation of relatively intolerant taxa. Some stream systems often naturally support fewer taxa, such as high-gradient, cold-water streams. This metric can also reflect temporarily higher numbers of taxa (relative to reference conditions) due to nutrient enrichment.

NCRN Biological Stream Survey - Data Analysis Standard Operating Procedure #20

Number of EPT taxa.

The richness of the generally intolerant insect orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) can indicate stream condition, since these taxa tend to become more scarce with increasing levels of disturbance (Lenat 1988). Some EPT taxa are less sensitive to pollutants or disturbance, so low taxa counts are usually represented by more tolerant taxa.

Number of Ephemeroptera taxa.

The richness of mayfly taxa indicates the ability of a stream to support this generally intolerant insect order. Mayflies have medium to high oxygen requirements and some taxa need clean gravel substrate. Organic enrichment and excess fine sediment, indicators of anthropogenic stress, will often reduce the diversity of mayflies.

Number of Diptera taxa.

Diptera as an order are relatively diverse and Dipterans are variable in their tolerance to stress. Many taxa, especially Chironomidae, have cosmopolitan distributions and may occur even in highly-polluted streams. However, a high diversity of Diptera taxa generally suggests good water and habitat quality.

Percent Ephemeroptera.

The degree to which mayflies dominate the community can indicate the relative success of these generally pollution intolerant individuals in sustaining reproduction. The presence of stresses will reduce the abundance of mayflies relative to other, more tolerant individuals; although, some mayfly groups, such as several genera of the family Baetidae, are known to increase in numbers in cases of nutrient enrichment.

Percent Tanytarsini of Chironomidae.

The tribe Tanytarsini is a relatively intolerant group of midges. The degree to which they represent the total number of midges indicates the general sensitivity of the midge assemblage. A high percentage of Tanytarsini among the midges may indicate lower levels of anthropogenic stress. This metric increases with high numbers of Tanytarsini (among all Chironomidae) and decreases with high numbers of non-tanytarsine Chironomidae.

Percent Tanytarsini.

Tanytarsini as a percentage of the entire sample has a significance similar to the percent Tanytarsini of Chironomidae, except that other midges do not affect the metric value.

Number of intolerant taxa.

NCRN Biological Stream Survey - Data Analysis Standard Operating Procedure #20

Intolerant taxa are the first to be eliminated by perturbations. Often, intolerant taxa are specialists and perturbations can disturb or eliminate specialized habitat or water quality requirements. Taxa with tolerance ratings from 0 to 3 on the 0 to 10 scale were considered intolerant.

Percent tolerant.

As perturbation increases, tolerant individuals (tolerance values 7–10) tend to predominate in the sample. Intolerant individuals become less abundant as stress increases, leading to more individuals in tolerant, opportunistic taxa.

Beck's Biotic Index.

The weighted enumeration of intolerant individuals in the community expresses the relative abundance of individuals in the most intolerant and second most intolerant classes. Since the most intolerant taxa are weighted more heavily, their abundance in the assemblage is more important to this metric. The metric increases with better water and habitat quality.

Number of scraper taxa.

High diversity of the herbivorous scraper fauna can indicate a lack of stressors. This metric illustrates a food web effect; these genera feed on periphyton and associated microfauna which may themselves be more abundant under conditions of minimal perturbation.

Percent collectors.

Abundance of detritivores, which feed on fine particulate organic matter in deposits, typically decreases with increased disturbance. This ecological response may be a food web effect, where organic material becomes scarce or unsuitable with increased perturbation, or membership within this feeding group may be highly represented by intolerant taxa.

Percent clingers.

The taxa which cling to surfaces in fast moving water by means of morphological adaptations or construction of fixed retreats increase in abundance in the absence of stressors. The stressors which most adversely affect this metric are those that directly disturb or eliminate high quality habitat, such as clean gravel riffles.

All of the above described metrics can be analyzed at a site for temporal trends using linear regression to detect changes in slope. In addition, a Benthic Index of Biotic Integrity (BIBI) score can be calculated to give an overall assessment of the site for each year. The BIBI score is the average score across all of the metrics and is interpreted as shown in Table 3 in the narrative. As with water chemistry data and benthic macroinvertebrate metric data, the BIBI can be analyzed for temporal trends using simple

linear regression or BIBI scores can be combined to look at overall park scores through time (see estimators for combining IBI data subsection below)

Estimators for combining IBI data. For years, parks, or specific sites (through time) where there are sufficient samples in each group to calculate a mean and standard error, the estimates for each group can be combined into a single estimate using composite estimation (Korn and Graubard 1999). It is recommended that the combined estimate only be applied when the combined data represent an effective sample size of at least 10 samples. If comparing among parks or years, a minimum of two samples per stream order are required (i.e., two samples in each of stream orders 1, 2, and 3).

Assume that two years provide estimates for the same population of streams and that the two surveys were independent. Under this assumption temporal differences in the actual stream network caused by variation in rainfall or other factors are not taken into account. Let $\bar{x}_1$ and $\bar{x}_2$ be the mean IBIs for two rounds, with respective standard errors SE_1 and SE_2 calculated according to the respective survey design.

Equal weights are assigned to each year's estimate, and use the simple combined estimator

$$\bar{x} = \frac{\bar{x}_1 + \bar{x}_2}{2}$$

for the pooled mean IBI, with variance

$$\mathrm{var}(\bar{x}) = \frac{1}{4}\{\mathrm{var}(\bar{x}_1) + \mathrm{var}(\bar{x}_2)\}$$

and standard error

$$SE = \frac{1}{2}\sqrt{SE_1^2 + SE_2^2}$$

This simple approach was applied to avoid that the combined mean would be driven by the estimate for one particular year.

Testing for Differences in Mean IBI Scores Between Years

Comparisons of statistical differences between mean IBI scores from two years were conducted using the standard method recommended by Schenker and Gentleman (2001). This test was used because it is more robust than the commonly used method of examining the overlap between the two associated confidence intervals. Assume that $\hat{Q}_1$, and $\hat{Q}_2$ are two independent estimates of mean IBI, and that the associated standard errors (SE) are estimated by $\hat{Q}_1$ and $\hat{Q}_2$. We estimated the 95% confidence interval for $\hat{SE}_1$ by $\hat{SE}_1$. We estimated the 95% confidence interval for $\hat{Q}_1 - \hat{Q}_2$ by

$$\left(\hat{Q}_1 - \hat{Q}_2\right) \pm 1.96\left[\hat{SE}_1^2 + \hat{SE}_2^2\right]^{1/2}$$

and tested (at 5% nominal level) the null hypothesis that $\hat{Q}_1 - \hat{Q}_2 = 0$ by examining whether the 95% confidence interval contains 0. The null hypothesis that two estimates are equal was rejected if and only if the interval did not contain 0 (Schenker and Gentleman 2001).

Analysis of Fish Data

The fish data can be analyzed in the same fashion as the benthic invertebrate data using the Fish Index of Biotic Integrity (FIBI) scores or their component metrics to analyze for temporal trends. Scores can also be compared across sites to assess site condition relative to other sites, other parks, and relative to sites in the surrounding region contained in the extensive MBSS database. FIBI scores are interpreted the same as BIBI scores and are described in Table 11-2.

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Table 20-7: Metrics and scoring criteria for the recommended final fish IBI. Some metrics[(a)] were adjusted for watershed area, based on linear relationships between the metric and log (watershed area) in acres

	Scoring criteria		
	5	**3**	**1**
Coastal Plain			
Number of native species	Criteria vary with stream size (see below)		
Number of benthic fish species	Criteria vary with stream size (see below)		
Number of intolerant species	Criteria vary with stream size (see below)		
Percent tolerant fish	≤ 50	$50 < \times \leq 93$	> 93
Percent abundance of dominant species	≤ 33	$33 < \times \leq 78$	> 78
Percent generalists, omnivores, and invertivores	≤ 92	$92 < \times < 100$	100
Number of individuals per square meter	≥ 0.79	$0.42 \leq \times < 0.79$	< 0.42
Biomass (g) per square meter	≥ 9.9	$3.6 \leq \times < 9.9$	< 3.6
Eastern Piedmont			
Number of native species	Criteria vary with stream size (see below)		
Number of benthic fish species	Criteria vary with stream size (see below)		
Number of intolerant species	Criteria vary with stream size (see below)		
Percent tolerant fish	≤ 41	$41 < \times \leq 65$	> 65
Percent abundance of dominant species	≤ 30	$30 < \times \leq 52$	> 52
Percent generalists, omnivores, and invertivores	≤ 86	$86 < \times \leq 99.7$	> 99.7
Number of individuals per square meter	≥ 0.81	$0.35 \leq \times < 0.81$	< 0.35
Biomass per square meter	≥ 8.0	$3.7 \leq \times < 8.0$	< 3.7
Percent lithophilic spawners	≥ 62	$22 \leq \times < 62$	< 22
Highlands			
Number of benthic fish species	Criteria vary with stream size (see below)		
Number of intolerant species	Criteria vary with stream size (see below)		
Percent tolerant fish	≤ 28	$28 < \times < 71$	> 71
Percent abundance of dominant species	≤ 49	$49 < \times < 91$	> 91
Percent generalists, omnivores, and invertivores	≤ 49	$49 < \times < 92$	> 92
Percent insectivores	≥ 48	$8 < \times < 48$	< 8
Percent lithophilic spawners	≥ 70	$42 < \times < 70$	< 42
Coastal Plain			
Number of native species - Adjusted value	≥ 1.06	$0.53 < \times < 1.06$	< 0.53
Number of benthic fish species - Adjusted value	≥ 1.06	$0 < \times < 1.06$	0
Number of intolerant species - Adjusted value	≥ 0.34	$0 < \times < 0.34$	0
Eastern Piedmont			
Number of native species - Adjusted value	≥ 1.02	$0.56 \leq \times < 1.02$	< 0.56
Number of benthic fish species - Adjusted value	≥ 0.99	$0.50 < \times < 0.99$	< 0.50
Number of intolerant species - Adjusted value	≥ 0.59	$0.18 < \times < 0.59$	< 0.18
Highlands			
Number of benthic fish species - Adjusted value	≥ 1.03	$0.33 < \times < 1.03$	< 0.33
Number of intolerant species - Adjusted value	≥ 0.73	$0.23 < \times < 0.73$	< 0.23

NCRN Biological Stream Survey - Data Analysis Standard Operating Procedure #20

Ecological relevance of the selected FIBI metrics

The initial compilation of candidate metrics, and the process of metric selection and testing, was in part driven by a goal of representing different categories of ecological information. Effort was made not only to maximize the effectiveness of detecting degradation, but also to communicate meaningful ecological information. The following provides a description of the ecological relevance of metrics that were selected and what changes in their values may mean. More details can be found in Roth et al. (2000).

Number of native species (adjusted for watershed area)

Total number of native fish species; adjusted for watershed area (see Table FIBI). Fishes were classified as native or introduced to Chesapeake Bay or Youghiogheny/Ohio River drainage.

Number of benthic fish species (adjusted for watershed area)

The number of fish species that reside primarily on the stream bottom, adjusted for watershed area (see Table 20-7. Benthic fishes include all darters (*Etheostoma* spp., *Perca* spp.), sculpins (*Cottus* spp.), madtoms (*Noturus* spp.), and lampreys (*Petromyzon* spp., *Lampetra* spp.).

Number of intolerant species (adjusted for watershed area)

The number of fish species rated as intolerant of anthropogenic stress, adjusted for watershed area. Tolerance ratings (intolerant, tolerant) were based on statewide analysis comparing species occurrences with presence/absence of anthropogenic stressors.

Percent tolerant fish

The percentage of individuals rated as tolerant to anthropogenic stress.

Percent abundance of dominant species

The percentage of individuals within the single most abundant (dominant) species at a site.

Percent generalists, omnivores, and invertivores

The percentage of individuals classified into the trophic groups of generalist, omnivore, or invertivore; these are the most general of all feeding habits. Invertivores eat insects and other invertebrates including crustaceans, mollusks, and worms. Omnivores consume two or more food types (insects, invertebrates other than insects, fish, plankton, algae, vascular plants, and detritus) with the exception of the combination of invertebrates and fishes. Generalists eat both invertebrates and fishes but not other food items.

Percent insectivores

The percentage of individuals classified into the group insectivore; this is a specialized trophic group, feeding almost exclusively on insects.

Number of individuals per square meter

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

The number of individuals captured at a site, divided by the surface area fished. Surface area was computed as length of stream fished (usually 75 m) multiplied by average stream width.

Biomass (g) per square meter

Total mass in grams of fish captured at a site, divided by the surface area fished.

Percent lithophilic spawners

The percentage of individuals reported to use rock substrates for spawning.

As with the BIBI information, individual metrics can be analyzed for temporal trends by either examining plots of metrics through time or through a more formal statistical analysis using linear regression. The overall FIBI score for each site provides an integrated assessment of condition that can be evaluated and interpreted using the guidance provided in Table IBI. IBI scores can be compared across sites and also through time to get a good understanding of site condition relative to other sites in the parks and surrounding region as well as through time as data accumulates.

Analysis of Physical Habitat Data

Physical habitat data can be analyzed similarly to the fish and benthic invertebrate data. A Physical Habitat Index (PHI) is calculated similarly to the BIBI and the FIBI where component metrics (Table 11-3) are used to generate an overall index score that represents a comprehensive evaluation of habitat at a site. In contrast to the FIBI and the BIBI, the PHI sums the metric scores so that the scale is based on a 0-100 rating where 100 is the highest possible score. Well defined criteria for interpreting the PHI do not exist as habitat can be quite variable. However a general rule of thumb is PHI > 75 is good and PHI < 55 is impaired.

More information about the development of the PHI can be found in Paul and Stribling (2002).

NCRN Biological Stream Survey - Data Analysis
Standard Operating Procedure #20

Table 20-8: Metrics used to calculate the Physical Habitat Index (PHI) for each region. The direction of change denotes the behavior of the metric as sites degrade, whereas the feature denotes the attribute described by the metric. Metrics denoted with an asterisk are watershed area corrected.

Region	Direction of Change	Feature
Coastal Plain		
Bank stability (square root)	Decreases	Geomorphology
Instream Wood *	Decreases	Wood
Instream Habitat *	Decreases	Visual Habitat
Epibenthic substrate *	Decreases	Visual Habitat
percent shading (arc-sine square-root)	Decreases	Riparian Condition
Remoteness	Decreases	Remoteness
Piedmont		
Riffle quality *	Decreases	Geomorphology
Bank stability (square root)	Decreases	Geomorphology
Instream Wood	Decreases	Wood
Instream Habitat *	Decreases	Visual Habitat
Epibenthic substrate	Decreases	Visual Habitat
percent shading (arc-sine square-root)*	Decreases	Riparian Condition
Remoteness	Decreases	Remoteness
Embeddedness	Increases	Geomorphology
Highlands		
Bank stability (square root)	Decreases	Geomorphology
Epibenthic substrate	Decreases	Visual Habitat
percent shading (arc-sine square-root)	Decreases	Riparian Condition
Riparian width	Decreases	Riparian Condition
Remoteness	Decreases	Remoteness

NCRN Biological Stream Survey – Contractor Annual Reporting Requirements
Standard Operating Procedure #21

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Purpose

The purpose of this SOP is to inform cooperators and NPS staff about the National Capital Region Network (NCRN) Inventory and Monitoring Program's (I&M) annual reporting. The sampling design is to monitor six sites per year on a six year panel, for a total of Monitoring will continue indefinitely. A complete set of data for all sites will be available every 6 years. Since the contractor is simply carrying out the data collection and processing, and the index (FIBI, BIBI, PHI) generation for 6 sites at a time and may not have the entire data set, it is unreasonable to require any detailed data analysis and interpretation A report prepared as described in this SOP will provide the information required for the RPRS IAR, Metadata questionnaire, and Closeout Checklist).

Scope

This SOP applies to all reports prepared by contractors carrying out BSS sampling for the NCRN I&M Program.

Reference Documents

- NCRN BSS SOP# 17 Metadata
- NCRN BSS SOP #19 QA QC
- NCRN BSS SOP #20 Data Analysis
- NCRN BSS SOP #22 Protocol Revision

Key Terms

NPS Key Official – The National Park Service staff member who is responsible for managing the project. In cases where the project is conducted by NCRN personnel, the Key Official will often

NCRN Biological Stream Survey – Contractor Annual Reporting Requirements
Standard Operating Procedure #21

also be the Project Leader. The NPS key official is responsible for ensuring that the cooperators and contractors are aware of all NPS requirements and guidelines.

Project Leader – The individual responsible for the "day-to-day" operation of the project. The project leader can be either NPS personnel or a cooperator working through a contract or agreement. In the cases where the project is conducted through a contract or agreement the project leader must work closely with the NPS key official to ensure that all standards are met.

Procedures and General Requirements

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which is defined as structured information about the content, quality, condition, and other characteristics of a data set. Basically speaking, the 'who', 'what', 'when', 'where', 'why' and 'how' of the data set. In addition, metadata include information about data format, collection and analysis methods, access/use constraints, and distribution. Metadata provide the means to catalog data sets, within intranet and internet systems, making their associated data sets available to a broad range of potential users. While most frequently developed for geospatial data, metadata describing non-geospatial data sets are also needed. For example, water samples collected daily for an annual report to summarize water quality should be documented with complete protocols and metadata for the database in which the data are stored.

The general goal of the NPS metadata system is to catalog all data sets and to produce FGDC-compliant metadata for those data sets that require comprehensive documentation. The NPS Natural Resource, GIS and I&M Programs released the NPS Data Store in 2005 as an FGDC-structured database and data server system that provides a secure web interface and tools to import metadata records from desktop metadata authoring programs.

Document Preparation

Based on guidance developed by the Natural Resource Program Center in Fort Collins, CO, all documents generated to report findings from any I&M funded inventory or monitoring project should be prepared in accordance with the *Natural Resources Technical Report Series* (NRTR) requirements.

The "Instructions to Authors" document referenced above provides detailed instructions on preparing Natural Resource Technical Reports including formatting guidance on typing and page formatting and figures and table preparation and documentation. The following describes the basic content required for these reports:

- *Title Page* – Should include: title, report date, authors and their roles, the contract number, associated permit numbers, and who the report was prepared for. Also include complete current mailing address (including zip + four), email, phone and fax number of the person to whom correspondence should be sent. The following page (inside front cover) should contain the photo credits for the cover photo as

well as a disclaimer if the report contains sensitive information and should not be circulated

- *Table of Contents*
- *List of Figures, Tables and Appendices*
- *Data Abstract –A* brief abstract of 250 words or less, describing the data produced from this sampling. This should include the names of the parks where data collections took place,
- *Keywords* - Below the abstract, provide 5-6 keywords in the following categories: Thematic, Place, Temporal, Taxonomic.
- *Introduction* – Should include the purpose of the investigation, research objectives, conditions under which the study was conducted, the general plan of treatment of the subject, and summary of previous work (literature review) that relates to the project. Does the data set contain sensitive information, of so describe them? For all data sets: does the data set contain sensitive information? If so, describe them. Provide any advice/caveats for potential data users.

  Study Area – describe the area(s) and habitat(s) included in the study. A map can be used in this section to aid in defining the study area.
- *Methods* – Present a detailed explanation of the methods, materials and analytical techniques that were used in the field, laboratory, and office during the study. The methods should be documented so that the investigation could be exactly repeated if necessary. Be sure to include a description of data analysis methods and what statistical tests were used, if any. Describe the processes used for determining whether the data met data quality objectives and, if not, what corrective actions were taken. Detailed QA/QC procedures for the data collection, verification and validation should be placed in an appendix. Since the MBSS methodologies and Indices are constantly revised and updated, this section must contain citation for all protocols and SOPs followed, if different or in addition to the NCRN BSS Protocol. Changes to contractual sampling plan and the rationale for those changes should also be included in this section, if they occur. Indicate when the data was collected, on single date or across a date range, include the start and end dates. Does the data set contain biological information? If so, what species or communities were studied? Was a taxonomic authority or field guide used for identification? Were voucher specimens collected? If so, were they herbarium specimens, animal specimens, or photographs? Was the data set developed using an analytical tool or model? If yes, please reference the tool or model and provide a URL if one exists. Describe the methodologies behind data collection and analysis: Summarize field methods (copy/paste from other documents): If existing protocols were used, provide the reference. Summarize laboratory

NCRN Biological Stream Survey – Contractor Annual Reporting Requirements
Standard Operating Procedure #21

methods (if any): If existing protocols were used, provide the reference. Describe the quality assurance and quality control measures taken to ensure that the data are accurate:

- *Findings / Project Status*

- Include here any unusual field conditions encountered, problems experienced with data collection, processing, etc. List any data sets that could be cross-referenced.

- *Literature Cited* - List literature citations alphabetically by the first author's last name in a literature cited section following the acknowledgments. Literature cited entries should use a consistent format and follow the format used by the journal Ecology. Carefully double-check citations against citations in the text. See Exhibit K in the "Instructions to Authors" document for examples..

Refer to Appendix 21-A for a report preparation checklist to help ensure that all reporting sections are included in the final product.

Document Submission:

Upon the completion of the draft report, all documents should be submitted to the NPS Key Official for review. At the time of submission of the draft report, the project lead should inform the NPS Key Official of whether the report contains information relating to sensitive resources (e.g. rare, threatened or endanger species, or specific sensitive habitat types). If the report does contain sensitive material it should be marked as such on the inside of the cover page.

The NPS Key Official will review the document. All review comments will be forwarded to the project lead who then should address the comments as necessary. The project lead will ensure that all comments are addressed. An electronic copy of the report will be submitted to the NPS Key Official as an MS Word file (preferably accompanied by a Adobe PDF version as well). The NPS Key Official will ensure that the document is properly posted for dissemination and added into the NatureBib database.

The project lead must submit the following:

- Hard Copy: Submit two (2) hard copies of the report to the NPS Key Official.

- Electronic copy: Submit electronic copy in MS Word (version 2002 or higher) via e-mail, the FTP site, or on CD/DVD to the NCRN Inventory and Monitoring Key Official.

- Copies of paper data sheets

- Electronic data including:

NCRN Biological Stream Survey – Contractor Annual Reporting Requirements
Standard Operating Procedure #21

- Raw field data (with metadata)
- Database
- GIS data (with metadata)
- An IAR to each park that provided a permit is required in the RPRS. The permit applicant will receive email from Bill Commins in December of the calendar year of the permit explaining how to submit the IAR online. Information for the IAR may be copy/paste from this report into the online IAR form. However, it should be noted that the contractor report produced from this SOP contains more information than is required in the IAR.

Refer to Appendix 21-B for a submission checklist to help ensure that all required products are submitted to the NPS Key Official.

Appendix 21-A – Report Checklist

	Report Checklist	
	Title page contains all of the following:	
		Title
		Representative Photo
		Contract Number and Permit Numbers
		Authors (with addresses) and their roles
		Report date (month/year) and to whom it was submitted
		Photo credits provided on following page
	Abstract	
	Body of document includes all of the following:	
		Introduction
		Methods
		Findings and Status
	Tables, figures, maps, and illustrations have:	
		Descriptive titles
		Sequentially numbered
	Document has been reviewed for content, spelling and grammar.	
	Document is supported by scientific literature.	
	Literature Cited has been checked against the text.	

NCRN Biological Stream Survey – Contractor Annual Reporting Requirements
Standard Operating Procedure #21

Appendix 21-B – Submission Checklist

	Submission Checklist	
	Two hard copies of the report.	
	Electronic copy is in MS Word Format (2002 or later) and/or Adobe PDF and is submitted on CD/DVD, or sent by email as an attachment.	
	All raw data have been submitted.	
		Field data sheets
		Electronic data
		Calculated indices
	Metadata is provided for all electronic databases (Data fields are defined and database structure is discussed).	
	Metadata is provided for any GIS data (following FGDC standards)	
	Photographs have been submitted along with permission for their use in brochures, websites, or other published materials.	
	Final Check	
	Checklist has been reviewed and all items checked off before final submission. Indicate YES or NO.	

NCRN Biological Stream Survey - Revising the Protocol Standard Operating Procedure #22

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	2/2009	Marian Norris	Renumbering, grammar, spelling and terminology edits	Clarification	1.1

Purpose

The Standard Operating Procedure (SOP) explains how to make changes to the Biological Stream Survey Protocol narrative for the National Capital Region. Persons editing the protocol narrative or any of the SOPs need to follow this outlined procedure to avoid confusion in how the data are collected and analyzed. Note: this SOP follows directly from the example provided for the bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas written by Peitz et al. (2002).

Scope and Applicability

This SOP applies to the Biological Stream Survey Protocol (BSS) when applied to NCRN parks.

Reference Documents

Peitz, D.G., S.G. Fancy, L.P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas.

Procedures and General Requirements

The Biological Stream Survey Protocol narrative and the accompanying SOPs have attempted to include the most sound methodologies for analyzing and collecting aquatic monitoring data. However, all protocols, regardless of how sound, require as editing as new and different information becomes available. Edits should be made in a timely manner and appropriate reviews undertaken.

All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by National Capital Region Inventory and Monitoring staff. However, if a complete change in methods is sought, than an outside review is required. Regional and National staff of the National Park Service with familiarity in aquatic research and data analysis will be used as reviewers. Also, experts in aquatic research and statistical methodologies outside of the Park Service will be used in the review process.

Document edits and protocol versioning in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, …etc) for

NCRN Biological Stream Survey - Revising the Protocol Standard Operating Procedure #22

minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.

Inform the Data Manager about changes to the Protocol Narrative or SOP so the new version number can be incorporated in the Metadata of the project database. The database may have to be edited by the Data Manager to accompany changes in the Protocol Narrative and SOPs.

Post new versions on the internet and forward copies to all individuals with a previous version of the effected Protocol Narrative or SOP.

NCRN Biological Stream Survey – 6 Year Reporting Requirements Standard Operating Procedure #23

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Purpose

The purpose of this SOP is to inform cooperators and NPS staff about the National Capital Region Network (NCRN) Inventory and Monitoring Program's (I&M) reporting requirements for the 6 year report on a round of BSS sampling. This reporting follows the templates established in the Natural Resource Reporting Series. Two types of reports are described in this series: Natural Resource Reports (NRR) and Natural Resource Technical Reports (NRTR).

Natural Resources Reports: target a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability. Examples of reports published in this series include vital signs monitoring plans; monitoring protocols; "how to" resource management papers; or newsletters.

Natural Resources Technical Reports: are used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The reports provide contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. Current examples of such reports include the results of research that addresses natural resource management issues; natural resource inventory and monitoring activities; and resource assessment reports.

This document is intended to only provide a broad overview of the requirements. Additional documents and websites exist to provide contributors with very detailed information on how to prepare reports for these reporting series.

Scope

This SOP applies to the 6 year BSS Round reports prepared by the NCRN I&M Program. These reports follow a formal, multi-column Adobe InDesign template.

Reference Documents

- Natural Resource Publications Management Website (www.nature.nps.gov/publications/NRPM/index.cfm)
- National Park Service. 2006. Instructions to Authors – Natural Resource Reports and Natural Resources Technical Report. Natural Resource Report NPS/NRPC/NRR – 2006/001. National Park Service, Fort Collins, Colorado. (www.nature.nps.gov/publications/NRPM/docs/Instructions_to_Authors.pdf)

NCRN Biological Stream Survey – 6 Year Reporting Requirements Standard Operating Procedure #23

- National Park Service. 2006. Editorial Style Guide for *Park Science* and *Natural Resource Year in Review*. Natural Resource Report NPS/NRPC/NRR – 2006/004. National Park Service, Fort Collins, Colorado. (www.nature.nps.gov/publications/NRPM/docs/Editorial_Style_Guide.pdf)

Procedures and General Requirements

Document Preparation

Based on guidance developed by the Natural Resource Program Center in Fort Collins, CO, all documents generated to report findings from any I&M funded inventory or monitoring project should be prepared in accordance with the *Natural Resources Technical Report Series* (NRTR) requirements.
The "Instructions to Authors" document referenced above provides detailed instructions on preparing Natural Resource Technical Reports including formatting guidance on typing and page formatting and figures and table preparation and documentation. The following describes the basic content required for these reports:

- *Front Cover* – Should include the title of the report along with a picture that is representative of the project. The following page (inside front cover) should contain the photo credits for the cover photo as well as a disclaimer if the report contains sensitive information and should not be circulated..

- *Title Page* – Should include: title, report date, and authors as well as the report number. Also include complete current mailing address (including zip + four), email, phone and fax number of the person to whom correspondence should be sent.

- *Table of Contents*

- *List of Figures, Tables and Appendices*

- *Keywords* - Below the abstract, provide 5-6 keywords that describe the subject of the paper; these need not duplicate words in the title.

- *Abstract/Executive Summary* – report can contain both but short reports normally contain a brief abstract of 250 words or less. Executive summaries are usually reserved for longer documents and should be a "stand alone" section of the document that summarizes the important points of the document.

- *Acknowledgements (optional)*

- *Introduction* – Should include the hypotheses and purpose of the investigation, research objectives, conditions under which the study was conducted, the general plan of treatment of the subject, and summary of previous work (literature review) that relates to the project.

- *Study Area* – describe the area(s) and habitat(s) included in the study. A map can be used in this section to aid in defining the study area.

NCRN Biological Stream Survey – 6 Year Reporting Requirements Standard Operating Procedure #23

- *Methods* – Present a detailed explanation of the methods, materials and analytical techniques that were used in the field, laboratory, and office during the study. The methods should be documented so that the investigation could be exactly repeated if necessary. Be sure to include a description of data analysis methods and what statistical tests were used, if any. Describe the processes used for determining whether the data met data quality objectives and, if not, what corrective actions were taken. Detailed QA/QC procedures for the data collection, verification and validation should be placed in an appendix.

- *Results* – In a logical sequence (e.g. by park), present the findings of the study that either support or provide contrary evidence against the hypotheses or that answer questions posed in the introduction. Basic, descriptive statistics (sample size, mean, max/min, trends etc.) are appropriate when clearly presented. Avoid highly technical discussions of complex statistical testing; instead refer readers to a separate appendix for additional information. Consider presenting results separately for each park.

- *Discussion* – The "Discussion" and the "Conclusion" sections are the most important sections of the report. Present a clear interpretation of the data that addresses the hypotheses, objectives, or purpose for which the study was conducted. Be sure to include how this research is applicable to each park where the study occurred and to other studies that have been conducted in that specific area of research. Other findings may be reported that would be of general interest to the scientific community.

- *Conclusions* – Provide a specific and detailed summation of the conclusions of the project.

  In addition the conclusion section should have three subsections that are of significant interest to the parks.

  - Public Interest Highlights: This section has significant potential to create interest and support for this and other resource management projects. Provide a bulleted list of highlights from this project. Resource managers may use these as talking points with other park staff including management. Interpretation staff may use these to highlight aspects of interest to the general public.

  - Management Recommendations: If management recommendations are warranted, highlight them here. If the study was initiated due to specific park management needs, management implications should be emphasized and discussed.

  - Research Recommendations: Summarize additional research needs. This section may serve as a way to develop priority research projects for the parks and to support future funding.

- *Literature Cited* - List literature citations alphabetically by the first author's last name in a literature cited section following the acknowledgments. Literature cited entries should use a consistent format and follow the format used by the journal Ecology. Carefully double-check

citations against citations in the text. See Exhibit K in the "Instructions to Authors" document for examples..

- *Appendices* - Provide additional data as necessary, including a hard copy printout of the data contained in the electronic spreadsheet or database.

- *Back Cover* – The NPS TIC Number and report date are the only pieces of information that need to be added to the back cover of the report.

Refer to Appendix 23-1 for a report preparation checklist to help ensure that all reporting sections are included in the final product.

Document Submission:

Upon the completion of the draft report, all documents should be submitted to the NPS Key Official for review. At the time of submission of the draft report, the project lead should inform the NPS Key Official of whether the report contains information relating to sensitive resources (e.g. rare, threatened or endanger species, or specific sensitive habitat types). If the report does contain sensitive material it should be marked as such on the inside of the cover page.

The NPS Key Official will review and circulate the document for "peer review". Reviewers may include park managers, network level, regional level or national level NPS staff, or colleagues from other agencies or academia. The level of peer review required will be determined by the NPS Key Official and choice of reviewers may also be affected by whether the report contains information on sensitive resources. All review comments will be forwarded to the project lead who then should address the comments as necessary.

Once all of the review comments have been addressed, the NPS Key Official will obtain the appropriate series number and Technical Information Center (TIC) number for the report and provide these numbers to the project lead.

The project lead will ensure that all comments are addressed and that report numbers are added to the final document in the proper locations (cover page and title page). An electronic copy of the report will be submitted to the NPS Key Official as an MS Word file (preferably accompanied by a Adobe PDF version as well). The NPS Key Official will ensure that the document is properly posted for dissemination and added into the NatureBib database.

The project lead must submit the following:

- Hard Copy: Submit two (2) hard copies of the report to the NPS Key Official.

- Electronic copy: Submit electronic copy in MS Word (version 2002 or higher) via e-mail or on CD/DVD to the NCRN Inventory and Monitoring Key Official.

- Copies of paper data sheets

- Electronic data including:

    - Raw field data (with metadata)

NCRN Biological Stream Survey – 6 Year Reporting Requirements Standard Operating Procedure #23

- GIS data (with metadata)

Refer to Appendix 23-2 for a submission checklist to help ensure that all required products are submitted to the NPS Key Official.

Appendix 23-1 – Report Checklist

	Report Checklist	
	Cover page includes all of the following:	
		Title
		Representative Photo
		Report Number (provided by NPS)
		Photo credits provided on following page
	Title page contains all of the following:	
		Title
		Report Number (provided by NPS)
		Authors (with addresses)
		Report date (month/year)
	Table of Contents properly references the various sections of the report.	
	Exhibits lists properly references all figures and tables throughout the report.	
	Abstract and /or Executive Summary are provided.	
	Body of document includes all of the following:	
		Introduction
		Description of Study Area
		Methods
		Results
		Discussion
		Conclusion
	Conclusion Section includes Public Interest Highlights.	
		Public interest highlights
		Management recommendations
		Research recommendations
	Tables, figures, maps, and illustrations have:	
		Descriptive titles
		Sequentially numbered
	Back cover includes TIC Number (provided by NPS)	
	Document has been reviewed for content, spelling and grammar.	
	Document is supported by scientific literature.	
	Literature Cited has been checked against the text.	

NCRN Biological Stream Survey – 6 Year Reporting Requirements Standard Operating Procedure #23

Appendix 23-2 – Submission Checklist

	Submission Checklist	
	Two hard copies of the report.	
	Electronic copy is in MS Word Format (2002 or later) and/or Adobe PDF and is submitted on CD/DVD, or sent by email as an attachment.	
	All raw data have been submitted.	
		Field data sheets
		Electronic data
	Metadata is provided for all electronic databases (Data fields are defined and database structure is discussed).	
	Metadata is provided for any GIS data (following FGDC standards)	
	Photographs have been submitted along with permission for their use in brochures, websites, or other published materials.	
	Final Check	
	Checklist has been reviewed and all items checked off before final submission. Indicate YES or NO.	

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 800/100122, July 2009

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov