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Natural Resource Stewardship and Science

Northeast Temperate Network Lakes, Ponds, and Streams Monitoring Protocol

2014 Revision

Natural Resource Report NPS/NETN/NRR—2014/770



ON THE COVER
Clockwise from top left: Lake monitoring (Photograph by B. Arsenault, 2008), Saugus Iron Works NHS (NETN photo, 2009), stream monitoring (Photograph by E.Davis, 2009), measuring volumetric discharge (Photograph by B. Arsenault, 2008).

Northeast Temperate Network Lakes, Ponds, and Streams Monitoring Protocol

2014 Revision

Natural Resource Report NPS/NETN/NRR—2014/770

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data

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Revision History

Version numbers are incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers are incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version Number	Version Date	Revised by	Changes from previous version	Justification
1.00	12/15/06	NA	NA	Original protocol
2.00	3/23/07	Brian Mitchell, Bill Gawley, Emily Seger, and Joe Bartlett	See Appendix B, Revision Details	Protocol update
2.01	3/31/07	Brian Mitchell	In section 1.1.7.7, Added mg/L to ueq/L conversion factor.	Correction
2.02	04/15/09	Brian Mitchell	See Appendix B, Revision Details	Protocol update
3.00	6/30/13	Brian Mitchell, Bill Gawley, Beth Arsenault, Eric Davis	See Appendix B, Revision Details	Complete reorganization of protocol to match Northeast Temperate Network (NETN) standard, as well as updated methods, sites, and procedures.
3.01	12/16/2013	Brian Mitchell	Minor clarifications and edits to address peer review comments See Appendix B, Revision Details, for other changes	NPS review prior to publishing revised protocol.

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Acknowledgments

This version of the Northeast Temperate Network Lakes, Ponds, and Streams Monitoring Protocol is based on the original protocol by Lombard et al. (2006), with the addition of subsequent modifications necessitated by changes in field procedures. The efforts of Pam Lombard and Jim Caldwell on the original protocol are still clearly reflected herein. Indeed, much of the text was written by the original authors, and their contribution cannot be understated.

Thanks also to Joe Bartlett, Eric Davis, Alan Ellsworth, Meghan Goff, Adam Kozlowski, Aaron Rinehart, Hali Roy, Brian Schuetz, and Emily Seger for their tireless efforts in the field, technical assistance and contributions to revisions of various protocol sections.

List of Acronyms

ACAD	Acadia National Park
ANC	Acid Neutralizing Capacity
ASTM	American Society for Testing and Materials
BOHA	Boston Harbor Islands National Recreation Area
Chl *a*	Chlorophyll *a*
DI	Deionized water
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
ELRO	Eleanor Roosevelt National Historic Site
GIS	Geographic Information System
GPS	Global Positioning System
HDPE	High Density Polyethylene
HOFR	Home of Franklin D. Roosevelt National Historic Site
IRMA	Integrated Resource Management Applications
MABI	Marsh-Billings-Rockefeller National Historical Park
MCIAP	Maine Center for Invasive Aquatic Plants
MDEP	Maine Department of Environmental Protection
MDI	Mount Desert Island
MQO	Measurement Quality Objective
MIMA	Minute Man National Historical Park
MORR	Morristown National Historical Park
MDS	Multiparameter Display System
NAWQA	National Water Quality Assessment Program
NHP	National Historical Park
NHS	National Historic Site
NP	National Park
NPS	National Park Service
NRA	National Recreation Area
NETN	Northeast Temperate Network
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information System
NWQL	National Water Quality Lab
ONRW	Outstanding National Resource Waters
ORW	Outstanding Resource Waters

OSHA	Occupational Safety and Health Administration
PAR	Photosynthetically Active Radiation
PCU	Platinum Cobalt Units
PDA	Personal Digital Assistant
PFD	Personal Flotation Device
PLB	Personal Locator Beacon
PPFD	Photosynthetic Photon Flux Density
PRIMENet	Park Research and Intensive Monitoring of Ecosystems Network
QA/QC	Quality Assurance/Quality Control
RSD	Relative Standard Deviation
ROVA	Roosevelt-Vanderbilt National Historic Site
SAGA	Saint-Gaudens National Historical Site
SAIR	Saugus Iron Works National Historic Site
SARA	Saratoga National Historical Park
SD	Secchi Disk Depth
SECRL	Sawyer Environmental Chemistry Research Laboratory
SOP(s)	Standard Operating Procedure(s)
SPU	Standard Platinum Units
STORET	U.S. Environmental Protection Agency's storage and retrieval database
TMDL	Total Maximum Daily Load
TSI	Trophic State Index
USCG	U.S. Coast Guard
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VAMA	Vanderbilt Mansion National Historic Site
VLMP	Volunteer Lake Monitoring Program
WEFA	Weir Farm National Historic Site
YSI	Yellow Springs Instrumentation

Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.0929	square meter (m^2)
square mile (mi^2)	2.59	square kilometer (km^2)
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
	Volume	
ounce, fluid (fl. oz)	0.02957	liter (L)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

- Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

  °F = (1.8 × °C) + 32

- Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

  °C = (°F - 32) / 1.8

- Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C)
- Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or micro-equivalents per liter (µeq/L)
- Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88)
- Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)
- Altitude, as used in this report, refers to distance above the vertical datum

Background and Introduction

The Northeast Temperate Network (NETN) is made up of the following 13 National Park (NP) units, including four National Historical Parks (NHP), one National Recreation Area (NRA), six National Historic Sites (NHS), and one National Park and National Scenic Trail (NST):

- Acadia NP, Maine (ACAD)
- Appalachian NST, Maine to Georgia (APPA)
- Boston Harbor Islands NRA, Massachusetts (BOHA)
- Marsh-Billings-Rockefeller NHP, Vermont (MABI)
- Minute Man NHP, Massachusetts (MIMA)
- Morristown NHP, New Jersey (MORR)
- Roosevelt-Vanderbilt NHS, New York (ROVA); includes Eleanor Roosevelt NHS (ELRO), Home of Franklin D. Roosevelt NHS (HOFR), and Vanderbilt Mansion NHS (VAMA)
- Saint-Gaudens NHS, New Hampshire (SAGA)
- Saugus Iron Works NHS, Massachusetts (SAIR)
- Saratoga NHP, New York (SARA)
- Weir Farm NHS, Connecticut (WEFA)

The Appalachian NST is too large to be cost-effectively monitored by the methods in this protocol, and will not be considered further in this document. Boston Harbor Islands NRA is also not included in this monitoring protocol, because it lacks streams and its single freshwater pond is not accessible.

Freshwater resources in the NETN parks are subjected to natural and anthropogenic impacts and alterations, which have imposed stress on these resources for many years. Current and historic threats to aquatic ecosystems in National Park Service (NPS) units throughout the northeastern U.S. have led to specific physical, biological, or chemical stresses to the freshwater ecosystems. The documentation of baseline water quality and water-quantity conditions is essential to the long-term maintenance of freshwater resources. Documenting the changes in baseline conditions will assist natural resource managers to identify and manage stressors in park freshwater ecosystems.

NETN conducted a three-phase project to design a freshwater-resources monitoring plan, and now monitors indicators (vital signs) that represent the overall health or condition of park resources and tracks the effects of stressors. The U.S. Geological Survey (USGS) worked in cooperation with NETN on each phase of the project to develop this lakes, ponds, and streams monitoring protocol. The phases can be described as follows:

PHASE I: Development of a scoping report for long-term monitoring in NETN parks. This report (Lombard 2004) included an inventory of freshwater resources in the parks, a description of monitoring programs in each park, descriptions of current and emerging threats to NETN ecosystems, and a list of stressors and candidate monitoring indicators (vital signs) that could be used to assess the status of park ecosystems over the long term.

PHASE II: Design of prototype guidance for monitoring freshwater resources in NETN parks and development of a list of priority monitoring variables (vital signs) that will be measured in NETN parks.

PHASE III: Development of a monitoring protocol for selected high-priority vital signs in NETN lakes, ponds and streams. Conduct feasibility (pilot) testing of recommended freshwater quality/aquatic-resource vital signs at select NETN parks to finalize the freshwater resource monitoring design for NETN.

Phase I showed that although baseline freshwater quality data were collected in some NETN parks, NETN as a whole did not have a comprehensive freshwater long-term (greater than 10 years) data-collection program that included systematic quality control and data management. Environmental threats common to all NETN parks include climate change, atmospheric deposition, visitor overuse and invasive species (Shriver et al. 2004). Phase I was initiated in 2003 and the report was completed in 2004 (Lombard 2004). The Phase II report included a summary of a workshop at ACAD in May 2004 in which freshwater quality professionals discussed the potential list of vital signs and made recommendations as to their ecological relevance, management significance and utility, feasibility, and response variability. The potential vital signs developed in Phase I were reviewed and ranked, and specific measures for high-priority vital signs were proposed. The Phase II report also included a comparison of the recommended list of high-priority vital signs with the water quality monitoring that was currently (2004) taking place in each park. Phase II was initiated in 2004 and the report was completed in that same year (Lombard and Goldstein 2004).

This protocol is a revision of the Phase III document (Lombard et al. 2006), the results of the study to design a water quality monitoring protocol for lakes, ponds, and streams. The revisions consist of a reorganization of the protocol to match the NETN reporting standard, as well as updated methods, changes to monitoring sites, and revised procedures resulting from 5 years of field work and annual protocol review meetings.

Procedures for NETN monitoring adapt existing procedures that meet the objectives and standards of this vital signs program to maintain consistency of data wherever possible. Measures of lake water chemistry, nutrient enrichment in lakes, and lake water levels have been monitored in ACAD since 1997 (Breen et al. 2002) and ACAD has developed procedures for these measures (Gawley 1996). Methods are consistent with those described in the Maine Department of Environmental Protection (MDEP) Lake Assessment Program Standard Operating Procedures (Maine Department of Environmental Protection 2004) and with Maine Volunteer Lake Monitoring Program protocols (VLMP) (Williams 2004). Survey methods for the detection of non-native invasive species are adapted from VLMP protocols and SOPs downloaded on March 23, 2012, from http://www.mainevlmp.org/wp/?page_id=33.

Procedures for measuring water quality vital signs in streams are based on USGS National Water quality Assessment Program (NAWQA) protocols (USGS variously dated). Techniques for collecting stream discharge data are also based on USGS methods (Rantz et al. 1982).

Periodic review of future versions of NAWQA, MDEP and VLMP protocols by NPS Inventory and Monitoring staff will ensure that NETN protocols remain current.

Justification

The vital signs for freshwater bodies included in the Phase III protocol are water quantity, water chemistry, nutrient enrichment, and the early detection of non-native plant species. These measures directly address the NPS Inventory and Monitoring Program's objective to detect change in the status of physical, chemical, or biological attributes of park ecosystems. Measures of water chemistry including specific conductance, pH, water temperature, and dissolved oxygen (DO) are fundamental to any long-term water quality monitoring program, are critical for interpreting the biotic condition and ecological processes of freshwater bodies, and are mandatory as directed by the Inventory and Monitoring Program at the national level (National Park Service 2002). Measures of water quantity are necessary for monitoring the physical status of the freshwater ecosystems, and are fundamental to the interpretation of water-chemistry measures. Although only a qualitative estimate of water quantity is mandatory as a part of the Inventory and Monitoring Program, hydrologists at the workshop in Phase II identified quantitative measurements of water quantity, such as discharge and lake levels, as a top priority.

In addition to the fundamental water chemistry metrics listed above, acid-neutralizing capacity (ANC), and apparent color are measured at all NETN parks. A long-term record of these basic water chemistry parameters in the lakes, ponds and streams of NETN parks enables resource managers to detect trends that could be related to global and regional climate change, acid deposition, and site-specific anthropogenic change. Moreover, a long-term data set of the selected parameters is essential to interpreting any trends noted from long-term biological and process-oriented data sets.

Nutrient enrichment metrics for all freshwater bodies in NETN parks include total phosphorus, multiple forms of nitrogen, chloride, sulfate, and dissolved organic carbon (DOC). At lakes and ponds, algal biomass (chlorophyll *a*) is also measured, along with water clarity (Secchi disk depth or a light penetration profile). Turbidity is measured for NETN streams. These metrics give managers guidance regarding the trophic status and productivity of freshwater bodies in parks. Nutrient enrichment and the acceleration of eutrophication have been identified in most NETN parks as stressors of great concern (Lombard and Goldstein 2004).

Non-native invasive species (often shortened to just "invasive species" in this protocol) are the stressor of greatest concern across all systems in NETN parks, including freshwater aquatic, wetlands, marine, and terrestrial systems (Shriver et al. 2004). Procedures for the early detection of invasive plant species in lakes and ponds are included in this protocol. The detection of invasive animal species was identified as high priority, but the development of a protocol for detection depends on future funding and (or) collaboration with other agencies.

Other vital signs identified as high priority for protocol development include macroinvertebrates in streams, zooplankton community composition in lakes, and fish community composition in lakes and streams. Because of funding constraints, however, protocol development for these vital signs is on hold indefinitely, and would depend on collaboration with other agencies. Currently, ACAD staff implement benthic macroinvertebrate monitoring at five stream sites in collaboration with the Maine Department of Environmental Protection (MDEP), but NETN has not established specific objectives or monitoring questions related to this monitoring.

The NETN protocol for freshwater wetlands at Acadia NP (Miller and Mitchell 2013) is implemented separately. The water quality of ground water, springs, and seeps were considered during the vital sign prioritization process, but were determined to be beyond the scope of the vital signs program. NETN would, however, benefit greatly from information regarding groundwater resources, especially in parks such as MORR where many of the streams are groundwater fed. Groundwater data and data on springs and seeps can be integrated into a vital signs program in the future.

Fecal bacteria in water were also considered in the prioritization process because this parameter is included in state water quality standards. Fecal bacteria are a human health issue for specific designated uses (generally consumptive or recreational uses involving direct contact). Although it is necessary in most states to meet standards for bacteria, fecal bacteria were not necessarily considered to be an indicator of overall freshwater ecosystem health, and thus they are not included in the protocol.

For additional justification and prioritization of vital signs and measures, see the Phase II water quality report (Lombard and Goldstein 2004).

Goals and Objectives

Our overall goal is to monitor the status and trends of NETN lakes, ponds, and streams in order to assess changes in ecological integrity and the impacts of key stressors, and to guide management decisions affecting these resources. The two specific objectives of this program and the questions that frame these general monitoring objectives are:

Objective 1: Detect changes over time in the status of physical (e.g., stream flow and stage), chemical (e.g., pH and DO), and nutrient status (e.g., nitrogen or chlorophyll *a*) of the lakes, ponds, and streams in NETN parks.

- Question 1: What is the natural range of temporal variability of the selected metrics of the vital signs for NETN lakes, ponds, and streams?
- Question 2: Are the selected metrics of the vital signs outside the range of natural variability?
- Question 3: Are the selected metrics of the vital signs exceeding thresholds set by states as a part of their legal mandate under the Clean Water Act?

Objective 2: Ensure the early detection of aquatic invasive plants in the lakes, ponds and streams of NETN parks and alert park and state environmental managers of any new incidences of aquatic invasive species to facilitate a rapid response.

- Question 1: What non-native invasive aquatic plant species currently exist in the lakes, ponds and streams of NETN parks?
- Question 2: Are there any new incidences of non-native invasive aquatic plant species in the lakes, ponds and streams of NETN parks?

The metrics associated with each vital sign and the specific questions to be addressed by collecting these water quality data are outlined in Tables 1 and 2 for streams and lakes, respectively.

Table 1. Monitoring questions for NETN streams. Questions in italics require additional data that are not collected through this protocol. In addition to the metrics below, rapid hydro-geomorphic assessments are made annually to provide qualitative supporting data, and ACAD monitors benthic macroinvertebrates in collaboration with MDEP.

Vital Sign	Metrics	Monitoring Questions
Water quantity	Stream discharge (partial record stream flow gaging stations and continuous record stream flow gaging stations), stream stage	• What is the relation between the stage and the discharge (the rating) at each partial record and at each continuous record stream flow gaging station? • What are the long-term (>10 year) stream flow statistics such as seasonal means and medians at each stream flow gaging station? • *How do variations in stream flow explain deviations or trends in chemical or biological data observed in these same streams or in the park?* • Are there long-term (>10 year) trends in any of the annual or monthly stream flow statistics at the index station(s)?
Water chemistry	Specific conductance, pH, water temperature, DO, ANC, apparent color	• What is the natural range in variability in water chemistry parameters for streams in each NETN park based on streams in the park that are relatively unaffected? • Are water chemistry metrics exceeding thresholds indicating that they are outside the range of natural variability? What is the spatial and temporal extent of these deviations? • Are freshwater bodies in NETN parks in compliance with the applicable federal and state water quality standard for the highest use classifications in each state for water chemistry? • Are water chemistry parameters showing long-term (> 10 year) spring, summer or fall seasonal trends after accounting for flow? • *Can water chemistry data be used to explain deviations in biological data at collocated sites?* • *Can changes in water chemistry be linked to trends in human activity in the park such as increased roads or erosion?*
Nutrient enrichment	Total phosphorus, total nitrogen, nitrite, nitrate, ammonia, chloride, sulfate, DOC, clarity (turbidity)	• What is the natural range in variability in nutrients for streams in each NETN park based on streams in the park that are relatively unaffected? • Are freshwater bodies in NETN parks in compliance with the applicable federal and state water quality standard for the highest use classifications in each state for nutrients, especially total phosphorus and stream nitrates? • Are nutrient loads to freshwater aquatic resources in NETN parks increasing? *What is the spatial and temporal extent of these increases?* • *Are freshwater aquatic resources changing in response to increased loads? Is eutrophication approaching or exceeding levels that could cause shifts in ecosystem structure and function?* • Are nutrients showing spring, summer or fall seasonal trends after accounting for flow? *Can trends in nutrient enrichment be used to explain deviations in biological data at collocated sites?* • *Can changes in nutrient enrichment be linked to trends in human activity in the park such as increased roads, erosion, and fertilizers?*
Non-native invasive plants - early detection	Presence/absence	• What non-native invasive plants are established in park streams? • What non-native invasive plants are a threat to park streams on the basis of state lists of non-native invasive plants found in the region? • Are there any substantiated new occurrences of non-native invasive plants in any park stream based on an annual survey and reports from park staff, volunteers, or visitors to the park?

Table 2. Monitoring questions for NETN lakes and ponds. Questions in italics require additional data that are not collected through this protocol.

Vital Sign	Metrics	Monitoring Questions
Water quantity	Lake and pond stage	• What are the long-term trends in lake and pond levels and how are they related to climatic records? • *Can variations in lake and pond levels explain deviations or trends in chemical or biological data observed in these same lakes and ponds?*
Water chemistry	Specific conductance, pH, water temperature, DO, ANC, apparent color	• What is the natural range in variability in water chemistry parameters for lakes and ponds in each NETN park based on lakes and ponds in the park (or the region) that are relatively unaffected? • Are water chemistry metrics exceeding thresholds indicating that they are outside the range of natural variability? *What is the spatial and temporal extent of these deviations?* • Are freshwater bodies in NETN parks in compliance with the applicable federal and state water quality standard for the highest use classifications in each state for water chemistry? • Are water chemistry parameters showing long-term (>10 year) spring, summer or fall seasonal trends? • *Can water chemistry data be used to explain deviations in biological data at collocated sites?* • *Can changes in water chemistry be linked to trends in human activity in the park such as increased roads or erosion?*
Nutrient enrichment	Total phosphorus, total nitrogen, nitrite, nitrate, ammonia, chloride, sulfate, DOC, algal biomass (chlorophyll *a*), and clarity (Secchi disk depth or light penetration profile)	• What is the natural range in variability in nutrients for lakes and ponds in each NETN park based on lakes and ponds in the park (or the region) that are relatively unaffected? • What is the trophic status of each lake and pond based on the natural range of variability of chlorophyll a, phosphorus content and Secchi disk depth? *Is cultural eutrophication accelerating natural eutrophication processes? Does the lake experience algal blooms?* • Are lakes and ponds in NETN parks in compliance with federal and state water quality standard for the highest use classifications in each state for nutrients, especially total phosphorus? • Are freshwater resources changing in response to increased nutrient loads? *Is eutrophication approaching or exceeding levels that could cause shifts in ecosystem structure and function?* • Are nutrients showing spring, summer, or fall seasonal trends? *Can trends in nutrient enrichment be used to explain deviations in biological data at collocated sites?* • *Can changes in nutrient enrichment be linked to trends in human activity in the park such as increased roads, erosion, and fertilizers?*
Non-native invasive plants - early detection	Presence/ absence	• What non-native invasive plants are established in park lakes and ponds? • What non-native invasive plants are a threat to park lakes and ponds on the basis of state lists of non-native invasive plants found in the region? • Are there any substantiated new occurrences of non-native invasive plants in any park pond or lake based on an annual survey and reports from park staff, volunteers, or visitors to the park?

State and Regional Water Quality Standards

NETN (excluding APPA) includes parks in seven states in the Northeast (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, and New Jersey). Water quality standards have been established by each state for all freshwater bodies according to the Clean Water Act, section 305b. The goal of the Clean Water Act is to restore and maintain the

chemical, physical, and biological integrity of the Nation's waters. Water quality standards, established by states, districts, territories and tribes consist of the following four basic components: designated uses, water quality criteria, antidegradation requirements, and general policies as outlined on the U.S. Environmental Protection Agency (USEPA) web site, http://www.epa.gov/waterscience/standards/about/.

A state's designated use includes existing and desired uses of water that require good to excellent water quality. Water quality criteria, which have been developed to protect each designated use, can be numeric or narrative descriptions of the chemical, physical, and biological conditions necessary to support each of the designated uses, and can be site-specific. The antidegradation policy for each state must ensure that no activity is allowed that 1) compromises existing uses, 2) lowers water quality that currently meets or is better than the standard, or 3) degrades Outstanding National Resource Waters (ONRWs) – waters of exceptional ecological or recreational significance. 40 CFR 131.12 indicates that ONRWs include waters of national and state parks. Although individual freshwater bodies are not all classified by states, park streams, lakes, and ponds are held to the highest classification standards designated by each state.

NETN adheres to state water quality standards that can and do vary across the network; consequently, this means that individual parks within NETN will not be adhering to the same standards. Descriptions of each state's water quality standards are included in the following sections and in Tables 3 and 4 that summarize state standards for streams and for lakes and ponds, respectively.

Connecticut

Connecticut water quality standards define ranges of total phosphorus, total nitrogen, chlorophyll *a*, and Secchi disk transparency which are assessed collectively to determine the trophic state of a lake or pond. For the purpose of determining consistency with the water quality standard, the natural trophic state of a lake or pond is compared with the current trophic state to determine if it has been altered due to excessive anthropogenic inputs. Lakes and ponds in advanced trophic states which exceed their natural trophic state due to anthropogenic sources are considered to be inconsistent with water quality standards. Connecticut does not have parallel standards for streams, but does have standards for temperature, DO, pH, and nutrients (State of Connecticut Department of Energy and Environmental Protection 2013).

Table 3. Summary of stream water quality standards for states in NETN containing stream monitoring sites.

State: Water quality classification code	Maximum Temperature (°F)	Minimum Dissolved Oxygen (mg/L)	pH Range (standard units)	Maximum Total Nitrogen (µg/L)	Maximum Total Phosphorus (µg/L)	Color (color units, platinum-cobalt method)	Turbidity (NTU)	Sulfate (mg/L)
Maine: AA	As naturally occurs	7.0 (or 75% saturation)[1]	As naturally occurs	As naturally occurs	As naturally occurs	--	--	--
Massachusetts: A	68 (cold[2]) 83 (warm[3])	6.0 (cold[2]) 5.0 (warm[3])	6.5-8.3	As naturally occurs	As naturally occurs	Not objectionable and does not impair use	Not objectionable and does not impair use	--
New Hampshire: A	As naturally occurs	6.0 (or 75% saturation[4])	6.5-8.0[1]	As naturally occurs	As naturally occurs	As naturally occurs	As naturally occurs	--
New Jersey: FW2	72 (66 for 7 day average max temp)	7.0	6.5-8.5	As naturally occurs	100	--	50 (15 for 30-day average)	250
New York: AA	--	7.0 (cold[2]) 4.0 (warm[3])	6.5-8.5	No algae growth[5]	No algae growth[5]	15	5	--
Vermont: A(1)	--	6.0-7.0 (or 70-75% saturation; cold[2])[1] 5.0 (or 60% saturation; warm[3])[1]	6.5-8.5	2,000	As naturally occurs	None that would prevent full support of uses	10[6]	

[1] Criteria is "as naturally occurring." Numerical standards are based on next most restrictive class
[2] Cold refers to cold water fisheries
[3] Warm refers to warm water fisheries
[4] In cold water, fish spawning areas from October 1 - May 14, the instantaneous minimum DO concentration shall be at least 8 mg/L
[5] There shall be no phosphorus or nitrogen that will result in growths of algae or impair the waters for their best usages
[6] Annual average under dry weather base flow conditions

Table 4. Summary of lake and pond water quality standards for states in NETN containing pond or lake monitoring sites.

State: Water quality classification code	Maximum Temperature (°F)	Minimum Dissolved Oxygen (mg/L)	pH Range (standard units)	Maximum Total Nitrogen (µg/L)	Maximum Total Phosphorus (µg/L)	Color	Maximum Chlorophyll *a* (µg/L)	Minimum Secchi Disk Depth (m)
Connecticut: Mesotrophic	85, or maximum of 4° increase from natural conditions	5.0	6.5-8.0[1]	200-600	10-30	None other than of natural origin	2-15	2-6
Eutrophic				600-1,000	30-50		15-30	1-2
Maine: GPA	As naturally occurs	As naturally occurs	As naturally occurs	As naturally occurs	As naturally occurs	--	As naturally occurs	As naturally occurs
New Hampshire: Ponds	As naturally occurs	5.0 (or 75% saturation)	6.5-8.0[1]	As naturally occurs	As naturally occurs	As naturally occurs	--	--
Vermont: Ponds	--	5.0 (or 60% saturation)[1]	6.5-8.5	5,000	As naturally occurs	None that would prevent full support of uses	--	--

[1] Criteria is "as naturally occurring." Numerical standards are based on next most restrictive class

Maine

Maine Statutes, Title 38, Sections 464, 465, and 465-A define the classification program and water quality standards for Maine waters (Maine State Government 2011, 2007a, 2007b). Existing in-stream water uses and the level of water quality necessary to protect those existing uses must be maintained and protected. All waters in national parks are considered outstanding national resource waters (ONRW) in Maine. The water quality of ONRW must be maintained and protected. Class AA is the highest classification and its standards shall be applied to waters that are outstanding natural resources.

"Class AA waters must be of such quality that they are suitable for the designated uses of drinking water after disinfection, fishing, agriculture, recreation in and on the water, navigation, and as habitat for fish and other aquatic life. The habitat must be characterized as free-flowing and natural. The aquatic life, DO, and bacteria content of Class AA waters shall be as naturally occur" (Maine State Government 2007a). No quantitative criteria are given for AA waters, but the DO content of Class A waters (the next lowest classification) "shall be not less than 7 parts per million [7 mg/L] or 75 percent of saturation, whichever is higher".

Great ponds and natural ponds and lakes less than 10 acres in size are all classified as Class GPA waters. "Class GPA waters must be of such quality that they are suitable for the designated uses of drinking water after disinfection, recreation in and on the water, fishing, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation, and as habitat for fish and other aquatic life. The habitat must be characterized as natural" (Maine State Government 2007b).

"Class GPA waters shall be described by their trophic state based on measures of the chlorophyll *a* content, Secchi Disk Depth (SD), total phosphorus content, and other appropriate criteria." Water quality standards for Maine indicate that class GPA waters "shall have a stable or decreasing trophic state, subject only to natural fluctuations, and shall be free of culturally induced algal blooms" (Maine State Government 2007b). Bloom conditions are defined as SD measurements of less than 2 meters in lakes having color less than 30 standard platinum units (SPU). Lakes that chronically (more than 5 of the past 10 years) show algal blooms are not in attainment of state water quality standards. Trophic status break points are based on over 20 years of SD measurements in Maine lakes (Williams 2004).

Carlson's trophic state index (TSI) (Carlson 1977) was modified for Maine and can be calculated using the following equations:

$$TSI\ (SD) = 70 \log [(105/SD^2) + 0.7]$$

$$TSI\ (Chl) = 70 \log (chl + 0.71)$$

$$TSI\ (TP) = 70 \log (0.33TP + 0.7)$$

(L. Bacon, Maine Department of Environmental Protection [MDEP], written communication 2005); where TSI is the Trophic State Index; SD is Secchi disk depth in meters; Chl is Chlorophyll *a* in ppb, TP is total phosphorus in ppb. General numerical guidelines of trophic status for Maine based on these formulas are shown in Table 5. Guidance from the MDEP indicates that the parameters used in the equations shall be calculated as the mean of the monthly means for each water sample. A minimum of one reading per month from May through

November is used with no 2 consecutive months of missing data. Samples are to be taken from open water, SD must be less than total depth, and depth-integrated samples taken to a depth equal to that of the late summer epilimnion or to a concentration of 2.0 mg/L DO, (whichever is less) are used for chlorophyll *a* and total phosphorus samples (L. Bacon, MDEP, written communication 2005). In adherence to this guidance, only TSI (SD) can be calculated from NETN monitoring data.

Table 5. Maine State lake trophic parameters and guidelines. SDT = Secchi disk depth; chl a = chlorophyll *a*; TSI = Trophic State Index; ppb = parts per billion. From: Maine Department of Environmental Protection (2004).

Numerical Guidelines for Evaluation of Trophic Status in Maine *			
(Note: Dystrophy is not often evaluated as a trophic category separately from categories below.)			
	Trophic Status		
Parameter[1]	Oligotrophic	Mesotrophic[2]	Eutrophic
SDT[3]	> 8 meters	4-8 meters	< 4 meters
CHL a	< 1.5 ppb	1.5 – 7 ppb	> 7 ppb
Total Phosphorus[3]	< 4.5 ppb	4.5 – 20 ppb	>20 ppb
TSI[3,4]	0-25	25-60	>60 and/or repeated algal blooms

[1] SDT, CHL a, and Total Phosphorus based on long-term means.
[2] No repeated nuisance algal blooms.
[3] If color is > 30 Standard Platinum Units (SPU) or not known, chlorophyll a concentration (CHL a), dissolved oxygen and best professional judgment used to assign trophic category.
[4] TSI = Trophic State Indices are calculated when adequate data exists and color is at or below 30 SPU.
* This table is a duplicate of Table 4-5 in the Assessment Methodology Section of this report (appears twice for the reader's convenience).

Massachusetts

Massachusetts surface water quality standards designate Class A waters as "excellent habitat for fish, other aquatic life and wildlife, and suitable for primary and secondary contact recreation" (Massachusetts Department of Environmental Protection 2013). ORW is used to denote those waters, other than Public Water Supplies, designated for protection as outstanding resources. The DO concentrations of Class A waters "shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions." Temperature "Shall not exceed 68° F (20° C) based on the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring… Temperature shall not exceed 83°F (28.3°C) in warm water fisheries… pH shall be in the range of 6.5 through 8.3 standard units but not more than 0.5 units outside of the natural background range… These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class." (Massachusetts Department of Environmental Protection 2013).

New Hampshire

Surface waters of National Forests and surface waters designated as natural are considered outstanding resource waters (ORW) in New Hampshire. "Water quality shall be maintained and protected in surface waters that constitute ORW" (New Hampshire Department of Environmental Services 2008). Class A is the most protective surface water classification in New Hampshire's Surface Water Quality Regulations (New Hampshire Department of Environmental Services 2008).

According to the standards, "Class A waters shall have a dissolved oxygen content of at least 75% saturation, based on a daily average, and an instantaneous minimum of at least 6 mg/l at any place or time except as naturally occurs… For the period from October 1st to May 14th, in areas

identified by the fish and game department as cold water fish spawning areas of species whose early life stages are not directly exposed to the water, the 7 day mean dissolved oxygen concentration shall be at least 9.5 mg/l and the instantaneous minimum dissolved oxygen concentration shall be at least 8 mg/l… surface waters within the top 25 percent of depth of thermally unstratified lakes, ponds, impoundments and reservoirs or within the epilimnion shall contain a dissolved oxygen content of at least 75 percent saturation, based on a daily average and an instantaneous minimum dissolved oxygen content of at least 5 mg/l."

The standards state that Class A waters shall contain no color, turbidity, phosphorus, or nitrogen "unless naturally occurring." Additionally, "there shall be no change in temperature in class A waters, unless naturally occurring… The pH of Class A waters shall be as naturally occurs. The pH of Class B waters shall be 6.5 to 8.0, unless due to natural causes" (New Hampshire Department of Environmental Services 2008). The standards also provide criteria for ammonia that vary by pH, temperature and the animal species of concern for toxicity (general, salmonids, or fish; New Hampshire Department of Environmental Services 2008).

New Jersey

New Jersey water quality standards (State of New Jersey Administrative Code 2011) designate the general surface water classification applied to freshwater bodies as FW. FW1 means those freshwater bodies that are to be maintained in their natural state of quality and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, or other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s).

"Surface water quality criteria for FW1 waters shall be maintained as to quality in their natural state" (State of New Jersey Administrative Code 2011). The tributaries in the Passaic River Watershed in MORR are all listed as FW2 waters. Surface-water quality criteria for FW2 waters state that DO concentrations shall be "not less than 7.0 mg/L at any time" and that "temperatures shall not exceed a daily maximum of 22 degrees Celsius or rolling seven-day average of the daily maximum of 19 degrees Celsius, unless due to natural conditions" (specifically for FW2-TP waters; TP refers to waters supporting trout production; State of New Jersey Administrative Code 2011). For all FW2 waters, total phosphorus cannot exceed 0.1 mg/L, pH must remain between 6.5 and 8.5, sulfate must be below 250 mg/L, and for turbidity a "maximum 30-day average of 15 NTU, a maximum of 50 NTU at any time" (State of New Jersey Administrative Code 2011). For all waters, "except as due to natural conditions, nutrients shall not be allowed in concentrations that render the waters unsuitable for the existing or designated uses" (State of New Jersey Administrative Code 2011).

New York

New York's Surface Water Quality Standards (New York State Department of Environmental Conservation 2008) designates Class AA as the most restrictive stream classification for water quality. The standard for color states there will be none that will "impair the waters for their best usages". For phosphorus and nitrogen, there will be "none in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages." pH "shall not be less than 6.5 nor more than 8.5," color "shall not exceed 15 color units (platinum-cobalt method),"

and turbidity "shall not exceed 5 nephelometric units" (New York State Department of Environmental Conservation 2008).

"For trout spawning waters (TS), the DO concentration shall not be less than 7.0 mg/L from other than natural conditions. For trout waters (T), the minimum daily average shall not be less than 6.0 mg/L, and at no time shall the concentration be less than 5.0 mg/L. For nontrout waters, the minimum daily average shall not be less than 5.0 mg/L, and at no time shall the DO concentration be less than 4.0 mg/L" (New York State Department of Environmental Conservation 2008).

Vermont

Certain waters are designated as ORW according to Vermont Water Quality Standards (State of Vermont Natural Resources Board 2011), "where the existing quality shall, at a minimum, be protected and maintained. Class A(1) Ecological Waters are managed to achieve and maintain streams in a natural condition".

In all waters in Vermont, "the change or rate of change in temperature, either upward or downward, shall be controlled to ensure full support of aquatic biota, wildlife, and aquatic habitat uses… [For cold water fish habitat,] the total increase from the ambient temperature resulting from all activities shall not exceed 1 ^{o}F" (State of Vermont Natural Resources Board 2011). In lakes, ponds, and reservoirs the total increase from ambient temperature shall not exceed 1 ^{o}F if the ambient temperature is above 60 ^{o}F; 2 ^{o}F if the ambient temperature is between 50 and 60 ^{o}F; and 3 ^{o}F if the ambient temperature is below 50 ^{o}F. In all other waters, the total increase from ambient temperature shall not exceed 1°F if the ambient temperature is above 66 ^{o}F; 2 ^{o}F if the ambient temperature is between 63 and 66 ^{o}F; 3 ^{o}F if the ambient temperature is between 59 and 62 ^{o}F; 4 ^{o}F if the ambient temperature is between 55 and 58 ^{o}F; and 5 ^{o}F if the ambient temperature is below 55 ^{o}F (State of Vermont Natural Resources Board 2011).

All total phosphorus and nitrate concentrations "shall be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses" (State of Vermont Natural Resources Board 2011). In lakes, ponds, and reservoirs, nitrate concentrations are "not to exceed 5.0 mg/L as NO_3-N regardless of classification" (State of Vermont Natural Resources Board 2011). In class A(1) waters, nitrates are "not to exceed 2.0 mg/L as NO_3-N at flows exceeding low median monthly flows" (State of Vermont Natural Resources Board 2011).

There should be no color "that would prevent the full support of uses," and pH "shall be maintained with the range of 6.5 and 8.5" (State of Vermont Natural Resources Board 2011). Turbidity will not be present "in such amounts or concentrations that would prevent the full support of uses, and not to exceed 10 NTU… as an annual average under dry weather base-flow conditions" (State of Vermont Natural Resources Board 2011).

DO concentrations are as naturally occurs in all Class A(1) ecological waters. DO concentrations in cold water fish habitat is "not less than 7 mg/L and 75 percent saturation at all times, nor less than 95 percent saturation during late egg maturation and larval development of salmonids in areas that the Secretary determines are salmonid spawning or nursery areas important to the establishment or maintenance of the fishery resource. Not less than 6 mg/L and 70 percent

saturation at all times in all other waters designated as a cold water fish habitat." In warm water fish habitat DO concentrations are "not less than 5 mg/L and 60 percent saturation at all times" (State of Vermont Natural Resources Board 2011).

Ecoregional Nutrient Standards

Although individual states do not often give numerical values for nutrient standards, the USEPA has established ecoregional nutrient criteria. EPA water quality criteria for nutrients help translate narrative criteria within State or Tribal water quality standards by establishing values for causal variables (e.g., total nitrogen and total phosphorus) and response variables (e.g., turbidity and chlorophyll *a*). Causal variables are necessary to provide sufficient protection of designated uses before impairment occurs and to maintain downstream uses. Early response variables are necessary to provide warning signs of possible impairment and to integrate the effects of variable and potentially unmeasured nutrient loads (U.S. Environmental Protection Agency 2002).

These criteria were developed specifically for each ecoregion and are designed to represent conditions of surface waters that are minimally impacted by human activities and thus protect against the adverse effects of nutrient over-enrichment from cultural eutrophication. The values are EPA's scientific recommendations regarding ambient concentrations of nutrients that protect aquatic resource quality (U.S. Environmental Protection Agency 2002; Table 6). They do not have any regulatory impact or meaning.

For lakes (waterbodies greater than 10 acres and with mean water residence time of 14 or more days; U.S. Environmental Protection Agency 2000a), the criteria were established based on the lower 25th percentile of lakes that EPA found data for (Table 7). This percentile of all lakes is expected to approximately correspond to the 75th percentile of reference (undisturbed) lakes. In other words, 75% of lakes in the ecoregion do not meet the criteria, nor do roughly 25% of reference lakes. For streams and rivers, a parallel approach was used to establish the nutrient criteria (U.S. Environmental Protection Agency 2000b).

Table 6. USEPA Ecoregional nutrient criteria that apply to NETN streams.[1]

Nutrient criteria	Ecoregion 7 (ROVA, SARA)	Ecoregion 8 (ACAD, MABI, SAGA)	Ecoregion 9 (MORR)	Ecoregion 14 (MIMA, SAIR, WEFA, BOHA)
Total Phosphorus-µg/L	33.00	10.00	36.56	31.25
Total Nitrogen-mg/L	0.54	0.38	0.69	0.71
Chlorophyll *a*- µg/L	1.5 (fluorometric)	0.63 (fluorometric)	0.93 (spectrophotometric)	3.75 (spectrophotometric)

[1] Accessed at http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/index.html on June 23, 2005. These numbers represent the 25th percentiles of all values compiled for the region for all seasons

Table 7. USEPA Ecoregional nutrient criteria that apply to NETN lakes and ponds.[1]

Nutrient criteria	Ecoregion 7 (ROVA, SARA)	Ecoregion 8 (ACAD, MABI, SAGA)	Ecoregion 9 (MORR)	Ecoregion 14 (MIMA, SAIR, WEFA, BOHA)
Total Phosphorus-µg/L	14.75	8.00	20.00	8.00
Total Nitrogen-mg/L	0.66	0.24	0.36	0.32
Chlorophyll *a* -µg/L - fluorometric	2.63	2.43	4.93	2.90
Secchi disk depth (m)	3.33	4.93	1.53	4.50

[1] Accessed at http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/index.html on June 23, 2005. These numbers represent the 25th percentiles of all values compiled for the region for all seasons

Clean Water Act Section 303d Impairment

Impaired and threatened waters that do not meet state water quality standards are placed on the state 303(d) list, named for the section of the USEPA Clean Water Act where the list is described. This list is reviewed and updated every 2 years. If a waterbody is placed on the 303(d) list, it is placed in line for a Total Maximum Daily Load (TMDL) plan to identify the cause(s) of the impairment and outline how to clean up and restore the waterbody.

Freshwater bodies in NETN parks that have been included on the USEPA Clean Water Act 303(d) impairments list are listed in Table 8. It is important to note that these lists are continually changing and need to be updated over time. The waterbodies listed on 303(d) lists are mostly large rivers, since states often do not have data from smaller streams. The Hudson River forms the outside boundary of two parks (SARA and ROVA), and really only affects the parks during times of major backwater. The Connecticut River is adjacent to SAGA and has the potential to affect the park during times of flooding. The Concord River and the Saugus River flow through MIMA and SAIR respectively, but in all cases the part of the river in, or affected by, NETN parks is small relative to the size of the watershed. Conducting a TMDL and performing long-term water quality monitoring on these large rivers outside of NETN parks is a state responsibility, and is beyond the scope of the NPS Inventory and Monitoring program for the affected parks.

Table 8. USEPA 303d impairments in freshwater resources in NETN parks.[1]

Waterbody	Waterbody ID (WBID)	Park	Impairment(s)
Blow-Me-Down Brook	NHRIV801060303-11_2010	SAGA	Aluminum, Mercury
Concord River	MA82A-07_2010	MIMA	Non-Native Aquatic Plants (Myriophyllum spicatum), Fecal Coliform, Mercury in Fish Tissue, Phosphorus (Total)
Hudson River	NY-1301-0003-2010	ROVA	Cadmium, PCBs
Hudson River	NY-1101-0002-2010	SARA	PCBs
Saugus River	MA93-35_2010	SAIR	Alteration in stream-side or littoral vegetative covers, Low flow alterations, Fecal Coliform
Saugus River	MA93-43_2010	SAIR	Flow regime alterations, Oil and Grease, Water Temperature, Fecal Coliform

[1] From USEPA 2010 cycle of listings for New Hampshire, New York and Massachusetts

The parks can avoid adding to the impairments in these rivers by monitoring the streams that flow into these large rivers. TMDLs and long-term monitoring of the Saugus, Concord, and Hudson Rivers is outside the scope of this protocol. Data from the nearest up-river monitoring stations on these rivers and water quality monitoring on adjacent freshwater bodies is included in the USEPA STORET database, and is available for use in reports.

Water Quality Parameters

This section includes basic descriptions of the water quality parameters that are used for long-term data collection and analysis in NETN parks. Typical values are included in some cases to give a general range that can be expected from waterbodies in the northeast.

Water Clarity

Secchi disk depth (SD) is used to measure water clarity (transparency) in NETN lakes and ponds, and values can range from 1 to 20 meters (Breen et al. 2002, Farris and Chapman 2000). Generally SDs of greater than 8 meters indicate an oligotrophic lake, between 4 and 8 meters indicate a mesotrophic lake and less than 4 meters indicate a eutrophic lake (Maine Department of Environmental Protection 2004).

Ponds outside of Acadia are too shallow for use of a Secchi disk, and a transparency tube was used to measure water clarity at these sites from 2006 to 2011 (see Appendix S8.A). This method was selected because there is a loose relationship between SD and transparency tube values, plus transparency tubes can be used in streams as well as ponds (Dahlgren et al 2004). However, the water at most NETN pond (and stream) sites was too clear for effective use of the transparency tube.

Beginning in 2012, a Li-Cor LI-1400 light meter is used to document trends in water clarity in these ponds instead. NETN utilizes a light meter to obtain light penetration profiles at shallow lakes in Acadia (i.e., lakes where the Secchi disk regularly hits bottom), and the use of this procedure has been expanded to the rest of the network parks following the purchase of a second set of equipment.

Stream turbidity is measured monthly using a LaMotte 2020e turbidity meter (beginning in 2012).

Temperature

Temperature standards for New England, New York, and New Jersey vary substantially. Within states, there may be separate standards for warm water and cold water fisheries. Changes in temperature regimes over time can affect the community of species that can survive in the stream, pond, or lake, primarily because warmer water does not hold as much oxygen. This protocol includes procedures for sampling monthly pH *in situ* with a multiparameter sonde.

pH

Most New England states indicate that a pH between 6.5 and 8.5 meets state water quality standards (Tables 3 and 4). The documented distribution of pH in Maine lakes by the VLMP and the MDEP (Williams 2004) indicates that the pH of most Maine lakes ranged from 6.0 to 7.0. This protocol includes procedures for sampling monthly pH *in situ* with a multiparameter sonde. Historical pH measurements were often made on a discrete sample in the laboratory. Differing

types of pH measurements are not expected to be equivalent. Both types of measurements can be taken for a season to determine the effect of changing methods.

Dissolved Oxygen

Dissolved oxygen is a critical indicator of water quality because aquatic life generally needs DO concentrations at or above 5 mg/L to thrive. Individual readings are made *in situ* with a DO meter or with a DO probe on a multiparameter sonde. Mesotrophic lakes can drop below 5 mg/L or became anoxic from July through September. The combination of thermal stratification and increased biological activity in lakes during the summer can result in DO concentration depletion or anoxia in lake hypolimnions. Oligotrophic lakes occasionally drop below 1 mg/L, but only at the bottom of the water column (Seger et al. 2005).

Specific Conductance

Specific conductance is an indicator of pollutants in the water, and is directly related to the level of dissolved ions in the water. Specific conductance values can range from less than 20 to more than 1,000 microsiemens per centimeter (µS/cm), but is most often less than 100 µS/cm in Maine lakes (Williams 2004). For sites in LNETN, typical values range from 200 to 400 µS/cm. Specific conductance was historically measured in the laboratory using grab samples and depth-integrated epilimnetic samples taken from NETN ponds and lakes. The SOPs included in this protocol call for specific conductance readings to be taken *in situ* with a multiparameter sonde. Differing types of specific conductance measurements are not necessarily equivalent. Both types of measurements can be taken for a season to determine the effect of changing methods.

Acid Neutralizing Capacity (ANC)

Acid Neutralizing Capacity (ANC) is the capacity of solutes plus particulates in an aqueous system to neutralize acid and is thus determined on an unfiltered sample. Water's ability to neutralize acid (i.e. buffering capacity) is largely a function of the bicarbonate and carbonate ions derived from dissolution of calcium carbonate in the drainage basin. When there is little input of calcium carbonate to a surface waterbody, the dissociation of dissolved carbon dioxide is the reaction that predominates. This results in slightly acidic waters with little buffering capacity.

Most states do not have numerical criteria for ANC in their water quality standards. ANC values greater than 100 µeq/L are considered well-buffered, while values less than zero typify acidic waters (Stoddard et al. 2003). The NWQL reports ANC as mg/L of $CaCO_3$; at 1 mg/L = 20 µeq/L, values greater than 5 mg/L are considered well-buffered.

Apparent Color

Color in lake and stream water is caused by natural metallic ions, humus and peat materials, plankton, weeds, and industrial wastes. Color is reported in Platinum-Cobalt (Pt-Co) units (PCU). True color (not measured by NETN) is the color of water from which turbidity has been removed. Apparent color (measured by NETN) is determined on original samples without filtration. Apparent color can be a rough indicator for organic acidity, which can result in low pH. Sampling apparent color will allow parks to determine whether a low pH is of concern or whether it is because of natural organic acidity, for example, derived from wetlands.

Lakes and ponds with apparent color values of greater than 25 PCU are considered to be highly colored and in these lakes transparency is often depressed and phosphorus concentrations are often high. Values of color are usually not included in water quality standards, except to note that

they be as naturally occurs and that in highly colored lakes, it is best to use chlorophyll *a* as opposed to total phosphorus or SD as an indicator of trophic status. The color of Maine lakes varies from 2 to 194 SPU, with most lakes between 10 and 20 PCU (Williams 2004).

Dissolved Organic Carbon (DOC)

Carbon is a nutrient required for biological processes. Sources of organic carbon in water include humic substances from plant and soil organic matter, wetland peat deposits, and atmospheric deposition. Certain forms of DOC can contribute to "tea" color in water, which can affect light attenuation. DOC is also an important part of the energy balance and acid-base chemistry in many freshwater systems. It also affects the transport (solubility and bioavailability) of metals, including mercury, in aquatic systems. Measurement of dissolved organic carbon began in 2012, and baseline values are not known.

Total Phosphorus (TP)

The total phosphorus occurring in water includes orthophosphate, condensed phosphates and organically bound phosphates. Phosphates are in solution, in particles, or in aquatic organisms. Phosphorus originates from water treatment, laundry detergents, or agricultural or residential fertilizers and often indicates agricultural pollution. It is essential to the growth of aquatic organisms and is thus frequently a limiting nutrient in aquatic systems.

Although several forms of phosphorus (total P, total dissolved P, and soluble reactive P or "orthophosphate") were tested individually in the 2006 through 2011 monitoring seasons, beginning in 2012 NETN only measures total phosphorus. Total phosphorus is the common water quality standard or criteria metric, and more specific analyses can be conducted as necessary to better understand the sources and sinks of elevated phosphorus concentrations should they occur.

The addition of phosphates to a waterbody usually results in the growth of aquatic microorganisms in nuisance quantities (American Public Health Association 1998) and it is an indicator of trophic status or the productivity of a waterbody. Typically, lakes have total phosphorus concentrations of between 10 and 50 µg/L, but can range in lakes from less than 1 µg/L to 200 µg/L (Wetzel 1983). Data from the MDEP and the VLMP indicate that most lakes in Maine have total phosphorus concentrations of between 5 and 10 ppb (roughly equivalent to 5-10 µg/L) in integrated water samples taken from the epilimnion (Williams 2004). USEPA ecoregion criteria range from 8 µg/L to 20 µg/L (Table 7). Similar data is not typically available for streams, but USEPA total phosphorus criteria for streams are higher than for lakes, ranging from 10 µg/L to 37 µg/L (Table 6).

Nitrogen (N)

Nitrogen is found in freshwater bodies in the following forms: nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and organic nitrogen. Nitrate is an essential nutrient for many photosynthetic autotrophs and is thus a major limiting nutrient in most aquatic systems. Nitrite is rare in unpolluted waters. Under high pH conditions, nitrogen in the form of un-ionized ammonia (NH_3) may be present and can be toxic to aquatic life in high concentrations. The organic form of nitrogen is typically un-ionized ammonia (NH_3) that primarily results from the bacterial decay of humic matter or urea from animal or human waste.

An increase in nitrogen usually results in accelerated eutrophication. Nitrogen is indicative of agricultural pollution or acid rain. The drinking water standard for nitrate, the most highly oxidized state of nitrogen, is 10 mg/L (American Public Health Association 1998), but nitrate can be found in concentrations up to 30 mg/L in wastewater effluent.

NETN analyzes lake, pond and stream water samples to total nitrogen (TN), nitrate, nitrite, and ammonia. Total dissolved nitrogen (TDN) analysis was discontinued after 2011. There are no state or EPA criteria for nitrogen analytes other than TN.

Chloride (Cl)

Chloride is one of the major negatively-charged ions in freshwater systems. The chloride content of natural surface waters will depend to a great extent on the geology of the area. Concentrations are generally greater in lakes that are in proximity to marine regions. Another source of chloride is road run-off from de-icing materials. Chloride is important in terms of metabolic processes, as it influences osmotic salinity balance and ion exchange. Chloride analysis began in 2012 and baseline values are not known.

Sulfate (SO_4)

Sulfate is found in most natural waters, originating from watershed geology, soils, and precipitation. Sulfate can play a major role in acidification of lakes and streams. Sulfate analysis began in 2012 and baseline values are not known.

Algal Biomass (Chlorophyll a)

The amount of chlorophyll *a* in a water sample is a measure of the concentration of suspended phytoplankton and can be used as an indicator of algal biomass and thus of water quality. Chlorophyll *a* is responsible for photosynthesis and is found in various forms within the living cells of algae, phytoplankton, and other plant matter of water environments. Like other biological response variables, chlorophyll *a* tends to integrate the stresses of various parameters over time, and thus is often an important nutrient-stress parameter to measure. USEPA criteria for chlorophyll *a* range from 2.4 µg/L to 4.9 µg/L, and values at ACAD are generally below 7 µg/L.

Non-native Invasive Plants

Non-native invasive plants have the potential to dramatically alter stream, pond, and lake ecology. Because of this potential, opportunistic surveys are conducted at stream sites, and more formal boat-based surveys are conducted at ponds and lakes.

Sampling Design

Sampling designs outlined in this section for each NETN park allow for the detection of changes in the status of physical, chemical, and biological attributes of freshwater resources over time. Water quality sampling at additional sites – especially the continuation of historic sites or the sampling of sites in cooperation with other agencies – is encouraged. Consistency of sampling procedures across all sites in the park is critical in the analyses and interpretation of water quality data in NETN parks. Although attempts were made within this protocol to continue the use of historic sites and existing methods, adjustments were made to historical methods and sites so that there would be consistency across NETN or as the result of improvements in methods. Adjustments can compromise the ability to compare new data with historical data in some cases.

General Sampling Design in Lakes and Ponds

The target population is the lakes and ponds with surface area greater than 1 acre (0.4 ha) in NETN parks. As all lakes and ponds greater than 1 acre (0.4 ha) will be sampled over time (except the four ponds discussed below), this design is a census and thus there is no concern about the representativeness of the sampled population. Measurements are taken from a boat at the deepest point in the pond. A mid-lake sample at the area of maximum depth is the conventional sampling strategy used in lake chemistry monitoring programs, and lakes in ACAD have been sampled at the deepest point since 1970. Mid-lake samples at the deepest point have been shown to be representative of surface-water chemistry in lakes of up to 1,650 acres (668 ha) in Sweden (Goransson et al. 2004). Reports will clearly indicate that only the deepest point was sampled and thus conclusions will only be drawn for these sites. A lake water quality study showing how well the deepest point represents water quality at other sites in the lakes at ACAD and the other parks is recommended, although it is beyond the scope of this protocol.

There are a total of 27 ponds and lakes larger than 1 acre (0.4 ha) in or partially in NETN park boundaries. The 13 lakes that have a surface area greater than 15 acres (6 ha) are all in ACAD. Four of these lakes are partially outside the park boundary. There are 14 ponds between 1 acre and 15 acres. Seven of these are in ACAD, two in ROVA, and one each in MABI, WEFA, SAGA, BOHA and MORR.

Because limited funding resources prevent all ACAD lakes and ponds from being sampled every year, a subset of the lakes are visited annually while three sets of lakes and ponds are revisited every 3rd year (an augmented serially alternating design) (Larsen et al. 1995, Urquhart et al. 1998). The augmented serially alternating design gives more power to detect trends over the long term than does an annual revisit design in which a fraction of the lakes and ponds are visited every year. The greatest increase in the power to detect trend in all cases comes from increasing the interval over which the trend is to be detected (Larsen et al. 1995, Urquhart et al. 1998).

For the other NETN parks, all ponds are sampled each year (Table 9). All accessible lakes and ponds greater than 1 acre are sampled monthly from May through October with the following exceptions. Nine lakes and ponds in ACAD are monitored as a part of the serially alternating design where they are sampled every 3rd year (three lakes and ponds per year in addition to the eight lakes sampled every year). Two ponds in ACAD are not accessible by vehicle and are not sampled as part of this protocol. One pond in ACAD is less than 1 m in depth and it is recommended that this pond be sampled as a wetland. The pond in MORR and the two

impoundments in ROVA were considered low priority for monitoring relative to the stream resources in the parks, and thus are not monitored. The ROVA impoundments are also very shallow, with detectable flow, and are generally functioning as wetlands. The one pond greater than 1 acre in BOHA will not be sampled because of the logistical challenges of sampling in Boston Harbor. The option of partnering with other agencies already working on the islands can be pursued to track water quality in this pond.

Sonde water quality measurements can be taken in the flowing water exiting each pond if a boat is not available for sampling. This location is less desirable than the deepest point because a Secchi transparency measurement cannot be taken. Water quality samples can be collected with the use of a throw bottle towards the center of the pond.

In addition, permanent shore sites were established for each lake and pond from which to monitor the water levels. These sites were selected on the basis of access, the presence of a stable benchmark, and the ease of getting an accurate water level measurement.

General Sampling Design in Streams

The challenge in creating a stream sampling design for NETN parks was to balance the importance of using a random probabilistic design so that results could be extrapolated to all locations in each park with the sometimes conflicting priorities of selecting targeted sites based on accessibility, the ability to get an accurate discharge measurement, and the existence of historical data. A targeted design was chosen to obtain the best sites to measure discharge and water quality. The targeted design favors downstream integrator sites that are optimum for determining nutrient loads in park streams. As the majority of watersheds in NETN parks will be monitored over time, there is less of a concern about representativeness, and results pertain only to the sites sampled. For nutrients in streams, the downstream sites help us to determine if the total nutrient loads draining a watershed are exceeding standards or changing over time. In cases where sampling does indicate that standards are exceeded or approached or that nutrients are increasing in a watershed, additional upstream samples can be taken to identify the cause(s) of the change.

NETN's targeted design is not ideal for monitoring the status and trends of acid deposition. High elevation sites unimpacted by humans would be more appropriate for monitoring changes in acidity. It is recommended that the ACAD acidification study (Nelson 2002) be continued to better understand acidity in the park. The two long-term sites in this study record data year round and will more quickly be able to show changes in sampled watersheds.

There are about 50 miles of perennial rivers and streams flowing through, or adjacent to, nine NETN parks (Table 9). Thirty-five miles of stream are in ACAD, 8 miles in SARA, and less than 2.5 miles in each remaining park. In all parks except ACAD, every perennial stream with reasonable access to a site where stream flow can be accurately measured is monitored monthly from May through October for freshwater quality vital signs. In ACAD, every *watershed* (see section on individual park sampling design for *Acadia National Park, Maine*) that allows reasonable access to a site where stream flow can be accurately measured is monitored monthly from May through October as a partial record site under an augmented serially alternating design (three sites sampled annually and 16 sites sampled every other year; Urquhart et al. 1998). In

addition, a continuous-record stream flow gage at ACAD tracks water quantity at one site in the park to quantify and interpret water quality data such as the estimation of nutrient loads.

Although May through October is the minimum period during which stream flow measurements can be taken, annual high flow spring runoff measurements would have considerable value. The timing of this type of high flow measurement would differ among parks from north to south in NETN and from year to year, but generally will occur in March or April in most parks. High flow measurements have not been included in this protocol because this type of measurement is harder to schedule in advance than other measurements; requires an earlier start time for seasonal staff; requires additional equipment, safety gear, and expertise; and requires access to seasonally closed roads.

Table 9. Number of sampling sites at each park in NETN.

Park	Size (acres)	Perennial river miles	No. Stream Sampling Sites	No. Lake Sampling Sites	No. Pond Sampling Sites	Total Sites
ACAD	47,498	35.00	17 (10-11/yr)	13 (9-10/yr)	4 (1-2/yr)	34 (21-22/yr)
MABI	643	0.47	1	0	1	2
MIMA	967	1.54	3	0	0	3
MORR	1,707	2.19	3	0	0	3
SAGA	150	0.62	2	0	1	3
SAIR	9	0.12	2	0	0	2
SARA	3,392	8.11	3	0	0	3
ROVA	401	1.57	5	0	0	5
WEFA	74	0.17	0	0	1	1
TOTAL	54,841	50.00	36 (29-30/yr)	13 (9-10/yr)	7 (1-2/yr)	56 (43-44/yr)

Initially, sample sites were selected randomly by use of GIS coverages of linear stream features. Streams were arranged end to end, the total length of streams was divided by the number of stations that the network felt was feasible to sample, and a site was selected every X^{th} number of miles. GIS-selected sites were often inaccessible, or were on reaches of stream that were inappropriate for obtaining a discharge measurement because of the presence of braided channels, steep slopes, or reaches that would likely have zero flow during a typical August (despite being labeled as perennial on USGS 1:24,000 topographic maps). This sampling design was abandoned in favor of a targeted sampling design.

The targeted sampling design avoided the above listed complications. The best sampling site with reasonable access was selected for each stream or watershed on the basis of the ability to get a discharge measurement and water quality sample. If multiple sites were possible, the most downstream site was selected. If a historical site on the stream met the objectives of the vital-signs program, that site was selected for the stream. Targeted sites (see maps in Appendix A) were chosen according to the following criteria:

1. All permanent sites and access to these sites are within park boundaries and accessible from public roads and have a hike less than 30 minutes
2. Each site is at the downstream end of the section it represents

3. Sites are on perennial sections of the stream, have drainage areas greater than 0.3 mi^2 and have measurable flow during an average August
4. Sites allow for an accurate measure of discharge and the potential to define a stage/discharge rating. Sites do not have steep gradients/waterfalls, braided channels, excessive beaver presence or the inability to identify a single channel because of swamps and wetlands
5. Each site has a pool with a single control at its outflow in which a stable marker can be established and used to measure stage, accessible during a range of flow conditions
6. Ideally there would be a location to get a high-flow discharge measurement if wading is not possible (such as a bridge)

If there was no site within the watershed that satisfied these criteria, that watershed was eliminated from the design.

Once a sampling site was selected for sampling on a stream, all additional sites on that stream were eliminated except in the following parks. ROVA (Appendix A, Figure A6) only has one stream per park unit (except HOFR, where a 2007 land acquisition added an additional stream). In the interest of sampling more than one site in each park unit, a second station was chosen on each stream (although only one site in ELRO and VAMA are currently sampled). MORR (Appendix A, Figure A5) and SARA (Appendix A, Figure A9) have watersheds that involve multiple perennial tributaries that are entirely contained within park boundaries. Additional sites were originally selected to characterize the entire watershed, and then the additional sites were removed from regular monitoring once a baseline data set was collected (after the 2013 field season).

ACAD (Appendix A, Figure A2) has significantly more streams than any of the other parks, and the specifics of its stream sampling design are discussed in the *Acadia National Park, Maine (ACAD)* section of *Individual Park Sampling Designs*.

Individual Park Sampling Designs

Sampling design for lakes, ponds and streams in each of the NETN parks is discussed in this section.

Acadia National Park, Maine (ACAD)

Lakes

Vital-signs monitoring of freshwater resources at ACAD is limited to Mount Desert Island for logistical reasons. This is where most of the freshwater resources are found.

A maximum of 11 out of the 17 lakes selected for sampling can be sampled monthly from May to October each year. This was determined after assessing the staff available at ACAD who would be able to collaborate with NETN staff, the logistics of lake sampling (including boat access), weather and the desire to limit the sampling window to a 2 week period each month. Although a more ambitious sampling design might identify existing trends more quickly, the lake water quality data from the historical monitoring program at ACAD showed data gaps where samples were lost or not obtained because of weather conditions, equipment problems, or scheduling factors (Breen et al. 2002). The goal of the current design is to utilize the optimal

sampling frequency and number of lakes that is consistent with staff availability and funding resources.

Given the maximum of 11 lakes sampled monthly, a balance was obtained between permanent sites and rotating sites (shown in Table 10 and Appendix A, Figure A1). Annual sampling of lakes where there was a long-term historical database was preferred, but this schedule needed to be balanced with the goal of cycling through the remaining sites within 2 to 4 years. The eight lakes that had historically been sampled annually as a part of the park's eutrophication regime (including three lakes with long-term data since 1980: Bubble Pond, Eagle Lake, and Long Pond) were selected as permanent sites to be monitored each year.

The serially alternating design for ACAD allows the remainder of the lakes and ponds that are easily accessible and greater than 1 acre (0.4 ha) to be sampled every 3rd year. Three of the nine remaining lakes and ponds are each assigned to year 1, 2, or 3 to balance sampling sites according to size, location, and accessibility.

Table 10. Lake and pond water quality monitoring sites at Acadia NP

Waterbody	NETN Site Code	Latitude	Longitude
	Annual sites		
Eagle Lake	ACEAGL	44.36351	-68.25042
Bubble Pond	ACBUBL	44.34506	-68.23886
Witch Hole Pond	ACWHOL	44.40001	-68.24295
Jordan Pond	ACJORD	44.33111	-68.25526
Upper Hadlock Pond	ACUHAD	44.32136	-68.28744
Long Pond	ACLONG	44.32752	-68.36333
Seal Cove Pond	ACSEAL	44.30147	-68.39719
Echo Lake	ACECHO	44.32702	-68.33771
	Rotating sites		
YEAR 1 (2006, 2009, 2012, etc.)			
Aunt Betty's Pond	ACANTB	44.37038	-68.27467
Lower Breakneck[1]	ACLBRK	44.39076	-68.25786
Bear Brook Pond[1]	ACBRBK	44.36114	-68.19526
YEAR 2 (2007, 2010, 2013, etc.)			
Lower Hadlock Pond	ACLHAD	44.31140	-68.2893
Hodgdon Pond	ACHODG	44.32222	-68.39780
Seawall Pond[1]	ACSEAW	44.24265	-68.30074
YEAR 3 (2008, 2011, 2014, etc.)			
Round Pond	ACROUN	44.35279	-68.37770
Lake Wood	ACWOOD	44.40778	-68.26844
Upper Breakneck[1]	ACUBRK	44.38655	-68.25545

[1] Between 1 and 15 acres, so "ponds" according to this protocol. All other sites are greater than 15 acres and considered "lakes," even if the name includes the word "pond."

All lakes are sampled at the location of maximum depth, which was determined through bathymetric surveys and the use of an electronic depth finder and a Global Positioning System (GPS) unit. Coordinates for these sampling sites are listed in Table 10 and in the NETN_H2O database. Historically there were two stations monitored on Eagle Lake and four stations monitored on Long Pond. Monitoring a single deepest point (station 1) in Eagle Lake was deemed sufficient as historical stations 1 and 2 are in the same basin, and the historical data (Bill Gawley, unpublished data) indicate that they are equally representative of the overall lake. Although it was recommended that annual monitoring continue at all four stations on Long Pond, only one site per lake is possible with this protocol. More sites at Long Pond would have required a large boat or trips from several separate launch sites because of the size of the lake. Station 1 (112 ft deep, at the lake's deep hole) has the longest data record and was selected as the monitoring site.

In addition to procedures in this protocol, ten lakes are sampled by ACAD staff in April and in October for indicators of acidification. Although most of the acidification analytes are not measured as a part of the NETN monitoring program for all lakes and ponds, it is within the goals and objectives of the vital signs program to include this long-term data set at ACAD in the lake, pond, and stream monitoring database. Therefore, the autumn acidification samples are collected from eight of the 10 lakes and ponds during the October NETN monitoring visits. The remaining two ponds (Sargent Mountain Pond and The Bowl) are not included in the regular monthly NETN sampling schedule because the hike to each site is longer than 30 minutes. These two ponds are sampled from shore with the water quality sonde and with a throw bottle to obtain grab samples in April and October.

Streams

Streams are monitored at ACAD through the use of partial-record stream flow gaging stations in which both stage and discharge are measured by the field crew during monthly monitoring visits, and continuous-record stream flow gages in which stage data are electronically collected and stored every 5 minutes and discharge is calculated using a rating. Continuous-record stream flow gages are the best way to track water quantity and to interpret water quality data. Continuous stream flow data can be used to calculate total amounts of analytes (primarily nutrients) over time (loads) as compared to only the instantaneous concentrations of analytes.

Stream monitoring locations were selected by clipping a GIS layer of watersheds delineated by Perrin (1996) to the park boundary. Sampling sites were chosen from every watershed in ACAD that allows reasonable access to a site where stream flow and water quality can be accurately measured. Occasionally, results consisted of portions of watersheds that had only intermittent streams or very small stream segments or drainage areas; these watersheds were excluded. Watersheds were also eliminated from the list if sampling sites could not be found that fit with the criteria listed in the section of this protocol entitled *General Sampling Design in Streams*.

If a historical site in the watershed met the objectives of the vital signs program, that site was selected. If multiple sites met the criteria, the most downstream site was chosen. Initially, 20 sites including three continuous-record sites were selected. One site, Man of War Brook, was discontinued in 2011. Two additional sites, Bubble Pond Outlet and Jordan Pond Outlet, were discontinued after 2013 (Table 11; Appendix A, Figure A2). There are currently three

continuous-record sites and one partial-record site sampled annually. The remaining 13 partial-record sites are sampled on a rotating basis, with six or seven sites sampled every other year.

One continuous-record stream flow gage was installed by USGS in 2006 and is maintained as an index of stream flow at ACAD because of the extent of the stream resources in ACAD. This gage provides detailed stream flow information about one stream in the park, allowing for estimates of loads of constituents at this site, and also provides data to make estimates of stream flow at hydrologically similar ungaged sites or partial-record sites. The selection of the stream flow gage site to serve as an index station was chosen according to the following criteria: (1) The station must allow for accurate discharge measurements at a range of flows, (2) be near a location such as a bridge for measuring high flows, and (3) have similar watershed characteristics to other streams in the park for which stream flow will be estimated based on the index site. Six candidate sites for the index gage were evaluated according to historic measurements. These sites were measured concurrently up to 12 times from 1999 to 2000. Correlations of stream flow between each pair of partial record stations were compared to determine which gage site correlated with the greatest number of other stations. Otter Creek near Bar Harbor, ME (USGS station 01022840) was selected as the index gage because it had instantaneous flows that correlated well with other measured sites, had good access at low, medium, and high flows, and had a suitable site for a gaging house. Breakneck Brook (USGS station 01022825) was also considered, correlated well with other stations, and had good access, but had a large beaver dam upstream that made it unsuitable as the permanent continuous record site.

Prior to the Otter Creek gage installation, two continuous-record stream flow gages were maintained in the park from 1999 until 2006 at Cadillac Brook (USGS station number 01022835) and Hadlock Brook (USGS station number 01022860). These gages were operated by the University of Maine, the NPS, the USEPA and the USGS as a part of the PRIMENet (Park Research and Intensive Monitoring of Ecosystems Network) project focusing on the atmospheric deposition of nitrogen and mercury and the ecological consequences of this deposition (Nelson 2002). Atmospheric deposition and its ecological consequences are a concern in NETN parks and were recognized as high priority issues (Shriver et al. 2004) during Phase II of the NETN vital signs monitoring plan process. These stream flow gages provided detailed information about stream flow in small, high-elevation watersheds but did not, however, work as index gages of stream flow because they did not correlate well with the stream flow in many of the other streams selected for long-term monitoring (Nielsen et al. 2002; Nielsen, M.G., U.S. Geological Survey, personal communication 2005). In an effort to maintain the continuous-record history at these headwater sites, NETN has operated continuously recording Global WL16S water level loggers during the ice-free season since 2007.

The original Duck Brook site (ACEGLO), located several meters downstream of the dam at the outlet of Eagle Lake (44.37653 °N, 68.24558 °W), was sampled only during 2007. The location proved difficult to measure for stream flow, and water quality measurements were more representative of the lake than the contributions of the stream watershed. After discussion during the 2008 protocol review meeting, the Duck Brook monitoring site was moved approximately 200 meters downstream, on the opposite (north) side of Route 233. The site was given a new code “ACDUCK” to distinguish it from the outlet site. The USGS determined that the relocated

site did not require a new station number for their records (L. Flight, U.S. Geological Survey, written communication 2011).

Table 11. Stream-water quality monitoring sites at Acadia NP. Sites at ACAD are predominately cold water fisheries.

Waterbody	NETN Site Code	USGS Station Number	Latitude	Longitude
Annually Sampled Sites (Continuous and Partial-Record Sites)				
Cadillac Brook (*NETN continuous*)	ACCADS	01022835	44.34456	-68.21700
Hadlock Brook (*NETN continuous*)	ACHADB	01022860	44.33167	-68.28000
Otter Creek (*USGS continuous*)	ACOTRC	01022840	44.33278	-68.20722
Stanley Brook *(Partial-record site; initially rotating year 2, permanent since 2011*)	ACSTNL	01022850	44.30556	-68.24306
Biennially Sampled Sites (Partial-Record Sites)				
YEAR 1 (2006, 2008, 2010, etc.)				
Hunters Brook	ACHNTR	01022845	44.30939	-68.22236
Kebo Brook	ACKEBO	01022829	44.37241	-68.22185
Sargent Brook	ACSGTB	10228665	44.35029	-68.29020
Breakneck Brook	ACBRKB	01022825	44.41123	-68.25204
Aunt Bettys Pond inlet	ACABIN	01022869	44.36512	-68.27241
Marshall Brook	ACMRSL	01022890	44.27474	-68.35150
Heath Brook	ACHTHB	01022895	44.27782	-68.36817
YEAR 2 (2007, 2009, 2011, etc.)				
Browns Brook	ACBRWN	01022866	44.33944	-68.30169
Duck Pond Brook -inlet to Long Pond	ACDKLI	10228755	44.33108	-68.37847
Lake Wood Outlet	ACLKWO	01022808	44.41160	-68.27309
Duck Brook - North of Rt. 233 (*2009- present*)	ACDUCK	01022827	44.37760	-68.24509
Lurvey Brook	ACLVYB	01022892	44.27889	-68.35778
Lurvey Spring Brook-inlet to Echo Lake (*switched to Year 2 in 2011*)	ACLSIE	01022878	44.31242	-68.33522

Sampling of Man of War Brook (ACMOWB, USGS station 01022880, 44.31833 °N, 68.31667 °W) was discontinued in 2011 when the fire road used for vehicle access to the site became impassable and was not scheduled for repair. August stream flow at this site was marginal at best, so it was decided during the 2010 protocol review meeting to suspend monitoring of this stream. Also effective starting in 2011, Lurvey Spring Brook (which is in an adjoining watershed to Man of War) was moved to the Year 2 panel, and Stanley Brook was switched to permanent monitoring status. Concerns about potential threats from residential development in the Stanley Brook watershed made it a good candidate for annual sampling.

Sampling of Bubble Pond Outlet (ACBUBO, USGS station 01022826, 44.35019 °N, 68.24108 °W) and Jordan Pond Outlet (ACJRDO, USGS station 01022852, 44.31972 °N, 68.25580 °W) was discontinued after 2013 because both of these sites are immediately adjacent to lake outflows and are captured by the lake monitoring. ACDUCK and ACLKWO are also near lake outlets, but not as close and NETN will continue to monitor these sites.

Marsh-Billings-Rockefeller National Historical Park (MABI), Vermont

Water monitoring sites at MABI (Table 12) are depicted in Appendix A, Figure A3. One stream sampling site was selected to represent Pogue Stream. This is the only stream within the park, and there are no long-term historic stream water quality stations. This site was chosen because it is the most downstream location within park boundaries with easy access and the ability to obtain an accurate discharge measurement over a range of flows. The Pogue is a pond at the headwaters of Pogue Stream and will be monitored at its deepest point.

Table 12. Water quality monitoring sites at Marsh-Billings-Rockefeller NHP

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Streams				
Pogue Stream	MABISA	43.63493	-72.52937	Cold water fisheries
Ponds				
The Pogue	MABIPA	43.63336	-72.54263	Cold water fisheries

Minute Man National Historical Park (MIMA), Massachusetts

There has been no routine water quality monitoring at MIMA. Current NETN monitoring sites are listed in Table 13. One river, the Concord River, and two streams, Elm Brook and Mill Brook, cut through the two park units (Appendix A, Figure A4). The monitoring site on Mill Brook is located upstream of Lowell Road with tape-down points on the culvert and on a rock just upstream of the culvert. The Mill Brook monitoring site is not located within park boundaries because the brook is intermittent where it flows through the Wayside Unit, and it becomes a wetland where it flows through the North Bridge Unit.

The site on Elm Brook is within park boundaries at State Route 2A, 4.3 miles upstream from the confluence of Elm Brook with the Shawsheen River. The sampling site represents water quality conditions in Elm Brook within the Park's Battle Road Unit. The site is accessible by vehicle. Discharge measurements are made using a current meter on the downstream side of Rt. 2A. A tape down point is located on the downstream side of the box culvert where the stream passes under Rt. 2A.

The Concord River site is at the Old North Bridge, 0.49 miles downstream from the confluence of the Sudbury and Assabet Rivers. The site is within the MIMA boundary and the site is intended to represent water quality conditions in the Concord River within the park's North Bridge Unit. The site is accessible by vehicle. Discharge measurements cannot be made by wading because of the size of the river but could potentially be made off of the Old North Bridge, although bridge measurements are too expensive for NETN to cover at this time. This site also requires specialized techniques to obtain water quality sonde samples. During the 2007 field season, YSI measurements were taken at seven points (near both banks and at each of five

bridge pylons, measured at half depth) on the bridge. Results showed that water near the banks was stagnant when the river was low, but that the main channel was well-mixed even when measured at low to moderate flows. The recommendation from the 2007 protocol review meeting was to collect a two-point measurement (at pylons 2 and 4) in the channel at each monitoring visit, and to obtain a cross-section of all seven points once each year, to confirm that the two-point measurement strategy is still representative. The cross-sectional measurements should be taken at varied depths.

Table 13. Water quality monitoring sites at Minute Man NHP, Massachusetts

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Streams				
Concord River at Old North Bridge, Concord, MA	MIMASC	42.46902	-71.35063	Warm water fisheries
Elm Brook at Rt. 2A near Lincoln, MA	MIMASB	42.45293	-71.30422	Cold water fisheries
Mill Brook at Lowell Rd, Concord, MA	MIMASA	42.46280	-71.35142	Cold water fisheries

Morristown National Historical Park (MORR), New Jersey

Five water quality monitoring sites were selected at MORR for the NETN monitoring program (Table 14). Sites were chosen to represent the accessible, perennial streams in the Jockey Hollow and New Jersey Brigade Units, the two park units with significant freshwater resources. Four historic water quality sampling sites were continued as these stations met the objectives of the vital signs program.

Three of the selected sites are in the Primrose Brook Watershed within the Jockey Hollow Unit. These sites are on the East Branch of Primrose Brook, the West Branch of Primrose Brook, and the main stem of Primrose Brook. The other sites are on the Passaic River and Indian Grove Brook in the New Jersey Brigade Unit (Appendix A, Figure A5). Jersey Brook is also in the park but it is ephemeral. The largest pond in the park, Cat Swamp Pond, has no natural outlet and is connected to East Branch of Primrose Brook only by an overflow outlet pipe.

In November 1996, the USGS established a water quality monitoring site at site EP1, just downstream of the confluence of East and West Branch Primrose Brooks, and monitors several chemical and physical parameters including stream flow on a quarterly basis (Deluca et al. 2003). The site has a staff gage, a stage discharge relation (rating), and is used as a water quality monitoring site by several other State and Federal agencies. The US Fish and Wildlife Service (USFWS) has monitored 15 water quality parameters and sampled aquatic life at this site since 1991 (Lombard 2004). Stream water quality monitoring at MORR should be coordinated with ongoing monitoring by other agencies at the park, especially at site EP1 (MORRSB).

Sampling of the East Branch of Primrose Brook (MORRSA, USGS station 01378778, 40.77013 °N, 74.52412 °W, cold water fishery) and the West Branch of Primrose Brook (MORRSC, USGS station 01378775, 40.76967 °N, 74.53620 °W, cold water fishery) was discontinued after 2013 because the Primrose Brook Confluence is representative of the Primrose Brook watershed and there were insufficient resources for continued monitoring of multiple sites

in the same watershed. MORRSA also had very low flows in the summer months. The network has a solid baseline for the discontinued sites, and if water quality changes at the Primrose Brook Confluence (MORRSB), the discontinued sites can be revisited to help determine the source of the change.

Table 14. Water quality monitoring sites at Morristown NHP

Waterbody	NETN Site Code	USGS Station Number	Latitude	Longitude	Site Remarks
Streams (Park site code)					
Indian Grove (IG2)	MORRSD	01378680	40.74465	-74.56542	Cold water fisheries
Primrose Brook confluence (EP1)	MORRSB	01378780	40.76433	-74.52937	Cold water fisheries
Passaic River	MORRSE	01378670	40.75187	-74.55143	Cold water fisheries

Roosevelt-Vanderbilt National Historic Sites (ROVA), New York

All of the basic field water chemistry parameters and nutrients identified by the vital signs program have been collected intermittently since 1994 at 11 stations in ROVA. Although the effort ranged from monthly to quarterly, there are some years that have no data (2002 and 2003), and 2 years that have only a single winter value (2000 and 2001). Prior to implementing this protocol, field parameters of specific conductance, pH, temperature, and DO were collected with Yellow Springs Instruments (YSI) probes, and grab samples were sent to a local laboratory for nutrients, alkalinity, total dissolved solids, chloride and bacteria analyses. Discharge measurements were not included in the data collection. Water quality data were checked for outliers, but were not analyzed and were not part of a rigorous quality assurance/quality control (QA/QC) program (D. Hayes, NPS, written communication, 2004).

The NPS Water Resources Management Plan for ROVA (National Park Service 1997a) contained recommendations for modifying the park's existing water quality program, several of which were similar to the design plan presented here. Six water quality monitoring sites were selected at ROVA for the NETN long-term monitoring program (Appendix A, Figure A6). These include five of the original sites mentioned above: VAMA-1, VAMA-3, HOFR-1, HOFR-3, and ELRO-3 (described in Table 15) (National Park Service 1997a). An additional site was chosen on the stream in the 2007 HOFR acquisition. Sites were chosen to represent the major streams in each park unit.

Although Val-Kill Pond at ELRO was monitored (as site ROVAPA) during the 2006 season, it was dropped as a sample location after discussion at the first protocol review meeting in December 2006. The site is shallow, has detectable flow, and appears to be a wetland.

Sampling of Upper Crum Elbow Creek (ROVASC, historic site VAMA01 where the stream enters the park, 41.79550 °N, 68.24108 °W, warm water fishery) was discontinued after 2013 because discharge can no longer be measured at the site (due to flooding changes caused by Hurricane Irene), and because the site is duplicative of the Lower Crum Elbow Creek site (ROVASD).

Table 15. Water quality monitoring sites at Roosevelt-Vanderbilt NHS

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Streams				
Lower Crum Elbow Creek (*Historic site VAMA-3 where stream exits park*)	ROVASD	41.78883	-73.94558	Warm water-includes sunfish
Upper FDR Brook (*Historic site HOFR-1 where stream enters park*)	ROVASB	41.77000	-73.93830	Cold water fisheries
Lower FDR Brook (*Historic site HOFR-3 where stream exits park*)	ROVASA	41.76420	-73.93975	Cold water fisheries
Maritje Kill	ROVASE	41.76287	-73.92047	Cold water fisheries
Fall Kill (*Historic site ELRO-3, downstream of upper Val-Kill Pond*)	ROVASF	41.76228	-73.89963	Warm water-includes sunfish

Saint-Gaudens National Historic Site (SAGA), New Hampshire

Three water quality monitoring sites have been selected at SAGA for the long-term monitoring program (Appendix A, Figure A7). The three sites represent the two streams and the major impoundment in the park and they are all water quality sites that have been measured by the park since 1997 (Walasewicz 2003). The sites are on Blow-Me-Down Brook (historic station 3), Blow-Me-Up Brook (historic station 1), and behind the impoundment on Blow-Me-Down Pond (historic site 5) (Table 16). The NPS reviewed the existing water quality sampling strategy at SAGA, and made specific recommendations for its improvement (Ellsworth 2005). The sampling design included in this protocol is roughly in accordance with the recommendations from the water sampling review.

A continuous-flow monitor would be beneficial to the park; however this did not receive a high priority in this protocol because of funding constraints. Stream flow is measured each time a water quality measurement is made at the two stream sites. A tape-down site was established at Blow-Me-Down Pond.

Table 16. Water quality monitoring sites at Saint-Gaudens NHS

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Streams				
Blow-Me-Up Brook (*historic Station 1*)	SAGASA	43.50188	-72.37083	Cold water fisheries - includes trout
Blow-Me-Down Brook (*historic Station 3: Below the confluence with Blow-Me-Up Brook*)	SAGASB	43.50333	-72.37908	Warm water fisheries-includes sunfish
Ponds				
Blow-Me-Down Pond (*historic Station 5*)	SAGAPA	43.49725	-72.37540	Warm water fisheries-includes sunfish

Saugus Iron Works National Historic Site (SAIR), Massachusetts

The USGS has operated a continuous-record stream flow gage on the Saugus River just upstream of the park boundary (USGS 01102345 Saugus River at Saugus, MA) since 1994 (Table 17). Temperature and specific conductance were measured continuously for a few years at this

station, beginning in 2001. The park would benefit from an annual download and report of continuous stage measurements. Although the gaging station is just upstream of the park, because the stream reach within the park boundary is only 0.25 miles, this station adequately represents water quality within the park. Data from this station can be accessed at: http://waterdata.usgs.gov/ma/nwis/uv/?site_no=01102345&agency_cd=USGS.

Water quality samples and sonde measurements are taken twice a year (May and August) at the location of the USGS gage and in the Turning Basin (Appendix A, Figure A8). NETN water monitoring at SAIR began in 2007, and from that year through 2011 sonde measurements are only available for the Turning Basin. The Turning Basin was the subject of a major restoration project between the 2007 and 2008 sampling years.

Table 17. Water quality monitoring sites at Saugus Iron Works NHS

Waterbody	NETN Site Code	USGS Station Number	Latitude	Longitude	Site Remarks
Streams					
Saugus River (*Historic/USGS site just upstream of park boundary*)	SAIRSA	01102345	42.46939	-71.00717	Warm water fisheries
Turning Basin	SAIRSB	n/a	42.46888	-71.00770	Warm water fisheries

Saratoga National Historical Park (SARA), New York

There are 8 miles of perennial streams divided between four watersheds in SARA that all flow into the Hudson River (Appendix A, Figure A9). These watersheds include the Kroma Kill, Mill Creek, American's Creek and Devil's Hollow. In addition, the Champlain Canal Cuts across the downstream end of the major drainages of the park, and water from the Hudson River can back up into the park. There are also two distinct channels that drain the Schuyler property (north of the main park unit and not shown on the map), which has recently been acquired by the park. Since there are no major ponds or impoundments in Saratoga, NETN monitoring is designed to characterize only the streams in the park.

One monitoring site has been identified in each major watershed in the park where water quality samples can be taken and stream flow measured (Table 18). In addition, there are major tributaries in the Mill Creek watershed within park boundaries, and thus an additional site has been identified on the North Fork of Mill Creek.

Kroma Kill is a third order stream in the park and is monitored upstream of the first bridge crossing along the Park Entrance Road from Route 4. The bridge provides an adequate staff gage site, a constricted area for hydraulic control, and a platform for sampling during high flows. Historic sample sites were deemed less desirable because of potential backwater effects from the Hudson River (SARA0044 and SARA0045), road (SARA0050) or park boundary constraints (SARA0049) (for historic site information see National Park Service 1997b).

Mill Creek enters the Hudson River as a second order stream. The Upper Mill Creek site is located on the North Fork, near where the stream enters the park, and just downstream of the

park tour road. The stream is very small at this location but appears to be perennial and the box culvert can be used for accurate discharge measurements when flows are elevated.

The Lower Mill Creek site is approximately 200 m downstream of the confluence of the North and South Forks (historic site SARA0053). This site provides an integrated sample for the watersheds of the North and South Forks as the South Fork can have low flow and does not meet sampling site criteria. The Lower Mill Creek site has a cobbled bed and a well-defined floodplain terrace similar to the North Fork. This site can be accessed from the Park Tour Road by crossing the open field above the American River Fortifications, traversing the higher part of the wooded hill slope west of the private land holding along Route 4, and dropping into the valley formed by Mill Creek. Downstream sampling near private property was not feasible because of low flows and likely backwater effect from the Old Champlain Canal. The reach from the recommended site downstream to the private property was meandering, braided, or otherwise not conducive to sampling. The Lower Mill Creek site is difficult to access but achievable within 20 minutes.

A reasonable sample site was identified for American's Creek below Bemis Point at the end of the American River Fortifications. Here the stream flows through a narrow channel incised to bedrock. Flow was continuous when observed during the site selection visit for this protocol, but proved difficult to measure in very dry years, exemplified in 2008 and 2010. The historic sites SARA0056, SARA0057, and SARA0058 were deemed inappropriate because of Hudson River backwater and Champlain Canal drainage.

The following stream watersheds are a lower priority for the park and do not have fixed monitoring sites: (1) Two channels that drain the Schuyler property; (2) the Hudson River is not monitored because other agencies are monitoring it and only its backwater is within park boundaries; (3) the Champlain Canal is not monitored because although it may demonstrate cumulative effects of water pollution in the park, it would be difficult to trace effects if long-term trends are detected; (4) Fish Creek, adjacent to the Schuyler House, is affected by backwater from the Hudson River during high flow events and, therefore, deemed inappropriate for the vital signs program; and (5) Devil's Hollow, which does not have year-round flow.

Sampling of American's Creek (SARASB, 42.97717 °N, 73.63100 °W, warm water fishery) was discontinued after 2013. This site drains a very small watershed fully contained within the park, and has very low flows. NETN has a solid baseline data set for this site, and monitoring of this site is only warranted if a construction or other project that may impact the watershed is anticipated.

Table 18. Water quality monitoring sites at Saratoga NHP

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Streams				
Kroma Kill	SARASA	43.00583	-73.61730	Warm water fisheries
Lower Mill Creek (historic site SARA0053)	SARASD	42.98895	-73.62555	Warm water fisheries
Upper Mill Creek (at culvert of Battlefield Rd.)	SARASC	42.99738	-73.64855	Warm water fisheries

Weir Farm National Historic Site (WEFA), Connecticut

There was almost no water quality data available that had been collected at WEFA, so a long-term monitoring site was set up in Weir Pond, the largest freshwater body in the park (Table 19; Appendix A, Figure A10). In 2005, the NPS regional hydrologist reviewed the existing water quality sampling strategy at Weir Farm National Historic Site, and specific recommendations from this evaluation (A. Ellsworth, NPS, written communication, 2005) have been incorporated into the NETN pond monitoring protocol.

Table 19. Water quality monitoring sites at Weir Farm NHS, Connecticut

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Ponds				
Weir Pond	WEFAPA	41.25952	-73.45150	Warm water fisheries

Detectable Level of Change

The lake and pond monitoring in this protocol is conducted as a census, and stream sites were selected using expert judgment rather than systematic or random sampling. A power analysis (which assumes a statistically sampled population rather than a census or judgment sample) is not strictly appropriate. Nevertheless, there will be some minimum level of change that can be statistically detected as data are collected over the long term at fixed index sites. Observer variation, often a significant contributor to variability and inability to detect trends, is controlled through adherence to strict QA/QC procedures documented in this protocol. However, there are some important factors that will affect the ability to detect change, especially the different components of temporal variation (daily, seasonal, and annual; generally driven by weather patterns). These temporal variations will be modified by site-specific factors that may be hard to quantify, making modeling of the effects of temporal variability difficult. Additionally, major flooding events or geologic shifts can permanently alter sites, making data from before and after an event difficult to compare.

It is unlikely that trends in water quantity will be detectable using the non-continuous methods in this protocol (i.e., six synoptic measurements per year). The weekly stage measurements taken at some ACAD lakes may be sufficient for some level of trend detection, but no power analysis has been conducted on these data. Continuous measurements are ideal and should be pursued at all sites (using pressure transducers to record stage); continuous data should facilitate the detection of trends that exceed the amount of annual variation in water quantity. A power analysis of the existing continuous stream data is needed to quantify the actual detectable level of variation.

Although we do not expect to be able to detect trends in water quantity based on our synoptic water quantity measurements, these data are important for interpreting water quality measurements. Many metrics of water quality that stem from fairly steady inputs (e.g., phosphorous from human development) will vary inversely with the water quantity. In other situations, high flows might "flush" the system and produce temporarily elevated readings. The availability of water quantity data from the time that the water quality data were collected will be needed to maximize our ability to detect trends in these data.

The network will conduct a power analysis by the end of 2015 to document the ability to detect change from baseline levels for a variety of metrics (including weekly lake levels, continuous water quantity, water chemistry, and nutrients). The first 5 years of data (2006-2010) will be the

base years for determining means and the range of variability for different metrics. Bootstrap simulations will be conducted to determine the level of true change that must occur before the change can be detected. At a minimum, we expect to be able to detect a 50% change from baseline levels in any metric within 5 years, while controlling type I error at 10% and type II error at 20%.

Field and Laboratory Methods

Field Methods

The sequence of events during the field season is described in *SOP 16 – Annual Timeline of Activities*. Field season preparations and end of season activities are described in *SOP 3 – Preparation and Equipment List* and *SOP 15 – Post-Season Activities*.

Tables 20 and 21 summarize the parameters that are measured monthly in the field from May through October, with reference to the appropriate SOPs. These metrics include stream discharge, stream and lake stage (water level), water clarity (transparency, light attenuation, and turbidity), and *in situ* water quality (pH, specific conductance, temperature, and dissolved oxygen measured with a multiparameter sonde). The Standard Operating Procedures (SOPs) provide specific instructions for techniques to obtain these measurements. NETN strives to maintain consistency of staff whenever possible to minimize variation from technical error. Appropriate training and consistency in the use of calibration and QA/QC methods is similarly important to maintaining data quality, and these methods are also documented in the individual SOPs.

Water samples are collected twice each season – as grab samples in streams and LNETN ponds and as depth-integrated epilimnetic samples in ACAD lakes and ponds. The samples are sent to a central laboratory, currently the University of Maine's Sawyer Environmental Chemistry Research Laboratory (SECRL), for analyses. These samples are collected from streams in May and August and from lakes and ponds in June and August. From 2006 through 2011, samples were analyzed for acid neutralizing capacity (ANC), apparent color, total nitrogen, total phosphorus, total dissolved nitrogen, total dissolved phosphorus, ammonia, nitrite, nitrate, and orthophosphate. In addition, portions of the ACAD lake epilimnetic samples were filtered at the park and the filters were sent to the laboratory for chlorophyll *a* extraction and analysis. In an attempt to obtain a broader range of information from the water sample analyses while making the collection and analysis processes more efficient and economical, the list of analytes was modified after the 2011 monitoring season to consist of ANC, apparent color, total nitrogen, total phosphorus, ammonia, nitrite, nitrate, dissolved organic carbon (DOC), chloride, and sulfate. Specifications for chlorophyll *a* testing were revised at the same time to include analysis of pond water samples from the lower NETN ponds. Implementation of the modified analytic regimen began in 2012.

Invasive aquatic plants are surveyed opportunistically at stream sites and once per year during the months of July through September (depending on the flowering schedules and presence of other key characteristics of target species) in lakes and ponds with boat access. NETN field crews conduct rapid hydro-geomorphic assessments of stream habitats, using a modified EPA Rapid Bioassessment protocol, during July stream monitoring sessions. At ACAD, park personnel sample benthic macroinvertebrates in five streams each August, in cooperation with the Maine Department of Environmental Protection (MDEP). There has been an ongoing dialogue regarding the implementation of benthic macroinvertebrate monitoring at other NETN parks, potentially in cooperation with other state agencies or I&M networks, such as the Eastern Rivers and Mountains Network (ERMN) and/or the Mid-Atlantic Network (MIDN). Plans for these expanded activities are highly dependent upon future budget and staffing levels.

Table 20. Monitoring parameters, methods, and frequency in lakes and ponds.

Parameter	Method	Frequency	SOP Number
Dissolved oxygen, temperature, specific conductance, pH	Multiparameter sonde profile	Monthly (May-October)	6
Lake stage	Tape down	Weekly (ACAD, April-Nov) Monthly (other parks, May-October)	5
	Leveling of monitoring locations	Annual	19
Clarity	Secchi disk depth *or* Li-Cor Light Meter[1]	Monthly (May-October)	8
ANC, apparent color, total nitrogen, total phosphorus, ammonia, nitrite, nitrate, DOC, chloride, sulfate, chlorophyll *a*	Depth-integrated epilimnetic sample	Biannually (June and Aug)	7, 12
Non-native invasive plants-early detection	Field surveys	Annually (July, Aug, early Sept)	10

[1]Secchi disk transparency is used at all sites where the Secchi disk depth is less than the depth of the deepest point. Only in cases where the Secchi disk is visible on the bottom of the pond, will a Li-Cor light meter be used.

Table 21. Monitoring parameters, methods, and frequency in streams.

Parameter	Method	Frequency	SOP Number
Dissolved oxygen, temperature, specific conductance, pH	Multiparameter sonde in centroid of flow	Monthly (May-October)	6
Stream discharge and stream stage	Current meter and staff gage or tape-down	Monthly (May-October)	9
	Pressure sensor[1]	Continuous (all year)[1]	
	Leveling of monitoring locations	Annual	19
Turbidity	LaMotte 2020 turbidity meter	Monthly (May-October)	8
ANC, apparent color, total nitrogen, total phosphorus, ammonia, nitrite, nitrate, DOC, chloride, sulfate	Grab sample	Biannually (May and Aug)	7, 12
Non-native invasive plants-early detection	Opportunistic surveys	Monthly (May-October)	10
Rapid Hydro-Geomorphic Assessment	EPA survey protocol	Annually (July)	11
Benthic macroinvertebrates	Colonization sampler	Annually (5 ACAD streams only)	n/a

[1]Pressure sensor is used at 1-3 continuous record gaging stations in ACAD, and one gaging station at SAIR, otherwise current meters are used.

Laboratory Methods

Quality and consistency of data for long-term trends depends on the selection of an accredited laboratory with adequate quality assurance and quality control (QA/QC) procedures. It is also critical that the analysis methods for each analyte are specified and clarified with the laboratory staff before analyses begin. Before sampling begins, field and laboratory staff will discuss the correct procedures for pretreatments, bottle sizes, types, and holding times to ensure high quality samples are collected. Current laboratory specifications and methods are detailed in *SOP 12 – Laboratory Analyses*.

Quality Assurance and Quality Control (QA/QC)

QA/QC is important to the success of a long-term data collection and trend detection program. Quality assurance (QA) is achieved through the establishment and use of this protocol. Specific procedures are used to control critical components of a project such as sampling at the right place with the right equipment and using the right methods. Over the years, staff will change, equipment may be updated, and methods may evolve. Although these changes will be kept to a minimum, changes are inevitable and therefore following an established and well-documented protocol will ensure that the data remain valid.

QA requirements incorporated in this protocol include consistency and low turnover in project leaders and staff, consistency in staff training and oversight, consistency in equipment used and calibration methods, the selection of a well-established chemical laboratory with a proven track record, and a robust sample design that includes an adequate number of field and laboratory quality control (QC) samples.

QC includes the assessment of bias and variability through the use of additional samples such as blank and replicate samples. QC samples are an objective assessment of whether or not QA protocols are adequate. QA is integrated into each SOP and into the protocol narrative. A section on QC is included in each SOP if appropriate.

Quality Assurance

Data representativeness and data comparability will be assured if standard protocols for lakes, ponds, and streams, are adopted. The most appropriate existing protocols for the goals and objectives of this monitoring program were selected and adapted. USGS Water Resources Division and NAWQA (National Water Quality Assessment Program) protocols were adopted for streams. Maine Department of Environmental Protection (MDEP) protocols were adopted for lakes as ACAD was the only park in NETN that includes lakes. All versions of this protocol will be archived and dated so that each piece of data collected by NETN can be linked to a specific version of a protocol from another agency at a later date.

Some parks have already been collecting data for a number of years, using more than one version of a protocol. Although not all versions of all protocols were documented in the past, every attempt will be made to compare and quantify old methods with new methods before a change is adopted to avoid bias from changes in methods.

To ensure consistency in analysis results, one laboratory is used by all parks in NETN. Samples were sent to the USGS National Water Quality Lab (NWQL) during the first year of monitoring (2006). Results from the June 2006 testing showed that some of the analytical methods used by the NWQL were not sensitive enough to detect low nutrient concentrations in many of the NETN samples. Lower level methods were utilized for the August 2006 analyses, but these still produced a large number of "non-detect" results. Samples were sent to both the NWQL and the University of Maine's Sawyer Environmental Chemistry Research Laboratory (SECRL) in 2007, and comparisons of results showed good agreement between both labs but better sensitivity of the SECRL methods. All NETN samples have been analyzed at SECRL since 2008.

Any laboratory chosen to analyze NETN samples must pass independent State and Federal (National Environmental Laboratory Accreditation Program or NELAP, see http://www.nelac-institute.org/newnelap.php) accreditation/approval QA/QC checks. These checks optimally include blind-sample round-robin trial analyses of proficiency test standards to see if the results the laboratory provides is similar to known (certified correct) ranges to pass QC performance standards. Rigorous and independent checks are needed to insure that the selected laboratory can produce accurate and comparable results. Federal and state agencies that have run round-robin testing programs have determined that many candidate laboratories cannot pass such checks (Irwin 2004). Both the NWQL and SECRL are among the central laboratories that meet these criteria.

As one of the biggest sources of data variability can be operator error, all attempts are made to maximize staff background, experience, and training and to minimize staff turnover. Staff responsible for field monitoring have the experience and training necessary to routinely perform all equipment calibrations, sample and data collection, and to recognize when a piece of equipment is not adequately meeting specifications. Furthermore, staff are trained to follow all procedures for processing and shipping samples including bottle types, pretreatments, and holding times.

Quality Control

QC data are generated to estimate the magnitude of the bias and variability in the processes for obtaining field data. Bias is the systematic error inherent in a method or measurement caused by contamination of samples and can be identified and quantified through the use of blank samples. Precision is a measure of the variability in results when one is measuring the same (homogenous) factor repeatedly, whereas variability is the degree of random error in repeated measurements of the same quantity. Precision and variability are the opposite of each other as defined by USGS NAWQA. Sample replicates are used to estimate precision or variability. In addition, reference samples are samples of sufficiently well-known composition to be used for an assessment of the measurement method. Calibration includes efforts to ensure an instrument is measuring with an acceptably low amount of systematic error or bias.

Specific sections for QC are included in individual SOPs where necessary. Field QC samples are submitted by field staff to measure errors in sample collection, processing and transport in the field. Laboratory QC samples are submitted by chemists to measure errors in sample preparation and analysis in the laboratory. It is important that adequate QC samples be taken routinely to ensure that future trend analyses are assessing true environmental trends rather than the bias and variability of the field staff or the equipment used.

Data Management

Data management is coordinated and overseen by the NETN Water Monitoring Coordinator and the NETN Data Manager. Data entry modules of the NETN water database "NETN_H2O" are populated at ACAD by ACAD staff and by NETN staff for the rest of NETN. All data collected and populated in NETN_H2O are imported to NPSTORET, the Inventory and Monitoring program database that serves as the initial portal to the EPA's STORET data warehouse, which is the ultimate repository for all NPS water data (see SOP 13 – Data Management for detailed data management procedures). The data are also compiled and made available to the Inventory and Monitoring Program, park managers, and the public annually in the form of annual data reports (see SOP 14 – Data Reporting and Analysis for Lakes, Ponds, and Streams section on Annual Data Reporting for Lakes, Ponds, and Streams). The NETN Water Monitoring Coordinator is responsible for ensuring that all data collected are compatible between parks.

Vital signs monitoring networks collect a wide variety of physical, chemical, biological, and other data in support of monitoring impaired, pristine, and other high-priority waters. The Implementation Plan for the water quality monitoring component of the NPS Vital Signs Monitoring Program states that all water quality data collected by Vital Signs Monitoring Networks will be funneled through the NPS Water Resources Division into the USEPA modernized STORET (STOrage and RETrieval) database where the data will be available to parks, Regions, and the public on the Internet at http://www.epa.gov/storet (Tucker 2007). Modernized STORET adopts a distributed database model that relies on government agencies and other entities to operate local copies of STORET ("WRD STORET" in the case of the NPS Water Resources Division [WRD]) and the database software Oracle.

The primary mechanism that is employed to enter Vital Signs Monitoring Network water quality data into WRD STORET is a series of input screens (forms/templates), developed as part of the Natural Resource Database Templates (http://science.nature.nps.gov/im/datamgmt/applications/template/index.cfm), and the STORET Interface Module (SIM ver. 2). The input screens (called NPSTORET), developed by the NPS Water Resources Division, allows Vital Signs Monitoring Networks to enter data about their projects, stations, metadata, and results. Data from spreadsheets, datalogger output files, and other similar sources can also be directly imported into NPSTORET. A module of the NETN_H2O that will facilitate import of all NETN data directly to NPSTORET is currently under development. Both NETN_H2O and NPSTORET run under Microsoft Access 2002 software or higher.

NPSTORET data are transferred annually to WRD STORET, and periodically the WRD STORET implementation replicates the entire database on the Web-accessible STORET National Data Warehouse (Water Quality Exchange [WQX] System). The WRD STORET platform is being replaced in 2012 with a commercial database system called EQuIS.

Analysis and Reporting

The data reporting format and schedule are designed to meet the major goals of the Vital Signs program, which are (a) determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources, (b) provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments, and (c) provide a means of measuring progress towards performance goals.

The NETN emphasizes communication and reporting as one of its major goals. The reporting approach is based on the belief that a vital sign is useful only if it provides information to help guide management decisions or quantify the success of past decisions. This information must be presented clearly so that vital sign analyses are understood by managers, scientists, policy makers, and the public.

Data analyses and reporting consist of two components. The first component is comprised of an annual data report with lake, pond, and stream water quality data that have been checked for quality and completeness. This report ensures that data are routinely available to the public for independent analyses, and to spur research projects that will be of benefit to the park and to NETN. Annual data reports must include all specified components listed in *SOP 14 – Data Reporting for Lakes, Ponds, and Streams*. Data reports can be digital, paper, or both as long as they are readily available to the public.

The second component of the data analyses and reporting for NETN includes trend analyses and scorecard reports. After sufficient data are accumulated, trend analyses are conducted on all parameters every 5 years by network staff on both individual waterbodies and on aquatic ecosystems as a group at a park. All measures within a vital sign are examined in the context of other measures within that same vital sign to determine if all eutrophication parameters (for example) such as nutrients, chlorophyll *a* and transparency have similar seasonal trends. These types of analyses help managers determine whether there is problem waterbody with a new or increased stressor or whether there is an overall regional trend to be investigated.

Communicating trends in 25 or more parameter measures that relate to multiple vital signs requires a framework or scorecard that clearly and concisely conveys the state of park ecosystems. The status and trends of parameters are used to populate an ecological integrity scorecard which includes data from all aquatic annual data reports from NETN parks and from all trend analyses.

Personnel and Operational Requirements

All NETN aquatic monitoring operations are overseen by the Water Monitoring Coordinator, whose time is also partially dedicated to water quality data management including a check of all data submitted by the field crews, data import and export, and QC. This person must have hydrologic training and be able to perform routine data summary statistics and trend analyses on long-term water quality data. This person must also have experience with spreadsheets and databases, checking and interpreting hydrologic data, and demonstrated experience producing and publishing reports. The Water Monitoring Coordinator also conducts the major administrative tasks for the program, including protocol development and revision; scheduling, purchasing and contracting; and hiring and supervision of the Field Crew Leader(s) and seasonal Field Crew. The Water Monitoring Coordinator is the primary point of contact with the NETN Program Manager and NETN Data Manager.

Field Crew

Many possible models are available for staffing the lakes, ponds, and streams monitoring program. In some parks, existing staff are able to perform some or all of the routine water quality and quantity monitoring, when provided training and oversight, and a part of their time is dedicated to this work. Alternatively, NETN has directly hired biological, hydrologic, or physical science technicians dedicated to collecting water quality and quantity data from May through October. Another option is to contract the work to an organization that routinely collects water quality and water quantity measurements. Where a relationship already exists with a nearby State or Federal agency, monitoring could be contracted to this agency. The Water Monitoring Coordinator at NETN, however, must remain in contact with the contracted agency to ensure that consistent protocols are being followed, and data are being entered or transferred appropriately. All staff decisions are evaluated for technical expertise, ability to collect water samples on a consistent and dependable basis, and program budgetary constraints.

As of 2012, NETN's field staffing consists of two Field Crew Leaders (GS-7 Hydrologic or Physical Science Technician) and a seasonal GS-5 Physical Science Technician. One Field Crew Leader and the seasonal technician are duty stationed at Acadia NP (both positions are fiscally shared with ACAD since a portion of their duties includes air monitoring and other tasks that are not part of this protocol), and they are responsible for monitoring the 36 sites in Acadia. The second Field Crew Leader is duty stationed at Marsh-Billings-Rockefeller NHP and monitors the sites in the remainder of NETN ("Lower NETN" or "LNETN") parks. The LNETN Field Crew Leader is accompanied in the field by host park or NETN staff, interns, or volunteers.

Any staff that are responsible for obtaining water quality measurements or water-discharge measurements under any of the models listed will have, or obtain, training as a hydrologic technician. Minimum qualifications for a hydrologic technician are: (1) be highly organized, and comfortable interacting with a wide range of people; (2) have adequate field sampling experience under rigorous conditions and be able to conduct reconnaissance surveys to evaluate the best locations within sites for water resources data collection; (3) be experienced in operation, maintenance, and calibration of multiparameter water quality equipment to perform routine field water quality measurements such as water temperature, specific conductance, pH, and DO; (4) be able to use well-defined methods and procedures to collect and process field water quality samples and perform limited field or laboratory analyses of sample constituents; (5) be able to

collect discharge measurements, and have experience making routine measurements of stage and discharge under a variety of field conditions applying established uniform methods; and (6) be able to use, maintain, and calibrate Price Pygmy and SonTek FlowTracker current meters and to make judgments regarding the best instrument or method to use in each situation.

It is preferable to conduct all water quality and quantity sampling in teams of two because of the inherent safety risks involved with working around water. Monitoring can, however, be done by one experienced hydrologic technician who is familiar with all safety protocols if samples can be collected or measurements made from the shore or when the water velocity is slow and the depth is shallow. When two staff members are used, the Field Crew Leader is responsible for crew safety, sample scheduling, equipment maintenance and calibration, and performance of all sample collection activities in accordance with procedures and QA/QC requirements specified in the appropriate SOPs. Field Crew members are responsible for carrying out the instructions of the Field Crew Leader and informing the Field Crew Leader of any unsafe conditions, equipment, or other problems observed that could jeopardize the health and safety of the crew or the quality of sample collections. Short-term or temporary Field Crew members need not have extensive training for water quality or quantity monitoring, but must receive safety training requirements described in the following section on *Health and Safety Training*.

Training, equipping, and retaining water monitoring staff by NETN is essential to acquiring high quality data. Staff turnover requires additional training, and could negatively affect data quality (National Park Service 2002).

Field Crew Training

Training includes safety training and field methods training. Hands-on training of new staff is scheduled, whenever possible, before the monitoring season begins.

Health and Safety Training

All monitoring staff should be physically fit and capable of conducting rigorous physical work in potentially adverse conditions. Hazard communication training is required for all staff working with chemicals or working in or around a laboratory. An online version is offered by National Oceanic and Atmospheric Administration (NOAA) at: http://www.labtrain.noaa.gov/ (accessed 19 November 2012). The Field Crew Leader at ACAD must obtain a U.S. Department of the Interior (DOI) approved Motorboat Operator Certification (MOC, 5-year certification), and all staff working in or near surface water should receive basic water safety training. Field crews are strongly encouraged to receive training in Basic First Aid (3-year certification) and CPR (1-year certification). Classes are offered by the Red Cross and other organizations.

Field crews are provided with, and instructed on the use of several forms of communication and emergency location equipment, including radios, cellular phones, and personal locator beacons. Training on communication includes preferred methods for each park or site, daily check-in and check-out requirements, and emergency communication procedures.

All staff must be informed that field work may expose the incumbent to extreme weather conditions such as rain, snow, extreme temperatures, and hazards such as flooding, ice, tick and insect bites, and that field work also involves moderate risks such as measuring in swift streams, and slip/trip/fall hazards when hiking to and from monitoring sites. Special safety precautions are

required in and around water, and crew members must wear life jackets and other personal protective equipment (PPE) designed for each particular work assignment. Monitoring sites are often isolated and occasionally difficult to reach. Field Crew members are required to discuss routine safety precautions and actions to be taken in an emergency with the Field Crew Leader. All staff are informed as to the risks and protection measures for Lyme disease. All staff are encouraged to participate in any safety trainings offered or required by the NPS and the park in which they are working.

Field Methods Training

All staff collecting water quality or water quantity data should have formal training and some period of field apprenticeship to be able to correctly calibrate and operate field equipment, implement sampling procedures, and document the field protocols used and sampling results with the necessary metadata. Field training is necessary to ensure that the most representative measurements possible are made, and that data are consistent and comparable throughout NETN. Crews must have training in methodologies for (1) collecting and processing samples of surface water for water quality analyses, (2) obtaining *in situ* field water quality measurements with a multiparameter probe and (3) collecting stage and discharge measurements. Such training includes the theory, methodology, and equipment used to measure stream flow, stream stage, lake levels, water temperature, specific conductance, DO, and pH. Annual training and apprenticeship for NPS personnel are planned and budgeted before execution of monitoring activities by NPS staff. In addition, field crews must review all SOPs included in this protocol to become familiar or reacquainted with established monitoring methods, and any updates since the previous field season. Field staff must be familiar with travel directions to the sites.

Field crews are trained in the use of the water quality probes and current meters, and must become familiar with the manufacturer's instructions for calibration and operation of the specific equipment planned for use in the monitoring effort. Experience in equipment handling, calibration, and operation of the sondes, probes and meters is best obtained through a combination of apprenticeship, trainings, testing of the equipment at the office, and becoming familiar with the manufacturers equipment operation and maintenance manual before entering the field. Improper handling and storage of the multiparameter sonde and probes can lead to equipment damage or premature sensor failure. All staff involved in water quality instrument calibration and maintenance should receive training from the vendor or be supervised by someone who has recently completed training (such as the Field Crew Leader).

Information on continuous-record stream flow gaging stations (continuous gaging stations) and the collection of discrete discharge measurements is included in this protocol (*SOP 9 – Collecting Stream Flow and Stage Data*). This SOP, however, must be used in combination with the instruction manuals for all field equipment, guides for the collection of stream flow data (Rantz et al. 1982), and a period of apprenticeship and training with qualified hydrologic technicians. If the collection of stream flow data is not to be contracted to an organization that routinely collects and analyzes stream flow data, it is recommended that the technicians making these measurements be overseen by such an organization. This would include routine annual reviews of data collection and analysis methods, equipment calibration, and refresher courses.

Inventory and Purchase of Supplies and Equipment

The inventory and purchase of supplies, equipment, and services are planned several months in advance of the field season. This early planning ensures adequate lead time for equipment that needs to be ordered, replaced or sent for factory servicing or calibration. Preseason preparation is detailed in *SOP 3 – Preparation and Equipment List* and includes the following: (1) inventory equipment listed in SOP 3; (2) contact the laboratory to coordinate delivery of clean sample containers; (3) confirm that any necessary vehicles, watercraft and other associated field gear will be available and operational for scheduled monitoring trips; (4) check expiration dates and quantities of field chemicals and supplies and replenish or replace as necessary; and (5) install new batteries in all meters and other electronic gear.

Calibration of Equipment

All equipment, including the water quality sonde and all sensors and thermometers must be reassembled after winter storage, calibrated, and tested for accuracy each year before the field season begins. All instruments must be accurate within the standards listed in Table 22. Most equipment needs to be regularly recalibrated throughout the field season.

Table 22. Stabilization criteria for recording field measurements.

Standard direct field measurement	Stabilization criteria for measurements (variability should be within value shown)
Temperature:	
Thermistor thermometer	± 0.2° C
Liquid-in-glass thermometer	± 0.5° C
Specific conductance:	
When ≤ 100 µS/cm;	± 5 percent
When > 100 µS/cm	± 3 percent
pH:	
Meter displays to 0.01	± 0.2 standard pH units
Dissolved Oxygen:	
Amperometric method	± 0.3 mg/L

Instructions in the SOPs of this protocol for calibrating and operating sampling and field measurement equipment are not intended to replace those of the manufacturer but are to be considered as supplementary information. Field staff must be familiar with the instructions provided by equipment manufacturers. This protocol provides only generic guidelines for general equipment use and maintenance and focuses on particular instruments that currently are in common use for NETN monitoring. There is a large variety of available field instruments and many are frequently updated or replaced with newer technology. Field staff are encouraged to contact equipment manufacturers for answers to technical questions.

Field measurements will only be made with calibrated instruments. Each field instrument must have a permanent log book for recording calibrations and repairs. Staff must review the log book before leaving for the field. Monitoring staff will test each instrument (meters and sensors) before leaving for the field and practice the measurement method if the instrument or measurement is new to any member of the field crew who will be performing those

measurements. Having backup instruments readily available and in good working condition will prevent loss of data if equipment has to be sent to the manufacturer for repair. Additional calibration is required at the field site for most instruments.

Sampling Schedule

Lake and pond monitoring begins before spring turnover of dimictic lakes (as soon as possible after maximum snowmelt runoff) and continues through fall turnover, a period that normally extends from late April to late October. Stream sampling occurs during the months that are generally without ice, from May through October. In southern parks such as parks in Connecticut and/or New Jersey, it may be possible to extend this season into April to catch a sample during spring runoff. In ACAD this earlier sampling schedule may be challenging because of inaccessibility of sites due to road closures, but can be considered where feasible.

April monitoring is not currently conducted by NETN, except for the lake acidification study at ACAD. Inclement weather and staff workloads preclude the scheduling of sampling events to specific annual dates, however all lake and pond sampling is ideally accomplished during the same 2 weeks of each month for each park (for example the middle 2 weeks from the 8th to the 21st), and all stream sampling during the same week of each month (for example, the 1st week from the 1st to the 7th). Sampling can occur in a different 2-week period in different parks. Tentative sampling dates are scheduled and logistics organized before the start of each field season.

Grab samples and depth-integrated epilimnetic samples (in lakes) are taken during two trips, once in May and once in August for streams, and once in June and once in August for lakes and ponds. These grab samples must be treated according to laboratory instructions with regard to filtering and chilling and sent to a laboratory within the specified time for analyses.

A two-person crew (ideally one person to observe and sample and one to assist and record data) is normally required for lake and pond monitoring. A moderately deep lake will require approximately 2 hours for a complete monitoring visit, while LNETN ponds typically take 45 minutes. Generally two and a maximum of three lakes are scheduled to be monitored on each field day. All monitoring is performed between 0900 and 1500 hours to provide consistent observation windows for the SD measurement.

Stream sampling can be conducted any time during daylight hours. A one-person field crew may conduct stream sampling unless a discharge measurement is to be made during high water or the site is located in a very remote area. A two-person field crew is mandatory in these instances for safety reasons. Two-person crews are preferred for all monitoring activities since it is always helpful to have assistance with carrying equipment, and recording data.

Determine which sites will be sampled each day on the basis of the most efficient travel logistics. If monitoring a site during the narrower target window each month cannot be conducted because of weather or other scheduling constraints, schedule data collection later in the month. If, however, no data were obtained for a month, it is not worthwhile to obtain two sets of samples during the following month. Contact the NETN Water Monitoring Coordinator for guidance in this situation.

Facility and Equipment Needs

In addition to the equipment listed in *SOP 3 – Preparation and Equipment List*, suitable facilities are required for storing and calibrating equipment and supplies. This includes an appropriate way to dispose of standards and other chemicals used for equipment calibration. None of the standards or other chemicals currently used by NETN for this protocol require special disposal, and they can be safely discarded down a sink. Storage shelves and a bench top or table are also needed; these should be kept clean and placed in a low traffic area or room.

Startup Costs and Budget Considerations

Because of the equipment required, this protocol has significant startup costs. Major equipment includes current meters ($9,000 each), multiparameter sondes ($9,000 each), an autolevel and leveling rod ($3,000), and equipment for light penetration profiles ($2,000 each). Several thousand dollars are needed for additional startup equipment, including turbidity probes, digital cameras, thermometers, waders, and other durable supplies (see *SOP 3 – Preparation and Equipment List*).

A rough budget for annual monitoring follows:

- Personnel
    - Water Monitoring Coordinator - $31,000
    - Field Crew Leader (ACAD) - $14,000
    - Field Crew Leader (LNETN) - $43,000
    - Field Crew (ACAD seasonal) - $11,000
    - Field Crew (LNETN intern) - $13,000
- Travel
    - GSA Vehicle Lease - $7,000
    - Per Diem - $8,000
    - Lab Analyses - $17,000
    - Equipment and Supplies - $6,000
    - TOTAL - $150,000

Version Control Procedures

Until version 3.00 of the protocol narrative and SOPs, all sections had the same version number. This system does not match the convention used for other NETN protocols, so beginning with version 3.00, the narrative and SOPs can each have different version numbers. The entire protocol is archived at the beginning of each field season, so that it is clear what version of the protocol was in use at what time. Also beginning with version 3.00, the date of any changes will be recorded, to further facilitate matching procedures with the appropriate field season.

The version number of the narrative or an SOP will be changed following any major or minor revision. Major revisions, such as a change in method or instrumentation, are designated by whole numbers (e.g., version 3.00 to 4.00). Minor revisions such as editorial changes increase incrementally by hundredths (e.g., version 1.01to 1.02). If there are no changes to the narrative or an SOP, the version number does not change. All changes made to a protocol or SOP are documented in each new version. All revisions are provided to the Northeast Region I&M Program Manager, who will make a determination regarding whether internal or external review is required. Version changes to SOPs and protocols are tracked in the format given in Table 23:

Table 23. Version Tracking Table (Sample).

Version Number	Version Date	Sections changed	Changes from previous version
1.00	12/30/04	NA	NA

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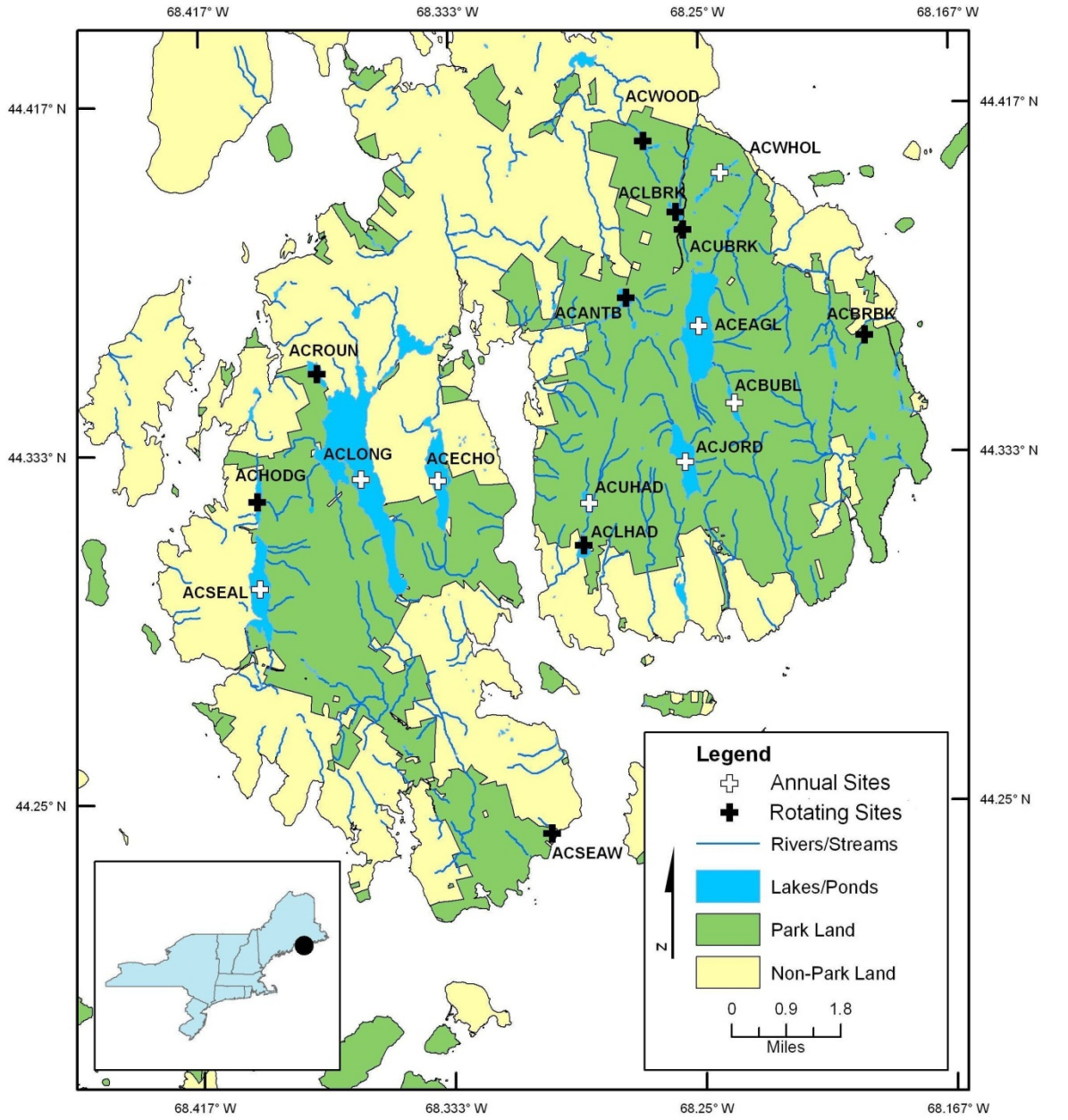
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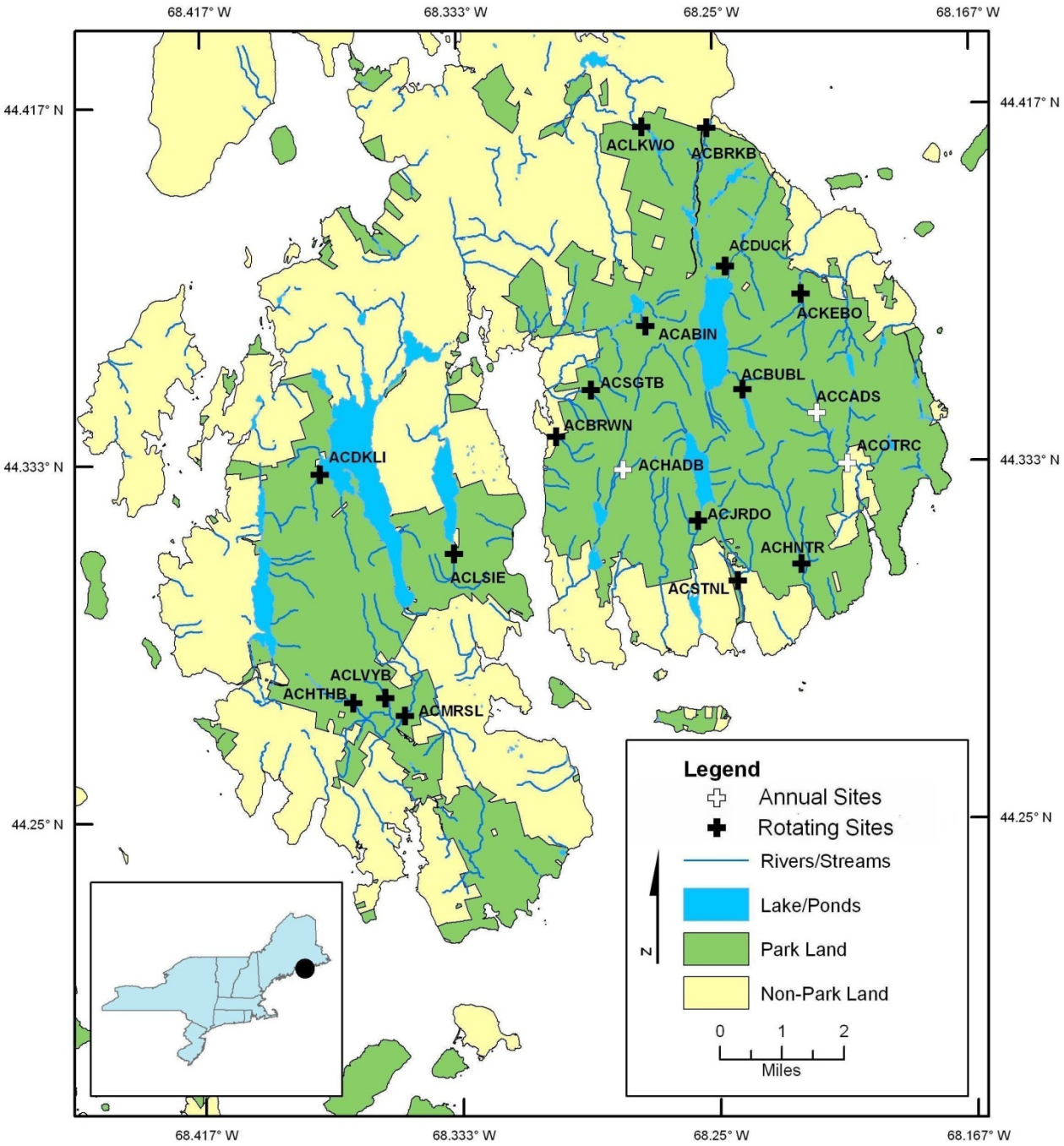
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Appendix A. Maps of Monitoring Locations for all Northeast Temperate Network Parks



ACANTB – Aunt Bettys Pond
ACBRBK – Bear Brook Pond
ACBUBL – Bubble Pond
ACEAGL – Eagle Lake
ACECHO – Echo Lake
ACHODG – Hodgdon Pond
ACJORD – Jordan Pond
ACWOOD – Lake Wood
ACLONG – Long Pond (MDI)
ACLBRK – Lower Breakneck Pond
ACLHAD – Lower Hadlock Pond
ACROUN – Round Pond
ACSEAL – Seal Cove Pond
ACSEAW – Seawall Pond
ACUBRK – Upper Breakneck Pond
ACUHAD – Upper Hadlock Pond
ACWHOL – Witch Hole Pond

Figure A1. Location of lake sampling sites at Mount Desert Island, Acadia National Park, Maine.



ACABIN – Aunt Bettys Pond Inlet
ACBRKB – Breakneck Brook
ACBRWN – Browns Brook
ACBUBL – Bubble Pond Outlet
ACCADS – Cadillac Stream*
ACDUCK – Duck Brook
ACDKLI – Duck Pond Brook
ACHADB – Hadlock Brook*
ACHNTR – Hunters Brook
ACHTHB – Heath Brook
ACJRDO – Jordan Stream
ACKEBO – Kebo Brook
ACLKWO – Lake Wood Outlet
ACLVYB – Lurvey Brook
ACLSIE – Lurvey Spring Brook
ACMRSL – Marshall Brook
ACOTRC – Otter Creek*
ACSGTB – Sargent Brook
ACSTNL – Stanley Brook
Continuous record site

Figure A2. Location of stream sampling sites at Mount Desert Island, Acadia National Park, Maine.

Appendix A. Maps of Monitoring Locations for all Northeast Temperate Network Parks (continued).

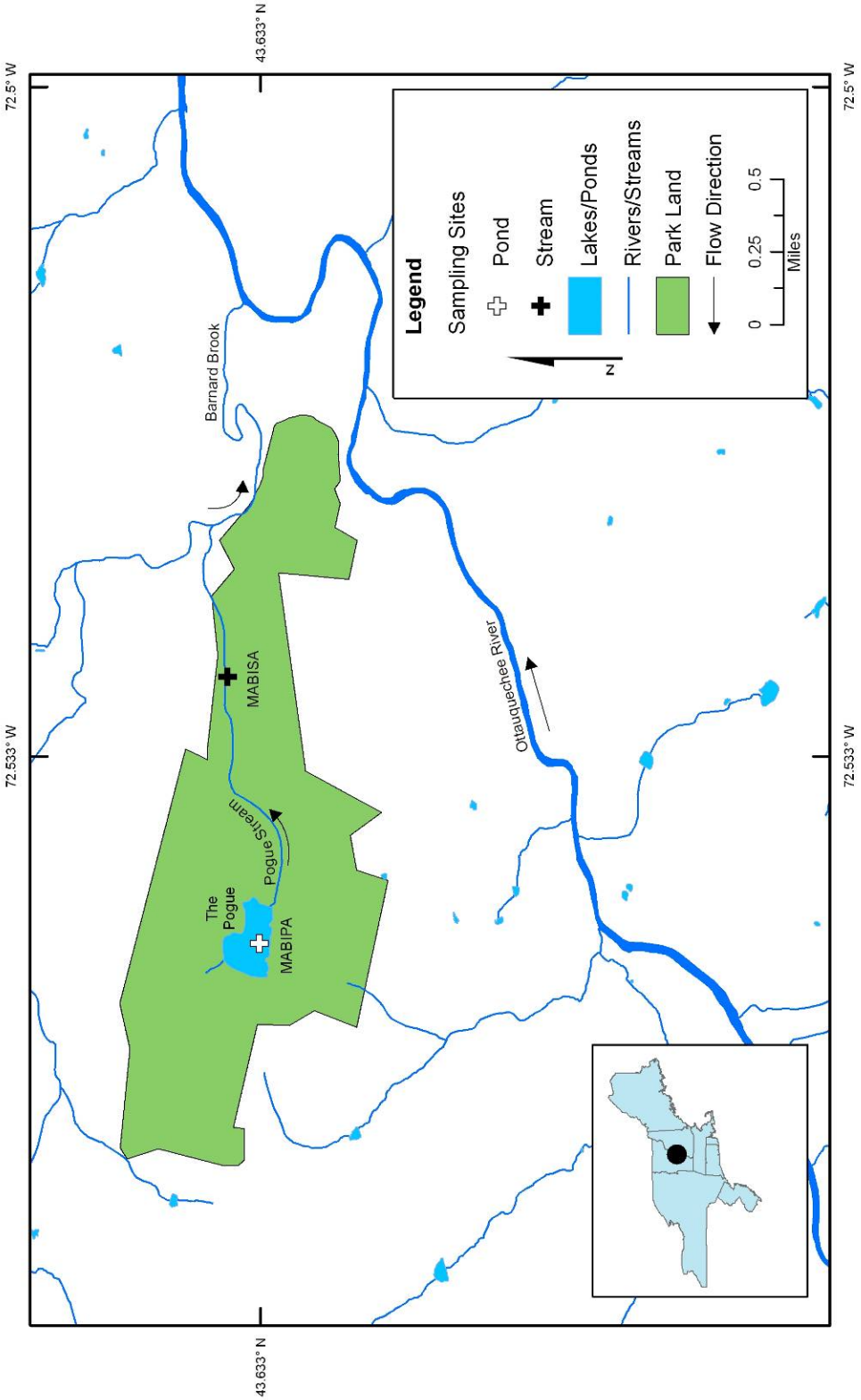


Figure A3. Location of pond and stream sampling sites at Marsh-Billings-Rockefeller National Historical Park, Vermont.

Appendix A. Maps of Monitoring Locations for all Northeast Temperate Network Parks (continued).

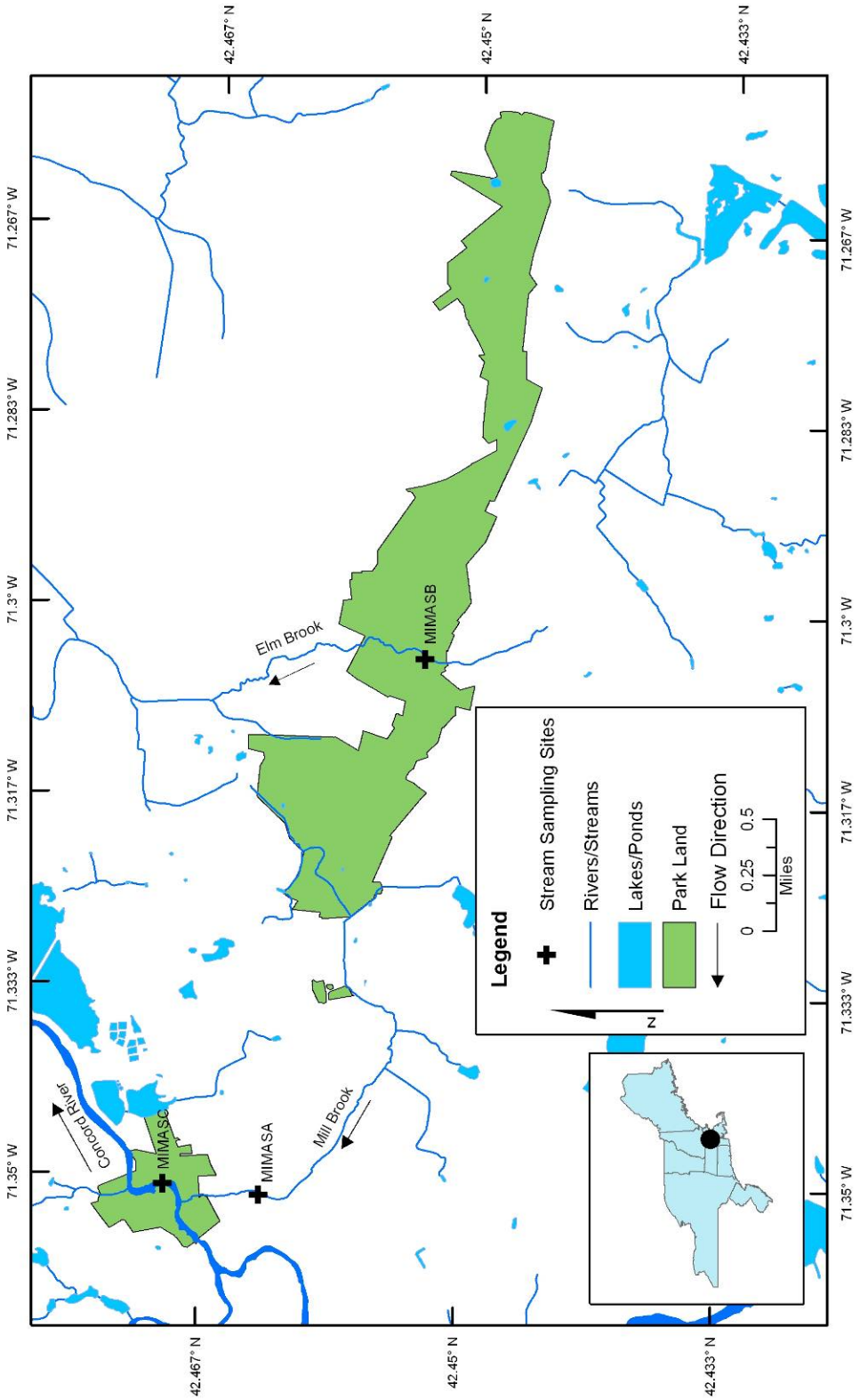


Figure A4. Location of stream sampling sites at Minute Man National Historical Park, Massachusetts.

Appendix A. Maps of Monitoring Locations for all Northeast Temperate Network Parks (continued).

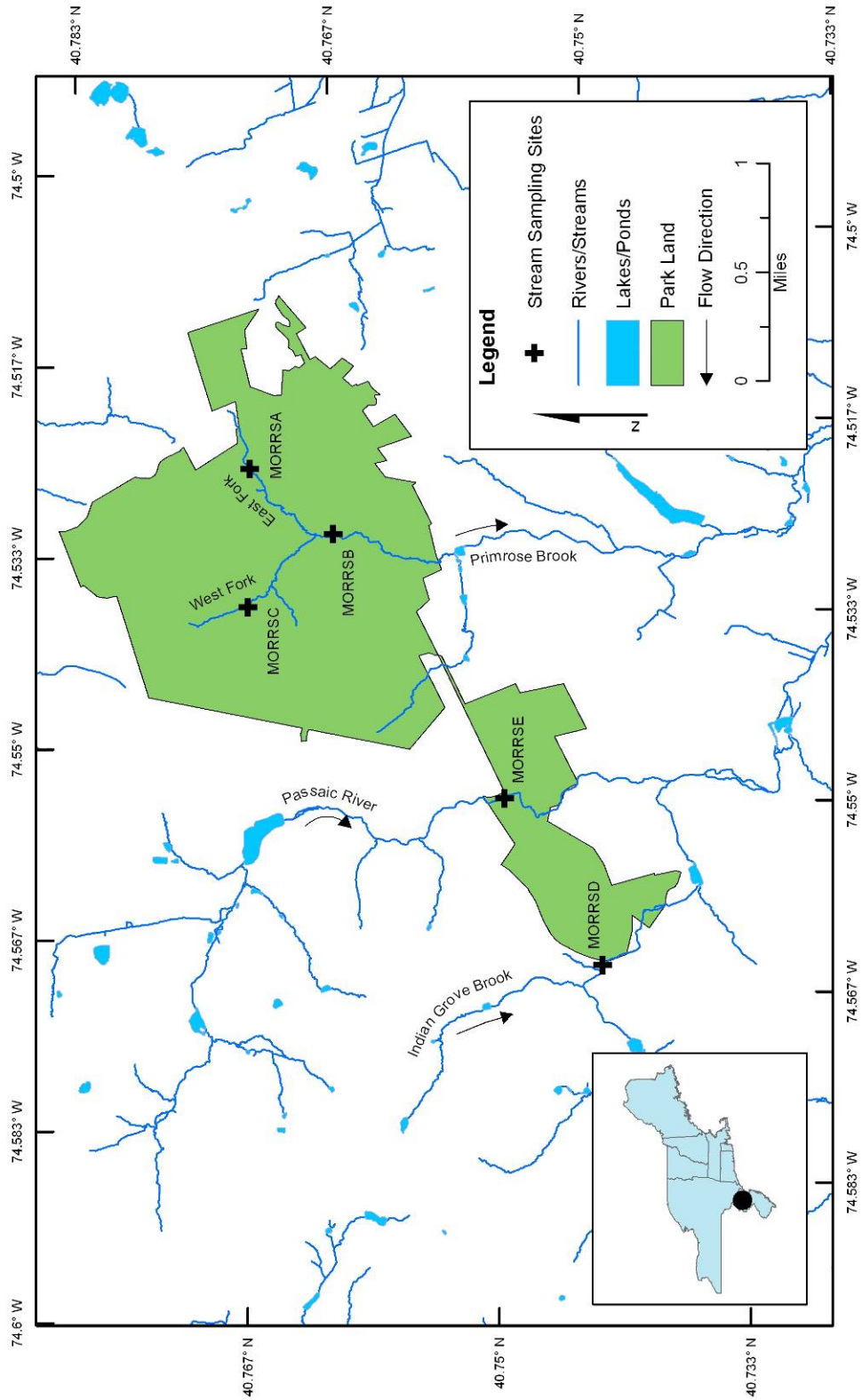


Figure A5. Location of stream sampling sites at Morristown National Historical Park, New Jersey.

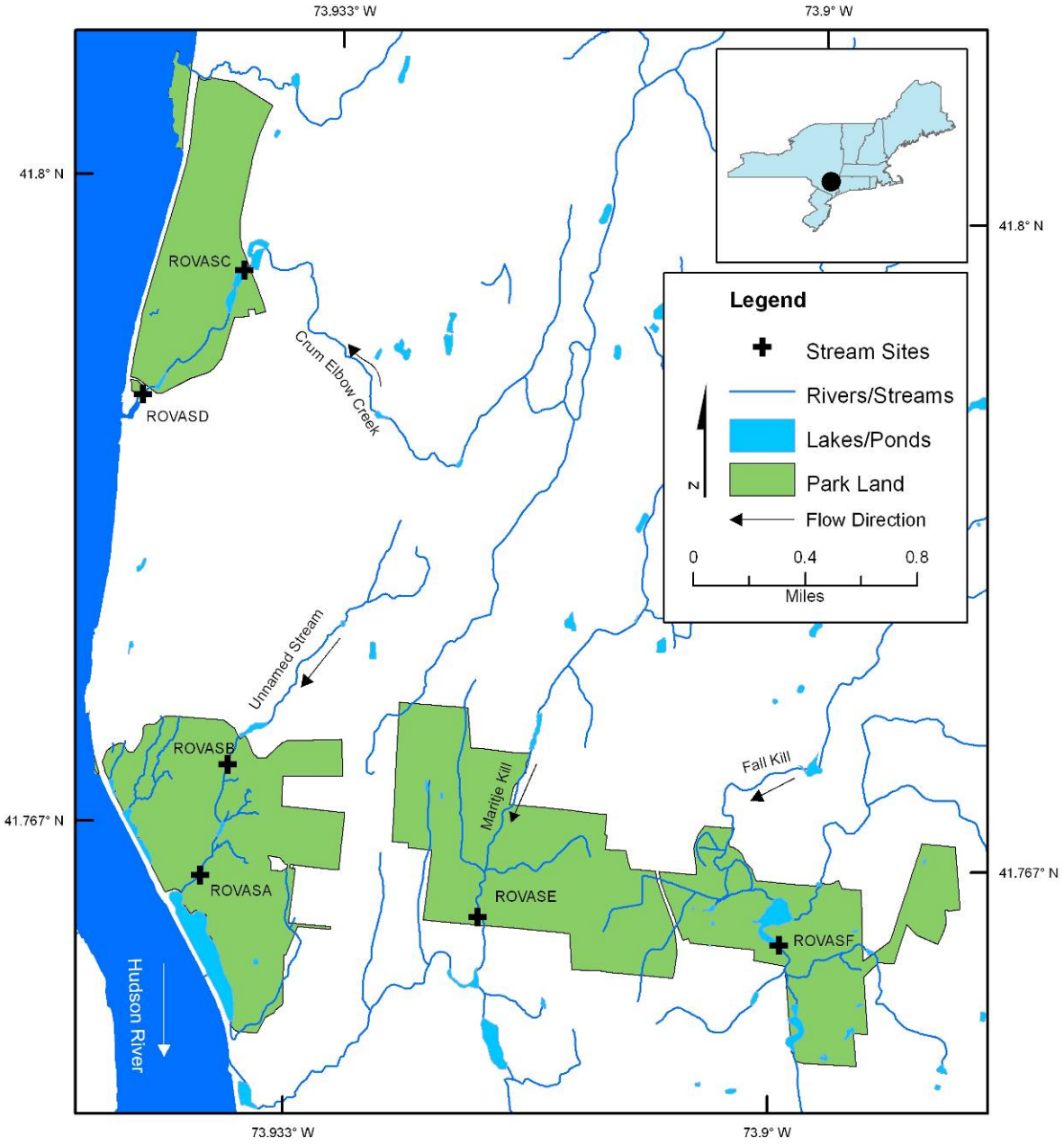


Figure A6. Location of stream sampling sites at the Roosevelt-Vanderbilt National Historic Sites, New York.

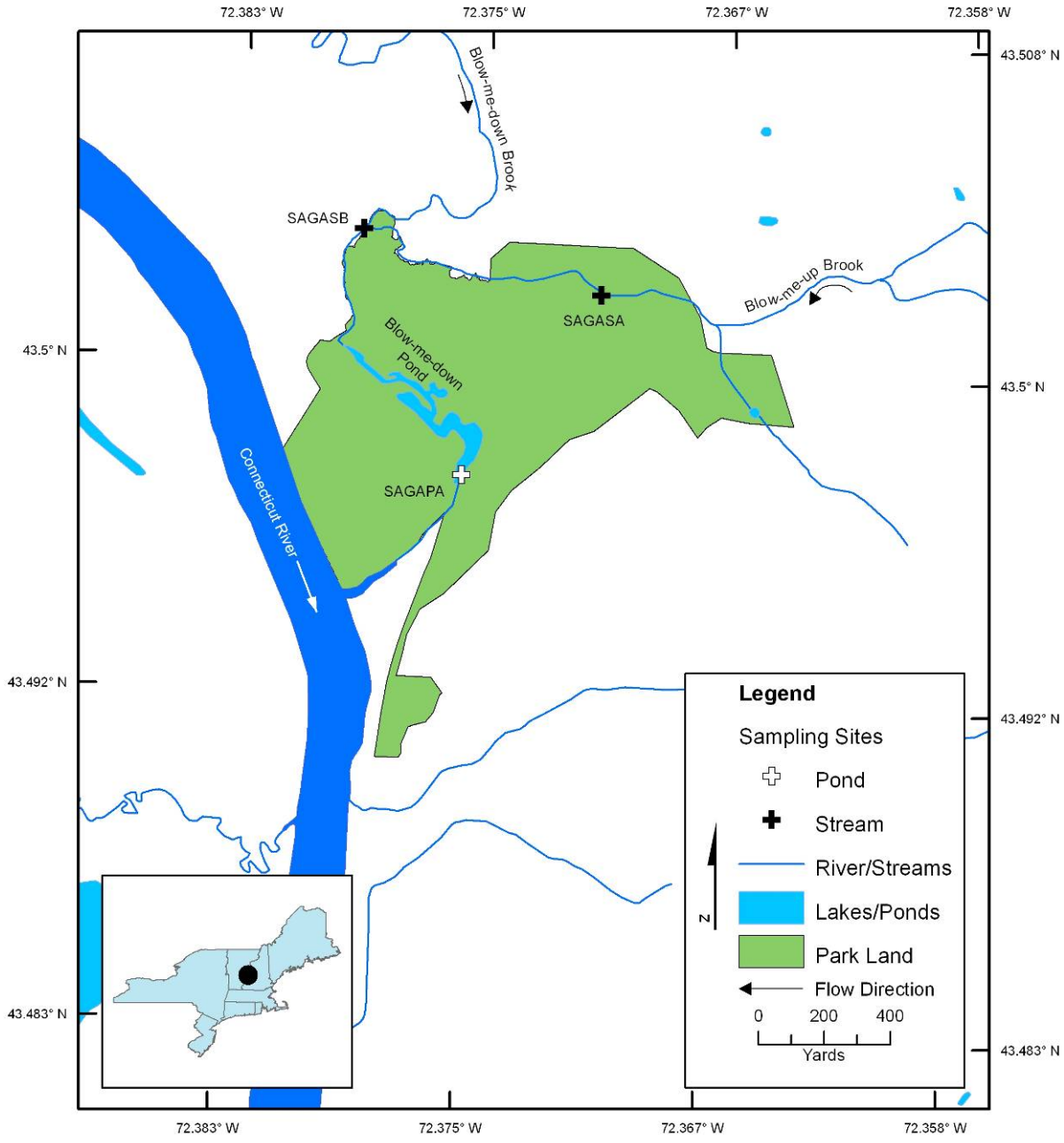


Figure A7. Location of stream and pond sampling sites at Saint-Gaudens National Historic Site, New Hampshire.

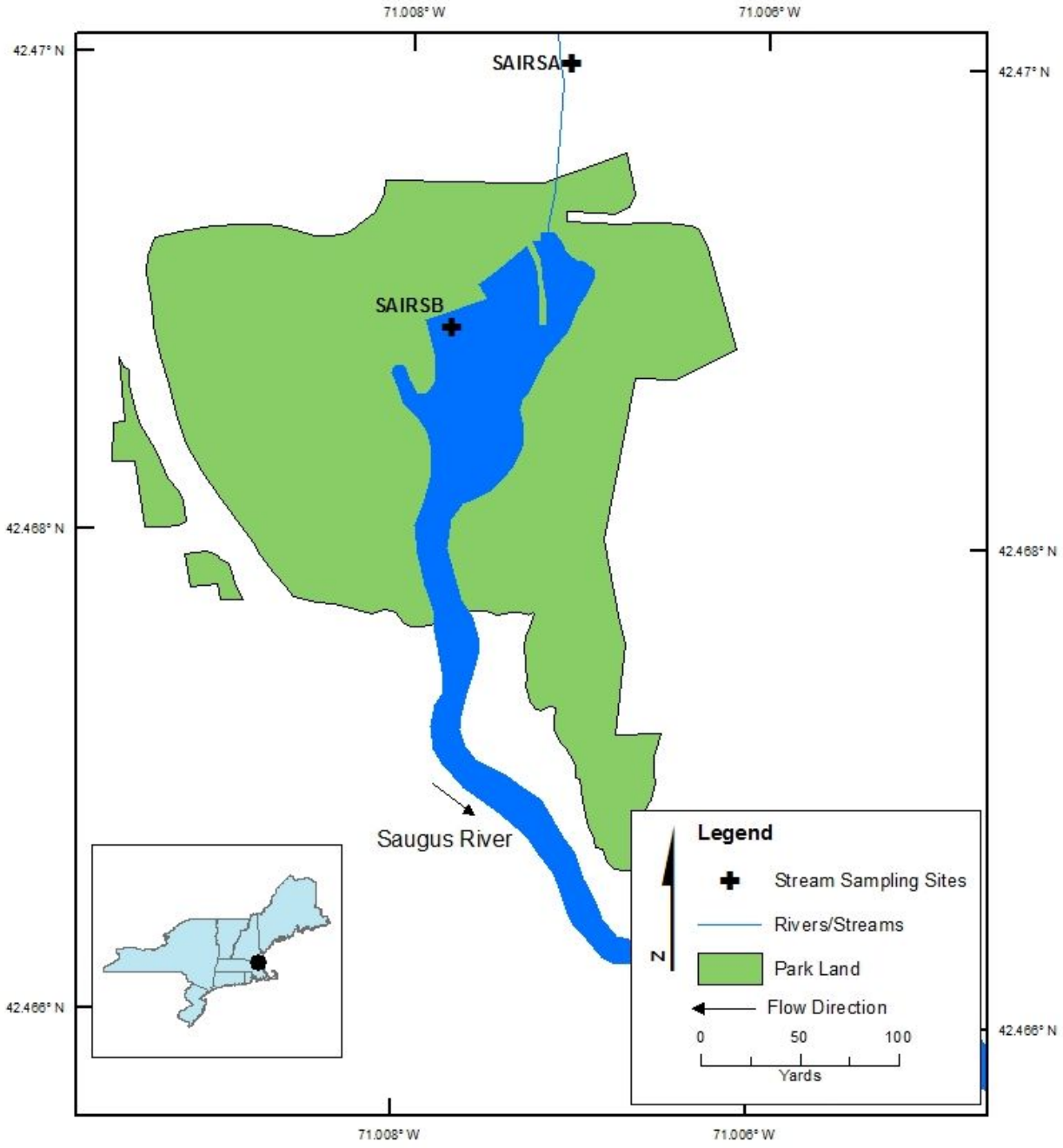


Figure A8. Location of stream sampling site at Saugus Iron Works National Historic Site, Massachusetts.

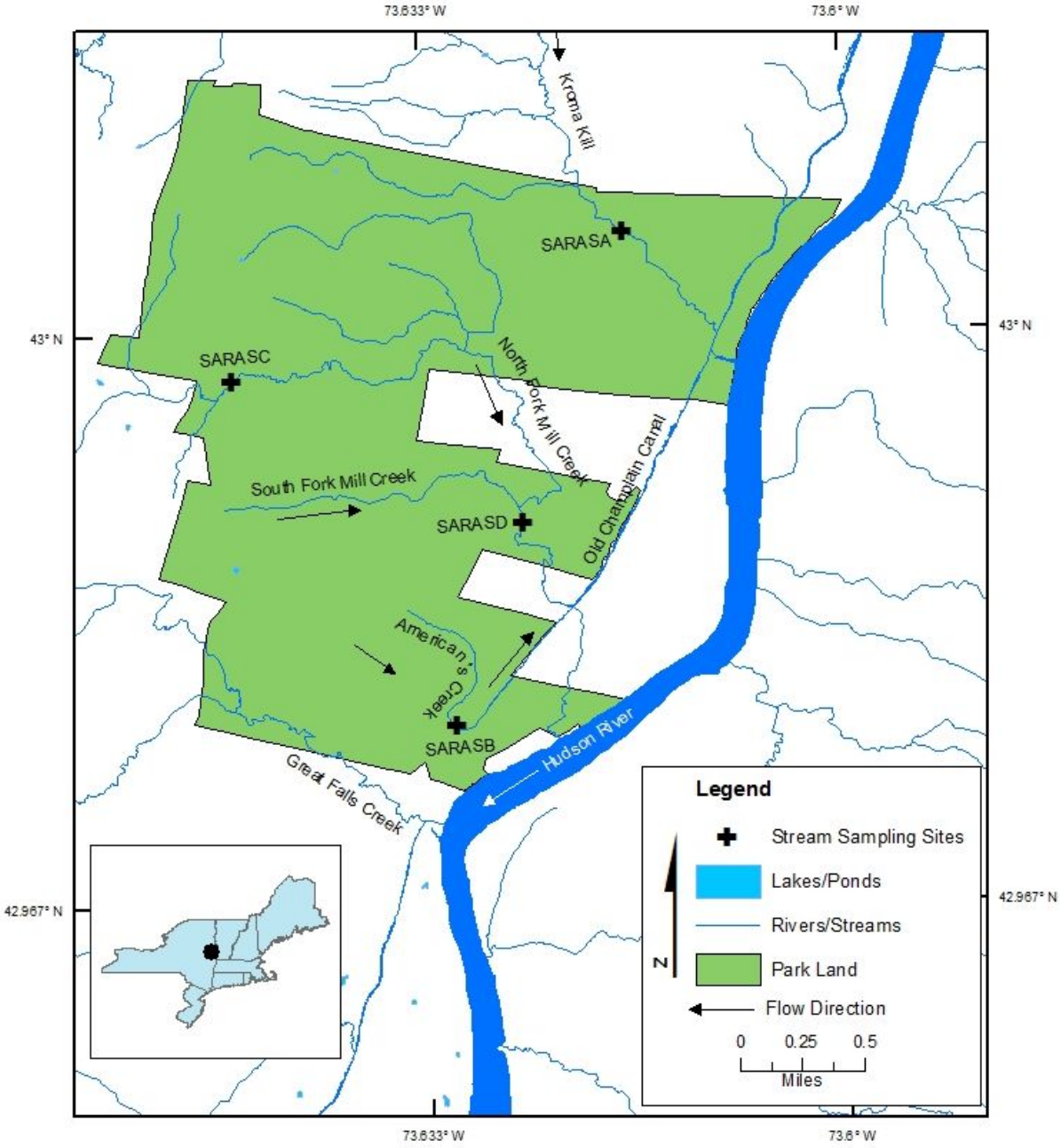


Figure A9. Location of stream sampling sites at Saratoga National Historical Park, New York.

Appendix A. Maps of Monitoring Locations for all Northeast Temperate Network Parks (continued).

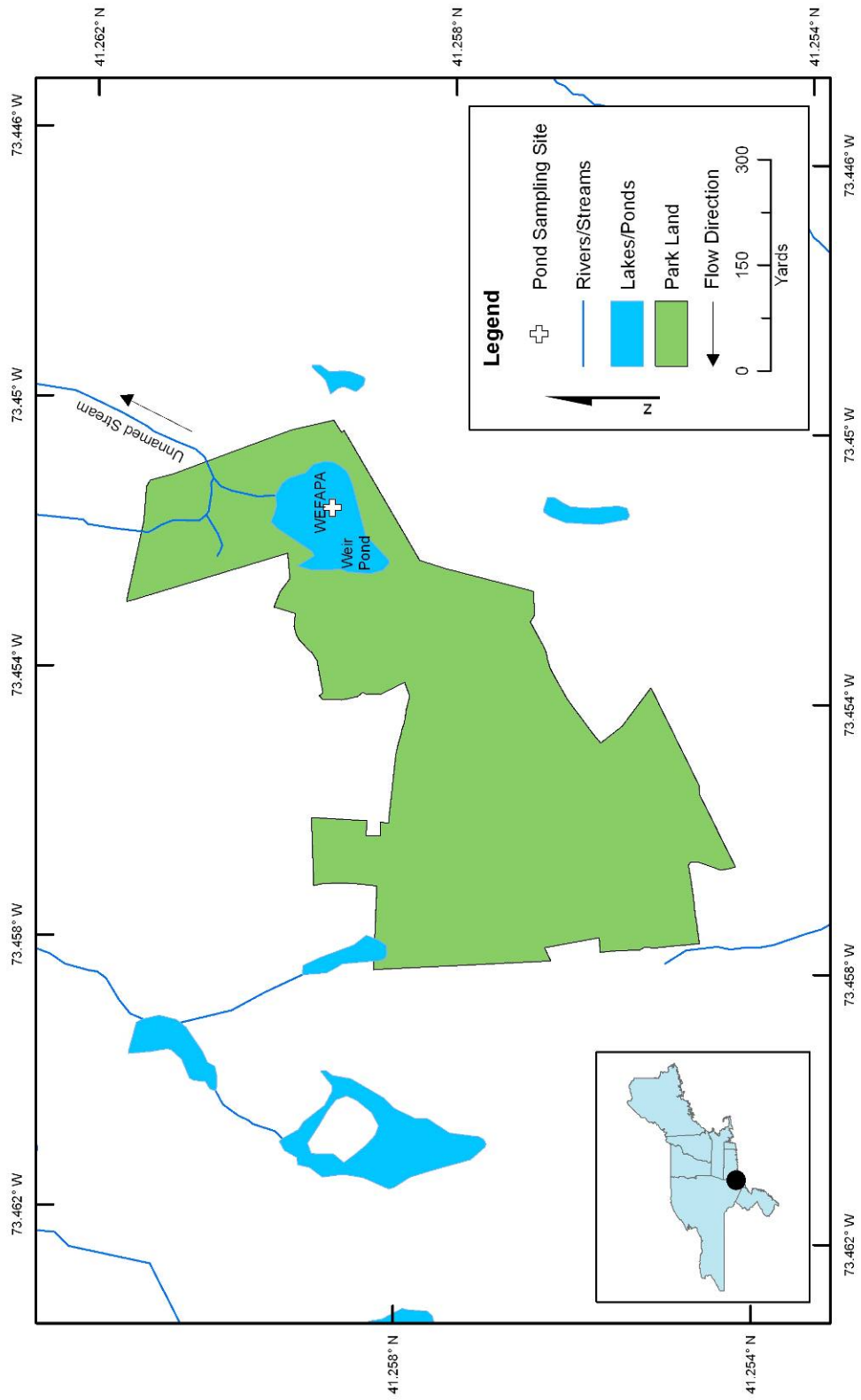


Figure A10. Location of pond sampling site at Weir Farm National Historic Site, Connecticut.

Appendix B. Revision Log

Version 1.0 to 2.0 (Brian Mitchell, Bill Gawley, Emily Seger, and Joe Bartlett; March 2007)

Updated title page and version number

1.1: Added Appalachian NST to list of parks, plus comment that A.T. is outside of the scope of this protocol.

1.1.7.1: Secchi Disk Depth: Added comment that SD does not work outside of ACAD, and that we will begin using a transparency tube in 2007. Added citation for transparency tube.

1.1.7.9: Other Nutrients: This section is new, and is a placeholder until documentation of the rationale for the additional nutrient measures can be added.

1.2.1: 4th paragraph: Outside of ACAD, ponds measured April (not May) to October, conditions permitting. Two impoundments at ROVA (rather than one) will not be monitored, due to shallow depth and detectable flows.

1.2.2: 3rd paragraph: Stream measurements April to October, conditions permitting, not May to October.

Table 9: MIMA has three sites now, with addition of Concord River.

MORR has five sites now, with addition of Passaic River.

SARA has four sites now, with removal of Devil's Hollow.

ROVA has six sites now, with removal of ELRO pond.

Table 12: Updated with current site identifiers.

1.2.3.3: MIMA – Added information about Mill Brook site, Concord river site and methods, and Elm Brook site.

Table 13: Updated site identifiers and add Mill Brook site.

1.2.3.4: MORR – Updated site info in paragraph 2. Passaic River site description is still needed.

Table 14: Updated site identifiers and added Passaic river site.

1.2.3.5: ROVA – Updated site information in paragraph 2.

Table 15: Updated site identifiers and remove pond site.

Table 16: Updated site identifiers.

1.2.3.7: SAIR – Updated to reflect twice yearly nutrient samples and sonde samples, and possibility of samples at the turning basin.

Table 17: Updated site identifier.

1.2.3.8: SARA – Updated site information, including removal of Devil's Hollow.

Table 18: Updated site identifiers.

Table 19: Updated site identifier.

1.3.1: Paragraph 2: added that pond samples will be grabs.

Table 21: Transparency tube for clarity measurements if Secchi disk can't be used.

1.6.6: Paragraph 3: stream grab samples only in May (not earliest trip of season).

Literature Cited: Added Dahlgren paper on transparency tubes.

Appendix : This Appendix is new, and documents revisions to the protocol.

Version 2.00 to 2.01 (Brian Mitchell, March 2007):

Section 1.1.7.7: Added mg/L to ueq/L conversion factor

Version 2.01 to 2.02 (Brian Mitchell, April 2009):

1.2.3.1.1: Revised table 10 to match format of other tables in this section.

1.2.3.1.2: Revised text to include operational dates of USGS gages, and note that NPS-operated pressure transducers are installed at Cadillac Brook and Hadlock Brook.

1.2.3.7: Water samples and sonde measurements will be taken twice per year at Saugus, at the turning basin and at the USGS gage. The turning basin restoration project occurred between the 2007 and 2008 sampling years.

Version 2.02 to 3.00 (Brian Mitchell and Bill Gawley, November 2012):

Narrative reorganized to match standardized NETN format.

Numerous edits to clarify the text.

Clarified ecoregional nutrient standards with additional text.

April sampling is no longer conducted outside of ACAD (only happened one year). ACAD April sampling is limited to lake acidification study.

Water clarity methods changed, effective for the 2012 field season: light penetration profiles now collected at all ponds where SD not found. Stream turbidity is measured at all stream sites. Use of the transparency tube has been discontinued.

Water quality analytes changed, effective for the 2012 field season: TDP, ortho-P, and TDN were dropped. Chloride and sulfate were added. Chlorophyll a is now measured in all ponds and lakes, not just ACAD sites.

Changes to sites:

- ACAD Stanley Brook (ACSTNL) is now a permanent site, sampled every year (2011)
- ACAD Man of War Brook (ACMOWB) has been discontinued (2011)
- ACAD Duck Brook Outlet of Eagle Lake (ACEGLO) moved and renamed Duck Brook – North of Rt. 233 (ACDUCK) between 2007 and 2009 sampling years
- ACAD Lurvey Spring Brook inlet to Echo Lake (ACLSIE) switched to Year 2 panel from Year 1 panel to balance the number of sites in each panel (2011)

Added section on Detectable Level of Change to Sampling Design.

Added section on Facility and Equipment Needs to Personnel and Operational Requirements.

Added section on Startup Costs and Budget Considerations to Personnel and Operational Requirements.

Significantly revised Version Control Procedures: Instead of an overall "protocol version", there are separate version numbers for the narrative and each SOP. These numbers are updated only if there is a minor (in increments of one hundredth) or major (in whole number increments) changes to the protocol. The new procedure matches version control methods used for other NETN protocols.

Version 3.00 to 3.01 (Brian Mitchell, December 2013):

Numerous minor edits and clarifications to address comments from Jim Comiskey, Marian Norris, and Hali Roy as part of the NPS review needed prior to publishing the revised protocol.

Six sites were removed from regular monitoring during the annual review (see text for each park for documentation): ACBUBO, ACJRDO, MORRSA, MORRSC, ROVASC, and SARASB.

Removed unused acronyms from List of Acronyms

For consistency, refer only to "non-native invasive" or "invasive" species; "exotic" is no longer used.

Revised justification text and Tables 1 and 2 for clarity and to reflect current metrics.

Revised Tables 3 and 4 and state standards section to include most recent state standards.

Updated Table 9 to reflect correct numbers of sites.

Added Temperature and Non-Native Invasive Plants sections to "Water Quality Parameters".

Detailed directions to MORR sites removed, since this level of detail is not provided for other parks.

Removed discussion of potential trend and range of variability analyses for historic ROVA data.

Removed details of the SAGA water sampling review recommendations.

Revised power analysis section to include a 2015 due date (rather than 2014), and a new power target of 50% change in 5 years (rather than 2) with type I error at 10% (rather than 20%) and type II error at 20%.

SOP Revisions

SOP revisions are also described in the individual SOP tables. However, due to the complete reorganization of the protocol, revisions through version 3.00 of the SOPs are also documented here.

Version 1.0 to 2.0 (Brian Mitchell, Bill Gawley, Emily Seger, and Joe Bartlett; March 2007):

2.3.2.1.2: Site Number = 0 (not 1) for stream sites. Pre-deployment QC check is 89 (Joe used 99 outside of ACAD in 2006), and post-deployment QC check is 99.

2.3.2.2.5: Added informational paragraph at start of section. Acadia uses a 2-point calibration daily, and a 3-point calibration monthly, while other parks use a 3-point calibration daily.

2.3.2.2.6: Added information to start of section. Calibration should be performed weekly, with a 2-point field check each morning.

2.3.2.2.9: In step 5, add information referring to the DO% Local option. This makes it easier to tell if the sensor is within specifications, since it automatically adjusts the DO% for local barometric pressure.

2.3.3: Refer to DO percent local rather than DO percent in step 2 and 3. Inserted step 4 – recording pre-deployment data to site 89. Revised step 6 to include selection of proper site code. Added step 8 – recording post-deployment data to site 99.

2.4.3: Added first sentence; if clean filtering location is not available, samples can be stored and kept cold until a suitable location is available.

Table 25: Lab code changed for total phosphorus; code and reporting limit changed for total dissolved phosphorus, ammonia, nitrite, nitrite + nitrate, orthophosphate.

2.4.5: Added paragraph specifying numbers and times for collection of blanks and replicates, and that replicates should be swapped between labs if multiple labs are being used.

3.1: For first series of steps: Refer to DO percent local saturation in steps 2 and 3. Insert step 4 (log to 89 file). Clarify step 8 (only one point needed in well-mixed, small streams; multiple points only needed for Concord River). Add step 9 (log to 99 file).

3.3.2.1: Added second paragraph, specifying that QC for discharge must be done monthly (one second measurement), plus an additional 3 measurements per field season at a USGS gaged station.

4.1A: Added this SOP (SOP 9A) to cover Transparency Tube readings.

4.2: Changed steps 3 and 4 to refer to DO percent local. Insert step 5 (pre-deployment "89" reading). Insert step 12 (reading just above bottom for shallow ponds). Insert step 13 (post-deployment "99" reading).

5.2: Added information for Sawyer Lab ANC analysis, and specified that the Sawyer lab will process all ANC samples starting in 2007.

5.3: Title changed to apparent color. ACAD samples will be analyzed by Sawyer; others by NWQL. Added information for Sawyer Lab color analysis.

5.4: Updated to correct lab codes. ACAD samples will be analyzed by Sawyer; others by NWQL. Added information for Sawyer Lab color analysis.

5.5: Updated to correct lab codes. ACAD samples for total N and total dissolved N will be analyzed by Sawyer lab. Added information for Sawyer analysis.

5.6: Updated to state that chl *a* analysis is conducted by the Sawyer lab. Added Sawyer lab info.

Version 2.01 to 2.02 (Brian Mitchell, April 2009):

2.1.1: Added contributing (upstream) watershed area to the background stream data.

2.2.2: Updated to reflect monthly photographs of stream sites, and an annual panoramic set of photos for lakes.

2.3.2.2.6: Updated to reflect replacement of probe yearly, with probe from previous year as a backup.

2.3.5.6.4: New section; included info for pH calibration check, describing problem in the field at Acadia and specifying need for low-ionic strength standard and replacing the probe annually.

3.3.2: Revised to reflect use of FlowTracker acoustic Doppler meter outside of Acadia NP, and the use of a Pygmy meter at Acadia (and clarified the discussion of Pygmy versus Price AA meters to indicate that only the Pygmy meter is used).

3.4: Inserted Transparency Tube procedures, SOP 9. These measurements should be made annually, at high flow.

3.5: Inserted placeholder for Rapid Habitat Assessment SOP (number 10). All subsequent SOP's renumbered.

4.1: Incorporated 4.1A into this section, and clarified location and timing of transparency tube measurements.

5.3: Revised to note that all samples were analyzed by SERCL (University of Maine) starting in 2008.

5.4: Revised to note that all samples were analyzed by SERCL (University of Maine) starting in 2008.

5.5: Revised to note that all samples were analyzed by SERCL (University of Maine) starting in 2008.

Version 2.02 to 3.00 (Bill Gawley, March 2012):

ALL SOPs: Reformatted using NRPS-NRR template.

ALL SOPs: Revision history logs are included as the last section of all SOPS. All SOP revision details are now documented in these locations.

ALL SOPs: Explained change to SOP version numbering procedures in first entry of each SOP revision history log: Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP.

NEW SOPs: Created or renamed/restructured the following SOPs:

SOP 1 – Safety (*Rename/restructure*)

SOP 2 –Establishing and Documenting Monitoring Sites (*Rename/restructure*)

SOP 3 - Preparation and Equipment List (*New*)

SOP 4 – Monitoring Streams (*combined several previous SOPs*)

SOP 5 – Monitoring Lakes and Ponds (*combined several previous SOPs*)

SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration (*combined several previous SOPs*)

SOP 12 – Laboratory Analyses (*combined several previous SOPs*)

SOP 14 – Data Reporting and Analysis for Lakes, Ponds, and Streams (*combined several previous SOPs*)

Appendix B. Revision Log (continued).

SOP 15 – Post-Season Activities (*New*)

SOP 16 – Annual Timeline of Activities (*New*)

SOP 17 – Decontamination Procedures (*New*)

SOP 1 – Safety

Northeast Temperate Network

Version 3.01

Definitions (alphabetical)

Designated Office Staff (DOS): Refers to the individual who is designated to remain in the office and available to provide daily field work plans and emergency response services for field teams. The default DOS for the ACAD field team is the protocol lead. The DOS for the Lower NETN field team is the NETN Program Manager.

Crew member: Refers to a member of the water monitoring team who, along with the crew leader, conduct the majority of the field work for this protocol.

Crew leader: Refers to the field team leader for the water monitoring crew. The field crew leader is responsible for planning and making changes to the daily field work plans, communicating those changes to the DOS, and following daily check-in procedures.

Field team: Refers to the 2-3 person group of water monitoring staff who are working together at a sampling location.

Monitoring staff: Refers to all personnel engaged in field activities related to this protocol. This includes National Park Service (NPS) employees, contractors, and volunteers either actively participating in or observing monitoring activities. Volunteers are required to have read and signed a Volunteer Agreement and all monitoring staff must read and sign the Job Safety Analysis before participating in any surveys.

Protocol lead: Refers to the individual responsible for coordinating implementation of the water protocol (NETN Water Monitoring Coordinator). The Protocol lead is responsible for ensuring monitoring staff are properly trained in NPS Safety procedures, and is the default Designated Office Staff (DOS) for the ACAD field team.

Overview

The Northeast Temperate Network (NETN) considers the occupational health and safety of its employees, cooperators, contractors and volunteers to be of utmost importance, and is committed to ensuring that all monitoring staff receive adequate training on National Park Service (NPS) safety procedures, incident reporting, and emergency response prior to field work. This SOP and supporting appendices were designed to provide a summary of safety issues and general hazards for field sampling, as well as hazards that are unique to water monitoring, and to serve as a first reference in case of an incident.

Topics covered include physical hazards common around water and biological hazards, emergency procedures, incident reporting, field preparation, safe field procedures, vehicle safety, and workers compensation procedures. A Job Safety Analysis (JSA), which documents hazards

associated with this protocol and recommends approaches to mitigate these hazards, is included as an appendix (Appendix S1.A) to this SOP. A Green, Amber, Red risk assessment (GAR) has been conducted for this protocol and is included as an appendix (Appendix S1.B). The JSA must be read and signed by all monitoring staff who conduct field work for this protocol, including volunteer assistants who help out occasionally in Lower NETN parks. In addition, Appendix S1.C identifies the nearest hospital facilities to each NETN park, and contains maps and written directions for the most direct route from the park to the hospital. This SOP does not cover first aid.

All safety procedures included in this SOP that are related specifically to working in and around water and water-quality sampling are adapted from Chapter A9 of the USGS National Field Manual. Staff performing hydrologic field work must familiarize themselves with that document found at: http://water.usgs.gov/owq/FieldManual/Chap9/content.html.

Responding to an Incident

Life-Threatening Medical Emergency

- **Call 9-1-1 or park emergency number. If in NETN, use park radios to contact dispatch.** Uninjured, assisting personnel: Administer first aid to the best of your knowledge, ability and training. If appropriate, transport to emergency room. Directions to the nearest hospital from each park are in Appendix S1.C and emergency numbers are provided during training.

- Uninjured, assisting personnel: As soon as it is safe and practical to do so, inform the Protocol Lead and the park's emergency contact (provided during training) of the incident.

- For injured NPS employees and NPS volunteers, complete Worker's Compensation paperwork (Appendix S1.D). For other, non-NPS Monitoring Staff (i.e., contractors and cooperators), follow your organization's procedures for documenting accidents.

Non-Emergency Incidents

1. For a non-emergency incident that may require medical attention, injured monitoring staff must contact the protocol lead immediately after incident.

2. For injured NPS staff and NPS volunteers, complete Worker's Compensation paperwork (must be done within 48 hours of incident, Appendix S1.D).

3. Injured monitoring staff should seek medical attention, if needed.

NOTE: Never discard original paperwork related to workers compensation claims (including information from doctor's visits, CA-1, CA-2, CA-16 or CA-17 forms).

Field Preparation

All monitoring staff are responsible for maintaining a safe work environment for themselves and their coworkers.

Job Safety

An important tool used to promote safe conduct is the Job Safety Analysis (JSA; sometimes called a Job Hazard Analysis or JHA). This approach is consistent with NPS Directors Order 50 and Reference Manual 50B for Occupational Health and Safety. The JSA process is to (1) identify hazards associated with field and laboratory settings, and (2) as appropriate, develop approaches to mitigate those hazards. All monitoring staff for this protocol must read and sign the JSA in Appendix S1.A. In addition, water monitoring crew leaders and crew members must read the entire Safety SOP during training week.

First Aid Kits and Training

Every NETN vehicle should have a first aid kit that is to remain with the vehicle at all times. In addition to the vehicle first aid kit, a backpacking first aid kit should be with the monitoring crew at all times while in the field. An inventory of first aid kits should be performed by the crew leader prior to each field season to ensure that all medical supplies are in sufficient quantity and haven't expired. Each first aid kit will have an inventory list of the supplies it should contain. Items in first aid kits that are used should be promptly replaced.

At the beginning of every field season the water monitoring team will receive basic first aid and CPR training if they do not already have current certifications. Having a team member with Wilderness First Aid or Wilderness First Responder certification is strongly encouraged.

Daily Communication and Planning

Field teams are expected to carry a functioning primary and secondary mode of communication at all times while in the field. Unless they are water proof, these items should be stored in a water resistant or water proof container (e.g. Ziploc bag). At ACAD, monitoring staff will have a radio as the primary mode of communication, and a cell phone as the secondary communication device (cell phones, however, are not reliable in many sections of the park). For Lower NETN parks, monitoring staff will have a park radio, cell phone, and personal locator beacon (PLB), since cell reception and radio usage vary significantly across the parks.

Field sampling requires planning that anticipates the risks and dangers to monitoring staff so that precautions can be taken to limit threats to human safety as much as possible. As a result, field teams must produce a trip plan, or float plan (in the case of monitoring from watercraft) before conducting field work. A thorough review and familiarity with the trip plan is required of all monitoring staff and a copy of the plan for ready reference always accompanies the field team to the field (Penoyer 2003).

Always check weather conditions before departure, and leave itinerary copy of the trip plan with the protocol lead. If the protocol lead will be in the field, or otherwise unavailable, another designated office staff (DOS) should receive a copy of the trip plan. The protocol lead or DOS must be made cognizant of the absolute necessity of checking in with the team. If the field team fails to check in on or before the planned check-in time for completion of field work, the protocol lead or DOS will immediately try to reach the team by all available methods. If the field team has not been reached within 30 minutes, the protocol lead or designee must notify emergency services and initiate a search. The trip/float plan includes at a minimum, the following:

1. Date and purpose of trip
2. Name of all people on trip

3. Vehicle license plate number(s) and parking location(s)
4. Destination and route
5. Time of departure and estimated time of return
6. Check-in time for completion of field work
7. Radio frequency or cell phone number
8. Type of watercraft, if applicable

If the trip is cancelled or if the plan changes while in the field, the field team must notify the protocol lead or DOS immediately. At the end of the day, field teams must notify the protocol lead or DOS that they have returned from the field.

All field teams are responsible for being aware of the time and ensuring that end of day check-ins occur on schedule; the protocol lead or DOS will call emergency services if the field team misses their check-in and cannot be located within 30 minutes of the check-in time.

Personal Gear

Each person is responsible for ensuring he/she is wearing field appropriate clothing and footwear such as long pants, a hat and hiking boots. Depending on the weather, rain gear or warm clothing should be taken into the field and it is recommended that an extra set of clothing be kept in the vehicle. Monitoring staff should take care to avoid over exposure to the sun by wearing sunscreen and/or protective clothing. Monitoring staff should always carry ample water (2-3 liters) and food when working in the field. Dehydration is a serious condition that can lead to more serious conditions if untreated, and should be avoided. It is important to drink liquid frequently to maintain hydration on a warm day, even before thirst sets in.

Environmental Conditions

Field work often is necessary under adverse atmospheric and other environmental conditions. Prepare for extreme temperature conditions. Before leaving for the field, check the weather forecast. Be familiar with temperature-related conditions such as hypothermia and sun exposure including how to recognize and treat them.

Weather

Weather conditions in the eastern U.S. can be hazardous and can change quickly. The field team is responsible for planning their day according to the local weather forecast and for being aware of their surroundings and changing conditions.

Rain can fall at a rate of several inches per hour and rapidly create dangerous flash flood conditions. Use local weather forecasts to plan activities and to ensure safety. Always be aware of rapidly rising stages in rivers and creeks. Beware of dry creek beds that can become raging rivers in a short period of time.

Working on ice requires experience, training, and knowledge of the waterbody over which the ice has formed. No monitoring staff for this protocol should work on ice.

Thunderstorms

Thunderstorms, which can be accompanied by hail, are common throughout the United States. Some are predicted by weather forecasters. Others can move into an area with almost no advance warning. Storms that produce strong winds and lightning are dangerous and should be avoided in the field.

If monitoring in a boat, watch the sky for signs of thunderstorms, and seek shelter by heading to shore before the weather deteriorates. If caught in a lightning storm ashore, seek shelter in a building or car as soon as possible. If no shelter is available, spread out and move to an open space. Squat low to the ground on the balls of your feet with your hands on your knees (do NOT lie flat on the ground). Avoid high elevations, conductive materials, and tall structures such as trees or telephone poles. If you are in the open and feel your hair stand on end (indicating lightning is about to strike), immediately make yourself the smallest target possible and minimize contact with the ground.

NOTE: A person struck by lightning can often be revived by prompt administration of CPR and oxygen.

Excessive Heat and Sun

Over exposure to heat and sun can cause dehydration, heat exhaustion, or heat stroke. All are serious conditions that can be life threatening, and should be avoided. When working in hot weather, be sure to drink plenty of water and eat foods that can replace electrolytes. Wear loose and light colored clothing, including a hat to block the sun's rays. It may help to shift the field schedule to avoid working outside during the hottest part of the day.

WARNING: Signs of heat stroke include hot, red or spotted (usually dry) skin, and the sufferer may be mentally confused, delirious, having convulsions, or unconscious. If heat stroke is suspected, seek immediate medical attention!

Poor Air Quality

Summer ozone and particulate matter levels occasionally exceed federal health standards. Young children, seniors, and those suffering from asthma, chronic bronchitis, chronic obstructive pulmonary disease or heart problems are especially sensitive to poor air quality and should minimize outdoor activity when poor air quality warnings are posted. The risks of occasional exposure to ozone and fine particulate matter are minimal for healthy individuals.

When poor air quality warnings occur, it is advisable for monitoring staff to avoid overly strenuous activity during the hottest part of the day (pollution levels tend to be lowest early in the morning), and to stick to lower elevations under a forest canopy.

To check local air quality forecasts, or learn more about health risks of air pollution, visit the AIRNow intergovernmental agency website: http://www.airnow.gov/.

Surface-water Activities

Safety of monitoring staff is always the first concern in conducting a sampling program and in the selection of sampling sites. The desired sampling frequency for most monitoring exposes monitoring staff to a variety of potentially hazardous field conditions across all seasons and

climatic conditions, in addition to unforeseen, potentially catastrophic, short-term natural events (e.g., floods and storms) that can occur during the field effort.

Wading

Examine the section of a stream or river to be waded through. Check any available site notes for information relating to safety, including maximum depths in relation to stage, wading-section anomalies such as slippery conditions and drop-offs or holes (a wading rod can be used to help assess streambed conditions), and velocity curves for determining wadable stages. **Do not attempt to wade a stream for which values of depth multiplied by velocity equal or exceed 10 ft^2/s.** For example, a stream only 2 ft deep but with velocities of 5 ft/s or more can be dangerous to wade.

1. Always wear an approved personal floatation device (PFD) when wading in streams. The PFD must fit properly, be properly rated for weight, be in good condition, and be kept dry and indoors between trips. Whenever chest waders are worn, a PFD also must be worn.
2. Wear hip boots or chest waders. Boots and waders provide protection from cold and pollutants, as well as from underwater objects. Be aware of the possibility of slipping and going underwater (feet up, head down) while wearing them. Practice wearing hip boots and waders in a controlled, group-training situation that includes immersion in a swimming pool before using for field work. Avoid hip boots with tight ankles or chest waders that are tight fitting at the top. These are difficult to remove in an emergency situation. Hip boots and chest waders with a strap that is pulled closed reduce water coming into the boot.

Watch for debris floating downstream, such as logs, aquatic vegetation, or "rafts" of animals seeking higher ground. Watch for sand channels that can shift under foot and become quicksand. Watch the stream stage, especially when it could rise rapidly. When wading below a dam or control structure, contact the park resource manager or gate operator before entering the stream.

Working from Boats

All boats must carry equipment as required by the U.S. Coast Guard (USCG). Checklists are useful for ensuring that all the proper equipment is in place. Safety regulations for the various types of boats used by the NPS when obtaining water-quality samples are comprised of USCG and Occupational Safety and Health Administration (OSHA) rules.

Before working from a boat, obtain the appropriate training for the vessel being used. NPS staff operating motorized watercraft must complete the DOI Motorboat Operator Certification Course (MOCC), and keep their certification current. This training will cover all the specifics regarding boat operation as per USCG regulations. Before taking a boat on the water, ensure that the vessel is in operating condition. Boats are to be inspected annually. If a vehicle is being used to trailer the boat to the site, the vehicle and trailer are to be included in the preliminary inspection. Equip the boat with all items that the protocol lead deems appropriate for emergencies or equipment failures.

General Field Safety

Teamwork

Monitoring staff should work in teams (usually pairs) when conducting monitoring activities. When using a boat, working in a team is mandatory. Working in a team ensures that if one

person is injured or incapacitated, another person will be available to respond to the incident. In some situations, it is expected that Lower NETN parks will not always be able to provide a second person to assist the crew leader at stream sites; in this case the crew leader must use his or her best judgment, and only proceed with sampling if the work can be done safely.

Slip, Trip, Fall Prevention

Uneven terrain, slippery rocks, dense brush, and fatigue are all hazards that could result in a slip, trip, or fall. The following guidelines should be obeyed by monitoring staff to avoid injury from slips, trips, or falls:

- Always wear appropriate footwear such as sturdy hiking boots
- Pay attention to where you are going, and remain alert of potential hazards
- Walk at an appropriate pace and adjust pace for changes in terrain (e.g., slow down and take smaller steps on slippery surfaces)
- When hiking long distances, take breaks to avoid fatigue
- When navigating to a location off trail, choose the safest route (this may not be the shortest route). Avoid river crossings, excessively steep terrain and sudden drop-offs. Always be careful when navigating over piles of scree, and alert others of falling rocks.

Proper use of Backpacks

Monitoring staff may occasionally be expected to carry ≥ 35 pound packs over uneven terrain, and it is important for monitoring staff to understand appropriate ways to pack, lift and carry a heavy backpack to avoid serious back, neck and shoulder injuries. Monitoring staff must follow these guidelines:

- All monitoring staff are expected to use a sturdy field pack with padded and adjustable hip and shoulder straps. Packs will be provided for each field team member.
- Pack heavy items in the center of the pack and close to your back.
- Make sure weight is evenly distributed from side to side.
- Once equipment is packed, tighten the compression straps to minimize movement inside the pack during travel.
- When picking up a heavy pack, use your legs to do the lifting, and use slow, smooth movements. Keep your back straight, and keep the pack close to your body. Do not twist or bend at the waist, and do not swing the pack quickly over one shoulder.
- Always carry a pack with both shoulder straps and with the hip belt and chest straps secured.
- The pack should be positioned near the center of the back, and most of the weight should rest on your hips.
- Keep your pack organized, and only carry the necessary equipment, food and water to reduce weight.

Carrying Other Gear

In addition to backpacks, some gear will be hand-carried (e.g., Hilti drill, wading rod). Whenever possible, put heavier items (e.g., drill batteries) into backpacks. If you must hand-carry heavy items, remember to slow down and rest frequently to avoid hand and arm fatigue. Any person hand-carrying a heavy item should always have one hand free for balance, and so that the item can be shifted between hands. If carrying a long item like a wading rod, be careful not to allow it to extend upwards and behind you, where it could injure a colleague.

Deer ticks and Lyme Disease

Several species of ticks are commonly encountered in eastern U.S. parks while working in the field (Figure S1.1). This includes the deer tick (*Ixodes scapularis*), which is a known vector of Lyme disease and Ehrlichiosis. Monitoring staff must take the precautions outlined below to help minimize the chances of having an embedded tick that could lead to illness:

- Clothes treated with tick and insect repellents have been found to be fairly effective tick repellant. Monitoring staff are strongly encouraged to treat their clothing with permethrin prior to conducting monitoring. Monitoring staff should carefully follow the application instructions on the spray bottles to ensure their safety. Permethrin will remain active for several weeks and through several washings.
- Monitoring staff should take additional precautions to protect themselves from ticks, including tucking pants in socks and tucking in shirts. Long sleeves and gaiters (especially when treated with permethrin) have been found to help. Monitoring staff may consider other barrier devices, such as RynoSkin™, Under Armor®, elastic bands, and duct tape, when they are an option.
- Check clothes and skin for ticks at the end of every field day. Ticks typically need to be embedded for at least 24 hours for disease transmission to occur; therefore, the earlier ticks are found and removed, the lower your chances are of acquiring a tick-borne illness.
- It is recommended that monitoring staff obtain a specialized tick remover spoon and use it to remove embedded ticks. If a spoon is unavailable, use fine-tipped tweezers to firmly grasp the tick close to your skin. Slowly and steadily pull the tick's body away from your skin. Be careful not to crush the tick's body to minimize the chances of it regurgitating fluids into the wound. Clean the bite area once the tick is removed with soap and water.
- NPS staff or NPS volunteers who receive a deer tick bite should notify the protocol lead to start a worker's compensation CA-1 claim to get a CA-16.
- Keep an eye out for any early symptoms of tick borne diseases. If you start to notice symptoms, use the CA-16 to seek medical attention.
- Be sure to tell the doctor that you had an embedded tick, and that you regularly come in contact with ticks at work. Show the tick, if you saved it.

Signs and symptoms of tick-borne diseases:

- **Lyme disease** symptoms may include a characteristic "bull's-eye" rash that develops a few days or weeks after the tick bite. At the same time, flu-like symptoms such as fever, malaise, fatigue, headache, muscle and joint aches appear. Other symptoms may include tingling or numbness in extremities, a spotted rash on extremities, bad headaches, high

fever, joint aches, stiff neck, fatigue, or swollen glands. *Ixodes* ticks are most likely to transmit infection after feeding in skin for 2 or more days.

- **Rocky Mtn. Spotted Fever** symptoms include sudden onset of fever, headache, and muscle pain, followed by development of spotted rash at wrists or ankles.
- **Ehrlichiosis s**ymptoms are similar to Lyme disease, but differ with a rapid on-set of fever and severe headache and the absence of the rash around the tick bite.
- **Babesiosis:** Most infected people have no symptoms. For those that do, there is a gradual on-set of not feeling well and loss of appetite and fatigue.
- **Red Meat Allergy** symptoms may include an initial painful, itchy lesion greater than 50mm that lasts at least a week after the tick bite. Within 6 months a severe anaphylactic reaction may occur as much as 3-6 hours after eating beef, pork or lamb.

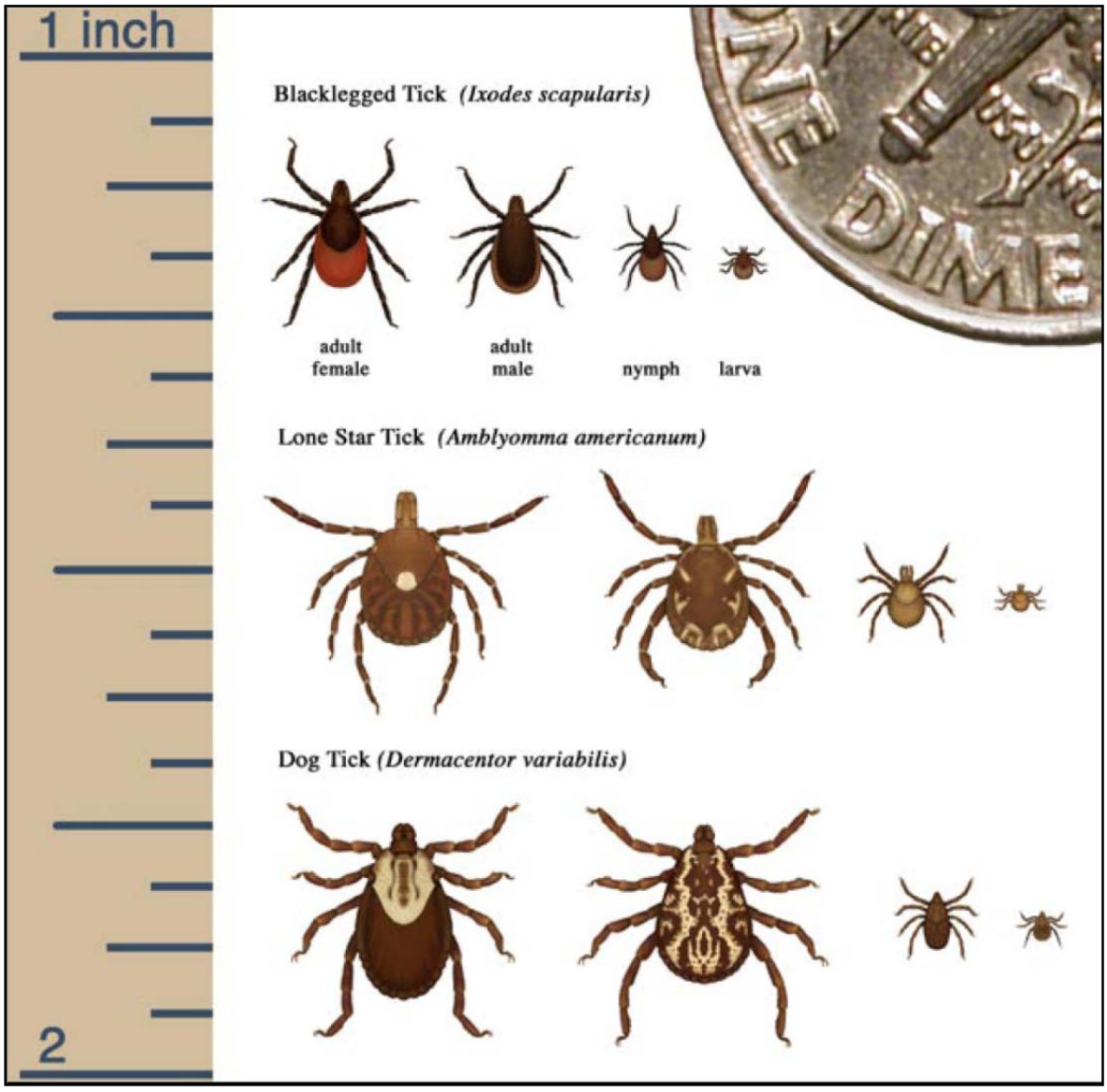


Figure S1.1. Tick species found in the eastern US.

Considerations for using repellents containing DEET:

- DEET products have been widely used for many years; these products have occasionally been associated with some adverse reactions. Frequently, reported reactions are about skin or eye irritation. There have been reports of central nervous system problems.
- By using products with lower concentrations of DEET and by applying as little of the product as needed for your outdoor work, you can reduce your expose to DEET.
- Products with about 20 - 30% DEET are considered effective for most insects, but do not seem to be effective against the black-legged or deer tick (*Ixodes scapularis*)
- Generally, products with about 20 - 30% DEET are considered safe for adults (except for those with allergies to DEET products) when applied as directed.

Considerations for using repellents containing permethrin:

- Products containing permethrin are for use on **clothing only – not for use on skin**. If permethrin is used improperly (e.g., sprayed directly on the skin), it can have negative health effects.
- Permethrin kills ticks that come in contact with treated clothing and one application lasts 2 weeks or more. Do not treat the clothing more than once every 2 weeks.
- Carefully read and follow manufacturer's instructions for application, and refer to the MSDS sheet if you have questions.
- Do not apply while clothing is being worn.
- Apply to clothing item in a well-ventilated outdoor area, protected from wind.
- Lightly moisten the fabric with permethrin – do not saturate the fabric.
- Allow clothing item to dry outdoors for at least two hours before wearing (4 hours in humid conditions).
- Keep treated clothes in a separate bag for storage and transport.
- Launder treated clothing, separately from other clothing.

More information on permethrin:
http://www.epa.gov/oppsrrd1/REDs/factsheets/permethrin_fs.htm
http://drugsafetysite.com/permethrin/

Prophylactic (preventative) use of antibiotics:
In addition to treating early stages of Lyme and other tick borne diseases, a new approach involves administering antibiotics to prevent Lyme disease transmission from the deer tick. While evidence is still preliminary, a single dose of antibiotics may reduce chances of Lyme transmission following a deer tick bite if 1) the tick was attached for 24 or more hours, 2) the bite occurred in an area where Lyme disease is common, AND 3) antibiotics can be started with 72 hours (3 days) of the time the tick was removed. It is only after symptoms of Lyme develop that a longer duration of antibiotics should be administered.

A few things to keep in mind about antibiotic therapy:
According to the US Public Health Service, Centers for Disease Control:

- Every time a person takes antibiotics, sensitive bacteria are killed, but resistant germs may be left to grow and multiply. Repeated and improper uses of antibiotics are primary causes of the increase in drug-resistant bacteria.
- Misuse of antibiotics jeopardizes the usefulness of essential drugs. Decreasing inappropriate antibiotic use is the best way to control resistance.
- Antibiotic resistance can cause significant danger and suffering for people who have common infections that once were easily treatable with antibiotics. When antibiotics fail to work, the consequences are longer-lasting illnesses; more doctor visits or extended hospital stays; and the need for more expensive and toxic medications.

More information on Lyme Disease and Ticks:

Center for Disease Control:
http://www.cdc.gov/lyme/
(also a free webinar on tickborne diseases)

American Lyme Disease Foundation:
http://www.aldf.com/

Tick Management Handbook:
http://www.ct.gov/caes/lib/caes/documents/publications/bulletins/b1010.pdf

Poisonous Plants and Animals

Both for safety and protection of park resources, it is never advisable for monitoring staff to eat wild plants while working in a National Park, regardless of their confidence in plant identification. Monitoring staff should also keep a safe distance from wildlife.

Poison Ivy

Poison ivy (*Toxicodendron* spp.) is present in most NETN parks, and can be very abundant in localized areas. Abundance of poison ivy is not a justification for excluding a sample site. However, if anyone is susceptible to extreme allergic reactions to poison ivy, this person should avoid working in areas infested with poison ivy, and all gear that has been near poison ivy needs to be carefully cleaned. When working in areas with poison ivy, it is advisable that monitoring staff take precautions to avoid skin contact with any part of the poison ivy plant. Using a pre-exposure cream and wearing long sleeves and long pants, hats, and work or rubber gloves can help reduce amount of skin contact with the plant, and if needed, use poison ivy wipes after contact. Monitoring staff should be careful not to rub their faces when working around poison ivy. After working in an area with abundant poison ivy, monitoring staff should gently wash exposed skin in cool water with the specially provided poison ivy soap, and should change into fresh field clothes. At the end of a field day, monitoring staff should also wash (with cool soapy water) potentially contaminated equipment. If someone has a minor allergic reaction, use the provided cream. If a severe allergic reaction occurs, the person should seek medical attention, notify the protocol lead as soon as possible, and if an NPS employee or NPS volunteer, file a workers compensation claim.

Venomous Snakes

The following species of venomous snakes may occur in some NETN parks: copperhead (*Agkistrodon contortrix*), and timber rattlesnake (*Crotalus horridus*). The best course of action is to avoid all snakes by keeping them at a safe distance. When in venomous snake country, pay attention to where you put your hands and feet, and be aware around rock piles and bedrock outcrops. Note that many snake bites are purely defensive, and contain no venom. Bites from immature snakes are much more likely to contain a more dangerous amount of venom than bites from adult snakes. Should you receive a snake bite from a potentially venomous snake, follow the procedure below:

- Treat all bites as if envenomation has occurred.
    - Time is of the essence
    - The field team should assign one person to use the radio or cell phone to call for assistance. This person should identify the call as a snakebite incident, and identify the victim's location and the closest possible point of access for responders.
    - In treating the victim, quickly remove rings, watches, shoes etc., before swelling begins.
    - Immobilize the bitten limb firmly with a splinted elastic (Ace) bandage and get the victim out of the woods and to a hospital as quickly as possible.
    - **Do not** use thin circulation restrictive cords, pack with ice for long periods (more than five minutes) or attempt to cut open or otherwise enlarge the fang punctures.
- Reassure the victim that they will be OK and try to remain calm both for the victim and for all others involved.
    - In a field team situation, begin leading the victim slowly out of the woods as soon as the bitten limb has been immobilized. **Move as slow as necessary to maintain a normal heart rate for the victim.** Waiting for assistance will only prolong the process of getting proper medical treatment.
    - In a solitary situation, establish radio contact and relay the necessary information as you walk slowly out of the woods. Focus on remaining calm and maintaining a normal heart rate.
- It is better to spend your time getting to proper medical treatment facilities than it is to attempt field therapy or wait for assistance to reach you.

The range of the copperhead covers the following NETN parks: Morristown NHP (MORR), Roosevelt Vanderbilt NHS (ROVA), Saratoga NHP (SARA) and Weir Farm NHS (WEFA). The likelihood of encountering a copperhead is low in NETN parks. Copperhead bites are not typically considered life threatening, and in most cases antivenin is not administered.

The range of the timber rattlesnake covers all NETN parks except Acadia NP (ACAD). This species is listed by NatureServe as "critically imperiled" (S1: New Hampshire, Vermont, Massachusetts, and Connecticut) or "vulnerable" (S3: New York, Pennsylvania) throughout

NETN, and the likelihood of encountering a timber rattlesnake in NETN parks is very low. Adult timber rattlesnakes are capable of delivering a lethal dose of venom.

Bees, Wasps, and Yellow Jackets

If any monitoring staff are allergic to bee stings, they should alert the protocol lead and crew leader, and make sure to carry appropriate medications. If they carry an epinephrine injector and are working in a team, they should make sure all members of their field team know where it is carried. Be alert to potential hive and nest locations while hiking to plots and working on plots. Look for insects travelling in and out of one location (e.g., brush, ground holes, and hollow logs). If someone is stung, Benadryl and a cold compress may bring relief. If stinger is left behind, scrape it off of skin. Do not use tweezers as this squeezes the venom sack, worsening the injury. If the victim develops hives, asthmatic breathing, tissue swelling or a drop in blood pressure, seek medical help immediately.

Black Bears

Black bears range throughout the Northeast, but an encounter with a bear in the field is not likely since bears generally avoid people. Nevertheless, be alert for bears near dawn or dusk, and be especially aware of mother bears with cubs. Never approach cubs or come between a mother bear and her cubs. If a bear is encountered, face the animal and continually make noise – do not freeze or remain silent. Appear larger by standing tall, waving arms or jacket over your head, and slowly back away. Never run from a black bear; if charged or attacked, throw objects and shout loudly, and fight back aggressively.

Chemicals

Monitoring staff may be routinely exposed to chemicals during the water-quality sampling process. Chemicals—as solids, liquids, or gases—range from dilute salt solutions to strong acids, bases, dyes, and organic compounds. Virtually all of the chemicals used in this protocol are not hazardous. However, field measurements and the processing of sample water can cause chemical reactions that generate dangerous fumes and by-products. Crew leaders will identify to members of the field team any substances that require special care and handling prior to their use, and will explain and demonstrate precautionary measures.

Be cognizant of the regulations that govern the use, transportation, and disposal of chemicals and wastes. Because regulations vary greatly from state to state, contact your safety officer or state agency for the proper procedures in your locality. Use proper personal protective equipment, and apply common sense when working with dangerous substances. Adhere to the following safety guidelines:

- Avoid unnecessary exposures and spills. Never place chemical containers where they can be knocked over.
- Clean up chemical residues or spills immediately and appropriately. Keep chemical spill kits near the work area.
- Work with adequate ventilation or under a hood when working with hazardous or reactive chemicals and gases.
- Keep eye wash kits readily accessible while working with chemicals.

- Handle and mix chemicals and compounds appropriately (check the MSDS). For example: when transferring flammable liquids, all metal containers must be grounded to eliminate igniting the liquid with an electrical spark. When preparing a hydrochloric or nitric acid cleaning solution, the sequence is to put water in the vessel first and then add the acid.
- Open chemical containers slowly and carefully, wearing proper personal protective equipment. Open frozen or encrusted lids with caution. For example, to open fused-glass ampules, break the ampule at the base of neck, in a direction away from you and others. Use an ampule breaker if it is safer for you, and wear latex gloves. Check containers and ampules for contents lodged near the container top or neck. Dislodge trapped material by gently tapping the container at the top.
- Properly dispose of all wastes. Do not let any wastes accumulate in your vehicle or work area – they can produce corrosive and/or potentially explosive fumes. Do not discard any wastes into the environment.

Vehicle Safety

Responsibilities of NPS Vehicle Operators

Field teams are responsible for inspecting their vehicles before every use to ensure the vehicles are in safe working condition. This includes visually checking tire pressure, adjusting mirrors, and making sure equipment is secure. Field teams must perform preventative maintenance in a timely manner (e.g., having oil changed by a qualified mechanic), and report any potential hazards or needed repairs to the protocol lead.

Rules that must be followed when operating an NPS vehicle:

- Everyone in a government vehicle is required to wear a seat belt.
- Cell phone use and texting is strictly prohibited while driving.
- Only NPS employees or authorized volunteers, cooperators and contractors are allowed to operate a government vehicle.
- Passengers who are not NPS employees or authorized volunteers, cooperators and contractors are forbidden from riding in a government vehicle.
- Drivers must adhere to all federal and state vehicle regulations, including all posted speed limits.

Because government vehicles are self-insured, damage resulting from government vehicle accidents are generally paid by the driver's program (e.g., NETN). However, in cases of severe negligence, the driver found at fault for the accident may be personally liable.

GSA Rental Information

Preventative maintenance records are monitored by GSA Fleet. When service is required, the contact person for the rental (likely the NETN program manager) will receive an e-mail that identifies the maintenance service required and when the vehicle is due for that service. Field teams must have requested services performed promptly after the notification.

Procedures for reporting a motor vehicle accident

A copy of this SOP (including all appendices) should be in every NPS and GSA vehicle at all times. Note that some procedures are different if vehicles are National Park Service (NPS) owned versus Government Services Administration (GSA) owned. Therefore GSA vehicles

should also have a GSA Motor Vehicle Accident Reporting Kit (GSA Form 1627) in the glove compartment.

In case of automobile accident in a **GSA-owned vehicle**, locate the GSA Motor Vehicle Accident Reporting Kit (GSA Form 1627) in the glove compartment, and follow the instructions therein. Also contact Duane Vallee, NETN's GSA Representative at 603-666-7955.

In the event of an automobile accident in an **NPS-owned** vehicle, follow the procedures listed in Appendix S1.E to respond to the accident, follow the NER guidelines for reporting an accident (Appendix S1.F), and complete the corresponding forms (SF-91 and SF-94) in Appendices S1.G and S1.H. Note that this SOP and corresponding appendices address Federal guidelines and requirements for accident reporting only. Cooperators and contractors may have additional reporting requirements.

Contact Information

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Appendix S1.A. Job Safety Analysis (JSA) for Water Monitoring Field Work

JOB SAFETY ANALYSIS:	**JOB TITLE:** **Water Quality/Quantity Field Monitor** **DEPARTMENT:** **Northeast Temperate Network** **ANALYSIS BY:** **Elizabeth A. Arsenault, ACAD/NETN** **Physical Science Technician**	☒ **NEW** ☐ **REVISED** ☒ **REVIEWED** **William G. Gawley, ACAD/NETN Biologist**
Required and/or Recommended Personal Protective Equipment: *Required:* At least two methods of communication (i.e., park radio and cell phone in most parks; Personal Locator Beacon as backup), driver's license, personal flotation device (PFD), throw-bag lifeline, first aid kit. *Recommended as appropriate:* Rain gear, condition-appropriate gloves, footwear and clothing, safety glasses, sunglasses, sunscreen, insect repellent, sufficient food and water.		

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
Planning and Communication	Not being prepared and following plan/itinerary. Communication breakdowns.	Plan ahead. Know where you will be going, the stream, lake or pond to be monitored, and any particular hazards associated with the monitoring site. Check the weather forecast and plan accordingly. Check in with DOS prior to field work with a trip plan, and after field work to confirm the work is safely completed. Contact the DOS with any changes, including cancellation of field work. If return will be delayed, contact DOS before agreed-upon check-in time to establish a new check-in time. Always carry at least two methods of communication, and verify that they are full charged before starting field work.

Tasks	Potential Hazards	Recommended Action or Procedure
Emergency Preparedness	Not knowing emergency procedures. Not having emergency supplies.	Know who to contact and how to reach them in the event of a life-threatening or non-life-threatening emergency. Have directions to emergency medical facilities Have current CPR and first aid certification. Carry a well-maintained first aid kit.
Working outdoors during storms	Being struck by falling trees or branches; being struck by lightning; being caught on lakes during high wind and wave conditions; being caught in flash floods/high streamflow	Listen to the weather forecast each morning (park radio and/or internet). Plan or adjust field work to avoid being out in thunderstorms. Water monitoring is never conducted during thunderstorms. If you see or hear a thunderstorm coming, retreat from high ground and exposed areas. Go inside a sturdy building or vehicle, if possible. If you can't get inside and if you feel your hair stand on end, lightning is about to strike. Make yourself the smallest target possible and minimize contact with the ground. Crouch down on your pack on the balls of your feet and keep your feet close together. Place your hands on your knees and lower your head. During a thunderstorm, members of the field team should stay separated by at least ten feet. Postpone lake or pond monitoring when excessive wind speeds or whitecaps exist. Postpone work if safety will be compromised by storm and/or flooding conditions.
Working in heat, humidity, or cold	Heat exhaustion, sunburn, dehydration, hypothermia	Evaluate the weather forecast each morning and plan field work accordingly. Carry and drink plenty of water. Take extra breaks during extreme weather events. Adjust the work routine to minimize exposure to extreme heat and humidity. Take adequate garments for all possible weather conditions. Choose clothing that will keep you warm even if it gets wet. Wear sunglasses to avoid eye damage. Apply sunscreen and lip balm.
Hazard trees	Being struck by falling trees or branches	Look up. Be alert for widow-makers, storm damaged trees with large broken limbs, and unstable standing dead trees. Do not spend extended time in an area with hazard trees.

Tasks	Potential Hazards	Recommended Action or Procedure
Poisonous plants, especially poison ivy	Contamination/toxicity from contact with poisonous plants	Learn to identify poison ivy in its many growth forms. Wear long sleeves and pants. Be aware of poison ivy and avoid coming in direct contact with it. Thoroughly wash hands, equipment, and clothes with Tecnu or similar specialized soap if you come into contact with poison ivy.
Bee, wasp, or yellow-jacket stings	Multiple stings from disturbing or stepping into nest areas	Be alert to hives in brush, ground holes, or hollow logs. Watch for insects traveling in and out of one location. If you are allergic to bee stings, tell your partner (if working in a pair). Make sure you carry emergency medication with you at all times and that your partner (if applicable) knows where you keep it. Wear long sleeve shirts and trousers, tuck in shirt. Bright colors and metal objects may attract bees or wasps. If you are stung, a cold compress may bring relief. If stinger is left behind, scrape it off of skin. Do not use tweezers as this squeezes the venom sack, worsening the injury. If the victim develops hives, asthmatic breathing, tissue swelling or a drop in blood pressure, seek medical help immediately.
Bites from mosquitoes, black flies, and other insects	Itchy reactions to multiple bites	Wear long sleeves and pants. Avoid sitting on the ground or on logs, especially in dry sunny grassy areas. Use insect repellants. Do not apply Permethrin, Permanone, or greater than 30% DEET directly to skin, only to clothing. Carry after-bite medication to reduce skin irritation.
Ticks	Contracting diseases transmitted from ticks	Use tick avoidance precautions, including pre-treating clothing with Permethrin, tucking pants into socks and shirt into pants when hiking. Wear clothes (including pants and long-sleeved shirts) that are light colored and check for ticks on clothing after traveling through vegetation. Conduct a thorough tick check every evening after completing field work. Know how to identify tick life forms, and the signs & symptoms of tick-borne diseases.

Tasks	Potential Hazards	Recommended Action or Procedure
Venomous snakes	Being bitten by a venomous snake	Venomous snakes are rare in NETN parks. Be alert for snakes in thick vegetation and rocky habitats. Look **before** putting hands or feet in places out of immediate view. Treat all bites as if envenomation has occurred. Immobilize the bitten area and keep it lower than the heart. Apply a bandage, wrapped two to four inches above the bite, to help slow the venom. This should **not** cut off the flow of blood from a vein or artery - the band should be loose enough to slip a finger under it. Remove rings, watches, shoes, etc. before swelling begins in earnest. Seek medical attention immediately and/or call for help. Remain calm. Rattlesnake bites are more likely to be life-threatening.
Working in bear territory	Black bear encounter	Be especially alert near dawn or dusk. Be especially aware of mother bears with cubs. Never approach cubs or come between a mother bear and her cubs. Face the animal, continually make noise – do not freeze or remain silent. Appear larger by standing tall, waving arms or jacket over your head. Slowly back away – do not approach a bear. Never run from a bear. Throw things and shout loudly. Fight back aggressively.
General foot travel	Falling or tripping due to wet areas, poor footing, uneven terrain, loose/rolling rocks and heavy pack.	Use caution at all times. Walk carefully, watching footing. Wear appropriate boots for conditions. Stay aware of your feet. Address blisters and hot spots promptly. Avoid carrying excessive weight loads or unbalanced loads. When walking on a steep slope, lean upslope. Ensure that stems and vines are alive and can support your weight before relying on them. Use extreme caution traversing wet rocks, streams, steep slopes or blowdown areas.
Walking through thick vegetation	Cut, scratched, or bruised by vegetation; eye or ear injuries	Shield your eyes and face with your hands, glasses, or hat when moving through tall thick brush. Keep your head and eyes pointed somewhat downward so your head hits obstacles before your eyes. Wear pants and long-sleeved shirts to protect bare skin. Look before you grab vegetation to avoid grasping thorny stems. Do not follow closely behind other people to avoid having branches snap back and hit you.

Tasks	Potential Hazards	Recommended Action or Procedure
Carrying a pack and other equipment	Injuries from improper packing, adjustment, and lifting of backpacks. Injuries from improper carrying of gear	Learn how to properly pack, adjust, lift, and carry a pack. When hand-carrying gear, keep one hand free. If carrying long equipment, be aware of other people and never swing around quickly. Avoid allowing a long piece of equipment to project up and behind you, where you cannot see it.
Working in streams	Injuries from slipping, tripping, falling and/or drowning, upstream and downstream hazards, such as dam releases, downstream rapids or outlet into large river	Attend wader safety training. Wear PFD when wading, and have throw bag available. Check with park resource manager about upstream conditions such as scheduled or other releases from impoundments, or construction. Be aware of downstream conditions such as swift water or rapids, or confluence into a large river. Do not monitor a stream if the velocity x depth is greater than 10 ft^2/sec. Conduct a visual inspection of stream site for potential hazards. Wear appropriate foot gear for stream monitoring. To ensure safety and to stay dry, use the appropriate knee boot, hip, or chest wader. If crossing a stream, unbuckle your pack and be prepared to jettison gear should you lose your balance or fall in. Be aware of shifting sandy bottoms, slippery rocks, and holes between rocks. Be aware of and avoid underwater hazards such as snags, trash, broken glass and rusted metal. Use a sturdy pole or walking stick for balance.
Working from a boat	Injuries from improper carrying of boat, motor and other equipment, falling and/or drowning, equipment malfunctions	Do not overload boat with people or equipment. Wear PFD when working in and around water and have throw bag available. Attend the one-time DOI Motorboat Operations Certification Course (MOCC) and refresher training every 3 years. Attend canoe and wader safety training and refreshers. Learn how to properly lift and carry a boat and motor. Consider using canoe dolly to transport boat if possible. Have motor inspected each year prior to monitoring season and fire extinguisher inspected monthly. Regularly check inflatable boat for leaks. Conduct a visual inspection of boat launch and surrounding area for noticeable hazards. Maintain a low center of gravity, especially in canoes. Use extreme caution when standing in canoes and small boats. Use caution when reaching overboard to obtain samples, retrieve the anchor, etc. and know self-rescue techniques.

Tasks	Potential Hazards	Recommended Action or Procedure
Calibrating instruments and other lab work	Injuries from slips, trips, and/or falling, chemical spills and exposure	Attend hazard communications training, which includes proper labeling procedures, use of MSDSs, spill procedures and emergency lab procedures. Obtain training to ensure proper equipment use techniques. Utilize lab ventilation and wear proper personal protective equipment (PPE) when using chemicals. Keep lab or other workspace clean and uncluttered.

Northeast Temperate Network

Please sign your name below to certify that you have read the Job Hazard Analysis and fully understand the Safety Standard Operating Procedures for the NETN water quality monitoring protocol.

Print Name:_____ Signature:_____ Date:_____

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Appendix S1.B. Green-Amber-Red Analysis (GAR) for Water Monitoring Field Work

This appendix describes application of the GREEN-AMBER-RED (GAR) Risk Assessment Model as outlined in the NPS Operational Leadership Student Manual (Version 2; July 2011) to the NETN Lake, Pond, and Stream Monitoring Protocol. This GAR was written by the Acadia Water Monitoring Crew Leader (Elizabeth Arsenault) and William Gawley (Water Monitoring Protocol Lead) on 29 March 2012 and approved by the NPS Northeast Region I&M Program Manager (John Karish) on April 2012

The GAR model allows for a general assessment of a task or operation and generates communication concerning the risks of an activity (in this case, conducting the field-based activities of the NETN Lake, Pond, and Stream Monitoring Protocol). The most important parts of the process are the team discussions leading to an understanding of the risks and how they will be managed.

The GAR analysis is a seven step process. Each step is defined and explained in the context of the NETN Lake, Pond, and Stream Monitoring Protocol below.

Step 1: Define the Mission or Task

The NETN Water Monitoring protocol includes two field-based monitoring activities: stream monitoring while wading, and lake monitoring from a boat or lake's edge. Monitoring staff are part of two-person field teams who work independently from each other. One field team samples in ACAD, and one team samples in Lower NETN. The activity may be conducted away from roads and trails but no site includes a hike more than 30 minutes from the parked vehicle.

Step 2: Define the Threats

The threats/hazards for this activity along with mitigation measures are described in the associated JSA (Appendix S1.A). Of specific concern is that monitoring staff will regularly be working on uneven and possibly slippery streambed surfaces. In lakes and ponds, staff will be working from a canoe or inflatable boat or at the water's edge. A fatality through drowning or a severe slip and fall is possible and is the most significant risk encountered when conducting this activity.

Step 3: Assess Risk and Assign a Numerical Value

The numerical ranks (**Error! Reference source not found.** S1.B.1) were assigned by Elizabeth Arsenault, the Acadia Water Monitoring Crew Leader, and William Gawley, the NETN Water Monitoring Protocol Lead. NETN staff reviewed the ratings and analysis and their suggestions were incorporated. It should be noted that at the time final numerical values were assigned (April 2012), the protocol had been implemented for several years and considerable time and effort had already gone into evaluating and mitigating risks.

The activity risk can be visualized using the colors of a traffic light. If the total risk value falls in the GREEN ZONE (1-35), risk is rated as low. If the total risk value falls in the AMBER ZONE (36-60), risk is moderate and you should consider adopting procedures to minimize the risk. If

the total value falls in the RED ZONE (61-80), you should implement measures to reduce the risk prior to starting the event or evolution.

The ability to assign numerical values or "color codes" to hazards using the GAR Model is not the most important part of risk assessment. The critical steps in the process are team discussions leading to an understanding of the risks and how they will be managed.

Table S1.B.1. NETN Water Monitoring Protocol assigned risk codes of 0 (For No Risk) through 10 (For Maximum Risk) to each of the eight Green-Amber-Red Risk Assessment elements.

Element	Rating
Supervision	2
Planning	2
Communication	2
Contingency Resources	5
Team Selection	3
Team Fitness	3
Environment	6
Event/Evolution Complexity	6
Total Risk Score	29

Step 4: Identify Risk Control Options

Supervision

The NETN Lake, Pond, and Stream Protocol clearly identifies personnel, roles and responsibilities, and a chain of command. The NETN protocol lead is responsible for the safety of both the Acadia and Lower NETN (LNETN) field teams and is available to answer questions from all monitoring staff during normal operational hours (i.e., 8:00 am to 4:30 pm, Monday-Friday). The crew leaders at Acadia and in the LNETN are the safety officers for their respective field teams, and conduct a daily briefing to ensure that safety procedures are explained, understood, and followed. If a crew leader is not present in the field, the next most senior crew member is the designated safety officer. All monitoring staff are required to work with a partner in the field. Monitoring staff are required to follow check-in procedures with the NPS staff at their assigned park. Additionally, there is a NPS Safety and Environmental Protection Specialist stationed at Acadia who is available for consultation and who provides safety training for all staff based in the park. A score of 2 was assigned due to the availability of on-site supervision and the fact that the team is not large, and work is conducted in pairs with regular check-ins.

Planning

The NETN Lake, Pond, and Stream Protocol includes numerous SOPs that explain hiring, training, personal safety, emergency communication (equipment and contacts), and appropriate field activities. Crew members are required to review these materials during training, and crew members are encouraged to have first aid and CPR training. Due to this advance planning, written documentation, and training procedures, a low score (2) was assigned.

Communication

Routine and emergency communication equipment and procedures are explained in manuals and instructions supplied with the equipment. Contact information for appropriate park staff and emergency services, and most effective communication methods for each park and sample site

are provided during training at the beginning of the season and reviewed upon arrival at each park. Communication includes early coordination by the crew leader with park natural resource managers, rangers, and dispatch at least one month in advance of a visit to schedule field assistance and logistics. Daily monitoring and sampling plans are agreed upon and communicated to all crew members and the protocol lead at the beginning of the day. A daily check-in procedure is in place for the field team to ensure that a responsible party knows if someone has not returned from the field activity in a timely manner. Due to this advance planning, written documentation, and training procedures, a low score (2) was assigned.

Contingency Resources

Contingency resources include communication equipment and procedures that explicitly involve park rangers, park dispatch, and 9-1-1. Crew members must always have at least two modes of communication (park radio, cell phones, and/or Personal Locator Beacon). Acadia crews are assigned park radios and have access to park cell phones, and Lower NETN crews are assigned a park cell phone and a park radio. Notification of emergency services should happen within minutes of an incident, but emergency services may not be able to reach the crew quickly due to the remoteness of some sites. A score of 5 was assigned instead of a lower score because of the potential delay before emergency services could reach the crew. This score was also assigned because neither crew currently has access to a Personal Locator Beacon or SPOT GPS Messenger, and cell reception is not always reliable in ACAD.

Team Selection

The monitoring protocol clearly identifies the essential skills and abilities required to execute this protocol in a competent manner. Prior experience with sampling water chemistry and performing field work is required for most team members. Each year before the field season, permanent ACAD and LNETN staff attend a refresher training as well as training on new or modified activities. Seasonal employees entering duty later in the season and temporary field assistants in the LNETN receive on-site training by the crew leader while monitoring if they are unavailable for pre-season training. This is due to the long field season (April through October) and limited hours available for seasonal employees. A score of 3 was assigned (instead of a lower score) because some crew members may have limited experience and a lack of extensive pre-season training. Learning job skills in the field can distract from attention to safety issues, even though a review of hazards and safety practices is conducted at the beginning of each site visit.

Team Fitness

Team selection seeks to strive for an overall high level of initial team fitness. Water monitoring field teams are in the field for approximately six hours per day at ACAD (not including drive times) and up to eight hours per day (not including drive times) in the LNETN. Teams may be required to hike several miles through rough terrain and work during harsh weather conditions (i.e. high heat/humidity, cold, and rain). Team members are instructed to carry adequate water and food, rain gear, and changes in clothes, as there is a potential to get wet while working in, near, or on the water. Team members also check daily weather forecasts and the crew leader has the option to adjust the daily field schedule during days with high heat, high humidity, high air pollution, or other hazardous weather conditions. Sampling always occurs during daylight hours. A score of 3 was assigned because the shifts are not long, even though the work can be

strenuous. Monitoring staff must be diligent about adequate rest and nourishment to ensure that fatigue does not become a factor.

Environment

Environment was assigned a higher score (6) primarily because of the inherent dangers associated with working in streams and on lakes or ponds. Streams often have a very uneven and slippery substrate, and caution is needed to avoid slipping and falling in this environment. Activities occur during a variety of weather conditions, but are cancelled during thunderstorms and high winds. The crew leader is responsible for deciding when to cancel field activities due to weather or otherwise hazardous conditions. The protocol lead may also call off field activities, and will communicate decisions to field teams through the crew leader. Unexpected encounters with dangerous wildlife are possible (e.g., black bears, venomous snakes, etc.), mostly at the LNETN parks. Despite training, working in pairs, and using a life vest on lakes/ponds and streams the possibility exists for an individual to slip and be rendered unconscious, potentially leading to a drowning.

Incident Complexity

Incident complexity was assigned a higher-medium score (6) because daily field conditions vary constantly due to weather, and water conditions (waves, currents, flash flooding) can change quickly and unpredictably. Individual monitoring staff must use judgment and experience to respond appropriately. In addition, field teams can be (or perceive themselves to be) under considerable pressure to complete the field workload within stringent time intervals to accommodate water sample holding times and shipping requirements, and travel schedules. These administrative and operational pressures may tempt field teams to become careless or work longer hours, which can lead to accidents and injury caused by fatigue. The protocol lead must communicate regularly with field teams and adjust schedules or program goals if they cannot be accomplished or achieved safely.

Step 5: Evaluate Risk vs. Gain

The NETN Water Monitoring Protocol Lead has determined that the activity, if carried out in accordance with all SOPs, has an acceptable level of risk.

Step 6: Execute Decision

The decision made by the NETN Water Monitoring Protocol Lead is to conduct the activity in accordance with NETN Lake, Pond, and Stream Monitoring Protocol Standard Operating Procedures (SOPs).

Step 7: Supervise – Watch for Change

The NETN Water Monitoring Protocol Lead continually solicits feedback from all members of the water monitoring field team on safe execution of the protocol, including risk control options not considered thus far.

Appendix S1.C. Directions to nearest hospital from each park.

Acadia National Park – Headquarters

Directions to nearest hospital start at the **Headquarters building** (A) in Acadia National Park and end at the **Mount Desert Island Hospital** (B) in Bar Harbor, Maine. Destination is 1.6 miles and **five minutes** away:

Phone Number: (207) 288-5081.

Location: 10 Wayman Lane, Bar Harbor, ME 04609

Directions:

1. Head East (turn right) on Eagle Lake Road/ ME- 233 toward Arata Drive. Continue to follow ME-233 for 1.3 miles
2. ME-233 turns right and becomes Main St./ ME -3. Continue for 0.2 miles.
3. Turn left at Wayman Ln. MDI Hospital will be on the left (115 ft).

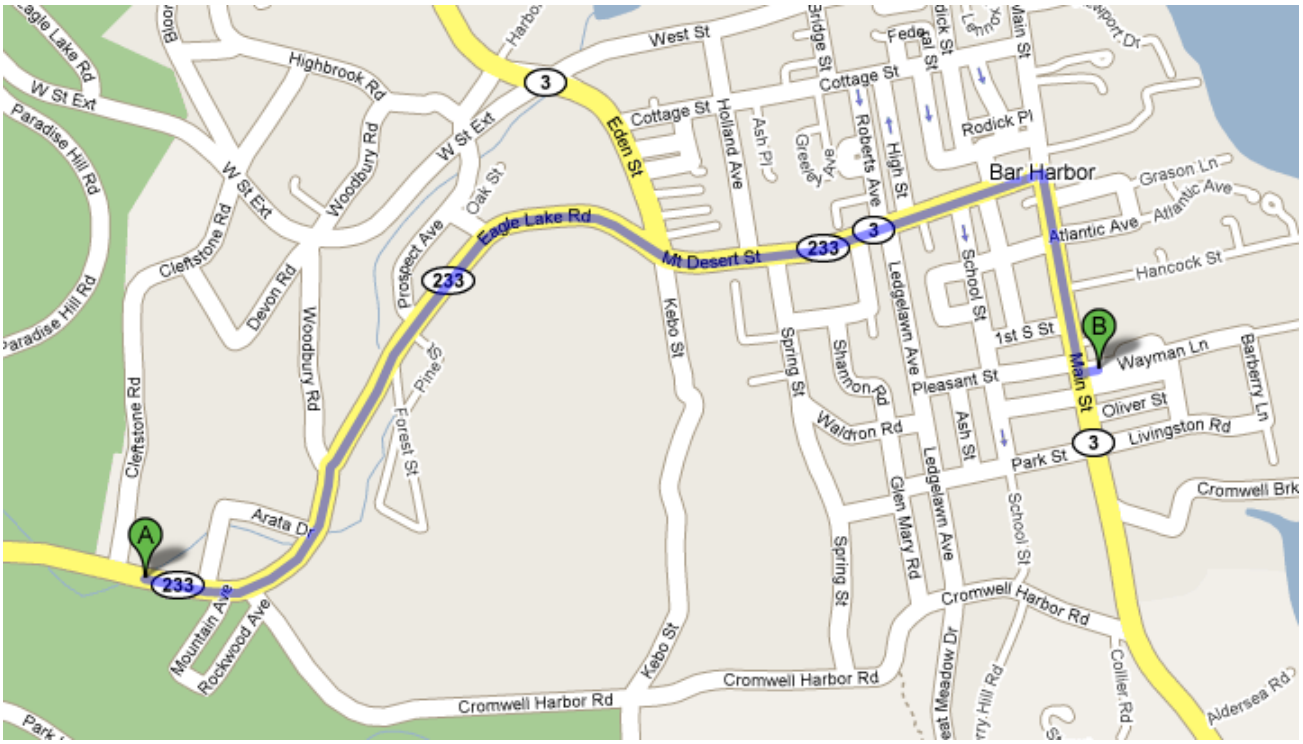


Figure S1.C.1. The route from Acadia NP Headquarters to the Mount Desert Island Hospital in Bar Harbor, Maine.

Acadia National Park – Seawall

Directions to nearest health clinic start at the **Seawall Park Housing** (A) in Acadia National Park and end at the **Community Health Center** (B) in Southwest Harbor, Maine. This clinic has been good for treating Lyme disease, but does not have emergency services. Destination is 2.3 miles and **four minutes** away:

Phone Number: (207) 244-5630.

Location: 9 Village Green Way, Southwest Harbor, ME 04679

Directions:

1. Head east on ME-102 Alt N/Seawall Road toward Seascape Ln for 2.2 miles.
2. Turn right onto ME-102 N/ Main St. and go 0.7 mi.
3. Turn left onto Village Green Way and go 0.1 mi. Community Health Clinic is at 9 Village Green Way.

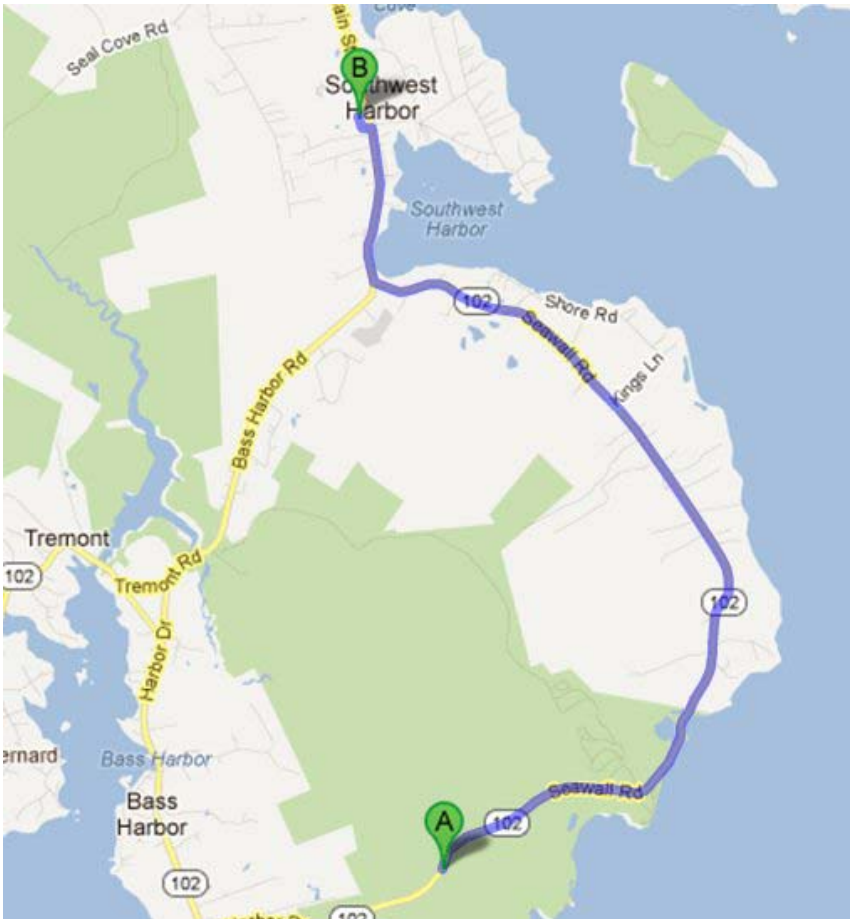


Figure S1.C.2. The route from Acadia NP Seawall Park Housing to the Community Health Center in Southwest Harbor, Maine.

Acadia National Park– Schoodic

Directions to nearest health clinic start at the **Schoodic Education and Research Center Entrance** (A) in Acadia National Park and end at the **Eleanor Eidener Dixon Memorial Clinic** (B) in Gouldsboro, Maine. Destination is 11.5 miles and **24 minutes** away.

Phone Number: (207) 963-4066.

Location: 37 Clinic Road, Gouldsboro, ME 04607

Directions:

1. 1. Head south out of parking lot and go about 240 feet.
2. Take the 1st left and go 0.1 miles.
3. 3. Turn left toward Moore Rd and follow 3.3 miles.
4. Continue straight onto Moore Rd for 1.5 miles.
5. Turn left onto ME-186 W/Main St and proceed 0.6 miles.
6. Turn right onto ME-186 W/Newman St and follow for 6.0 miles.
7. Continue onto Clinic Rd and go 0.1 miles. Clinic will be on the left.

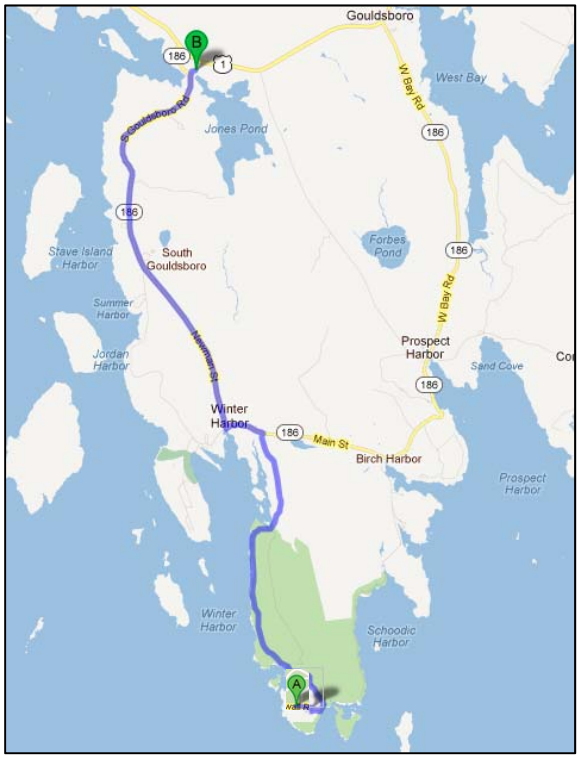


Figure S1.C.3. The route from Schoodic Education and Research Center (A) in Acadia National Park to Eleanor Widener Dixon Memorial Clinic (B) in Gouldsboro, Maine.

Marsh-Billings-Rockefeller National Historic Park

The nearest hospital to Woodstock, Vermont is Dartmouth Hitchcock Medical Center (DHMC) in Lebanon, New Hampshire, and is about 22 miles and **31 minutes away**. Directions to nearest hospital start at the **Billings Farm parking lot** (A) in Woodstock, Vermont and end at the **Dartmouth Hitchcock Medical Center** (B) in Lebanon, New Hampshire:

Phone Number: (603) 650-5000

Location: 1 Medical Center Drive, Lebanon, NH.

Directions:

1. From the Billings-Farm parking lot, turn left at the Y onto Elm Street/ VT-12. Continue for 0.4 miles.
2. Turn left at Pleasant St./ VT-12. Continue for 0.6 miles.
3. Turn left at US-4/VT-12/Woodstock Rd. Continue to follow US-4 for 9.4 miles.
4. Turn right and go 0.1 miles.
5. Take the ramp onto 1-89 South and go 8.1 miles.
6. Take exit 18 for NH-120 toward Hanover and go 0.2 miles.
7. Turn left at Centerra Pkwy/Lahaye Drive and continue on Lahaye Drive for 0.5 miles.
8. Turn right at the Hitchcock Loop Road/ Medical Center Drive and continue for 0.3 miles.
9. Turn left at DHMC East Entrance, and turn right to stay on DHMC East Entrance.



Figure S1.C.4. Route from Marsh-Billings-Rockefeller NPS in Woodstock, Vermont to Dartmouth Hitchcock Hospital in Lebanon, New Hampshire.

Minute Man National Historic Park

Directions to nearest hospital start at the **Brooks Village parking lot** (A) on 2A (N Great Road) in Minute Man National Historical Park, and end at **Emerson Hospital**. Destination is 4.7 miles and about **7 minutes** away.

Phone Number: (978) 287-3690 (Hospital) or 978-287-3690 (Polo Emergency Center)

Location: 133 Old Road to Nine Acre Corner, Concord MA 01742

Directions:

1. Head northwest on Massachusetts 2A W/N Great Rd toward Bedford Ln. Continue to follow Massachusetts 2A W. Continue for 4.6 miles.
2. Turn left onto Old Road to 9 Acre Corner. Continue for 433 feet.
3. Turn left. Continue for 0.1 miles.
4. Destination will be on the right.

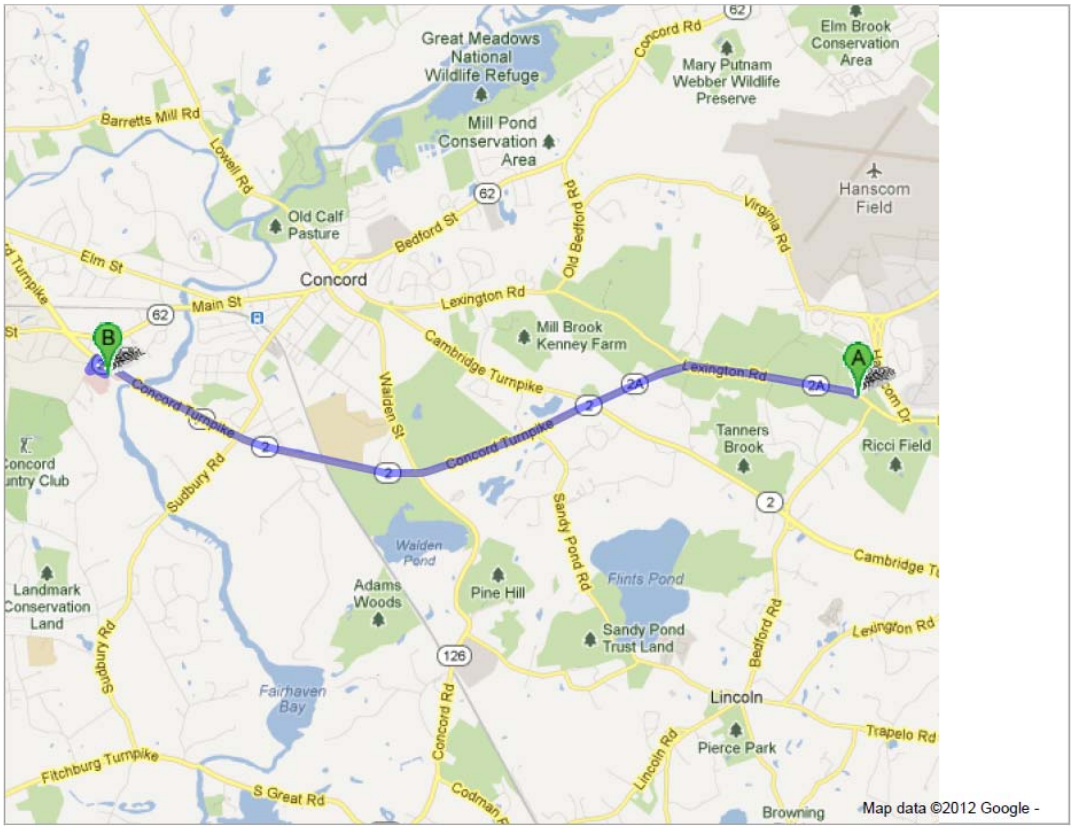


Figure S1.C.5. Route from Minute Man NHP Brooks Village parking lot in Concord, Massachusetts to Emerson Hospital.

Morristown National Historic Park

Directions to nearest hospital start at the **Jockey Hollow Visitor Center** (A) in Morristown National Historic Park, and end at **Morristown Memorial Hospital** (B). Destination is 6.5 miles and about **18 minutes** away:

Phone Number: (973) 971-5000.

Location: 100 Madison Ave, Morristown, NJ 07962.

Directions:

1. Head northwest on Cemetary Rd. toward Sugarloaf Rd. Continue 1.2 miles.
2. Turn left at Sugarloaf Rd. Continue 1.3 miles
3. Turn left on Jockey Hollow Rd. Continue 0.8 miles
4. Continue on Western Ave. Continue 1.9 miles.
5. Turn right on NJ-24/ Washington St. Continue 0.2 miles.
6. Continue on NJ-53/ South St. for 0.7 miles.
7. Turn slight left at Madison Ave/ NJ-53. Continue 0.5 miles. Destination is on the left.

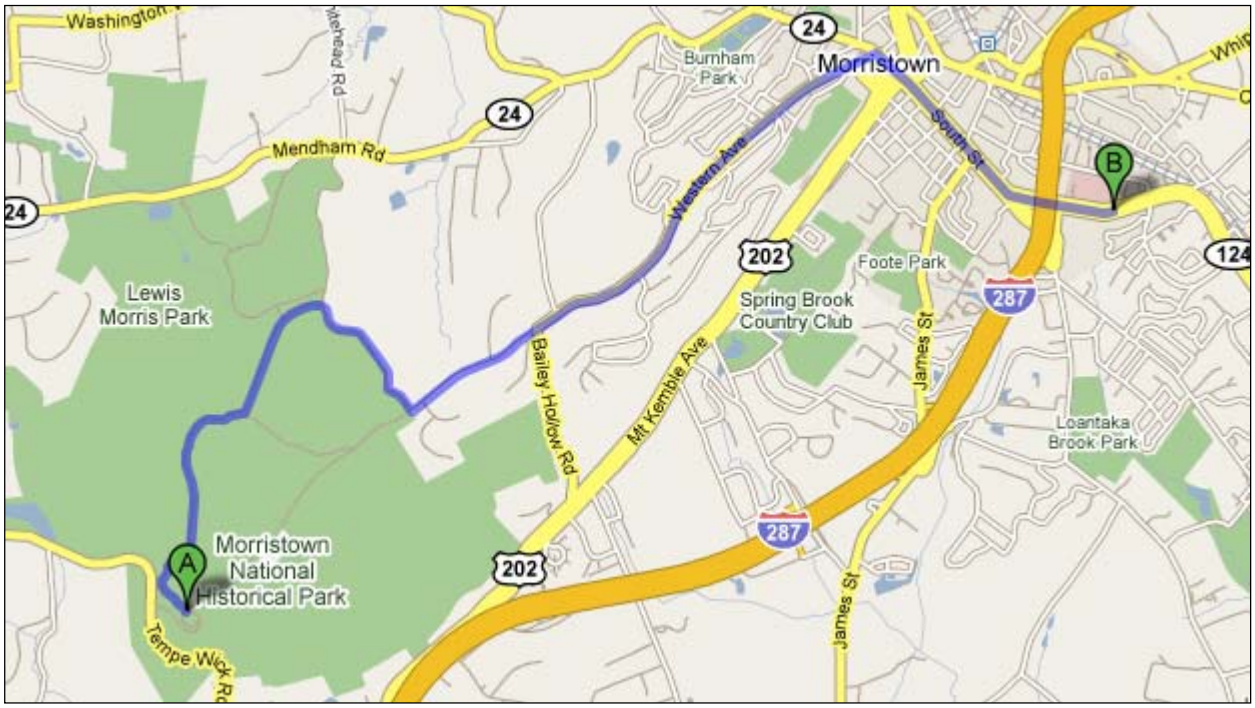


Figure S1.C.6. Route from Morristorn NHP Jockey Hollow Visitor Center to the Morristown Memorial Hospital, both in Morristown, New Jersey.

Roosevelt-Vanderbilt National Historic Sites (ELRO, HOFR, VAMA)

Directions to nearest hospital start at the **Visitor Center parking lot** (A) at the Home of FDR National Historic Site**,** and end at **St. Francis Hospital** (B). Destination is 4.8 miles and about **9 minutes** away:

Phone Number: (845) 483-5000.

Location: 241 North Road, Poughkeepsie, NY 12601.

Directions:

1. Head south on Albany Post Rd./ Rte-9/ US-9 toward Kessler Dr. Continue for 3.7 miles.
2. Turn left onto Delafield St. Continue for 0.2 miles.
3. Turn left onto Spruce St. Continue for 308 ft.
4. Spruce St. turns right and becomes Talmadge St. Continue for 0.2 miles.
5. Turn left at NY-9G/ Washington St. Continue for 0.4 miles.
6. Destination is on the right side of Washington St.

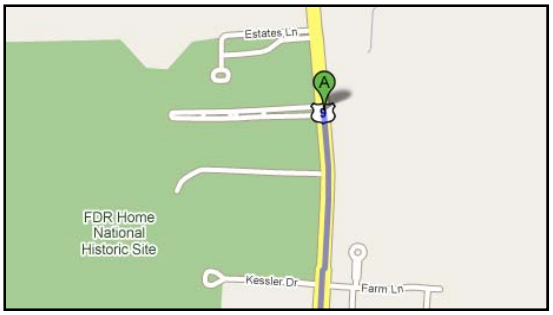


Figure S1.C.7. Start point at Home of FDR NHS Visitor Center parking lot.

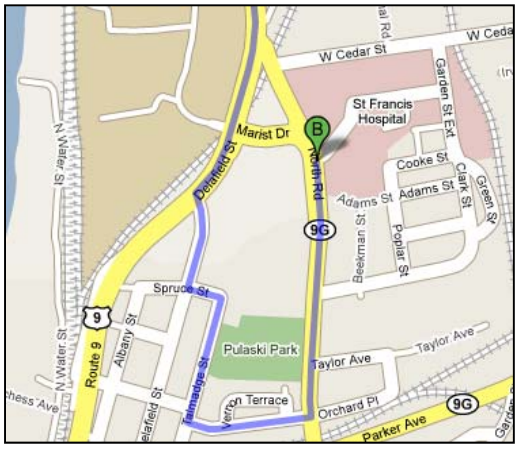


Figure S1.C.8. End point at St. Francis Hospital.



Figure S1.C.9. The entire route.

Saint-Gaudens National Historic Site (Option 1)

Directions to nearest hospital start at the **Visitor Center parking lot** (A) at Saint-Gaudens National Historic Site**,** and end at **Mount Ascutney Hospital** (B). Destination is 3.8 miles and about **10 minutes** away:

Phone Number: (802) 674-6711.

Location: 289 County Road, Windsor, VT 05089.

Directions:

1. Head southwest on St. Gaudens Rd. toward NH-12A/ NH Rte 12A/ Wilson Rd. Continue for 0.6 miles.
2. Take a slight left at NH-12A/ NH Rte 12A/ Wilson Rd, and continue for 1.5 miles.
3. Turn right onto Bridge St. and continue for 0.3 miles.
4. Turn left on State St. and go 0.7 miles.
5. Turn right at County Rd. and go 0.3 miles.
6. Destination is on the left side of County Rd.

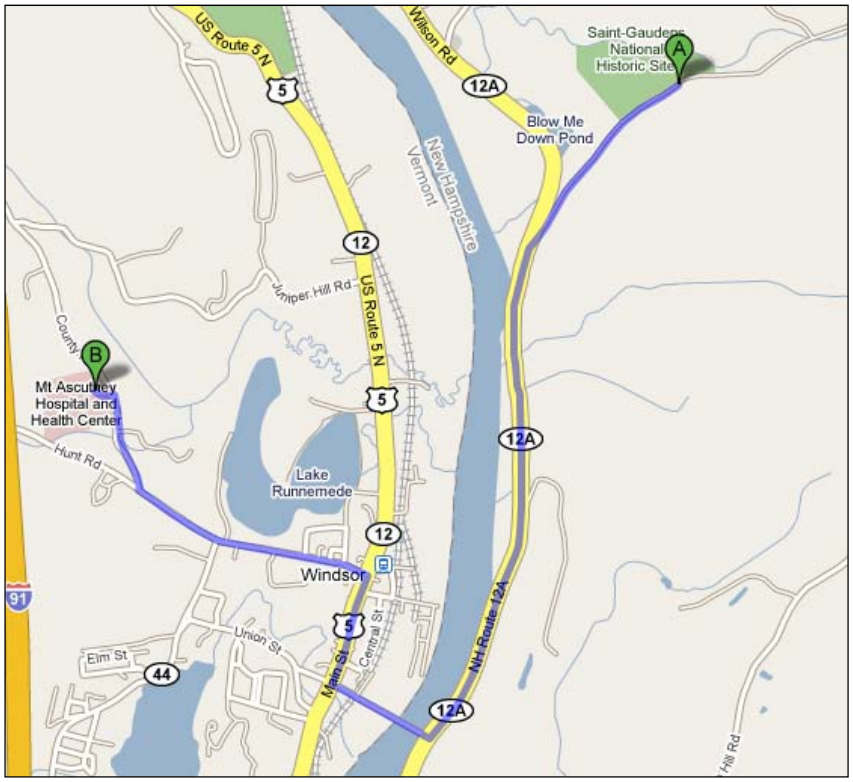


Figure S1.C.10. Option 1 route from Saint-Gaudens NHS Visitor Center parking lot to Mount Ascutney Hospital.

Saint-Gaudens National Historic Site (Option 2)

An alternative to Mount Ascutney Hospital is the Dartmouth Hitchcock Medical Center in Lebanon, New Hampshire. For injuries that are not life-threatening, DHMC is the better option. Directions to DHMC start at the Visitor Center parking lot (A) at Saint-Gaudens National Historic Site**,** and end at Dartmouth Hitchcock Medical Center in Lebanon, NH (B). Destination is 19.5 miles and about **33 minutes** away:

Phone Number: (603) 650-5000

Location: 1 Medical Center Drive, Lebanon, NH.

Directions:

1. Head southwest on St. Gaudens Road toward NH-12A/NH Route 12A/ Wilson Rd. Continue for 1 mile.

2. Turn sharp right at NH-12A/NH Route 12A/ Wilson Road, and continue on NH-12A for 11.4 miles.

3. Merge onto I-89 S via the ramp to Concord/Lebabon and go 3.8 miles.

4. Take exit 18 for NH-129 toward Hanover and go 0.2 miles.

5. Turn left at Centerra Pkwy/Lahaye Drive and continue on Lahaye Drive for 0.5 miles.

6. Turn right at the Hitchcock Loop Road/ Medical Center Drive and continue for 0.3 miles.

7. Turn left at DHMC East Entrance, and turn right to stay on DHMC East Entrance.



Figure S1.C.11. Option 2 route from Saint-Gaudens NHS to Dartmouth Hitchcock Medical Center.

Saratoga National Historic Park

Directions to nearest hospital start at the **Saratoga National Historic Park entrance on NY- 32** (A)**,** and end at **Saratoga Hospital** (B). Destination is 11.6 miles and about **24 minutes** away.

Phone Number: (518) 587-3222

Location:.211 Church Street, Saratoga Springs, NY 12866

Directions:

1. Turn right onto NY-32 N and go 0.8 mi.
2. Turn left onto Co Rd 71 and go 1.5 mi.
3. Turn right onto Sweer Rd. and go 1.4 mi.
4. Continue on Nielson Road for 0.9 mi.
5. Turn right onto Chapman Hill Rd and go 0.5 mi.
6. Continue onto Fitch Rd.
7. Turn right onyo New York 9P N and continue 2.2 mi.
8. Turn right onto Gilbert Rd. and go 1.3 mi.
9. Turn left onto Lake Ave. and go 2.1 mi.

10 Continue onto Church Street. After 0.6 mi, destination will be on the right.

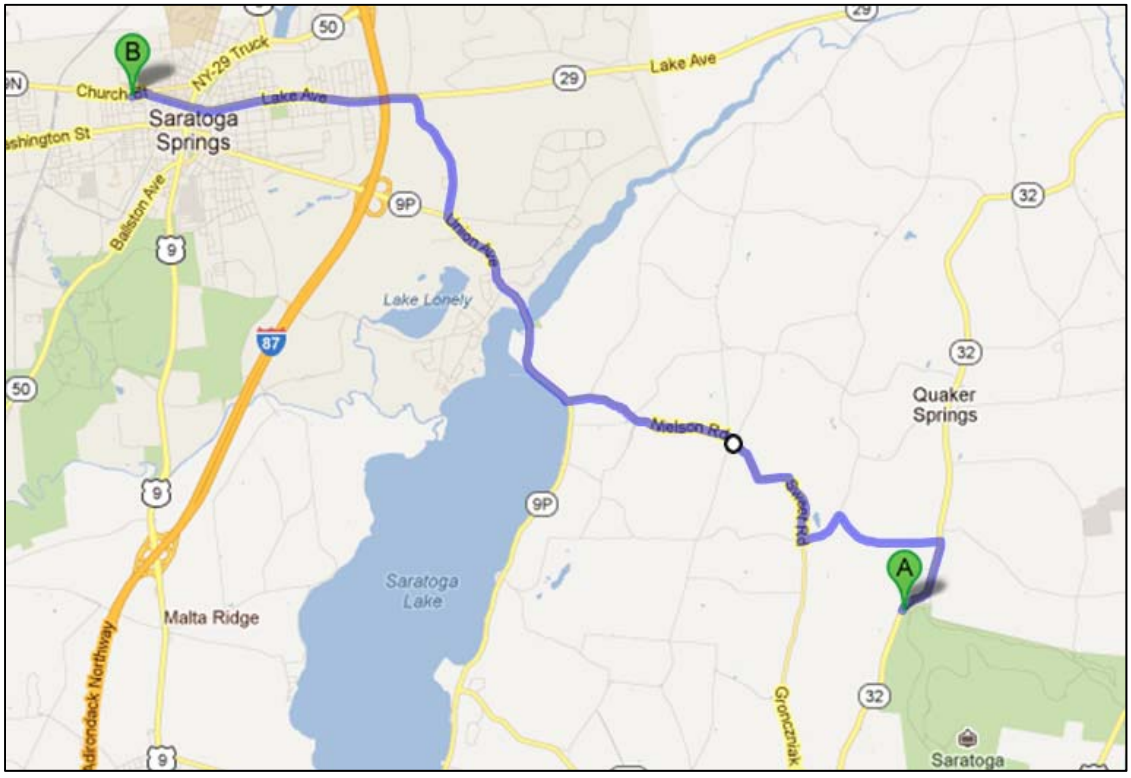


Figure S1.C.12. Route from Saratoga NHP entrance on NY-32 to Saratoga Hospital.

Weir Farm National Historic Site (Option 1)

Directions to nearest hospital start at **Weir Farm National Historic Site** on Nod Hill Road (A), and end at **Danbury Hospital** (B). Destination is 12.2 miles and about **22 minutes** away.

Phone Number: (203) 739-7000

Location: 24 Hospital Avenue, Danbury, CT 06810

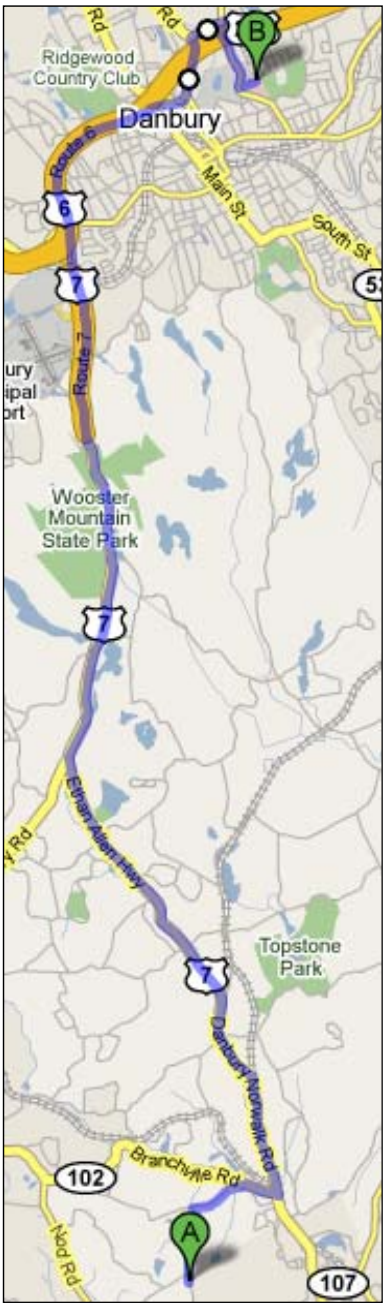


Figure S1.C.13. Route from Weir Farm NHS to Danbury Hospital

Directions:

1. Exit park North onto Nod Hill Road. Head North on Nod Hill Road toward Pelham Ln. Continue for 0.7 miles.

2. Turn right at Old Branchville Rd, and continue 0.5 miles

3. Turn right at Branchville Rd/CT-102, and continue 0.3 miles.

4. Turn left at Danbury Norwalk Rd/US-7 Continue to follow US-7 for 8.6 miles

5. Take the exit onto 1-84 E/ US-7 N toward New Milford/Waterbury and continue for 1.7 miles.

6. Take exit 5 toward CT-37/Bethel/CT-39/CT-53. Go 0.2 miles.

7. Merge onto Downs St. and go 0.7 miles.

8. Continue on CT-37/North St. / Rte-37 for 0.7 miles

9. Turn right at Hayestown Avenue and go 0.3 miles.

10. Turn right at Tamarack Avenue and go 0.6 miles.

11. Turn left at Hospital Avenue.

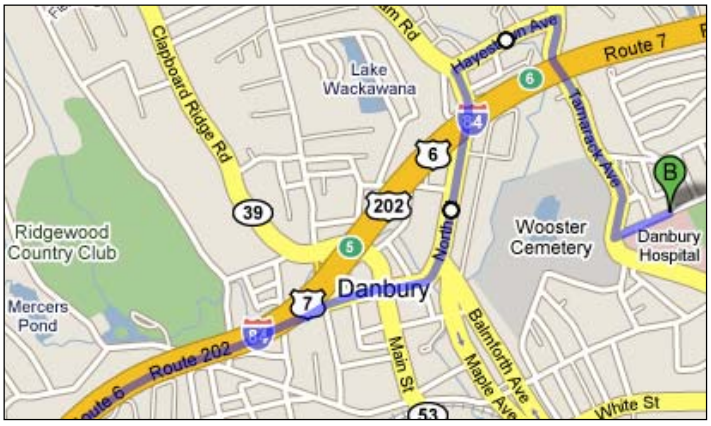


Figure S1.C.14. End point at Danbury Hospital

Weir Farm National Historic Site (Other options)

WEFA has requested that we also include **Norwalk Hospital**, which is the same distance away:

1. Exit park South onto Nod Hill Road- Follow Nod Hill Road down to the end where it meets with CT-33.
2. Take a left on CT-33 S/Ridgefield Rd and follow it down to US-7
3. Take a right onto US-7 S for about 3.5 miles and follow signs toward Norwalk until you come to a traffic light with the D.M.V. on your left and the Interstate 95 connector on your right.
4. By this time you will see blue hospital directional signs on your right – take right then left to get onto connector .
5. Follow the connector south to Exit #1(again, look for blue hospital sign) go left at the end of the exit onto VanBuren St.- then at second light take right onto Maple St.- hospital is on the left.

Urgent care centers in Norwalk and Ridgefield are closer and can handle most situations where monitoring staff would be transporting someone (as opposed to an ambulance):

Urgent Care of Norwalk
346 Main Ave.
Norwalk, CT 06851
Phone: (203) 846-0005 Fax: (203) 846-0012

1. Head south on Nod Hill Rd toward Granite Dr (2.0 mi)
2. Turn left to stay on Nod Hill Rd (1.3 mi)
3. Turn left onto CT-33 S/Ridgefield Rd (2.0 mi)
4. Turn right onto CT-33 S/US-7 S/Danbury Rd (1.2 mi)
5. Slight right onto US-7 S/Danbury Rd. Continue to follow US-7 S (2.0 mi)
6. Continue onto Main Ave. Destination will be on the left (1.4 mi)

Urgent Care of Ridgefield
10 South Street
Suite 101
Ridgefield, CT 06877
Phone: (203) 431-4600 Fax: (203) 431-4601

1. Head north on Nod Hill Rd toward Pelham Ln (443 ft)
2. Turn left onto Pelham Ln (0.9 mi)
3. Turn right onto Whipstick Rd (0.2 mi)
4. Continue onto Nod Rd (1.4 mi)
5. Continue straight onto Branchville Rd (1.2 mi)
6. Turn right onto Main St (1.0 mi)

7. Turn right onto Danbury Rd (0.3 mi)
8. Take the 2nd right onto South St. Destination will be on the right (171 ft)

Appendix S1.D. Workers compensation procedures for each park, Version 1.1.

Workers compensation procedures

March 21, 2012

Human Resources contacts for workers compensation are Cecelia Neugebauer (410-962-4290), the NER regional contact; and Carol D. Moore (202-619-7297), the contact for NER/NCR combined. A useful resource on Worker's Compensation is the NPS 2007 Supervisor's Guide to Worker's Compensation.

EXTREMELY IMPORTANT: Make sure that the employee gets prompt medical treatment, if medical attention is needed. If the injury is life-threatening, the employee should be taken to an emergency room immediately; the paperwork can wait. For non-life-threatening injuries, it is OK to issue a CA-16 and CA-17 before the on-line information is entered.

IMPORTANT: Makes sure the employee sees a doctor, not a nurse, nurse practitioner, or physician's assistant. The Worker's Compensation Program tends to deny payment when a doctor is not seen, according to Frank Alvarez (7/11/2008).

Initial Reporting

If the injured person is a volunteer, Cecelia Neugebauer will likely need to set up a profile for them in SMIS. A volunteer who is a foreign national (and does not have a social security number) will need to be processed on paper; Frank will need to help with this as well.

1. If an employee has an accident or other workers compensation incident (e.g., bitten by a deer tick), the first step is for them to report the incident. THIS MUST BE DONE WITHIN 48 HOURS, AND MUST BE DONE FOR EACH INCIDENT. Note that if there is a recent claim in the system for this employee, he or she may not be able to start a new report. Contact Cecelia Neugebauer for assistance.
2. Go to https://www.smis.doi.gov, and click on Accident Reporting.
3. Click on "File a Worker's Compensation Claim (CA1/CA2)".
4. Log in using your last name and the last four of your Social Security Number
5. Enter your e-mail address if needed, then click "Verify E-mail and Request a Claim ID". This can be any e-mail address that you have regular access to.
6. Check your e-mail to get your claim ID, then enter the claim ID in the box on the web site.
7. Verify or input all information requested on the next page. Tick bites would be an injury/traumatic injury rather than an occupational disease or illness.
8. On the next page, enter the details that are asked for, including date, location, and cause and nature of injury.
9. Fill out the employee certification. I have not been able to get solid guidance on this, but apparently checking "Continuation of Regular Pay (COP)" will allow employees to claim

doctor's visits and other lost time due to the incident as regular pay (i.e., not use sick or annual leave). This box should probably be checked. Make sure to read all the statements,

10. and click the check box that you have read the statements. Then click "Complete your claim submission".
11. Make sure to send a note to your supervisor. Don't forget to *include the claim number* generated by the system. He or she will need to enter information into the same system
12. about your report, and will also need to issue the CA-16 form that you will need to bring to any doctor's appointment.

Once the employee fills out the CA-1 or CA-2, the supervisor needs to go into SMIS (Safety Management Information System) to fill out the supervisor portion of the form. The supervisor should receive an automated message from the SMIS system.

1. Go to https://www.smis.doi.gov, and click on Accident Reporting.
2. Click on "Perform All Supervisor Safety Activities", and click "Proceed".
3. Log in using your last name and the last four of your Social Security Number
4. Enter your e-mail address if needed, then click "Submit/Verify your E-mail Address". This can be any e-mail address that you have regular access to.
5. Choose "Complete the supervisor section of a CA-1 or CA-2" and click "Perform".
6. Enter the Claim Identifier provided by the employee, and click "Submit".
7. Fill in the Supervisor's Report and Certification, and click "Submit". Each box has hyper-linked help if you have any questions about what is needed.
8. Fill in the additional information requested about the supervisor's investigation into the accident, and click "Submit".
9. Next, print and sign the CA-1, and also have the employee sign the CA-1. Keep the form on file in the employee's local personnel file.
10. Print the OSHA Form 301, and save this with the CA-1

Fill out form CA-16. The CA-16 MUST be issued within seven days of the incident. DO NOT post this form on any web site; it should not be accessible to employees (it was described as a "blank check" by Carol Moore).

1. Fill in blocks 2 through 14. Box 1 can be filled in by the employee.
2. NOT CLEAR on whether tick bites require OWCP approval (box 7).
3. Cecelia Neugebauer will fill in box 12 at a later date.

Fill out form CA-17. This form is available at http://www.dol.gov/libraryforms/go-us-dol-form.asp?FormNumber=367. It is the supervisor's statement about the injury, and information about the employee's job.

1. Fill out all information on Side A.

2. On page 2, supply the agency address (e.g., network mailing address). Cecelia Neugebauer will supply the OWCP address at a later date.

Give the CA-16 and CA-17 to the employee. The employee will need the doctor to fill in the back of form CA-16 (boxes 15 – 39), side B and address on page 2 of form CA-17, and return the form to the employee. Things to keep in mind:

1. Employees need to ask the doctor's office whether they accept federal Worker's Compensation BEFORE they go for their appointment.
2. Employees should be provided with the information at http://www.dol.gov/esa/owcp/dfec/regs/compliance/infoinjuredwrkers.htm.
3. Employees should provide the information at http://www.dol.gov/esa/owcp/dfec/regs/compliance/infomedprov.htm to the doctor. Among other things, the doctor must be aware that they are responsible for signing up in an online system (ACS) in order to be paid for the Worker's Compensation case.

If possible, a typed medical summary (from the doctor's office) should be attached to the medical form; at the very least, employee should ensure that doctor's responses on the CA-16 are legible.

When the employees return forms CA-16 and CA-17 to you:

Everything needs to go to Cecelia Neugebauer. Keep copies and send her the originals at the address below.

Cecelia R. Neugebauer
National Park Service/Northeast Region
Central Servicing Human Resources Office
2400 E. Fort Avenue
Baltimore, MD 21230-5393
(410) 962-4290 x111 (voice)
(410) 962-2182 (fax)

Other important information

Use this link to find forms used by OWCP:
http://www.dol.gov/owcp/dfec/regs/compliance/forms.htm

Employees can use this link for tracking the progress of their claim:
http://owcp.dol.acs-inc.com/portal/main.do

Jim Comiskey compiled information about billing from a series of interactions with Frank Alvarez (previous OWCP contact). The document covers information on billing for the employee, and information on billing for doctors, hospitals, and pharmacies.

Alternative Work Assignment (AWA)

1. If the doctor says that the employee cannot return to regular work, then it is important to set up an Alternative Work Assignment for the employee.

2. Use the AWA template to describe the alternative work assignment. The Supervisor's Guide has a filled-out example.
3. Use the AWA physician letter template to create a letter to the employee's doctor.
4. Use the AWA employee letter template to create a letter to the employee.
5. Send the above documents to the employee, along with a copy of their PD. Copy Frank Alvarez on the e-mail.
6. The employee should return to the doctor with the AWA, physician letter, PD, and CA-17, and discuss the alternative work assignment with the doctor. The doctor will need to sign off on the AWA or make suggestions.
7. Once you receive the doctor's input, discuss the AWA with Frank Alvarez, to ensure that the AWA is within the doctor's restrictions before the employee returns to work.

Time sheets

Make sure that the employee's time sheet is filled out correctly to reflect any lost time due to the injury; this is required under FECA, the Federal Employees Compensation Act.

1. Time lost on the day of injury due to a traumatic injury is coded as Administrative Leave (060).
2. Lost time ("Continuation of Pay" or COP) after the day of injury includes time spent going to doctor's appointments, physical therapy, or time the employee is not able to work due to the injury.
3. Record the amount of hours lost due to the injury on the employee's time sheet using the appropriate code. NOTE: Frank Alvarez (7/11/2008) recommended claiming the full day that has any time lost as COP. Even if the employee only spends 1 hour at a doctor's appointment, he thought that the full day should be coded COP. This advice seems to run counter to the pay code information that Carol Daye supplied: "Code the T&A Record with the actual number of hours absent."
4. If the employee is unable to work for a period that includes lieu days, use the codes for Unpaid COP on each lieu day.
5. Continuation of Pay codes:
    a. 160 – FECA/COP Paid (1st Occurrence)
    b. 164 – FECA/COP Paid (2nd Occurrence)
    c. 166 – FECA/COP Paid (3rd Occurrence)
    d. 168 – FECA/COP Paid (4th Occurrence)
    e. Other codes are available for 5th through 11th occurrences; starting at 16L
    f. My assumption is that an "occurrence" is any time related to a specific accident or injury. So if an employee has a tick bite and then sprains an ankle, you'd use the "first occurrence" codes for the tick bite and the "second occurrence" codes for the sprain.
6. Unpaid Continuation of Pay codes:

a. 161 – FECA/COP Unpaid (1st Occurrence)
b. 165 – FECA/COP Unpaid (2nd Occurrence)
c. 167 – FECA/COP Unpaid (3rd Occurrence)
d. 169 – FECA/COP Unpaid (4th Occurrence)

7. Other codes are available for 5th through 11th occurrences; starting at 16M
8. There are separate codes for "Light Duty" work, but the NPS 2007 Supervisor's Guide says to use code Regular Hours (010) for "Light Duty" or an AWA.

Revision Log

June 26, 2009 – Added a paragraph about handling injured volunteers.
January 7, 2010 – Added section "Other important information".
March 21, 2012 – Changed NPS OWCP contact to Cecelia Neugebauer.

Appendix S1.E. Instructions for responding to an automobile accident in an NPS-owned vehicle.

1. Stop immediately and turn on emergency flashers.
2. Take steps to prevent another accident at the scene.
3. Call 911 or ambulance if necessary.
4. Notify police, NPS law enforcement and your supervisor.
5. In the event of death, actual or potential serious injury, or significant property damage (damage greater than $2,500), the employee involved must immediately notify the NER Regional Tort Claims Officer (TCO), Cyrille Young (215-597-7701), in addition to their supervisor.
6. In reporting an accident, employee should state the facts to the best of her/her knowledge. **Conclusions as to fault or responsibility should not be stated.** The employee should report the accident only to authorized representatives of the Government, the employee's insurance company, and police officers investigating the accident. The employee shall also file any report required by law.
7. Get name and address of witness (preferably two witnesses). Ask witness to complete Standard Form (SF) 94, Statement of Witness, contained in vehicle glove compartment.
8. State/provide your name, address, place of employment, name of your supervisor, and upon request show your driver's license and vehicle registration information.
9. Complete Standard Form (SF) 91, Motor Vehicle Accident Report at the scene. If conditions prevent this, make notes of the following:
    a. Registration information for other vehicle(s) (owner's name, owner's address, tag number, VIN, and vehicle description)
    b. Information on other drivers (name, address, operator's permit, and expiration date)
    c. Name and address of each person involved and extent of injury, in any.
    d. Name and address of company insuring other vehicle(s) and insurance policy number
    e. General information such as location, time, measurements, weather, damage, etc.
10. Encourage police to provide a Police Report and, if available, submit a copy with SF 91.
11. If you have a camera, take pictures of the accident scene and any damage to the vehicles involved. Submit along with SF 91.

Appendix S1.E. Instructions for responding to an automobile accident in an NPS-owned vehicle. (continued).

12. If vehicle is unsafe to operate, arrange for a towing services and pay for these services on vehicle charge/gas card.
13. Submit all reports and data to your supervisor within one working day.
14. If federal employee is injured, workers compensation process needs to be initiated within 48 hours of incident. Supervisor will assist with this process. It is important for injured employee to receive prompt medical treatment. Make sure the employee sees a doctor, not a nurse, nurse practitioner, or physician's assistant.
15. Supervisor will submit copies of all reports and data to the employee's regional TORT Claims Officer (TCO) [Cyrille Young 215-597-7701] as soon as possible but no later than 10 calendar days after the accident.

Accident/collision reports should be filed for:

1. All motor vehicle accidents involving federally owned or leased vehicles and employee-owned or rented vehicles while being used on official business, regardless of the amount of damage.
2. All public/visitor accidents will be reported on a SF-91 when a government-owned vehicle is involved, government property is damaged, fatality occurs, medical treatment is required and/or a reasonable possibility of a tort claim is expected.
3. Thefts and Vandalism should be reported to Park Law Enforcement Officials rather than reported on SF-91.
4. Reporting Multiple Vehicle Accidents – when a privately owned vehicle damages Government property, two reports (SF-91) are required: one report for the Government property and one for the private operator.

Appendix S1.F. Northeast Region accident/incident reporting process.

Northeast Region

Tort Claims – Accident/Incident Reporting Process

Regional office employees travel on official government business and may be injured and/or involved in a motor vehicle accident while in travel status. Use this checklist to ensure all required report information is gathered and proper notifications have been made immediately following an injury and/or accident that may result in a possible tort claim against the Government in accordance with Departmental Manual, Part 451, *Claims*.

REPORTING GUIDELINES

- ☐ Employees will immediately report any incident or accident involving a *private person* or *private property* which may give rise to a tort claim against the Government.
- ☐ In the event of death, actual or potential serious personal injury or significant property damage the employee involved will immediately notify his or her supervisor and the Regional Tort Claims Officer (TCO), Cyrille Young (215-597-7701).
- ☐ Employee supervisor will immediately follow up with the regional TCO to ensure the employee report was received and determine if additional information is needed.
- ☐ Damage to a government motor vehicle (GMV), as defined by Reference Manual 50B, *Occupational Safety and Health Program* as <u>any vehicle</u> <u>owned</u>, <u>leased</u>, <u>rented</u> <u>or otherwise acquired for official purposes</u>, or to private property resulting from GMV operation will be reported immediately as described above.
- ☐ Standard Form (SF) 91, *Motor Vehicle Accident Report*, and SF 94, *Statement of Witness*, as necessary must be completed for all motor vehicle accident cases and promptly submitted to the regional TCO. These forms should be printed and kept with you while on official government travel when operating a GMV. Copies of all accident reports will be furnished to the employee's regional TCO as soon as possible but <u>no later than 10 calendar days after the accident</u>.
- ☐ In reporting an accident, employee should state the facts to the best of his/her knowledge. Conclusions as to fault or responsibility should not be stated. The employee should report the accident only to authorized representatives of the Government, the employee's insurance company, and police officers investigating the accident. The employee shall also file any report required by law.
- ☐ If an employee involved in an accident carries liability insurance which may cover the employee or the Government, the employee shall report the accident to the insurance company and shall also furnish the regional TCO a copy of the insurance policy together with applicable endorsements and amendments.

Appendix S1.F. Northeast Region accident/incident reporting process (continued).

DEFINITIONS

Government Motor Vehicle: Any vehicle owned, leased, rented or otherwise acquired for official purposes.

Incident: An event involving National Park Service employees or other personnel directly supervised by the NPS, that results in a near-hit, injury, illness, fatality, damage to government property, or damage to other property being used for government business.

Minor Incident/Accident: An event involving National Park Service employees, or other personnel directly supervised by the NPS, that results in:

1) Injury or illness requiring only first-aid treatment (per OSHA definition) and is not otherwise a recordable injury/ illness; and/or

2) Property damage of less than $2,500.

NPS Employee: All NPS employees, or other Federal, State, or local agency employees under NPS supervision/jurisdiction, and/or contractors and volunteers directly supervised by NPS or under NPS jurisdiction.

Significant Property Damage/Operating Loss Incident: Incidents that result in property damage or operating loss from $2,500 up to, but less than $250,000.

Serious Accident: An incident involving National Park Service employees, or other Federal, State, or local agency employees under NPS supervision/jurisdiction, and/or contractors and volunteers directly supervised by NPS (e.g. volunteers, SCA, emergency workers, etc.), that results in:

1. One or more work-related fatalities, or imminently fatal injuries or illnesses;

2. Hospitalization of three or more employees from a single occurrence;

3. Property damage under Departmental/NPS control, and/or operating loss of $250,000 or more; and/or consequences that the NPS Designated Agency Safety and Health Official (DASHO) or the Regional Designated Safety and Health Official (RDSHO) judges to warrant investigation under the serious accident investigation procedures.

Appendix S1.G. SF-91 Motor Vehicle Accident Report.

MOTOR VEHICLE ACCIDENT REPORT	Please read the Privacy Act Statement on Page 3	INSTRUCTIONS: Sections I thru IX are filled out by the vehicle operator. Section X, items 72 thru 82c are filled on by the operator's supervisor. Section XI thru XIII are filled out by an accident investigator for bodily injury, fatality, and/or damage exceeding $500.

SECTION I - FEDERAL VEHICLE DATA

1. DRIVER'S NAME (Last, first, middle)	2. DRIVER'S LICENSE NO./STATE/LIMITATIONS	DATE OF ACCIDENT

4a. DEPARTMENT/FEDERAL AGENCY PERMANENT OFFICE ADDRESS	4b. WORK TELEPHONE NUMBER ( )

5. TAG OR IDENTIFICATION NUMBER	6. EST. REPAIR COST	7. YEAR OF VEHICLE	8. MAKE	9. MODEL	10. SEAT BELTS USED
	$				☐ YES ☐ NO

11. DESCRIBE VEHICLE DAMAGE

SECTION II - OTHER VEHICLE DATA (Use Section VIII if additional space is needed)

12. DRIVER'S NAME (Last, first, middle)	13. SOCIAL SECURITY NO./ TAX IDENTIFICATION NO.	14. DRIVER'S LICENSE NO./STATE/LIMITATIONS

15a. DRIVER'S WORK ADDRESS	15b. WORK TELEPHONE NUMBER ( )
16a. DRIVER'S HOME ADDRESS	16b. HOME TELEPHONE NUMBER ( )
17. DESCRIPTION OF VEHICLE DAMAGE	18. ESTIMATED REPAIR COST $

19. YEAR OF VEHICLE	20. MAKE OF VEHICLE	21. MODEL OF VEHICLE	22. TAG NUMBER AND STATE

23a. DRIVER'S INSURANCE COMPANY NAME AND ADDRESS	23b. POLICY NUMBER
	23c. TELEPHONE NUMBER ( )

24. VEHICLE IS	25a.OWNER'S NAME(S) (Last, first, middle)	25b. TELEPHONE NUMBER
☐ CO-OWNED ☐ RENTAL ☐ LEASED ☐ PRIVATELY OWNED		( )

26. OWNER'S ADDRESS(ES)

SECTION III - KILLED OR INJURED (Use Section VIII if additional space is needed)

A

27. NAME (Last, first, middle)	28. SEX	29. DATE OF BIRTH

30. ADDRESS

31. MARK "X" IN TWO APPROPRIATE BOXES	32. IN WHICH VEHICLE	33. LOCATION IN VEHICLE	34. FIRST AID GIVEN BY
☐ KILLED ☐ INJURED ☐ DRIVER ☐ HELPER ☐ PASSENGER ☐ PEDESTRIAN	☐ FED ☐ OTHER (2)		

35. TRANSPORTED BY	36. TRANSPORTED TO

B

37. NAME (Last, first, middle)	38. SEX	39. DATE OF BIRTH

40. ADDRESS

41. MARK "X" IN TWO APPROPRIATE BOXES	42. IN WHICH VEHICLE	43. LOCATION IN VEHICLE	44. FIRST AID GIVEN BY
☐ KILLED ☐ INJURED ☐ DRIVER ☐ HELPER ☐ PASSENGER ☐ PEDESTRIAN	☐ FED ☐ OTHER (2)		

45. TRANSPORTED BY	46. TRANSPORTED TO

47. Pedestrian

a. NAME OF STREET OR HIGHWAY	b. DIRECTION OF PEDESTRIAN (SW corner to NE corner, etc.)	
	FROM	TO

c. DESCRIBE WHAT PEDESTRIAN WAS DOING AT TIME OF ACCIDENT (Crossing intersection with signal, against signal, diagonally; in roadway playing, walking, hitchhiking, etc.)

NSN 7540-00-634-4041
Previous edition not usable

STANDARD FORM 91 (REV. 2/2004)
Prescribed by GSA-FMR 102-34.295

SECTION IV - ACCIDENT TIME AND LOCATION (Use Section VIII if additional space is needed.)

48. DATE OF ACCIDENT

50. TIME OF ACCIDENT
AM
PM

49. PLACE OF ACCIDENT (Street address, city, state, ZIP Code; Nearest landmark; Distance nearest intersection; Kind of locality (industrial, business, residential, open country, etc.); Road description).

51. INDICATE ON THIS DIAGRAM HOW THE ACCIDENT HAPPENED

Use one of these outlines to sketch the scene. Write in street or highway names or numbers

a Number Federal vehicle as 1, other vehicle as 2, additional vehicle as 3 and show direction of travel with arrow

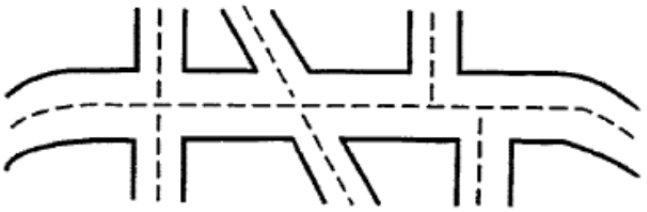
Example. → [1] [2] ←

b Use solid line to show path before accident → [2] *and broken line after the accident* ····· [2]

c Show pedestrian by →○

d Show railroad by +++++++++++

e Place arrow in this circle to indicate NORTH



52. POINT OF IMPACT (Check one for each vehicle)

FED	2	AREA
		a. Front
		b. R. Front
		c. L. Front
		d. Rear
		e. R. Rear
		f. L. Rear
		g. R. Side
		h. L. Side

53. DESCRIBE WHAT HAPPENED (Refer to vehicles as "Fed", "2", "3", etc. Please include information on posted speed limit, approximate speed of the vehicles, road conditions, weather conditions, driver visibility, condition of accident vehicles, traffic controls (warning light, stop signal, etc.), condition of light (daylight, dusk, night, dawn, artificial light, etc.), and driver actions (making U-turn, passing, stopped in traffic, etc.)

SECTION V - WITNESS/PASSENGER (Witness must fill out SF 94, Statement of Witness) (Continue in Section VIII.)

A

54. NAME (Last, first, middle)
55. WORK TELEPHONE NUMBER ( )
56. HOME TELEPHONE NUMBER ( )
57. WORK ADDRESS
58. HOME ADDRESS

B

59. NAME (Last, first, middle)
60. WORK TELEPHONE NUMBER ( )
61. HOME TELEPHONE NUMBER ( )
62. WORK ADDRESS
63. HOME ADDRESS

SECTION VI - PROPERTY DAMAGE (Use Section VIII if additional space is needed.)

64a. NAME OF OWNER (Last, first, middle)
64b. WORK TELEPHONE NUMBER ( )
64c. HOME TELEPHONE NUMBER ( )
64d. WORK ADDRESS
64e. HOME ADDRESS
65a. NAME OF INSURANCE COMPANY
65b. TELEPHONE NUMBER ( )
65c. POLICY NUMBER
66. ITEM DAMAGED
67. LOCATION OF DAMAGED ITEM
68. ESTIMATED COST

SECTION VII - POLICE INFORMATION

69a. NAME OF POLICE OFFICER
69b. BADGE NUMBER
69c. TELEPHONE NUMBER ( )
70. PRECINCT OR HEADQUARTERS
71a. PERSON CHARGED WITH ACCIDENT
71b. VIOLATION(S)

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SECTION VIII - EXTRA DETAILS

SPACE FOR DETAILED ANSWERS. INDICATE SECTION AND ITEM NUMBER FOR EACH ANSWER. IF MORE SPACE IS NEEDED, CONTINUE ITEMS ON PLAIN BOND PAPER.

PRIVACY ACT STATEMENT

The information on this form is subject to the Privacy Act of 1974 (5 U.S.C. section 552a). Authority to collect the information is Title 40 U.S.C. Section 491 and title 31 U.S.C. Section 7701. The information is required by Federal Government agencies to administer motor vehicle programs, including maintaining records on accidents involving privately owned and Federal fleet vehicles, and collecting accident claims resulting from accidents. Federal employees, and employees under contract, will use the information only in the performance of their official duties. Routine uses of the collected information may include disclosures to: appropriate Federal, State, or local agencies or contractors when relevant to civil, criminal, or regulatory investigations or prosecutions; the Office of Personnel Management and the General Accounting Office for program evaluation purposes; a Member of Congress or staff in response to a request for assistance by the individual of record; another Federal agency, including the Departments of Treasury and Justice, or a court under judicial proceedings; agency Inspectors General in conducting audits; private insurance and collection agencies (including agencies under contract to Treasury to collect debt), and to other agency finance offices for fiscal management and debt collection. Furnishing the requested information is mandatory, including the Social Security Number or Taxpayer's Identification Number (TIN) for use as a unique identifier to ensure accurate identification of individuals or firms in the system.

SECTION IX - FEDERAL DRIVER CERTIFICATION

I certify that the information on this form (Sections I thru VIII) is correct to the best of my knowledge and belief.

72a. NAME AND TITLE OF DRIVER	72b. DRIVER'S SIGNATURE AND DATE

SECTION X - DETAILS OF TRIP DURING WHICH ACCIDENT OCCURRED

73. ORIGIN	74. DESTINATION

75. EXACT PURPOSE OF TRIP

	DATE	TIME (Include AM or PM)		DATE	TIME (Include AM or PM)
76. TRIP BEGAN			77. ACCIDENT OCCURRED		

78. AUTHORITY FOR THE TRIP WAS GIVEN TO THE OPERATOR	79. WAS THERE ANY DEVIATION FROM DIRECT ROUTE?
☐ ORALLY ☐ IN WRITING (Explain)	☐ NO ☐ YES (Explain)
80. WAS THE TRIP MADE WITHIN ESTABLISHED WORKING HOURS?	81. DID THE OPERATOR, WHILE ENROUTE, ENGAGE IN ANY ACTIVITY OTHER THAN THAT FOR WHICH THE TRIP WAS AUTHORIZED?
☐ YES ☐ NO (Explain)	☐ NO ☐ YES (Explain)

82. COMPLETED BY DRIVER'S SUPERVISOR	a. DID THIS ACCIDENT OCCUR WITHIN THE EMPLOYEE'S SCOPE OF DUTY	b. COMMENTS
	☐ YES ☐ NO	

83a. NAME AND TITLE OF SUPERVISOR	83b. SUPERVISOR'S SIGNATURE AND DATE	83c. TELEPHONE NUMBER
		( )

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SECTION XI - ACCIDENT INVESTIGATION DATA

84. DID THE INVESTIGATION DISCLOSE CONFLICTING INFORMATION. ☐ NO ☐ YES (If checked, explain below.)

85. PERSONS INTERVIEWED

NAME	DATE	NAME	DATE
a.		c.	
b.		d.	

86. ADDITIONAL COMMENTS (Indicate section and item number of reach comment).

SECTION XII - ATTACHMENTS

87. LIST ALL ATTACHMENTS TO THIS REPORT

SECTION XIII - COMMENTS/APPROVALS

88. REVIEWING OFFICIAL'S COMMENTS

89. ACCIDENT INVESTIGATOR			90. ACCIDENT REVIEWING OFFICIAL		
a. SIGNATURE		b. DATE	a. SIGNATURE		b. DATE
c. NAME (First, middle, last)			c. NAME (First, middle, last)		
d. TITLE			d. TITLE		
e. OFFICE			e. OFFICE		
f. OFFICE TELEPHONE NUMBER			OFFICE TELEPHONE NUMBER		
AREA CODE	NUMBER	EXTENSION	AREA CODE	NUMBERf.	EXTENSION

Appendix S1.H. SF-94 Statement of Witness.

STATEMENT OF WITNESS (*Attach additional sheets if necessary*)	1. DID YOU SEE THE ACCIDENT?	2. WHEN DID THE ACCIDENT HAPPEN? a. TIME ☐ a.m. ☐ p.m.	b. DATE	FORM APPROVED O.M.B. NUMBER 3090–0118

3. WHERE DID THE ACCIDENT HAPPEN? (*Give street location and city*)

4. TELL IN YOUR OWN WAY HOW THE ACCIDENT HAPPENED

5. WHERE WERE YOU WHEN THE ACCIDENT OCCURRED?

6. WAS ANYONE INJURED, AND IF SO, EXTENT OF INJURY IF KNOWN?

7. DESCRIBE THE APPARENT DAMAGE TO PRIVATE PROPERTY

8. DESCRIBE THE APPARENT DAMAGE TO GOVERNMENT PROPERTY	9. IF TRAFFIC CASE, GIVE APPROXIMATE SPEED OF: a. GOVERNMENT VEHICLE *Miles per Hr.* b. OTHER VEHICLE *Miles per hr.*

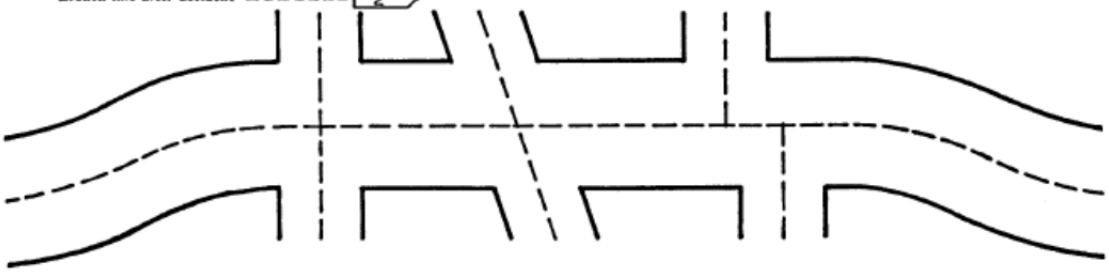
10. GIVE THE NAMES AND ADDRESSES OF ANY OTHER WITNESSES TO THE ACCIDENT (*If known*)

a. NAMES	b. ADDRESSES (*Include ZIP Code*)

WITNESS COMPLETING THIS FORM	11. HOME ADDRESS (*Include ZIP Code*)	12. WITNESS (Print Name)	a. HOME TELEPHONE NO.
		Sign here ►	b. TODAY'S DATE
	13. BUSINESS ADDRESS (*Include ZIP Code*)		TELEPHONE NO.

14. INDICATE ON THE DIAGRAM BELOW WHAT HAPPENED:

1. Number Federal vehicle as 1—other vehicle as 2—additional vehicle as 3, and show direction of travel by arrow (*Example:* → 1 2 ←)
2. Use solid line to show path before accident → 2
   Broken line after accident - - - - - → 2
3. Show pedestrian by →○
4. Show railroad by +++++++++++++++
5. Give names or numbers of streets or highways
6. Indicate north by arrow in this circle ○



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94-105

STANDARD FORM 94 (REV. 2–83)
Prescribed by GSA, FPMR 101–39.8

SOP 1 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
1.00	2006	N/A	Initial version. Originally numbered SOP 5	
3.00	December 2011	Bill Gawley	Reformatted using NRPS-NRR template. Re-numbered as SOP 3 to increase prominence. Added and adapted much of Safety SOP from NETN Forest Monitoring and Landbird Monitoring Protocols. Expanded sections on water-based activity safety. Added Appendices containing JHA and GAR	Aquatic Protocol v2.02 safety SOP inadequate.
3.01	December 2012	B. Mitchell	Minor edits for clarity New directions and info for hospital near MIMA, per Lou Sideris (MIMA)	Internal review
3.02	August 2013	E. Sharron	Minor grammatical and edits Renumbered as SOP 1 for consistency with other NETN protocols.	NETN standards

SOP 2 – Establishing, Maintaining, and Documenting Monitoring Sites

Northeast Temperate Network

Version 3.01

Overview

This SOP details the requirements and procedures for physically establishing a freshwater monitoring site and the documentation of the site's geographic location and characteristics.

Background and Inventory of Streams

The physical and morphological characteristics of stream channels and basins in NETN are compiled or collected and entered into the NETN water database (NETN_H2O) before a given stream is monitored. Watershed area, contributing (upstream) watershed area, basin geologic composition, and elevation data are obtained from current GIS and other data clearinghouses. In many cases, and particularly at historical monitoring sites, this information has already been documented in park data records, or those of cooperating agencies. The accuracy of these records should be verified against modern data layers whenever possible.

Verification and updating of these site attributes is planned for FY 2013 and FY 2014. This SOP will be updated with more specific information and procedures once they are available, including data sources and the Hydrologic Unit Code (HUC) level (or other definition) used for "watershed" and data processing steps (e.g., calculation of upstream watershed area using the hydrology tools in the Spatial Analyst Tools section of ArcGIS' ArcToolbox). Potential data sources include: USGS HUC map, USGS or NPS geologic map, Digital Elevation Models (DEM), and National Hydrology Dataset (NHD) layers. Where morphological information is not currently available from digital sources, watershed areas must be delineated, and stream channel and basin characteristics defined. For example, to determine watershed area, draw or digitize the watershed on the best available map, which at a minimum is on a topographic map with a scale of 1:24,000, and 10 or 20 ft contour intervals. Boundaries of the watershed that cannot be accurately determined from the topographic maps are field verified.

This morphological information in NETN_H2O is supplied, like the monitoring data, to the EPA STORET database via NPSTORET or EQuIS. When the morphological data in NETN_H2O are updated, these data will be transferred to STORET in the next export cycle.

Background and Inventory of Lakes and Ponds

The physical and morphological characteristics of all lakes and ponds in NETN are compiled or collected and entered into the NETN water database before a given lake or pond is monitored. If available, bathymetric data, surface area, maximum depth and location, perimeter, inlet and outlet locations, watershed area, basin geologic composition, and elevation data are entered. All of the long-term trend sites in ACAD have bathymetric maps with the maximum depth location and sampling site identified. These maps are found at the Maine Department of Inland Fisheries and Wildlife web site: http://www.maine.gov/ifw/fishing/lakesurvey_maps/index.htm (Maine Department of Inland Fisheries and Wildlife, 2012). Where the above listed morphological

information is not readily available, at least the maximum depth site is surveyed during the first field visit and documented in the NETN database. Verification and updating of most of these site attributes is planned for FY 2013 and FY 2014. New bathymetric maps will take several years to complete at ACAD (target completion FY 2018). This SOP will be updated with more specific information and procedures during the 2014 update, including data sources and the Hydrologic Unit Code (HUC) level (or other definition) used for "watershed" and data processing steps. Potential data sources include: USGS HUC map, USGS or NPS geologic map, Digital Elevation Models (DEM), and National Hydrology Dataset (NHD) layers.

Establishing a Stream Site

Site selection

Although a core panel of stream monitoring sites was selected during the original development of this protocol (following the process detailed in the narrative section entitled *General Sampling Design in Streams*), occasionally sites must be relocated or new sites have to be established for logistical or administrative reasons. If a site has to be relocated to ensure better access or safer monitoring conditions, more consistent streamflow, or for other reasons, the new site should be located as close as possible to the original to ensure consistency and comparability of the water quality and quantity data measured at the two locations.

If conditions influencing the original and relocated sites are markedly different (e.g. shift from upstream to downstream of a major road, introduction of streamflow from a tributary), the new location should be assigned a new site code, and considered a "new" site. Even if the relocated site is not assigned a new site code, the new location and morphology data, as well as the reason for the move and any other pertinent information, should be documented in the NETN water database and the protocol narrative.

If a totally new site is established (in a new network park, or additional area of concern), it should be selected using the same criteria as the original sites, which are documented in the *General Sampling Design in Streams* section in the narrative of this protocol. When selecting a new site, strong consideration should be given to reactivating a historic monitoring site, if available.

Establishing site infrastructure

As explained in *SOP 9 – Collecting Streamflow and Stage Data*, each stream monitoring site should have a permanent datum point for measuring stream stage in order to establish and maintain a stage-discharge rating for the stream. Also, continuous dataloggers to record temperature and water level can be deployed to increase the resolution of physical data for the stream. Each of these infrastructure items should be installed as soon as possible after establishment of the site and maintained according to the following procedures. All details of the establishment and maintenance of infrastructure for each site are documented in a Site Record Form containing site sketches and photos, locations and descriptions of datum and reference points, elevation summary tables, and level-summary tables.

Installing stream stage measurement points

Establish tape down sites in pools that can be measured at a range of flows and that have a single stable controlling feature at their outflow. The measurement point ("tape-down point", "tape-up point", or "datum") can be a hole drilled in bedrock or other solid object in which a bolt has been installed, or a metal or fiberglass staff gage or plate bolted to a secure post or bridge abutment. A

range of one to three additional stable reference points should also be established and maintained, depending on site characteristics. Set reference marks in boulders, bedrock or manmade structures that are anchored below the frost line and marked for easy identification. These reference points are used to determine whether the measurement point has shifted, and should ideally be within line-of-sight of the measurement point to facilitate use of an autolevel. If necessary, reference points can be placed such that both the reference point and the measurement point can be seen from a third location (where the autolevel will be placed).

Rock and concrete can be drilled with a portable impact ("hammer") drill using hardened masonry bits. A small (3/4" to 1" long) stainless steel hex head bolt is inserted into a ¼" diameter hole using a plastic anchor. Leave a flat portion of the bolt head on top (when bolts are installed in a vertical surface) to provide a horizontal line to which to measure. *NOTE: Be sure to consult park staff before drilling into structures to avoid damaging important cultural resources.*

Staff gages should be either bolted to a permanent structure like a bridge abutment or pier, or securely fastened to a free-standing metal post that has been driven deep into the stream bed to minimize movement from frost, ice, or high streamflow. Free-standing staff gages should be installed plumb (vertically level), and periodically (i.e., annually or after a flooding event) checked for plumb with a carpenters level. If the staff gage is out of plumb, it must be reset and then surveyed with an autolevel to determine the new datum.

After installing a stage measurement benchmark, document the location by obtaining GPS coordinates (in decimal degrees) of the datum, and a general elevation (using a RTK GPS or barometric altimeter – NOT a standard GPS unit). Also obtain coordinates for all supplemental reference points, and take photos (both close up and in context) of the datum and all reference points. Draw a site sketch documenting the relative locations of the benchmark and reference points to geographic and morphological features of the site. Perform an initial survey of all points (using an autolevel) to determine the exact differences in elevation for the site records. The procedure in which surveying instruments are used to determine the differences in altitude between points is known as "leveling" and is described in detail in Kennedy (1990). The use of an autolevel to determine relative elevations is described in the Cape Cod Long-Term Hydrologic Monitoring Protocol (Medeiros 2011; section 2.3.5.2). In this protocol, *SOP 19 – Leveling Water Monitoring Sites* specifically documents the use of a Sokkia SDL30 or SDL50 Digital Level with a bar code staff to level water monitoring sites. Document all datum and reference point levels on the level-summary table of the Site Record Form.

<u>Deploying continuous dataloggers</u>

When possible, continuous water level and/or temperature loggers should be securely mounted to the stream bed near the stage datum point, or (preferably) mounted to the same permanent submerged structure as the datum or stream gage. This arrangement provides better opportunities for comparing automated and manual measurements for quality control purposes, and also consolidates the equipment in one physical area.

Mounting techniques will vary depending on the types and models of dataloggers employed, but generally the equipment can be fastened to the appropriate substrate with bolts or heavy duty, UV-stabilized plastic cable ties. In streams, a "stilling well" will be needed so that flow over the logger does not lead to erroneous water level data. Consult the manufacturer's operation manuals for specialized mounting instructions.

When determining a mounting location, use care to select an area in which the logger will remain submerged in all flow levels. Avoid areas with heavy, turbulent streamflow which can affect the accuracy of the measurements as well as threaten the security of the mounting system. Try to find mounting locations that will be accessible to field crews for maintenance and data downloads during a wide range of flow levels, and that meet the same surveying requirements as other benchmark locations.

Be sure to record the serial number of each logger in the Site Record Form before deployment. After installation, take photos of the loggers *in situ*, and record coordinates and survey the elevation as for the stage measurement datum. Add the logger location(s) to the site sketch, and also note the time and date the datalogging routine was initiated.

Take tape-up or tape-down measurements at all available datum points and compare to the logger water level measurement to determine the relative elevation of the logger to the datum points:

> **$Elevation_{Logger} = Qm_{Datum} - Qm_{Logger} + Elevation_{Datum}$** *(where* Qm_{Datum} *is the water level measurement from the datum point, and is a* ***negative*** *number if the datum is above the water, and* Qm_{Logger} *is the water level measurement from the logger).*

The relative elevation difference between the datum and the logger should be checked at each monthly site visit to determine if the logger has moved during the previous sampling interval. This elevation difference can be checked by looking for a change in the value of Qmdatum – Qmlogger. Values of Qmdatum – Qmlogger calculations from previous site visits are recorded on the stage calculation worksheet on page 2 of the Site Record Form.

Maintaining stream stage measurement points

The datum point, reference marks, and any other infrastructure (e.g., loggers or staff gages) should be surveyed ("leveled") every year to ensure that the datum point or infrastructure has not shifted in elevation over time. The supporting structures of the gage, such as backings, shelters, bridges, and other structures, tend to settle or rise as a result of earth movement, frost action, static or dynamic loads, vibration, or battering by floodwaters and flood-borne ice or debris. Vertical movement of a structure makes the attached gages read too high or too low and, if the errors go undetected, can lead to increased uncertainties in streamflow records.

It is the responsibility of the crew leader to ensure that all stage measurement points are leveled annually. The level information is entered in the level-summary table of the Site Record Form maintained for each site. A level-results table, which shows the results of each set of levels at a station by year, is also maintained in the NETN_H2O database.

A datum can have supplementary marking using paint, or another method such as a plastic tab, to aid re-identification. These markings should be inspected and reapplied as necessary at each site visit, especially at the beginning and end of each monitoring season. Check the graduations and other markings on staff gages to ensure they are intact and legible. Replace the staff gage if necessary. The elevation of the stream level logger should be checked at every site visit.

Establishing a Lake or Pond Site

Site selection

The same caveats outlined in the section on stream site selection apply to lakes and ponds. Although there is generally little need to relocate a lake or pond site, new sites may have to be established if new parks join the monitoring network or as a result of a review of the sampling

design. As discussed in the section on stream site selection, if a new lake or pond site needs to be established, it should be selected using the criteria detailed in the *General Sampling Design in Lakes and Ponds* section in the narrative of this protocol. Again, strong consideration should be given to reactivating a historic monitoring site, if available.

Establishing and maintaining site infrastructure

Lake and pond monitoring sites should have permanent datum points for measuring water levels (stage), and can also employ continuous dataloggers to record temperature and water levels. Installation, documentation, and maintenance procedures for these infrastructure items are similar to the procedures outlined in the previous sections for stream sites. Lake stage datum points require only one associated reference mark for annual elevation verification.

The deepest point ("deep hole") of a lake or pond is the preferred monitoring location in these waterbodies. It may be difficult and time consuming to locate the deep hole of some larger lakes, even with the aid of bathymetric maps and GPS coordinates. In these cases, a small buoy (attached by a stout line to a cinder block) can be deployed at the deep hole in the beginning of the monitoring season to ensure easy relocation and a secure point to tie off the boat or canoe during monitoring sessions. Field crews should consult with park staff and/or other local authorities before installing buoys, and all buoys should be clearly marked as "NPS-NETN Water Monitoring Site".

Site Documentation

Thorough documentation of qualitative and quantitative information describing each water monitoring site is required. This documentation, in the form of a site description and photographs, provides a permanent record of site characteristics, structures and facilities, equipment, instrumentation, altitudes, location, and changes in conditions at each site.

Site descriptions

A site description is prepared for each monitoring site, and becomes part of the permanent record for each site. The site description is started at the time the site is established and completed when the first year's records are computed. Site descriptions are written and updated by the field personnel that normally monitor the site. Site descriptions are reviewed and updated annually.

The description should include a sketch or diagram of the stream section showing the location of all stage and reference marks and measuring locations (or a lake/pond depth map marked with the deep hole and stage monitoring site locations); photos of the stream cross-section most commonly measured and upstream and downstream views from this point (or a 360 degree panorama photo series from the deep hole), and a description of the site in paragraph format. The physical and morphological information detailed in the first two sections of this SOP can also be included in the site description. All site descriptions are prepared and maintained in the NETN_H2O database as well as in notebooks to be used as field references.

Photographs

Photographs of newly installed gages and tape down marks, station controls, reference marks, and buoys are made by field staff for the purpose of documenting monitoring locations, changes in control or shoreline conditions, or to supplement various forms of written descriptions. Each digital photograph that becomes part of the station record can be supplemented by appending descriptive information such as location, date, lake stage and/or depth, or flow rate on the

electronic photograph. Electronic photographs are named using conventions detailed in *SOP 13 – Data Management*, and are stored in files maintained on the NETN network server. Historic paper photographs, if present, are kept in office photograph files. Whenever possible, these historic photos should be scanned and stored on the NETN server.

Site Record Form

Site and Datum Information

Site: **ACHADB**

Monitoring Year: 2013

USGS Station name: Hadlock Brook nr. Cedar Swamp Mtn. nr. Northeast Harbor, ME **USGS #:** 1022860

USGS Gage Datum: 7.00 ft Assumed

Level summary table

Date	Party Chief	RM1	RM2	RM3	RP1	RP2	Orifice Cap	Global Logger	Notes
4/27/1999	LEF	7.000*	3.59	3.231	4.96	3.30	3.29		
6/15/2000	LEF	7.000*	3.596	3.238	4.96	3.31	3.30		
6/21/2001	JMC	7.000*	3.598	3.239	4.96	3.31	3.30		
6/17/2002	ARC	7.000*	3.595	3.237	4.96	3.30	3.30		
7/2/2003	LEF	7.000*	3.594	3.237	4.96	3.30	3.29		
6/22/2004	JDP	7.000*	3.596	3.238	4.96	3.30	3.30		
5/19/2005	NWS	7.000*	3.592	3.234	4.96	3.30	3.30		
4/28/2006	NWS	7.000*	3.595	3.236	4.96	3.30	3.30		
6/8/2009	WGG	7.000*	3.593	3.216	4.96	3.30	3.30		(replaced bolts)
9/6/2012	WGG	Not meas.	3.596	3.216	4.956	3.306			Relative measurements with engineer ruler
4/25/2013	WGG	7.000*	3.567	3.213	4.94	n/m	n/m	3.09	NETN autolevel and folding ruler. Logger elev. Calc from RP1 and RM2 gage readings

Depth logger s/n: 50169

Logger install date: 4/25/2013

Logger removal date:

Elevation summary table

Point	Elevation (13)	Description
RM1	7.000*	Lag bolt flush in ledge approx. 7 feet from REW and in line with orifice pipe
RM2	**3.567**	Lag bolt flush in ledge approx. 1 foot d.s. of orifice pipe at its bend
RM3	**3.213**	Lag bolt flush in ledge approx. 1 foot u.s. of orifice pipe and 1 foot more toward LEW
RP1	**4.94**	Lag bolt in side of large boulder approx. 1 foot d.s. of orifice pipe at REW
RP2	3.303	Lag bolt on last clamp before orfice cap on orfice pipe
Orifice	3.304	Highest point on orifice cap
Global logger	3.09	Calc. 4/25/2013 from RP1 and RM2 gage readings

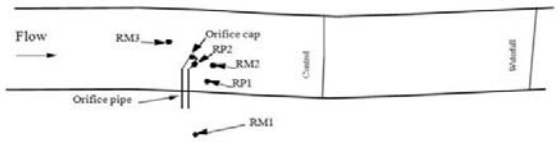


Figure S2.A.1. Example Site Record Form, page 1 (Site and datum information).

Site Record Form

Monthly Stage and Elevation Calculations

Site: **ACHADB**

Monitoring Year: 2013

USGS Station name: Hadlock Brook nr. Cedar Swamp Mtn. nr. Northeast Harbor, ME **USGS #:** 1022860

USGS Gage Datum: 7.00 ft Assumed

Date	Time	Logger GH	RM2 GH	RM3 GH	RP1 GH	RM2 Stage	RM3 Stage	RP1 Stage	QmRM2-LGR	QmRM3-LGR	QmRP1-LGR	Notes	Deployed	Retrieved
4/25/2013	16:42	0.887	0.41		-0.96	3.977		3.98	-0.48		-1.85	Logger installation/Survey	4/25/2013	12:52
5/9/2013	14:08	0.675	0.17	0.54	-1.2	3.737	3.753	3.74	-0.51	-0.14	-1.88		RP1 Elev:	4.94
6/6/2013	13:47	0.588	0.15	0.519	-1.213	3.717	3.732	3.727	-0.44	-0.07	-1.80		RM2 Elev:	3.567
6/6/2013	14:17	0.585	0.149	0.52	-1.213	3.716	3.733	3.727	-0.44	-0.06	-1.80		RM3 Elev:	3.213

Figure S2.A.2. Example Site Record Form, page 2 (Monthly stage and elevation calculations).

SOP 2 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.02	April 2009	B. Mitchell	Added contributing (upstream) watershed area to the background stream data. Updated to reflect monthly photographs of stream sites, and an annual panoramic set of photos for lakes.	Version 2.01 to 2.02
3.00	December 2011	B. Gawley	Reformatted using NRPS-NRR template. Changed title from “Background and Inventory of Freshwater Resources” Changed focus of SOP to physical and administrative tasks needed to establish and document a water monitoring site Copied/moved text from v2.02 SOP #s 2, 8, and 16.	Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Numerous clarifications Additional detail on site-level information needs	Internal review

SOP 3 – Preparation and Equipment List

Northeast Temperate Network

Version 3.02

Overview
This SOP outlines and describes the tasks and procedures that must be completed before the start of the freshwater monitoring field season, and the basic equipment that will be utilized. Some sections were adapted from the NETN Forest Monitoring Protocol (Tierney et. al. 2009).

Protocol Revisions
The NETN water monitoring staff, Program Manager, and Data Manager meet (in person or via conference call) at the end of each monitoring year to discuss the successes and shortcomings of the past water monitoring season and suggest changes and improvements to be made in the next monitoring year. If a proposed change is a substantial departure from the existing protocol, the protocol must be revised to reflect the new procedures. If necessary, database metadata documenting sites and procedures is also updated.

The NETN Water Monitoring Coordinator will assign the task of revising the protocol to the appropriate member of the staff during the review meeting/call. All revisions should be complete before March 31st of the next monitoring year. After the protocol has been revised, all network personnel will receive a summary of the changes, and any new procedures and/or responsibilities for the upcoming season. Minor program changes that do not require protocol revisions will be made on the same timetable, and will be communicated in the same document as the protocol revisions.

Annual Reports for Previous Year
All field data from the previous year should be entered, proofed and validated by January 31. Once validated, the data can be queried by the NETN_H2O database reporting module to provide the framework for annual data summary reports. The NETN Water Monitoring Coordinator will assign the task of constructing annual reports for each park. Annual reports for all parks should be completed and submitted for publication before March 31st of the next monitoring year. See *SOP 14 – Data Reporting and Analysis* for more information on annual reports.

Administrative Needs
Any administrative actions necessary for the upcoming year should be identified and initiated as early as possible. Servicing human resource offices and administrative staff often require significant lead time (e.g., up to 6 months for a new hire), and contracting and human resource procedures are often subject to considerable delays. Staff hiring should be accomplished at the earliest possible opportunity. Review expiration dates of all contracts and agreements and renew/renegotiate as necessary.

Routine personnel actions are required to be scheduled up to 6 weeks in advance. Consider staff furlough and detail needs and make these arrangements as early as possible to ensure maximum flexibility.

Planning and Coordination

The water monitoring coordinator or the field crew leader should ensure that each park natural resource manager has a current version of the water monitoring protocol including all SOPs, as well as a current map of monitoring locations. Park resource managers should be contacted at least a month prior to the beginning of the field season to discuss schedules for monitoring visits, field assistants, and any other concerns. Park lodging, if available, should also be arranged at this time.

Network personnel or the crew leader should reserve or acquire a field vehicle for transport to and within parks.

The water monitoring coordinator will contact the laboratory that will be analyzing water samples at least a month in advance of the first scheduled sample collection dates to order sample bottles and other needed supplies. He or she will also review preservation and shipping requirements, holding times, and any other logistical issues. Contact information for delivery of data results and other coordination is updated at this time, if necessary.

Schedule

Though not essential, it is strongly suggested that the order in which parks are visited during the field season should be consistent from month to month. This will minimize the seasonal variation when the data are compared from year to year. Travel schedules and lodging arrangements should be made accordingly. Wherever possible, lodging should include access to kitchen facilities and internet. Lodging space should be sufficient to comfortably accommodate all crew members and their gear.

The water monitoring coordinator and the crew leaders should carefully consider the field crew's capabilities when deciding upon a workday schedule. Flex-time (e.g., four 10-hour days) offers some advantages—but is not appropriate if crew members tire too much to maintain data quality on a long workday. The crew schedule should start as a standard work week (e.g., five 8-hour days, starting at 8:00 or 8:30 am), and only convert to flex-time if both the crew leader and the water monitoring coordinator agree that it will work well for that particular crew.

Network personnel and collaborators should hold a meeting with the crew to discuss the crew's progress and any concerns that have surfaced. This meeting should take place after the first round of sampling has occurred.

Training

Prior to commencement of each field season, the network must ensure that all members of the field crew fully understand this protocol by conducting in-situ training sessions. Crew preparation should involve careful review and discussion of all protocols, in addition to field training sessions led by experienced personnel. Crew must be given sufficient time to read the entire protocol thoroughly. It may be useful to divide the training into discrete "phases"—so that a particular SOP or set of SOPs can be read, learned and practiced before moving onto the next.

Some discussion of how the data will be used to assess water quality and quantity should also be included to help the crew better understand the process.

Training should cover:

- water safety procedures such as wading and boat safety
- safe field practices to avoid injury such as how to properly pack and wear a field pack and work in areas with poison ivy and ticks
- emergency procedures
- introduction to network stream, lake, and pond ecosystems
- proper use of water quality sonde, current meters, light and turbidity meters, and Secchi disk
- proper use of water samplers (core sampler and churn splitter, VanDorn sampler)
- collecting grab samples
- filtering and preserving water samples
- proper use of all auxiliary equipment including GPS, field weather instruments, and digital camera
- orientation to monitoring site locations
- rules for selecting discharge measurement locations
- alternate methods of discharge measurement (volumetric and flume)
- collecting accurate stage measurements
- leveling procedures
- procedures for conducting invasive aquatic plant surveys
- practice using procedures for careful data collection and quality assurance/quality control (QA/QC)
- procedures to minimize resource damage (Leave No Trace)
- expectations of crew behavior
- proper use and maintenance of park radios and emergency communication devices

Training should include both demonstration of all measurements by trainers, and hands-on practice of all measurements by trainees. Training groups should be small to ensure that all trainees have sufficient opportunity to practice measurements thoroughly and question the trainer as needed. Training should thoroughly demonstrate how to enter data into the water monitoring database (NETN_H2O). Training materials should include screen captures of each form in the database.

Training must emphasize the critical importance of careful, accurate and steady data collection to this long-term monitoring program. Trainers must stress the importance of exact adherence to

SOP instructions to prevent bias in measurements among years, which will inhibit the networks' ability to detect long-term trends. Trainees should be encouraged to discuss with network supervisors any concerns that arise over field procedures or the datasheet or database recording systems during training or later during the field season—the crew should never deviate from established protocols or alter the datasheet or database without first getting approval from the water monitoring coordinator.

Training must emphasize the critical importance of avoiding transfer of invasive aquatic species and aquatic pathogens between sites. Decontamination procedures should be demonstrated and conducted between each site visit. Instruction will be provided on appropriate gear selection (e.g., no felt-soled waders). Training must also include techniques (e.g., "Leave No Trace") to avoid trampling the surrounding habitat when hiking to and from a monitoring site. Extra care should also be taken at sites with a delicate or moss-covered forest floor.

Field crews are encouraged to seek out training to recognize priority aquatic invasive plant species that is offered in the areas in which they will be conducting the invasive aquatic plant surveys. Crew should also carry Early Detection ID cards to help with priority species identification (Keefer et al. 2010).

All NPS personnel shall complete required annual service-wide training including IT Security, Records Management, Non-Discrimination, and Whistle-blowing.

Communication and Crew Oversight

It is essential for the field crew to keep in regular contact with the water monitoring coordinator and any other supervisors throughout the field season. The crew should carry NETN radios in parks where there is a radio use agreement (currently: Acadia NP, Marsh-Billings-Rockefeller NHP, Minute Man NHP, Morristown NHP, Saint-Gaudens NHS, Saratoga NHP, and Weir Farm NHS). The crew should also carry a cell phone in the field every day in any parks with cell coverage—both for safety and to attempt to call in if any important questions arise. The crew leader for the Lower NETN parks will carry a personal locator beacon (PLB) for use in emergencies at locations where there may not be radio or cell phone communication. A regular (perhaps twice weekly) telephone call or meeting should be set up between the field crew and supervisors to discuss the week's events while they are still fresh. This regular update should include discussion of any questions or problems encountered with sites, protocol, logistics, etc.

The water monitoring coordinator and any other supervisors should endeavor to join the crew in the field at least twice during the course of the field season for direct observation of data collection.

Equipment

The basic field equipment and supplies that should be obtained are listed below. Equipment should be organized and maintained in good working condition. At the end of each season, the crew leader should inventory the condition of all equipment and prepare a list of equipment that needs to be repaired or replaced.

The field computers, PDAs, and dataloggers must be handled carefully and their screens protected from injury at all times. When traveling between sites, the devices should be placed in

cases. During hard rain, the field computer should be put away in a waterproof bag and datasheets should be used instead.

General Field Equipment

Maps showing site locations
Protocol
Digital camera, batteries
Datasheets (on waterproof paper)
Clipboard and/or looseleaf binder
Field computer and/or PDA
Garmin Etrex GPS unit with RS232 cable
Sharpened pencils and permanent markers
Compass
Digital thermometer
Portable anemometer (optional for LNETN)
NETN Park Radio, cell phone, and/or PLB
Extra batteries: 9v (4), AA (12), C (4)
Sunscreen and polarized sunglasses
Daypacks
First aid kit
Insect repellant
Deionized water
PFD vests
Boat (or raft), oars, and anchor
Raingear
Boots/waders
Screwdriver and/or multi-tool
Invasive aquatic plant species list/ ID cards

Leveling

Autolevel, tripod, and leveling rod

Water Quality Sonde

YSI 600XL Sonde, 650 MDS Datalogger
3m and longer cables, RS232 cable
Calibration cup and cap
pH 4, 7, 10 buffers. pH 4.63 check sample
1,000, 100, 50[1] µS/cm conductance standards
Extra membranes, probe supplies

Discharge & Stage Measurements

Pygmy current meter w/wading rod, earphone
FlowTracker current meter w/wading rod
50 foot vinyl engineer's tape
2 wire stakes or long screwdrivers
USGS discharge Qm forms/ Q-Calc software
Stopwatch
Folding engineer's ruler
Level stick
Site description forms
Download cable/data shuttle for level loggers
Plastic bin and plastic sheet for volumetric Q_m

Water Sample Collection

Sample bottles from lab
Gloves (vinyl, non-powdered)
10m Tygon core sampler
Teflon churn splitter
VanDorn bottle sampler
Throw bottle

In Field Office

Pump, tubing, filters, funnels, and flasks for chlorophyll *a* filtering
Blue ice packs for sample shipment
FedEx forms
Contact info for network and park staff, analytical lab, etc.
Small tool kit, including multimeter, precision screwdrivers

Light Penetration Profiles

LI-1400 Datalogger
Deck cell, PAR submersible cell
Lowering frame and cable

Turbidity

Turbidity meter and supplies

[1] 50 µS/cm conductance standard is only used at ACAD

Equipment Repair/Replacement

Major equipment and equipment components that require service or replacement should have these needs addressed well before the beginning of the field season. Some sonde probes require periodic replacement (pH probes should be replaced annually), and Li-Cor radiation sensors should be sent to the manufacturer for calibration and recertification every 3 years. Any piece of equipment that is not performing within desired specifications should be evaluated by qualified repair technicians and repaired or replaced during winter "down time".

Equipment that is assumed to be in good working order should be taken out of storage, tested, and prepared in advance of its anticipated use in the field. Fresh batteries should be installed, and measurement cells and probes should be filled with fresh electrolyte solutions, where applicable. Dataloggers should be updated with the current date and time, and should be tested to ensure that they can store data (and that the data can be downloaded/retrieved). Necessary firmware updates should also be performed at this time. Perform pre-season accuracy checks on sondes to compare their performance and accuracy when measuring known standards.

Boats, canoes, and other watercraft should be checked for leaks or other damage, and repaired as necessary. Outboard motors should be de-winterized, serviced, and filled with fresh fuel and other fluids. Check all boots and waders for leaks and repair or replace if needed.

The condition of small equipment such as digital thermometers, wooden engineer rulers, and Secchi disks should not be overlooked. Replace any of these items that are worn or damaged enough to affect data quality. Check tape marks used as depth guides on Li-Cor and sonde cables and core samplers for accuracy and missing marks. Clean Secchi disks and viewing scopes. Perform accuracy comparison checks on digital thermometers, and replace outliers.

Supplies

Expendable supplies such as buffers, standards, filters, and blank water should be inventoried (and expiration dates noted) at the end of each monitoring season. Sufficient quantities of new solutions to last through the upcoming season should be ordered in late winter. Keep in mind that some standard solutions and other reagents are "made to order" by the chemical companies. Allow sufficient time for preparation and shipping of these products when placing orders.

Clean bottles for water samples are provided by the analytical laboratory and shipped to NETN offices before each sampling month. Provide a complete list of required container types and quantities (for the month) to the lab manager at least a month prior to the first anticipated date of sample collection. Be sure to order a few spares of each type of container in case of breakage or contamination.

Check and resupply small expendables (waterproof paper and labels, markers, vinyl gloves, etc.) at the beginning of each season. There is often a significant savings in shipping charges when multiple supplies can be obtained from the same supplier. Be sure all portable data storage media (thumb drives, external hard drives, data cards, etc.) are functional and replace when needed.

Preparing Field Infrastructure

In some instances (particularly in the Lower NETN parks) it is difficult to conduct site visits prior to the beginning of the monitoring season to ensure that site infrastructure (benchmarks, dataloggers, etc.) are intact and re-surveyed after being unattended during the winter. There are decided advantages to these preliminary visits (more time available to accomplish site work,

ensuring uninterrupted data collection from the beginning of the sampling season, etc.), and field staff should exercise this option whenever possible.

The following tasks should be performed as early in the season as possible, either during a preliminary site visit or during the first monitoring visit of the year:

- Check integrity of access to site. Make sure there are no current or planned road/trail closures or washouts, or other impediments to traveling to the monitoring site.
- Make sure all benchmarks (datum bolts, staff gages, etc.) are present and survey their locations (see *SOP 2 – Establishing, Maintaining, and Documenting Monitoring Sites* and *SOP 9 – Collecting Streamflow and Stage Data* for further information) to document any change in elevation. Replace and survey any missing benchmarks and update site records.
- Re-deploy temperature and/or water level loggers that have been removed to avoid damage from freezing. Be sure to document initial water level logger measurements to enable calibration with fixed reference points. If loggers have been left in place over the winter, make sure they are operational, in the proper locations, and securely fastened.
- Take a new set of site photos and document any changes to the site and surrounding area in the site records.

Final Preparation for Fieldwork

Print labels and field forms on waterproof paper/label stock. Assemble miscellaneous gear in field packs and bags. Ensure that all equipment has both fresh batteries installed and available spares and double check inventory of sample bottles. Check in via email with park resource management staff and the contact(s) at the analytical lab to discuss any last minute changes in logistics.

SOP 3 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
3.00	December 2011	B.Gawley	Reformatted using NRPS-NRR template. Changed title and focus of SOP 2 from "Metadata" (v2.02+) to "Preparation and Equipment List" (tasks and equipment needed in preparation for each field season). Some sections adapted from NETN Forest Monitoring Protocol Safety SOP.	Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell and B. Gawley	Minor edits for clarification Addition of turbidity gear to equipment list	Internal review
3.02	December 2013	B. Mitchell	Noted that database metadata may need an update along with protocol, in "Protocol Revisions" section 12.9 µS/cm conductivity standard replaced by 50 µS/cm standard (and that only used at ACAD). Anemometer is optional for LNETN.	Reviewer comment

SOP 4 – Monitoring Streams

Northeast Temperate Network

Version 3.02

Overview

This standard operating procedure (SOP) for monitoring streams includes instructions for the collection of streamflow (water quantity) data and for the collection of stream water-quality data, including the water chemistry and nutrient vital signs. Water-quality procedures are adapted from the USGS's National Field Manual for the Collection of Water-quality Data (U.S. Geological Survey variously dated; http://water.usgs.gov/owq/FieldManual/index.html) and from a Water-quality Inventory Protocol for Riverine Environments prepared for the NPS (Stednick and Gilbert 1998) unless otherwise noted. **Properties such as temperature, pH, specific conductance, and DO concentration are measured directly *in situ*.** Other parameters such as color, nutrients, algal biomass, and acid neutralizing capacity (ANC) are collected as grab samples and analyzed in a laboratory. Water quantity or streamflow SOPs follow USGS protocols in all cases (Rantz et al. 1982). Water-quality measurements in streams are taken according to the schedule outlined in the *Sampling Design* section of the protocol narrative.

Before Field Activities

Several activities should be performed before field monitoring:

- Check current weather conditions and forecast. Postpone monitoring if conditions are unsafe or are expected to become unsafe.
- Provide supervisor or designee with the trip/float plan of the day's field work.
- Pre-deployment sonde calibrations and quality checks detailed in the "Pre-Deployment Preparation" and "Calibration and Quality Assurance" sections of *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde* should be performed in the laboratory, office, etc., as appropriate, before each day in the field.
- Calibrate the LaMotte 2020e turbidity meter according to the schedule and instructions in the "Measuring Turbidity with a Turbidity Meter" section of *SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration*. The meter should be calibrated before arriving at the site using a standard with a concentration similar to expected turbidity values.
- Choose a current meter based on guidance in Table S9.1, and perform pre-deployment inspection and quality checks of the current meter as described in *SOP 9 – Collecting Streamflow and Stage Da*
- Turn the digital thermometer on to verify that it is operational and the display is legible. Carry an extra battery in the field bag. If using a liquid-in-glass thermometer, inspect to be certain liquid columns have not separated, inspect bulbs to be sure they are clean and inspect protective cases to be sure they are free of sand or debris.

- Turn on the field camera and check to make sure it has charged batteries and a clean memory card. Double check that sufficient quantities and types of sample bottles have been packed, including several extras in case of breakage or contamination.

Field Data Forms

Upon arrival at the monitoring site, observers must note weather conditions, general descriptions of site and streamflow conditions, and all pertinent metadata (times, dates, logger filenames, etc.) for the monitoring visit. A field data form (Appendix S4.A) is used to document all information collected during water-quality monitoring. All notations are made in either pencil or waterproof pen. Fill in all blanks provided that pertain to the data that you will be collecting. Indicate with a "–" if the data are not available or not applicable but do not leave the entry blank. Blank entry lines leave the QA/QC checker to wonder if the data were forgotten or not available. The following information is to be completed on all field data forms:

- **Name and NETN site code**- Full name and 6-character code of waterbody being monitored.
- **Surveyor(s)**- Name of person(s) doing the observations.
- **Date and Time**- Date, start time and end time of monitoring visit.
- **Cloud Cover (ACAD only)**- Estimate amount of sky obscured by clouds, in 10% increments.
- **Wind Velocity and Direction (ACAD only)**- Determine wind direction and record the appropriate code using the diagram on the left side of the data sheet. Determine the average wind velocity using a hand-held anemometer or estimate the velocity using tree movement/wave height as a guide. Record the corresponding Beaufort Scale (Table S4.1) code in the space provided.

Table S4.1. Beaufort Scale codes and associated descriptive information.

Code #	km/h	mph	Description (Land)	Description (Sea)
0	<2	<1	Smoke rises vertically	0 ft waves; flat
1	2 to 5	1 to 3	Wind direction shown by smoke drift	0-1 ft waves; ripples without crests
2	6 to 11	4 to 7	Wind felt on face; leaves rustle	1-2 ft waves; small wavelets, crests not breaking
3	12 to 20	8 to 12	Leaves, small twigs in constant motion; light flag extended	2-3.5 ft waves; large wavelets, crests begin to break, scattered whitecaps
4	21 to 32	13 to 18	Small branches are moved	3.5-6 ft waves; small waves, frequent whitecaps
5	33 to 30	19 to 24	Small trees begin to sway	6-9 ft waves; moderate waves, many whitecaps

- **Air Temperature**- See Section below on *Temperature Measurements*
- **Surface-water Temperature**- See Section below on *Temperature Measurements*
- **Gage Height**- Note stage height from staff gage or stage datum mark at beginning and end of site visit. If you measure DOWN to reach the water from a reference bolt, the value must be recorded as a negative number.

- **Photographic Documentation**- Note picture number and description of all pictures. See section on *Photographic Documentation*.
- **Observations**- This portion of the data sheet includes specific observations about water appearance (including clarity and color) and algae. Any additional information pertaining to the sampling session should be described in the notes, such as amount of emergent/floating vegetation, unusual occurrences, or equipment problems. Be sure to note any conditions that may cause distractions, or affect the quality of the measurements, like the presence of biting insects, rain, extreme heat/cold, new crew members or guests. Other observations that may be relevant are encouraged, such as observations of organisms (e.g., fish, macroinvertebrates, frogs). Observations should be relevant to the immediate monitoring site, which is approximately 50 m of stream (shorter if there is a nearby hydrologic change like a dam or culvert).

All information included on the field form is entered electronically into an MS Access data entry module (e.g., Figure S4.1). Although not mandatory, electronic data entry in the field can also be accomplished by running the data entry module on a ruggedized notebook computer, or by using a Personal Data Assistant (PDA) running a database designed in the open source software Cybertracker (ACAD uses this system). Examples of some of the Cybertracker data entry screens are shown in Figure S4.2. LNETN is developing a FileMaker Pro application for field data collection beginning in 2014.

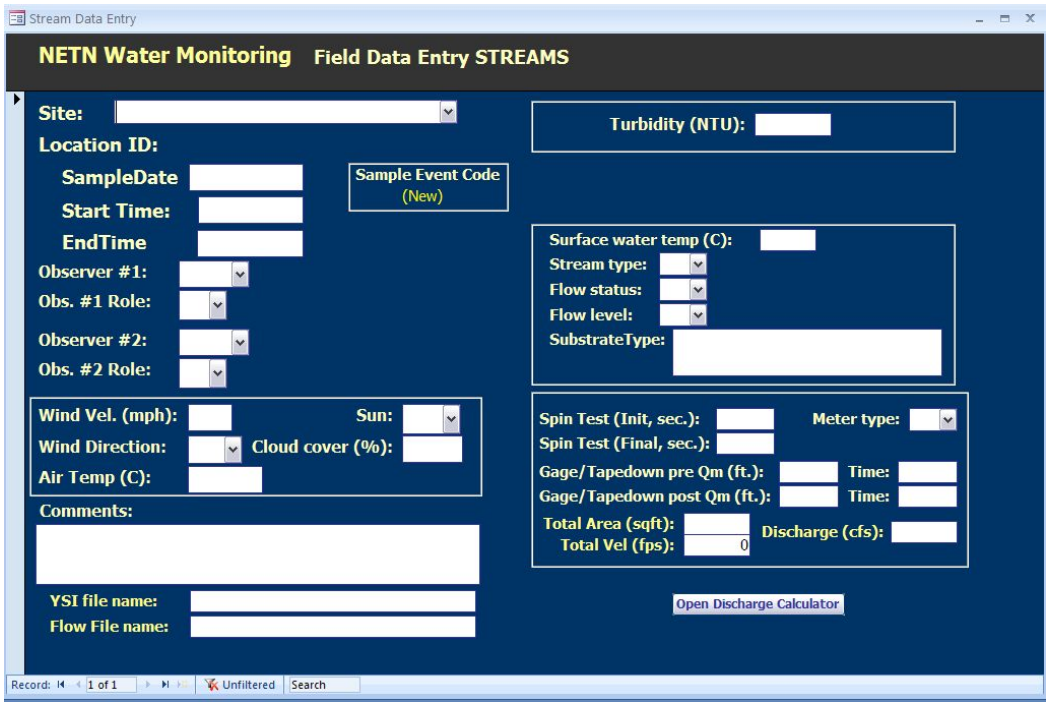


Figure S4.13. MS Access stream data entry screen for ACAD.

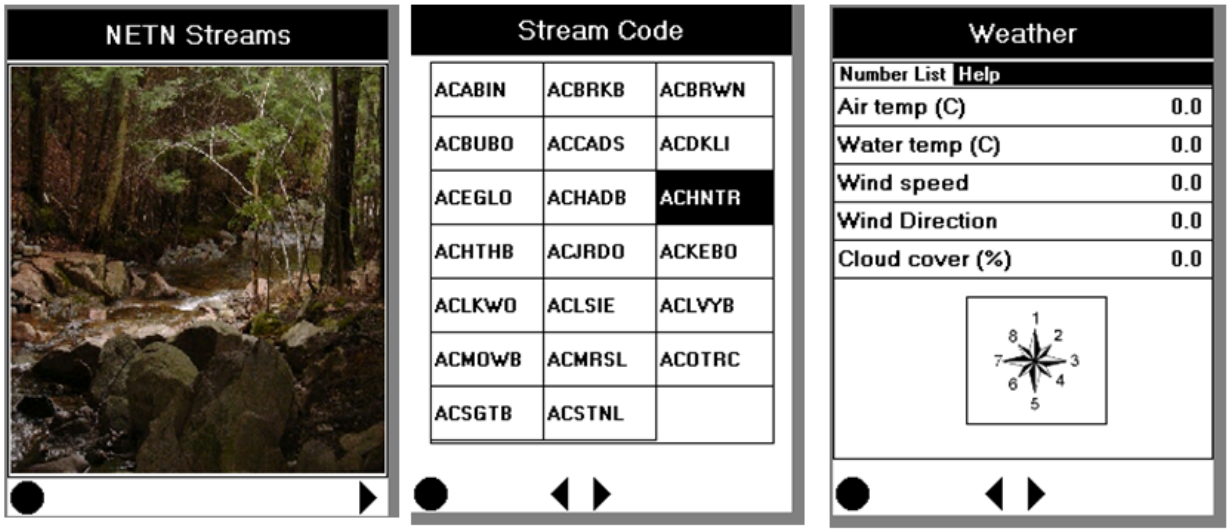


Figure S4.4. Cybertracker data entry screens for ACAD streams.

Photographic Documentation

Regular digital photographic documentation of all monitoring sites is mandatory. An initial photo or screen shot is taken of the data sheet (to document site name and date), then two sets of photos are taken at each stream site during every monitoring visit. Tag line photos help document the conditions and stream morphology where flow was taken. Photos taken from established photopoints can help show changes over time for the site in canopy cover, flow, and other habitat and channel conditions.

- Three "tag line" photos are taken documenting the cross section of the stream used to obtain flow measurement. These photos are taken across the stream at the measurement location (AC), with downstream to the left; looking upstream from downstream of the measurement site (US); and looking downstream from upstream of the measurement location (DS). All of these photos must show the full tag line (measuring tape) and can include people. Do not use a flash, hold the camera at between 5 and 6 feet above the ground (i.e., head height), and take the photo in landscape (wider horizontally) mode while holding the camera level (i.e., do not aim up or down). Tag line photos are named using standard NETN file-naming conventions described in *SOP 13– Data Management*, using the template:

  NETN Site code _ YYYYMMDD_qmUS *(or)* qmDS *(or)* qmAC_#

  An example using an upstream tag line photo from Saratoga NHP Stream A, taken on July 25, 2010 is:

  SARASA_20100725_qmUS_1.jpg

- Photopoint records are taken from a consistent, documented location during each monitoring visit. The stage datum (benchmark) or one of the associated reference points is often used for a photopoint location. Standing mid-stream, if possible, over or next to the datum, take one panoramic photo facing upstream and one panoramic photo facing downstream. Use the widest angle possible within the camera's zoom range. There should be no people in the photopoint pictures. Do not use a flash, hold the camera at

between 5 and 6 feet above the ground (i.e., head height), and hold the camera level (i.e., do not aim up or down). Center the stream as much as possible; if the stream reach is straight, it should be visible in the center of the image; if the reach is curved then the image may be shifted to include more of the reach. Bring a set of earlier photos into the field, and try to match them as closely as possible. Photopoint records are named using standard NETN file-naming conventions, using the template:

NETN Site code _ YYYYMMDD_ppUS *(or)* ppDS _#

An example using a downstream photopoint picture from Saratoga NHP Stream A, taken on July 25, 2010 is:

SARASA_20100725_ppDS_1.jpg

Descriptions of the locations and coordinates of the designated photopoints are documented in the NETN_H2O database and in the site reference information section of the field notebook.

Additional photographic documentation is encouraged. Take photographs of changes in the site after construction, erosion, flooding, or debris in the channel.

Temperature measurements

Water-quality sampling includes an air-temperature measurement and a water-temperature measurement, preferably taken with a digital thermometer (thermistor). Read air temperature with a dry, calibrated thermometer, prior to taking water temperature.

1. Place the thermometer about 5 ft above the ground in a shaded area protected from strong winds but open to air circulation. Avoid areas of possible radiant heat effects, such as metal walls, rock exposures, or sides of vehicles.
2. Allow time for the thermometer to equilibrate (usually less than a minute for a thermistor, but possibly up to 3 to 5 minutes for a liquid-in-glass thermometer), and then record the temperature and time of day.
3. Measure the air temperature as close as possible to the time when the water temperature is measured.
4. Report and record routine air temperature measurements to the nearest 0.1°C (to the nearest 0.5°C with liquid in glass thermometer).
5. Place the metal part of the digital thermometer in the water (do not submerge the thermometer completely) and record the water temperature in degrees Celsius after the display stabilizes. For the Concord River (MIMA), this measurement is taken in a sample of water collected with the Van Dorn sampler.

Water Clarity

Streamwater clarity is measured electronically using a portable turbidity meter. Water clarity should be measured as early as possible during the monitoring visit, before observers stir up sediment or create disturbance that could alter the stream turbidity. Samples should be taken from a few feet upstream of the site, and in an area where there is running water.

Detailed instructions on the use of the LaMotte 2020e turbidity meter can be found in the instrument's instruction manual and in *SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration*. The meter should be calibrated prior to the field site visit, and data should be

collected according to the procedures in "Measuring Turbidity with a Turbidity Meter," in *SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration*. At the Concord River (MIMA), clarity is measured on water collected from the middle of the bridge with a Van Dorn sampler.

Measuring Stream Stage (Water level) and Flow (Discharge)

Each stream site has an established benchmark (datum) from which to measure to the water surface ("tape-up" [positive] or "tape-down" [negative] measurement) to determine stream stage. The datum may be a staff gage or a bolt, and some sites have multiple datums to facilitate measurements at different water levels. All datums must be leveled annually as described in *SOP 19 – Leveling Water Monitoring Sites*. Stream stage is measured from at least one location on each visit. If a staff gage is installed, measurements should be from the staff gage. Otherwise one or two benchmarks are selected for the stage measurement. Stream stage should be measured immediately before and after each discharge measurement to determine if the stream flow is rising, falling, or stable; and to contribute to the body of data that will enable the establishment of a stage-discharge relationship (rating curve). If the site has an automatic water level logger, the logger elevation should be checked following procedures in the "Deploying Data Loggers" section of *SOP 2 – Establishing, Maintaining, and Documenting Monitoring Sites* at each monthly site visit to determine if the logger has moved during the previous sampling interval.

Discharge measurements are necessary for the interpretation of water-quality measurements and the calculation of loads of those water-quality parameters, and should be taken at each site visit. Specific instructions for measuring stage and discharge are detailed in *SOP 9 – Collecting Streamflow and Stage Data* and other references described in SOP 9.

Determining Discharge Measurement Method and Location

Several methods can be used to measure discharge, depending on the amount of stream flow, channel conditions, and other factors. Consequently, measurement location at each site can vary according to the measurement method used. The first decision when beginning a water quantity monitoring session is a) which method to use and b) where to take the measurements.

As detailed in *SOP 9 – Collecting Streamflow and Stage Data*, direct measurements of discharge in NETN parks are generally made with the current-meter method. A current-meter measurement is the summation of the products of the subsection areas of the stream cross section and their respective average velocities (Rantz et al. 1982). Discharge is measured in cubic feet per second and most often is determined by making measurements of a particular cross-sectional area of the stream and the velocity of the water past that cross section, using one of two types of current meters. The Price pygmy meter utilizes cups that are rotated by the action of flowing water. The speed of the rotation depends on the velocity of the water passing by the cups. The other meter (SonTek FlowTracker) uses the acoustic Doppler effect to calculate water velocity. Discharge then is calculated by multiplying the width, depth, and velocity of each section of the stream.

Both types of current meters have limitations in certain conditions (explained in *SOP 9 – Collecting Streamflow and Stage Data*) that affect the accuracy of their measurements. After selecting the most appropriate instrument for the available channel and flow conditions, choose a cross section that will provide the most accurate measurement possible. The spacing of observation verticals in the measurement section can affect the accuracy of the measurement (Rantz et al. 1982). Make observations of depth and velocity at 25-30 verticals, to ensure that no more than 5 percent of the total flow is measured in any one vertical. Even under the worst conditions the discharge computed for each vertical should not exceed 10 percent of the total

discharge and ideally not exceed more than 5 percent (Rantz et al. 1982). Exceptions to this policy are allowed in circumstances where accuracy would be sacrificed if this number of verticals were maintained, such as for measurements during rapidly changing stage (Rantz et al. 1982). Fewer verticals than are ideal are sometimes used for very narrow streams (about 5 ft wide when a pygmy meter is used). Measurement of discharge is essentially a sampling process, and the accuracy of sampling results typically decreases markedly when the number of samples is less than about 25.

If conditions are adverse to finding a suitable site on the stream to conduct a discharge method with a current meter, consider an alternate method. Direct volumetric measurements are often possible if the total stream flow is confined within a culvert during very low flow conditions, assuming all flow from the downstream side of the culvert can be captured in the measuring vessel. When performed properly, this method is more accurate than measurements using current meters, since it is a direct measurement of the volume of water passing over a given point during a specific time period. Specific instructions can be found in *SOP 9 – Collecting Streamflow and Stage Data*. Alternatively, an artificial control, such as a Parshall flume, can be used to isolate or concentrate the streamflow enabling a more reliable measurement. Details on using these specialized techniques can be found in Kilpatrick and Schneider (1983).

Conducting Discharge Measurement

The majority of NETN discharge measurements will be obtained with a current meter. The following steps supplement the generic procedures detailed in *SOP 9 – Collecting Streamflow and Stage Data*, which should be consulted for additional information about current meter measurements, or instructions on measuring discharge with alternate methods.

1. Take an initial stream stage measurement from the tapeup/tapedown datum or staff gage. Record the value on the field data sheet.
2. Once a suitable measurement section has been selected, the tagline (measuring tape) is stretched across the stream, perpendicular to the stream flow. Be sure the tagline is taut, and does not droop into the water, potentially altering the stream flow. Secure both sides on the stream banks with stakes or rocks.
3. If it is necessary to move rocks or make any minor modifications to the stream bed in order to provide better measurement conditions, do so with extreme caution. Allow sufficient time for the streamflow to equilibrate before beginning measurements.
4. Set up the current meter and conduct the appropriate pre-measurement quality control checks. In the case of the Pygmy meter, this is a spin test (ensuring that the Pygmy bucket wheel spins freely for over 45 seconds when manually spun). Record the initial spin test results on the field data sheet.
    a. When using the FlowTracker, first check the <Setup Parameters Menu> to check that the instrument settings (units, averaging time, equation, etc.) are set to the proper values. Next, enter the <System Functions Menu> to check operational parameters such as temperature, battery voltage, clock, and signal to noise ratio (SNR).
5. After the meter has passed all quality control checks, begin the measurement. Enter all the required preliminary information in the FlowTracker datalogger (initiated by pressing

the <Start Data Run> button) or after starting Q-Calc on the PDA. The FlowTracker needs to be in the water and at the correct height during the initiation procedure, and will run for 20 seconds to determine SNR and other parameters.

6. Record the tagline reading and depth at the initial edge of water in the datalogger (on the <Starting Edge> screen) or PDA.
7. Move the current meter and wading rod to the first vertical section. Record the tagline reading and depth at the first section in the datalogger or PDA. If possible, obtain an at-point velocity measurement by either counting clicks in a 40 second interval (Pygmy) or pressing the <Measure> button (FlowTracker). If the water is too shallow or there are other factors precluding measurement, estimate the section's velocity (as the percent of the next section's velocity) and record the estimate in the appropriate location on the datalogger/PDA.
8. When using the Pygmy, record the number of clicks and the exact averaging time from the stopwatch in the appropriate PDA fields then click the <Next> button to advance to the screen for the next station.
    a. The FlowTracker will automatically display a summary of the station measurement when complete. Press <1> to accept the measurement and advance to the next station, or <2> to repeat the measurement to address errors displayed in the summary.
9. Continue this process for each subsequent section. Be sure to include data and notes on observations of factors that affect the measurement (angled flow, eddies, obstructions, etc.). It may be necessary to estimate the final vertical section(s) depending on the configuration of the stream channel.
10. Record the tagline reading and depth at the final edge of water in the PDA and select the <End Measurement> option when using the Pygmy to complete the measurement.
    a. On the FlowTracker, first press the <End Section> button, then enter the ending edge information. Press <Calc Discharge> to compute the total discharge for all completed stations
11. Perform a final spin test (Pygmy only) and enter any required final information (final spin test value, measurement quality assessment, notes, etc.) into the PDA program.
12. Record the total discharge, total area, and average velocity values that were calculated by the program on the field data form. For FlowTracker measurements, also record the percent uncertainty.
13. Be sure to save the Q-Calc (PDA) or datalogger (FlowTracker) files before exiting the program. On the FlowTracker, *you must always return to the <Main Menu> to make sure all data is saved*. Whenever possible, save a copy of Q-Calc files on removable media (SD card, etc.) as well as in the PDA's internal memory. Record the file name on the field data form.
14. Take a final stream stage measurement from the tapeup/tapedown datum or staff gage. Record the value on the field data sheet.

Remove the tagline, and pack all equipment. If any modifications were made to the stream bed, restore it as close as possible to conditions before modification.

Measuring Water Quality

Measurement Sites

Make measurements on predefined waterbodies at predefined sampling sites according to the *Sampling Design* section of the protocol narrative. Flowing-water sampling sites optimally are located:

- At or near a streamflow-gaging station, to obtain concurrent surface-water discharge data required for computing constituent-transport loads and to determine discharge/constituent-concentration relations. Measure discharge at time of sampling if a gaging station is not at or near the sampling site or if discharge cannot be rated or estimated with sufficient accuracy;
- In straight reaches with uniform flow, with a uniform and stable-bottom contour, and where constituents are mixed along the cross section. Sample streams at a pool below a riffle or quickwater section. This ensures mixing just before the sample site, resulting in a more integrated sample, and minimizes inclusion of large particles of litter, soil, etc. in the sample;
- Far enough upstream and downstream of confluences of streamflow or point sources of contamination to avoid sampling a cross section where flows are poorly mixed or not unidirectional;
- In reaches upstream from bridges or other structures, to avoid contamination from the structure or from a road surface;
- In unidirectional flow that does not include eddies. (If eddies are present within the channel, sample only the unidirectional flow);
- At or near a transect in a reach where other data are collected (such as data for suspended sediment, bedload, bottom material, or biological material) and (or) for which historical data are available; or
- At a cross section where samples can be collected at any stage throughout the period of study, if possible.

Note that the optimal flowing-water-sampling site can vary depending on the flow. Adjust sampling site, if warranted, on each trip as long as the sampling site consistently remains within the same reach, there are no inflows or outflows between the original sampling site and the new sampling site, and there is reason to believe the stream is well-mixed at various stages.

In Situ Multiparameter Sonde Measurements in Streams

Detailed operating and quality control procedures for the water-quality sonde are outlined in *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde*.

Upon arrival at the monitoring site, the sonde must be allowed to warm up for 4 to 5 minutes before taking measurements. During this warm-up period, turn on the sonde by powering up the 650MDS and verify that the date and time settings are correct. If an ETrex GPS is connected to the 650MDS, make sure GPS readings are displayed on the datalogger. During the warm-up

period, the sonde does not need to be in the water but should be dipped in the water and then kept in a shady and DO-saturated environment.

Use the procedures in the "Making Measurements" section of *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde* to verify and record the DO calibration values and obtain the *in situ* water quality measurements. At Minute Man NHP, where sampling is from the bridge over the Concord River, samples are logged at mid-depth at bridge pylons 2 and 4 to obtain a representative sample of the river.

Grab Samples in Streams

Grab samples are often used for small streams where a grab sample taken at the centroid of flow represents the water quality throughout the cross-section (Stednick and Gilbert 1998). Single point grab samples are sufficient for well-mixed streams that are less than 2 ft in depth, which includes virtually all NETN streams. All samples should be collected directly into the sample bottle (except for the Concord River).

Grab samples and width-integrated sampling at the Concord River are made at predefined sampling sites (listed in the *Sampling Design* section of the protocol narrative) according to procedures outlined in section *SOP 7 – Grab Samples and Depth-Integrated Samples*.

Rapid Hydro-Geomorphic Assessment

An assessment for habitat and physiochemical characterization is conducted in July at each stream in the yearly rotation. Details can be found in *SOP 11 – Rapid Hydro-Geomorphic Assessment*, which explains how NETN has adapted assessment techniques from the EPA Rapid Bioassessment protocol. Detailed descriptions of procedures, methods and data forms can be found in the original EPA document (Barbour et. al. 1999), which is available at: http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm. The sections of this protocol used by NETN include Chapter 5: "Habitat Assessment and Physiochemical Parameters" and the field data forms in Appendix A-1. The major departure from EPA methods is NETN assesses a 20 meter reach of stream (upstream of the measurement site) rather than the EPA-prescribed 100 meters.

Benthic Macroinvertebrate Monitoring

Macroinvertebrate monitoring has been identified as a high priority for streams. Because of funding constraints, however, addition of this vital sign to the protocol would depend on collaboration with other agencies. Park staff at Acadia NP have been monitoring macroinvertebrates in cooperation with the Maine Department of Environmental Protection (MDEP) since 1997 using MDEP protocols (Davies and Tsomides 2002). Other parks may become involved in macroinvertebrate monitoring in the future in cooperation with other monitoring programs.

Macroinvertebrate monitoring by Acadia supplements data collected through this standardized program, which was first implemented by the DEP in 1983 (Davies et al. 1999). Acadia began sampling macroinvertebrates in NETN rotating stream sites in 2006. Samples are collected in association with other NETN monitoring such as YSI measurements, nutrient sampling and discharge measurements.

Didymo

During visits to all NETN parks, monitors are increasingly attentive for the presence of Didymo (*Didymosphenia geminata*), also known as "rock snot", a highly invasive alga that has recently invaded the northern reaches of the Connecticut River in New Hampshire and the White River and Battenkill River in Vermont. This species has a great potential to alter habitats and displace native species, and is of great concern to officials in regions where infestations have been established.

Didymo is easily spread by even just one cell of the alga breaking off in infested reaches and drifting downstream. It is also very easily spread by waders, and potentially, water monitoring equipment and other gear that touches the bottoms of streams in infested areas. Enhanced equipment cleaning and decontamination procedures are included in *SOP 17 – Aquatic Decontamination Procedures*.

Post Field Activities

Several "wrap-up" activities should be performed at the end of each day:

- Check in with supervisor or designee with the trip/float plan promptly upon completion of field work.
- If water samples were taken during the day, these samples should be packed with ice packs and a chain of custody form (*SOP 12 – Laboratory Analyses, Appendix S12.A*) in coolers and shipped via Federal Express to the analytical lab, or (if it is too late to meet the day's shipping deadline) the samples should be refrigerated until they can be shipped as early as possible on the next day.
- Send an advance copy of the chain of custody form to the lab (via email) listing the number of samples that are being shipped, and the sample dates and locations.
- All field equipment should be cleaned with fresh water (deionized water not required) to remove any residual mud, dirt, silt or other contamination. Perform additional decontamination tasks described in *SOP 17 – Aquatic Decontamination Procedures* after the initial rinse; proper decontamination will prevent the spread of pathogens and invasive species.
- Wash all tubes used with the turbidity meter during the monitoring activities.
- Check DO probe membranes for wrinkles and bubbles – the membrane should be immediately changed if either condition is present to allow enough time for the membrane to stretch and/or "burn in".
- Take the YSI sonde out of the saturated DO environment (typically a wet towel or PVC tube with sponge) and replace the probe guard with the calibration cup. Place approximately 0.5 inch of water in the calibration cup and screw the cup onto the sonde. Place the sonde in a clamp stand or other secure storage location. The cap for the calibration cup should be loosely screwed on (1-2 threads engaged) to prevent evaporation but allow some air flow so the DO probe will be in a 100% saturated environment.
- Data files and photos should be downloaded from dataloggers, cameras, PDAs, etc. onto computer hard disks, and backed up to removable media (thumbdrive, external hard

drive, etc.). Rename these files following the NETN file-naming conventions described in *SOP 13 – Data Management*. The FlowTracker can only store files for 63 discharge measurements, and the files should be deleted monthly (after downloading and backing them up) to make room for new data.

- Enter data from all field data sheets in to the NETN_H2O Field Data Entry Module or Cybertracker "NETNStreams" PDA database.
- Any critical observations (detection of invasive species, water quality issues, resource damage, etc.) should be relayed to park resource management staff as soon as possible, preferably before traveling to the next park (or site at ACAD).

Appendix S4.A. NETN (ACAD) water monitoring field form.

Stream Survey Form

Sample Event Code:

Stream: _____

NETN Code: _____

USGS Station #: _____

Date: _____

Start Time: _____

End Time: _____

Surveyor(s): _____

Measurement location:

☐ Pool ☐ Run ☐ Chute ☐ Riffle

Flow: ☐ Base ☐ Low ☐ Medium ☐ High ☐ Bank-full ☐ Flood

Status: ☐ Rising ☐ Stable ☐ Falling

Substrate:

SUN: ☐ Bright ☐ Cloudy ☐ Overcast

Cloud cover: _____%

Wind Vel:_____

Wind Dir:_____



Air Temp: ___.__ °C

Surface water temp: ___.__ °C

Turbidity: _____ NTU

YSI Multi-parameter Meter

GPS coordinates on 650? ☐

650 Time/date correct? ☐

DO % sat drifted high to low: ☐

Calibrate DO in field: ☐

Pressure at DO cal: _____

DO charge before calibration (25 to 75):_____

DO gain local (0.7 to 1.14) after calib:_____

DO % local in sat enviro (100 ±2%):_____

Sampling Information

Water sample time:_____

☐ *No sample taken* ☐ Blank ☐ Rep

Tapedown reading:

1) Time _____ Feet/ Meter_____

2) Time _____ Feet/ Meter_____

☐ Pygmy ☐ Flowtracker

☐ Other: _____

Pygmy spin test before QM: _____ (sec)

Pygmy spin test after QM: _____ (sec)

Discharge Measurement: _____cfs

Avg. Velocity: _____ f/s

Total Area: _____

Surveyor Roles *(initial each):*

YSI: _____

Discharge: _____

Collect water sample: _____

Filter water sample: _____

Photos:

Observations:

Water appearance:

☐ Clear ☐ Turbid ☐ Orange ☐ Tea-colored
☐ Milky ☐ Dark brown ☐ Greenish ☐ Foamy
☐ Oily sheen ☐ Other:_____

Extent of algae in the stream. (Mark all that apply)

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

☐ None ☐ Occasional ☐ Plentiful
☐ Light coating ☐ Heavy coating
☐ Brownish ☐ Greenish ☐ Other _____

(b) Are there any filamentous (string-like) algae?

☐ None ☐ Occasional ☐ Plentiful
☐ Brownish ☐ Greenish ☐ Other _____

(c) Are any detached "clumps" or "mats" of algae floating on the water's surface?

☐ None ☐ Occasional ☐ Plentiful
☐ Brownish ☐ Greenish ☐ Other _____

****

Notes:

SOP 4 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.00	March 2007	B. Mitchell	**Section 3.1:** For first series of steps: changed reference to DO percent local saturation in steps 2 and 3. Inserted step 4 (log to 89 file). Clarified step 8 (only one point needed in well-mixed, small streams; multiple points only needed for Concord River). Added step 9 (log to 99 file). *(Originally part of SOP 6- In Situ Measurements in Streams)*	Protocol review meeting
2.01	April 2009	B. Mitchell	- **Section 2.2.2:** Updated to reflect monthly photographs of stream sites. *(Originally part of SOP 2- Metadata collection)* - **Section 3.4:** Inserted Transparency Tube procedures, SOP 9. These measurements should be made annually, at high flow. *(Originally part of SOP 9- Transparency Tube)*	Protocol review meeting
3.00	January 2012	B. Gawley	- Reformatted using NRPS-NRR template. - Combined all or sections of v2.02 SOP #s 2, 3, 4, 6, 7, 8, 9, and 10 to consolidate tasks for a stream monitoring session. - Re-assigned as SOP 4. - Added procedures for sampling Concord River with YSI sonde. - Added/expanded references to: • CyberTracker • NETNH2O_FieldDE • Turbidity meter • FlowTracker • Didymo- decontamination • Post-field activities - Added copies of field forms as Appendix.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits, including link to USGS manual. Eliminate “Sun” measurement, since duplicative with “Cloud” measurement. Measurements DOWN from a bolt must be recorded as negative numbers. Wind speed will be measured with Beaufort Scale rather than in mph to eliminate need for wind meter and to save time in field. Added more detail to photo procedures. Decontamination procedures should be followed daily.	Internal review
3.02	December 2013	Brian Mitchell	- Minor edits - Noted that choice of current meter is needed in “Before Field Activities” - Removed detailed turbidity instructions	Reviewer suggestions

Version #	Date	Revised by	Changes	Justification
			since these are in SOP 8. - Removed detailed sonde instructions since these are in SOP 6 - Removed detailed grab sample instructions since thes are in SOP 7 - Station, Cloud Cover, and Wind information is no longer collected by LNETN. - Stream stage is measured from a staff gage preferentially, otherwise from one or more benchmarks. - Stage is measured immediately before and after the discharge is measured. - Record percent uncertainty for FlowTracker measurements. - Temperature and turbidity for the Concord River (MIMA) are measured on water collected with a Van Dorn sampler. - Grab samples for the Concord River (MIMA) are a composite, collected with a Van Dorn sampler. - FlowTracker files must be cleared monthly to make new for new data - Removed “Station” from required data since this is part of the metadata and is duplicative with NETN site code. - Updated photopoint procedures to clarify and allow panoramic photos.	Clarification

SOP 5 – Monitoring Lakes and Ponds

Northeast Temperate Network

Version 3.02

Overview

This SOP for measuring lakes and ponds is adapted from the MDEP's Lake Assessment Program Standard Operating Procedures (Bacon 2004) unless otherwise noted. The SOP is consistent with Maine's Volunteer Lake Monitoring Program (VLMP) protocols (Williams 2004). **Properties such as specific conductance, pH, temperature, and DO concentrations are measured *in situ*.** Other parameters such as color, nutrients, algal biomass, and ANC are collected as a grab or depth-integrated composite sample and analyzed in a laboratory. Lakes and ponds are sampled at the deepest point ("deep hole") of the lake.

Before Field Activities

Several activities should be performed before field monitoring:

- Check current weather conditions and forecast. Postpone monitoring if conditions are unsafe or are expected to become unsafe.
- Provide supervisor or designee with the trip/float plan of the day's field work.
- Pre-deployment sonde calibrations and quality checks detailed in the *Pre-Deployment Preparation* section of *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde* should be performed in the laboratory, office, etc., as appropriate, before each day in the field.
- Turn the digital thermometer on to verify that it is operational and the display is legible. Carry an extra battery in the field bag. If using a liquid-in-glass thermometer, inspect to be certain liquid columns have not separated, inspect bulbs to be sure they are clean and inspect protective cases to be sure they are free of sand or debris.
- Turn on the field camera and check to make sure it has charged batteries and a clean memory card.
- Double check that sufficient quantities and types of labeled sample bottles have been packed, including several extras in case of breakage or contamination.

Field Data Forms

Upon arrival at the monitoring site, observers must note weather conditions, general descriptions of site, lake level, and all pertinent metadata (times, dates, logger filenames, etc.) for the monitoring visit. A field data form (Appendix S5.A) is used to document all information collected during water-quality monitoring. All notations are made in either pencil or waterproof pen. Fill in all blanks provided that pertain to the data that you will be collecting. Indicate with a "–" if the data are not available or not applicable but do not leave the entry blank. Blank entry lines leave the QA/QC checker to wonder if the data were forgotten or not available. The following information is to be completed on all field data forms:

- **Name and NETN site code**- Full name and 6-character code of waterbody being monitored.
- **Station (ACAD only)**- Numbered location of sample site (needed for Maine DEP data sharing; refers to whether site is deep hole or some other location on the lake).
- **Surveyor(s)**- Name of person(s) doing the observations.
- **Date and Time**- Date, start time and end time of monitoring visit.
- **Sun**- Choose and circle the selection that best describes current conditions. At ACAD the choice is "Bright", "Cloudy", or "Overcast" for compatibility with Maine DEP; in LNETN parks the choice is "Steady" or "Variable" light.
- **Cloud Cover-** Estimate amount of sky obscured by clouds, in 10% increments.
- **Wind Velocity and Direction**- Determine wind direction and record the appropriate code using the diagram on the left side of the data sheet. Determine average wind velocity using a hand-held anemometer (ACAD; required for data sharing with Maine DEP) or estimate the velocity using tree movement/wave height as a guide (LNETN parks). Record the wind speed or corresponding Beaufort Scale (Table S5.1) code in the space provided.

Table S5.1. Beaufort Scale codes and associated descriptive information.

Code #	km/h	mph	Description (Land)	Description (Sea)
0	<2	<1	Smoke rises vertically	0 ft waves; flat
1	2 to 5	1 to 3	Wind direction shown by smoke drift	0-1 ft waves; ripples without crests
2	6 to 11	4 to 7	Wind felt on face; leaves rustle	1-2 ft waves; small wavelets, crests not breaking
3	12 to 20	8 to 12	Leaves, small twigs in constant motion; light flag extended	2-3.5 ft waves; large wavelets, crests begin to break, scattered whitecaps
4	21 to 32	13 to 18	Small branches are moved	3.5-6 ft waves; small waves, frequent whitecaps
5	33 to 30	19 to 24	Small trees begin to sway	6-9 ft waves; moderate waves, many whitecaps

- **Air Temperature**- See Section below on *Temperature Measurements*
- **Surface-water Temperature**- See Section below on *Temperature Measurements*
- **Gage Height**- Note stage height from staff gage or stage datum mark at beginning of site visit. If you measure DOWN to reach the water from a reference bolt, the value must be recorded as a negative number.
- **Photographic Documentation**- Note picture number and description of all pictures. See section on *Photographic Documentation*.
- **Observations-** A notes field is provided for any additional information pertaining to the sampling session, such as water clarity, amount of emergent/floating vegetation, unusual occurrences, or equipment problems. Be sure to note any conditions that may cause distractions, or affect the quality of the measurements, like the presence of biting insects,

rain, extreme heat/cold, new crew members or guests. A section is also provided for profile data, such as a Li-Cor light penetration profile.

All information included on the field form is entered electronically into an MS Access data entry module (Figure S5.1). Although not mandatory, electronic data entry in the field can also be accomplished by running the data entry module on a ruggedized notebook computer, or by using a Personal Data Assistant (PDA) running a database designed in the open source software Cybertracker. Examples of some of the Cybertracker data entry screens are shown in Figure S5.2. LNETN is developing a FileMaker Pro application for field data collection beginning in 2014.

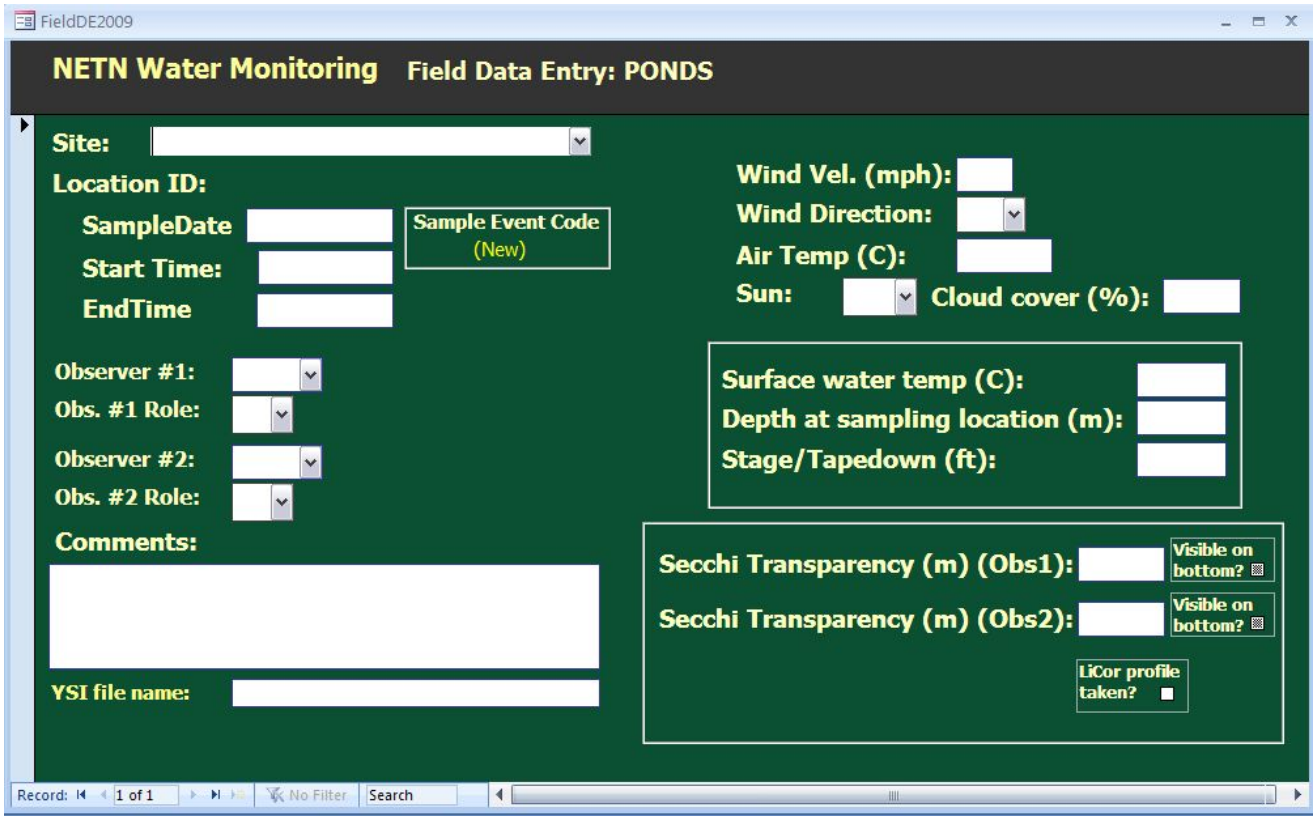


Figure S5.5. MS Access lake and pond data entry screen for ACAD.

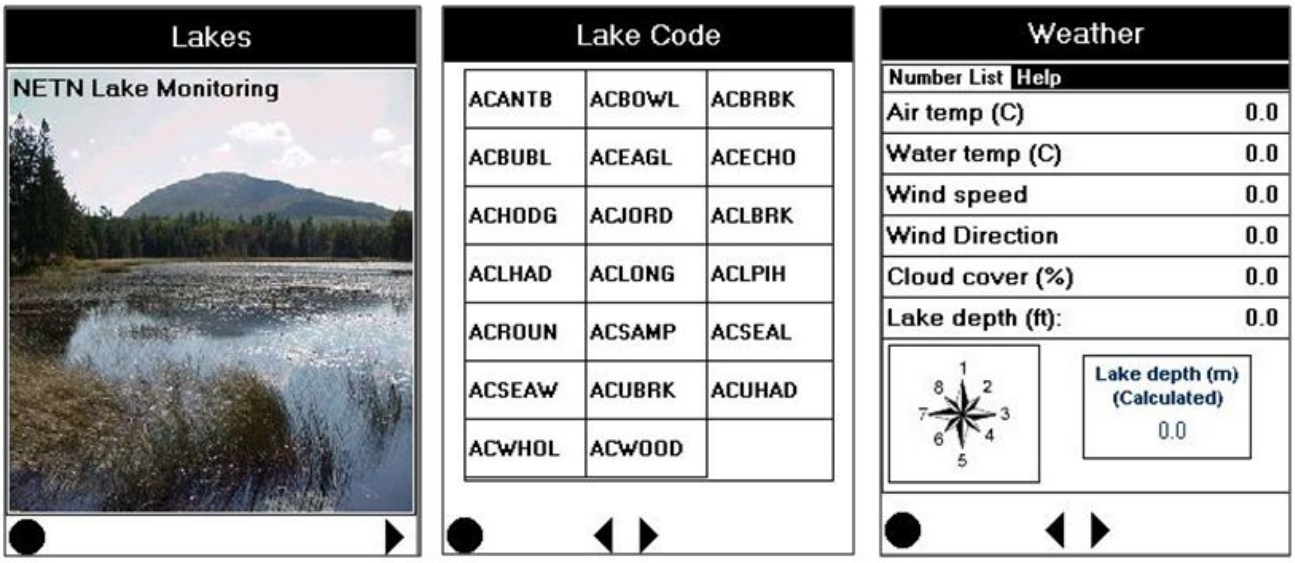


Figure S5.6. Cybertracker data entry screens for ACAD lakes and ponds.

Measuring Lake/Pond Stage (Water level)

Each lake and pond site has an established benchmark (datum) from which to measure to the water surface ("tape-up" or "tape-down" measurement) to determine lake stage. The datum may be a staff gage or a bolt, and some sites have multiple datums to facilitate measurements at different water levels. All datums must be leveled annually as described in *SOP 2 – Establishing, Maintaining, and Documenting Monitoring Sites*. In some NETN parks, park staff measure lake stage on a weekly basis during the entire open-water season. At a minimum, lake stage should be measured at the beginning of each monthly monitoring site visit to contribute to the body of data documenting seasonal and annual ranges of lake water levels, which are useful for the interpretation of water-quality data. Specific instructions for measuring stage using tape-up and tape-down techniques are detailed in *SOP 9– Collecting Streamflow and Stage Data.* If the site has an automatic water level logger, the logger elevation should be checked following procedures in *SOP 2 – Establishing, Maintaining, and Documenting Monitoring Sites* at each monthly site visit to determine if the logger has moved during the previous sampling interval.

Photographic Documentation

Annual digital photographic documentation for lake and pond monitoring sites consists of a "panorama" series of photographs, beginning at North, taken while anchored at the sampling site during the July site visit (at a minimum). If changes to the site are expected or time permits, monthly photos can be taken. Use the panoramic photo feature of the camera, or take individual photos and mosaic them later. These photos document changes to shoreline conditions. Use the widest angle possible within the camera's zoom range. Try to avoid getting people in the pictures. Take photographs from a sitting position, do not use a flash, and take the photo while holding the camera level (i.e., do not aim up or down). Bring a set of earlier photos into the field, and try to match them as closely as possible. Panoramic photos are named using standard NETN file-naming conventions described in *SOP 13 – Data Management*, using the template:

NETN Site code _ YYYYMMDD_PNR_#

An example using a north-facing picture from a panorama series taken at Marsh-Billings-Rockefeller NHP Pond A, taken on July 19, 2010 is:

MABIPA_20100719_PNR_1.jpg

Additional photographic documentation is encouraged. Take photographs of changes in the site after shoreline alteration/construction, erosion, flooding or drought conditions, algal blooms, etc.

Temperature measurements

Water-quality sampling includes an air-temperature measurement and a water-temperature measurement, preferably taken with a digital thermometer (thermistor). Read air temperature with a dry, calibrated thermometer, prior to taking water temperature.

1. Place the thermometer in a shaded area protected from strong winds but open to air circulation. Avoid areas of possible radiant heat effects, such as warm outboard motors, boat seats, or sides of the boat, raft, or canoe. A possible location is on the bottom of the boat, shaded by the seat.
2. Allow time for the thermometer to equilibrate (usually less than a minute for a thermistor, but possibly up to 3 to 5 minutes for a liquid-in-glass thermometer), and then record the temperature and time of day.
3. Measure the air temperature as close as possible to the time when the water temperature is measured.
4. Record the air temperature value on the field data form. Report all temperature measurements to the nearest 0.1°C (to the nearest 0.5°C with liquid in glass thermometer).
5. Place the metal part of the digital thermometer in the water (do not submerge completely) and record the value in degrees Celsius after display stabilizes.

Water Clarity

Water clarity (transparency) is generally measured visually using a Secchi disk and viewing scope, but can also be measured electronically using a Li-Cor light meter in ponds that are too shallow for the use of a Secchi disk. Water clarity should be measured as early as possible during the monitoring visit, before observers stir up sediment or create disturbance that could alter the measurement. Detailed instructions for using both the Secchi disk and Li-Cor meter can be found in *SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration*.

Secchi Transparency

Transparency, measured by viewing a Secchi disk as it descends through the water column, is one of the simplest methods for estimating lake-water quality. Transparency measured in this manner is recorded as "Secchi depth" (or "SD"), expressed in meters. Secchi disk measurements are affected by the presence of algae, plankton, water color, or suspended sediment. Transparency is inversely related to lake productivity – thus a shallow SD indicates a productive lake. Procedures for measuring Secchi transparency in a pond or lake are found in "Measuring Transparency with a Secchi Disk," in *SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration*.

Light Penetration Profiles using Li-Cor

A light penetration profile is taken using two solar radiation sensors and a datalogger. One of the sensors (with a spherical diffuser to enable accurate collection of photosynthetically available radiation- "PAR") is lowered into the water column on a weighted lowering frame, suspended from a graduated cord. The second sensor ("deck cell") is left on the surface to record ambient light. The datalogger records and processes readings from both sensors, calculating the percentage of the total light that reaches any given depth. Measurements are taken just below the surface, then at 0.5 m, 1.0 m, and then one-meter intervals (or smaller intervals if the site is a pond less than 3 m deep) until the light penetration drops below 1%. To obtain a light penetration profile, use the procedures in "Light Penetration Profile Field Method," in *SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration*.

Measuring Water Quality

In Situ Sonde Measurements in Lakes and Ponds

Detailed operating and quality control procedures for the water-quality sonde are outlined in *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde*.

Upon arrival at the monitoring site, the sonde must be allowed to warm up for 4 to 5 minutes before taking measurements. During this warm-up period, turn on the sonde by powering up the 650MDS and verify that the date and time settings are correct. If an ETrex GPS is connected to the 650MDS, make sure GPS readings are displayed on the datalogger.

Use the procedures in the "Making Measurements" section of *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde* to verify and record the DO calibration values and obtain the *in situ* water quality measurements.

Collecting Water Samples

Grab Samples in Lakes and Ponds

Grab samples are collected just below the surface of the water (0.5 m) from a boat at the deepest point in any of the non-stratified ponds in NETN. Although lake samples for NETN nutrient analysis are generally collected as depth-integrated composite (core) samples, there may be instances (such as that of a very shallow epilimnion) where collecting a grab sample from a lake is necessary. Follow the procedures in "Collecting Grab Samples in Sample Bottles" of *SOP 7 – Water Samples: Grab and Depth Integrated*.

Collecting Grab Samples with a Throw Bottle

For samples in lakes with poor accessibility by boat, a throw bottle can be used to collect epilimnion grab samples at a depth of 0.6 meters, and a distance of about 9 meters from shore. Use this method only when necessary as it does not allow for *in situ* field measurements of SD or lake profiles. The sonde measurements of specific conductance, pH, temperature, and DO are made from the shore. If possible, make *in situ* measurements without stirring up bottom sediments and note the location of the measurements. To collect the sample, follow the procedures in "Collecting Grab Samples with a Throw Bottle" of *SOP 7 – Water Samples: Grab and Depth Integrated*.

Depth-Integrated Samples of Epilimnion in Lakes and Ponds

Depth-integrated composite samples contain water that represents a range of depths, or a specific layer of the lake. Depth-integrated epilimnion samples are collected from stratified ACAD lakes and ponds using a 10 meter by half-inch inside diameter, flexible, weighted tube (core sampler)

and a churn splitter. The procedure to take a depth-integrated "core" sample is described in the "Depth-Integrated Samples of Epilimnion in Lakes or Ponds" section of *SOP 7 – Water Samples: Grab and Depth Integrated*.

Invasive Aquatic Plant-Screening Survey Procedures

The survey techniques for screening parts, or all, of a waterbody for target invasive plants have been adapted from Maine Center for Invasive Aquatic Plants (MCIAP) screening survey procedures (Maine Center for Invasive Aquatic Plants 2011). This semi-quantitative survey process is described in detail in *SOP 10 – Invasive Aquatic Plant Survey Procedures*. Surveys are done from mid-July through September so that plants will be sufficiently developed to allow for identification. Questionable plants are inspected in the field, and sent to professionals for positive identification.

Level I surveys of all monitored lakes in NETN with a public boat launch are conducted annually. Level II surveys are done on all monitored ponds and impoundments in NETN every year except for in ACAD (where sites without boat launches are not monitored). It is important that field staff who conduct invasive plants surveys attend a training that includes invasive plant identification methods and a tutorial field survey in a lake or pond. This training is offered by the MCIAP. Crew should also carry Early Detection ID cards to help with priority species identification (Keefer et al. 2010).

Level I and Level II surveys include the following:

Level I: Survey points are at public access and other areas of concentrated boat traffic such as marinas and narrow navigation channels. Boat launch survey areas extend horizontally along the shoreline at least 100 meters (~300 ft) on either side of the boat launch area, and offshore along the entire length to the depth at which rooted plants are no longer observed (the outermost extent of the littoral zone.) If the access area is in a distinct cove, the survey includes the entire littoral zone of the cove, even if the shoreline distance from the launch area to the mouth of the cove is greater than 100 meters.

Level II: Survey all Level I areas, plus all areas of the shoreline that are likely to provide suitable habitat for aquatic plants, such as shallow, sheltered coves. Floating leaved plants are often a good indicator of a rich plant community below the surface. In addition to supporting native plants, these areas can provide suitable habitat for invaders.

Step by step procedures for conducting invasive aquatic plant surveys can be found in SOP 10.

Post Field Activities

Several "wrap-up" activities should be performed at the end of each day:

- Check in with supervisor or designee with the trip/float plan promptly upon completion of field work.
- Water samples collected for chlorophyll *a* analysis should be filtered as soon as possible (no longer than 24 hours after collection) and the filters should be frozen in preparation for shipping. A detailed description of filtering methods can be found in *SOP 7—Grab Samples and Depth-Integrated Samples.*
- Any water samples collected during the day should be packed with ice packs and a chain of custody form (*SOP 12 – Laboratory Analyses*, Appendix S12.A) in coolers and

shipped via Federal Express to the analytical lab, or (if it is too late to meet the day's shipping deadline) the samples should be refrigerated until they can be shipped as early as possible on the next day.

- Send an advance copy of the chain of custody to the lab (via email) listing the number of samples that are being shipped, and the sample dates and locations.
- All field equipment should be cleaned with fresh water (deionized water not required) to remove any residual mud, dirt, silt or other contamination. Perform additional decontamination tasks (detailed in *SOP 17 – Aquatic Decontamination Procedures)* after the initial freshwater rinse; proper decontamination will prevent the spread of pathogens and invasive species.
- Take the YSI sonde out of the saturated DO environment (typically a wet towel or PVC tube with sponge) and replace the probe guard with the calibration cup. Place approximately 0.5 inch of water in the calibration cup and screw the cup onto the sonde. Place the sonde in a clamp stand or other secure storage location. The cap for the calibration cup should be loosely screwed on (1-2 threads engaged) to prevent evaporation but allow some air flow so the DO probe will be in a 100% saturated environment.
- Check DO probe membranes for wrinkles and bubbles – the membrane should be immediately changed if either condition is present to allow enough time for the membrane to stretch and/or "burn in".
- Data files and photos should be downloaded from dataloggers, cameras, PDAs, etc. onto computer hard disks, and backed up to removable media (thumbdrive, external hard drive, etc.). Rename these files following the NETN file-naming conventions described in *SOP 13 – Data Management*.
- Enter data from all field data sheets in to the NETN_H2O Field Data Entry Module or Cybertracker "NETNLakes" PDA database.
- Any critical observations (detection of invasive species, water quality issues, resource damage, etc.) should be relayed to park resource management staff as soon as possible, preferably before traveling to the next park (or site at ACAD).

Appendix S5.A. Sample Lake/Pond Monitoring Field Data Form for ACAD.

Lake /Pond Survey Form

MIDAS #:

Lake: _____ Sta.____

NETN Code: _____

Date: _____

Start Time: _____

End Time: _____

Surveyor(s): _____

_____

Transparency

Observer 1: _____

Observer 2: _____

Obs. 1 Secchi: ___ ___ .___ ___ m

Obs. 2 Secchi: ___ ___ .___ ___ m

Trans. tube: ___ ___ .___ ___ cm

Did disk hit bottom? _____ ("B"= yes)

Licor completed?: ☐

SUN: ☐ Bright ☐ Cloudy ☐ Overcast

Cloud cover: _____%

Wind Vel:_____

Wind Dir:_____



Air Temp: ____.___ °C

Surface water temp: ____.___ °C

Stage height: _____ ☐ m. ☐ ft.

Depth @ site: _____ ☐ m. ☐ ft.

YSI Multi-parameter Meter

650 MDS time & date correct: ☐

DO % sat drifted high to low: ☐

Calibrate DO in field: ☐

Pressure at DO cal: _____

DO charge
before calibration (25 to 75):_____

DO gain local
(0.7 to 1.14) after calib: _____

DO % local
in sat enviro (100 ±2%): _____

Calibrate depth: ☐

Water Sample Information

Sample location:
☐ Deep hole ☐ Other _____

Sample type: ☐ Core ☐ Grab

Sample Depth: ____ ☐ ft ☐ m.

Sample time: _____

Sample Set:
NETN/Nutrients ☐ Acidification ☐

Extra QA/QC: Replicate ☐ Blank ☐

Surveyor Roles *(initial each):*

YSI: _____

Collect water sample: _____

Filter water sample: _____

Photos:

Notes:

Sample Event Code: _____

(Side 2)

*Lake:*_____ *MIDAS*_____ *Date:*_____

DO/Temp **LiCor**
(Circle one)

PROFILE

DEPTH				DEPTH				DEPTH			
0.1				10				21			
0.5				11				22			
1				12				23			
2				13				24			
3				14				25			
4				15				26			
5				16				27			
6				17				28			
7				18				29			
8				19				30			
9				20				31			

Sample Event Code: _____

SOP 5 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.00	March 2007	B. Mitchell	**Section 4.1A:** Added to SOP to cover Transparency Tube readings (*Originally part of SOP 11- Secchi Disk*). **Section 4.2:** Changed steps 3 and 4 to refer to DO percent local. Inserted step 5 (pre-deployment "89" reading). Inserted step 12 (reading just above bottom for shallow ponds). Inserted step 13 (post-deployment "99" reading). (*Originally part of SOP 12- Profiles…*)	Protocol Review Meeting
2.02	April 2009	B. Mitchell	**Section 2.2.2:** Updated to reflect an annual panoramic set of photos for lakes. *(Originally part of SOP 2 – Metadata collection)* **Section 4.1:** Clarified location and timing of transparency tube measurements. (*Originally part of SOP 11- Secchi Disk*).	.
3.00	January 2012	B. Gawley	Reformatted using NRPS-NRR template. Combined all or sections of v2.02 SOP #s 2, 3, 4, 11, 12, 13, 14, 15, and 16 to consolidate tasks for a lake or pond monitoring session. Re-assigned as SOP 5. Corrected reference for MDEP Lake Assessment SOPs. Added/expanded sections on: CyberTracker NETNH2O_FieldDE Post-field activities Removed instructions for filtering Added copies of field forms as Appendix.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits. Measurements DOWN from a bolt must be recorded as negative numbers. Wind speed will be measured with Beaufort Scale rather than in mph to eliminate need for wind meter and to save time in field. Added more detail to photo procedures. Decontamination procedures should be followed daily.	Internal review
3.02	December 2013	B. Mitchell	Removed Secchi Transparency instructions since they are repeated in SOP 8. Removed light penetration profile instructions since they are repeated in SOP 8. Removed sonde instructions since they are repeated in SOP 6. Removed grab sample instructions since they are in SOP 7.	Reviewer recommendation

Version #	Date	Revised by	Changes	Justification
			Removed throw bottle sample instructions since they are in SOP 7. Removed depth-integrated sample instructions since they are in SOP 7. Clarified photo procedures and specifically request use of the panoramic photo mode on the camera.	

SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde

Northeast Temperate Network

Version 3.02

Overview

This SOP describes operation of the Yellow Springs Instrumentation (YSI) 600XL multiparameter water-quality monitor (sonde) for measuring water-quality parameters in lakes and streams. These procedures are adapted from *SOP 5 – Spatial Water Quality Monitoring with the YSI Sonde* in Kopp and Neckles (2004). Although this SOP is written specifically for the YSI model 600XL and the YSI 650 Multiparameter Display System (MDS) display/logger, other sondes that meet the requirements of this SOP can also be used. However, use of comparable instrumentation by NETN will simplify data management and QA/QC procedures which are integrated into the SOP and include calibration methods. The general calibration methods discussed herein are applicable to other manufacturer's sondes and displays/loggers, but consult the manufacturer's instruction manuals for specific procedures.

Background and Familiarization with Instruments

Data are collected using the YSI 600XL sonde connected to a YSI 650 MDS using a field cable. This SOP describes a standard procedure on how to prepare, calibrate, program, and upload data from these instruments. It also provides detailed methods for operating the instrument in the field.

It is beyond the scope of this SOP to review all of the information and methods that are required to operate the YSI 600XL sonde and the YSI 650 MDS and to make effective and accurate measurements. It is important that all field and laboratory staff familiarize themselves with the entire YSI 6-Series Multiparameter Water Quality Sondes User Manual (http://www.ysi.com/media/pdfs/069300-YSI-6-Series-Manual-RevH.pdf), the 650 MDS Multiparameter Display System Operations Manual (http://www.ysi.com/media/pdfs/655228-YSI-650-Operations-Manual-RevB.pdf), and the Technical Notes and Technical Documents available from YSI at their Web site (http://www.ysi.com/productsdetail.php?600XL-V2-and-600XLM-V2-6). The purpose of this instrumentation SOP is to standardize instrument handling, maintenance, calibration, and use for all NETN parks. The SOP provides step-by-step instructions specifically pertaining to this monitoring protocol; however, it does not provide adequate guidance to ensure consistent and accurate measurements. YSI, Inc offers courses on instrument calibration and maintenance and all NETN staff involved in instrument calibration are encouraged to receive training from YSI, Inc.

YSI, Inc. offers three different depth models of the 600XL: shallow (9 m), medium (61 m), and deep (200 m). Although all three models have the same resolution (0.001 m), the depth measurement accuracy of the shallow depth model (± 2 cm) is considerably better than that of the medium depth model (± 12 cm). The shallow model is appropriate for parks where depths are not expected to exceed 9 m; the medium depth unit is appropriate for the remaining park

(ACAD). In either case, the sonde will be non-vented for pressure, and equipped with the following sensors:

- YSI 6562 Dissolved Oxygen Probe with rapid pulse technology
- YSI 6561 pH Probe
- YSI 6560 Conductivity and Temperature Probe

YSI, Inc. also offers several options on the 650MDS. This SOP calls for the "650-04" configuration, which includes the 1.5 MB high-memory option and an integrated barometer. The rechargeable battery pack is optional, but always carry four extra C-cell batteries (third-party rechargeable C-cells can be used). With the C-cell configuration, the 650MDS can be powered for about 45 hours of continuous operation. The YSI rechargeable battery pack will allow for roughly 15 hours of operation.

Firmware should be updated at least annually from the YSI Web site http://YSI.com/edownloads. Confirm that the YSI instrument has a good power source or new batteries before initiating a firmware update. If power fails during the update, contact YSI technical support. Sondes and dataloggers should be sent to YSI bi-annually for a "winter tune-up".

Pre-Deployment Preparation

Preparation and programming of the YSI 650MDS Data Logger and Display

The YSI 650MDS serves several functions. It provides a user interface to the sonde while in the field, it logs data from the sonde, and it provides a real-time display of the output from each of the sonde sensors. At the beginning of each field season, install four fresh C-size alkaline batteries according to the directions in the 650 MDS Multiparameter Display System Operations Manual. Pay particular attention to the installation of the battery cover O-ring. These batteries can last for the duration of the field season, but the charge level (see charge level bar at bottom right corner of display) must be monitored and the batteries replaced as needed. Bring a spare set of batteries into the field.

Before the instrument can be deployed, it must be properly programmed. There are three menu sections that need to be programmed: <File>, <Logging Setup> and <System Setup>.

650MDS <File> menu

For ACAD monitoring, the following procedures should be performed before beginning each day of monitoring (LNETN keeps files on the sonde for the entire monitoring season):

1. Check to confirm that there are no remaining data (.dat) files stored in the 650MDS memory. All files will have been removed previously as part of the SOP for downloading data to computer; therefore, the presence of any data files will indicate a failure to follow the SOP. Proceed with caution!
2. Download any files to a specially labeled directory and annotate the calibration log to this effect. Use YSI EcoWatch (or EcoWatch Lite for 64-bit operating systems) software to open the date files and examine them to ensure they have not been corrupted and rendered unreadable in the upload process.

3. Immediately create a back-up of the data files on a server folder and/or removable media and confirm that they too are readable using EcoWatch. After these steps have been completed, select <Delete all files> from the 650MDS <File> menu.

650MDS <Logging Setup> menu

The following settings should be entered at the beginning of each monitoring season, and checked monthly. From the main menu in the 650MDS, go to <Logging Setup> and program as follows:

1. Set the sampling interval to one second (= 00:00:01)
2. Enable "Use site list"
3. Enable "Store Barometer"
4. Enable "Store Lat and Long"
5. Enable "Store site number"
6. Select <Edit Site List> and create a new file for each site
    a. As a standardized naming convention, each ACAD file name will start with a 2-character park code followed by a 4-character site name or number and a 2-digit year. LNETN file names start with a 4-character park code followed by a 2-character site code and a 2-digit year.
    b. In the "Site Number" field for each site use 0 for lake, pond, or stream water quality data, 899 for QC data before sonde is deployed, and 999 for QC data taken after stream/lake data obtained, at that site.
    c. The "Site Name" field is for your convenience only. It does not get appended to the data file, but it can be useful for differentiating between multiple stations or for keeping track of dates associated with each unique file name for the logging station.

650MDS <System Setup> menu

The following settings should be entered at the beginning of each monitoring season, and checked monthly. From the main menu in the 650MDS, go to <System Setup> and program as follows:

1. Set the correct date and LOCAL TIME. For all anticipated uses of this SOP, this will be Eastern Daylight Savings Time. Select the "4 digit year" option.
2. Make certain that the "Comma radix" option is NOT selected.
3. Set the "Shut off time" to 0 minutes. This will keep the unit on until manually shut off.
4. This menu also provides for user calibration of the barometer. Check the barometer annually for drift. Recalibration is a delicate procedure, therefore carefully follow the guidance in the 650MDS Operations Manual and be certain that you are calibrating in mmHg against barometric pressure that has not been corrected for altitude (the National Weather Service generally reports barometric pressure corrected to sea level). If in doubt, return the unit to YSI Inc. for a factory recalibration.

650MDS <Sonde Menu>
The following settings should be entered at the beginning of each monitoring season, and checked before beginning each day of monitoring:

1. From the main menu in the 650 MDS, choose <Logging Setup> and set the Interval to 1 second.
2. The following report parameters must be enabled in the <Report> menu:

   Date, Time, Temperature, Specific conductance, DO saturation, DO saturation (Local), DO concentration, DO charge, and Depth.
3. Go back to the main menu and choose <Sonde Menu>, <Advanced>, <Data Filter>, and set the time constant to 12 seconds. This will average values over the previous 12 seconds and update to the screen every 1 second. DO is re-calculated every 4 seconds, so an average over 12 seconds will be made up of three DO values. All other parameters are updated more frequently and will be made up of running averages.

Calibration and Quality Assurance

During the calibration procedure, never accept any calibrations that have produced a warning message. Instead, determine the cause of the problem, correct it, and recalibrate following this SOP and the instrument manual. Each field season, batteries and DO membranes must be replaced. The batteries may last for the duration of the field season, but the DO membrane is easily damaged and will likely need to be replaced several times during the field season.

Since DO membranes are unstable for the first 3 to 6 hours after installation, it is important to check their condition and performance in advance of any planned field work. This SOP calls for the DO membrane to be examined (and replaced if necessary) and the sonde run for 10-15 minutes. After this stabilization period, just the DO sensor is recalibrated, and the sonde is ready for use.

Digital/luminescent/optical DO is beginning to replace Clark cell membrane type DO probes and this likely will add longevity to the DO sensor stability and reduce drift in longer deployments (not currently required for NETN monitoring). It is possible that this new DO measurement system will replace the older technology Clark cells in the next several years, particularly as costs come down, but this type of sensor is not compatible with the 600XL.

Standard solutions

Except where explicitly noted in the SOP, standards are NOT to be used for more than one calibration. They can, however, be saved and used to pre-rinse the sensors and the calibration cup before putting them into fresh standard solutions. Rather than measure calibration solutions with graduated cylinders each time they are dispensed, mark the outside of the calibration cup at the appropriate levels for each probe. Dispensing standards directly into the calibration cup will also help prevent contamination from dirty glassware. For many of the calibration steps, reaching a stable calibration point requires the probe and calibration solution to thermally equilibrate. This occurs more quickly if both the sonde and all the calibration solutions are at laboratory temperature. Be sure to prepare deionized water in advance and store an ample supply in a carboy. Consult the Material Safety Data Sheet (MSDS) for all standards for health and safety information and proper storage and disposal requirements.

Deionized Water

Deionized ("DI") water is required for calibration of many of the sensors so some guidance is provided here on the quality of water that should be used for these purposes. Purchase water or purify it on site to a quality equal to, or better than American Society for Testing and Materials (ASTM) standards for Type III (Laboratory Grade) water. Deionized water used must have a maximum conductance of 2.0 µS/cm. Note that a sampling of supermarket distilled waters from around the country found hydrologic conductivity values well outside the standard for even ASTM Type III Laboratory Grade water (USGS Office of Water-quality Technical Memorandum 92.01; http://water.usgs.gov/admin/memo/QW/qw92.01.html).

NETN uses water filters hooked up to sinks on site to produce DI water; the output of these filters should be tested monthly and tested with a benchtop conductivity meter to ensure that conductivity is below 2.0 µS/cm. A new filter should produce water with a conductivity of 0.5 to 0.6 µS/cm. Higher readings indicate that there may be a leak in the system (e.g. the filter cartridge is not properly seated and some source water is flowing around it) or the source water is too "dirty" (in which case a standard household inline water filter can be used as a pre-filter). Additionally, it is important to not try to run the water through the filter too fast. A fairly slow flow rate is needed to allow enough contact time between the water and the filter media. Once the system is connected to the tap you can fill it quickly in order to purge all the air from the system (be sure to use the bleeder lever on the top of the filter holder) then slow the flow down to a steady trickle.

Use ASTM Type II (Reagent Grade) water for mixing buffer solutions. This SOP calls for the use of pre-prepared conductivity standards for calibration of the sonde. Do not prepare or dilute customized standards. Water prepared by distillation or ion exchange includes a polishing step by passing the water through a 0.45µm filter to remove bacteria and any ion-exchange medium that escapes the columns.

Instrument Preparation

Prepare and calibrate the 600XL while it is secure in a ring stand or custom-mounted hook. All procedures must be completed in the order they are presented in the following sections. Allowable variations in sonde readings are listed in Table S6.1.

Before the water-quality sonde can be used, it must be calibrated and several maintenance steps performed. Assemble the individual sensors onto the sonde per instructions in the manual using extra care not to cross-thread the sensors when installing them onto the softer PVC sonde bulkhead. Before calibration, visually inspect the sonde for any abnormalities. Attach the Dry Calibration Cable between the sonde and the 650MDS, and establish communication with the sonde.

Before beginning, verify the accuracy of your sonde's temperature probe with a traceable thermometer or other reference. Temperature compensation is used in almost every sonde measurement so its accuracy must be verified and recorded each time the sonde is calibrated.

Table S6.1. Allowable variations in YSI 600XL sonde readings.

Standard direct field measurement	Stabilization criteria for measurements (variability should be within value shown)
Temperature:	
Thermistor thermometer	± 0.2° C
Liquid-in-glass thermometer	± 0.5° C
Specific conductance	
When ≤ 100 µS/cm	± 5 percent
When > 100 µS/cm	± 3 percent
pH	
Meter displays to 0.01	± 0.2 standard pH units
Dissolved Oxygen	
Amperometric method	± 0.3 mg/L

Calibration of Dissolved Oxygen Sensor

The dissolved oxygen sensor should be calibrated in the laboratory before each field deployment day *and* at each field site prior to taking in-situ measurements.

1. Inspect the DO probe anodes. If they are darkened or gray in color, recondition using the 6035 reconditioning kit that is supplied with the probe.
2. Inspect the DO membrane. It must be undamaged, tightly stretched, wrinkle free, and free of air or gas bubbles beneath the membrane. If necessary, install a new membrane following guidance in the YSI 6-Series Operations Manual and Technical Notes. To install the membrane it is often easier to remove the sensor from the sonde and then install the membrane.
3. Place the sonde in the ring stand or custom support bracket. Put approximately 0.5 cm of water in the bottom of the calibration cup (do not allow water to touch the membrane) and loosely attach it to the sonde (engaging several threads). Make sure that the 650 datalogger displays the DO Charge and DO Local values. If necessary, go to the sonde <Report> menu and enable these options.

In the field, the probe end of the sonde (with probe guard in place) is wrapped in a wet, white towel or placed in a PVC tube with a sponge to provide the saturated DO environment, rather than using the calibration cup. During the following steps, keep the wrapped probe out of direct sunlight and sheltered from strong wind exposure.

4. Go to the sonde <Advanced> <Setup> menu and confirm that the "RS-232 auto-sleep" function is disabled.
5. If a new membrane has just been installed, go to the <Run> menu and start the sonde in the <Discrete Sample> mode with a 4-second sample interval. Allow the sonde to run for 10 minutes to "burn in" the new membrane. Record the DO charge on the calibration log or field data sheet. The number should be 50 plus or minus 25.
6. Perform a High-to-Low Transmission Test: Start the sonde in <Discrete Sample> mode with a 4-second sample interval. Disregard the first two DO percent saturation samples,

and then record the next 10 samples. The DO percent saturation values must start high and drop with each 4-second reading. It does not matter if the readings do not reach 100percent, but there must be a high to low trend. If the recorded values start low then climb upward, the sensor has a problem and must be reconditioned or replaced. Record the 10 readings and the pass-fail status of the test on the calibration log or field data sheet. Escape from the <Run> mode.

7. Wait at least 5 minutes in the idle (not <Run>) mode before proceeding. Wait at least 10 minutes from the time the calibration cup (with 0.5 cm water in bottom) was attached to the sonde body (or sonde was placed in a saturated DO environment). Once these minimum times have been reached, calibrate the DO sensor using the <DOpercent> method:
   a. From the 650MDS Main Menu, select <Sonde Menu>
   b. Select <Calibrate>
   c. Select <Dissolved Oxy>
   d. Select <DOpercent>
   e. Update the barometric pressure used for the calibration (large font numerals) so that it exactly matches the barometric pressure as measured by the 650MDS (small font numerals in the bottom right corner of the screen). Record the pressure value on the calibration log or field data sheet.
   f. Press <enter> and wait for the sensor to stabilize. Record the DO Charge on the calibration log or field data sheet. It should be 50 ± 25.
   g. If the sonde is properly programmed (auto-sleep off) you will be prompted to press <enter> to initiate the calibration once the values have stabilized (display will update with each reading). The "Continue" message should display in the upper right corner of the 650MDS screen when calibration is complete. After calibration, DO% Local readings should be 100% ± 2%. This value should be recorded on the calibration log or the field data sheet.
   h. If the probe needs to be recalibrated, go to the <Calibrate> menu and repeat the last two steps from the DO calibration section. Should the sensor fail to calibrate, follow trouble-shooting guidance in the YSI 6-Series Environmental Monitoring Systems Operations Manual.
   i. Press <Enter> or <Esc> to escape back to the 650MDS sonde menu.
8. Check the "DO local gain" for the sensor and record it on the calibration log. This is found under the sonde's <Advanced Menu> under the <Cal Constants> option. The target value for gain is 1.0, with an acceptable range from 0.7 to 1.4.
9. In the field, the 100% saturation measurement after calibration should be logged in the "899" site of the datalogger file. The calibration information should also be entered in the appropriate section of the field data sheet.

Note: If technicians are seeing DO values less than roughly 2 mg/L, a zero DO solution can be prepared in the field or can be taken to the field to check the DO sensor. A sodium sulfite solution is made by dissolving 1 gram of sodium sulfite (Na_2S0_3) and a few crystals (about 1 mg)

of cobalt chloride ($CoC1_2$) in 1 liter of distilled water. The zero DO solution is used as a check standard and should read less than 0.5 mg/L. Sodium sulfite can compromise the gold cathode of the DO sensor so use only as necessary.

Calibration of Conductivity Sensor

Check and/or calibrate conductivity in the laboratory before calibrating pH. The sensor should be calibrated a minimum of monthly, using 1 mS/cm (1,000 µS/cm) standard. At Acadia, perform a one-point calibration check (typically using 50 or 100 µS/cm standards) at the beginning of each sampling week. At other parks, perform this one-point check using 100 or 250 µS/cm standards. The check sample should use a standard similar to the conductivity that is expected in the field based on previous monitoring data. If the check sample is out of the acceptable range specified in Table S6.1, recalibrate the sensor and recheck.

Calibration of the conductivity probe is very vulnerable to contamination. Before performing the calibration, the calibration cup and all the surfaces of all the probes must be triple rinsed with DI water, followed by a triple rinse using a small amount of conductivity standard. Using standard saved from a previous conductivity calibration is acceptable for this step.

1. Pour approximately 50 mL of 1 mS/cm (1,000 µS/cm) conductivity standard into a clean and dry calibration cup and attach it to the sonde body. Swirl, tip, and gently shake the sonde to thoroughly wet all of the probe and bulkhead surfaces. Discard this standard solution (do not re-use rinse standards). Repeat this step two more times.
2. Pour enough fresh 1 mS/cm conductivity standard into the calibration cup to fully cover the conductivity probe.
3. Ensure that the conductivity probe is completely submerged in the standard. The hole in the side of the probe must be under the surface of the solution and not trap bubbles in the opening.
4. Initiate calibration of the probe by selecting the <specific conductance> option and entering the conductivity of the calibration standard. (Note: Be sure to enter the conductivity of the standard in mS/cm, not µS/cm. The NETN calibration standard is **1 mS/cm**).
5. Allow the sonde to run for at least 1 minute to ensure thermal equilibration (wait longer if the sonde, the conductivity standard, and the deionized water from previous steps are not all at the same laboratory temperature). After no changes occur in the reading for approximately 30 seconds, accept the calibration (hit <enter>) and record on the calibration log the last value reported before pressing <enter>. With an NBS-traceable thermometer, verify the accuracy of the sonde temperature reading and record it on the calibration log.
6. When the calibration has been accepted, check the "Conductivity Cell Constant" for the sensor and record it on the calibration log. This is found under the sonde's <Advanced Menu> under the <Cal Constants> option. The target value for this probe is 5.0 ± 0.45. Numbers outside this range usually indicate a problem in the calibration process or a contaminated standard. Never override a calibration error message and investigate any "Out of Range" report. Typical causes for error messages are incorrect entries. For example, entering 1,000 microsiemens (µS) instead of 1.0 millisiemens (mS) (Note: the

sonde requires the input in millisiemens). Low fluid level in the calibration cup and (or) air bubbles in the probe cell can also cause error messages to appear.

Calibration of pH Sensor

YSI pH probes can last up to 2 years and cost approximately $250, but response time and accuracy tends to decline relatively early in the second year of service. To be safe, replace the pH probe every year, and use the old probe as a back-up for one year. Older probes can be cleaned in the laboratory to improve performance but cannot be factory reconditioned. Calibrate the pH sensor in the laboratory before each field sampling day.

1. Make sure that the 650 datalogger displays the pH mV value. If necessary, go to the sonde's report menu and enable the pH mV output. This will allow the sonde to display both the millivolts (the probe's raw output) and the pH units during the calibration process.
2. Clean or replace the probe if a slow response in the field has been reported.
3. Select the "ISO pH" option from the <Calibration > menu, then select the calibration type (1 to 3-point). A two point calibration is standard for most situations. Use buffers that bracket the expected *in situ* pH values. Always use a primary pH 7 buffer and then select a secondary pH 4 buffer (if acidic conditions are expected) or pH 10 buffer (for alkaline waters). Use the three-point calibration only if the *in situ* pH value is unknown.
4. Type in first pH buffer value (7.##) when prompted. Exact buffer values vary with temperature. Determine the temperature of the buffer solution and enter the appropriate pH value from the chart on side of the buffer bottle. Ensure that the temperature probe is fully submerged in the buffer solution.
5. When the pH value is stable hit the <Enter> key to calibrate, and record the pH millivolts on the calibration log. The millivolt output is the unprocessed pH output; the acceptable tolerance for each buffer is shown below.

   Buffer 4 = +180 +/-50mV

   Buffer 7 = 0 +/- 50mV

   Buffer 10 = -180 +/-50mV

   When a probe is new, the millivolt values are close to the 0 and 180. As the probe begins to age, the numbers will shift to the higher side of the tolerance range. Buffer 4 response has a tendency to drift slightly out of the acceptable range of 180 mV ± 50. If this occurs, recondition the pH probe per the procedure in the YSI manual. If the probe has a response time of less than 60 seconds in buffers and the slope remains within spec, you can continue to use it. If you start to see slow response in the field or in the standards when checking calibration, then consider replacement.
6. Hit the <Enter> key again to continue to the next calibration point. Repeat steps 4 and 5 with the second buffer.
7. After recording the pH millivolts for the calibration points, determine the slope of the sensor. The slope is the difference between the two calibration points that were used. For example, if a +3mV was recorded for buffer 7 and a -177 for the buffer 10, then the slope

would be 180. The acceptable range for the slope is 165 to 180. Once the slope falls out of this range, the sensor must be taken out of service.

WARNING: Never override any "calibration error" or "out of range" warnings without fully understanding the reason for the message. In most cases, the warning indicates that there is a problem that will result in suspect field readings.

pH Check Sample

After calibrating the pH probe, use a low ionic strength pH 4.63 standard (buffer) solution to verify the accuracy of the probe in this range, since many NETN waters are low ionic strength. "Challenging" the probe with such a solution is also likely to detect accuracy degradation sooner than just monitoring the sensor slope and other performance indicators. Use the check sample during the first calibration session of each monitoring week. If the check sample results are out of range (> ±0.2 pH units), verify the check sample pH with a second meter. If the standard is within range of its certified value, follow the manufacturer's instructions for cleaning/reconditioning the probe. If the reconditioned probe continues to fail the check sample test, replace the probe.

Calibration of Pressure/Depth Sensor

The pressure sample is calibrated in the field to facilitate more accurate depth measurements. During the calibration process the sonde should be partially submerged in the water, with the round pressure port just *above* the water surface.

1. From the <Calibrate> menu, select <Pressure-Abs>.
2. Input 0.00.
3. Wait until no significant change in depth reading on the datalogger occurs for approximately 30 seconds, then press <enter> to confirm the calibration.
4. Calibrate pressure/depth again at each new site just before taking sample measurements

Final Preparation of the Sonde for Field Work

1. Remove the calibration cup from the sonde body and install the sensor guard. It is best not to attempt this in the field since the oxygen membrane is vulnerable to being damaged if it is bumped by the guard.
2. Wrap the sonde in a white towel that has been soaked in tap water. Cover the entire sensor guard with the towel and wrap it around it at least twice. Alternatively, place it in a PVC tube with a wet sponge. This will provide a humid environment for the sensors, protection from thermal extremes, and some degree of shock protection.
3. Transport the sonde to the field in a short section of 6" PVC pipe, capped on one end and cushioned on the bottom with a large damp sponge. The open end of the pipe can be fitted with a rubber cap with X-shaped slits to hold the sonde securely in place.

Making Measurements

Data can be logged either as a discrete point (after the user has verified stabilization) or as a continuous data stream at a fixed sample interval. Both of these types of data can be recorded in the same file. Most, if not all, data collected by NETN water monitors will be logged as discrete points. Set up a user site list on the YSI 650 MDS before taking readings in the field by selecting

<Logging Setup> and activate <Use site list> (see 650 MDS Multiparameter Display System Operations Manual, section 3).

1. The 650 MDS can be connected to a GPS unit (set to use NMEA communication protocol) via a pair of RS-232 adapter cables. This feature enables GPS coordinates to be saved with each water quality reading. Connect the GPS unit to the 650 MDS and turn both instruments on. Once the GPS begins receiving satellite data, the current coordinates (in decimal degree format) appear at the bottom of the 650 MDS display. Make sure the GPS unit is in communication with the 650 MDS before beginning water quality data collection.
2. Check the date and time on the 650 MDS display. These values are also saved with the water quality readings, and must be correct.
3. Allow the sonde electronics to "warm up" for 4 to 5 minutes before taking measurements. Turn on the sonde by powering up the 650MDS and selecting <Sonde run> from the main menu and run in <Discrete Sample> mode. Check the first few 650MDS display updates and verify that the DO readings drop from high to low.
4. During the warm up period, re-wet towel or sponge in the water at the sample site and wring out until damp. Submerge the sonde briefly in the water, and then rewrap with the towel or place it back in the PVC tube with the sponge in order to bring it closer to sampling temperature (especially if it has been in a hot vehicle).
5. Once the oxygen saturation readings have equilibrated (up to an additional 10 minutes), and with the unit still in a saturated DO environement and in a shady location, check the DO percent local saturation ("DO% L"). Confirm that it reads 100% ± 2%. If the DO% local saturation has drifted beyond these tolerances, the DO channel must be recalibrated on the spot.
6. After confirming that the DO% local saturation ("DO% L") reads 100% ± 2%, fill in the calibration information on the field data form.
7. Enter the 100% saturation readings into the 650MDS data file for the sample site. With the sonde still out of the water and in a saturated DO environment, select **Log one sample** (upper left) and press enter, choose the correct file and pre-deployment site number (899) from the list and press enter to log the sample. This reading is also recorded on the data sheet.
8. Remove the towel or take the sonde out of the PVC tube and place the sonde in the water and wait for readings to stabilize.
9. For lake or pond sampling, ensure that the small, circular pressure sensor on the side of the sonde is just *above* the water level to prepare for depth calibration. Then go to the <Calibrate> menu and select <Pressure-Abs>. Input 0.00 (or a known sensor offset in ft if working far from sea level). Wait until no significant change in depth reading on the datalogger occurs for approximately 30 seconds, then press <Enter> to calibrate. Return to the <Sonde run> <Discrete Sample> mode and submerge the sonde probes just below the surface of the water to obtain the surface reading
10. When readings are stable select **Log one sample** (upper left) and press enter. Select the correct file and site number (0) from the list and press enter to log the sample.
11. For stream or river sampling, record at as many points as is appropriate for the given site and cross section. If the stream is fully mixed and small, only one point is needed from the

middle of the channel. The only site within NETN that needs multiple points is the Concord River.

12. For lake or pond sampling, lower the sonde to the next depth station (one meter for Acadia lakes and ponds, 0.5 meters for Lower NETN ponds) and repeat the process above. Use the tape marks on the sonde cord as guide to depth and log the sample when both the water quality and depth values are stable on the datalogger display.
13. For lake or pond sampling, use care when obtaining readings near the bottom – avoid burying the probe tip in bottom sediments. Watch the datalogger closely when approaching the expected bottom depth – sharply increasing conductance and decreasing DO readings can be indicators that the probes are nearing sediment.
14. For ACAD lake or pond sampling when a depth-integrated core sample is to be collected, note the temperature and DO readings on the field data sheet to document the depth of the epilimnion to help determine the core sample depth.
15. Remove the sonde from the water and shake off excess water droplets from probes. Wrap probe in freshly wetted towel or re-wet the sponge and place the sonde back in the PVC tube and wait for readings to stabilize. When readings are stable select **Log one sample** (upper left) and press enter. Select correct file and the post-deployment site number (999) and press enter to log the sample. The post-deployment DO percent L should read 100 percent ± 2 percent.

Data Upload

Upload data from the 650MDS to a computer at the end of each field day. Connect the 650MDS to your computer using the YSI 655174 PC interface cable and launch YSI EcoWatch software.

1. From the EcoWatch <Sonde> menu, click "Connect" to establish communication with the 650MDS. A blank "Terminal" screen with a blinking cursor and "connected" message will appear on the computer screen.
2. From the 650MDS <File> menu, <Upload> all the data files collected that day using the PC6000 format. This format results in a computer file with a filename identical to the 650MDS filename and a.dat file extension. *Caution: Be sure to note the location on the computer to which the files are downloaded.* Only stations where data was collected will have data files.
3. Use EcoWatch to open each file that you just downloaded and examine them to ensure they have not been corrupted and rendered unreadable in the upload process.
4. Immediately create a back-up copy of the data files on external storage media and confirm that they too are readable using EcoWatch.
5. For ACAD (and LNETN at the end of the monitoring season): After these steps have been completed, reestablish communication with the 650MDS, select the <File> menu and <Delete all files>. Note that file names and site numbers entered as part of the "Site List" are not deleted in this process, only the data contained within the files are deleted.
6. Use an Excel spreadsheet stored with the data files to describe any data issues, like incorrect site codes or explanations for extra samples. This will facilitate identifying the correct data records to import into the water monitoring database.

Data Reduction and Quality Control

The PC6000 format data files uploaded from YSI sondes are not readily editable, making them ideal for archiving purposes. To perform the data-reduction steps in this SOP, use the <Export> feature in EcoWatch to create a comma-delimited file (assigned the .cdf extension by EcoWatch, or the .csv extension by EcoWatch Lite), which can then be imported by most spreadsheet and database programs. To assist in file tracking and management, change only the file extension when converting from one format to another, but do not alter the filename. Also create a text document (.txt) with this same filename for documenting all data-reduction steps that are specific to that data file (data rejection). For each station sampled perform the data checks and data-reduction steps described below.

Dissolved Oxygen Calibration Check

Check the calibration of the DO sensor before and after taking field measurements at each site. These calibrations are part of the data stream for each station since the sonde starts logging while still in water-saturated air. The in-air data (identified using the site numbers 899 and 999) at the beginning and end of each site should read between 97-103 percent. If this is not the case, then proceed as follows:

1. If the pre-deployment DO percent saturation fails this test, then omit the entire profile from the data analysis. This occurrence will be rare since the operator is instructed to perform a check in the field and take corrective action if necessary.
2. If only the post-deployment DO percent saturation fails this test, if bottom water DO concentrations were less than 1 mg/L, or if there is a record of the sonde having hit the substratum, then use only the downcast for data analysis.
3. If only the post-deployment DO percent saturation fails this test but a low DO concentration was not encountered, examine the DO and DO charge channels carefully and use best professional judgment on whether data can be salvaged.

Dissolved Oxygen Membrane Check

Check the "DO charge" for each reading to see that it ranges between 25 and 75. If the reading is outside this range, discard the DO readings (percent saturation and concentration) associated with this failed "DO charge" reading.

Sulfide-Interference Check

The presence of hydrogen sulfide will interfere with the Clarke-type electrode used for DO and make the output "jumpy". This effect is seen when the bottom water is anoxic and H_2S is present or when the sensor is run into anoxic sediments. Reject faulty data as follows:

1. Check to see if the sonde encountered low DO during the profile. If so, and the readings in the low DO portion of the profile are erratic, use best professional judgment to clean up DO data for further analysis.
2. Check to see if the sonde touched the bottom during the deployment (reported on the Field Data Sheet). If so, and if the DO channels show erratic performance on upcast measurements (not normally collected during NETN monitoring), use only the downcast DO data for further analysis.

Sensor-Performance Specification Check

Reject data outside the design specification range for each sensor. These specifications are currently as follows:

Temperature……..…-5 to 45 ˚C

Conductivity…….0 to 100 mS/cm

Dissolved Oxygen, percent saturation……0 to 500% air saturation

Dissolved Oxygen, mg/L…….0 to 50 mg/L

Dissolved Oxygen charge……...25-75

Absolute Data Rejection

Absolute data rejection is a means of removing erroneous values from the data record because the data do not meet basic principles of sensor behavior or proper sonde deployment. Because absolute data rejection is based upon basic principles, data can be rejected using automated computer scripts with conditional arguments. Data must be rejected when the recorded value for any sensor is outside its performance specifications. Environmental specifications for each sensor are listed in the previous section (*Sensor Performance Specification Check*). Any data that fall outside the specification intervals must be removed from the official record.

Discretionary Data Rejection, Drift Correction, and Data Reduction

Data rejection, drift correction, and data reduction must be carried out manually under the supervision of the water monitoring coordinator, who has experience in water-quality monitoring and knowledge of the YSI sonde and its application in this data-collection SOP. Ideally, these steps are taken as soon as possible after completing a site so that corrective action can be attempted for any subsequent measurements. A rapid evaluation for any gross problems with the data record can be made using the graphing features of YSI's EcoWatch software. Examine the output from each sensor individually for any discontinuity in the data, which generally indicates catastrophic failure during the measurement. Sensor-specific details for data rejection and drift correction are provided in the following sections.

Temperature

The temperature sensor on the YSI 6560 temperature and conductivity probe is robust and unlikely to fail. Rare failure has been observed, however, and is most often associated with an irreversible malfunction from leakage of the sensor housing. Incorrect temperature data are indicated by a clear point of temperature discontinuity followed by unreasonable and erratic values or unreasonable drift. If clearly incorrect temperature data are observed, all data from that point on must be removed from the official record. Since all the other sensors are temperature compensated using values from the 6560 thermistor, ALL data following failure of a temperature probe are suspect and must be removed from the official record.

Conductivity

Like the thermistor on the YSI 6560 temperature and conductivity probe, the conductivity cell is robust and rarely shows catastrophic failure. If an error occurs, it is usually a drift of the output from biofouling within the water ports of the conductivity cell. This results in a change in the effective volume of the cell, which, in turn, results in drift of the output. The post-deployment calibration indicates whether such a drift has occurred. Cleaning of the sensor ports usually resolves the issue.

In the unlikely event of catastrophic sensor failure, a sharp discontinuity is evident in the output, and all subsequent data must be removed from the record.

Dissolved Oxygen

The YSI 6562 DO probe is susceptible to both drift and catastrophic failure. Catastrophic failure of the DO probe is more common, and is usually the result of a puncture in the membrane, either by debris or organisms, or from an improperly installed membrane. Under these scenarios, output is generally characterized by a large discontinuity. Readings then become unreasonably high quickly and either become noisy or drift. The likely cause of this behavior is "crosstalk" through the membrane hole caused by electrical continuity between the DO and conductivity sensors. All data after the initial discontinuity must be removed from the record, regardless of later probe behavior. After this type of catastrophic failure, recondition the probe surface before it is put back in service. Follow guidance in the YSI 6-Series Environmental Monitoring Systems Manual. Occasionally the DO probe fails because of structural failure of the Clark-type electrodes. The symptoms are similar, and are accompanied by high DO-charge values. All data after the initial discontinuity must be removed from the record.

pH

The YSI pH probe is generally usable for two years, and should provide trouble-free performance. However, at Acadia in 2007, staff noticed that they were getting unusual readings during the second year of their probe's life, despite the acceptable calibration data. The problem was that the probe behaved differently in the field at Acadia (where the water has a very low ionic strength) than it did in the high ionic strength calibration standard. Because of this issue, calibration checks at Acadia should always use low-ionic strength standard, and the probes should be retired after one year of use.

YSI Sonde Accuracy Checks

In addition to weekly checks using certified standards, verify the accuracy of the YSI sonde pH and conductance readings using benchtop meters with traceable accuracy, and use a LaMotte dissolved oxygen test kit #5860 (Winkler Titration) to validate dissolved oxygen measurements.

During each sampling set, or twice per month, use one water sample collected in the field at a randomly-selected site (this sample is collected in addition to samples sent for nutrient analysis) to conduct several comparison measurements using any YSIs used during that sampling set and benchtop pH and conductivity probes that have been demonstrated to be accurate through manufacturers (re)certification, interlab comparison with a certified laboratory, and/or successful checks with certified standards.

1. In a lab setting, perform appropriate pH and conductivity calibrations on the YSI sonde using procedures found in the previous sections of this SOP. Also perform the appropriate calibrations on lab benchtop meters prior to comparison measurements. Record all calibration information on calibration logs and on the accuracy check worksheet.
2. Triple rinse the YSI calibration cup and all surfaces of probes with DI water, then triple rinse with water sample. Pour enough water into each calibration cup to cover all probes.
3. Prepare benchtop probes with the same rinsing procedures, and put probe in a sample of the same water.

4. Compare pH and conductivity measurements from all instruments. If using more than one YSI sonde, also compare temperature and barometric pressure values from each. Use a NBS-traceable thermometer to verify the accuracy of the sonde temperature. Check that the date and time are correct in all YSI data loggers.
5. Regardless of whether you are comparing readings between the YSI sondes or a YSI and a benchtop meter, the difference between the two measurements should be no more than the sensor specifications of both probes when added together. Record all values on the accuracy check worksheet.

    YSI 600XL Accuracy:

    a. pH accuracy: ±2% of reading or 0.2 pH units
    b. Conductance accuracy: ± 0.5% of reading + 0.001 mS/cm
    c. Temperature: ±0.15°C
    d. Dissolved Oxygen mg/L: 0 to 20 mg/L: ± 0.2 mg/L or 2% of reading,
    e. whichever is greater; 20 to 50 mg/L: ±6% of reading

A dissolved oxygen accuracy check should be done in the field to allow an in-situ YSI reading. To compare DO measurements, place the YSI in the waterbody being measured, and turn the 650 on to the run screen. While the DO probe equilibrates, collect a water sample and *immediately* perform the DO Winkler Titration using a LaMotte dissolved oxygen test kit, Code 5860. Refer to the procedure booklet enclosed in the kit for more details.

1. Rinse the provided glass bottle and cap three times with sample water.
2. Cap the bottle, and submerge to desired depth. Remove the cap under water and let the bottle fill. Tap the sides of the bottle to release any air bubbles clinging to the inside. Be sure to cap the bottle underwater to ensure no atmospheric oxygen interferes with the sample water.
3. Quickly and immediately add eight drops of Manganous Sulfate Solution and eight drops of Alkaline Potassium Iodide Azide. Cap and invert several times. A precipitate will form. Allow the bottle to sit until the precipitate settles below the shoulder of the bottle.
4. Add eight drops of Sulfuric Acid 1:1, cap, and mix until the precipitate has dissolved. The water will turn clear-yellow to brown-orange depending on the amount of dissolved oxygen in the sample.
5. After this step, the water sample is “fixed” and contact with the atmosphere will not affect the test result.
6. Pour the “fixed” sample into the titration tube to the 20 mL line.
7. Fill the Direct Reading Titrator (small syringe) with Sodium Thiosulfate, 0.025N, to where the plunger tip meets the zero mark on the scale. Insert the Titrator into the hole of the titration tube cap. Gently swirl the tube and slowly press the plunger to titrate until the sample is reduced to a faint yellow (“straw”) color. If the color is faint yellow before adding Sodium Thiosulfate, skip directly to step 8.

8. Remove cap and Titrator, without disturbing the plunger, as the titration begun in step 6 will be continued.
9. Add eight drops of Starch Indicator Solution, turning the sample blue or purple
10. Replace the cap and Titrator. Titrate drop by drop until the blue color just disappears. Read results where the plunger tip meets the scale, and record as ppm dissolved oxygen.
11. Record comparison results on field form.

Enter all accuracy comparison results from the accuracy check worksheet into the appropriate table(s) in the NETN_H2O water monitoring database. If comparison values are outside of accepted limits examine, clean and/or repair equipment suspected of being inaccurate and then repeat all check procedures. If the second comparison is still unacceptable, take the equipment out of service until the problem has been diagnosed and corrected.

Probe Care and Storage

Of the probes used for this protocol, the pH probe electrode has the most limited life expectancy, and must be kept clean and stored properly. If the response of the probe seems slow or contaminants or deposits appear on the glass or platinum surfaces, carefully clean the probe. Use clean water and a soft clean cloth or a cotton swab to remove all foreign material from the glass bulb. Be careful not to wedge swab tips between the guard and the glass sensor. If good pH response is not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.
2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.
3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water.

If good response is still not restored by the above procedure, clean with hydrochloric acid or return to YSI for cleaning or replacement. Because pH probes can dry out if improperly stored it is important for both short and long-term storage to make sure that the reference electrode junction does not dry out.

The YSI 5662 Dissolved Oxygen probes also have limited life expectancy. Under normal circumstances, the probe performs well for at least 2-3 years, and requires resurfacing during this period.

Consequently, it is important to keep replacement probes on hand to replace a probe that fails to calibrate properly. The NETN replaces pH probes annually, and the “replaced” probe is kept as a spare for one year. Note, however, that both the pH and DO probes have limited shelf lives, so do not purchase replacements too far in advance of need.

YSI recommends that short-term storage of all multiparameter monitoring instruments be accomplished by placing approximately 0.5 inch of water in the calibration cup that was supplied with the instrument, and screwing the sonde (with all of the probes attached) into the cup. The use of a moist sponge instead of a half-inch of water is also acceptable as long as its presence

does not compromise the attachment of the calibration cup to the sonde. The calibration cup should be sealed to prevent evaporation.

The long-term storage protocol for model 600XL, 6820, 6600 and 6920 systems is as follows:

1. Remove batteries from the 650MDS.
2. Remove the pH or pH/ORP probe from the sonde and seal the empty port with the provided plug.
3. Place the pH probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a 2 molar potassium chloride solution. Make certain that the vessel is sealed to prevent evaporation of the storage solution. Electrical tape can be used to provide a removable seal between the boot and the module body.
4. Store the sonde and remaining probes in the moist calibration cup, as in short-term storage.

Health and Safety Warnings

The standard solutions for calibrating conductivity contain Iodine and Potassium Chloride. Standard solutions for the calibration of pH contain the following compounds: pH 4 Solutions-- potassium hydrogen phthalate, formaldehyde, water; pH 7 solutions-- sodium phosphate (dibasic), potassium phosphate (monobasic), water; pH 10 Solutions-- potassium borate (tetra), potassium carbonate, potassium hydroxide, sodium (di) ethylenediamine tetraacetate, water.

When using the above mentioned standards, avoid inhalation, skin contact, eye contact, or ingestion. If skin contact occurs remove contaminated clothing immediately. Wash the affected areas thoroughly with large amounts of water. If any solutions are inhaled, ingested or contact eye surfaces, consult the Material Safety Data Sheets (MSDS) that are sent with the standards for prompt action, and immediately seek medical attention.

Appendix S6.A. Sample Calibration log form.

NETN Water Monitoring
YSI 600XL Calibration Log

Date	General	Dissolved Oxygen	Conductivity	pH	Notes:
	• RS-232 Autosleep off in sonde/advanced/	• 10 min in calib cup b/f turn on sonde	• Cal Constants 1000mL	• Buffer 7 Temp	
		• % sat drifted high to low	(4.55 to 5.45)	• Buf. 7 calib to:	
Time	/setup menu	• Inspect probe/membrane	• 1000 VWR check	• Buffer 4 Temp	
	• Files set up and ready	• Pressure at DO calibration	• 100 Conductivity check	• Buf. 4 calib to:	
	• Sonde time constant =12	• DO charge before accept calibration	YSI	• Buffer 4; 180mv ± 50	
Initials	• Interval in 650 = 1 sec	(25 to 75)	VWR	• Buffer 7; 0mv ± 50	
	• Sonde temp	• In sat enviro, % local (100 ± 2%)	• 12.9 Conductivity check	• Slope (btwn 165-180)	
	• Thermometer temp	• DO gain local (0.7 to 1.14) after calib.	YSI	• √ Sample Certified:	
			VWR	• √ Sample Measured:	

Date	General	Dissolved Oxygen	Conductivity	pH	Notes:
	• RS-232 Autosleep off in sonde/advanced/	• 10 min in calib cup b/f turn on sonde	• Cal Constants 1000mL	• Buffer 7 Temp	
		• % sat drifted high to low	(4.55 to 5.45)	• Buf. 7 calib to:	
Time	/setup menu	• Inspect probe/membrane	• 1000 VWR check	• Buffer 4 Temp	
	• Files set up and ready	• Pressure at DO calibration	• 100 Conductivity check	• Buf. 4 calib to:	
	• Sonde time constant =12	• DO charge before accept calibration	YSI	• Buffer 4; 180mv ± 50	
Initials	• Interval in 650 = 1 sec	(25 to 75)	VWR	• Buffer 7; 0mv ± 50	
	• Sonde temp	• In sat enviro, % local (100 ± 2%)	• 12.9 Conductivity check	• Slope (btwn 165-180)	
	• Thermometer temp	• DO gain local (0.7 to 1.14) after calib.	YSI	• √ Sample Certified:	
			VWR	• √ Sample Measured:	

Date	General	Dissolved Oxygen	Conductivity	pH	Notes:
	• RS-232 Autosleep off in sonde/advanced/	• 10 min in calib cup b/f turn on sonde	• Cal Constants 1000mL	• Buffer 7 Temp	
		• % sat drifted high to low	(4.55 to 5.45)	• Buf. 7 calib to:	
Time	/setup menu	• Inspect probe/membrane	• 1000 VWR check	• Buffer 4 Temp	
	• Files set up and ready	• Pressure at DO calibration	• 100 Conductivity check	• Buf. 4 calib to:	
	• Sonde time constant =12	• DO charge before accept calibration	YSI	• Buffer 4; 180mv ± 50	
Initials	• Interval in 650 = 1 sec	(25 to 75)	VWR	• Buffer 7; 0mv ± 50	
	• Sonde temp	• In sat enviro, % local (100 ± 2%)	• 12.9 Conductivity check	• Slope (btwn 165-180)	
	• Thermometer temp	• DO gain local (0.7 to 1.14) after calib.	YSI	• √ Sample Certified:	
			VWR	• √ Sample Measured:	

Date	General	Dissolved Oxygen	Conductivity	pH	Notes:
	• RS-232 Autosleep off in sonde/advanced/	• 10 min in calib cup b/f turn on sonde	• Cal Constants 1000mL	• Buffer 7 Temp	
		• % sat drifted high to low	(4.55 to 5.45)	• Buf. 7 calib to:	
Time	/setup menu	• Inspect probe/membrane	• 1000 VWR check	• Buffer 4 Temp	
	• Files set up and ready	• Pressure at DO calibration	• 100 Conductivity check	• Buf. 4 calib to:	
	• Sonde time constant =12	• DO charge before accept calibration	YSI	• Buffer 4; 180mv ± 50	
Initials	• Interval in 650 = 1 sec	(25 to 75)	VWR	• Buffer 7; 0mv ± 50	
	• Sonde temp	• In sat enviro, % local (100 ± 2%)	• 12.9 Conductivity check	• Slope (btwn 165-180)	
	• Thermometer temp	• DO gain local (0.7 to 1.14) after calib.	YSI	• √ Sample Certified:	
			VWR	• √ Sample Measured:	

Appendix S6.B. Sample Accuracy check worksheet.

NETN Water Monitoring
YSI Accuracy Assessment Worksheet

Tested by: _____
Date: _____
Time: _____

Test Location: *(circle one)* Lab Field

CERTIFIED STANDARD/ CHECK SAMPLE					
	YSI #:	YSI #:	Benchtop	Winkler	Thermometer
pH					
Conductance					
Temperature					
D.O. mg/L					
D.O.%					

FIELD/LAB DUPLICATE SAMPLE					
	YSI #:	YSI #:	Benchtop	Winkler	Thermometer
pH					
Conductance					
Temperature					
D.O. mg/L					
D.O.%					

Standard source:

Standard certified values:
Cond:
pH:

Duplicate sample source:

Duplicate known values (if applicable):

Calibration values entered in appropriate logs? YES NO

NOTES:

SOP 6 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.00	March 2007	B. Mitchell	**Section 2.3.2.1.2:** Site Number = 0 (not 1) for stream sites. Pre-deployment QC check is 89 (Joe used 99 outside of ACAD in 2006), and post-deployment QC check is 99.(*Originally part of SOP 3- In situ Measurements…using…sonde)* **Section 2.3.2.2.5:** Added informational paragraph at start of section. Acadia uses a 2-point calibration daily, and a 3-point calibration monthly, while other parks use a 3-point calibration daily. **Section 2.3.2.2.6:** Added information to start of section. Calibration should be performed weekly, with a 2-point field check each morning. **Section 2.3.2.2.9:** In step 5, add information referring to the DO% Local option. This makes it easier to tell if the sensor is within specifications, since it automatically adjusts the DO% for local barometric pressure. **Section 2.3.3:** Refer to DO percent local rather than DO percent in step 2 and 3. Inserted step 4 – recording pre-deployment data to site 89. Revised step 6 to include selection of proper site code. Added step 8 – recording post-deployment data to site 99.	Protocol Review Meeting
2.01	April 2009	B. Mitchell	**Section 2.3.2.2.6:** Updated to reflect replacement of probe yearly, with probe from previous year as a backup. .(*Originally part of SOP 3- In situ Measurements…using…sonde)* **Section 2.3.5.6.4:** New section; included info for pH calibration check, describing problem in the field at Acadia and specifying need for low-ionic strength standard and replacing the probe annually.	Protocol Review Meeting
3.00	January 2012	B. Gawley	Reformatted using NRPS-NRR template. Re-assigned as SOP 6. Updated to reflect one-point calibration of conductivity on a high-conductivity standard, followed by verification at two low conductivity standards. Expanded section on check sample using low-ionic strength standard. Added section on sonde accuracy checks, including DO titration instructions. Added calibration worksheet and accuracy check forms as appendices.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)

Version #	Date	Revised by	Changes	Justification
3.01	December 2012	B. Mitchell	Minor edits for clarity	Internal Review
3.02	December 2013	B. Mitchell	"Making Measurements" section revised to incorporate information previously found in SOP 5. "<File> Menu" check is only needed for ACAD; LNETN keeps files on the sonde for the whole season. ACAD site codes are two character park codes + 4 character site; LNETN has 4 characters for park and 2 for site. In "Data Upload", added a step about using an Excel spreadsheet to document the YSI data files, such as incorrect site codes and explanations for extra samples. A one-point check sample for conductivity is acceptable (previously a two-point check was conducted) Added details on using a filter to produce DI water Minor edits	Reviewer recommendation to eliminate inconsistencies and duplicated information; clarification of procedures.

SOP 7 – Grab Samples and Depth-Integrated Samples

Northeast Temperate Network

Version 3.02

Overview

This SOP provides descriptions of the methods for collecting grab samples in streams, lakes, and ponds, and methods for collecting depth-integrated epilimnetic samples in lakes (composite samples that contain water which is representative of a range of depths, or a specific layer of the lake). A grab sample is a discrete sample taken at a selected site, depth, and time; and analyzed for the constituents of interest (Table S7.1). A depth integrated sample is a composite sample taken with a collection bottle or tubing across a range of depths at a single vertical, and a width integrated sample is taken at more than one vertical in a stream cross-section. The decision on what sampling method to use will be dictated by the guidelines in *SOP 4 – Monitoring Streams* and *SOP 5 – Monitoring Lakes and Ponds* and the existing field conditions.

Sample Container Preparation

For single point grab samples, the sample bottle can be used as the sampling device. For composite samples such as depth or width integrated samples, a plastic core sampling tube or an isokinetic bottle sampler (e.g. VanDorn-type sampler) is used in conjunction with a churn in order to collect the sample and ensure it is well-mixed. Sample bottles are labeled with preprinted, waterproof labels that only require sample date and time to be filled out in the field (Figure S7.1). Samples should be taken in a prearranged priority so that all sample handling and preservation can take place as rapidly as possible. Numbers, types, and sizes of sample containers, as well as lists of analytes for each container are presented in Table S7.1. Pre-cleaned bottles are provided by the analytical laboratory.



Figure S7.7: Sample bottle labels.

Table S7.1. Containers for water sample analytes.

Container	Number	Analyte(s)
500 ml white HDPE	1	ANC, Apparent color, Cl, SO_4, NO_3
120 ml brown glass Black label (unfiltered)	3	Total P, Total N, DOC, NO_2, NH_3
1 L brown HDPE (Lakes and ponds only)	1	Chlorophyll *a*

Cleaning of Sampling Equipment

Clean the churn splitter, core or isokinetic samplers, and all other sampling containers before each field trip. Use a non-phosphate detergent (such as Liquinox) with tap water. Soak in detergent solution for 30 minutes. Wearing disposable, powder-free vinyl or latex gloves, scrub with a soft brush. Rinse well with tap water and then rinse with deionized water. Place cleaned equipment in clean storage bags. Upon arriving at each field site rinse the samplers and churn with native water. Rinse all sample collection equipment three times before filling with sample water. After sampling, rinse equipment used with deionized (DI) water.

Collecting Water Samples

Collecting Grab Samples in Sample Bottles

Grab samples are used to study the water quality unique to a specific depth. Grab samples are collected in either wide mouth sample bottles or syringes just below the surface of the water (0.5 m) from a boat at the deepest point in any of the lakes and ponds in NETN. For streams, collect the sample from the centroid of flow and where the water is well mixed, immediately downstream from a point of hydraulic turbulence such as a knick point or flume or where the stream flow appears laminar. Do not sample streams immediately below tributaries or other significant points of inflow. Sample far enough downstream for thorough mixing to have occurred (approximately 6 - 8 stream widths downstream should be adequate). For the Concord River, see "Width-Integrated Samples in Streams", below.

Generally, preservation and analytical methods do not allow the submission of one sample in a single container to the laboratory for analysis. The sample must be collected in a number of bottles of various types and sizes appropriate to the individual analyses. Each of these bottles (or other collection containers for samples that are to be filtered) can be filled using the following procedure:

1. Fill in all information (lake, pond, or stream site name; site code; sample date; time, etc.) on bottle labels with permanent marker *while labels are still dry*.
2. Put on vinyl or latex gloves (do not use nitrile gloves for nutrient samples). Avoid contaminating the gloves' outer surface.
3. Remove cap from sample container (bottle or syringe); fill with lake, pond, or stream water; and empty away from the sample site (downstream or on the opposite side of the boat). Repeat this THREE TIMES to rinse container. *Do not touch inside or rim of bottle, tip of syringe, or cap!*

4. For streams, do not walk on, or in any way disturb the stream bottom upstream from the sampling site. Collect the sample upstream of where the sample taker is standing. Clear surface debris if present. Avoid water-quality sampling in pools or standing water where floating solids tend to accumulate.
5. Fill sample container a final time at about 0.5 m (18 inches) below the surface of the water. Point the container opening in the direction of the waves or current. Avoid collecting sediment or debris floating in the water.
6. For streams, if the depth is inadequate for submersion of bottle, move upstream or downstream within the same reach. If the entire stream reach is of insufficient depth, water can be carefully pumped directly from the stream using a peristaltic pump. Collecting flowing water from flow off of a rock or small waterfall is an alternate possibility.
7. Cap the sample container while it is still underwater. Fill container completely, allowing no air in the container.
8. Record sample type (grab), depth, and collection time on field data form.
9. Store sample container in a cooler packed with ice until/during transport to the laboratory, following instructions in the "Shipping Samples to the Laboratory" section of *SOP 12 – Laboratory Analysis*.

Collecting Grab Samples with a Throw Bottle

For samples in lakes with poor accessibility by boat, a throw bottle can be used to collect epilimnion grab samples at a depth of 0.6 meters, and a distance of about 9 meters from shore. To collect the sample:

1. Choose a location along the shore that is free of aquatic vegetation, snags, or other obstructions that will interfere with throwing the bottle, near water deep enough so the deployed throw bottle will not rest on the lake bottom. Rock ledges and steep drop-offs are usually good locations.
2. Fill in all appropriate information (lake or pond, sample date, time, etc.) on bottle labels with permanent marker *while labels are still dry*.
3. Put on vinyl or latex gloves. Avoid contaminating the gloves' outer surface.
4. Replace the lid of a 500-mL HDPE bottle (which has been acid washed and is part of the set of bottles provided to send samples to the analytical laboratory) with a special lid with two holes cut into it (one holding a short piece of tygon tubing to let water flow into the bottle) and insert the bottle into the weighted bottle-holder, securing it with rubber bands. Store the original bottle lid in a clean location, away from possible contamination.
5. Uncoil the tether rope attached to the bottle holder and check for tangles. Swing the throw bottle several times to build momentum, and release the assembly in the direction of the desired sample location. *Be sure to have a firm grip on the end of the tether rope (or tie it to a fixed object)!*
6. The bottle holder and sample bottle will sink to the desired depth, suspended by a float. Bubbles will be visible on the lake surface as the bottle fills through the hole in the lid.

When the bubbles stop, quickly retrieve the throw bottle assembly by pulling it in by the tether rope.

7. Throw, retrieve, and empty the apparatus three times to rinse the bottle holder, sampling lid, and 500 mL sample bottle. It will take about three to four additional throws to obtain samples, pouring water from the 500 mL bottle to the other sample bottles and syringes (that have been rinsed three times with lake water from the shore). After the final throw (and all bottles on shore have been filled) retain the sample in the bottle in the sampler and cap the bottle with its original lid.
8. Record sample type (grab), depth, and collection time on field data form.
9. Store sample containers in a cooler packed with ice for transport.
10. Filter chlorophyll *a* samples and ship all samples to the laboratory as soon as possible, following instructions in the "Shipping Samples to the Laboratory" section of *SOP 12 – Laboratory Analysis*.

Depth-Integrated Samples of Epilimnion in Lakes or Ponds

Depth-integrated composite samples contain water that represents a range of depths, or a specific layer of the lake. To take a depth-integrated sample of the epilimnion, lower a 10 meter by half-inch inside diameter, flexible, weighted tube into the water column (subsequently referred to as the "core sampler"). When the bottom of the core sampler reaches the desired depth, pinch off clamp at the top of the tube to trap all the water inside. Lift the core sampler into the boat and release the clamp to transfer the sample to a churn to further homogenize the sample. Transfer water from the churn to bottles for transport. The procedure to take a depth-integrated sample is as follows:

1. Take temperature and DO profiles to determine the depth of the epilimnetic layer according to Figure S7.2. Carefully consider the temperature profiles to avoid sampling from an ephemeral epilimnion caused by calm, warm, weather. This condition is characterized by a temporary thermocline (1°C/m change), which will quickly disappear when the wind blows.

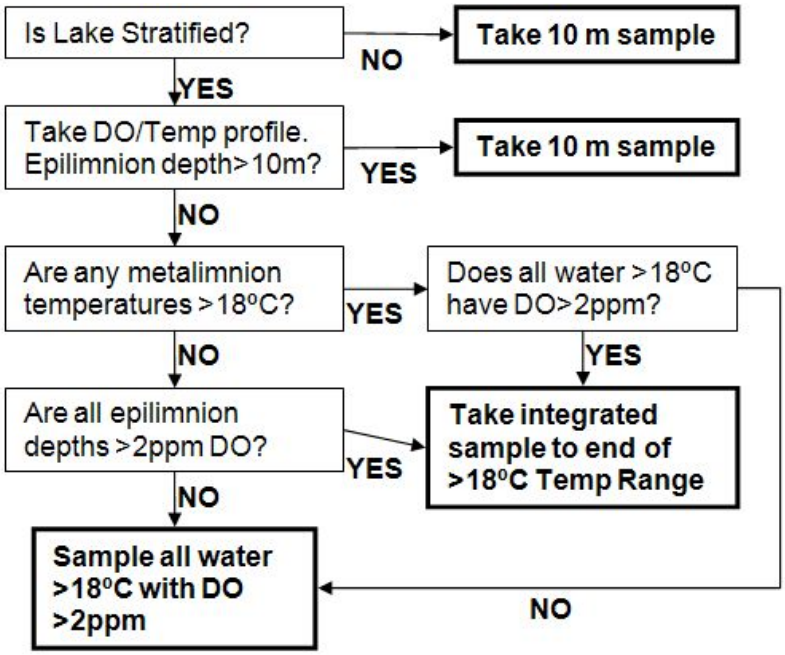


Figure S7.8. Method for determination of depth-integrated sample for lake water-quality samples

2. Fill in all appropriate information (lake, sample date, time, etc.) on bottle labels with permanent marker *while labels are still dry*.
3. The person in contact with the water should put on powder-free vinyl or latex gloves.
4. Start with a clean churn splitter.
5. Rinse the churn splitter and sample bottles three times with native water to be sampled and let the water sit in the churn while other work is being accomplished at the site. This allows the churn splitter to equilibrate to the temperature and to any ionic exchange capacity.
6. Rinse core sampler with lake water by lowering the weighted end of tube into water at least 1 meter deeper than the epilimnetic depth. Then lift the core sampler so that all water drains back into lake. REPEAT THREE TIMES.
7. Empty the churn splitter of all water before beginning to collect a sample.
8. Clear surface debris if present.
9. Slowly lower the core sampler to the desired depth, guided by the demarcations on the tube. Check to make sure the water level inside the tube equals the level outside the tube.
10. Close the top of the tube with the pinch clamp and carefully raise the weighted end into the boat.
11. Hold the weighted end over the mouth of the churn and open the pinch clamp to empty sampler contents into the churn. Do not pour water over hands since this will contaminate the sample.

12. Take a sufficient number of samples (repeat steps 8-11) to fill the churn. If a large sample volume must be obtained from a relatively shallow depth (less than or equal to 2 m) a composite sample made up of grab samples from several depths in the water column can be used. For example, a 2 m composite can be made up from 0.5 m, 1.0 m, 1.5 m, and 2.0 m grab samples.

Note: The following steps can be completed back at the vehicle, but as soon as possible after obtaining samples.

1. Empty the rinse water from all of the sample containers to be used and place them within easy reach of the churn splitter.
2. Rinse sample bottles once with water from the churn while operating the churn.
3. Continue to operate the churn and withdraw subsamples for all analytes

Width-Integrated Samples in Streams

For sampling sites located on a nonhomogeneous reach of a river or stream, it is necessary to sample the channel cross section at multiple points and depths in order to obtain a composite sample. The Concord River is the only current NETN site requiring a width-integrated sample. One water sample is collected with a throw bottle or Van Dorn sampler at each of the bridge pylons (2 and 4) at which sonde measurements have been taken. All sampling containers (throw bottle, Van Dorn sampler, churn splitter, and/or 4 L bottle) must be rinsed three times with native water. The water samples are collected at a depth of 0.5 meters, and equal amounts of sample water from both locations are composited in a churn splitter or 4 L wide-mouth HDPE (high density polyethylene) bottle. The water in the churn splitter or 4 L bottle is gently mixed, then distributed to the appropriate sample bottles. For more information on width-integrated sampling, refer to U.S. Geological Survey (2006).

Sample Filtering and Preservation

Portions of the water collected during sampling for chlorophyll *a* analysis must be filtered to capture algal biomass on the filter. Water for chlorophyll *a* analysis is drawn from the churn splitter in the field with the other nutrient samples and filtering is accomplished in the laboratory or field station at the end of the day. In this case, the filters are retained for analysis and the filtrate (liquid) is discarded. Procedures for filtering and preserving (through freezing) chlorophyll *a* samples are described below.

NETN discontinued analyzing samples for dissolved constituents in 2011, eliminating the need for filtering nutrient samples in the field, and the associated acid-washing of filters and tubing. However, if more rigorous sampling is required as part of a special project or investigation it may be necessary to use filtering procedures for dissolved constituents described in Appendix S7.A. Acid washing procedures are detailed in Appendix S7.B.

Sample Collection / Filtration for Chlorophyll a Analysis

Sample collection, filtration, preservation, and storage methods for chlorophyll *a* samples are based on preparation for analysis using Standard Methods 10200H **(**American Public Health Association 1998). Collect duplicate samples to assess accuracy. Use membrane filters with an effective pore size of 0.45µm (supplied by the laboratory). Check that all apparatus are clean and acid free.

Procedures for collecting and filtering chlorophyll *a* samples are as follows:

1. In the field, collect enough water from the composite sample in the churn splitter to concentrate phytoplankton on at least two filters which will be the duplicate samples. Filtration volume size will depend on the particulate load of the water, but 1 L or less is generally sufficient for a lake (500ml/filter). The sample is subsampled from a churn into a 1 L amber polypropylene bottle.
2. Chill the chlorophyll *a* sample bottle with the other water samples collected during the monitoring visit.
3. Filter water samples in subdued light as soon as possible (several hours maximum) after sampling. Algal populations, thus chlorophyll *a* concentration, can change in relatively short periods of time.
4. Assemble the filtration apparatus and attach the vacuum source with vacuum gauge and regulator. Vacuum filtration should not exceed 6 inches Hg (20 kPa). Higher filtration pressures and excessively long filtration times (greater than10 min) can damage cells and invalidate the analyses.
5. Agitate the container thoroughly, but gently, before drawing a subsample from the water sample container, to suspend the particulates (stir or invert several times).
6. Pour the subsample into a graduated cylinder and accurately measure the volume. Then pour the subsample into the filter tower of the filtration apparatus and add an eyedropper-full of supersaturated $MgCO_3$ solution to prevent acidification. The $MgCO_3$ solution is made at the beginning of the year using powder supplied by the analytical lab. Put a teaspoon of powder in a small (e.g. 50 mL bottle) and add DI water with a dropper. The solution should be cloudy when the bottle is shaken. Apply a vacuum (not to exceed 20 kPa).
7. A sufficient volume has been filtered when a visible green or brown color appears on the filter. Do not suck the filter dry with the vacuum; instead slowly release the vacuum as the final volume approaches the level of the filter and completely release the vacuum as the last bit of water is pulled through the filter.
8. Remove the filter from the fritted base with tweezers and place it on a small square of aluminum foil (folding once with the particulate matter inside and sealing the edges) to protect the phytoplankton from light, and freeze immediately.
9. Label each foil packet containing a filter with information on the lake name/code, sample time and date, amount of sample (ml) filtered in this replicate, and replicate number (e.g. “1 of 2”).

Field Quality Assurance for Water Samples

The Field Quality Assurance (QA) program is a systematic process which, together with the laboratory and data storage QA programs, ensures a specified degree of confidence in the data collected for an environmental survey. The Field QA program involves a series of steps, procedures, and practices described in the following sections.

General Measures

All equipment, apparatus, and instruments must always be kept clean and in good working condition by means of the methods and practices given elsewhere in this protocol. Records are kept of all repairs to the instruments and apparatus and of any irregular incidents or experiences that affect operation. It is essential that standardized and approved methodologies, such as those recommended in this protocol, be used by field staff. If any changes to the approved methods are made, they must be documented and experimental data obtained to ensure that the results are valid and comparable to the earlier data.

Prevention of Sample Contamination

The quality of data generated in a laboratory depends primarily on the quality of the samples received at the laboratory. Consequently, the field investigator must take the following precautions to protect samples from both contamination and deterioration. There are numerous routes by which samples can become contaminated. Potential sources of trace-metal contamination during sampling include metallic or metal-containing sampling equipment, containers, labware, reagents, and deionized water; improperly cleaned and stored equipment; atmospheric inputs such as dirt and dust from automobile exhaust, cigarette smoke, nearby roads, and wires. Human contact can also contaminate the samples. The following are some of the basic contamination prevention methods:

1. Clean collection bottles according to recommended methods.
2. Use only the recommended type of sample bottle for each parameter.
3. Use only water sample bottles for water samples. Do not use bottles that have been used for other purposes, such as storing concentrated reagents.
4. Follow recommended preservation methods. All preservatives must be of analytical grade and included as field blanks for identification of potential contamination.
5. Minimize the possibility of adding the wrong preservative to a sample or cross-contaminating the preservative stocks when preserving samples by preserving all the samples for a particular group of parameters together.
6. Do not touch the inner part of sample bottles and caps with bare hands, gloves, or mitts.
7. Keep sample bottles in a clean environment, away from dust, dirt, fumes and grime. Vehicle cleanliness is an important factor in eliminating potential contamination of samples and equipment.
8. Keep petroleum products (gasoline, oil, exhaust fumes), prime sources of contamination, away from samples. Exhaust fumes and cigarette smoke can contaminate samples with lead and other heavy metals. Air conditioning units are also a source of trace-metal contamination.
9. Keep filter units and related apparatus clean using procedures such as acid washes and soaking in special solutions, and protected from field contamination.
10. Keep bottles or sample bags, which have been sterilized, sterile until the sample is collected.
11. Keep all foreign, especially metal, objects out of contact with acids and water samples.

12. Store samples out of the sunlight at 4°C in a cool place, ice chest, or equivalent.
13. Ship samples to the laboratory without delay.
14. Keep hands clean while working with water samples and field equipment.

Field Quality Control for Water Samples

The total number of field QC samples will be at least 10% of the number of samples collected. At Acadia, one blank and one replicate will be collected in May (one stream), June (one lake/pond), and two blanks and two replicate will be collected August (one stream and one lake/pond). An identical number of QC samples (following the same schedule) will be collected from the combined "Lower NETN" sites. Given an overall number of 110 or 111 samples per year, these numbers mean that QC samples equal approximately 14% of the total samples. Collection sites for QC samples should be selected randomly. If multiple labs are used for any analyses, replicates will be swapped between labs to provide a check on procedures plus laboratory results. In the event of a discrepancy, additional replicates will be needed to isolate the source of the problem (e.g. lab versus field procedures).

Blanks for the assessment of contamination

Blank QC samples are free of the analyte(s) of interest and are used to test for bias from the introduction of contamination into field samples during collection, handling, and processing. Contamination results in a positive bias in the concentration. Field blanks measure nearly all of the sources of error that can affect field samples, and thus they are used to document data quality and to identify data-quality problems. If a data problem is found, topical blanks are used to locate the source of the problem and could consist of equipment blanks, source water blanks, trip blanks, or laboratory blanks. Protocols for grab samples must be followed for the collection of blank samples to ensure that blanks are representative of the type of field sample being tested. All blanks that are taken must be well documented as to how, when, why, and where they were taken. Environmental samples are labeled with the time to the nearest 5 minutes. Add a time tag for each blank sample that is 2 minutes after the time for the grab sample so that these blank samples can be easily identified.

See section on deionized water in *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde* for a justification of the importance of purchasing a laboratory grade water to be used for blank samples. Use inorganic blank water or universal water.

Blanks are submitted for all analytes by each monitoring team at the beginning of each month in which samples are being collected, or each time there is a change in equipment and staff. For example, if one technician is collecting samples from all of the "Lower NETN" parks in May, June, and August, collect one blank on each of these trips, at different parks each time. In Acadia, blanks are collected at different sites during each sampling month.

Initially, blanks are used singly to compare blank analysis to critical concentrations such as water-quality standards, and to alert staff of contamination problems and identify the need for topical blanks, if necessary. The laboratory has been instructed to notify NETN staff immediately if high analyte concentrations are detected in blank samples. As enough blanks are collected throughout each park and throughout NETN, nonparametric statistics can be done on the blanks to obtain confidence limits for selected percentiles of contamination that can be

estimated based on concentrations of the analytes in the blanks (see *Quality Control Reporting* section in *SOP 14 –Annual Data Reporting for Lakes, Ponds, and Streams*).

Examine blank samples when returned from the laboratory so that if contamination is occurring, topical blanks or adjustment of methods can be made as soon as possible. Confidence limits for selected percentiles of contamination and bias are calculated and reported annually as a part of the annual data report.

Replicate Samples for the Assessment of Precision

Each monitoring team collects field replicates during each month in which samples are being collected, or there is a change in equipment or staff. If possible, have old staff members and new staff members collect replicate samples to ensure that each staff member is following protocols adequately and not introducing additional variability. Collect one field replicate for every 10 samples to assess measurement precision. Collect one set of replicates on each trip around NETN, making sure that it is collected in different parks on different trips so that over time, the set of replicates can be used to determine QC across NETN. Do not to take replicate samples in waters in which one would expect a non-detect because the usefulness of two replicate "non-detects" is limited.

Measurement Sensitivity and Detection Limits

Censoring to quantitative detection limits, though not often optimal or even desirable for trend assessment, is appropriate when a data user is assessing compliance with environmental regulations or trying to determine if a concentration or summary statistic is below a concern threshold for endangered species or other special-value resources in National Parks. If such especially high-value resources are at risk, it is appropriate to apply the precautionary principle and avoid false negatives (saying the contaminant is below a certain concentration, when it really is not).

Some pristine waters in the NPS have low concentrations of nutrients, and the parks want to ensure that nutrient levels remain low. Thus it is beneficial to document and control measurement sensitivity with the lowest practicable low-level detection limits. For some parameters measured in the field such as pH, temperature, conductivity, biological observations, and physical habitat observations, extremely low levels are rare. In the high measurement ranges, the smaller the (true) change that a measuring system can reliably and accurately detect the more sensitive the instrument is.

Appendix S7.A. Sample Filtering

Portions of the water collected during sampling may (depending on laboratory specifications and preferences) need to be filtered in the field prior to being analyzed for dissolved constituents.

Sample filtering and splitting should be done as soon after collection as possible. If an appropriately clean location for filtering is not available, samples can be stored in bottles and kept cold until a more suitable filtering location is available. Some laboratories require samples to be preserved by acidification in the field. This procedure is *not* required by the current analytical laboratory (Sawyer Environmental Chemistry Research Lab, University of Maine-Orono).

Composite (e.g. depth-integrated epilimion core) samples can be filtered directly from the churn after the raw samples have been drawn off. Grab samples that will be filtered (dissolved constituent samples) can be collected into a clean glass collection bottle and then pumped directly from the collection bottle, through the filter and into the sample bottle. All samples should be immediately chilled and remain under chilled conditions until analysis.

Filtering for Dissolved Constituents:

A battery-powered peristaltic pump is commonly used for filtration of samples for the analysis of dissolved constituents. The pump forces the water through tygon tubing and through a 0.45-mm-pore-size capsule filter. The particulate matter is retained by the filter while the filtered water passes through to the sample bottle. Use filters for one site only and then discard. Filters are not to be reused.

1. Ensure that all filters and tubing have been acid washed, according to the instructions in Appendix S7.B.
2. Filtered samples are drawn directly out of the collection bottle (or directly from a stream if stream depth is too shallow to submerge a collection bottle), through the filter and into the sample bottle. If a churn is being used for a composite sample, filter the water remaining in the churn after all "total" samples have been drawn off from the churn splitter. The sample to be filtered does not need agitating.
3. Connect the pump discharge tube to the capsule filter. Be sure that the direction of flow through the capsule filter matches the arrow on the side of the filter. Rinse the intake tube with sample water and place the tube into the sample to be filtered.
4. Connect the pump to the appropriate power supply with power switch off.
5. Turn the pump on at low speed and allow air to vent. Do this by holding the filter so that the arrow is pointing up.
6. Flush the system (tubing and filter) with at least three times the filter capacity of sample water. If the sample water is full of particulate matter, first filter deionized water through the system.
7. Rinse the bottles three times. Fill all appropriate subsample bottles with the filtered sample. Include total dissolved nitrogen, total dissolved phosphorus, ammonia, nitrite, nitrate, and orthophosphate samples.

8. Fill the container to the desired volume (leave about 1 percent of the container's capacity to allow for the addition of preservatives (if necessary) and expansion if samples are to be shipped).
9. Ensure that all bottle caps are screwed on tight. Verify the sample labels are correct and complete. Place the labeled sample container in a cooler packed with ice.
10. Rinse the container's outside surface with clean water and dry with a paper towel. Rinse the hoses with deionized water.
11. Record notes on the filtering process on the field data form, including information on equipment settings, staff roles, equipment used, unusual environmental conditions, potential contamination sources, and problem areas.

Appendix S7.B. Acid-washing procedures

Acid-washing of sample bottles and sampling equipment is not required under current NETN water monitoring SOPs. The bottles used for nutrient sampling are supplied by the analytical laboratory, and have been cleaned to the proper QA/QC specifications prior to shipping. The NETN discontinued analyzing samples for dissolved constituents in 2011, eliminating the need for filtering samples in the field, and the associated acid-washing of filters and tubing. However, if more rigorous sampling or re-sampling is proscribed as part of a special project or investigation it may be necessary to use the procedures described below in preparation for specialized sampling.

Acid-washing filters and tubing

To ensure the purity of filters and tubing for peristaltic pumps, acid wash both prior to use. Filters and tubing can be washed as a group and stored in zip-top bags until ready for use or up to two weeks.

1. Using concentrated ACS grade or Trace Metal Grade Hydrochloric Acid (HCl) and deionized water (DI water), make up a quantity of 5% HCl by volume based on the amount of filters and tubing to be washed. For example, add 5mL of concentrated HCl to 95 mL of deionized water to make 100 mL of 5% HCl. *ALWAYS ADD ACID TO WATER. If water is added to acid, the mixture can boil and splash, potentially causing serious injury*.
2. Use as short a length of tubing as possible and connect the pump discharge end of the tube to the nozzle, and the nozzle to the input side of the capsule filter. Be sure that the direction of flow through the capsule filter matches the arrow on the side of the filter.
3. Turn on the peristaltic pump, and using a syringe, squeeze 10 mL of the HCl solution through the tubing and filter.
4. Follow the mixture with at least 60 mL of DI water and a squirt of air to remove residual moisture.
5. Pack the acid-washed filters and tubing in clean (new) zip-top bags for transport to the field.

Health and Safety

- *HCl is an acid, and should be stored in a protective corrosives cabinet in its own secondary containment bin, separate from other acids and bases. It can cause burns and can be harmful if inhaled or ingested. If skin contact occurs, wash off the affected area with water for 15 minutes and seek medical attention. If this chemical is inhaled, ingested or contacts eye surfaces, consult the Material Safety Data Sheet (MSDS) for prompt action, and immediately seek medical attention.*
- *Precautions should be taken by wearing chemical safety goggles, lab coats and by wearing powderless latex or nitrile gloves.*
- *When mixing the HCl solution, work under a chemical fume hood.*

SOP 7 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.00	March 2007	B. Mitchell	**Section 2.4.3:** Added first sentence; if clean filtering location is not available, samples can be stored and kept cold until a suitable location is available.(*Originally part of SOP 4- Grab Samples and Depth-Integrated Samples)* **Table 25:** Lab code changed for total phosphorus; code and reporting limit changed for total dissolved phosphorus, ammonia, nitrite, nitrite + nitrate, orthophosphate. **Section (2.4.5):** Added paragraph specifying numbers and times for collection of blanks and replicates, and that replicates should be swapped between labs if multiple labs are being used.	Protocol Review Meeting
3.00	January 2012	B. Gawley	Reformatted using NRPS-NRR template. Combined all or sections of v2.02 SOP #s 4, 7,13,and 14 to consolidate all instructions for preparation, collection, processing, and QA/QC of water samples. Re-assigned as SOP 7. Added photo of sample bottles. Updated analytes in Table 1 to reflect tests beginning in 2012. Added section on use of throw bottle. Added Appendix S7.B on acid washing of filters and tubing (including Health and Safety statement). Updated chlorophyll a filtration section to reflect current methodology and lab requirements. Moved field filtration instructions to Appendix S7.A to reflect current lab (SECRL) requirements for analytes beginning 2012.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits	Internal review.
3.02	December 2013	B. Mitchell	Updated depth-integrated sampling procedures to match those formerly in SOP 5. Steps 10-12 are new, as is the need in step 2 to rinse the splitter 3 times. Grab sample rinse water is emptied away from sample site (downstream or opposite side of boat). Revised “Collecting Grab Samples in Sample Bottles” section to incorporate stream site procedures that were formerly listed in SOP 4. Sampling containers for width-integrated sampling all need to be rinsed 3 times with native water.	Limit duplicated material and correct inconsistencies. Clarification.

SOP 8 – Measuring Water Clarity, Turbidity, and Light Penetration

Northeast Temperate Network

Version 3.02

Overview

This SOP describes techniques for determining water clarity (transparency), using a Secchi disk; turbidity, using a LaMotte Model 2020e turbidity meter; and light penetration and attenuation, using a Li-Cor light meter. All of these metrics can provide either a direct or indirect assessment of lake productivity. Turbidity measurements can be used to help quantify the amount of suspended material in the water column.

Background and Scope

Transparency, measured by viewing a Secchi disk as it descends through the water column, is one of the simplest methods for estimating lake-water quality. Transparency measured in this manner is recorded as "Secchi depth" (or "SD"), expressed in meters. *Secchi disk measurements are attempted at all lakes and ponds at every sampling event. If the bottom is reached before the SD is reached, then a light penetration profile is taken*. Secchi disk measurements are affected by the presence of algae, plankton, water color, or suspended sediment. Transparency is inversely related to lake productivity – thus a shallow SD indicates a productive lake.

Secchi depths in NETN lakes and ponds can range from 1 to 20 meters (Breen et al. 2002, Farris and Chapman 2000). Generally a SD of greater than 8 meters indicate an oligotrophic lake, between 4 and 8 meters indicate a mesotrophic lake and less than 4 meters indicates a eutrophic lake (Maine Department of Environmental Protection 2004). The annual mean of the six monthly Secchi transparency measurements can be used to calculate a Trophic State Index (TSI) for the lake. Further discussion of the TSI is found in "State and Regional Water-Quality Standards" in the narrative of this protocol and in the "Lake Water Quality Analysis" section of *SOP 14 – Data Reporting and Analysis for Lakes, Ponds, and Streams*.

Ponds outside of Acadia are too shallow for use of a Secchi disk, and a transparency tube was used to measure water clarity (see Appendix S8.A) at these sites from 2006 to 2011. This method was selected because there is a loose relationship between SD and transparency tube values, plus transparency tubes can be used in streams as well as ponds (Dahlgren et al 2004). However, the water at most NETN pond (and stream) sites was too clear for effective use of the transparency tube.

Light penetration profiles can tell us much about the conditions affecting lakes and ponds. Nearly all the energy that drives and controls lake processes is derived from solar energy. It is converted to chemical energy via photosynthesis, and then transported to other areas of the ecosystem in various forms of organic matter. Solar energy, absorbed by the lake and dissipated as heat, plays a large role in defining a lake's thermal structure, stratification, and circulation patterns. These factors in turn affect nutrient cycling and the distribution of dissolved gasses. By

understanding the quantity and behavior of the light entering a lake system, we can learn more about how the light is utilized in the system (Wetzel and Likens 2000). *Light penetration profiles are used to measure light attenuation in all ponds outside of Acadia (starting in 2012) and Jordan Pond plus the Acadia ponds that are typically too shallow for use of a Secchi disk (Aunt Betty's Pond, Bear Brook, Lake Wood, and Seawall)*.

A light penetration profile is obtained using two solar radiation sensors and a datalogger. One of the sensors (with a spherical diffuser to enable accurate collection of photosynthetically available radiation- "PAR") is lowered into the water column on a weighted lowering frame, suspended from a graduated cord. The second sensor ("deck cell") is left on the surface to record ambient light. The datalogger records and processes readings from both sensors, calculating the percentage of the total light reaching any given depth.

Turbidity is the measure of how clear a liquid is and how much light is scattered by the sample. It is measured in nephelometric turbidity units (NTU). It is caused by suspended matter or impurities that interfere with the clarity of the water. These impurities may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisms. Turbidity is an expression of the optical property that causes light to be scattered and absorbed by particles and molecules and should not be confused with suspended solids, which expresses the weight of suspended material in the sample (U.S. Environmental Protection Agency, 2004). In natural waters, turbidity is often used as an indicator of water quality and productivity.

Turbidity in the water can create aesthetic, ecological, and health issues. Turbid water may indicate runoff from construction, roads, agriculture or other types of pollution. Suspended sediment can carry nutrients and pesticides throughout the water system. Suspended particles near the surface absorb additional heat from sunlight, raising the water temperature. High turbidity levels can reduce the amount of light reaching lower depths of lakes and streams, which can inhibit growth of submerged aquatic plants, and can affect the ability of fish gills to absorb dissolved oxygen. *Turbidity is measured monthly at all stream sites using a LaMotte 2020e turbidity meter (beginning in 2012)*.

Measuring Transparency with a Secchi Disk

1. Take transparency readings between 9:00 AM and 3:00 PM (0900-1500) local time (Eastern Daylight Time).
2. Lower Secchi disk on the shady side of the boat while observing its descent with the viewing scope. DO NOT WEAR SUNGLASSES!
3. STOP lowering when the Secchi disk disappears completely from view. If the disk hits the bottom before it disappears (or is obscured by vegetation but would otherwise still be visible), note on the data sheet that the disk hit bottom.
4. Pull disk up slightly until it is just visible. (The disk may be seen as just a whitish-green "glow".)
5. Lower disk until it just disappears again.

6. Note the demarcation on the measuring tape at the point where the tape meets the surface of the water. Record this value to the nearest hundredth of a meter (0.01 m) in the space marked "SECCHI DEPTH" on the field-data form. Record a depth even if the disk hits bottom (in this case it is the lake or pond depth).
7. If the disk did not hit bottom, take a duplicate reading by a second staff person (if a trained individual is available), and mark the results in the field data form in the space marked "QC READING". Check to ensure readings are within 0.1 m. Repeat duplicate readings until ± 0.1 m agreement is obtained.

Measuring Turbidity with a Turbidity Meter

Calibration

Detailed instructions on the use of the LaMotte 2020e turbidity meter can be found in the instrument's instruction manual (http://www.lamotte.com/images/pdf/instructions/1979.pdf). The meter should be calibrated at the beginning of each sample week in the laboratory. For ACAD, use a 1 NTU standard in most situations and a 10 NTU standard after a rain event. For LNETN, use a 10 NTU standard for most situations. The standard should have a concentration similar to expected turbidity conditions.

1. Press **ON** to turn meter on. Press ***|OK** to select the "Measure" option from the Main Menu.
2. Be sure tubes are clean and dry before using. Rinse tube three times with blank water, then carefully fill to the fill line with blank water and dry outside of tube. Avoid creating bubbles. Put a dry positioning ring on the tube, aligning the index notch on the ring with the index mark on the tube, and cap.
3. Wipe the outside of the tube with a lint-free cloth or Kimwipe to remove fingerprints and smudges.
4. Place sample tube into the meter, aligning the index notch on the ring with the index arrow on the meter housing.
5. Close the lid and Press ***|OK** to select the "Scan Blank" option. Remove the tube when the scan is complete and discard the blank water.
6. Select a standard in the range of the samples to be tested. *NOTE: Only use LaMotte AMCO Standards specific to the 2020e Turbidity Meter.* Rinse the tube 3 times with the standard, then fill with standard to the index line, cap, and wipe the tube clean with a lint-free cloth.
7. Place the tube into the meter, aligning the index notch on the positioning ring with the index arrow on the meter housing.
8. Close the lid and press ***|OK** to select the "Scan Sample" option. If the displayed value is the same as the value of the standard, skip to step 12. If the displayed value is not the same as the value of the standard (within specification limits: below 100 NTU, ±0.05 or 2%, whichever is greater; above 100 NTU, ±3%) continue with the calibration procedure.
9. Press the ▼button to scroll to the "Calibrate" option. Press ***|OK** to calibrate.
10. Use the ▲ and ▼ buttons to change the highlighted digits to match the concentration of the standard. Press ***|OK** to accept a digit and move to the next digit.

11. When the value of the display matches the concentration of the standard, press the ***|OK** button to set the calibration. Calibration is complete.
12. Press ◄to exit to a previous menu or press **OFF** to turn the meter off.

Measuring Turbidity in the Field

Turbidity measurements should be taken early in the site visit, before observers begin wading in the stream or cause other disturbance that could affect measurements. The following steps apply to a calibrated meter:

1. Press **ON** to turn meter on. Press ***|OK** to select the "Measure" option from the Main Menu.
2. Be sure tubes are clean and dry before using. Rinse tube three times with blank water, then carefully fill to the fill line with blank water and dry outside of tube. Avoid creating bubbles. Put a dry positioning ring on the tube, aligning the index notch on the ring with the index mark on the tube, and cap.
3. Wipe the outside of the tube with a lint-free cloth or Kimwipe to remove fingerprints and smudges.
4. Place sample tube into the meter, aligning the index notch on the ring with the index arrow on the meter housing.
5. Close the lid and Press ***|OK** to select the "Scan Blank" option. Remove the tube when the scan is complete and discard the blank water.
6. Rinse the tube three times with water from the sample bottle. Gently mix sample in the bottle by inverting before pouring into tube but avoid introducing air bubbles. Fill with water sample a fourth time (to the fill line). Wipe the outside of the tube with a lint-free cloth or Kimwipe to remove fingerprints and smudges.
7. Place sample tube into the meter, aligning the index mark on the tube with the index mark on the meter housing.
8. Close the lid and press ***|OK** to select the "Scan Sample" option.
9. Record the result on the Field Data Form.
10. Press ◄to exit to a previous menu or press **OFF** to turn the meter off.
11. Remove tube, empty sample, and store used tube upside-down in a designated location until it can be washed.

Light Penetration Profiles

Configuring the Li-Cor Datalogger

The configuration settings for the Li-Cor 1400 datalogger should be checked at the beginning of each monitoring season and after each battery change, factory servicing, or system reset. Time and date settings should be correct, and values for averaging time, etc. should be set to NETN defaults. Cell types and multipliers should be entered from the factory QA certification tags and/or forms.

In the beginning of the monitoring season, install four fresh AA-size alkaline batteries according to the directions in the LI-1400 Data Logger Instruction Manual. These batteries are likely to last

for the duration of the sampling season, but it is wise to check the voltage on a regular basis. The best approach to tracking battery charge is to activate the battery voltage channel and check it regularly. As a backup to manually checking the battery voltage, the LCD display on LI-1400 will blink on and off when the voltage drops to 4.0 V (the nominal full-charge voltage is 6.0 V). The unit will then shut off when the voltage falls to 3.8 V. Batteries should be replaced well before this occurs, with the goal of avoiding the need to replace batteries in the field.

Programming the LI-1400 can be done either directly using its membrane keypad, or indirectly by downloading programming instructions from a personal computer running LI1400 PC Communications Software. Consult the manufacturer's manual for detailed configuration instructions. NETN default configuration values for the Li-Cor datalogger are displayed in Table S8.1. The following instructions are for setting the LI-1400 configuration using the PC software:

1. Connect the LI-1400 to the computer's COM port using a 9-pin RS-232 cable. *Note: If the computer does not have a serial COM port, it may be possible to connect the LI-1400 by using a serial to USB converter*.
2. Launch the LI1400 software on the computer. Turn on the LI-1400 datalogger using the <On/Off> button.
3. Click the "Remote" option on the computer program menu, then click "Connect" from the drop-down list.
4. Choose the appropriate COM port number to connect to (usually COM 1). A small dialog box will open and display a "Synchronizing" message. The box will disappear when the datalogger is connected.
5. Click the "Remote" option on the computer program menu again, then click "Receive Setup" from the drop-down list. This command uploads the current setup configuration from the datalogger to the left-hand pane of the computer software window.
6. When a channel number (I1, I2, etc.) is highlighted in the left-hand pane of the software, a dialog box containing the settings becomes visible in the right-hand pane. Enter the correct values from Table S8.1 (if necessary). Repeat for each channel until the full configuration matches the values in Table S8.1.
7. Click the "Remote" option on the computer program menu, then click "Send Setup" from the drop-down list. This will replace the datalogger's configuration with the edited configuration from the PC software.
8. The configuration settings from the computer program can be saved in a file so that the next time the datalogger needs to be restored to the saved configuration the settings do not have to be re-entered to the program. Choose "Save" from the "File" menu option list, then enter a file name and save location in the dialog boxes. A suggested file name is monitoring crew assignment and the year (e.g. "ACAD_2011" or "LNETN_2012").
9. After the settings have been transferred to the LI-1400, click the "Remote" option on the computer program menu, then click "Disconnect" from the drop-down list. The LI-1400 datalogger can now be shut off, and the LI1400 computer program can be shut down.

Table S8.1. NETN Default LiCor 1400 Datalogger Configuration Values.

Parameter	NETN Default Value
Channel I1:	
Sensor Type	Light
Description	DECK
Channel Label	D
Multiplier	*from calibration cert*.
Average	15 seconds
Logging options	None
Channel I2:	
Sensor Type	Light
Description	PAR
Channel Label	UW
Multiplier	*from calibration cert*.
Average	15 seconds
Logging options	None
Channel M1:	
Sensor Type	General
Description	PTRANS
Channel Label	PCT
Input Channel	I2
Average	15 seconds
Math Function	None
Channel Operation settings:	
Operator	/
Channel	I1
Function Type	NONE
Description	*Leave blank*
Parameter A1	*Leave all parameters blank*
VB BATT VOLTAGE	
Sensor Type	Battery
Logging routine	None

Light Penetration Profile Field Method

1. Connect both the deck cell (LI-190SA) and the submersible PAR sensor (LI-193SA) cables to the appropriate BNC connectors on the LI-1400 datalogger (deck connects to Channel 1, PAR to Channel 2).
2. Note the start time for the profile on the grid on page 2 of the field data form.
3. Secure the deck cell to a level spot on the boat, in full sun. In LNETN, where inflatable boats are used and the deck cell cannot be easily secured, an assistant can hold the cell in place.
4. Put the lowering frame in the water, on the sunny side of the boat (ACAD), or suspend the PAR globe sensor from an oar on the sunny side of the boat (LNETN).
5. Turn the data logger on and wait at least a minute for the logger to begin averaging readings. Keep the top of the PAR globe cell (on the lowering frame) barely below the surface of the water. Scroll through the datalogger readings and note when they begin to stabilize.

6. When readings become relatively stable (often hard to tell!) press the "Enter" key to record values to memory. Record the values on the field form in the spaces for the appropriate depth (in this case 0.1 meters). *Note: The datalogger DOES NOT record depth values (or site names) in the saved measurements. It is imperative to accurately record the values for each measurement so that depth data can be added during post-processing.*
7. Repeat this procedure at a minimum of six to eight depths within the photic zone. Readings should be spaced closer together near the surface where PAR attenuates the fastest.
    a. At deeper (>3m) lakes at Acadia, take the next reading at 0.5 meters (upper loop of lowering frame just below water surface) and then at 1 meter (first graduation on the cord). Repeat at one-meter intervals until the percent transmission drops below 1% for two consecutive readings.
    b. At shallower lakes and ponds (< 3 m), take readings at the following depths: 0.1 m, 0.25 m, and then at 0.25 m intervals. The deepest measurement should read below 5% on channel M1. Add additional depth readings up to 3.0 m until this is achieved or the bottom is reached. For very turbid and/or shallow stations, compress the six to eight readings into less depth. Do the opposite for stations with clear deep water.

Downloading Data from Datalogger

At the end of each day in the field, the light profile data should be downloaded from the datalogger to a PC and backed up to removable media and/or a data server. It is downloaded using the LI-1400 software via a RS-232 cable. The data are then pasted to a .txt file which is subsequently opened in Excel.

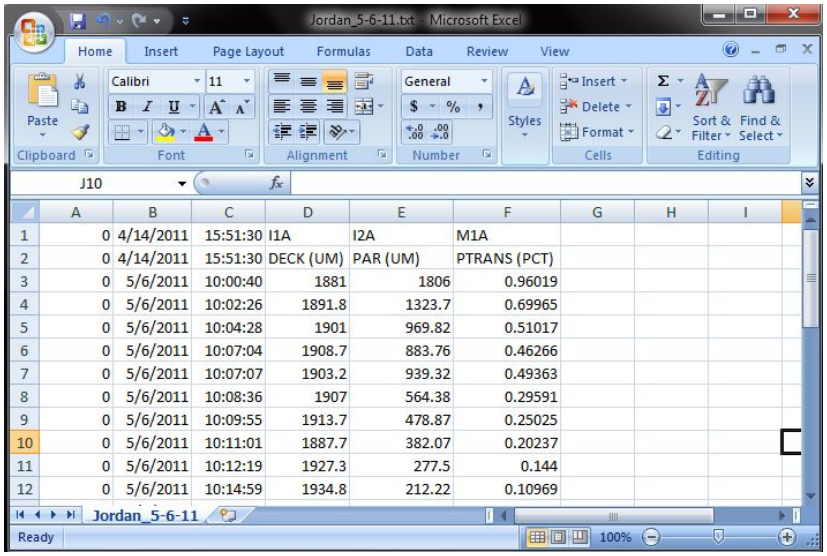
1. Connect the LI-1400 datalogger to the computer serial port using a 9-pin RS-232 cable.
2. Launch the LI1400 software on the computer. Turn on the LI-1400 datalogger using the <On/Off> button.
3. Click the “Remote” option on the computer program menu, then click “Connect” from the drop-down list.
4. Choose the appropriate COM port number to connect to (usually COM 1). A small dialog box will open and display a “Synchronizing” message. The box will disappear when the datalogger is connected.
5. Click the “Remote” option on the computer program menu, then click “Receive Data” from the drop-down list. This command downloads all (or selected portions) of the data from the LI-1400 memory to a text file.
6. Choose between downloading all data or a selected range and click “OK”.
7. Save the text file using a file name in the format “SITENAME_DATE_LPP.txt”, such as “MABIPA_8-15-2010_LPP.txt”.
8. After the File Transfer dialog box closes indicating the save is complete, click the “Remote” option on the computer program menu, then click “Disconnect” from the drop-

down list. The LI-1400 datalogger can now be shut off, and the LI1400 computer program can be shut down.

Post-Processing Downloaded Data

The LI-1400 datalogger does not record the depth of each light measurement nor the sample site at which the measurement was taken. These data must be added in post-processing (after the text file has been opened in Excel), by associating the information from the field sheet (using the date and time stamps in the profile, and the values for each reading which should approximate those recorded in the datalogger file). Extra columns are added for site name and depth, and blank rows are removed (see Figures S8.1 and S8.2) and the file is saved in the .xls format.

1. Launch MS Excel spreadsheet software and open the appropriate text file for post-processing. *Note: be sure the Excel browse window is set to display "Text files" or "All files" in the "Display file type" dropdown box.*
2. The Text Import Wizard will open to help determine how to properly open the text file. Select "Delimited" as the Original Data Type in the first screen, then click "Next".
3. Choose "Tab" (usually already checked) and "Space" as the data delimiters, then click "Finish".
4. The data will be displayed in a worksheet resembling Figure S8.1.

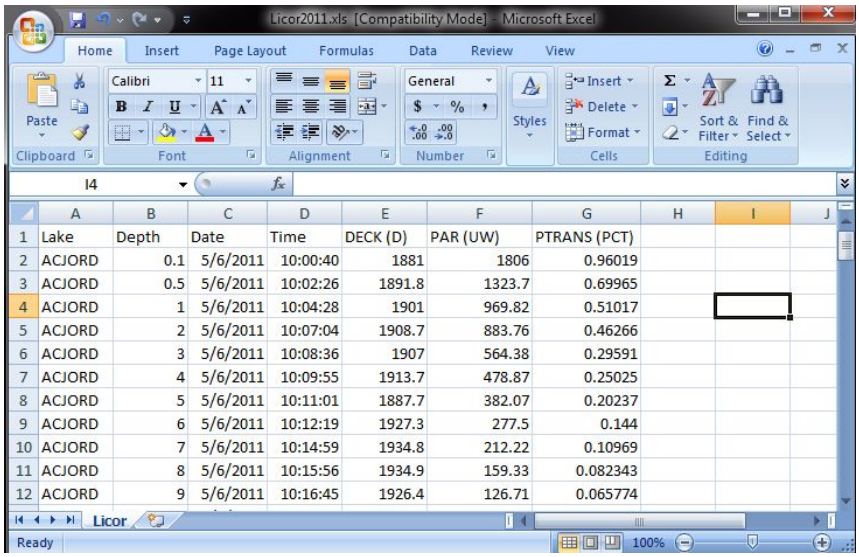


	A	B	C	D	E	F	G	H	I
1	0	4/14/2011	15:51:30	I1A	I2A	M1A			
2	0	4/14/2011	15:51:30	DECK (UM)	PAR (UM)	PTRANS (PCT)			
3	0	5/6/2011	10:00:40	1881	1806	0.96019			
4	0	5/6/2011	10:02:26	1891.8	1323.7	0.69965			
5	0	5/6/2011	10:04:28	1901	969.82	0.51017			
6	0	5/6/2011	10:07:04	1908.7	883.76	0.46266			
7	0	5/6/2011	10:07:07	1903.2	939.32	0.49363			
8	0	5/6/2011	10:08:36	1907	564.38	0.29591			
9	0	5/6/2011	10:09:55	1913.7	478.87	0.25025			
10	0	5/6/2011	10:11:01	1887.7	382.07	0.20237			
11	0	5/6/2011	10:12:19	1927.3	277.5	0.144			
12	0	5/6/2011	10:14:59	1934.8	212.22	0.10969			

Figure S8.9. Light profile data before post-processing

5. Insert extra columns in the worksheets to accommodate depth values and lake or pond name (6-letter NETN code). Delete rows and columns containing unnecessary information.
6. Add the depth and site codes from the field data sheet. When finished, the data should be formatted like the worksheet displayed in Figure S8.2.
7. Save the processed worksheet as an Excel spreadsheet (.xls format). Do not save any changes to the text (.txt) file from the datalogger. The text file should be archived with the other raw digital data from the sampling season (see the *Backup and Archiving* section of *SOP 13 – Data Management*).

8. All Excel worksheets will be merged prior to import into the NETN_H2O database. It is imperative that column order and formatting be consistent in all files.



	A	B	C	D	E	F	G	H	I	J
1	Lake	Depth	Date	Time	DECK (D)	PAR (UW)	PTRANS (PCT)			
2	ACJORD	0.1	5/6/2011	10:00:40	1881	1806	0.96019			
3	ACJORD	0.5	5/6/2011	10:02:26	1891.8	1323.7	0.69965			
4	ACJORD	1	5/6/2011	10:04:28	1901	969.82	0.51017			
5	ACJORD	2	5/6/2011	10:07:04	1908.7	883.76	0.46266			
6	ACJORD	3	5/6/2011	10:08:36	1907	564.38	0.29591			
7	ACJORD	4	5/6/2011	10:09:55	1913.7	478.87	0.25025			
8	ACJORD	5	5/6/2011	10:11:01	1887.7	382.07	0.20237			
9	ACJORD	6	5/6/2011	10:12:19	1927.3	277.5	0.144			
10	ACJORD	7	5/6/2011	10:14:59	1934.8	212.22	0.10969			
11	ACJORD	8	5/6/2011	10:15:56	1934.9	159.33	0.082343			
12	ACJORD	9	5/6/2011	10:16:45	1926.4	126.71	0.065774			

Figure S8.10. Light profile data after post-processing.

Determining the Attenuation Coefficient

LiCor light data can be used to calculate the attenuation coefficient of downwelling PAR (K_d) for each profile. Procedures detailed below are from Kopp and Neckles (2009).

1. K_d should be first calculated as the slope of the least squares regression of $\ln(I_z/I_{air})$ against depth in meters, where I_z is the irradiance at depth z, and I_{air} is the irradiance in air. Units of K_d are m^{-1}.
2. I_z/I_{air} is recorded on the data output from the Li-Cor 1400 under the column labeled "PTRANS (PCT)".
3. Calculate the coefficient of determination (r-squared) for the fit of this least square linear regression.
    a. If the r-squared is 0.95 or greater, report the slope of this line as K_d for this site. This method accounts for variation in ambient irradiance caused by changes in cloud cover.
    b. If the r-squared is less than 0.95, then calculate K_d as before, but substituting I_z for the ratio I_z/I_{air}. This data is labeled "PAR(UW)" from the Li-Cor 1400 data. If the r-squared for the new regression is 0.95 or greater, then use this new slope as K_d for the site. This method may yield better results if the readings in air ("deck" sensor) were faulty, but does not account for changes in cloud cover.
    c. If neither approach yields a coefficient of determination ≥ 0.95, then select the slope of the regression with the higher r-squared, provided it is ≥ 0.9. If this condition cannot be met, then use best professional judgment to determine whether a representative K_d can be calculated by eliminating outliers in the data or including data that had originally been struck through by the field technician.

Appendix S8.A: Transparency Tube

A transparency tube was used from 2006 through 2011 as an alternative method for measuring water clarity in streams and ponds that were too shallow for use of a Secchi disk. The transparency tube was only used outside of Acadia NP, and the only park streams tested in which the Secchi pattern was not always visible at the end of the tube were at Saratoga NHP.

There is a loose relationship between SD and transparency tube values, and transparency tubes can be used in streams as well as ponds (Dahlgren et al. 2004).

Measuring Transparency with a Transparency Tube

A 120 cm transparency tube can be used as a surrogate for water clarity measurements in streams or ponds that are too shallow to obtain a Secchi disk measurement. The clear tube is filled with sample water, which is slowly drawn off until the target (a black and white pattern resembling a miniature Secchi disk) at the bottom of the tube becomes visible.

1. Fill a clean sample container at about 0.5 m (18 inches) below the surface of the water. Point the container opening in the direction of the waves or current. Avoid collecting sediment or debris floating in the water.
2. Gently shake the sample bottle to re-suspend any sediment that may have settled.
3. Pour contents of sample bottle into transparency tube to the 120 cm mark.
4. *If the black and white Secchi pattern at the bottom of the tube is visible through 120 cm of water*, the water is too clear for transparency to be measured using this method. Record the 120 cm value on the field data sheet, and record "B" in the box after "Did disk hit bottom?"
5. *If the Secchi pattern is NOT visible through the 120cm of water*, open the clamp on the hose at the bottom of the tube to begin draining the water from the tube. It is often helpful to have a second person operate the hose clamp.
6. Immediately re-clamp the drain hose when the Secchi pattern becomes visible at the bottom of the tube.
7. Record the water height in the tube at the point when the Secchi pattern becomes visible.

SOP 8 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.00	March 2007	B. Mitchell	**Section 4.1A:** Added SOP *(SOP 9A)* to cover Transparency Tube readings. **Literature Cited:** Added Dahlgren paper on transparency tubes.	Protocol Review Meeting
2.02	April 2009	B. Mitchell	**Section 3.4:** Expanded Transparency Tube procedures. These measurements should be made annually, at high flow. (orig: SOP 9– Transparency Tube) **Section 4.1:** Incorporated 4.1A into this section, and clarified location and timing of transparency tube measurements. *(orig: SOP 11– Secchi disk & transparency tube)*	Protocol Review Meeting
3.00	January 2012	B. Gawley	Reformatted using NRPS-NRR template. Combined all or sections of v2.02 SOP #s 9, 11, 15, and 26 to consolidate all instructions for water clarity determination. Re-assigned as SOP 8. Added sections on LaMotte 2020e turbidity meter. Expanded sections on light penetration profiles, including configuration values, data download and post-processing instructions. Moved section on transparency tube to Appendix S8.A.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits	Internal review
3.02	December 2013	B. Mitchell	Minor edits Rearrange some content in the Background and Scope section, specify what techniques are used when and where, and add information about transparency tube and the collection of stream turbidity since 2012. Revised Secchi section for clarity: note when disk hits bottom, record depth even if the disk hits bottom, and don't take a QC depth if the disk hits bottom. Added specification limits for turbidity calibration. For Li-Cor profile, in LNETN an assistant can hold the deck cell in place. In LNETN the PAR globe sensor is suspended from an oar to keep it away from the side of the boat.	Reviewer comments

Version #	Date	Revised by	Changes	Justification
			Adjusted depth intervals for light penetration profile in shallow ponds to be at even 0.25 m intervals.	

SOP 9 – Collecting Streamflow and Stage Data

Northeast Temperate Network

Version 3.02

Overview

The purpose of this SOP is to document the standards, policies, and procedures for the collection, processing, storage, and analysis of streamflow and stream stage. Use this SOP in concert with more specific instructions as outlined in sources such as Rantz et al. (1982) and the technical manual for the FlowTracker (SonTek/YSI 2006).

Background and Scope

Streamflow is one of the most fundamental measurements of a stream ecosystem, and is necessary for the interpretation of water-quality measurements and the calculation of loads of those water-quality parameters including total maximum daily load (TMDL) calculations as specified in the Clean Water Act. It is useful to normalize water chemistry and water-nutrient measurements by flow in freshwater streams because many constituents tend to have strong relations with flow. Therefore, trend work in running waters is difficult unless one calculates flow-adjusted concentrations.

Discharge measurements can be made each time an estimate of streamflow volume is desired, using a current meter or direct volumetric measurement. Streamflow can also be calculated from continuous or discrete readings of stage. A continuous record of stage is obtained by installing instruments that sense and record water-surface elevations. Stage can also be obtained for discrete measurements by reading water levels off of a staff gage or tape-down from a fixed point (datum) whenever the site is visited.

Continuous measurement of stage verified by several annual measurements of discharge to define or verify the rating is the most accurate and complete method for estimating temporal fluctuations in streamflow. The installation and maintenance of this type of continuous gaging station may be cost prohibitive for most parks. Where a continuous gaging station is not feasible, or where additional streamflow information is desired to interpret water-quality measurements across the park, there are two options.

- Option 1 is to measure discharge each time an estimate of streamflow is desired. The advantages of this option are that an on-site or roving hydrologic technician can make these discharge measurements *if* given the proper training and support. One disadvantage of this option is that the streamflow measurements must be made on the same day that the water-quality sample is collected. If one agency is collecting streamflow data and another agency is collecting water-quality samples, these efforts must be closely coordinated. Another disadvantage is that ideally more than one field staff member must be trained and available at each park (or in NETN) to make discharge measurements when the first field staff member is sick or on vacation. Training, support and a back-up plan for when the trained staff member is unavailable is critical to the success of this option. Following

QA procedures is vital, including periodic check measurements by another qualified individual.

- Option 2 is to install a staff gage or tape-down point, develop a rating based on several calibration streamflow measurements per year, and then read off of the staff gage each time an estimate of streamflow is desired. The advantages of developing a rating are that just about any field staff member can quickly take a reading or make a tape-down from a fixed point, as many times as necessary throughout the year (including every time a water-quality sample is collected), once the rating is established. This option requires a lesser degree of training and thus more field staff members can be efficiently trained to obtain the reading. The disadvantages include the expense of obtaining and maintaining the rating. The establishment of a rating curve requires several measurements per year for at least the first 3 years. If the rating is stable, discharge measurements can be made less frequently in subsequent years.

NETN's approach is a combination of the two options. Discharge measurements are made each time water-quality measurements are taken (Option 1 as explained above), and tape-down points have been established at all stream water-quality-monitoring stations in all parks that do not have a continuous-record streamflow-gaging station (Option 2 as explained above) so that a rating can be developed sometime in the future. Small battery powered water level loggers (e.g., Hobo or Global loggers) are also being deployed in NETN streams to increase the resolution of stream stage data, as budget allows.

Measuring Discharge

Acceptable equipment

Direct measurements of discharge are made with any one of a number of methods; the most common being the current-meter method. Discharge is measured in cubic feet per second by making measurements of a particular cross-sectional area of the river and the velocity of the water past that cross section. Two types of current meters are used within NETN parks to measure stream velocity. The Price pygmy meter utilizes a horizontal "cup wheel" that is rotated by the action of flowing water. The speed of the cup wheel rotation is used to determine the velocity of the water passing by the cups. Alternatively, the SonTek FlowTracker uses acoustic (Doppler effect) measurements to calculate water velocity. Regardless of meter choice, discharge then is calculated by multiplying the width, depth, and velocity of each section of the river. A comparison of the features, strengths and limitations of the Pygmy and FlowTracker meters is presented in Table S9.1. Detailed procedures used for current-meter measurements are described in Rantz et al. (1982), Carter and Davidian (1968), Buchanan and Somers (1969), and SonTek/YSI (2006).

In NETN parks, the Price pygmy meter is the only cup-type current meter used, since all streams are shallow. However, staff should be aware of the types of cup meters available and their optimal operating conditions, presented in Buchanan and Somers (1969) and Rantz et al. (1982). In general, the larger Price AA meter is used when most depths are greater than 1.5 ft across the section, and a Pygmy meter is used for depths between 0.3 and 1.5 ft.

When field staff make measurements of stream discharge, attempts are made to minimize errors. Sources of errors are identified in Sauer and Meyer (1992). These include random errors such as depth errors associated with soft, uneven, or mobile streambeds, or uncertainties in mean

velocity associated with vertical-velocity distribution errors and pulsation errors. These errors also include systematic errors, or bias, associated with improperly calibrated equipment or the improper use of equipment. Current meters are also inspected before and after each measurement and tested at the conclusion of each field trip. The test results are recorded in the current meter log (Appendix S9.A) maintained for each meter and reviewed annually by the crew leader. All meters are also inspected annually by someone other than the person to whom the meters are assigned.

Table S9.1. Comparison of Pygmy and FlowTracker current meters.

	Price Pygmy meter	FlowTracker	Comment
Minimum depth for measurement	0.20 ft	0.10 ft (2 cm)	FlowTracker usually better in shallower streams
Low velocity threshold	0.2 ft/sec	0.003 ft/sec	FlowTracker usually better in lower flows
High velocity threshold	2.5 ft/sec. maximum measureable velocity is limited by the ability to count audible clicks	13 ft/sec, assuming no angles. (Ex: 6.5 ft/sec with a 20° angle)	FlowTracker usually better in higher flows
Particles in the water (Signal to Noise Ratio)	Can be used in any water, although the clearer, the better. Water with a lot of particles (i.e. suspended clay or detritus) can muck up moving parts.	Measurement is determined by Signal to Noise Ratio (SNR), which measures the strength of the acoustic reflection from particles in the water. SNR should ideally be above 10 dB (logarithmic units), but must be above 4 dB in order to take a reliable measurement. Take a measurement to determine the SNR, do not guess based on a visual observation of the water clarity.	FlowTracker needs more particles in the water, Pygmy does better in clearer water. Do not necessarily make this decision based on visual observations, take sample measurements.
Substrate and boundary errors	The more even the substrate, the better for both meters, but measurements on uneven substrate are more easily taken with pygmy meter than the FlowTracker	The more even the substrate, the better. Boundary errors will occur if measurement is taken less than 2 inches away from a boundary, such as a rock. Close boundaries can have impact on system performance	Pygmy will do better in narrower, shallower streams with uneven substrate. Accuracy of FlowTracker is compromised by close boundaries. Acoustic reflections can affect velocity data when working in shallow, narrow streams

Pygmy meter

The Pygmy meter can be used for depths between 0.3 and 1.5 ft, and is capable of measuring streamflow velocities from 0.1 to 4.9 feet per second (ft/s) (http://www.rickly.com/sgi/pygmy.htm). Rantz et al. (1982) point out that at depths below 0.75 ft, the Pygmy meter under-registers the velocity because of the boundary effects of the surface and stream channel. Despite this, the Pygmy meter is still recommended at depths down to 0.3 ft as the error associated with under-registration, estimated in Rantz et al. (1982) to be up to 5

percent at 0.3 ft, is considered acceptable when compared to the complexity of other measurement methods at these depths. When depths are consistently below 0.3 ft, the section can be slightly modified to produce the desired depths or an alternative measuring method must be used. In general, meters are used with caution when a measurement must be made in conditions outside of the recommended ranges. Any deviations from these criteria are noted and the measurement accuracy is downgraded accordingly

The Pygmy works well in moderate to low flows, although when flows are very low, there may not be enough energy to turn the meter cups. Alternatively, since the velocity is determined by counting the clicks produced as the Pygmy cups make each complete revolution, very high flows can make it difficult to get an accurate click count.

Operating principles:
The pygmy meter measures stream velocity using a mechanical method. As the bucket wheel turns one full revolution, a thin wire "whisker" makes contact with a flat spot on the axle shaft of the bucket wheel, registering an audible electronic click that can be heard through attached headphones. Each click indicates that the bucket wheel has been pushed a specified distance by the streamflow. Thus, the number of clicks recorded in a standard time interval (no less than 40 seconds) divided by the time in seconds produces the at-point velocity for the measured section (V=Distance/Time).
The meter is positioned at the proper measurement depth (0.6 of the water depth for stream depths less than 2.5 feet) by matching two sets of graduated marks on opposing sections of the adjustable wading rod.

Preparation and deployment notes:
All parts of the Pygmy assembly must be closely examined prior to each use to ensure that they are clean, intact, and in proper working order. These checks should be performed in the lab or home base before each field visit:

- Check pivot pin, shaft, and bearing surfaces to ensure they are clean, properly lubricated (over-lubrication is to be avoided as it can attract fine dirt and debris), and free of burrs, wobbles, and other signs of wear.
- Check pivot pin for magnetization with a steel paper clip (the pin should NOT attract the paper clip when touched).
- Remove the shipping plug and replace with pivot pin. Adjust pivot adjustment nut on pivot pin until there is only a slight amount of play in the bucket wheel. The bucket wheel must turn freely with minimum resistance.
- Attach the meter and the earphone to the wading rod, spin the bucket wheel, and listen for clicks after each full rotation. If no clicks are heard, first check/replace the battery in the earphone and check all wires and connections.
- If electronics are in good order, remove the contact chamber cap and check/adjust the binding post wire ("whisker") to ensure it engages properly with the shaft trigger spot.
- Once clicks have been re-established, perform a timed spin test by manually flicking the bucket wheel so it spins at a high rate of speed and measure the amount of time elapsed until the wheel comes to a complete stop. The minimum acceptable spin test time is 45

seconds. If the spin test is consistently near or below this value, disassemble, clean (using lint-free tissues), and/or repair meter and do not use until you obtain acceptable test results.

- Remove pivot pin and replace shipping plug in preparation for transport to the field.
- Record spin test results and details of any maintenance/repair activities performed in the equipment log sheet (see Appendix S9.A) for that meter.
- When in the field, avoid banging the Pygmy on rocks, roots, the stream bed, etc. since most of the moving parts are very fragile and easily damaged. Consider using a different discharge measurement method if there is a lot of silt or debris in the stream which will reduce the accuracy of the measurement and quickly foul and/or damage the Pygmy meter.
- Perform a spin test before and after each discharge measurement and record the results on the field data form.
- When taking measurements, hold the wading rod level (plumb) and loosely enough to allow the Pygmy to turn with any angle of the current. Be sure to document the angle coefficient on the data entry for the measurement(s) in which there was an angle deviation.

Q-Calc PDA software:

This Windows Mobile-based software utility was developed by the USGS to facilitate discharge data collection in the field. It provides a series of screens on which to record all data collected during a discharge measurement, including gage heights, spin test results, and field notes. The program calculates section areas and at-point velocities immediately after data for each section is entered. Final calculations (total discharge, average velocity, total area) are made immediately after ending the overall measurement. A formatted .html file containing measurement data, calculations, and notes is saved in the PDA memory and can be downloaded to a PC using Microsoft ActiveSync software.

Several items Q-Calc users should keep in mind:

- Be sure PDA batteries are fully charged before each field visit. The program contains a utility that displays remaining battery life – if levels drop below 25% there is risk of losing data! Strongly consider recording data on a paper form as a backup if battery reserves are questionable.
- Q-Calc creates a temporary plain text (.txt) file of measurement data that can often be used to recover information if the primary .html file is lost or corrupted. The text file is found in the same file directory as the .html file, with the same file naming convention.
- If your PDA accepts a memory card for removable data storage, it is strongly recommended to make a back-up copy of the measurement file on the card (in addition to the file stored in PDA main memory) before exiting the Q-Calc session.
- ALWAYS transcribe the total discharge, average velocity, and total area values to the field data form as soon as they are calculated and displayed on the PDA.
- More information on Q-Calc is found in *SOP 13 – Data Management*.

FlowTracker

Mechanical current meters like the Pygmy have limitations, including: 1) a shallow depth limit of 0.30 ft, 2) a low velocity threshold of 0.10 ft/s (feet per second), 3) extensive maintenance is required to maintain meter accuracy, 4) sensitivity to vertical velocities, and 5) disturbance of the flow measured by the meter. These limitations can hamper the usefulness of mechanical meters, particularly at very low flows when streams can be shallow and slow (Fisher and Morlock 2002). The SonTek FlowTracker, a "hydroacoustic" meter, can provide an attractive alternative to mechanical current meters for shallow-water discharge measurements.

The standard FlowTracker uses a 2D side-looking probe. The sampling volume is located 10 cm (4 in) to the side of the probe, and can operate in as little as 2 cm (1 in) of water (SonTek/YSI 2007). Hydroacoustic current meters use the Doppler principle applied to underwater sound to measure water velocities. Advantages of hydroacoustic current meters include: 1) no moving parts provides simple maintenance, 2) instrument calibration remains stable provided components are not damaged, 3) velocity accuracies of 0.01 ft/s are attainable, 4) high sample and data output rates, and 5) quality-assurance data not available for mechanical current meters can be collected (Fisher and Morlock 2002).

Disadvantages of hydroacoustic current meters include: 1) higher acquisition cost than mechanical meters, 2) damage or malfunctions cannot usually be repaired without return to the manufacturer, and 3) these instruments may function poorly or not at all in clear water (Fisher and Morlock 2002).

According to the technical manual (SonTek 2007), the FlowTracker is capable of measuring streamflow velocities as low as 0.003 ft/s and up to 13 ft/s. Fisher and Morlock (2002) state that based on laboratory and field tests, velocity measurements with hydroacoustic meters cannot be validated below about 0.07 ft/s. However, hydroacoustic meters provide valuable information on direction and magnitude of flow even at lower velocities, which otherwise could not be measured with conventional measurements.

The FlowTracker has a potential for acoustic interference from underwater objects. The system tries to avoid this interference, but you must be aware of system limitations. Reflections can occur from the bottom, the water surface, or submerged objects (e.g., rocks). If the sampling volume is on top of or beyond an underwater object, velocity data will be meaningless (SonTek 2007).

Acoustic reflections can potentially affect velocity data when working in very shallow water or near underwater obstacles (with the sampling volume within 15 cm [6 in] of the obstacle), At each measurement location, the FlowTracker looks for these conditions, and if necessary, adapts its operation to avoid interference. For most locations, any required changes do not affect system performance. In some environments, changes may result in a lower maximum velocity (SonTek 2007).

Operating principles:

The FlowTracker uses acoustic Doppler measuring technology (rather than a mechanical means like the Pygmy) to indirectly measure the velocity of the water. The FlowTracker measures the velocity of particles, sediment, small organisms, and bubbles suspended in the flow, assuming that these particles travel at the same velocity as the water. Therefore, the quality of the

measurement is dependent on the presence of particles within the sampling volume that reflect a transmitted signal (Rehmel 2007).

The meter is positioned at the proper measurement depth (0.6 of the water depth for stream depths less than 2.5 feet) by matching two sets of graduated marks on opposing sections of the adjustable wading rod.

Preparation and deployment notes:
It is beyond the scope of this SOP to explain the step-by-step operation of the FlowTracker. All field personnel should become familiar with the instructional resources (manuals and training video) supplied with the meter. The following checks should be performed, as noted, either in the lab or home base before field visits or in the field prior to measuring discharge:

- Before the first discharge measurement trip of each month, conduct a "*BeamCheck*" diagnostic procedure in the lab or office. The *BeamCheck* utility tests all aspects of system performance, and requires the FlowTracker to be connected to an external computer. Using the *BeamCheck* for the first time should take about 30 minutes-experienced users should require 5 to 10 minutes.
- In the field, first check the setup parameters. Turn the FlowTracker on, then press <ENTER> to display the *Main Menu*. Press option 1 to enter the *Setup Parameters Menu*. Review the settings and change if needed. Default settings for NETN monitoring are:

  Units: English **Averaging Time:** 40 seconds

  Mode: Discharge **Salinity:** 0.0 ppt (freshwater)

  Discharge Equation: Mid Section
- Press 0 to return to the *Main Menu*. Next press 2 to enter the *System Functions Menu.*
- Check the *Recorder Status* (option 2 in the System Functions menu) to verify the amount of available storage space and recorder setup parameters.
- Check *Temperature Data* (option 4 in the System Functions menu) to make sure it is reasonable for the environment.
- Check *Battery Data* (option 5 in the System Functions menu). Expected battery life at 20 ^{o}C (70 ^{o}F) is around 25 hours for alkaline batteries and about 15 hours for NiMH rechargeable batteries.
- Check *Raw Velocity Data* (option 6 in the System Functions menu). Place the probe in the area to be measured. SNR (signal to noise ratio) should ideally be above 10 dB, and no less than 4 dB. *Note: Choose an alternative measurement method, such as the Pygmy, if SNR value is very low.* The velocity reading should appear reasonable for the environment.
- Check *System Clock* (option 9 in the System Functions menu) for the correct time and date.

Establishing measurement sections

- When selecting an area of the stream in which to establish a measurement cross-section, care should be taken to avoid in-stream features that will hinder accurate velocity measurements. Boulders or large cobbles upstream of the measurement section can impede streamflow or cause angles and eddies. Try to utilize cross-sections with relatively uniform depth and bottom composition to enable more accurate measurements of cross-sectional area. Look for well-defined stream banks, since undercutting, braiding, and seepage through loosely packed substrate can contribute to the loss of measurement of considerable amounts of streamflow.
- Some manipulation of the stream bed (e.g. removing or re-arranging cobbles, plugging leaks with sand bags, etc.) is acceptable to create a more suitable measurement section, but extreme care must be taken to avoid resource damage. Allow the streamflow to equilibrate for several minutes after manipulation before beginning measurements.
- Set up the tagline (measuring tape) perpendicular to the majority of streamflow, anchored on each bank with stakes or heavy objects. Be sure the tagline is taut, so measurement intervals are accurate, and so the tape does not sag into the stream and affect the flow.

Measuring discharge

Depending on the type of meter used, specific details of this procedure will vary. Consult Rantz et al. (1982) for instruction on the use of the Pygmy meter, and the FlowTracker technical manual (SonTek 2007) for more information on using the FlowTracker.

- Perform a spin test (Pygmy) or field diagnostics (FlowTracker) and any other prescribed pre-deployment QA procedures.
- The measurements can be started on either the REW (right edge of water, determined while looking downstream) or the left edge of water (LEW).
- The observer should be standing (wading) downstream of the tagline, looking upstream.
- The observer's feet should be offset from the measurement point, and preferably one behind the other to minimize the disturbance to the streamflow.
- At each observation vertical (measurement section), the observer measures stream depth using the graduations on the wading rod, then sets the correct measurement height using the marks on the wading rod handle.
- Velocity is then measured by either counting the number of clicks produced by the bucket wheel in an approximately 40-second time interval (when using the Pygmy) or is determined automatically by the FlowTracker datalogger routine.

  When using narrowly spaced observation verticals (0.2 to 0.3 feet) it is often necessary to estimate the amount of flow in the first measurement section if a depth can be measured but the meter sensor cannot be positioned close enough to take an actual measurement. Both the FlowTracker datalogger and the Q-Calc PDA software for the Pygmy have utilities that will calculate and record this estimate, which will be based on a percentage of the flow of the next observation. If recording observations on a paper form, record the estimated percentage, and calculate the estimated value when making the final flow calculations.

- Section location measurement, stream depth, and (for Pygmy) number of clicks and time interval are recorded either on PDA, field form, or FlowTracker datalogger.
- The measurement process is repeated at each observation vertical until reaching the opposite stream bank (where an estimation may again be necessary). The spacing of observation verticals in the measurement section can affect the accuracy of the measurement (Rantz et al. 1982). Make observations of depth and velocity at a minimum of about 30 verticals where possible, to ensure that no more than 5 percent of the total flow is measured in any one vertical. Even under the worst conditions the discharge computed for each vertical should not exceed 10 percent of the total discharge and ideally not exceed more than 5 percent (Rantz et al. 1982). Exceptions to this policy are allowed in circumstances where accuracy would be sacrificed if this number of verticals were maintained, such as for measurements during rapidly changing stage (Rantz et al. 1982). Fewer verticals than are ideal are sometimes used for very narrow streams (about 12-ft wide when an AA meter is used and about 5 ft wide when a pygmy meter is used). Measurement of discharge is essentially a sampling process, and the accuracy of sampling results typically decreases markedly when the number of samples is less than about 25.
- After taking measurements at the final observation vertical, enter the necessary information to complete the PDA or FlowTracker software routine (or complete and perform the calculations on the paper form) and record the total discharge, average velocity, and total area values on the primary field form for the monitoring visit.
- Conduct post-measurement QA procedures (spin test, etc.) and rate the accuracy of the measurement.

Use procedures for the computation of mean gage height during a discharge measurement presented in Rantz et al. (1982). Mean gage height is one of the coordinates used in describing the stage-discharge relation at a streamflow-gaging site. The FlowTracker makes these calculations automatically, and the PDA software used with the Pygmy meter also makes these calculations.

Quality Control

When a stage-discharge relationship exists, a second discharge measurement is made for the purpose of checking a first discharge measurement when the first measurement differs from the current stage-discharge relation by more than the estimated accuracy of the measurement. This should be determined in the field, from a printed copy of the relationship, stage measurement, and discharge and discharge accuracy estimates provided by Q-Calc or the FlowTracker software. When a check measurement is made, as many factors affecting the measurement as possible are changed, including staff, instruments, and measuring section.

Until the stage-discharge relationship is established and maintained for all NETN streams, field staff should verify their accuracy with one second measurement each month at a randomly selected site, and three measurements per season taken at a USGS gaged station. Accuracy comparison measurements should agree within 10%.

Field Notes

Thorough documentation of field observations and data-collection activities performed by field staff is a necessary component of data collection and analysis. To ensure that clear, thorough, and systematic notations are made during discharge measurements, observations are recorded by field staff on the discharge-measurement paper forms (use the USGS standard form found in S9.B) or in an electronic format (such as the Q-Calc PDA application). Some examples of required discharge measurement data include gage (stage datum or staff gage) readings, depth, distance from initial point, revolutions, vertical or horizontal angles, and time. Other information required to be included by field staff on the measurement note sheet includes, at minimum, the initials and last name of all field-party members; date; times associated with gage readings and other observations; coefficients used; type of meter used; meter number; location of measuring site; measurement rating; condition of the meter before and after the measurement; and descriptions of the cross-section, flow, weather conditions, and control. Information on a discharge-measurement note sheet that is derived from original data, such as total discharge, mean gage height, area, and velocity, should also be recorded on the primary field data form for the monitoring visit.

Compute all discharge measurements before leaving the measurement site, unless emergency evacuation is required for reasons of safety. A review of field note sheets is required after each field trip by the crew leader. Field notes are also reviewed as a part of records computation to ensure that all computations have been checked and that numbers have been transferred correctly from the interior of the measurement form to the front sheet.

Low-Flow Conditions

Streamflow conditions encountered by field staff during periods of low flow are typically quite different from those encountered during periods of medium and high flow. Low-flow conditions can be roughly characterized by from 1 to 2 cubic ft per second per square mile (cfsm); flows typically seen from June through September in most streams during a typical year. Low-flow discharge measurements are made to define or confirm the lower parts of stage-discharge relations for gaging stations, to identify channel gains or losses as part of seepage runs, and to help in the interpretation of associated data. Additionally, low-flow measurements are made to define the relation between low-flow characteristics in one basin and those of a nearby basin for which more data are available.

In many situations, low flows are associated with factors that reduce the accuracy of discharge measurements. These factors include algae growth that impedes the free movement of current-meter buckets and larger percentages of the flow moving in the narrow spaces between cobbles. When natural conditions are in the range considered by the field staff to be undependable, the cross section is physically improved for measurement by removal of debris or large cobbles, construction of dikes to reduce the amount of non-flowing water, or other such efforts (Buchanan and Somers 1969). After modification of the cross section, the flow is allowed to stabilize before the discharge measurement is initiated. Channel modifications are noted on the measurement sheet, including whether or not the stage at the gage was affected by the modification. The use of alternative flow measurement methods such as the use of flumes or volumetric methods are encouraged as alternative methods for measuring low-flow conditions when appropriate for the situation (Kilpatrick and Schneider 1983).

Controls are cleaned of debris or aquatic growth whenever it is possible to completely clean the control. A measurement is made before cleaning the control to document the effect of the debris or aquatic growth on the stage-discharge relation.

Volumetric Measurements

Volumetric measurements can be obtained when streamflow is completely contained within a discrete channel and can be totally captured in a measurement vessel (e.g. low to moderate flow through a perched culvert). The technique entails filling a bucket or other large container with all of the stream water that passes through the channel for a specified amount of time (approximately 8 seconds), measuring the exact volume of water that has been captured in the container, and performing the calculations to determine discharge in cubic feet per second (cfs).

When using this method, it is imperative that no streamflow leaks around or under the control that directs flow into the collection vessel. A large flexible sheet of plastic, or similar device, can be used to help isolate and direct the stream flow. The procedure works best with two observers: one ("the timer") to operate the stopwatch and direct the beginning and end of the sample collection, and the other ("the collector") to physically capture the stream water in the container. The procedure is detailed in the following steps:

1. Carefully inspect the area in which you plan on taking the volumetric measurement. Is ALL the streamflow contained within the pipe, culvert, or stream channel? Is there enough physical space to place the container under the stream flow to collect it all? Do you have a large enough container (and is the flow low enough) to contain all the flow for 8 seconds? If you answer "No" to any of those questions, you may have to direct or isolate the flow with a plastic sheet, etc., or choose another method of discharge measurement.
2. Once the site is deemed suitable for a volumetric measurement, the timer checks that the stopwatch is on zero, and collector readies the collection container near, but not under, the streamflow.
3. The timer announces "One, Two, Three, GO", and starts the stopwatch on "Go".
4. The collector places the container in the streamflow (capturing it all without spilling, splashing, or missing any) on "Go".
5. As 8 seconds approaches, the timer announces "and…. STOP", and stops the watch on "Stop".
6. The collector removes the container from the streamflow on "Stop", and then proceeds to measure the volume of water in the container by carefully decanting into a graduated cylinder.
7. The timer records the exact time elapsed and total water volume captured during the collection repetition on the Volumetric Measurement field form or spreadsheet (Appendix S9.C) and calculates the discharge.
8. Repeat steps 2 through 7 for a total of 10 repetitions. Average the 10 discharge values and record the average value on the primary field form for the monitoring visit.

Measurement of Stage

Many types of instruments are available for measuring the water level, or stage, at gaging stations. There are non-recording gages and recording gages (Rantz et al. 1982). Collect surface-water stage records at stream sites with instruments and procedures that provide sufficient accuracy to support computation of discharge from a stage-discharge relationship. In general, operation of gaging stations for the purpose of determining daily discharge includes collecting stage data at the accuracy of ± 0.01 foot.

Staff gage/Tape-down

The simplest measurement of stage is a discrete measurement taken off of a staff gage with numbers marked on it or taping down from a fixed benchmark or bolt (tape-down). Establish a staff gage or tape-down sites in pools that can be measured at a range of flows and that have a single stable controlling feature at their outflow. Instructions for installing a stage benchmark (datum point) are found in *SOP 2 – Establishing, Maintaining, and Documenting Monitoring Sites*. The preferred stage measurement device is a staff gage. If a staff gage cannot be installed (due to substrate or park requirements), stage measurements are made from benchmarks (typically bolts, where the top flat edge of the bolt is the reference point). If a staff gage reading or vertical benchmark measurement (directly from benchmark to water surface) cannot be taken, use an extension wand. At the Concord River (MIMA), the stage measurement is made using the Secchi disk from the highest point of the bridge (the footpath, not the railing) to the surface of the water (where the Secchi disk just touches the water). All measurements are made to the nearest hundredth of a foot (nearest cm, for the Concord River). Procedures for taking a tape-down measurement using an extension wand (leveling stick) are:

1. Note weather conditions and surface-water temperature on stage monitoring field form. Weather conditions (especially the wave conditions) are important for interpreting the accuracy of the stage measurement.
2. Place one of the nails in the end of the extension wand into the benchmark hole or on the top flat surface of the bolt. Use the level bubble (keep bubble in the center of the circle) to keep wand straight and level.
3. Use folding ruler to measure from the exact surface of the water to the lower edge of the nail on the other side of the extension wand. Double check to make sure the wand is level at the time of measurement.
4. Write the measurement on the field sheet (to the nearest hundredth of a foot), along with all other required information.
5. Two gage readings (before and after measuring discharge) are taken during stream monitoring visits to determine if water level is rising, falling, or stable.
6. *Note: Do not use the extension wand if it is possible to obtain a true vertical measurement from the stage datum to the water surface.*

Continuous-Record Streamflow-Gaging Stations

Continuous-record gaging stations consist of the instrumentation necessary to have continual (at least every 15-minute) readings of water level or stream stage. Sites for installation of continuous-gaging stations are selected with the intent of achieving ideal hydraulic conditions to the greatest extent possible. This includes unchanging natural controls that promote a stable

stage-discharge relation, a stable pool to monitor stage, a satisfactory reach for measuring discharge throughout the range of stage, and the means for efficient access to the gage and measuring site (Rantz et al. 1982).

Typically, pressure-sensor recorders are installed as water-level recorders. Proper maintenance of gage instrumentation or replacement, if appropriate, of equipment is the responsibility of the individual or agency who services the gage. There are two types of continuous record sites in the NETN: those established and maintained by the USGS, and sites at which small battery powered water level loggers (e.g., Hobo or Global loggers) have been purchased and installed by network personnel.

Accurate stage measurement requires not only accurate instrumentation but also proper installation and continual monitoring of all system components to ensure the accuracy does not deteriorate with time. To ensure that instruments record water levels that accurately represent the water levels of the body of water being investigated, instrument readings are compared to those from a reference gage. At pressure-sensor gaging stations, the reference gage is a sturdy low-water outside staff gage or reference point of known elevation.

At all sites, NETN field staff are responsible for comparing the gage height measured by NETN level loggers with the gage height at all available gage datum (tape-up or tape-down) points to determine if the water level is being represented correctly by the recorders. Using the procedure described in the section of *SOP 1 – Establishing, Maintaining, and Documenting Monitoring Sites* entitled *Deploying continuous dataloggers*, determine the elevation of the level logger and verify that it has not changed since the last visit. If the logger elevation has changed, examine the logger data to identify the time of the shift, if possible. If the exact cause and time of the shift can be positively determined, that data can be corrected by adjusting the stage data for the new elevation. If the details of the change in elevation cannot be positively determined, the data for the affected sample period should be considered invalid and thrown out.

Any changes and corrections to gages are documented in the Site Record File, which contains all documentation of the establishment and maintenance of site infrastructure. Invalidations of and corrections to the stage data are noted in the comments field of the NETN_H2O database record for the visit in which the condition requiring correction was discovered.

Stage and discharge data for the USGS sites can be obtained at the "Real-time Data" section of the USGS National Water Information System (NWIS) web interface (http://waterdata.usgs.gov/nwis) by selecting a display option and entering the USGS station number in the search box. Time series (5-minute interval) data are available for 120 days from time of collection; summary data (daily average, etc.) are available for earlier data. The procedures and policies pertaining to the processing and analysis of data associated with the computation of USGS streamflow records, including data from partial-record streamflow-gaging stations and continuous-record streamflow-gaging stations are described in Rantz et al. (1982) and Kennedy (1983).

Data from NETN-owned water level loggers must be downloaded to a PDA, laptop, or data shuttle at each site visit. Download procedures vary depending on the brand and model of

equipment used at a particular site. Consult the manufacturer's operation manual for detailed instructions on this process.

In cold climates, winter stream stage measurements can be affected by ice. Some level loggers must be removed from the field before the streams freeze solid.

Stage-discharge relationship

The development of the relation between gage height (stage) and discharge, also called the rating curve (or rating), allows discharge measurements to be calculated from stage measurements, which are less expensive and easier to obtain, and can be determined continuously. Rating curves can take several years to develop and can change over time as stream-channel conditions change. Detailed information on developing ratings is found in Kennedy (1984). All measurements are plotted each year on the graphical rating plot.

At most USGS permanent record stations, a minimum of three manual discharge measurements are made to confirm the accuracy of the rating each year. One measurement, made either directly or indirectly, is made as close as possible to the highest discharge experienced during the year, one is made as close as possible to the lowest discharge experienced during the year, and one is made at an intermediate discharge. If the three measurements are within 5 percent of the rating in effect, the rating is presumed to be valid for the entire year. If any of the measurements are more than 5 percent different than the rating, additional field measurements are made as needed to confirm and define the cha

At USGS stations which are known to have unstable ratings, measurements are made at each site visit to the station to continually document changes to the rating. Most NETN sites also fall into this category, especially since NETN monitoring can rarely be planned to coincide with extreme high- or low-flow events, and the sites were not selected to have permanent controls and changes in the physical features of the channel may be more likely. A greater number of discharge measurements, and constant review and correction of the rating is necessary to ensure accuracy.

Appendix S9.A. Sample equipment maintenance log form.

NETN Current Meter Maintenance Log

METER TYPE: Pygmy Serial/ID Number: ______________________________

Date	Meter User	Entry Made By	Spin Time	Description of repairs, notation of disassembly, inspections, and remarks

Appendix S9.B. Sample USGS dischage measurement field form

9-275-G
(Rev. 10-81)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER RESOURCES DIVISION

Meas. No. . . . . .

Comp. by. . . . . .

Sta. No. . . . . **DISCHARGE MEASUREMENT NOTES** Checked by . . . . .

. . . . . .

Date . . . . . ., 19 . . . . . Party . . . . . .

Width . . . . . Area. . . . . Vel. . . . . G. H. . . . . Disch. . . . . .

Method . . . . . No. secs. . . . . G. H. change. . . . . in . . . . . hrs. Susp. . . . . .

Method coef. . . . . Hor. angle coef. . . . . Susp. coef. . . . . Meter No. . . . . .

Type of meter . . . . . Date rated . . . . . Tag checked . . . . . .

Meter . . . . . ft. above bottom of wt. Spin before meas. . . . . after . . . . . .

Meas. plots. . . . . % diff. from. . . . . rating. Levels obtained. . . . . .

GAGE READINGS					
Time		Inside	ADR	Graphic	Outside
Weighted M.G.H.					
G. H. correction					
Correct M.G.H.					

WATER QUALITY MEASUREMENTS

No . . . . . Yes. . . . . Time . . . . . .

Samples Collected

No . . . . . Yes. . . . . Time . . . . . .

Method Used

EDI . . . . . EWI . . . . . Other. . . . . .

SEDIMENT SAMPLES

No . . . . . Yes. . . . . Time . . . . . .

Method Used

EDI . . . . . EWI . . . . . Other. . . . . .

BIOLOGICAL SAMPLES

Yes. . . . . Time . . . . . .

No . . . . . Type . . . . . .

Check bar. chain found . . . . . changed to . . . . . at . . . . . .

Wading, cable, ice, boat, upstr., downstr., side bridge. . . . . feet, mile, above, below gage.

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%); based on the following cond:

Flow. . . . . .

Cross section . . . . . .

Control . . . . . .

Gage operating . . . . . Weather . . . . . .

Intake/Orifice cleaned . . . . . Air . . . . . °C@ . . . . . Water . . . . . °C@ . . . . . .

Record removed . . . . . Extreme Indicator: Max. . . . . Min. . . . . .

Manometer N_2 Pressure Tank . . . . . Feed . . . . . Bbl rate . . . . . per min.

CSG checked . . . . . Stick reading . . . . . .

Observer . . . . . .

HWM . . . . . outside, in well

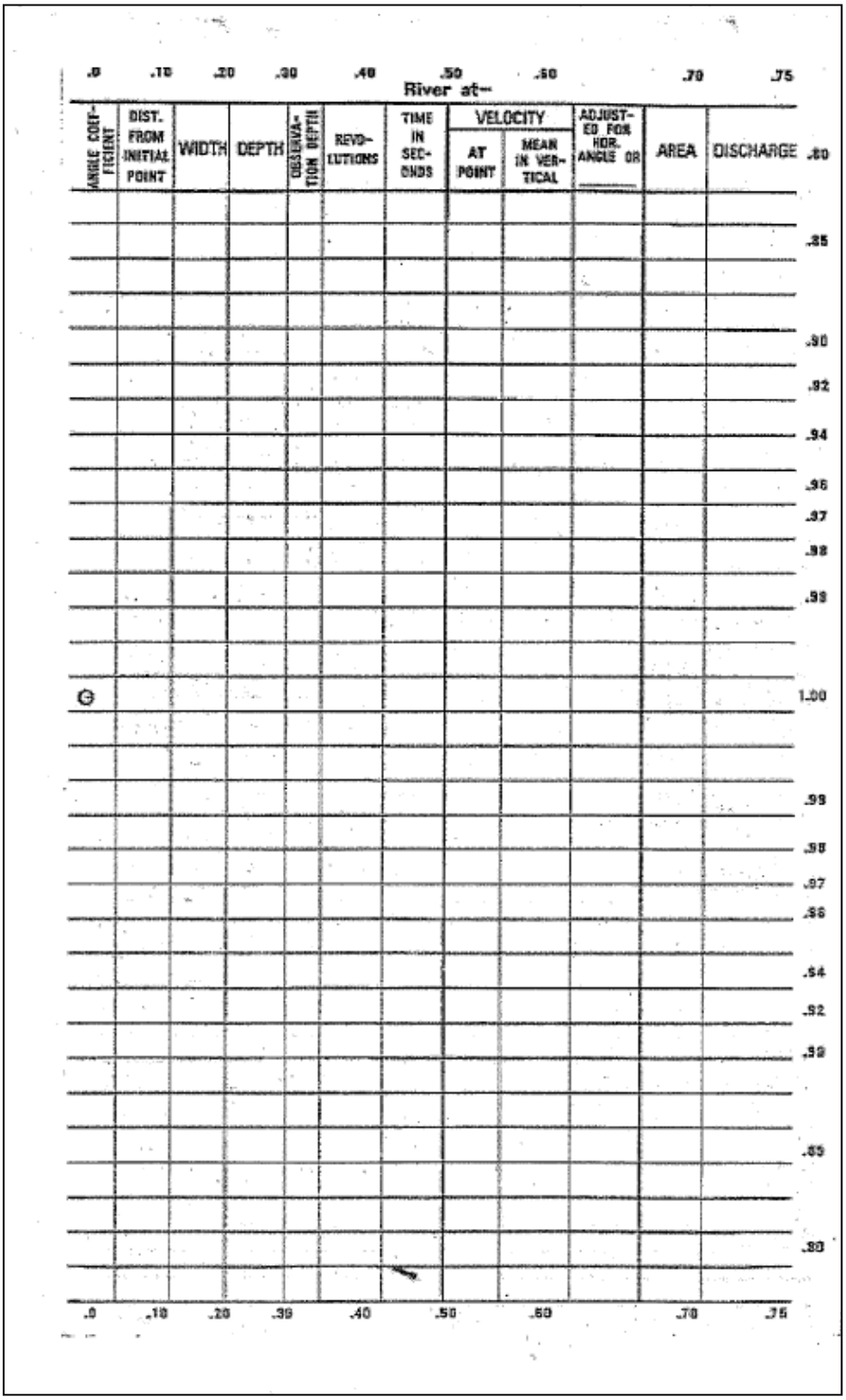
Remarks . . . . . .

. . . . . .

. . . . . .

G.H. of zero flow . . . . . ft. Sheet No. . . . . of . . . . . sheets

Appendix S9.B. Sample USGS dischage measurement field form (continued).



.0 .10 .20 .30 .40 .50 .60 .70 .75

River at—

ANGLE COEFFICIENT	DIST. FROM INITIAL POINT	WIDTH	DEPTH	OBSERVATION DEPTH	REVOLUTIONS	TIME IN SECONDS	VELOCITY: AT POINT	VELOCITY: MEAN IN VERTICAL	ADJUSTED FOR HOR. ANGLE OR _____	AREA	DISCHARGE

.80 .85 .90 .92 .94 .96 .97 .98 .99 1.00 .99 .98 .97 .96 .94 .92 .89 .85 .80

.0 .10 .20 .30 .40 .50 .60 .70 .75

Appendix S9.C. Sample volumetric measurement form.

NETN Volumetric Discharge Measurement Form

Site: _____ Date: _____

Rep #	Time	Volume (ml)	Convert	Volume (cf)	Calculate	Discharge (cfs)
1			x 0.00003531467		Volume (cf)/Time=	
2			x 0.00003531467		Volume (cf)/Time=	
3			x 0.00003531467		Volume (cf)/Time=	
4			x 0.00003531467		Volume (cf)/Time=	
5			x 0.00003531467		Volume (cf)/Time=	
6			x 0.00003531467		Volume (cf)/Time=	
7			x 0.00003531467		Volume (cf)/Time=	
8			x 0.00003531467		Volume (cf)/Time=	
9			x 0.00003531467		Volume (cf)/Time=	
10			x 0.00003531467		Volume (cf)/Time=	
					Mean:	

SOP 9 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.00	March 2007	B. Mitchell	**Section 3.3.2.1:** Added second paragraph, specifying that QC for discharge must be done monthly (one second measurement), plus an additional 3 measurements per field season at a USGS gaged station. *(Originally part of SOP 8– Collection of Streamflow)*	Protocol Review Meeting
2.02	April 2009	B. Mitchell	**Section 3.3.2:** Revised to reflect use of FlowTracker acoustic Doppler meter outside of Acadia NP, and the use of a Pygmy meter at Acadia (and clarified the discussion of Pygmy versus Price AA meters to indicate that only the Pygmy meter is used). *(Originally part of SOP 8– Collection of Streamflow)*	Protocol Review Meeting
3.00	January 2012	B. Gawley	Reformatted using NRPS-NRR template. Combined all or sections of v2.02 SOP #s 8, 16 and 26 to consolidate all instructions for water quantity monitoring. Re-assigned as SOP 9. Added Table 1 comparing current meters. Expanded section on Pygmy meter, including set-up and care instructions. Added section about Q-Calc Expanded information on use of FlowTracker, including pre-deployment and configuration information. Edited discharge measurement instructions to include both Pygmy and FlowTracker. Added section on volumetric measurements. Moved v2.02 section 7.2.3 into this SOP (*from v2.02 SOP 26*) Added maintenance log and field forms as appendices.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits	Internal review
3.02	December 2013	B. Mitchell	Updated “Staff Gage/Tape-Down” section to improve description of procedures, especially for the Concord River. Update “Quality Control” section to specify how decisions about a second discharge measurement are made when a rating curve exists.	Reviewer comment

SOP 10 – Invasive Aquatic Plant Survey Procedures

Northeast Temperate Network

Version 3.03

Overview

The purpose of the invasive aquatic plant survey is to screen parts or all of a lake or pond for target invasive plants. The early detection of an invasive plant infestation can make eradication or control more feasible, and it can help efforts that can reduce the spread of the plant to other areas of the waterbody. This SOP is adapted from Maine Center for Invasive Aquatic Plant (MCIAP) screening survey procedures (Maine Center for Invasive Aquatic Plants 2011). The survey process described here is semi-quantitative. Volunteers can effectively do screening surveys with a minimum of training if basic procedures are followed carefully, and questionable plants are inspected in the field, or sent to professionals for identification. Surveys are done from mid-July through September so that plants will be sufficiently developed to allow for identification.

Staff should also be on the lookout for invasive species that can affect streams, particularly didymo (*Didymosphenia geminata*), also known as "rock snot." Stream surveys are opportunistic and staff should be aware of potential stream invasive species and be vigilant for them when visiting stream sites.

Survey Types

Level I surveys of all lakes in NETN with a public boat launch are done annually. Level II surveys are done on all ponds and impoundments in NETN every year except for in ACAD. Because of the large number of ponds and lakes in ACAD, Level II surveys are conducted when staff availability permits, or in cooperation with certified MCIAP volunteers. It is important that field staff who survey for invasive plants attend a training that includes invasive plant identification methods and a field survey in a lake or pond. This training is offered by the MCIAP.

Level I and Level II surveys include the following:

- Level I: Survey points are of public access and other areas of concentrated boat traffic such as marinas and narrow navigation channels. Boat launch survey areas extend horizontally along the shoreline at least 100 meters (~300 ft) on either side of the boat launch area, and offshore along the entire length to the depth at which rooted plants are no longer observed (the outermost extent of the littoral zone.) If the access area is in a distinct cove, the survey includes the entire littoral zone of the cove, even if the shoreline distance from the launch area to the mouth of the cove is greater than 100 meters.
- Level II: Survey all Level I areas, plus all areas of the shoreline that are likely to provide suitable habitat for aquatic plants, such as shallow, sheltered coves. Floating leaved

plants are often a good indicator of a rich plant community below the surface. In addition to supporting native plants, these areas can provide suitable habitat for invaders.

Equipment Needs

See Appendix S10.A for the list of equipment necessary for invasive aquatic plant surveys. Please note that a boat is always needed for safety and documentation, and the survey can be accomplished much more easily and safely with at least two persons in the boat. Large boats and motors make the process of data collection more difficult, and could destroy sensitive aquatic vegetation. A diver outfitted with snorkel or SCUBA apparatus is helpful in getting close to the plants, and for obtaining specimens, but can also stir-up bottom sediments, reducing visibility.

General Guidelines

Mid-July is generally the best time to begin Invasive Aquatic Plant screening surveys, but the process can begin as late as mid-August. Prior to July, many aquatic plants are not fully developed. Emergent flowering structures are usually needed for plant identification. For example, in variable milfoil flowers do not typically start to develop until July with one exception. Curly leaf pondweed (*Potamogeton crispus*), one of the plants on Maine's watch list, usually reaches maturity by late spring to early summer. Lakes that are high risk for invasive plant infestation can be checked more than once during the season.

The survey can be conducted over a period of time (it does not have to be completed in one day). Survey when there is adequate light, and when conditions are relatively calm. Early morning conditions are often ideal because the water is calm and reflection on the water surface is minimal. It will be difficult to conduct an effective survey during windy conditions. Weekends can be problematic because of heavy powerboat activity on some lakes.

Survey Methods

1. Fill in Section 1 of the Screening Survey Documentation Form (example in Appendix S10.B). Data to be recorded here includes an estimate of the lake water level at the time of the survey using "water marks" on shoreline rocks to help determine whether or not the level is high, average, or low, and a Secchi Depth (clarity) reading if possible. Use a lake depth map to help determine where plant communities may be situated, and to mark the location of the surveyed areas.
2. Begin the survey. No matter which level of survey is undertaken, the survey area extends from the shoreline to the outer depth of the littoral zone--the point at which it is no longer possible to see the lake bottom with a viewing scope or diving mask. The depth of the littoral zone will vary, depending on the clarity of the water. Clear lakes can support rooted plants at depths of 15-20 ft. Shallow ponds can support rooted plants from shore to shore. In areas where the lake bottom drops steeply from the shore, plotting a straight course roughly parallel to the shore generally allows adequate screening of the area from both sides of the boat.
3. Working in teams of two, scan the area from the boat toward the shore with one surveyor, the other surveyor scans from the boat toward the outward extent of the littoral zone. The surveyor in the bow also watches for hazards and the surveyor in the stern steers the boat. The distance from the shore the boat travels is determined by water clarity, wind and wave activity, cloud cover, the angle of the sun, plant density, and the width of the littoral

zone. The width of the littoral zone can be verified occasionally by "spiking out" (heading out perpendicular to shore). The "straight" line of travel along the shore can wiggle and contort from time to time to conform to, and accommodate, shoreline features, docks, moored boats, floats, etc. Be alert to submerged mooring pulley lines!

4. In areas where the littoral zone is wider, in shallow coves, inlets and outlets, and where the plant community is dense and complex, use other course patterns including point-to-point transects. The configuration and spacing of the patterns and transects will vary according to the observation conditions, and density of the plant communities. The overall goal in selecting a proper course pattern is to optimize direct observation of the littoral zone.

Plant Identification

Refer to a regional field aquatic plant field guide to aid in the identification of aquatic plants, such as the MCIAP's *Maine Field Guide to Invasive Aquatic Plants and Their Common Native Look Alikes* (Maine Center for Invasive Aquatic Plants 2007). A number of native plants look similar in appearance to the 11 invasive species that are of greatest concern. The most common of these are bladderwort, coontail, elodea, water marigold, and common pondweeds. Several species of milfoil are native to Maine and it can be difficult to distinguish between native and invasive species of milfoil without assistance. If field staff learn the structural characteristics of the look-alike plants before beginning the survey, less time is needed for identification. Some native plants, such as bladderwort and coontail, grow in large dense stands, giving the impression of being invasive.

When a plant has been identified as suspicious

Indicate on the survey form and lake map (Appendix S10.C) the status of the plant using the following code:

S = Submerged – the entire plant is growing underwater (except possibly for a short stalk supporting the flower)

E = Emergent – parts of the plant grow above the water surface

FL = floating leaved – Underwater stem and roots, but most of the leaves float on the surface

FR = free floating – plants may have stems, but they are not rooted, and they float on the surface

Collect a plant specimen, but do not remove the entire plant from the water.

Collecting a plant specimen

1. Clean-cut the plant specimen. Carefully avoid fragmenting the plant because this could result in an invasive plant spreading to other areas of the lake. Scoop up any and all fragments with a net.
2. Collect several (3-5) healthy stems of the plant in question if possible. The flower, fruits, and winter buds of many aquatic plants are helpful in the identification process. If these structures are present, be sure to include them in your sample. Gently break off stem sections about 6-8 inches long from the top part of the plant. For rooted floating leaved plants, include as much of the stem as possible.

3. DO NOT attempt to pull the plant out by its roots. This is very important, since some plants break easily and attempts to pull them could result in spreading an invasive species more rapidly.
4. Mark the location of the plant with a weighted buoy. A small buoy (plastic milk jug) attached to string and a cored brick or rock is sufficient.
5. Mark the location on a map, and record the GPS coordinates, if possible. Indicate local landmarks such as shoreline cottages or unusual rocks or trees to help others re-locate the site.
6. If the plant is covered with algae or tangled in debris, remove as much of the unwanted material as possible, without damaging the specimens.
7. Carefully place the plant in a sealable bag with sufficient water to prevent the plant from becoming damaged. Immediately place the bag in a cooler and then refrigerate until you are ready to ship the specimens.

If a positive identification is not possible after checking the list of common look-alikes, seek assistance. If a plant that is thought to be on the list of invasive aquatic species needs to be identified, please contact the appropriate state agency immediately to confirm the species identification and initiate a rapid response if warranted. If the specimen must be mailed for identification, follow the guidelines listed for mailing specimens. Follow up with the appropriate agency after a week without a response. The names and contact information for the appropriate state agencies are listed in Appendix S10.D.

Preparation and guidelines for mailing specimens

1. Place wet specimens in a water-tight plastic bag.
2. If the plant is delicate or flimsy, add enough water to the bag to cushion the plant and keep it wet.
3. Remove all air from the bag and seal if the plant is relatively sturdy. DO NOT wrap the plant in a wet paper towel or other absorbent material.
4. Seal the bag securely and place it in a small box with enough packing material to prevent movement. Cardboard mailing envelopes are fine for sturdy specimens that are not packed in water. Padded envelopes do not work well for plant specimens.
5. Fill out and include a suspicious plant form (can be downloaded from: http://www.mainevlmp.org/mciap/SuspiciousPlantForm.pdf or other appropriate state agency form) in the box with the specimens. This information is critical to tracking plants submitted for identification, and ensuring a timely response.
6. Mail the specimen to the appropriate agency on a Monday or Tuesday, to minimize the possibility of weekend delays.

Contacts for invasive species identification

Each state has its own state agency responsible for the early detection and rapid response of aquatic invasive species. These organizations, listed in Appendix S10.D, conduct trainings, have lists of the most problematic or potentially problematic aquatic species in the state, and have technical assistance for the positive identification of species. Although aquatic invasive species

data will be compiled for NETN, it is important that any new outbreaks of aquatic invasive species be reported to the appropriate state agency as soon as possible. Natural resource managers and volunteers should attend annual trainings organized by the state in which they reside so that they will be apprised of new problematic species, new outbreaks of known invasive species, and the current procedures and contacts for the identification and reporting of species. Species of concern in NETN parks are listed in Appendix S10.E.

Appendix S10.A. Equipment Needs for an Invasive Aquatic Plant Screening Survey

- Small boat, canoe, or kayak. Note that large boats and motors can make the process more difficult, and could destroy sensitive aquatic vegetation
- Personal flotation devices for each crew member
- First aid kit
- Park radio
- Sunscreen, bug repellent
- Waders or hip boots
- Invasive Aquatic Plant Screening Survey documentation sheets (available from VLMP/MCIAP), pencil, permanent markers and clipboard
- Bathymetric maps
- Applicable protocols
- Digital camera
- GPS unit, compass
- Pocket knife, scissors, or hand pruner for snipping specimens
- Small grass rake for grabbing specimens and retrieving fragments
- Secchi disk depth viewing scope- available commercially, or construct from 5 gallon. bucket and Plexiglas. (Constructions plans available from VLMP/MCIAP)
- Depth gun, weighted measuring tape, or Secchi disk to determine depths
- Large and small Zip-Lock plastic bags and cooler for storing specimens (bags must contain enough water to float the specimens)
- Boat anchor
- Polarized sunglasses (not essential, but very helpful)
- Plant identification guides and keys, (such as the MCIAP's Maine Field Guide to Invasive Aquatic Plants and Their Common Native Look Alikes, available through VLMP/MCIAP)
- Makeshift buoys to mark the location of suspicious plants (can be 1/2 gallon jug, string and brick or rock)
- Magnifying glass or hand lens for examining plant specimen structure (5-10X pocket magnifiers)
- Small white tray or shallow plastic dish for floating and observing specimens in the field
- Drinking water/food

Appendix S10.B. MCIAP Screening Survey data form.

Section 3: Native Plant Inventory — **For inventory:** ✓ = presence; D = dominant; U = uncommon

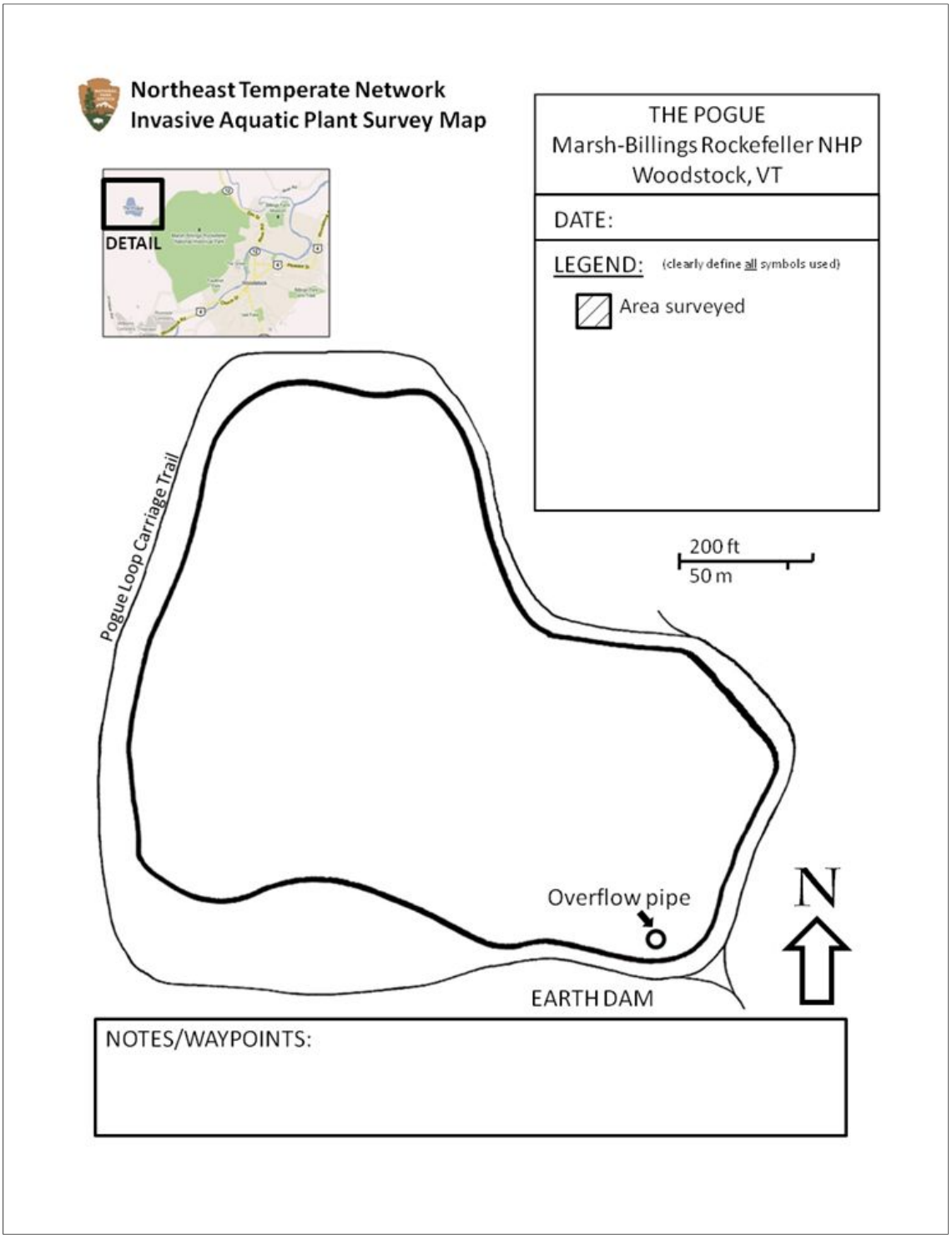
Common Native Plant Checklist	Inventory by Multiple Discrete Areas								Composite Inventory	NOTES:
aquatic moss spp.										
arrowhead, spp. *Sagittaria spp.*										
bladderwort, common *Utricularia macrorhiza*										
bladderwort, large purple *Utricularia purpurea*										
bladderwort, spp. *Utricularia spp.*										
bur-reed, floating leaf *Sparganium fluctuans*										
bur-reed, narrow floating-leaf *S. angustifolium*										
bur-reed, spp. (emergent) *Sparganium spp.*										
coontail *Ceratophyllum demersum*										
little floating heart *Nymphoides cordata*										
metaphyton (colonial algae "clouds")										
muskgrass *Chara spp.*										
naiad, slender *Najas flexilis*										
pickerel weed *Pontederia cordata*										
pipewort *Eriocaulon aquaticum*										
pondweed, clasping-leaf *Potamogeton perfoliatus*										
pondweed, fern *Potamogeton robbinsii*										
pondweed, flat-stem *Potamogeton zosteriformis*										
pondweed, floating-leaf *Potamogeton natans*										
pondweed, large-leaf *Potamogeton amplifolius*										
pondweed, ribbon-leaf *Potamogeton epihydrus*										
pondweed, small *Potamogeton pusilloid spp.*										
pondweed, spiral-fruited *Potamogeton spirillus*										
pondweed, spp. *Potamogeton spp.*										
pondweed, variable *Potamogeton gramineus*										
quillwort spp. *Isoetes spp.*										
rush, bayonet *Juncus militaris*										
spatterdock, *Nuphar variegata*										
spikerush, needle *Eleocharis acicularis*										
stonewort spp. *Nitella spp.*										
water lily, fragrant *Nymphea odorata*										
water lobelia *Lobelia dortmanna*										
water marigold *Bidens beckii*										
water milfoil, dwarf *Myriophyllum tenellum*										
water milfoil, alternate-flowered *M. alterniflorum*										
water milfoil, Farwell's *M. farwellii*										
water milfoil, low *Myriophyllum humile*										
water milfoil, northern *Myriophyllum sibericum*										
water milfoil, whorled *Myriophyllum verticillatum*										
watershield *Brasenia schreberi*										
waterweed, common *Elodea canadensis*										
waterweed, slender (Nutall's) *Elodea nuttallii*										
wild celery (eel grass) *Vallisneria americana*										

Section 4: Observed Species of Concern

SPECIES	Sector / Location	GPS Waypoint	Buoy Code	NOTES

EXAMPLE SPECIES OF CONCERN: purple loosestrife, Chinese mystery snail, gleotrichia, didymo

Appendix S10.C. Sample NETN Invasive Aquatic Plant Survey map



Appendix S10.D. State Agencies for Reporting Invasive Aquatic Plants

Contact the organizations listed below for aquatic invasive identification survey trainings for individual states, for the most current list of potentially problematic and (or) illegal plants in each state, for technical assistance in the positive identification of aquatic species, and for the initiation of rapid response actions. If instructed to send in a specimen, review the instructions in the *Preparation and guidelines for mailing specimens* section in body of this SOP.

Maine:

Maine Center for Invasive Aquatic Plants
Tel. 207-783-7733
24 Maple Hill Road
Auburn, ME 04210
mciap@mainevlmp.org
See their virtual online herbarium at: http://www.mciap.org/herbarium/invasive.php for aid in identifying invasive plants. This agency will contact you within 72 hours of receiving your plant sample, identify the plant and confirm whether or not it is an invasive species. If the plant is invasive, the Maine Department of Environmental Protection will be notified, and a rapid response action plan will be initiated.
Maine Department of Environmental Protection
17 State House Station; Augusta, ME 04333
Tel. 1-800-452-1942

New Hampshire:

Exotic Species Coordinator
NH Department of Environmental Services
29 Hazen Drive
Concord, NH 03301
http://des.nh.gov/organization/divisions/water/wmb/exoticspecies/index.htm
Email: asmagula@des.state.nh.us

Vermont:

Vermont Department of Environmental Conservation
Water-Quality Division
103 South Main Street
Building 10 North
Waterbury, Vermont 05671-0408
1-802-241-3777
http://www.anr.state.vt.us/dec/waterq/lakes/htm/ans/lp_ans-index.htm

Appendix S10.D. State Agencies for Reporting Invasive Aquatic Plants (continued).

Massachusetts:

Weed Watchers Program
Department of Conservation and Recreation
Lakes and Ponds Program
251 Causeway St. Suite 700 Boston, MA 02114
http://www.mass.gov/dcr/waterSupply/lakepond/weedwatch.htm
Fax: 617-626-1349

Connecticut

Invasive Aquatic Plants Program
The Connecticut Agricultural Experiment Station (CAES)
123 Huntington St
New Haven, CT 06511
http://www.ct.gov/caes/cwp/view.asp?a=2799&q=376972&caesNav=|&caesNav_GID=1805

Other States:

- To find lists of invasive plants that have been found in each state or to report an invasive plant for any state in New England, contact Invasive Plant Atlas of New England (IPANE) at the website http://invasives.uconn.edu/ipane/earlydetection/early.htm

- The Northeast Aquatic Nuisance Species Panel (NEANS) lists contacts for reporting aquatic invasive plants in northeastern states at their Web site: *http://www.northeastans.org/sitemap.htm*

Appendix S10.E. Invasive aquatic plant species of concern.

Table S10.E.1. Invasive aquatic plant species of concern at Acadia NP.

Common name	Latin name
European Frogbit	*Hydrocharis morsus-ranae*
Water Chestnut	*Trapa natans*
Yellow Floating Heart	*Nymphoides peltata*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Variable Water Milfoil	*Myriophyllum heterophyllum*
Parrot Feather	*Myriophyllum aquaticum*
Fanwort	*Cabomba caroliniana*
Hydrilla	*Hydrilla verticillata*
Brazilian Elodea	*Egeria densa*
European Naiad	*Najas minor*
Curly-Leaved Pondweed	*Potamogeton crispus*

Table S10.E.2. Invasive aquatic plant species of concern at Marsh-Billings-Rockefeller NHP.

Common name	Latin name
Didymo	*Didymoshpenia geminata*
Brazilian Waterweed	*Egeria densa*
Variable Water Milfoil	*Myriophyllum heterophyllum*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Yellow Floating Heart	*Nymphoides peltata*

Table S10.E.3. Invasive aquatic plant species of concern at Saint-Gaudens NHS.

Common name	Latin name
Didymo	*Didymoshpenia geminata*
Brazilian Waterweed	*Egeria densa*
Hydrilla	*Hydrilla verticillata*
Common Frogbit (European Frogbit)	*Hydrocharis morsus-ranae*
Variable Water Milfoil	*Myriophyllum heterophyllum*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Brittle Waternymph (European Naiad)	*Najas minor*
Curly-Leaved Pondweed	*Potamogeton crispus*
Water chestnut	*Trapa natans*

Table S10.E.4. Invasive aquatic plant species of concern at Weir Farm NHS.

Common name	Latin name
Didymo	*Didymoshpenia geminata*
Brazilian Waterweed	*Egeria densa*
Water Hyacinth	*Eichhornia crassipes*
Hydrilla	*Hydrilla verticillata*
Purple Loosestrife (riparian)	*Lythrum salicaria*
Parrot Feather	*Myriophyllum aquaticum*
Variable Water Milfoil	*Myriophyllum heterophyllum*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Brittle Waternymph (European Naiad)	*Najas minor*
Curly-Leaved Pondweed	*Potamogeton crispus*
Water chestnut	*Trapa natans*

SOP 10 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
3.00	January 2012	B. Arsenault, B. Gawley	Reformatted using NRPS-NRR template. Updated/expanded equipment list in Appendix S10.A. Added contact info for CT Invasive Plant program in Appendix S10.D. Added field forms and sample map as Appendices S10.C and S10.D.	Protocol review meeting; Version 2.02+ to 3.00 (major revision); new maps created.
3.01	December 2012	B. Mitchell	Minor edits.	Internal review
3.02	August 2013	B. Gawley	Added lists of species of concern as Appendix S10.E.	In response to internal review.
3.03	December 2013	B. Mitchell	Revised overview to specify that this SOP is for lakes and ponds, but staff should be vigilant for stream invasives when collecting data. Clarify the reason suspected invasives should not be pulled out by the roots.	Reviewer comment

SOP 11 – Rapid Hydro-Geomorphic Assessment

Northeast Temperate Network

Version 3.02

Overview

An assessment for habitat and physiochemical characterization is conducted in July at each stream in the yearly rotation. NETN has adapted assessment techniques from the EPA Rapid Bioassessment protocol. Detailed descriptions of procedures, methods and data forms can be found in Barbour et al. (1999), specifically Chapter 5: "Habitat Assessment and Physiochemical Parameters". The major departure from EPA methods is that NETN monitors assess a 20 meter reach of stream rather than the EPA-prescribed 100 meters. Data are stored in a table in the NETN_H2O database.

Background and Scope

Rapid hydro-geomorphic assessment evaluations of NETN stream characteristics are conducted to provide a qualitative assessment of conditions upstream and influencing the stream discharge and sampling site. This information will support stream discharge, *in situ* chemistry, and nutrient sampling analyses. The rapid hydro-geomorphic assessment will be performed at each NETN stream in July of each year, to supplement observations of obvious changes in stream characteristics that are noted on monthly stream data forms. Assessments should be conducted in teams of two as a safety measure.

It is beyond the scope of this SOP to present all of the information and methods that are required to perform a rapid hydro-geomorphic assessment. Monitors should become familiar with the EPA document, "Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition" (Barbour et al 1999). This document is comprised of several bioassessment protocols, including sections on habitat assessments, periphyton, benthic macroinvertebrates, and fish. NETN's rapid hydro-geomorphic assessment procedures are taken from *Chapter 5: Habitat Assessment and Physicochemical Parameters* and its accompanying data sheets, "Physical Characterization/Water Quality Field Data Sheet", and the "Habitat Assessment Field Data Sheet". This protocol, including data forms and other appendices, can be downloaded from http://www.epa.gov/owow/monitoring/rbp/download.html.

The EPA recommends performing a rapid hydro-geomorphic assessment on a 100-meter reach of stream. For the purpose of NETN's evaluations, a 20-meter stretch upstream of the discharge and sampling site was determined to be sufficient. This should take the observer about 20 to 30 minutes to complete. Two replicate measurements will be done at Acadia and at the Lower NETN sites by two independent teams each year. This QC check ensures that observers conducting these assessments are following the same guidelines and that measurements are comparable.

Equipment Needs

Since the rapid hydro-geomorphic assessment will be conducted during a regular stream monitoring site visit, much of the required equipment will already be on hand. The EPA field forms (Appendices S11.A and S11.B) call for channel widths, water depths, etc. to be measured in metric units, so a metric measuring tape and/or wooden folding ruler (to supplement the engineer-scaled tape and ruler used for stage and discharge measurements) comes in handy to avoid having to convert from English-system measurements.Equipment List for rapid hydro-geomorphic assessment

- Physical Characterization and Habitat Assessment Field Data Sheets (printed on waterproof paper).
- copy of EPA protocol *Chapter 5: Habitat Assessment and Physicochemical Parameters* (Barbour et al. 1999)
- clipboard
- pencils or waterproof pens
- digital camera
- 50m or 100m measuring tape
- wooden folding ruler (metric scale)
- rangefinder or laser measuring device (optional)
- Global Positioning System (GPS) Unit

Rapid Hydro-Geomorphic Assessment Procedures

The beginning of the assessment includes physical characterization and water quality field data. Use the EPA protocol (Barbour et al. 1999) and data sheet to conduct these measurements. The Habitat Assessment Field Data sheet includes ten categories of physical stream characteristics that are evaluated and rated on a numerical scale of 0 to 20 (highest) for each sampling reach. The ratings are then totaled and compared to a reference condition to provide a final habitat ranking. Scores increase as habitat quality increases. To ensure consistency in the evaluation procedure, descriptions of the physical parameters and relative criteria are included in the rating form.

1. Although the Physical Characterization/Water Quality data form is used for all stream types, there are different Habitat Assessment data forms for high-gradient and low-gradient streams. Refer to section 5.2 of the EPA protocol for instructions on how to determine the appropriate classification (and Habitat Assessment data form) for the stream that is being assessed. NETN will maintain information about the gradient of each stream in a table that should be referred to prior to data collection.
2. Select the stream reach to be assessed. The habitat assessment is performed on the 20 m reach directly upstream from the location in which the water quality sampling and flow monitoring is conducted. Note that some parameters require an observation of a broader section of the catchment than just the sampling reach.
3. Complete the station identification section of each field data sheet and habitat assessment form.

4. It is best for the investigators to obtain a close look at the habitat features to make an adequate assessment. If the hydro-geomorphic characterization and habitat assessment are done before the water quality sampling and discharge measurements, care must be taken to avoid disturbing the sampling habitat.
5. Complete the **Physical Characterization and Water Quality Field Data Sheet** (Appendix S11.A). Sketch a map of the sampling reach on the back of the form. Take additional digital photos (both upstream and downstream) to supplement the regular monthly photos taken from the established and documented photopoint.

- Two photos are taken to document the section of the stream used for the assessment. People should not be visible within the reach on these photos. One photo is taken from the top of the stream reach, looking downstream. The second photo is taken from the bottom of the reach looking upstream. Do not use a flash, hold the camera between 5 to 6 feet above the ground (i.e., head height), and take the photo in landscape (wider horizontally) mode while holding the camera level (i.e., do not aim up or down). Alternatively, use the panoramic mode on an iPhone or similar device and hold the camera in portrait mode (wider vertically), capturing a 180 degree view. These photos are named using standard NETN file-naming conventions described in *SOP 13 – Data Management*, using the template:

  NETN Site code _ YYYYMMDD_hgmUS *(or)* hgmDS

  An example using an upstream tag line photo from Saratoga NHP Stream A, taken on July 25, 2010 is:

  SARASA_20100725_hgmUS.jpg

6. Complete the **Habitat Assessment Field Data Sheet** (Appendix S11.B), in a team of two or more observers, if possible, to come to a consensus on determination of quality. Those parameters to be evaluated on a scale greater than a sampling reach require traversing the stream corridor to the extent deemed necessary to assess the habitat feature. As a general rule-of-thumb, use two lengths of the sampling reach (40 meters) to assess these parameters.

Quality Assurance Procedures

- Each observer is to be trained in the visual-based habitat assessment technique for the applicable region or state.
- The judgment criteria for each habitat parameter are calibrated for the stream classes under study. Some text modifications may be needed on a regional basis.
- Periodic checks of assessment results are completed using pictures of the sampling reach and discussions among the biologists in the agency.
- Two replicate measurements will be done at Acadia and at the Lower NETN sites by two independent teams each year.

Post Field Activities

At the end of each hydro-geomorphic assessment, the scores for each parameter are added and the stream is given a total score. Review all calculations back at the office prior to transcribing

data from paper field forms to the computer. Photos are stored on the network drive (in a folder within Z:\PROJECTS\MONITORING\Water_Quality\WaterMonitoring_Implementation\5_Data\Photos\YYYY_WQ_Photos\, where YYYY is the monitoring year). All hydro-geomorphic data and evaluation scores are entered into a table associated with the NETN_H2O water quality database. Field data sheets are to be scanned and archived. Electronic copies of the scanned data forms will be archived in IRMA (Integrated Resource Management Applications, https://irma.nps.gov), the NPS-wide repository for documents, publications, and data sets that are related to NPS natural and cultural resources.

Appendix S11.A. Physical Characterization/Water Quality Field Data Sheet.

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS	**Now** / **Past 24 hours** ❑ ❑ storm (heavy rain) ❑ ❑ rain (steady rain) ❑ ❑ showers (intermittent) ___% ❑ %cloud cover ❑ clear/sunny **Has there been a heavy rain in the last 7 days?** ❑ Yes ❑ No **Air Temperature**____° C **Other**_____
SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled (or attach a photograph)**
STREAM CHARACTERIZATION	**Stream Subsystem** ❑ Perennial ❑ Intermittent ❑ Tidal **Stream Type** ❑ Coldwater ❑ Warmwater **Stream Origin** ❑ Glacial ❑ Spring-fed ❑ Non-glacial montane ❑ Mixture of origins ❑ Swamp and bog ❑ Other_____ **Catchment Area**_____km²

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ❑ Forest ❑ Commercial ❑ Field/Pasture ❑ Industrial ❑ Agricultural ❑ Other _____ ❑ Residential **Local Watershed NPS Pollution** ❑ No evidence ❑ Some potential sources ❑ Obvious sources **Local Watershed Erosion** ❑ None ❑ Moderate ❑ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ❑ Trees ❑ Shrubs ❑ Grasses ❑ Herbaceous **dominant species present** _____
INSTREAM FEATURES	**Estimated Reach Length** _____m **Estimated Stream Width** _____m **Sampling Reach Area** _____m^2 **Area in km^2 (m^2 x 0.001)** _____km^2 **Estimated Stream Depth** _____m **Surface Velocity (at thalweg)** _____m/sec **Canopy Cover** ❑ Partly open ❑ Partly shaded ❑ Shaded **High Water Mark:** _____m **Proportion of Reach Represented by Stream Morphology Types** ❑ Riffle _____% ❑ Run _____% ❑ Pool _____% **Channelized** ❑ Yes ❑ No **Dam Present** ❑ Yes ❑ No
LARGE WOODY DEBRIS	**LWD** _____m^2 **Density of LWD** _____m^2/km^2 **(LWD/ reach area)**
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ❑ Rooted emergent ❑ Rooted submergent ❑ Rooted floating ❑ Free floating ❑ Floating Algae ❑ Attached Algae **dominant species present** _____ **Portion of the reach with aquatic vegetation** _____%
WATER QUALITY	**Temperature**_____° C **Specific Conductance**_____ **Dissolved Oxygen** _____ **pH** _____ **Turbidity** _____ **WQ Instrument Used** _____ **Water Odors** ❑ Normal/None ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Fishy ❑ Other_____ **Water Surface Oils** ❑ Slick ❑ Sheen ❑ Globs ❑ Flecks ❑ None ❑ Other_____ **Turbidity (if not measured)** ❑ Clear ❑ Slightly turbid ❑ Turbid ❑ Opaque ❑ Stained ❑ Other_____
SEDIMENT/ SUBSTRATE	**Odors** ❑ Normal ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Anaerobic ❑ None ❑ Other_____ **Oils** ❑ Absent ❑ Slight ❑ Moderate ❑ Profuse **Deposits** ❑ Sludge ❑ Sawdust ❑ Paper fiber ❑ Sand ❑ Relict shells ❑ Other_____ **Looking at stones which are not deeply embedded, are the undersides black in color?** ❑ Yes ❑ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			**ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)**		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

Appendix S11.B. Habitat Assessment Field Data Sheet (Low gradient).

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ❑ Forest ❑ Commercial ❑ Field/Pasture ❑ Industrial ❑ Agricultural ❑ Other _____ ❑ Residential **Local Watershed NPS Pollution** ❑ No evidence ❑ Some potential sources ❑ Obvious sources **Local Watershed Erosion** ❑ None ❑ Moderate ❑ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ❑ Trees ❑ Shrubs ❑ Grasses ❑ Herbaceous **dominant species present** _____
INSTREAM FEATURES	**Estimated Reach Length** _____m **Estimated Stream Width** _____m **Sampling Reach Area** _____m^2 **Area in km^2 (m^2x 0.001)** _____km^2 **Estimated Stream Depth** _____m **Surface Velocity** _____m/sec **(at thalweg)** **Canopy Cover** ❑ Partly open ❑ Partly shaded ❑ Shaded **High Water Mark** _____m **Proportion of Reach Represented by Stream Morphology Types** ❑ Riffle_____% ❑ Run_____% ❑ Pool_____% **Channelized** ❑ Yes ❑ No **Dam Present** ❑ Yes ❑ No
LARGE WOODY DEBRIS	**LWD** _____m^2 **Density of LWD** _____m^2/km^2 **(LWD/ reach area)**
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ❑ Rooted emergent ❑ Rooted submergent ❑ Rooted floating ❑ Free floating ❑ Floating Algae ❑ Attached Algae **dominant species present** _____ **Portion of the reach with aquatic vegetation** _____%
WATER QUALITY	**Temperature**_____° C **Specific Conductance**_____ **Dissolved Oxygen** _____ **pH** _____ **Turbidity** _____ **WQ Instrument Used** _____ **Water Odors** ❑ Normal/None ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Fishy ❑ Other_____ **Water Surface Oils** ❑ Slick ❑ Sheen ❑ Globs ❑ Flecks ❑ None ❑ Other_____ **Turbidity (if not measured)** ❑ Clear ❑ Slightly turbid ❑ Turbid ❑ Opaque ❑ Stained ❑ Other_____
SEDIMENT/ SUBSTRATE	**Odors** ❑ Normal ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Anaerobic ❑ None ❑ Other_____ **Oils** ❑ Absent ❑ Slight ❑ Moderate ❑ Profuse **Deposits** ❑ Sludge ❑ Sawdust ❑ Paper fiber ❑ Sand ❑ Relict shells ❑ Other_____ **Looking at stones which are not deeply embedded, are the undersides black in color?** ❑ Yes ❑ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			**ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)**		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

Appendix S11.B. Habitat Assessment Field Data Sheet (Low gradient) (continued).

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score _____

Appendix S11.C. Habitat Assessment Field Data Sheet (High gradient).

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Appendix S11.C. Habitat Assessment Field Data Sheet (High gradient) (continued).

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score _____

SOP 11 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.02	April 2009	B. Mitchell	**Section 3.5:** Inserted placeholder for Rapid Habitat Assessment SOP. All subsequent SOP's renumbered. *(SOP 10– Rapid Hydro-Geomorphic Assessment)*	Protocol Review Meeting
3.00	January 2012	B. Arsenault, B. Gawley	Reformatted using NRPS-NRR template. Expanded SOP for implementing rapid habitat assessment at stream sites. Re-assigned as SOP 11 Incorporated EPA documents by reference (list web sites) and described all changes to procedures. Highlighted which portions of the EPA procedures are implemented. Added equipment list, basic assessment, QA, and data management procedures. Added field forms as appendices.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2013	B. Mitchell	Minor edits People should not be visible in the sampled reach on the photos of the stream reach	Reviewer comments
3.02	February 2014	B. Mitchell	Panoramic photos can be taken at photopoints	Updated equipment

SOP 12 – Laboratory Analyses

Northeast Temperate Network

Version 3.02

Overview

This SOP covers NETN requirements for analytical laboratories, procedures for shipping samples and receiving analysis results, and descriptions and specifications of individual analytical methods.

Background and Scope

To ensure consistency of results and QA/QC, use a central laboratory for all samples. The laboratory selected must pass independent State and Federal (National Environmental Laboratory Accreditation Program or NELAP, see http://www.epa.gov/ttn/nelac/accreditlabs.html) accreditation/approval QA/QC checks, optimally including blind-sample round-robin trial analyses of proficiency test (PT) standards to see if the answer the laboratory provides is close enough to known (certified correct) ranges to pass QC performance standards. Review the choice of laboratory periodically to ensure that methods have not changed, and that routine QC samples are included in analyses. Make arrangements with the laboratory preceding the field season to ensure that the samples are expected, and adequate bottles and other necessary supplies are available.

Laboratories should participate in a standard reference sample program such as that outlined in Long et al. (1998) for nutrients and other inorganic constituents. This is not a certification program, but the program is used to detect and correct possible analytical deficiencies and problems.

Acid neutralizing capacity (ANC), color, nitrogen and phosphorus are collected biannually as grab samples (or depth-integrated epilimnetic samples for lakes at ACAD) and sent to a certified laboratory for analysis. Beginning in 2012, dissolved organic carbon (DOC), sulfate, and chloride were added to the analyte list. Samples are collected in May and August for streams and in June and August for lakes. Additionally, algal biomass (chlorophyll *a*) samples are collected from lakes and ponds. All samples are collected and filtered (for chlorophyll *a*) according to *SOP 7 – Water Samples: Grab and Depth Integrated*. Table S7.1 in that SOP indicates the bottle size, type, and quantity for each sample set. Treatment and preservation requirements (listed in Appendix S12.A of this SOP) such as acidification, filtering and chilling, holding times and labeling must be strictly adhered to in order to ensure a consistency of results. It is critical that all methods and pretreatments be stated when reporting results.

Analytical Methods

Beginning in 2008, all NETN lake, pond, and stream water samples have been analyzed by the University of Maine's Sawyer Environmental Chemistry Research Laboratory (SECRL). Prior to 2008, analyses were performed at the USGS National Water Quality Laboratory (NWQL) in Denver, CO., or split between the NWQL and SECRL. Information on and references for the

NWQL water-quality analytical methods are published in Version 2.02 of this protocol (Lombard et al. 2006). SECRL laboratory analysis methods are discussed in the following sections with a reference for each analyte. Appendix S12.A provides a complete list of analytes, methods, reporting limits, holding times, etc.

Acid Neutralizing Capacity (ANC)

Acid Neutralizing Capacity (ANC) is the capacity of solutes plus particulates in an aqueous system to neutralize acid and is thus determined on an unfiltered sample. Water's ability to neutralize acid (i.e. buffering capacity) is largely a function of the bicarbonate and carbonate ions derived from dissolution of calcium carbonate in the drainage basin. When there is little input of calcium carbonate to a surface-waterbody, the dissociation of dissolved carbon dioxide is the reaction that predominates resulting in slightly acidic waters with little buffering capacity. From the inception of NETN water quality monitoring acid neutralizing capacity has been analyzed by SECRL because of their ability to detect low levels of ANC characteristic of some NETN parks. ANC is analyzed at SECRL using the Gran Titration method. References are:

1. Standard Methods for the Examination of Water and Wastewater, 20th edition, copyright 1998. Method 2320.
2. EPA Handbook of Methods for Acid Deposition Studies, Laboratory Analyses for Surface Water Chemistry, Section 5.0, 1987.

Apparent Color

Color in water results from natural metallic ions, humus, and peat materials, plankton, weeds, and industrial wastes. Color is reported in Pt-Co units. True color is the color of water from which turbidity has been removed. Apparent color is determined on original samples without filtration. Apparent color is analyzed at SECRL with a spectrophotometer (457.5 nm). References are:

1. Standard Methods for the Examination of Water and Wastewater, 20th edition, copyright 1998. Method 2120.
2. Milton Roy Spectronic 601 Operator's Manual, 1991.
3. Spectronic Geneysis 5 Operator's Manual, 1997.

Phosphorus (P)

The total phosphorus occurring in water includes orthophosphate, condensed phosphates and organically bound phosphates. Phosphates are in solution, in particles, or in aquatic organisms. Phosphorus originates from water treatment, laundry soap, or agricultural or residential fertilizers and often indicates agricultural pollution. It is essential to the growth of aquatic organisms and is thus frequently a limiting nutrient in aquatic systems. The addition of phosphates to a waterbody usually results in the growth of aquatic microorganisms in nuisance quantities (APHA 1998) and thus it is an indicator of trophic status or the productivity of a waterbody.

After 6 years of analyzing several forms of phosphorus, including total P, total dissolved P, and orthophosphate, beginning in 2012 the NETN will only test for total P. Examination of all of the phosphorus test results showed a strong correlation between the various forms, and the strategy of focusing on total P still allows detection of elevated P levels at a reduced cost. More specified analyses can be conducted to determine the source of the elevated levels if necessary.

Total phosphorus is analyzed by persulfate digestion/ascorbic acid using manual colorimetry. References are:

1. Standard Methods for the Examination of Water and Wastewater, 20th edition, copyright 1998. Methods 4500-P-B-5 and 4500-P E.
2. Maine Department of Environmental Protection. Preliminary method for automated determination of low level phosphorus. November 20, 1973.
3. Methods for the Determination of Inorganic Substances in Environmental Samples, EPA600/R-93-100, 1993.

Nitrogen (N)

Nitrogen is found in freshwaters in the following forms; nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and organic nitrogen. Nitrate is an essential nutrient for many photosynthetic autotrophs and is thus a major limiting nutrient in most aquatic systems. An increase in nitrogen usually results in accelerated eutrophication. Nitrogen is indicative of agricultural pollution or acid rain. The drinking-water standard for nitrate, the most highly oxidized state of nitrogen is 10 mg/L (APHA, 1998), but nitrate can be found in concentrations up to 30 mg/L in wastewater effluent. NETN tests for total nitrogen, nitrite, nitrate, and ammonia.

At the Sawyer Environmental Chemistry Research Laboratory, total nitrogen and nitrite (NO_2) are analyzed using automated colorimetry. References are:

1. Ebina J. (1983), Simultaneous determination of total nitrogen and total phosphorous in water using peroxodisulfate oxidation. Water Res. vol 17, pp 1721-1726.
2. Nydahl F. (1978), On the peroxodisulfate oxidation of total nitrogen in waters to nitrate. Water Res. vol 12, pp 1123-1130.
3. D'Elia C. (1977), Determination of total nitrogen in aqueous samples using persulfate digestion. Linmol Oceanogr. vol 22, 760-764.
4. Smart M. (1981), A comparison of a persulfate digestion and the kjeldhahl procedure for determination of total nitrogen in freshwater samples. Water Res. v15, pp 919-921.
5. Handbook of Methods for Acidic Deposition Studies, Laboratory Analysis for Surface Water Chemistry, EPA 600/4-87/026 1987.
6. Bran & Luebbe, Method 818-87T, Nitrate/Nitrite in water and seawater, 1987.
7. Nitrate and Nitrite Nitrogen and Nitrite Nitrogen Method (P/N 000142 and P/N 000143), Doc. 000589, Rev. 1/94, OI Analytical, College Station, TX 77842-9010.
8. RFA Methodology, Nitrate and Nitrite Nitrogen, Rev. 4-90.
9. Cadmium Coils, Continuous Flow News, 20, 1994.
10. Handley M., Total Nitrogen Method, Environmental Chemistry Laboratory, Sawyer Research Center, University of Maine, Orono, ME 04469.

Nitrate (NO_3) is analyzed directly using Ion Chromatography. References are:

1. EPA Method 300.0, Methods for the Determination of Inorganic Substances in Environmental Samples, EPA 600/R-93-100, 1993.

2. Dionex model 2010i Ion Chromatograph manual.
3. Dionex model DX-500 manual and assorted components manuals

Ammonia (NH_3) is analyzed by an autoanalyzer. References are:

1. Standard Methods for the Examination of Water and Wastewater, 18th ed., copyright 1992. Method 4500-NH3 H.
2. Ammonia Nitrogen (P/N 000156 and P/N 000157), Doc. 000578, Rev. 12/93, OI Analytical, College Station, TX 77842-9010.

Dissolved Organic Carbon (DOC)

Carbon is a nutrient required for biological processes. Sources of organic carbon in water include humic substances from plant and soil organic matter, wetland peat deposits, and atmospheric deposition. Certain forms of DOC can contribute to "tea" color in water, which can affect light attenuation. DOC is also an important part of the energy balance and acid-base chemistry in many freshwater systems. It also affects the transport (solubility and bioavailability) of metals, including mercury, in aquatic systems.

DOC is analyzed using the sodium persulfate oxidation method - detected with a carbon analyzer, via infrared spectrophotometry. Reference:

1. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, 1979, Revised 1983

Chloride (Cl)

Chloride is one of the major negatively-charged ions in fresh water systems. The chloride content of natural surface waters will depend to a great extent on the geology of the area. Concentrations are generally greater in lakes that are in proximity to marine regions. Another source of chloride is road run-off, from de-icing materials. Chloride is important in terms of metabolic processes, as it influences osmotic salinity balance and ion exchange.

Chloride is analyzed using ion chromatography. Reference:

1. Methods for the Determination of Inorganic Substances in Environmental Samples, EPA 600/R-93-100, 1993.

Sulfate (SO_4)

Sulfate is found in most natural waters, originating from watershed geology, soils, and precipitation. Sulfate can play a major role in acidification of lakes and streams.

Sulfate is analyzed using ion chromatography. Reference:

1. Methods for the Determination of Inorganic Substances in Environmental Samples, EPA 600/R-93-100, 1993.

Algal Biomass (Chlorophyll a)

The amount of chlorophyll *a* in a water sample is a measure of the concentration of suspended phytoplankton and can be used as an indicator of algal biomass and thus of water quality. Chlorophyll *a* is responsible for photosynthesis and is found in various forms within the living cells of algae, phytoplankton, and other plant matter of water environments. Like other biological

response variables, chlorophyll *a* tends to integrate the stresses of various parameters over time, and thus is often an important nutrient-stress parameter to measure.

Chlorophyll *a* is analyzed at SECRL with a spectrophotometer. References are:

1. Spectronic 1201 Operators Manual, Milton Roy. Section 4.6.8
2. Standard Methods for the Examination of Water and Wastewater, 18th ed., 1992. Method 10200H
3. Technology Applications Inc. SOP #IN-027-00, Aug. 1993, Spectrophotometric Determination of Chlorophyll 'a'.
4. USEPA method 445.0, In Vitro Determination of Chlorophyll 'a' and Phytoplankton by Fluorescence, Version 1.1, Nov. 1992, Section 7.0.

Shipping Samples to the Laboratory

All samples must be sent to the central laboratory (SECRL) within specified holding times. The following shipping procedures assume that the SECRL is used. If another laboratory is used, directions for sending samples can be obtained directly from the laboratory.

1. Ensure that each sample-container sent to the lab is marked with a waterproof preprinted label securely attached to the sample container. Sample date and time information should be marked on the label with a permanent, waterproof marking pen. The label and the information on it must remain intact and legible throughout the shipping process.
2. Group all sample bottles for a site in a single zip-top bag. Place all bags in an appropriately sized cooler and add enough ice packs (preferred) or ice to keep the samples chilled until they reach the lab. Add packing material if there is extra space in the cooler. This will provide extra insulation and protect breakable sample containers.
3. When shipping foil packets of chlorophyll filters, "sandwich" the packets between two ice packs to ensure they remain frozen during transit.
4. Include the following information on all sample container labels:
    - Site name and six character NETN code.
    - Date of collection
    - Time of collection
    - QC type (BLANK or REP, if applicable)
    - *For chlorophyll a filters only:* Quantity (in ml) filtered and Rep number ("# of #")
    - This information serves as a link between the sample container and the chain of custody form. A sample chain of custody form can be found in Appendix S12.B.
5. Include a chain of custody form listing all sample containers in each shipping container. Do not send samples in a shipping container without a chain of custody form. Place the form in a sealed, watertight bag. When shipping samples in coolers, be sure there is a return address (using street address) on the inside lid of the cooler.

6. Email a digital copy of the chain of custody form(s) to the lab manager or designate when the samples have shipped to allow the laboratory staff to expect their arrival and prepare for their analysis.
7. Ensure that samples are not discarded or set aside by the carrier by taking special precautions to make certain that the coolers are not leaking, and that they can remain leak-proof even after the ice has begun to melt. None of the package-carrier services will deliver leaking coolers or boxes. Tape coolers closed by encircling with packing tape before shipping.
8. Send chilled and time-dependent samples to the laboratory by the most expedient means possible. In general, ship all time-dependent samples by a reliable express delivery service, such as Federal Express, Priority Overnight. *Samples should not be shipped any later in the week than on Thursday afternoon- lab staff will not be available to log in and process samples after Friday noon.* Please indicate "Priority Overnight" on the Federal Express air bill. The SECRL is closed on all Federal holidays; therefore, extremely time-dependent samples are not to be shipped in conjunction with a holiday. Use the following address when shipping samples to the SECRL:

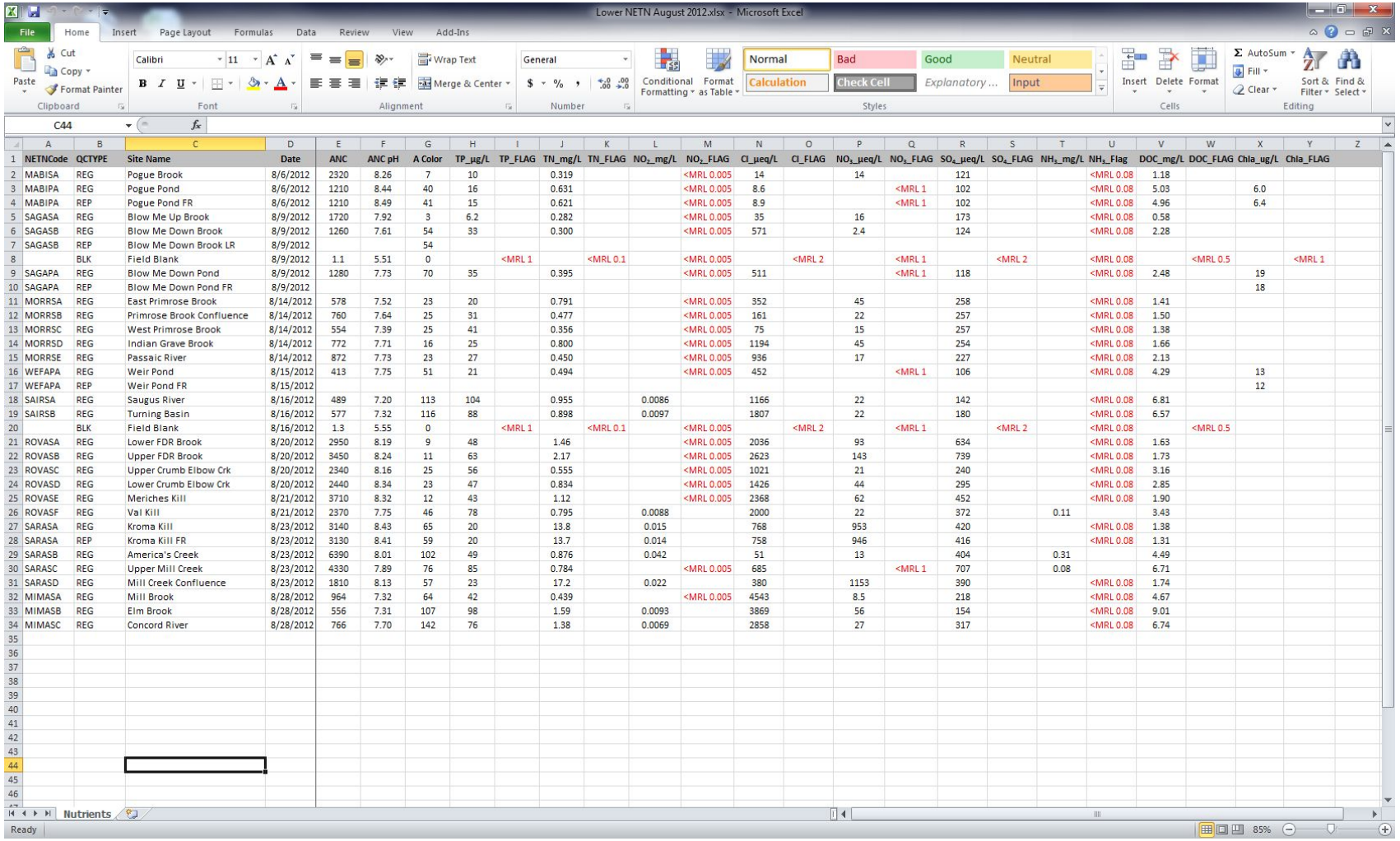
    Clive Devoy – Lab Manager
    Sawyer Environmental Center Research Laboratory
    5764 Sawyer Research Center
    University of Maine
    Orono, ME 04469-5764

Data Reports from the Laboratory

The Lab Manager will immediately notify the NETN Water Monitoring Coordinator if analyses detect a blank sample that is out of range, or a parameter violating national or regional water quality standards. Preliminary analytical results will be discussed at this point, and re-samples and/or re-tests will be scheduled if applicable.

Final analytical results are delivered electronically to the NETN Water Monitoring Coordinator and the NETN Program Manager after certification by the SECRL Lab Manager. The data are provided in a specially formatted MS Excel workbook (Figure S12.1) that can be directly imported into the NETN_H2O water quality database.

Retests of individual samples are possible if Quality Control or other issues are suspected after NETN staff review the final results. The SERCL Lab Manager provides comments with the final data report on analytical issues, possible contamination, or any other factors potentially affecting the analytical results.



Lower NETN August 2012.xlsx - Microsoft Excel

NETNCode	QCTYPE	Site Name	Date	ANC	ANC pH	A Color	TP_µg/L	TP_FLAG	TN_mg/L	TN_FLAG	NO_2_mg/L	NO_2_FLAG	Cl_µeq/L	Cl_FLAG	NO_3_µeq/L	NO_3_FLAG	SO_4_µeq/L	SO_4_FLAG	NH_3_mg/L	NH_3_Flag	DOC_mg/L	DOC_FLAG	Chla_ug/L	Chla_FLAG
MABISA	REG	Pogue Brook	8/6/2012	2320	8.26	7	10		0.319			<MRL 0.005	14		14		121			<MRL 0.08	1.18			
MABIPA	REG	Pogue Pond	8/6/2012	1210	8.44	40	16		0.631			<MRL 0.005	8.6			<MRL 1	102			<MRL 0.08	5.03		6.0	
MABIPA	REP	Pogue Pond FR	8/6/2012	1210	8.49	41	15		0.621			<MRL 0.005	8.9			<MRL 1	102			<MRL 0.08	4.96		6.4	
SAGASA	REG	Blow Me Up Brook	8/9/2012	1720	7.92	3	6.2		0.282			<MRL 0.005	35		16		173			<MRL 0.08	0.58			
SAGASB	REG	Blow Me Down Brook	8/9/2012	1260	7.61	54	33		0.300			<MRL 0.005	571		2.4		124			<MRL 0.08	2.28			
SAGASB	REP	Blow Me Down Brook LR	8/9/2012			54																		
	BLK	Field Blank	8/9/2012	1.1	5.51	0		<MRL 1		<MRL 0.1		<MRL 0.005		<MRL 2		<MRL 1		<MRL 2		<MRL 0.08		<MRL 0.5		<MRL 1
SAGAPA	REG	Blow Me Down Pond	8/9/2012	1280	7.73	70	35		0.395			<MRL 0.005	511			<MRL 1	118			<MRL 0.08	2.48		19	
SAGAPA	REP	Blow Me Down Pond FR	8/9/2012																				18	
MORRSA	REG	East Primrose Brook	8/14/2012	578	7.52	23	20		0.791			<MRL 0.005	352		45		258			<MRL 0.08	1.41			
MORRSB	REG	Primrose Brook Confluence	8/14/2012	760	7.64	25	31		0.477			<MRL 0.005	161		22		257			<MRL 0.08	1.50			
MORRSC	REG	West Primrose Brook	8/14/2012	554	7.39	25	41		0.356			<MRL 0.005	75		15		257			<MRL 0.08	1.38			
MORRSD	REG	Indian Grave Brook	8/14/2012	772	7.71	16	25		0.800			<MRL 0.005	1194		45		254			<MRL 0.08	1.66			
MORRSE	REG	Passaic River	8/14/2012	872	7.73	23	27		0.450			<MRL 0.005	936		17		227			<MRL 0.08	2.13			
WEFAPA	REG	Weir Pond	8/15/2012	413	7.75	51	21		0.494			<MRL 0.005	452			<MRL 1	106			<MRL 0.08	4.29		13	
WEFAPA	REP	Weir Pond FR	8/15/2012																				12	
SAIRSA	REG	Saugus River	8/16/2012	489	7.20	113	104		0.955		0.0086		1166		22		142			<MRL 0.08	6.81			
SAIRSB	REG	Turning Basin	8/16/2012	577	7.32	116	88		0.898		0.0097		1807		22		180			<MRL 0.08	6.57			
	BLK	Field Blank	8/16/2012	1.3	5.55	0		<MRL 1		<MRL 0.1		<MRL 0.005		<MRL 2		<MRL 1		<MRL 2		<MRL 0.08		<MRL 0.5		
ROVASA	REG	Lower FDR Brook	8/20/2012	2950	8.19	9	48		1.46			<MRL 0.005	2036		93		634			<MRL 0.08	1.63			
ROVASB	REG	Upper FDR Brook	8/20/2012	3450	8.24	11	63		2.17			<MRL 0.005	2623		143		739			<MRL 0.08	1.73			
ROVASC	REG	Upper Crumb Elbow Crk	8/20/2012	2340	8.16	25	56		0.555			<MRL 0.005	1021		21		240			<MRL 0.08	3.16			
ROVASD	REG	Lower Crumb Elbow Crk	8/20/2012	2440	8.34	23	47		0.834			<MRL 0.005	1426		44		295			<MRL 0.08	2.85			
ROVASE	REG	Meriches Kill	8/21/2012	3710	8.32	12	43		1.12			<MRL 0.005	2368		62		452			<MRL 0.08	1.90			
ROVASF	REG	Val Kill	8/21/2012	2370	7.75	46	78		0.795		0.0088		2000		22		372		0.11		3.43			
SARASA	REG	Kroma Kill	8/23/2012	3140	8.43	65	20		13.8		0.015		768		953		420			<MRL 0.08	1.38			
SARASA	REP	Kroma Kill FR	8/23/2012	3130	8.41	59	20		13.7		0.014		758		946		416			<MRL 0.08	1.31			
SARASB	REG	America's Creek	8/23/2012	6390	8.01	102	49		0.876		0.042		51		13		404		0.31		4.49			
SARASC	REG	Upper Mill Creek	8/23/2012	4330	7.89	76	85		0.784			<MRL 0.005	685			<MRL 1	707		0.08		6.71			
SARASD	REG	Mill Creek Confluence	8/23/2012	1810	8.13	57	23		17.2		0.022		380		1153		390			<MRL 0.08	1.74			
MIMASA	REG	Mill Brook	8/28/2012	964	7.32	64	42		0.439			<MRL 0.005	4543		8.5		218			<MRL 0.08	4.67			
MIMASB	REG	Elm Brook	8/28/2012	556	7.31	107	98		1.59		0.0093		3869		56		154			<MRL 0.08	9.01			
MIMASC	REG	Concord River	8/28/2012	766	7.70	142	76		1.38		0.0069		2858		27		317			<MRL 0.08	6.74			

Figure S12.11. Example of final chemistry analysis results from SECRL

Appendix S12.A. List of Analytes and Specifications.

Analyte	Method	Precision Objective +/-		Net Accuracy Objective +/-		Reporting Limit	Holding Time	Sample Container	Field treatment /filtering	Preservation
ANC	SM Method 2320 B (Gran Titration)	<100 µeq/L 5 µeq/L	≥100 µeq/L 5%	<100 µeq/L 5 µeq/L	≥100 µeq/L 5%	N/A	14 days	500 ml white poly	None	Chill
Apparent Color	SM Method 2120 C (Spectrophotometry)	<20 PCU 2 PCU	≥20 PCU 10%	<20 PCU 1 PCU	≥20 PCU 5%	5 PCU	72 hours	500 ml white poly	None	Chill
Total P	SM Methods 4500-P-B-5 and 4500-P E (Persulfate digestion, spectrophotometry)	<10 µg/L 1 µg/L	≥10 µg/L 10%	<10 µg/L 1 µg/L	≥10 µg/L 10%	1 µg/L	28 days	125 ml brown glass	None	Chill
Total N	EPA Handbook 600/4-87/26 Ch. 18.0 (Alkaline persulfate digestion); Bran & Luebbe Method BL-818-87T (Automated colorimetry)	<0.2 mg/L 0.01 mg/L	≥0.2 mg/L 5%	<0.2 mg/L 0.02 mg/L	≥0.2 mg/L 10%	0.1 mg/L	28 days	125 ml brown glass	None	Chill
DOC	SM Method 5310C (Carbon analyzer: persulfate oxidation, infrared spectrometry)	<2 mg/L 0.1 mg/L	≥2 mg/L 5%	<1 mg/L 0.1 mg/L	≥1 mg/L 10%	0.25 mg/L	14 days	125 ml brown glass	None	Chill
Cl	EPA Method 300.0 (Ion chromatography)	<20 µeq/L 1 µeq/L	≥20 µeq/L 5%	<20 µeq/L 1 µeq/L	≥20 µeq/L 5%	2 µeq/L	28 days	500 ml white poly	None	Chill
Nitrate: NO_3	EPA Method 300.0 (Ion chromatography)	<10 µeq/L 0.5 µeq/L	≥10 µeq/L 5%	<10 µeq/L 0.5 µeq/L	≥10 µeq/L 5%	1 µeq/L	7 days	500 ml white poly	None	Chill
SO_4	EPA Method 300.0 (Ion chromatography)	<20 µeq/L 1 µeq/L	≥20 µeq/L 5%	<20 µeq/L 1 µeq/L	≥20 µeq/L 5%	2 µeq/L	28 days	500 ml white poly	None	Chill
Nitrite: NO_2	Bran & Luebbe Method BL-818-87T (Automated colorimetry)	<20 µg/L 1 µeq/L	≥20 µg/L 5%	10%		5 µg/L	48 hours	125 ml brown glass	None	Chill
Ammonia: NH_3	SM Method 4500-NH3 G (Automated colorimetry)	<0.31 mg/L 0.016 mg/L	≥0.31 mg/L 5%	10%		0.1 mg/L	48 hours	125 ml brown glass	None	Chill
Chlorophyll a	Standard Methods 10200H (trichromatic spectrophotometric method)	10%		10%		1 µg/L	28 days (filters)	1L brown poly (raw)	Filter within 24 hrs	Chill raw, Freeze filters

Appendix S12.B. Sample Chain of Custody Form.

Northeast Temperate Network

Acadia National Park

Water Chemistry Sample Submission Lab: SECRL

NETN Stream Analytes

Sample Site / Type	500 ml HDPE	125 ml Brown glass (filtered) Red Label	125 ml Brown glass	Sample Date	Deliv. Date
Brown's Brook (ACBRWN)					
0.2m grab	2	0	2	8/3/2011	8/4/2011
Bubble Outlet (ACBUBO)					
0.2m grab	2	0	2	8/4/2011	8/4/2011
Total:	4	0	4		

Analytes for this group of samples:

ANC
apparent color
total P
total N
DOC
NO3, SO4, Cl
NO2
NH3

Notes:

SOP 12 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
2.00	March 2007	B. Mitchell	**Section 5.2:** Added information for Sawyer Lab ANC analysis, and specified that the Sawyer lab will process all ANC samples starting in 2007. *(Originally part of SOP 19 – Acid Neutralizing Capacity)* **Section 5.3:** Title changed to apparent color. ACAD samples will be analyzed by Sawyer; others by NWQL. Added information for Sawyer Lab color analysis. *(Originally part of SOP 20 – A Color)* **Section 5.4:** Updated to correct lab codes. ACAD samples will be analyzed by Sawyer; others by NWQL. Added information for Sawyer Lab color analysis. *(Originally part of SOP 21 – Phosphorus)* **Section 5.5:** Updated to correct lab codes. ACAD samples for total N and total dissolved N will be analyzed by Sawyer lab. Added information for Sawyer analysis. *(Originally part of SOP 22 – Nitrogen)* **Section 5.6:** Updated to state that chl a analysis is conducted by the Sawyer lab. Added Sawyer lab info. *(Originally part of SOP 23 – Algal Biomass)*	Protocol Review Meeting
2.02	April 2009	B. Mitchell	**Section 5.3:** Revised to note that all samples were analyzed by SECRL (University of Maine) starting in 2008. *(Originally part of SOP 20 – A Color)* **Section 5.4:** Revised to note that all samples were analyzed by SECRL (University of Maine) starting in 2008 *(Originally part of SOP 21 – Phosphorus)* **Section 5.5:** Revised to note that all samples were analyzed by SECRL (University of Maine) starting in 2008. *(Originally part of SOP 22 – Nitrogen)*	Protocol Review Meeting
3.00	January 2012	B. Gawley	Reformatted using NRPS-NRR template. Combined all or sections of v2.02 SOP #s 18 - 26 to consolidate all instructions for preparation, collection, processing, and QA/QC of water samples. Re-assigned as SOP 12. Updated list of analytes and methodology to reflect analysis schedule beginning in 2012. Revised shipping and labeling instructions, and contact information to reflect change from NWQL to SECRL. Added section on SECRL data reporting	Protocol review meeting; Version 2.02+ to 3.00 (major revision); change in analytes.

Version #	Date	Revised by	Changes	Justification
			policies and procedures. Added table of analytes and specifications as Appendix S12.A Added sample chain of custody form as Appendix S12.B.	
3.01	December 2012	B. Mitchell	Minor edits	Internal review
3.02	December 2013	B. Mitchell	Minor edits	Reviewer comment

SOP 13 – Data Management

Northeast Temperate Network

Version 3.02

Overview

This SOP describes the various phases of the data management "life cycle", from data entry to back up and archiving. It also provides an overview of NETN file naming conventions and of the computer data platforms used to record, store, and process information obtained from NETN freshwater monitoring activities.

Background and Scope

Whether initially recorded on a paper data form or in the volatile memory of an electronic datalogger, all information obtained from field monitoring or laboratory analysis goes through a number of stages or processes from the moment of collection until final archiving. These stages are known as the "Data Life Cycle", and are diagrammed in Figure S13.1. Data entry is the initial transcription or import of the field data (collected during the data acquisition stage) to the database or other data management platform. Verification and validation are quality control processes ensuring that the data that have been transferred to this platform are both accurate and within expected ranges. Metadata creation provides "data about the data" so that future users will understand the structure and significance of the information. Finally, backup and archival procedures guarantee that the information will remain accurate and available for future use.

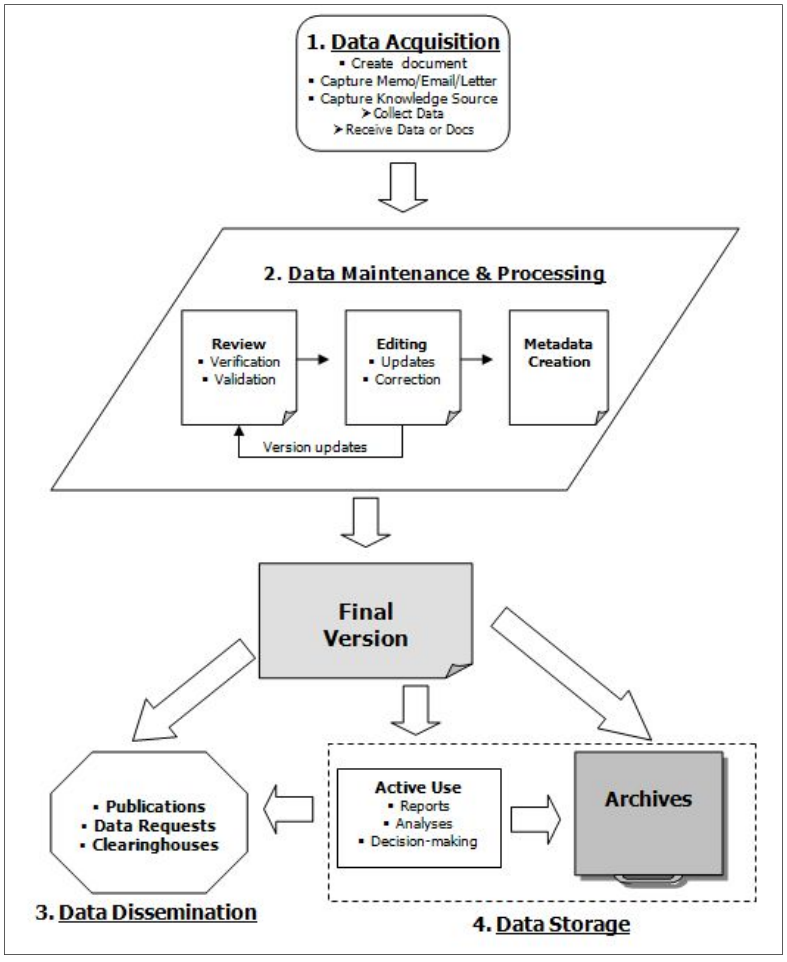


Figure S13.12. The Data Lifecycle.

The NPS I&M program and NETN utilize a number of electronic applications to record (and subsequently retrieve) data in the office or field, to store and process data, and to summarize and analyze data for reports and

data requests. Much of the water quality and quantity data are saved directly to logging devices, and are imported to NETN's master water monitoring database, NETN_H2O, which has several modules for viewing/editing, exporting, and reporting functions. One of the modules currently in development will facilitate exporting data from NETN_H2O to NPSTORET or directly to EQuIS, the I&M program database that serves as an initial portal to the EPA's STORET data warehouse, which is the ultimate repository for all NPS water data.

File Naming Conventions

During the data collection process, data files created by electronic dataloggers must be appropriately named using standard file naming conventions. Digital photographs and exported files that have been processed and saved in a new format also must be named properly. Standard naming is essential for good data management – it provides the initial association of metadata (e.g. sampling location and date) with the field data. Some filenames are generated automatically by dataloggers (such as the Q-Calc PDA program), using the location names or codes entered into the logger by field crews during the monitoring process combined with the system date and time. Other devices, like the YSI 650 MDS or the FlowTracker, require the user to enter a filename before beginning to collect data. These names may be restricted to a certain number of characters due to hardware or software limitations. File naming conventions for NETN water monitoring data are displayed in Table S13.1.

Table S13.1. NETN Water Monitoring File Naming Conventions.

File Type	Naming convention	Example
YSI Sonde (Ecowatch)	NETN Site code + 2-digit year *(Limited to 8 characters)*	MABIPA12.dat
FlowTracker	NETN Site code + .MMYY	MIMASA.1011.wad
Q-Calc	"Q" + USGS Station # + MMDDYY + HHMMSS	Q1022808_060611_102612.html
Li-Cor	NETN Site code + _MM-DD-YY_ + "LPP" *(Note: if multiple profiles are in one file, use site code for 1st profile in filename)*	ACJORD_06-24-10_LPP.txt
Photos	NETN Site code + _YYYYMMDD_ + short description_# *(if necess.) (Note: Specific details for stream and lake photo naming in SOP 4 and SOP 5, respectively)*	ACEAGL_20070515_YSI_3.jpg *or* SARASA_2010725_US.jpg

Data Entry

Data entry is the initial set of operations in which raw data from paper field forms or field notebooks are transcribed into a computerized form (into a database). Several methods (electronic datalogger or paper field form) are used to record data in the field; therefore, there will be several ways of inputting data into NETN_H2O.

Data entry is best performed by a person who is familiar with the data, and ideally takes place as soon as data collection is complete. It becomes more difficult to track down questionable information on a field form as the time period increases after data collection. Since there can be a considerable lag time for analytical results to be sent from off-site laboratories, results are usually added by editing an existing record that was created when field data were entered for that monitoring visit.

General procedures for data entry are as follows:

1. *Become familiar with the data forms.* Some errors or omissions are detectable or suspected at this point and can necessitate setting aside some of the forms for clarification or correction by the field staff *before* attempts at entering such data into the computer. Identify in the documents a good stopping point to prepare for interruptions or the end of the work day. The best stopping point is at the completion of the entry of any single, complete field form rather than in the middle of a logically single operation.
2. *Transcribe the data.* Data are entered in one logical set at a time – usually one complete field form. Errors or questions about the data content can be recorded in separate data entry notes; such notes are useful during data verification. Initial each paper form after data are entered to avoid confusion about whether it has been processed (a colored pen is useful for this purpose). Interrupt data entry only at logical stopping points.
3. *Create a hardcopy of the data.* Print a copy of all the entered data for later verification (consult the NETN Water Monitoring Coordinator for formatting details). Do not sort the file because it must be checked in the same order as it was entered to speed verification from matching field forms. Check whether *all* the data were printed and are readable (font size and attributes) for later use. Carefully formatted reports are not prepared at this stage because the data have not been checked and probably contain some errors.
4. *Document the data entry.* Indicate on a cover sheet or other suitable location the name or initials of the operator and the date of entry completion. Record identical information at the top of the printout of the entered data. The field data and the printout are kept together from this point on for use in data verification.

Manual Data Entry

Information exclusively residing on paper field forms is manually typed into the system, although this method is the least desirable because of the increased likelihood of transcription errors. The data entry module of NETN_H2O (NETNH2O_FieldDE) and some other dedicated data entry applications have built in QC features to provide error messages when values that are obviously out of range are mistakenly entered.

Substantial progress has been made toward limiting the amount of NETN water monitoring data that must be entered manually. Whenever possible, data are entered electronically from the start. In some cases, data that are primarily recorded on paper forms are also entered into an electronic field data entry system almost simultaneously. The electronic data are imported into NETN_H2O and reconciled with the paper sheets during the proofing (verification and validation) process.

Electronic Data Entry

Data captured on field dataloggers (such as the YSI sonde, FlowTracker, or Li-Cor light meter) can be imported into the NETN_H2O interface using customized import routines. Similar routines can be developed for data delivered from analytical laboratories in standardized electronic formats. Once an import routine has been developed to accept the output from a field datalogger or electronic laboratory result report it is incorporated into the "NETNImportTools" module of NETN_H2O to provide a user-friendly interface (Figure S13.1) to associate the data with a particular monitoring event. A user manual is in development to describe the step by step import process. The manual will be appended to this SOP upon completion.

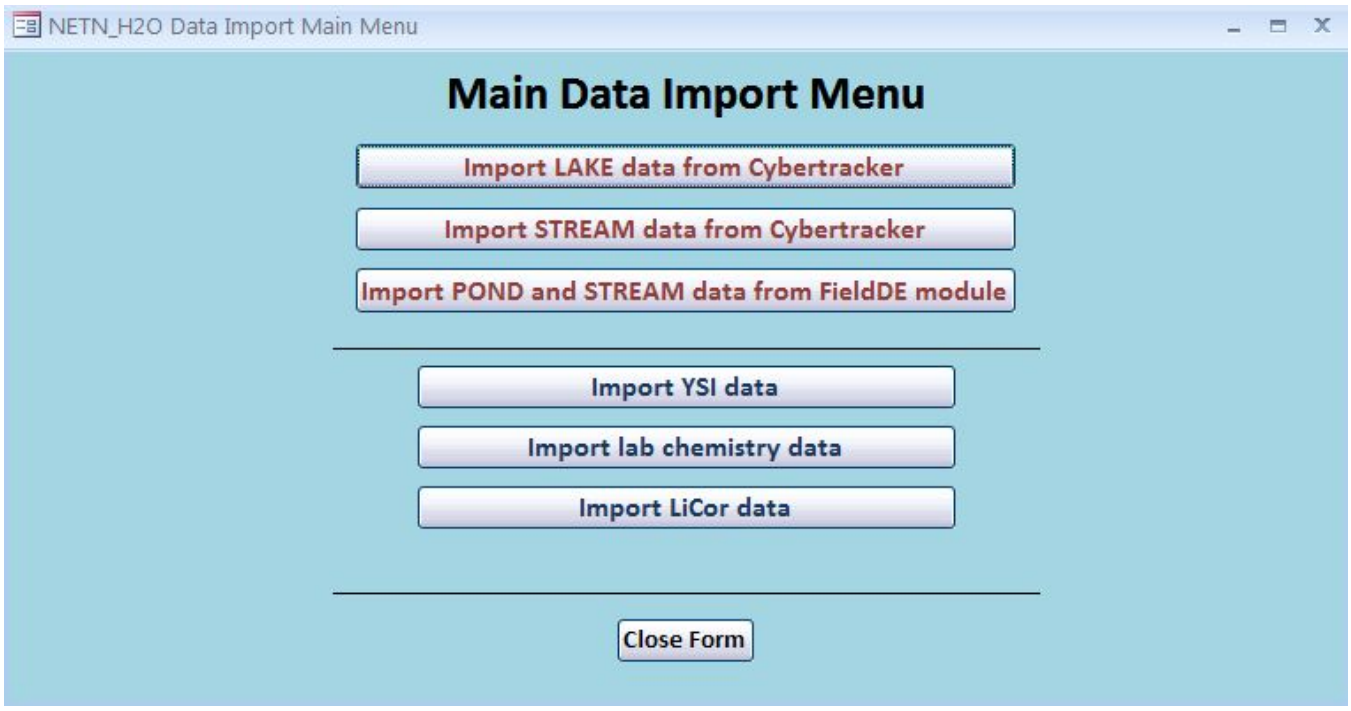


Figure S13.1. NETNImportTools Main Menu.

Verification

Data verification ("proofing") immediately follows data entry and involves checking the accuracy of computerized records against the original source—usually paper field records. Although the goal of data entry is to achieve 100 percent correct entries, this is rarely accomplished. To minimize transcription errors, 100 percent of records are verified to their original source during the first review. Further, 10 percent of records are reviewed a second time by a different person (preferably the NETN Water Monitoring Coordinator) and the results of that comparison reported with the data. If errors are found in the second review, then the entire data set is verified again. Once the computerized data are verified as accurately reflecting the original field data, the paper forms are archived and the electronic version is used for all subsequent data activities.

Verification is often best accomplished using teams of two people (but can be done by a single person), with one person reading the original data sheets (the reader) and the second person reading the same data on a computer screen or printout (the checker). In the following process, a reader and a checker work together. The checker needs a fine-tipped marker for identifying errors and for indicating corrections. The reader needs to use a different color marker. Use of a straight edge make reading aligned tabular data easier. A notepad is important for making notes that are useful during validation.

1. *Compare entered data with field forms.* The reader reads the original data (field forms) out loud so that the checker can compare the original data with the entered data. The three common types of error are: duplicated records (entered twice), missing records (inadvertently skipped during entry), and misspellings (wrong number or code). The checker controls the speed of the reader and halts the reader when a discrepancy is found.

When an error in the computerized records is found, the correction to be made is noted in red on the printout or a copy of the data sheet, *not on the original data sheet.*

2. After verifying the data from each field sheet, the reader dates and initials the original field form at the top (or where indicated), indicating that verification was done. The reading and checking is continued until all the data sheets in a data set are compared. Thereafter, an original set of data sheets with completion marks (for entry and verification) and a set of printouts or data sheet copies with needed corrections marked in red are available.
3. *Correct identified errors in the computer files*. An application for data entry (or one provided specifically for editing) is used to correct the errors. Each correction is made separately in the computer file. Do not use the *search and replace* as it often produces unexpected consequences. As each correction is made, check the red mark on the printout or data sheet copy with a green check mark. When all identified errors are corrected in the computer file, the printout or data sheet copy is inspected again for any corrections that were missed (a red check without a green check). Finally, initial and date the printout or data sheet copy at the top to indicate that all errors were corrected. Save the printout or data sheet copy with the original field form because it serves as direct evidence of the completion of entry and verification.
4. *Complete a simple summary analysis*. Run simple summary statistics of the entered data on the computer. This is important because even when care is taken up to this point, a duplicate or omitted entry could have been overlooked. For example, the number of known constant elements, such as the number of sampling sites, samples per site, or sites per date can be viewed. Ask the same question in different ways to find differences in the answer that will provide clues to errors. The more variety of checks to test the completeness of the data, the greater is the confidence that the data are completely verified.

Data Validation and Quality Control

The NETN Water Monitoring Coordinator must validate the data after verification is complete. Validation is the process of reviewing computerized data for range and logic errors. Although data are correctly transcribed from the original field forms, the results may not be accurate or logical. For example, a stream pH of 25.0 or a temperature of 95°C is illogical and almost certainly incorrect, whether or not it was properly transcribed from field forms.

Step-by-step instructions are not possible for data validation because each data set has unique measurement ranges, sampling precision, and accuracy requirements. Nonetheless, validation is an important step in the certification of the data. Certain components of data validation are built into data entry forms (such as range limits). Additional data validation can be accomplished during verification, if the operator is sufficiently knowledgeable about the data. Data can be compared to previous years to identify gross differences. Validation procedures will identify generic errors such as missing, mismatched, or duplicate records, or errors specific to particular projects.

One of the most important tasks of rigorous validation is when the checker returns to the original data media (*and* the printout or 2nd copy) to make corrections and notations about the errors that were found and fixed in the digital files. Without annotating the original field forms, the digital

and paper records do not match. If this mismatch is discovered without adequate documentation, *all* data are rendered suspect.

The following generic procedures can be used to develop a validation strategy for most data sets. Examples of validation strategies (and strange errors) are also provided.

- *Catalog the error types found in each data set*. When particular validation errors are found, it is important to catalog them in an error log for that data set. Notes on the error(s) include a description, how detected, and how corrected. Simple, generic errors and more esoteric and cryptic errors must be documented. This list of errors is a valuable reference for the next validation session and will ultimately be used for building formal validation procedures into the data entry process and other automated, post-entry error-checking routines.
- *Perform exploratory data analysis to look for outliers*. Database, graphic, and statistical tools can be used for ad-hoc queries and displays of the data. Histograms, line plots, and basic statistics reveal possible logic and range errors. Such exploratory methods identify obvious outliers. Some of these data results could appear unusual but prove to be quite valid after confirmation. Noting correct but unusual values in documentation of the data set saves other users from repeating the same confirmation.
- *Modify field data forms to avoid common mistakes*. With a list of validation errors and exploratory data results in hand, the field-data forms as the source of the logic errors can be reevaluated. Often minor changes, small annotations, or adding check boxes to a field form remove ambiguity about what to enter on the form. In fact, any time the same type of validation errors occurs repeatedly in different data sets, the field form – not the field crew – is usually at fault. Repeated validation errors can also mean that protocol(s) or field training is faulty, which must be recognized and corrected.

Data generated from digital dataloggers such as the YSI 650MDS must be reviewed for validity, especially values indicating that the sensor(s) failed or were improperly calibrated. More detailed instructions for detecting and deleting these types of errors are found in the SOP for the specific monitoring equipment. This proofing and validation process can be performed in the datalogger's computer data-viewing application (such as YSI's EcoWatch software), *before* the data are imported to NETN_H2O.

Creating Metadata

Metadata (which typically answers the question of “How” something was done) is the most critical improvement to modernized STORET. At a time when states are increasingly passing “Credible Data” statutes and ignoring improperly documented data, the NPS must ensure that metadata about sample collection, preservation, transport, and storage; laboratory preparation and analytical methodology; quantification and detection limits; and other metadata that help users judge the usefulness of data are stored with the data. In short, poorly documented data are a waste of money and effort.

NPSTORET allows users to document the entire monitoring procedure, from field-data collection to final result generation. Before any results can be entered into the system, NPSTORET must be prepped with the appropriate metadata documenting the field

sampling/measurement procedure; gear configurations; sample preservation, transport, and handling; field/laboratory analytical procedures; laboratory sample preparation; complete detail about the characteristics measured; laboratory information; staff and their roles; and any literature citations pertinent to the monitoring effort. Metadata only needs to be entered once in one place in the database before entering results. The metadata documentation section of the NETN_H2O database is currently being upgraded, in an effort to more efficiently "feed" the NPSTORET system.

Editing Data

Data sets are rarely static. They often change through additions, corrections, and improvements made from summary and analysis. There are three main exceptions to this process:

- Only make changes that improve or update the data while maintaining data integrity.
- Document any changes made to the data set, especially once archived.
- Be prepared to recover from mistakes made during editing.

The NETN Water Monitoring Coordinator edits all archived data. Document every change in an edit log and accompany it by an explanation that includes pre- and post-edit data descriptions. Practice careful version control during editing to ensure that changes are incremental and that roll-back to a previous editing session is possible until such time as the file being changed is certified as correct, up to date, and ready for archiving.

Backup and Archiving

After each month's monitoring data are entered, verified, and validated, the NETN_H2O database is backed up to the ACAD and NETN network drives. These drives are each regularly backed up by data management or IT staff. The edit log files, documenting major edits and changes to the database, are also backed up and stored with the database copies. NETN_H2O is a complex database containing many linked files and documents. To ensure that all of the NETN_H2O information is copied or backed up, always copy the entire NETN_H2O folder (at the highest level under the root drive or folder).

The annual roll up and archiving of NETN's data to the NPSTORET database will occur at the end of each calendar year, once all laboratory results from offsite analyses have been entered and all corrections and edits are complete and fully documented in the edit log. The NETN Water Monitoring Coordinator will conduct a final "spot check" of randomly selected records representing 10 percent of the data from the monitoring year. The resulting end-of-year copy of the NPSTORET database will reflect the complete annual water-quality-monitoring information for NETN parks, and will be used by the NETN Water Monitoring Coordinator or Data Manager for submission to the NPS WRD for transfer to the national STORET data warehouse.

The NETN_H2O Database

NETN_H2O is the master "working" database for entry, import, storage, viewing and editing, and export of NETN water monitoring data. It was developed by the NETN using Microsoft Access software, and consists of a "back-end" for data storage which can be linked to a series of "front-end" modules containing forms and queries designed for specific activities like viewing or editing data (Figure S13.2) or exporting summary statistics (Figure S13.3).

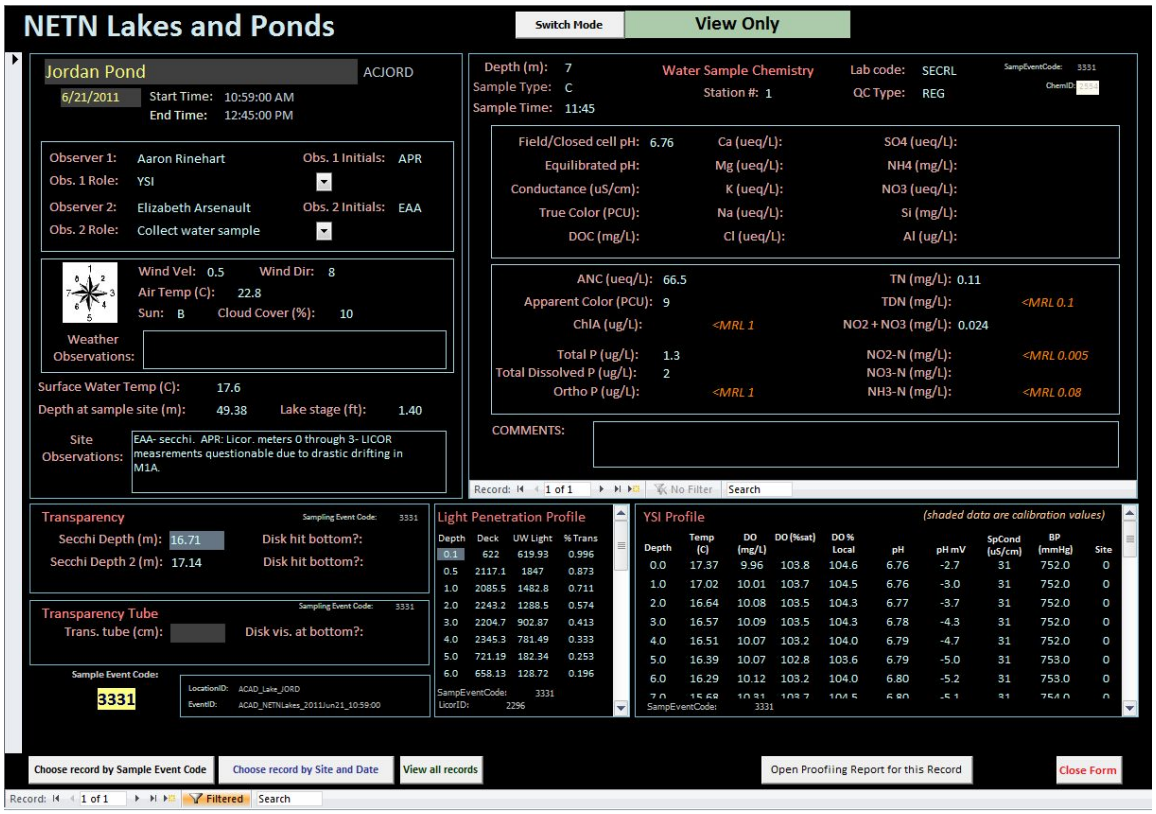
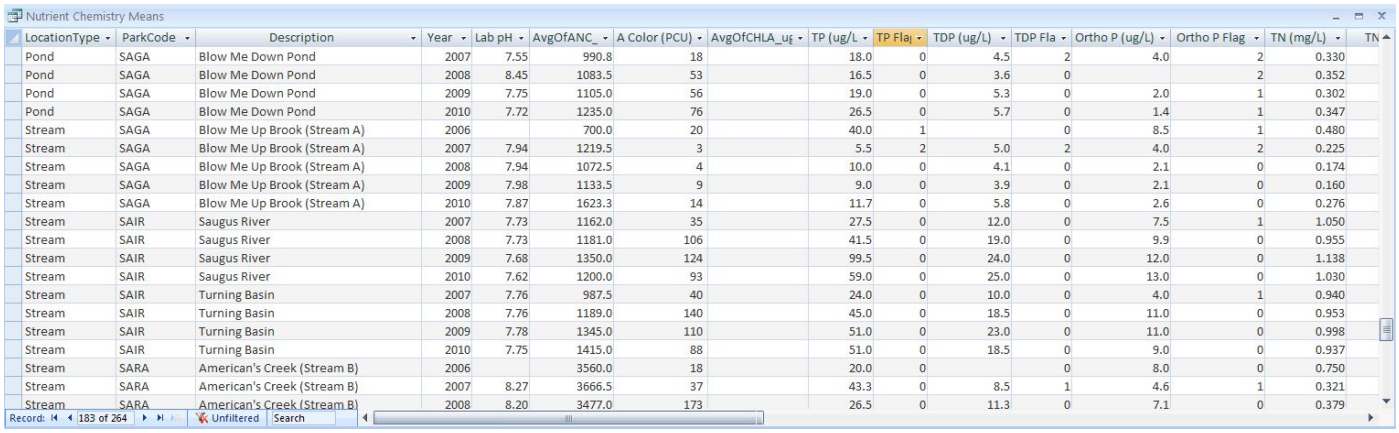


Figure S13.2. NETN_H2O Data View/Edit Screen.



LocationType	ParkCode	Description	Year	Lab pH	AvgOfANC_	A Color (PCU)	AvgOfCHLA_ug	TP (ug/L	TP Fla	TDP (ug/L)	TDP Fla	Ortho P (ug/L)	Ortho P Flag	TN (mg/L)	TN
Pond	SAGA	Blow Me Down Pond	2007	7.55	990.8	18		18.0	0	4.5	2	4.0	2	0.330	
Pond	SAGA	Blow Me Down Pond	2008	8.45	1083.5	53		16.5	0	3.6	0		2	0.352	
Pond	SAGA	Blow Me Down Pond	2009	7.75	1105.0	56		19.0	0	5.3	0	2.0	1	0.302	
Pond	SAGA	Blow Me Down Pond	2010	7.72	1235.0	76		26.5	0	5.7	0	1.4	1	0.347	
Stream	SAGA	Blow Me Up Brook (Stream A)	2006		700.0	20		40.0	1		0	8.5	1	0.480	
Stream	SAGA	Blow Me Up Brook (Stream A)	2007	7.94	1219.5	3		5.5	2	5.0	2	4.0	2	0.225	
Stream	SAGA	Blow Me Up Brook (Stream A)	2008	7.94	1072.5	4		10.0	0	4.1	0	2.1	0	0.174	
Stream	SAGA	Blow Me Up Brook (Stream A)	2009	7.98	1133.5	9		9.0	0	3.9	0	2.1	0	0.160	
Stream	SAGA	Blow Me Up Brook (Stream A)	2010	7.87	1623.3	14		11.7	0	5.8	0	2.6	0	0.276	
Stream	SAIR	Saugus River	2007	7.73	1162.0	35		27.5	0	12.0	0	7.5	1	1.050	
Stream	SAIR	Saugus River	2008	7.73	1181.0	106		41.5	0	19.0	0	9.9	0	0.955	
Stream	SAIR	Saugus River	2009	7.68	1350.0	124		99.5	0	24.0	0	12.0	0	1.138	
Stream	SAIR	Saugus River	2010	7.62	1200.0	93		59.0	0	25.0	0	13.0	0	1.030	
Stream	SAIR	Turning Basin	2007	7.76	987.5	40		24.0	0	10.0	0	4.0	1	0.940	
Stream	SAIR	Turning Basin	2008	7.76	1189.0	140		45.0	0	18.5	0	11.0	0	0.953	
Stream	SAIR	Turning Basin	2009	7.78	1345.0	110		51.0	0	23.0	0	11.0	0	0.998	
Stream	SAIR	Turning Basin	2010	7.75	1415.0	88		51.0	0	18.5	0	9.0	0	0.937	
Stream	SARA	American's Creek (Stream B)	2006		3560.0	18		20.0	0		0	8.0	0	0.750	
Stream	SARA	American's Creek (Stream B)	2007	8.27	3666.5	37		43.3	0	8.5	1	4.6	1	0.321	
Stream	SARA	American's Creek (Stream B)	2008	8.20	3477.0	173		26.5	0	11.3	0	7.1	0	0.379	

Figure S13.3. NETN_H2O Chemistry Means Query Screen.

Currently, the "Main" (View/Edit), FieldDE (Data Entry, shown in Figure S13.4), Import, and Export modules are fully operational. The Reporting module and the Export to NPSTORET module are under development. A comprehensive user manual is also in development, and will be appended to this SOP upon completion.

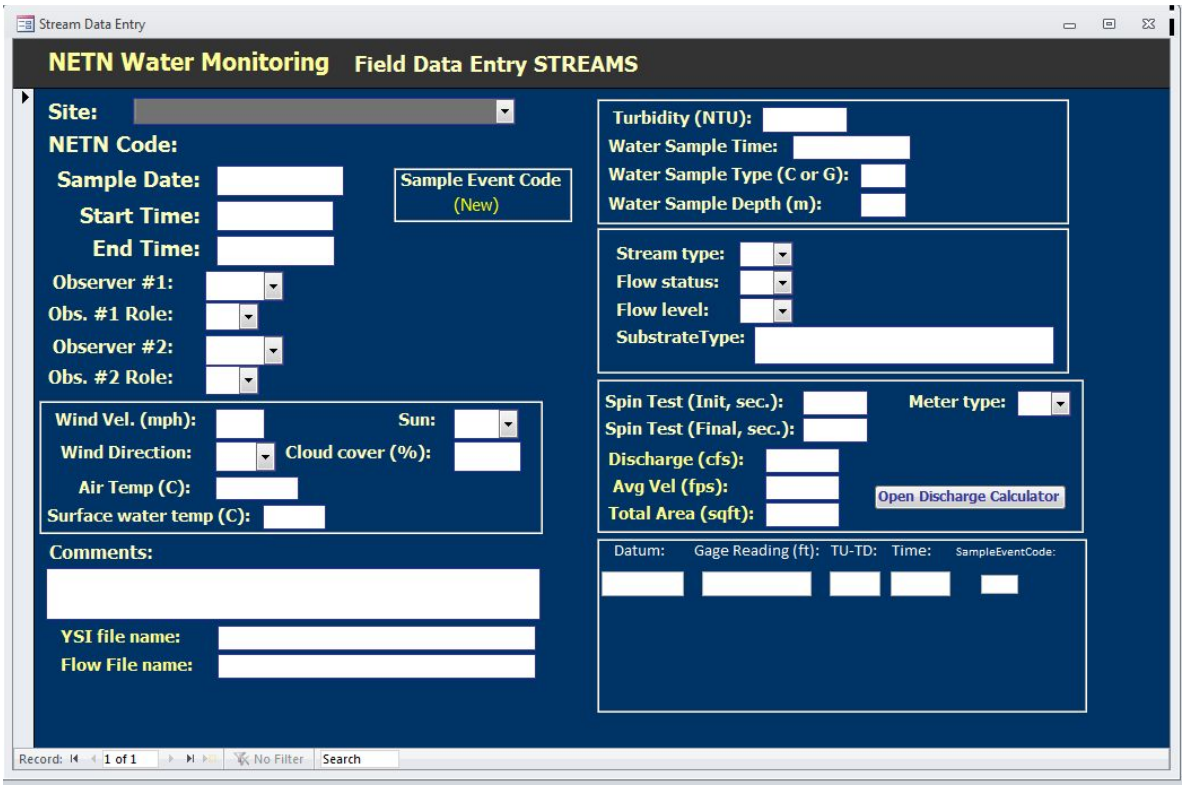


Figure S13.4. NETNH2O_FieldDE (Field Data Entry) Module used in 2012.

The NPSTORET Database

All data collected by vital signs water-quality-monitoring activities is ultimately entered into EQuIS either directly or via the NPSTORET database (Figure S13.5). This database was developed by the NPS Water Resources division to serve as a portal to the USEPA STORET data warehouse. NPSTORET and EQuIS ensure that monitoring data are in the proper format and contain the appropriate metadata for migration to STORET.

Guidance for using NPSTORET is available in the on-line Help System, system documentation, the Vital Signs Water-quality Data Management and Archiving Web site (http://www.nature.nps.gov/water/infoanddata/index.cfm), and in the *Guidance on Water Quality, Contaminants, and Aquatic Biology Vital Signs Monitoring Under the Natural Resource Challenge Long-Term Water-quality Monitoring Program - Part E: Draft Guidance on Data Reporting and Archiving in STORET* at http://www.nature.nps.gov/water/infoanddata/wqPartEtest.pdf. Step-by-step instructions for exporting data from NETN_H2O to NPSTORET are under development and will be appended to this SOP upon completion.

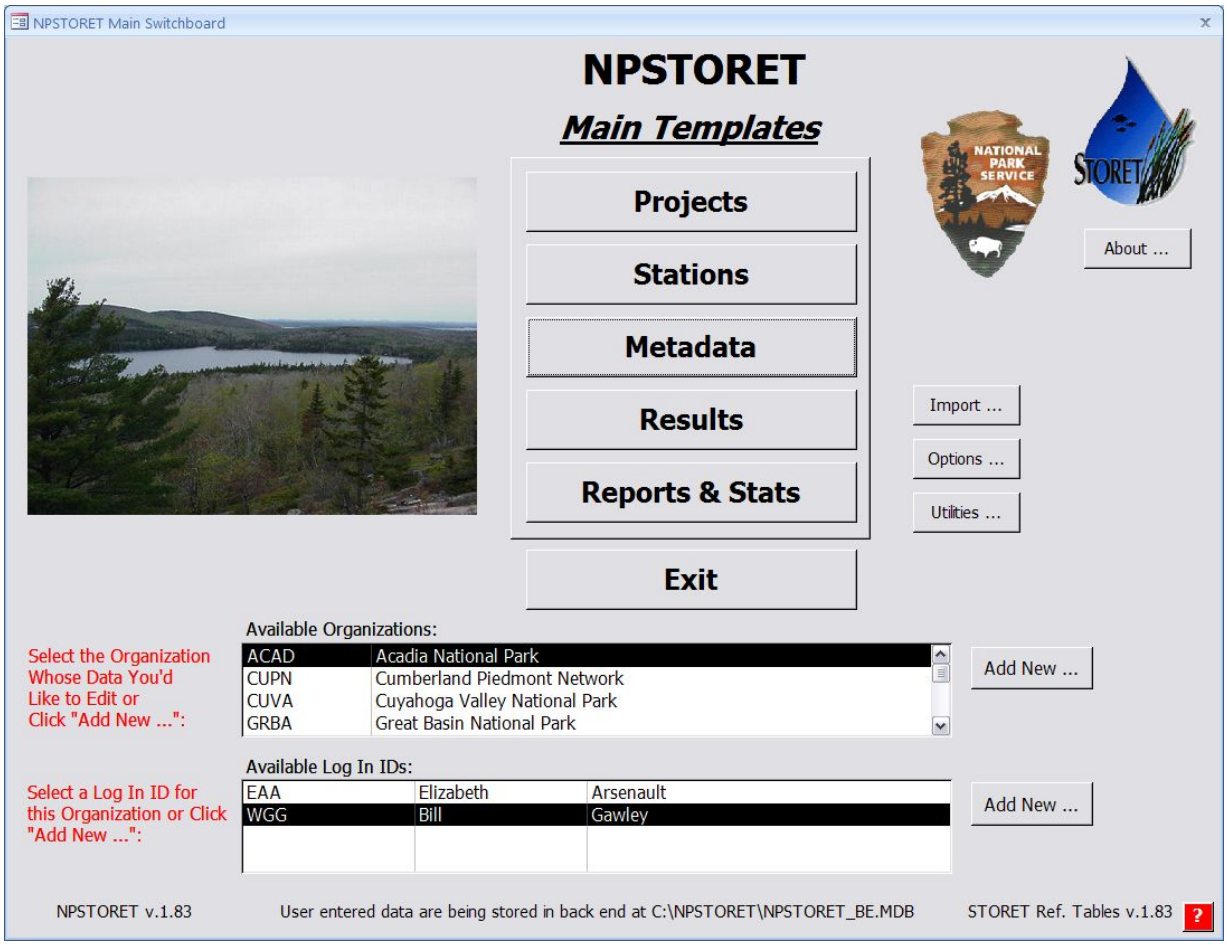


Figure S13.5. NPSTORET Main Menu Screen

Aquatic Data Utility Software

Most or all of the field dataloggers and other electronic monitoring equipment used by NETN have an associated software application that runs on a PDA or standard computer for configuration and data download. These programs are often specific to the individual manufacturer and/or model of the hardware items they support. It is difficult to fully document all of these applications, since there is some variability across the network in the types of equipment used. Instructions on the use of the programs are usually found in the user manuals or other documentation for the monitoring equipment, or in the software help files.

Some of the most frequently used support software, common to all NETN monitoring activities, are described below:

Cybertracker PDA Field Data Entry

At Acadia, electronic data entry in the field is often accomplished using a Personal Data Assistant (PDA) running a database designed in the open source software Cybertracker. Information such as site location, sampling date, weather conditions, QA/QC data, and notes is entered on a series of screens (Figure S13.6) containing pick lists and option boxes, formatted numerical fields, and free text boxes.

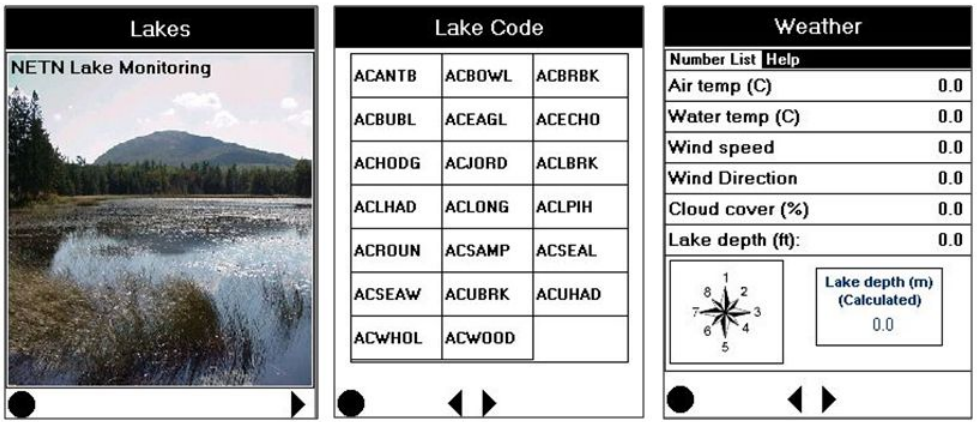


Figure S13.6. Cybertracker Data Entry Screens

The data records are downloaded to a "flat file" database (on an office computer) which generates an MS Excel export file formatted for direct import to NETN_H2O.

USGS Q-Calc PDA software

USGS's Q-Calc is another PDA application used by NETN monitors when obtaining discharge measurements with a Pygmy meter. Developed at the USGS Maine Water Science Center, Q-Calc is a Windows Mobile based application (Figure S13.7) that stores site data and observations, records and processes measurements of velocity and section area, and calculates total discharge and other measurement statistics. Data are output to a formatted .html file (Figure S13.8) which is archived as a portion of the measurement record.

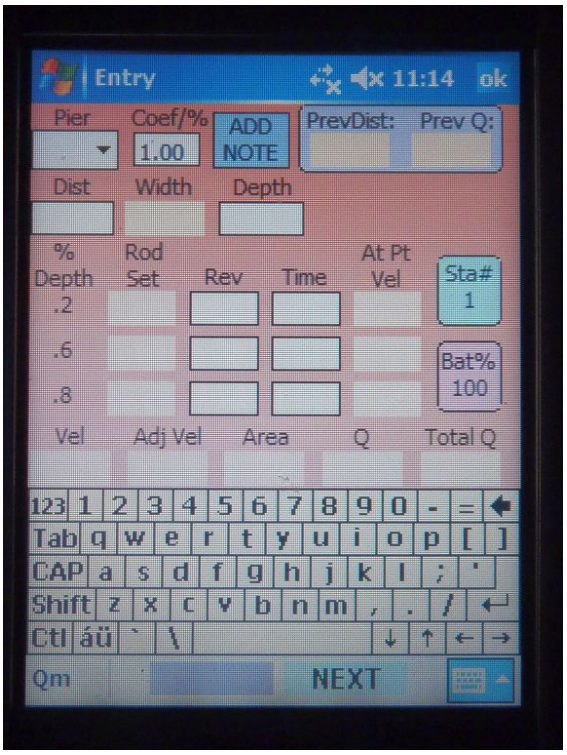


Figure S13.7. Q-Calc Data Entry Screen.

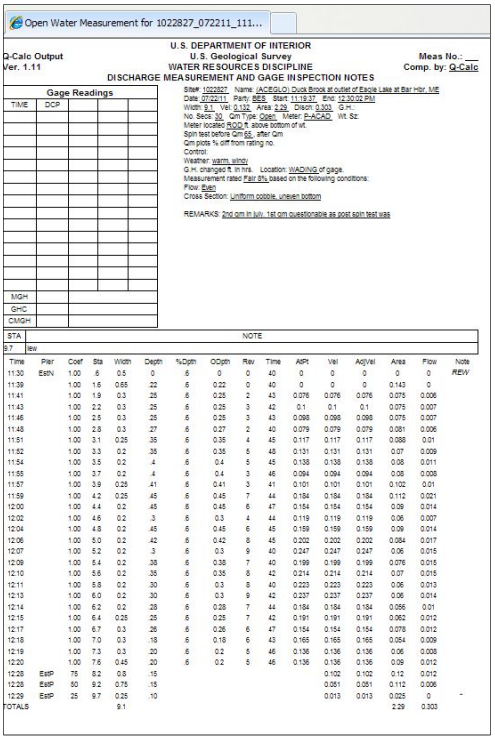
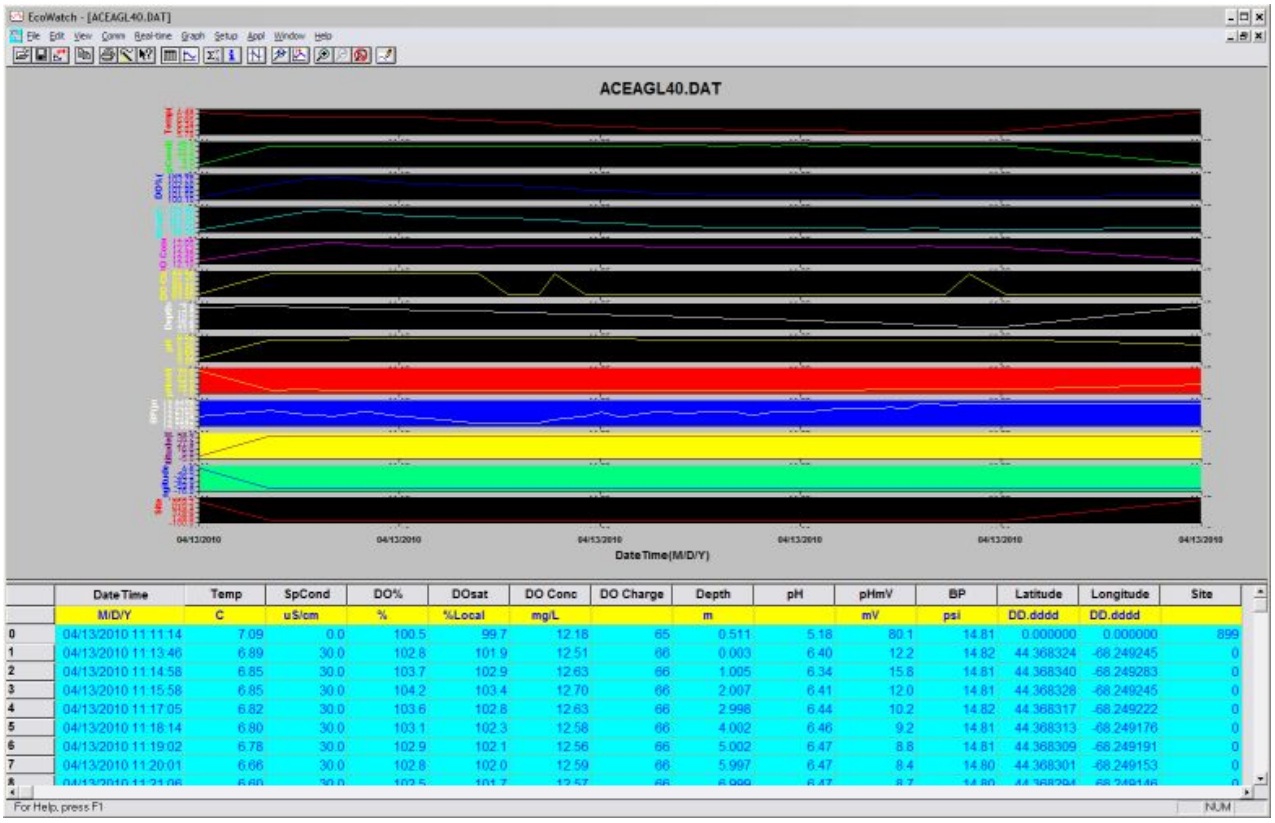


Figure S13.8. Q-Calc Data Output Report.

YSI EcoWatch Software

EcoWatch software is supplied with the YSI 600XL water quality sonde, and is used to configure the sonde, download and display data from the 650MDS datalogger (Figure S13.9), and perform file management functions (file merges, etc.). Instructions for use of the software are found in the software help files. EcoWatch Lite was introduced in 2013 for use with 64-bit operating systems.



	Date Time	Temp	SpCond	DO%	DOsat	DO Conc	DO Charge	Depth	pH	pHmV	BP	Latitude	Longitude	Site
	M/D/Y	C	uS/cm	%	%Local	mg/L		m		mV	psi	DD.dddd	DD.dddd	
0	04/13/2010 11:11:14	7.09	0.0	100.5	99.7	12.18	65	0.511	5.18	80.1	14.81	0.000000	0.000000	899
1	04/13/2010 11:13:46	6.89	30.0	102.8	101.9	12.51	66	0.003	6.40	12.2	14.82	44.368324	-68.249245	0
2	04/13/2010 11:14:58	6.85	30.0	103.7	102.9	12.63	66	1.005	6.34	15.8	14.81	44.368340	-68.249283	0
3	04/13/2010 11:15:58	6.85	30.0	104.2	103.4	12.70	66	2.007	6.41	12.0	14.81	44.368328	-68.249245	0
4	04/13/2010 11:17:05	6.82	30.0	103.6	102.8	12.63	66	2.998	6.44	10.2	14.82	44.368317	-68.249222	0
5	04/13/2010 11:18:14	6.80	30.0	103.1	102.3	12.58	66	4.002	6.46	9.2	14.81	44.368313	-68.249176	0
6	04/13/2010 11:19:02	6.78	30.0	102.9	102.1	12.56	66	5.002	6.47	8.8	14.81	44.368309	-68.249191	0
7	04/13/2010 11:20:01	6.66	30.0	102.8	102.0	12.59	66	5.997	6.47	8.4	14.80	44.368301	-68.249153	0

Figure S13.9. EcoWatch file viewer.

FlowTracker software

Several utility programs are provided with the SonTek FlowTracker to support and maintain the acoustic discharge measurement and datalogger functions. The “FlowTracker” program facilitates the downloading and viewing of data files from the datalogger, and produces a formatted results report for each measurement (Figure S13.10). Instructions for use of the software are found in the software help files.

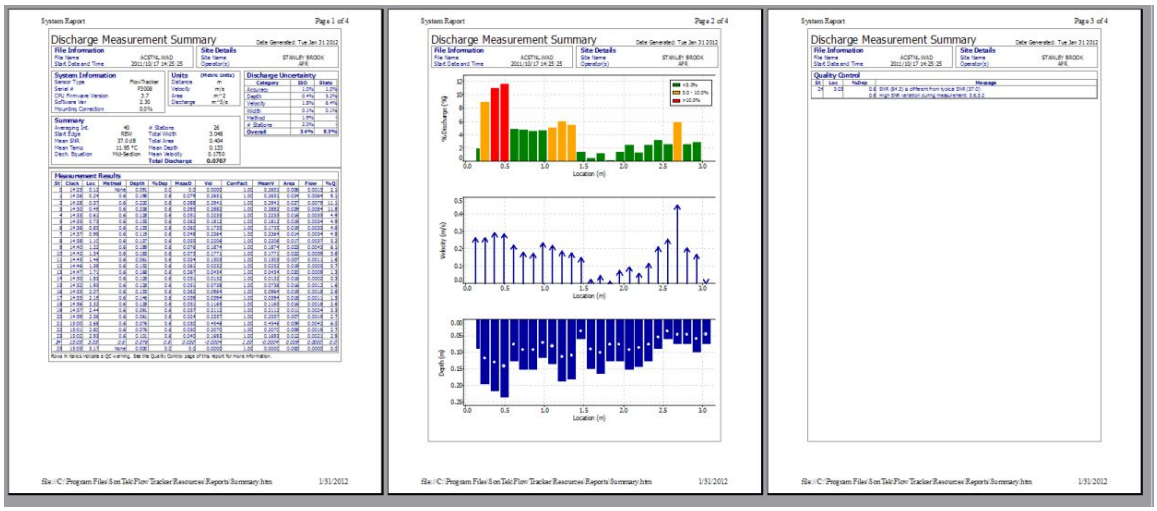


Figure S13.10. FlowTracker Data Report.

The "SonUtils4" software (Figure S13.11) is used for calibration, configuring system settings, and performing QA checks (beam checks, etc.) on the FlowTracker hardware. Instructions for use of the software are found in the software help files.

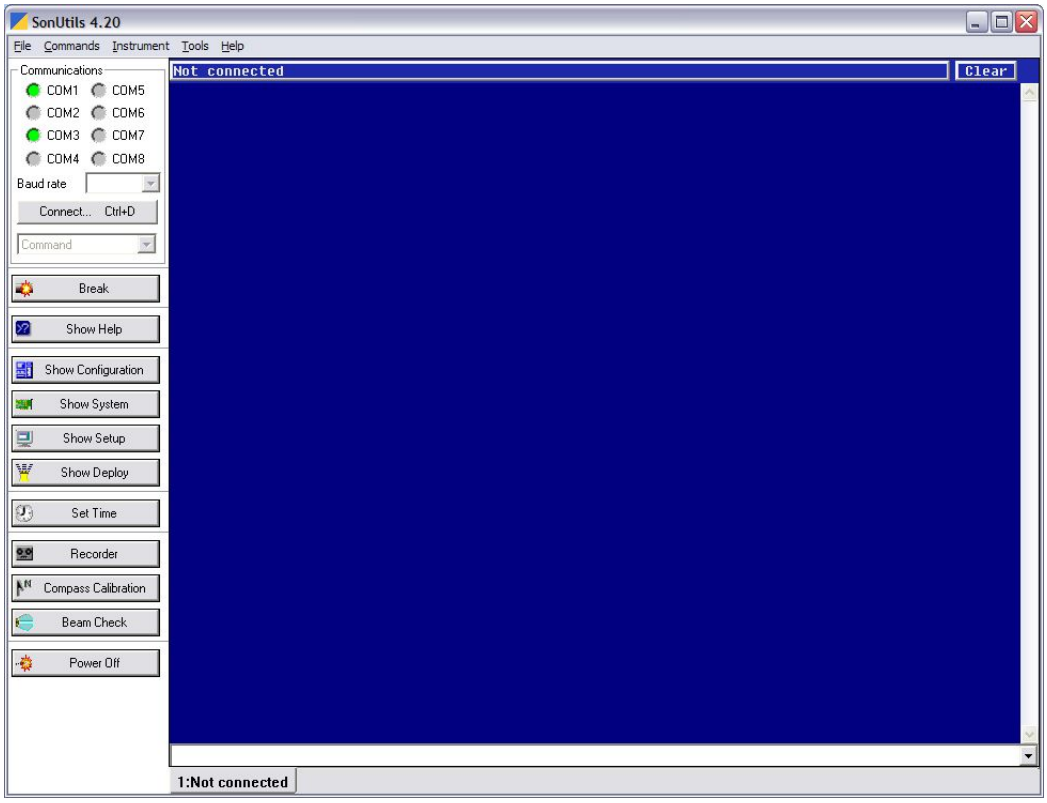


Figure S13.11. SonUtils4 Main Screen.

NETN Water Monitoring Data Flow

Data management is a constant process. There are tasks and responsibilities that are performed on daily, weekly, and seasonal (annual) schedules. An outline of these responsibilities is provided in Table S13.2.

Table S13.2. NETN Water Monitoring Data Flow and Responsibilities

Interval	Responsible Party	Tasks
Daily	Monitoring teams	Data are collected from lake, pond, stream, and other associated monitoring activities. Data and photos are downloaded from all dataloggers, PDAs, field computers, cameras, etc. to an "office" computer and with backup copies loaded to the NETN file server (as soon as possible). Supplementary backup copies are loaded to removable media (thumb drive, external HD, etc). Data from paper field forms are entered to first stage of electronic data entry system (Cybertracker PDA program or NETNH20_FieldDE). All paper field forms are filed in folder.
Monthly	Monitoring teams, NETN Water Monitoring Coordinator	After monthly monitoring is complete, all new data from Cybertracker flat file(s) and NETNH20_FieldDE are imported to the NETN_H2O database using the Import Module. (Monitoring Team) YSI profiles and Li-Cor data are merged, converted, and imported to the NETN_H2O database using the Import Module. (Monitoring Team) Photos are renamed following NETN naming conventions. (Monitoring Team) Other associated data (Rapid hydro-geomorphic, lake level, etc.) are entered into NETN_H2O. (Monitoring Team) Water monitoring coordinator performs initial data validation (for completeness). Paper "Proof Reports" are generated, and Sample Event Codes from the database are transcribed to each original field data form. Data forms are scanned and saved as .pdf files. (Monitoring Team) If laboratory results for earlier samples have been delivered from lab they are imported to the NETN_H2O database using the Import Module. (Water monitoring coordinator) Updated copy of NETN_H2O backend is loaded to NETN file server. (Water monitoring coordinator)
Seasonally	Monitoring teams, Water Monitoring Coordinator, NETN Data Manager	All data from current monitoring year have been loaded to NETN_H2O, all data are verified and validated using original data sheets and Proof Reports. (All, as assigned) After final data edits are completed and documented, annual export queries are run for cooperators (e.g. states, EPA), annual reporting, analysis, etc. (Water monitoring coordinator) Complete dataset is exported for NPSTORET input. Updated NPSTORET backend is delivered to NETN Data Manager. (Water monitoring coordinator) NETN Data Manager delivers current NPSTORET database to NPS Water Resources Division. Updated (final) copy of NETN_H2O backend is loaded to NETN file server. (Water monitoring coordinator) All annual data files, photos, scanned field sheets, etc. are archived on NETN file server. (Water monitoring coordinator) All annual data files, photos, scanned field sheets, etc. are archived on IRMA. (NETN Data Manager)

SOP 13 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
3.00	February 2012	B. Gawley	Reformatted using NRPS-NRR template. Re-assigned as SOP 13. *(was SOP 24 in Protocol v2.02)* Expanded overview of basic data management functions Added sections on NETN_H2O database, file naming conventions, and other computer data utility programs. Added table of water monitoring data flow and responsibilities.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits	Internal review
3.02	December 2013	B. Mitchell	All references to “NETN_H2Ov1” changed to “NETN_H2O” Data verification can be done using a computer screen and copy of the data sheets OR a printout of the entered data.	Reviewer comment

SOP 14 – Data Reporting and Analysis for Lakes, Ponds, and Streams

Northeast Temperate Network

Version 3.02

Overview

This SOP describes the topics and analysis methods included in NETN water monitoring reports.

Background and Scope

Data reporting will follow the data-reporting guidelines detailed in Chapter 7 of the NETN Vital Signs Monitoring Plan (Mitchell et al. 2006). Data analyses and reporting will consist of an annual data report, and periodic trend analyses and scorecard reports. The annual data report will ensure that all data are being checked for quality and completeness, and will be available to the public. Whenever possible, data will be presented in a "scorecard" format that compares data to ecological and regulatory thresholds. After enough data are collected for initial analysis, trends will be analyzed every five years on all water quality vital-sign measures for each park. Where statistically and ecologically significant trends are found, further analyses will be conducted to determine if these trends hold across waterbodies in a park or a region or if they are unique to one waterbody in a park.

Annual Data Reporting for Lakes, Ponds, and Streams

All data and QC samples that are collected as a part of this protocol will be included in the annual upload of the NETN database to the NPSTORET database as described in *SOP 13 – Data Management.* In addition, an annual data report will be published that will make the data and basic summary statistics available to cooperators, park managers, state databases, and the public.

An annual data report will be prepared at the end of each calendar year summarizing the status of each metric at each park for the previous monitoring season (May 1- October 31). Annual data reports will be produced by NETN water monitoring staff by the end of February following the field season. The NETN data report will include links or references to any cooperator data reports (e.g., USGS reports incorporating continuous gage data), and will be available to the public. State water quality standards are updated triennially, and part of the annual reporting process entails looking for updated water quality standards and updating the appropriate sections of the protocol narrative and annual reports with the latest standards.

Data reports include all water monitoring data, all QC samples, basic summary statistics for the data and the QC data, descriptions of field and laboratory methods, and the name, number, and description of each site where data were collected. An assessment of the data quality includes minimum reporting limits, estimates of precision and accuracy, and sources of error. Annual data reports also include any new instances of invasive plant species, although substantiated new outbreaks of invasive plant species will already have been brought to the attention of park managers and the appropriate state agencies. Data values less than state water-quality standards will be flagged in these reports. Much of this data report can be standardized by use of a template that includes all methods and background information. This background data information is

usually similar from year to year. Interpretive work is not included in these data reports. Annual reports are compiled and reviewed by NETN and made available to the public in the April of the year following data collection before the upcoming field season begins.

Data reports are highlighted in NETN outreach efforts and any concerns with the data including QC concerns are discussed with the NETN technical committee (the park resource managers). Feedback from these meetings will be used to guide monitoring effort in the following year and to refine protocols where appropriate.

Quality-Control Reporting

All QC data are included in the annual report. It is the responsibility of the field staff to bring QC problems to the attention of NETN and to suggest solutions to improve the monitoring program. NETN reviews all QC data and ensures that problems are addressed before the next field season begins.

Data quality must be indicated whenever data are reported. Data quality is most easily indicated by estimates of precision and accuracy and by the results of blank analyses. Each analytical batch includes an estimate of precision and accuracy. Raw data used in estimates of precision and accuracy and in results of blank analyses are to be reported with all data. Summaries of estimates of precision and accuracy for a sampling period can be used when data reports are prepared. Precision data can be included by listing the range of precision values obtained in percent relative standard deviation (RSD) by variable for each year or sampling period, noting the number of duplicates, and the number of duplicates that exceeded the QA objectives.

Accuracy data can be included by listing the range of accuracy values in percent difference by variable for each year or sampling period, noting the number and type of samples used to determine accuracy, and noting the number of samples that did not meet the QA objectives. Similarly, summaries of blank analyses can be included by listing the range of blank values by variable for each sampling period, the number and concentration of blanks that exceeded the concentration values listed, and the total number of blank analyses. If the total number of duplicates or blanks is 10 or less, report results from all duplicates or blanks, instead of providing a written a summary. Field blanks are used to identify contamination being introduced through field procedures.

Analyses for Field Blanks

Results of field blank sample analyses from the laboratory are examined immediately to see if contamination is occurring. These results can then be used to adjust collection methods and guide the use of topical blanks before sampling continues. Confidence limits for selected percentiles of contamination and bias are calculated and reported annually in the annual data report. Initially, blanks are used singly to compare blank analysis to critical concentrations, such as water-quality standards, and to alert staff of contamination problems and identify the need for topical blanks if necessary. When enough blanks are collected throughout each park and throughout NETN, use nonparametric statistics on the blanks to obtain confidence limits for selected percentiles of contamination that are estimated based on concentrations of the analytes in the blanks.

1. Rank the blank data from lowest to highest. The rank (u) that equals or exceeds the selected 1-α confidence limit for the selected percentile (p): $100\ (1-\alpha) \geq B\ \{p, n, u-1\}$

can be determined, where B is a binary probability. The upper 1-α confidence limit for the percentile is the value of the rank *u* observation: $C_{ucl} = X_{(u)}$ where C_{ucl} is the concentration that goes with the rank *u* (Helsel and Hirsch 1992).

2. Systematic error or bias is expressed as a percent recovery (with the correct or expected answer at 100 percent). The systematic error or bias measurement-quality objective (MQO) percent recovery ranges from 80 to 120 percent. If the MQO for a particular parameter is outside of that range (70 to130 percent), all values associated with that blank batch qualify as an error, and recalibration or other adjustments to the blanks must be done until the MQO can be met. The raw values used to calculate these percentages are also reported in the annual data report to allow for future statistical analyses (such as long-term or multi-laboratory means or standard deviations).

Analyses for Replicates

Replicates measure both field variability and method variability. Results of field replicate sample analyses from the laboratory are examined immediately to check these sources of variability among samples. These results can then be used to adjust collection before sampling continues. Standard deviations and means are calculated from the analysis results and reported in the annual data report.

1. The mean and the standard deviation are calculated for replicate samples as

$$C_{ave} = (C_1 + C_2 + \ldots C_n)/n$$

$$SD = ((\sum [C_i - C_{ave}]^2) /(n-1))^{1/2}$$

where *C* is the concentration and *n* is the sample size (Helsel and Hirsch 1992). The RSD is calculated so that the standard deviation does not depend on the concentration of the sample. $RSD = 100*(SD/C_{ave})$.

2. With the RSD and SD, variability for ranges of mean concentration can be graphed and estimated (Helsel and Hirsch 1992). In this way an estimate of the uncertainty of the concentration measured in a single sample can be obtained for a given degree of confidence as

$$\text{Confidence Interval} = C_{samp} \pm Z_{(1-\alpha/2)} SD_{reps}$$

For a 90 percent confidence interval ($\alpha /2 = 0.05$, $z = 1.645$).

QC measurement quality objectives (MQOs), should not exceed a relative percent difference of 10 percent (RPD, for a sample size of two [duplicates] or a RSD for sample size of three or more). Field-probe measurements for this performance standard are specific conductance, pH, temperature, DO, light transmittance (PAR), and SD.

Measurement precision for nutrients and chlorophyll *a* are less stringent and should not exceed 30 percent. Although RPDs are sometimes reported for a sample size as small as two, two is not a large enough sample size for a reliable estimate of precision, and 8-20 replicates (perhaps by pooling data over time), is necessary to keep measurement uncertainty to reasonable levels (Irwin 2004). If MQOs are not met, all values associated with that batch of QC samples are discarded, and recalibration or other adjustments are done until the MQO is met.

Data Analyses and Scorecard Report for Lakes, Ponds, and Streams

Data analyses and reports are the responsibility of NETN staff. In the analyses for long-term continuous streamflow gages, analyses could be contracted out to the agency performing the work, but it remains the responsibility of NETN to compile and integrate all reports from all contractors and network staff into a single summary document that is useful for NPS managers and Inventory and Monitoring staff at a national level.

Data analyses include the following: 1) basic statistics such as maximums, minimums, means, and standard deviations for each analyte and 2) seasonal and annual trend analyses. Data analyses are designed to answer the following questions:

3. What is the range of variation of water-chemistry parameters in pristine waters with minimum anthropogenic stressors?
4. What are the long-term trends in water chemistry in each waterbody, each park, and in the region? Are these trends statistically and ecologically significant?
5. Can trends in water chemistry be explained by changes in flow and/or climate?
6. Are trends among all of the measures in a vital sign changing in the same way?
7. Are waterbodies meeting state water-quality standards?
8. Have invasive plant species been introduced into any new ponds or lakes in the park network?

The presence of trends can be tested with the nonparametric Seasonal Kendall Test (a seasonal extension of the nonparametric Mann-Kendall test) (Helsel and Hirsch 1992), and the slope of the linear trend is estimated with the nonparametric Sen's method (Gilbert 1987). Seasons are defined as months when sufficient data is available for the analyses. If monthly data are not available, groups of months that would not be expected to differ significantly from one another can be combined into larger seasons as long as these seasons are consistent from year to year. The data must be tested for trends within that period. The longer the defined season, however, the more variability there will be in the data, and the more difficult it will be to demonstrate a trend or lack thereof. Alternatively, variability can be determined and summarized for the single month for which the most data is available (often August). Trends are reported whether or not they are statistically significant, but are highlighted if they are statistically significant at $p \leq 0.05$. An excel template (MAKESENS) is used for all calculations (Salmi et al. 2002).

Measures and trends are also analyzed for each vital sign. Indices for each vital sign can be developed so that all measures within a vital sign can be compared with one another. These indices will help resource managers understand an integrated picture of the aquatic resources at each park. The index will be numerical, such as the trophic status index in lakes or the indices will be graphed side by side and compared to one another such as an acidification index. Examples of the types of information to be included in data analyses are included for lakes and for streams.

Categories such as good, caution, and significant concern are included and are primarily based on water-quality standards when available. These categories can change as more data are collected. How these categories apply to management is beyond the scope of this SOP.

Lake Water Quality Analyses

Measures of lake water quality are separated into those measures that are indicators of a lake or pond trophic status and those measures that are indicators of water chemistry. Water quality implies a subjective judgment depending on water-chemistry measures and the desired uses and attainment classes of the water. Water quality is different from the more objective trophic status which offers a framework within which evaluations of water quality can be made (Carlson 1977). Eutrophication of lakes and ponds is a natural process and unaffected lakes and ponds are at all points along the trophic continuum. Eutrophication only becomes a problem when it is accelerated from anthropogenic causes.

For the parameters used to estimate the trophic condition of lakes such as Secchi depth (SD), total phosphorus and chlorophyll *a*, population variance or (lake-to-lake variance) dominates all other variance components including within-year variance, year-to-year variance and sampling error by a substantial amount (Larsen et al. 1995). Thus it is most meaningful to calculate summary statistics, (including an estimation of the variability of the statistics) on individual lakes – and then summarize the variability and trends across all sites. The report could then include a number or proportion of sites with statistically significant trends upward or downward. Likewise standard deviations or estimates of seasonal or year to year variability are most meaningful if the variability of individual sites is summarized.

A trophic status index can be calculated based on measurements of SD, total phosphorus and chlorophyll *a*. For Maine, this index can be calculated with the equations generated by the state of Maine as listed in the section on Maine in the section *Water-quality Standards* in the protocol narrative. Each of these three measures, when converted to the trophic scale, will give a similar estimate of the trophic state index. Arguably, only one of these measures is needed to estimate the trophic state of a lake. The calculated trophic state number, however, is only an index of trophic status, or a lake or pond's productivity. Having more than one measure of a lake's productivity allows for a QA check, options for estimating trophic state during various seasons of the year, and a better understanding of why the trophic state is changing if it is in fact fluctuating.

Each of these measures is used to understand lake processes throughout the year. Phosphorus is relatively stable throughout the year, and can be used as an index in the fall and spring when algal biomass is limited by other factors than phosphorus and thus may be below its maximum potential. The measurement of chlorophyll *a*, however, can be used in the summer for the best estimate of algal biomass. Chlorophyll *a* will be used to calculate the TSI if values of Apparent Color are greater than 25 PCU. SD is the least expensive and easiest measurement to make, is widely measured, and allows for comparison across many lakes in the region. It usually provides an index very similar to that determined with measurements of chlorophyll *a*.

SD is the only parameter of the three that is measured monthly, and thus TSI for the example scorecard is calculated based on the monthly means for each sample. A minimum of one reading per month from May through October is used with no two consecutive months of missing data (see section in the protocol narrative entitled *Water-quality Standards: Maine*). Five lakes in Acadia were chosen in 1995 to be more intensely monitored for trophic status (Witch Hole Pond, Upper Hadlock Pond, Echo Lake, Seal Cove Pond and Jordan Pond). These lakes vary in their vulnerability to accelerated eutrophication and in their physical characteristics. In addition, Long

Pond is included as it has sufficient SD measurements for analysis as a part of its long-term monitoring history. Although many of these Acadia lakes have SD measurements back through 1982, a modified SD viewing scope came into use in 1995, therefore pre-1995 measurements may not correspond to post-1995 measurements (Breen et al. 2002). Furthermore, trophic status in some lakes appears to have decade-long cyclic trends, indicating that it may be most appropriate to look at linear trends for only the most recent period (L. Bacon, MDEP, written commun., 2005).

For some lakes, up to 30 years of SD data are available. Test these longer datasets for cyclical trends. An example of the type of graph that could be used in the scorecard based on ten years of data is given in Figure S14.1.

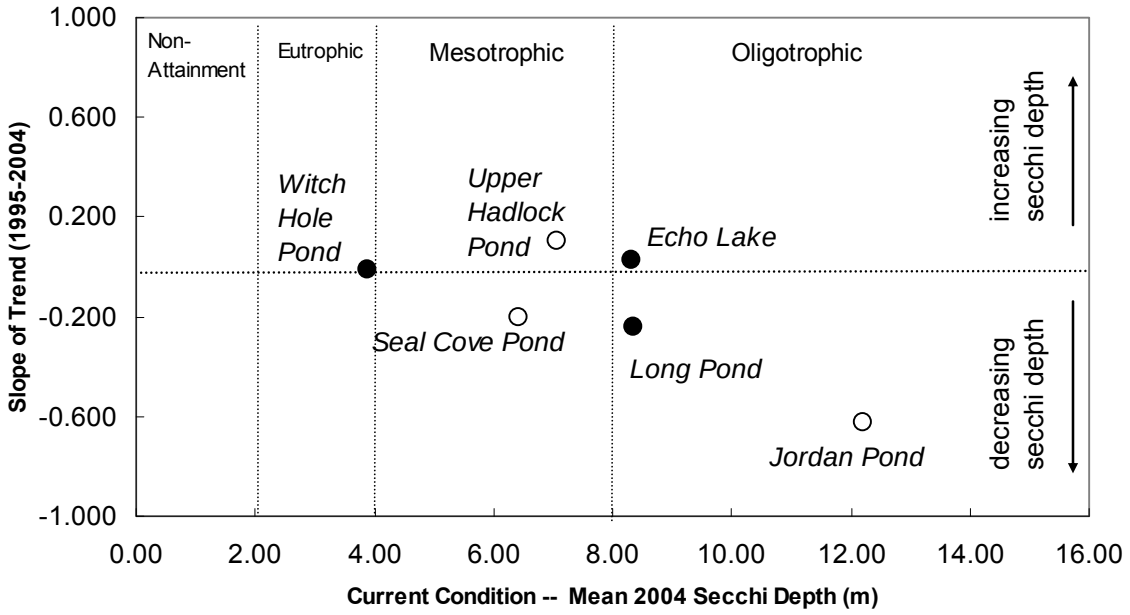


Figure S14.1. Example of a trophic scorecard for current condition and slope of trend of yearly mean Secchi disk depths in Acadia National Park lakes from 1995 to 2004. Hollow circles indicate that trend is significant at $p \leq 0.05$.

The graph shows the mean 2004 SD for each lake as the current condition against the slope of the trend for the period of record. The presence of a trend is tested with the nonparametric Mann-Kendall test, and the slope of the linear trend is estimated with the nonparametric Sen's method (Gilbert 1987). Trends are shown whether or not they are statistically significant, but hollow circles indicate that the trend is statistically significant at $p \leq 0.05$.

Lakes with a negative slope of trend have decreasing SDs that perhaps indicate accelerated eutrophication. Jordan Pond and Seal Cove Pond are the only lakes in which negative trends are statistically significant. When trends in August SDs are examined, Seal Cove Pond is the only lake with a downward trend in SDs from 1995 to 2004 that is statistically significant. Although some trends are statistically significant, trends might not be ecologically significant. Ecologically significant trends in trophic status usually indicate an acceleration of natural eutrophication

processes, which usually indicates declining water quality. This graph is an example and not a comprehensive evaluation of trends at lakes in Acadia National Park (ACAD).

As more monthly data are collected, longer time frames will allow for better evaluation of documented trends, causes, and ecological significance. Additional lakes at ACAD could be included in the analyses, and monthly analyses would then be possible for all parameters. Scorecards show the status and trends of various indices of water quality such as an index for trophic status and acidification. Categories of trophic status equate to state water-quality standards.

Water-quality judgments for a lake consider not only trophic status, but also water-chemistry measures, changes in trophic status, and the presence and extent of invasive plant species. The graphs of the condition and trends of pH and ANC in ACAD lakes (Figures S14.2 and S14.3) indicate the acidification status of ACAD lakes. Five lakes have been monitored consistently since 1995 to evaluate long-term acidification status. Jordan and Bubble Ponds represent the large deep water lakes in ACAD, Sargent Mountain Pond and The Bowl represent smaller headwater or high-elevation lakes most likely to show chronic acidification, and Witch Hole Pond represents a lake affected organically by its adjacent wetland (Breen et al. 2002). Samples are half-meter deep grab samples taken from the deepest point in all lakes. These lakes have intermittent pH and ANC data since 1982. These earlier data are included in trend analyses despite large data gaps, in 1984-85, 1987-88, and 1990-97.

Both graphs show the condition as of October 2004 against the slope of the trend for the period of record. The presence of a trend is tested with the nonparametric Mann-Kendall test, and the slope of the linear trend is estimated with the nonparametric Sen's slope estimator method (Gilbert 1987). Trends are shown whether or not they are statistically significant, but hollow circles indicate that the trend is statistically significant at $p \leq 0.05$. Lakes in ACAD tend to be poorly buffered (low ANC) and with low to neutral pH values; thus pH and ANC indicate improvement in lake water quality if trends show a significant increase (Breen et al. 2002).

Maine does not currently (2011 standards) have numerical water-quality standards for pH and ANC. Lake standards are "as naturally occurs" (Maine State Government 2011). In the absence of numerical standards, the categories of good, caution, and concern for current condition are determined on the basis of the documented distribution of pH in Maine lakes (Williams 2004). Most Maine lakes have pH values between 6.0 and 7.0, which meet the standards for other New England states. ANC categories are determined on the basis of documentation that values above 100 µeq/L are insensitive to acidification, and values below zero typify acidic waters (Stoddard et al. 2003).

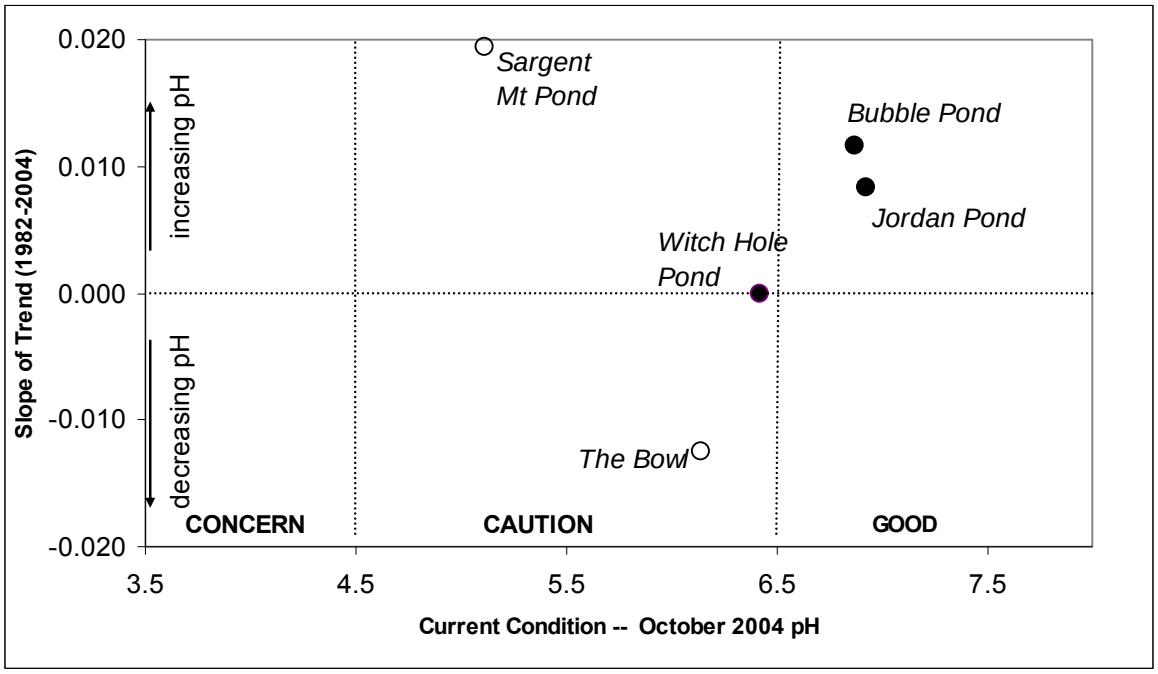


Figure S14.2. Current condition (2004) and slope of trend of October pH grab samples in lakes in Acadia National Park from 1982 to 2004. Hollow circles indicate that trend is significant at $p \leq 0.05$.

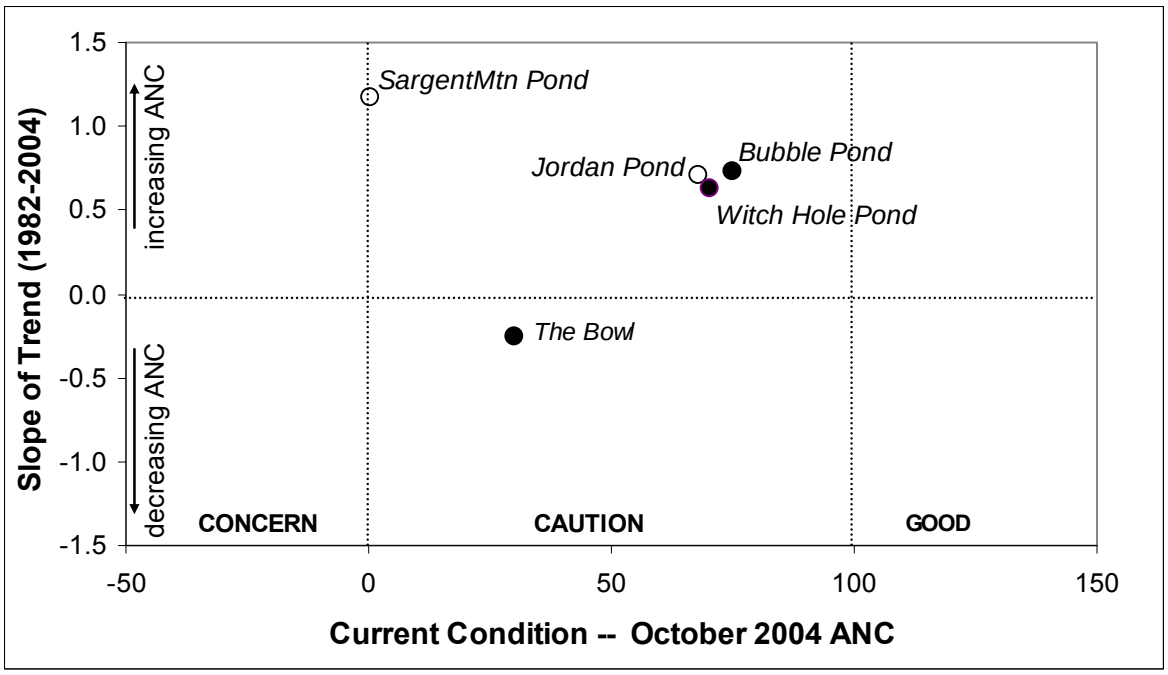


Figure S14.3. Current condition (2004) and slope of trend of October Acid neutralizing capacity grab samples in lakes in Acadia National Park from 1982 to 2004. Hollow circles indicate that trend is significant at $p \leq 0.05$.

Of the five lakes shown, all have average pH as compared to other lakes in Maine, except for Sargent Mountain Pond with a pH of 5.11. Sargent Mountain Pond is also poorly buffered with

an ANC of 0.41, but shows a trend towards improving conditions of both acidification parameters. The Bowl is the only lake showing decreasing trends in ANC and pH, although only the trend in pH is statistically significant. Although some trends were statistically significant, trends might not be ecologically significant. As more data are collected, longer time frames will allow for better evaluation of documented trends, causes, and ecological significance. These graphs are examples and not comprehensive evaluations of trends at lakes in ACAD.

Stream Water Quality Analyses

Stream water-quality status is evaluated on the basis of state water-quality standards for its fisheries classification (Table 3 in the protocol narrative). Most streams or watersheds in NETN parks have been classified by the state either directly or indirectly. Streams have been identified as cold water fisheries or warm water fisheries. See the table in each park's sampling design (protocol narrative section *Sampling Design in Streams*) for the fisheries classification of each stream if available. These classifications are important to defining water-quality standards and thus will be the framework used to evaluate stream water quality standards. In cases where a stream does not meet one or more of these water-quality standards for chemistry or nutrients, it will be flagged in the annual data report and analyzed for trends in the scorecard report.

For streams, most water-quality parameters, including nutrients, are strongly correlated with streamflow. Streamflow data analyses are addressed in a later section of this SOP and once completed are used to calculate streamflow-adjusted concentrations or loads. If there is a strong correlation between the concentrations and flow, streamflow-adjusted concentrations or loads are included in trend analyses of streams. Load is calculated as the discharge (Q) times the concentration (C) for a given time period such as a day. Trend analyses are analyzed for all parameters by use of the seasonal Mann-Kendall test for trend. Seasons are comprised of monthly data for any month with sufficient data.

Light-Penetration-Profiles Analyses

Photosynethetic photon flux density (PPFD) is measured with a light meter in lakes with average SD readings less than 5 meters, or in any lake where at least one SD has been greater than the lake depth. A relation between SD and PPFD has been established for lakes in ACAD. A non-linear relation between SD and the light attenuation coefficient that has often been cited in the literature is $K_d = 1.7/ Z_{SD;}$ where K_d is the light attenuation coefficient and Z_{SD} is SD (Poole and Atkins 1929, Short and Coles 2001). Although this may be a reasonable approximation if site-specific data are not available, a more specific relation was approximated from 6 years of data on seven lakes in ACAD; $K_d = 4.7/ (Z_{SD})^{1.18}$ (Figure S14.4). The average summer SDs in the seven lakes ranged from 4 to 14 m. It is not appropriate to use this relationship outside the range of variables from which the equation was developed. In lakes at ACAD with average SDs of 5 meters or greater, the light attenuation coefficient can be estimated based on the relationship; $K_d = 4.7/ (Z_{SD})^{1.18}$ (Figure S14.4).

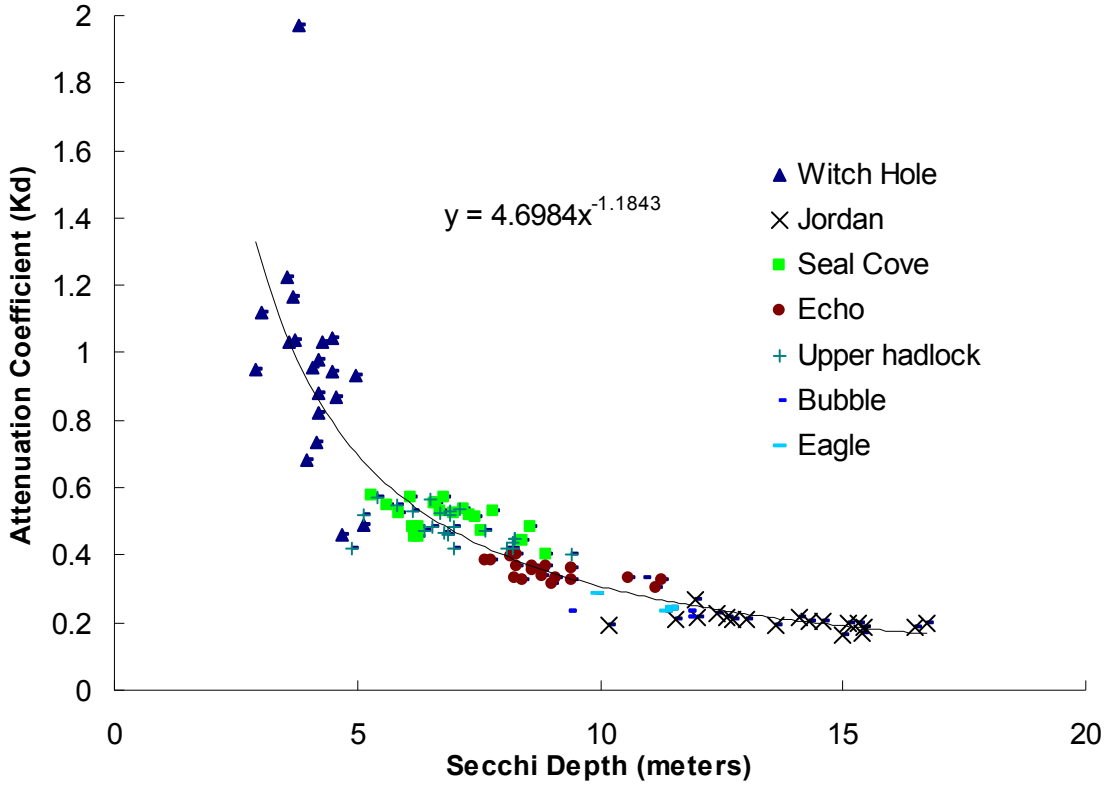


Figure S14.4. Relation between Secchi disk depth and light attenuation coefficient calculated from light meter data in seven lakes in Acadia National Park.

Water Level and Streamflow Analyses

There are a number of analysis methods that can be used to document the status and trends of water quantity in water resources in NETN parks. Graphical and numerical methods can indicate spatial or temporal trends in streams, lakes, and ponds. More than one continuous-record streamflow-gaging station is needed, however, to determine if long-term trends in streamflow are related to long-term climatic records.

Analyses of streamflow statistics at continuous-record streamflow-gaging stations

Hydrographs show water levels as a function of time and are the best visual description of seasonal and annual water-level fluctuations. Once significant data have been collected, simple statistics such as maximums, minimums, means, medians, and 25th and 75th quartiles can all be included in a hydrograph made up of either daily or monthly values. Regulatory values such as minimum low flows (August median) can be plotted to see visually how much of the time the streamflow went below this line.

It is also useful to calculate a duration curve to show how often the discharge of a stream meets or exceeds a given value. To create a duration curve, start by ranking the discharge data (for example 1 year) from the highest value to the lowest value. The chance that a given flow will be equaled or exceeded, expressed by a percentage, can be calculated as P =

100(m)/(n+1), where P is the percentage; m is the rank, and n is the total number of values. This type of a graph can show if streamflow is adequate to meet designated requirements.

Analyses of streamflow statistics at partial-record streamflow-gaging stations

After significant data have been collected, discharge measurements at partial-record streamflow-gaging stations are correlated with concurrent mean daily streamflow measurements at nearby continuous-record streamflow-gaging stations with similar hydrological and (or) geomorphological characteristics to determine if a relation can be established between the two stations. If a relation can be established, daily mean discharges, and streamflow statistics such as monthly means and medians can be estimated at the partial record station on the basis of the streamflow measurements at the continuous-record stations. Estimates can only be made for the season in which measurements have been taken at the partial-record station.

SOP 14 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
3.00	February 2012	B. Gawley	Reformatted using NRPS-NRR template. Changed annual reporting period from previous water year to previous calendar year. Changed annual report due date to end of February following monitoring season. Moved section on Water-Level and Streamflow-Data Analysis (v2.02 Section 7.2.3) to SOP 9.	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits. Trend reports every 5 years, not every 2 years.	Internal review
3.02	December 2013	B. Mitchell	Minor edits Added sentence to the end of the second paragraph of “Annual Data Reporting for Lakes, Ponds, and Streams”, indicating that an annual review of state standards is needed.	Reviewer comment

SOP 15 – Post-Season Activities

Northeast Temperate Network

Version 3.02

Overview

This SOP consists of a checklist of the tasks and procedures that must be completed at the conclusion of the freshwater monitoring field season.

Post-season Checklist:

- ☐ Clean, winterize, and store field gear and boats.
    - For YSI sonde follow procedures in the *Probe Care and Storage* section of *SOP 6 – In Situ Water-Quality Measurements using Multiparameter Sonde*. YSI sondes should be sent to the manufacturer for testing and calibration every two years, even if they appear to be functioning properly.
    - Remove batteries from all electronic equipment.
    - Wash all boats and canoes with fresh water.
    - Flush outboard motors and follow appropriate "winterizing" procedures recommended by the manufacturer.
    - Identify and set aside all items needing repair/replacement.
- ☐ Enter/import all data.
    - Follow procedures in *SOP 13 – Data Management*.
- ☐ Proof (verify and validate) all data.
    - Follow procedures in *SOP 13 – Data Management*.
- ☐ Submit final data to NETN Data Manager and cooperators (where applicable).
- ☐ Continue monitoring lake levels until ice-in (ACAD). Monitor ice-in/ice-out dates where applicable.
- ☐ Remove Global water level loggers before hard freeze; download and manage data from all continuous loggers.
- ☐ Update inventories of equipment and expendables.
    - Provide estimate of needs for next season and projected cost to NETN Program Manager for budget formulation and approval.
- ☐ Repair/replace gear/instruments as needed.Plan purchases, other expenditures, and hiring for next year.
- ☐ Renew contracts/agreements as needed.

- Training, as needed/available.
- Prepare for and participate in annual program/protocol review conference call or meeting.
- Reporting (***Annual reports due end of February following the field season***).
- Update protocol to reflect action items from protocol review meeting.

SOP 15 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
3.00	Feb 2012	B. Gawley	New SOP established for Protocol Version 3.00	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Download and import data from continuous loggers.	Internal review
3.02	December 2013	B. Mitchell	YSI sondes go to manufacturer every two years for service	Codify current procedure

SOP 16 – Annual Timeline of Activities

Northeast Temperate Network

Version 3.01

Overview

This SOP establishes the timeline for tasks and procedures that must be completed to implement and support NETN freshwater monitoring.

Annual Timeline:

Month	Tasks and Procedures
January	• All previous season's data entered to NETN_H2O database and validated by January 31. (*Water Monitoring Coordinator*). • All previous season's raw data, scanned field sheets, and photos uploaded to NETN server by January 31. (*Water Monitoring Crew Leader[s]*). • Begin/continue protocol revisions identified at December protocol review meeting. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Make sure all administrative needs (contracts, purchase requests, invoice payments, personnel/hiring) for previous & upcoming seasons have been addressed. (*Water Monitoring Coordinator, NETN Program Manager*)
February	• Continue protocol revisions identified at December protocol review meeting. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Deliver previous season's data to all cooperators (states, EPA, etc.) as required. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Complete dataset is exported for NPSTORET input. Updated NPSTORET backend is delivered to NETN Data Manager. (*Water Monitoring Coordinator*) • Begin/continue writing annual data reports for all parks. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Hiring/re-hiring in progress. (*Water Monitoring Coordinator, NETN Program Manager*) • All field equipment requiring repair, factory recalibration, recertification sent back to manufacturer. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*)

Table Continued on Next Page

Month	Tasks and Procedures
March	• Complete protocol revisions identified at December protocol review meeting by March 31. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Summary of protocol changes sent to all water monitoring staff and other appropriate parties. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Complete annual data reports for all parks by March 31. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Hiring/re-hiring complete. (*Water Monitoring Coordinator, NETN Program Manager*) • Complete full inventory of all supplies and equipment. *(Water Monitoring Crew Leader[s])* • Order necessary equipment and supplies. *(Water Monitoring Crew Leader[s])* • Order sample bottles from lab for April ACAD acidification monitoring and all NETN May (stream) nutrient sampling. *(ACAD Water Monitoring Crew Leader)* • Record ice-out dates when possible. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Install Global stream level loggers in ACAD when possible. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Survey/install stage benchmarks when possible. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Begin ACAD weekly lake level monitoring when possible. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Complete necessary training as available. (*All*)
April	• Field crew EOD. • Cross-training session with ACAD and LNETN teams (LNETN to ACAD). (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*) • Meet with lab manager to discuss logistics and analysis. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Prepare/service boats, motors, vehicles. *(Water Monitoring Crew Leader[s])* • Unpack/prepare and perform accuracy checks on YSI, current meters, Li-Cor. (see *SOP 6 – In Situ Water Quality Measurements Using Multiparameter Sonde*) (*Water Monitoring Crew Leader[s], Field Crew*) • Label and bag sample bottles for April ACAD acidification monitoring. *(ACAD Water Monitoring Crew Leader)* • Make travel arrangements for May LNETN monitoring. *(LNETN Water Monitoring Crew Leader*) • Contact LNETN park Resource Managers re: May monitoring schedule and assistance. *(LNETN Water Monitoring Crew Leader*) • Record ice-out dates if necessary. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Install Global stream level loggers in ACAD if necessary. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Survey/install stage benchmarks when possible. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Begin/continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Conduct ACAD lake acidification monitoring (10 lakes). (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*) • Complete necessary training as available. (*All*)
May	• Complete necessary training as available. (*All*) • Survey/install stage benchmarks when possible. (*Water Monitoring Coordinator, Water*

Month	Tasks and Procedures
	Monitoring Crew Leader[s])
	• Order sample bottles from lab for June (lake & pond) nutrient sampling. *(Water Monitoring Crew Leader[s])*
	• Label and bag sample bottles for May nutrient sampling. *(Water Monitoring Crew Leader[s])*
	• Continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*)
	• Conduct stream, lake, and pond monitoring at all NETN sites. Collect water samples for nutrient analysis from streams. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*)
	• Conduct YSI accuracy check (see *SOP 6 – SOP 6 – In Situ Water Quality Measurements Using Multiparameter Sonde*). (*Water Monitoring Crew Leader[s], Field Crew*)
	• Make travel arrangements for June LNETN monitoring. *(LNETN Water Monitoring Crew Leader*)
	• Contact LNETN park Resource Managers re: June monitoring schedule and assistance. *(LNETN Water Monitoring Crew Leader*)
	• After monthly monitoring is complete, all new data are entered to the NETN_H2O database using the Data Entry and Import Modules. Photos are renamed and filed. (*Water Monitoring Crew Leader[s], Field Crew*)
	• Begin initial data validation of May data (for completeness). Paper "Proof Reports" are generated, and Sample Event Codes from the database are transcribed to each original field data form. (*Water Monitoring Coordinator)*
	• Data forms are scanned and saved as .pdf files. (*Field Crew*)
June	• Complete necessary training as available. (*All*)
	• Meeting or conference call to discuss the field crew's progress and any concerns that have surfaced after the first month of monitoring. (*All*)
	• Survey/install stage benchmarks when possible. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*)
	• Label and bag sample bottles for June nutrient sampling. *(Water Monitoring Crew Leader[s])*
	• Continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*)
	• Conduct stream, lake, and pond monitoring at all NETN sites. Collect water samples for nutrient analysis from lakes and ponds. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*)
	• Conduct YSI accuracy check (see *SOP 6 – SOP 6 – In Situ Water Quality Measurements Using Multiparameter Sonde*). (*Water Monitoring Crew Leader[s], Field Crew*)
	• Make travel arrangements for July LNETN monitoring. *(LNETN Water Monitoring Crew Leader*)
	• Contact LNETN park Resource Managers re: July monitoring schedule and assistance. (*LNETN Water Monitoring Crew Leader*)
	• After monthly monitoring is complete, all new data are entered to the NETN_H2O database using the Data Entry and Import Modules. Photos are renamed and filed. (*Water Monitoring Crew Leader[s], Field Crew*)
	• Complete validation of May data and begin initial data validation of June data (for completeness). Paper "Proof Reports" are generated, and Sample Event Codes from the database are transcribed to each original field data form. (*Water Monitoring Coordinator)*
	• Data forms are scanned and saved as .pdf files. (*Field Crew*)
	• Compile "wish list" for end-of-year purchasing. (*Water Monitoring Crew Leader[s], Field Crew*)
July	• Complete necessary training as available. (*All*)
	• Survey/install stage benchmarks when possible. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*)
	• Order sample bottles from lab for August nutrient sampling. *(Water Monitoring Crew Leader[s])*

Month	Tasks and Procedures
	• Continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*) • Cross-training session with ACAD and LNETN teams (ACAD to LNETN, budget/schedule permitting). (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*) • Conduct stream, lake, and pond monitoring at all NETN sites. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*) • Take panorama photo series at lakes and ponds during monitoring events. (*Water Monitoring Crew Leader[s], Field Crew*) • Begin conducting Invasive Aquatic Plant surveys after mid-July, during lake and pond monitoring events. (*Water Monitoring Crew Leader[s], Field Crew*) • Conduct Rapid Hydro-Geomorphic Assessments during stream monitoring events. Survey for Didymo. (*Water Monitoring Crew Leader[s], Field Crew*) • Conduct YSI accuracy check (see *SOP 6 – SOP 6 – In Situ Water Quality Measurements Using Multiparameter Sonde*). (*Water Monitoring Crew Leader[s], Field Crew*) • Conduct mid-season inventory of all supplies. Order all supplies needed for remainder of monitoring season. (*Water Monitoring Crew Leader[s], Field Crew*) • Finalize "wish list" for end-of-year purchasing & submit to NETN Program Manager by 2nd week of July. (*Water Monitoring Coordinator)* • Make travel arrangements for August LNETN monitoring. *(LNETN Water Monitoring Crew Leader*) • Contact LNETN park Resource Managers re: August monitoring schedule and assistance. *(LNETN Water Monitoring Crew Leader*) • After monthly monitoring is complete, all new data are entered to the NETN_H2O database using the Data Entry and Import Modules. Photos are renamed and filed. (*Water Monitoring Crew Leader[s], Field Crew*) • Complete validation of June data and begin initial data validation of July data (for completeness). Paper "Proof Reports" are generated, and Sample Event Codes from the database are transcribed to each original field data form. (*Water Monitoring Coordinator)* • Data forms are scanned and saved as .pdf files. (*Field Crew*)
August	• Complete necessary training as available. (*All*) • Continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*) • Conduct stream, lake, and pond monitoring at all NETN sites. Collect water samples for nutrient analysis from all sites. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*) • Conduct remaining Invasive Aquatic Plant surveys during lake and pond monitoring events. (*Water Monitoring Crew Leader[s], Field Crew*) • Deploy benthic macroinvertebrate samplers at 5 ACAD streams. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*) • Conduct YSI accuracy check (see *SOP 6 – SOP 6 – In Situ Water Quality Measurements Using Multiparameter Sonde*). (*Water Monitoring Crew Leader[s], Field Crew*) • Make travel arrangements for September LNETN monitoring. *(LNETN Water Monitoring Crew Leader*) • Contact LNETN park Resource Managers re: September monitoring schedule and assistance. *(LNETN Water Monitoring Crew Leader*) • Receive data from lab analysis of April-June samples. Check on status of lab invoice #1. (*Water Monitoring Coordinator)* • After monthly monitoring is complete, all new data are entered to the NETN_H2O database using the Data Entry and Import Modules. Photos are renamed and filed. (*Water Monitoring Crew Leader[s], Field Crew*) • Complete validation of July data and begin initial data validation of August data (for completeness). Paper "Proof Reports" are generated, and Sample Event Codes from the

Month	Tasks and Procedures
	database are transcribed to each original field data form. (*Water Monitoring Coordinator)*
	• Data forms are scanned and saved as .pdf files. (*Field Crew*)
September	• Complete necessary training as available. (*All*)
	• Meeting or conference call to discuss the field crew's progress and any concerns that have surfaced after monitoring to date. (*All*)
	• Order sample bottles from lab for October ACAD acidification monitoring. *(ACAD Water Monitoring Crew Leader)*
	• Continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*)
	• Conduct stream, lake, and pond monitoring at all NETN sites. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*)
	• Retrieve benthic macroinvertebrate samplers at 5 ACAD streams. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader, ACAD Field Crew*)
	• Conduct YSI accuracy check (see *SOP 6 – SOP 6 – In Situ Water Quality Measurements Using Multiparameter Sonde*). (*Water Monitoring Crew Leader[s], Field Crew*)
	• Make travel arrangements for October LNETN monitoring. *(LNETN Water Monitoring Crew Leader*)
	• Contact LNETN park Resource Managers re: October monitoring schedule and assistance. *(LNETN Water Monitoring Crew Leader*)
	• After monthly monitoring is complete, all new data are entered to the NETN_H2O database using the Data Entry and Import Modules. Photos are renamed and filed. (*Water Monitoring Crew Leader[s], Field Crew*)
	• Complete validation of August data and begin initial data validation of September data (for completeness). Paper “Proof Reports” are generated, and Sample Event Codes from the database are transcribed to each original field data form. (*Water Monitoring Coordinator)*
	• Data forms are scanned and saved as .pdf files. (*Field Crew*)
October	• Complete necessary training as available. (*All*)
	• Continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*)
	• Label and bag sample bottles for October ACAD acidification monitoring. *(ACAD Water Monitoring Crew Leader)*
	• Conduct stream, lake, and pond monitoring at all NETN sites. Collect water samples for acidification analysis from 10 ACAD lakes. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s], Field Crew*)
	• Conduct YSI accuracy check (see *SOP 6 – SOP 6 – In Situ Water Quality Measurements Using Multiparameter Sonde*). (*Water Monitoring Crew Leader[s], Field Crew*)
	• After monthly monitoring is complete, all new data are entered to the NETN_H2O database using the Data Entry and Import Modules. Photos are renamed and filed. (*Water Monitoring Crew Leader[s], Field Crew*)
	• Complete validation of September data and begin initial data validation of October data (for completeness). Paper “Proof Reports” are generated, and Sample Event Codes from the database are transcribed to each original field data form. (*Water Monitoring Coordinator)*
	• Data forms are scanned and saved as .pdf files. (*Field Crew*)
	• Field crew end of season.
November	• Continue ACAD weekly lake level monitoring. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*)
	• Winterize boats, motors, vehicles. *(Water Monitoring Crew Leader[s])*
	• Conduct end-of-season inventory of all equipment supplies. Identify all equipment needing repair/replacement. (*Water Monitoring Crew Leader[s])*
	• Winterize and store all monitoring equipment. *(Water Monitoring Crew Leader[s]*
	• Receive data from lab analysis of August samples. (*Water Monitoring Coordinator)*

Month	Tasks and Procedures
	• Complete validation of October data. Other associated data (Rapid hydro-geomorphic, lake level, etc.) are entered into NETN_H2O. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Compile agenda for protocol review meeting and schedule meeting. (*Water Monitoring Coordinator, NETN Program Manager, Water Monitoring Crew Leader[s]*)
December	• Receive data from lab analysis of October samples. Check on status of lab invoice #2. (*Water Monitoring Coordinator)* • All data from current monitoring year have been loaded to NETN_H2O, all data are verified and validated using original data sheets and Proof Reports. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Continue ACAD weekly lake level monitoring until ice-in. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Record ice-out dates when possible. (*Water Monitoring Coordinator, Water Monitoring Crew Leader[s]*) • Remove and manage data from Global stream level loggers in ACAD before hard freeze. (*Water Monitoring Coordinator, ACAD Water Monitoring Crew Leader*) • Conduct protocol review meeting. (*Water Monitoring Coordinator, NETN Program Manager, Water Monitoring Crew Leader[s]*)

SOP 16 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
3.00	Mar 2012	B. Gawley	New SOP established for Protocol Version 3.00	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits. Deleted “Responsible Parties” column since all months listed the same responsible parties. Year-end wish list needed by end of June. Complete data validation by end of the month after data collection. Invasive plant surveys can begin after mid-July.	Internal review

SOP 17 – Aquatic Decontamination Procedures

Northeast Temperate Network

Version 3.02

Overview

This SOP outlines the operational practices and decontamination procedures that are used to minimize the spread of invasive aquatic plants and animal species, and fish and wildlife pathogens from NETN freshwater monitoring activities.

Background

There is a growing concern about the spread of invasive aquatic organisms into previously unaffected areas in the Northeast. The NETN has been conducting invasive aquatic plant monitoring since 2006, and though no invasive aquatic plant species have been detected during NETN monitoring, species of concern are present in all states containing NETN parks. The range of the invasive alga Didymo (*Didymosphenia geminata*), also known as "rock snot", has expanded dramatically in the past several years as has the spread of a variety of pathogens that cause fish and amphibian diseases.

NETN water monitoring crews have the potential to spread aquatic invasive species and fish and wildlife pathogens from watershed to watershed and park to park. Taking precautions to minimize the spread of these threats is essential. Combining a series of informed scheduling and operational choices with thorough and effective decontamination measures is the best strategy for keeping invasive organisms out of NETN parks.

Operational Practices

- Contact park resource managers annually for updates on detection of invasive species in or near NETN parks. ***Follow all park-specific guidance or requirements for disinfection frequencies and procedures***.
- Consult the NETN Invasive Aquatic Plant Early Detection Cards or other identification resources for species of concern. If you suspect that one or more of these target species is present, alert the park resource manager, and use extra diligence in cleaning and disinfection procedures. Further information on reporting suspected invasive aquatic plants can be found in *SOP 10 – Invasive Aquatic Plant Survey Procedures.*
- Whenever possible, schedule monitoring visits to sites with suspected or confirmed presence of invasive species *after* visits to "uncontaminated" sites.
- When monitoring several sites on the same stream or within the same watershed, visit the sites in a downstream sequence. Most algae and aquatic invasives and pathogens can't swim upstream.
- Use easily disinfected equipment and wading gear. Non-absorbent equipment is easier to disinfect quickly than absorbent equipment. Use only rubber-soled wading boots–felt-soled boots have been banned in some states.

- Designate waders/boots/canoes/rafts for different watersheds or have multiple sets available for same-day travel, when needed.
- If equipment can be rinsed and air-dried thoroughly for at least 2 days (in a NON-HUMID (<60%) environment) before use in a new watershed, disinfection is not needed.
- In all other situations, clean/disinfect all equipment using soap or bleach before entering a new watershed. *This will likely require a minimum of 15 to 20 minutes of time at the conclusion of a monitoring visit, and scheduling should be adjusted to accommodate these procedures.*
- Certain equipment items cannot be disinfected easily between sites (e.g., the boats at ACAD), however, these items should still be carefully inspected and have any visible debris and other contamination removed from all external surfaces.
- Construct and use a simple, portable disinfection kit. A typical kit includes:
    - Large trash can and/or medium sized Rubbermaid-type bin for soaking wading boots and gear.
    - Large stiff bristle brush for scrubbing.
    - Spray bottle(s) or pump sprayer(s).
    - Graduated cylinder or measuring cup.
    - Detergent (5% Palmolive soap) solution and bleach solution.
    - Fresh water (several gallons) for rinsing.

Standard Cleaning Procedures

To prevent the accidental introduction of organisms transported through water, all watercraft and equipment that have been in a waterbody should be thoroughly cleaned to remove invasive species, including any fragments, seeds, or other materials. This recommendation applies to equipment arriving at the monitoring site as well as equipment that is taken out of the water after monitoring.

- Visually inspect your boat, gear and equipment before entering and leaving the water. Remove all plants, plant fragments, animals, mud or other debris and discard in the trash. Check trailer (if used), including axle and wheel areas, in and around the boat itself: anchor, props, ropes, boat bumpers, paddles. After wading, remove all visible detritus from boots before exiting a stream, pond or lake.
- Drain **every conceivable space** or item that can hold water. Always drain the bilges of the boat by removing the drain plug. Empty water out of kayaks, canoes, rafts, etc.
- Set up the best staging area possible for cleaning operations. Step into the bin containing the soap solution for 1 FULL MINUTE while scrubbing your boots. Place the field equipment into the solution. Visually inspect all surfaces during washing and feel by hand to remove any remaining foreign material. You can use this method for all equipment and boots that touched stream or pond water. Rinse waders and equipment *thoroughly* with tap water. Be sure to transport enough water to rinse after decontaminating at each stream (approx. 1 gallon per stream) because the soap is

concentrated and difficult to rinse. Allow the rinse water to run onto the ground away from the stream.

- Adhesive rollers are also considered to be moderately effective in removing the majority of plant material from equipment or gear. Seed and fragment materials readily attach to the adhesive sheets and are effectively lifted out of seams and the weave of loose particle fabrics; proper attention and care given during removal is a direct reflection of the potential efficiency of this technique. A follow up with water washing, high-pressure air blasting, or high-pressure wash is also recommended. To prevent contained plant and soil matter from being redeposited following the cleaning process, adhesive sheets should be bagged and incinerated or disposed of in a sanitary landfill.

Disinfection Procedures

There are a number of disinfection techniques that will kill most aquatic invasive species and fish and wildlife pathogens, including Didymo. Solutions of bleach or dishwashing detergent products are suggested as they provide the best combination of availability, cost AND effectiveness against Didymo as well as other aquatic invasive species and fish and wildlife pathogens, such as whirling disease. These procedures should always be used in high-risk areas, and those known to be contaminated. Choose the appropriate agent based on the actual items requiring disinfection (i.e. bleach solutions will destroy some items). It is recommended that all disinfected equipment be rinsed on dry land, away from natural waters. It is preferable to contain all used disinfectant solutions in the field and drain them into treated wastewater (e.g. pour down a sink drain) at the end of the day. Do NOT dispose solutions into a septic system.

Non-absorbent items (boats, canoes, rubber waders, 'hard-sided' objects)

- Household cleansers/disinfectants, such as Formula 409® and Fantastic® that contain the quaternary ammonium compound alkyl dimethyl benzyl ammonium chloride can also be used to disinfect equipment. These solutions can be used full strength as a spray, or diluted for soaking with two parts water to one part disinfectant. For all materials, follow label instructions and be sure to soak equipment for a minimum of 10 minutes. *Be sure to dispose of materials away from surface waters in accordance with label restrictions.* 'Green' products are less effective and not recommended for disinfecting.

- Diluted household bleach solution provides an inexpensive, effective way to control invasive species. Soak or spray equipment for at least one minute with a 2% bleach solution (3 ounces of household bleach mixed with 1 gallon of water). If invasive pathogens or diseases are suspected, a 10% solution should be used (13 ounces of household bleach mixed with 1 gallon of water). Bleach is an extremely effective disinfection agent, but it is a caustic substance that can be corrosive to aluminum and other sensitive equipment. Bleach solutions must be replaced daily to remain effective.

- Although impractical in the field, hot water treatments are also effective: soak gear for at least one minute in very hot water (above 140°F – hotter than most tap water) OR for at least 20 minutes in hot water kept above 120°F (hot tap water, uncomfortable to touch).

- Drying: Drying will kill Didymo, but slightly moist environments will support some organisms for months. This approach should only be used for gear that can be left in the sun for extended periods of time (i.e. a canoe that's left in the yard for several days between uses).

Absorbent items require longer soaking times to allow thorough penetration into the materials. Felt-soled waders, for example, are difficult and take time to properly disinfect. Other absorbent items include clothing, wetsuits, sandals with fabric straps, or anything else that takes time to dry out. The thicker and denser a material, the longer it will require for adequate disinfection. Err on the side of caution. Bleach solutions are not recommended for absorbent materials.

- Hot Water: Soak items for at least 40 minutes in very hot water kept above 140°F (hotter than most tap water).
- Detergent and hot water: ('Green' products are less effective and not recommended for disinfecting): soak for 30 minutes in a hot 5% detergent/water solution kept above 120°F.

Recommended after all washing/disinfection procedures*:* Allow equipment to air dry, preferably in direct sunlight, at 84°F or warmer for more than 4 hours.

Additional Resources:

- NOAA Habitat conservation Restoration Center Invasive Species website: http://www.habitat.noaa.gov/restoration/programs/invasivespecies.html
- http://protectyourwaters.org/

SOP 17 Revision History Log

Version #	Date	Revised by	Changes	Justification
N/A	N/A	N/A	Prior to version 3.00, the narrative and SOPs for a given year all had the same version number. Beginning with version 3.00, SOP version numbers are allowed to vary from each other, and are only updated when there are changes to the SOP. Entries in this table prior to 3.00 reflect changes specific to this SOP; if numbers are missing, there were no changes between the original procedures and version 3.00.	Convert version numbering to NETN standard
3.00	Mar 2012	B. Gawley	New SOP established for Protocol Version 3.00	Protocol review meeting; Version 2.02+ to 3.00 (major revision)
3.01	December 2012	B. Mitchell	Minor edits.	Internal review
3.02	December 2013	B. Mitchell	Disinfectant solutions should not be disposed into a septic system.	Reviewer comment

SOP 18 – Differences, Deviations, and Summary of Major Changes

Acadia National Park /Lower Northeast Temperate Network parks

Version 1.01

Overview

This SOP documents:

- Differences between water monitoring methods used by NETN at Acadia National Park (ACAD) and the lower Northeast Temperate Network (LNETN) parks.
- Known deviations from established methods. Deviations are situations where data were collected in a manner that is substantially different from the methods documented within the SOPs used during a particular field season.
- Major changes in the protocol. Major changes are fundamental shifts in the way data are collected that cannot easily be rectified with earlier data. Major changes are not deviations, provided that the changes are documented in the SOPs. Ideally, any time there is a major change in methods NETN will use both methods long enough to determine whether the results from the different methods are sufficiently correlated to allow old data to be corrected. In some cases (especially early in the use of the protocol), the small amount of data lost by the protocol change will not be worth the cost of overlapping methods.

Differences between ACAD and LNETN Methods

Table 1 documents any known differences between the established methods used by field crews at ACAD and LNETN parks. The purpose of this portion of the SOP is to facilitate the task of the field crew members in adapting to the change in methodology when moving from one park to the next.

Table S18.1. Differences between established methods used at ACAD and LNETN parks, by SOP.

SOP	ACAD Methods	LNETN Methods
Narrative	Discharge is measured monthly at all sites except USGS continuous record site.	Discharge is measured monthly at all sites except Concord River.
	Benthic macroinvertebrate monitoring is conducted at 4-5 sites during August and September visits.	Benthic macroinvertebrates collected by USGS at MORR (Primrose Brook)
	Water samples are collected in 10 lakes for acidification analytes in April and October.	No acidification analysis in LNETN parks.

SOP	ACAD Methods	LNETN Methods
Establishing and Documenting Monitoring Sites	Lake/pond bathymetry from historic (ca. 1960s) depth maps.	Pond bathymetry data collected in 2013 for SAGA and MABI using GPS and sounding weight and processed using GIS software.
	Continuous stream level loggers are Global model WL16S, deployed during ice-free season.	Continuous stream level/ temperature loggers are HOBO model U20-001-01, deployed year-round.
Preparation and Equipment	All monitoring sites within ACAD boundary - no interstate or overnight travel required.	Interstate (most) and overnight (some) travel required to reach parks.
	Field crew consists of two NPS technicians	Field crew consists of one NPS technician and one intern or volunteer
Safety	No difference	
Monitoring Streams	Nearly all discharge measurements use Pygmy.	Nearly all discharge measurements use FlowTracker.
	Pygmy discharge measurements entered in Q-Calc PDA program during collection.	Pygmy discharge measurements recorded on paper form during collection. Data entered in Excel spreadsheet for final calculations.
Monitoring Lakes and Ponds	Lake stage is measured weekly from May-November in addition to monthly monitoring visits.	Pond stage is measured at monthly monitoring visits.
	Lakes and ponds are measured using canoe or inflatable boat with outboard motor transported to each site.	Ponds are monitored using small inflatable boat with oars kept at each site.
	Depth-integrated composite (epilimnion core) samples are collected for nutrient analysis.	Grab (~0.5 m depth) samples are collected for nutrient analysis.
YSI Sonde Measurements	600XL sonde used is medium-depth (to 61 m) model.	600XL sonde used is shallow-depth (to 9 m) model.
	2-point pH calibrations conducted using pH 7 and pH 4 buffers (for acidic water).	2-point pH calibrations conducted using pH 7 and pH 10 buffers (for alkaline water).
	Specific conductance checks conducted using 50 µS and 100 µS standards (for low-ionic strength water).	Specific conductance checks conducted using 100 µS and 1,000 µS standards (for moderate to high-ionic strength water).
	Each file on 650MDS contains data from one site visit for one monitoring site. Files are downloaded and datalogger is cleared monthly. File name includes month.	Each file on 650MDS contains data from all site visits for one monitoring site. Files are downloaded monthly but datalogger is not cleared (files are cumulative). File name only includes year.
Water Samples	Depth-integrated composite (epilimnion core) samples are collected from lakes and ponds for nutrient analysis.	Grab (~0.5 m depth) samples are collected from ponds for nutrient analysis.
	Grab (~0.5 m depth) samples are collected from all streams for nutrient analysis.	Width-integrated composite (from pylons 2 and 4) sample is collected from Concord River for nutrient analysis. All other samples are 0.5 m grab samples.
Water Clarity and Light	Li-Cor profiles taken in Jordan Pond (1 m intervals) and in all lakes and	Li-Cor light profiles taken in all ponds (using < 0.25 m intervals).

SOP	ACAD Methods	LNETN Methods
	ponds in which SD ≥ lake depth (using <1 m intervals).	
	PAR sensor suspended from 1m boom off side of boat.	PAR sensor suspended off of oar to side of boat.
	Blank (0 NTU) turbidity standard prepared in park lab by filtering deionized water.	Blank (0 NTU) turbidity standard purchased from commercial suppliers.
Streamflow	Nearly all measurements use Pygmy.	Nearly all measurements use FlowTracker.
	Pygmy discharge measurements entered in Q-Calc PDA program during collection.	Pygmy discharge measurements recorded on paper form during collection. Data entered in Excel spreadsheet for final calculations.
	Discharge is measured monthly at all sites except continuous record sites.	Discharge is measured monthly at all sites except Concord River.
	Discharge is occasionally measured using volumetric method at some sites.	Discharge is occasionally measured using Parshall flume at some sites.
	Continuous stream level loggers are Global model WL16S, deployed during ice-free season.	Continuous stream leve/temperature loggers are HOBO model U20-001-01, deployed year-round.
Invasive Aquatic Plant Surveys	Level I surveys are conducted annually at all lakes and ponds with public boat launch areas. Level II surveys conducted as time/staffing permits.	Level II surveys are conducted annually at all NETN ponds.
	Target species are MCIAP list and state-specific species of concern.	Target species are MCIAP list and state-specific species of concern.
	Monitors attend MCIAP training.	Monitors attend alternative trainings, as time permits
Hydro-Geomorphic Assessments	No difference	
Laboratory Analysis	Samples are shipped to lab via Fedex from park headquarters.	Samples are shipped to lab via Fedex from commercial FedEx shipping locations.
Data Management	YSI data files are downloaded and datalogger is cleared monthly. File name includes month.	YSI data files are downloaded monthly but datalogger is not cleared (files are cumulative). File name only includes year.
	Data can be entered electronically in the field using a Windows Mobile PDA.	Data can be entered electronically in the field using a Windows-based notebook PC.
Data Reporting and Analysis	No difference	
Post-season Activities	Global stream level loggers removed prior to ice season.	Onset loggers remain installed year-round.
Annual Timeline of Activities	Differences are detailed within SOP	
Decontamination Procedures	No difference	
Deviations and Changes	N/A	
Leveling	No difference	

Known Deviations and Major Changes

This portion of the SOP documents the major changes over time in the procedures and program administration, so that changes that may impact data analyses are all summarized in one place. This portion of the SOP also documents situations where procedures were not followed as specified in the SOPs that were current at the time of data collection.

Overall Protocol Changes and Data Issues by Year

2006 Major Changes

- MIMA: Confirmation that no discharge measurements will be taken at the Concord River due to expense.
- MORR: Added Passaic River site. Implemented addition on Indian Grove site.
- ROVA: Added Maritjes Kill site. Dropped monitoring of Vanderbilt Pond and ELRO Pond (Val Kill).
- SAIR: WQ samples collected at the Saugus River USGS gaging station, as well as sonde measurements twice per year (May and August).
- SARA: Devil's Hollow site dropped. Proposed moving Mill Creek South Fork site to North Fork.

2006 Deviations

- Conductivity calibration – LNETN found it useful to do a 3-point conductivity check instead of the 1-point in the protocol.
- NWQL did not perform TDN and TDP analysis on any samples due to mix-up in contracting instructions.
- LNETN performs a monthly 3-point check for pH; ACAD performs a pH calibration at the start of every sampling day.
- LNETN crew had contamination issues trying to filter immediately; went to storing 2L samples in a cooler for a few hours before filtering in a cleaner environment. Lab manager at NWQL approved this procedure, and it seems reasonable.
- LNETN investigating use of transparency tubes to measure clarity since Secchi measurements are almost always $\geq$ pond depth.
- LNETN taking 0 and 1 m readings and a reading just above the bottom for pond profiles. No guidance in protocol for alternate closer intervals in shallow ponds.
- Began using YSI "Site" field 89 recording for pre-sampling DO calibration, and 99 for post-sampling calibration confirmation.
- Photopoints are written into the protocol. Need to add more specificity to these procedures and attention in the field to ensure that the photos are taken.
- Issues with detection/reporting limits for ANC, TP and color being too high in NWQL analytical methods. Investigated alternative test methods, and use of University of Maine laboratory.

- Very few stream stage sites established at ACAD. Marks at many LNETN parks were on inappropriate locations (trees, impermanent substrate). Poor documentation of those that do exist.

2007 Major Changes

- Used transparency tube to measure water clarity in LNETN ponds. Transparency tube used through 2011.
- Continued using two labs (NWQL, SECRL) for nutrient sample analysis.
- MIMA: Conducted 7-point YSI measurement at Concord River to quantify mixing.
- SARA: Mill Creek main stem and North Branch sites were started this year.
- SAIR: Turning Basin was added as a sonde site (no nutrient chemistry)

2007 Deviations

- Issues at several parks with site access or ability to monitor:
  - MIMA – beaver activity, Mill Creek; stream can't be monitored for flow because culvert is completely full, and above tape-down point.
  - ROVA – Upper Crum Elbow, construction by state or city on Route 9 bridge led to flow diversion; also added several cubic yards of gravel.
  - SAGA – beaver activity, Blow-Me-Down – tape-down point flooded, had to go upstream and around bend to find suitable site. Small dam, and if it gets bigger will have to move the dam.
  - SARA – America's Creek is always difficult to measure, very low flow, no place for volumetric, and flume may not work well either. North Fork of Mill Creek is also a problem – bone dry in Sept and Oct.
  - ACAD – Some problems with low stream flow – very marginal in some streams. Volumetric measurements possible in some sites. Man-O-War Brook, outlet to Eagle Lake; problems started in August and September.
- Some descriptive metadata that should be recorded in fields listed in the "Field Data Forms" sections of SOP 4 – Monitoring Streams and SOP 5 – Monitoring Lakes and Ponds were not collected for all sites. Different field data forms used in ACAD and LNETN.
- Issues with slowing response time/failure of YSI pH probes. Began pH check with low ionic strength standard at ACAD.
- Encountered some flagged TN and TP measurements where TDN or TDP were coming out greater than the total (TN, TP) values.
- LNETN crew had issues with timing and UMO lab; short holding times were a problem logistically. Joe Bartlett (UVM) was not able to appropriately randomize his replicates in order to accommodate the shipping schedule to the lab.
- LNETN crew used EPA's rapid-bioassessment worksheet for habitat assessment. No habitat assessments performed at ACAD.

- ACAD shifted its sites for macroinvertebrate collection to locations that have NETN stream measurements. Stanley Brook, Man-O-War, and Duck Brook (Eagle Lake Outlet) were sampled using Maine DEP methods. The pilot samples at other NETN parks used EPA's kick-sampling method.

2008 Major Changes

- Began collecting nutrient chemistry samples at SAIRSB (Turning Basin) site.
- UMO's SECRL laboratory used for analysis of all NETN samples. Use of USGS-NWQL discontinued.
- LNETN began using Sontek FlowTracker for discharge measurements.

2008 Deviations

- Transparency tube is only used at SARA.
- LNETN crew conducted comparison between the pygmy meter and FlowTracker. At low flows and velocities, there was a departure from the pygmy data; lower velocities measured and higher variance. ACAD used pygmy exclusively.
- YSI data recording convention has become a problem, because calling each depth a different site on the 650MDS became an issue with datalogger memory. All actual measurements were saved to the "0" site- sites "899" and "999" (changed from "89" and "99" in previous years) were retained for pre- and post-measurement 100% DO saturation readings.
- Continued to see a number of cases for where the dissolved measures of P and N were higher than the total. Some of the differences are definitely higher than the test error. Some of this may be field protocol issues. The dissolved samples are filtered, while the total samples are not filtered. Clive Devoy (SECRL Lab) tested bottle and filter blanks in laboratory and found some detectable P and N in filters. Suggested acid-washing filters and tubing.
- LNETN crew used EPA's rapid-bioassessment worksheet for habitat assessment. Habitat assessments performed at ACAD using Maine DEP survey methods.

2009 Major Changes

- Relocated stream sites at Acadia. Eagle Lake outlet site near dam moved across Route 233 because original site gradient was too low and seemed redundant with lake measurement. Now get a better flow measurement and signal from the road. Lurvey Brook moved upstream side of road to obtain a better discharge measurement.
- Purchased second FlowTracker for use in ACAD.
- Migrated from UTM coordinates to decimal degrees for all spatial data. NPStoret requires coordinate information in decimal degrees. NETN_H2O capable of storing both DD and UTM. Decimal degrees are now the primary coordinate format.
- EPA's rapid-bioassessment worksheet for habitat assessment used at all sites (ACAD and LNETN).

- Established schedule for YSI sonde winter factory maintenance.

2009 Deviations

- LNETN flowtracker was reporting error messages (beam 1 not matching beam 2). Ultimately it was determined that probe sustained some type of physical damage when being used in shallow stream in MORR and required repair. Eric Davis (UVM) borrowed ACAD FlowTracker for October 2009 data collection.
- Began acid washing filters and tubing to reduce potential P and N contamination in filtered constituents.
- Hydro-geomorphic assessment methods not detailed in NETN protocol, and inconsistent between teams. USGS protocol suggests taking measurements on 100m reach, but 20 meters was deemed appropriate for NETN at last protocol review meeting. USGS protocol does not break sampled stream reach into smaller sections. Breaking 20 meter stream reach into four 5-m sections each measured separately was initiated by ACAD staff. Takes more time, but lends more accuracy to the process (more quantitative; 30 minutes once comfortable with the process). LNETN crew reviewed the entire 20 m reach as a whole without sub-sampling (more qualitative; 15-20 minutes).
- ACAD crew using a low-ionic strength buffer as a weekly pH check sample. There is no description of this procedure in the NETN protocol.
- ACAD and MORR (Primrose Brook) are the only sites in NETN that currently collect macroinvertebrates.

2010 Major Changes

- Conducted summer QA/QC trip with ACAD crew leader spending a week in the field with LNETN crew.
- Rapid hydro-geomorphic assessment moved to July. Both crews surveyed entire 20-m reach as a whole without sub-sampling (more qualitative; 15-20 minutes), as per decision at 2010 protocol review meeting.
- Eagle Lake Outlet (ACEGLO) site renamed Duck Brook (ACDUCK). Site moved 2 years ago. Because moved far enough away, decided to rename the site (more than 100 m and across Route 233).
- Standardized site photo procedures. Streams: monthly core photos are one upstream, one downstream, and one of water quantity cross-section (the last may not be in protocol). Annual pond and lake panorama from monitoring site (N and clockwise, 8-9 photos).

2010 Deviations

- Documentation at many stage measurement sites is spotty; lacking good photos and physical descriptions, including surveying of tape-downs and sampling spots.
- Inconsistency in stage measurement techniques; ACAD crew uses a “level stick” about a meter long with a bubble level to help with tape-downs by getting further out from point. LNETN crew has not been using one of these.

- Inconsistency in transparency measurement methods. Secchi depth should be metric – LNETN using Secchi disk with cord marked in feet.
- Secchi depth is usually not measurable in LNETN parks, using disk or transparency tube, since water is too clear and ponds are too shallow.
- ACAD crew began sampling turbidity in May, using a turbidity meter, to see how much time it will take.
- ACAD crew uses Extech digital thermometers for field measurements, not NIST traceable, but checks them against each other and the YSI periodically. Lower NETN will pick two up.

2011 Major Changes

- GS-07 Hydrologic Technician (Brian Schuetz; LNETN, permanent STF) was hired and started in June. Duty station was Troy, NY (USGS Water Science Center) and moved to MABI in 2012. Spent 2 weeks of initial training at ACAD, accompanied UVM technicians in LNETN parks in August and September, and monitored LNETN independently in October.
- Installed fixed stage datum points at ACAD, MORR, ROVA, and WEFA.
- Utilized separate inflatable rafts at each of the three LNETN parks with ponds to minimize contamination.

2011 Deviations

- LNETN and ACAD both have turbidity meters. Collected trial measurements in preparation for taking readings in FY2012, and an SOP will be produced for measuring turbidity at all stream sites. Transparency tube will no longer be used.
- Conducted summer QA/QC trip with water monitoring coordinator and ACAD crew leader spending a week in the field with LNETN crew (UVM technicians).
- LNETN field GPS unit (providing location coordinates for sonde data files) was not used because RS-232 interface cord was malfunctioning.
- October field data for SAGASA interchanged with SAGASB data due to LNETN crew leader being supplied with inaccurate site identification information.
- In three attempts, ROVA's Lower Crum Elbow site could not be measured for discharge because flow was too high. Looked for better site upstream for a tag line. Further upstream is a dam, but there is space above it. Also, the section of stream that has been monitored is not on park property, while upstream is on park property. Tape-down point is across the stream, which is a potential issue since at high flow will not get any stage measurements. Considered moving site.

2012 Major Changes

- Eagle Lake Outlet site (ACEGLO) was moved and renamed Duck Brook (ACDUCK).
- ROVA Lower Crum Elbow site was moved, but name was retained (ROVASD).

- Nutrient sample analyte suite was modified: Total dissolved nitrogen, nitrate + nitrite, total dissolved phosphorus, and orthophosphate analyses were discontinued. Dissolved organic carbon (DOC) analysis was added, as well as testing for nitrate, sulfate, and chloride. Sample filtering in the field was no longer required.
- Chlorophyll *a* testing began for samples from LNETN ponds.
- Began taking *in situ* water quality measurements (with YSI sonde) at SAIRSB (Turning Basin).
- Began taking monthly field turbidity measurements at all NETN streams; this method replaced the transparency tube.
- Installed fixed stage datum points at ACAD, MABI, MIMA, SAGA, and SARA.
- Site photo methodology expanded to include monthly upstream/downstream pictures from fixed photopoint.
- In LNETN parks, the hydro tech was assisted by park staff or volunteers.

2012 Deviations

- Lake and pond sampling not conducted in May due to administrative demands on monitoring staff.
- May and June field data for SAGASA interchanged with SAGASB data due to LNETN crew leader being supplied with inaccurate site identification information.
- ROVA Lower Crum Elbow site moved upstream to a site better suited for obtaining discharge measurements. The section of stream that has traditionally been monitored is not on park property, while upstream site is on park property. Protocol has not yet been updated with new site description.
- ROVA Upper Crum Elbow site severely impacted by Hurricane Irene in August 2011. Changes in stream channel made it extremely difficult to obtain discharge measurement, and changing site location was recommended.
- Beaver impact at SAGA Blow-Me-Down Brook site. Now a pool at the monitoring site, with some (minimal) flow. Unable to measure discharge at this location during August and later visits, only collected *in situ* water quality and lab samples. Depth was up to 4 feet.
- Variations on camera positions for photopoints, inconsistency in tagline photos (some did not contain tagline).
- Missed several light profiles late in ACAD season due to equipment problems.
- No consistent procedures implemented for cleaning gear between sites to prevent disease transmission and invasive species transport.
- MORR and ROVA strongly affected by Hurricane Sandy (Oct 29-30), mostly wind damage. MORR had significant tree loss. October ROVA visit was completed November 1.

2013 Major Changes

- GS-07 Hydrologic Technician (Brian Schuetz; LNETN, permanent STF) left unexpectedly in September 2013. Hali Roy (SCA intern) took over managing the LNETN monitoring.
- Hali Roy assisted Brian Schuetz from May through August. For September sampling, NETN staff (Adam Kozlowski and Ed Sharron) assisted with the monitoring.
- Bathymetry of MABI and SAGA ponds was mapped in the winter.
- Construction at the ROVASF site between July and August resulted in the loss of tape-down bolts and the installation of rip-rap at the site. Sandbags and fencing were used to reduce runoff from the construction.
- ACSTNL site moved approximately 50 meters downstream from previous sampling location to take advantage of better cross section for discharge measurement.

2013 Deviations

- Due to failure of the LNETN turbidity meter, a Hach 2100p meter was used for most of September and all of October at LNETN streams.
- LNETN specific conductance checks used 50 or 250 µS/cm standard instead of 100 µS/cm.
- LNETN used only pH 7 and 10 buffers in the pH sensor calibration for the multiparameter sonde. One park (MIMA) occasionally has acidic waters and a 3-point calibration should have been used. Also used the 7 or 10 buffer for the pH check, not the pH 4.63 solution.
- LNETN did not check multiparameter sonde accuracy against benchtop units or Winkler titration.
- LNETN FlowTracker "BeamCheck" diagnostic procedure was only run once during the season rather than monthly.
- Both LNETN and ACAD did not conduct duplicate discharge measurements or conduct QC discharge measurements at a gaged location.
- Replicate Hydrogeomorphic assessments for quality control were not conducted in LNETN or ACAD.
- A lab mix-up resulted in the loss of the WEFA chlorophyll *a* sample from August; a new sample was collected in September.
- Composite water samples were not collected for the Concord River (MIMA); instead a single sample was taken from the middle of the bridge.
- Discharge was not measurable at the ROVASC site (Upper Crum Elbow Creek) all year (except October). ROVASD may be close enough that ROVASC can be removed from the protocol.
- A new beaver dam below ROVASA may have affected September and October data.

- A possible beaver dam below SAGASB may have affected the October data.
- Concord River (MIMA) stage was measured to the nearest 0.25 m, not the nearest cm.
- ACAD missing GPS coordinates on YSI data files from June 19- 25 due to cable adaptor malfunction.
- ACAD collected lake water quality profiles from August 20- 28 with YSI 6600 due to YSI 600XL being at manufacturer for repair.

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.3 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version	Date	Revised By	Changes	Justification
1.00	August 2013	Brian Mitchell and Bill Gawley	New SOP	
1.01	January 2014	Brian Mitchell	Update to include 2013 field season	Annual review

SOP 19 – Leveling Water Monitoring Sites

Northeast Temperate Network

Version 1.02

Overview

This SOP documents the use of a Sokkia SDL30 or SDL50 Digital Level with a bar code staff to level water monitoring sites. Leveling is the process of using nearby permanent datum benchmarks and the level to ensure that the tape down points and any equipment (e.g. pressure transducers and staff gages) have not shifted vertically.

The basic procedure for leveling involves setting up the autolevel between a datum point and the equipment. Ideally both locations would be visible from a location between them. The elevation of the datum (the "backsight") is taken with the level, and then the elevation of the equipment (the "foresight") is taken, and the vertical distance is calculated based on the difference between the two measurements. When the equipment is not visible from a location between the datum point and the equipment, a series of measurements are taken that use intermediate "turning points". If the measurement does not agree with a previous measurement (the USGS standard is for the measurements to be within 0.005' [1.5 mm] over distances up to 300' [91 m]), the measurement must be repeated until it does agree. If measurements from multiple datum benchmarks agree with each other (i.e., both show an elevation, corrected for elevation difference between the datum points, that agrees within 1.5 mm), then the equipment or tape down has shifted. If the datum point and the tape down or equipment cannot both be seen from an intermediate location, then leveling involves a circuit where an intermediate point is chosen as a foresight, and that point then becomes the backsight for the next measurement.

BOLD indicates buttons on the level; *ITALICS* indicates menu items on the screen. This SOP is not intended to provide detailed instructions for the use of a Sokkia level; users should review the Operator's Manual for additional information. The only difference between the SDL30 and the SDL50 is that the SDL30 is more accurate.

Basic Maintenance and Operation of the Level

- When removing the level from the case, check the lens for dust and clean with a lens brush and lens cleaning cloth, if necessary.
- If leaving the level on the tripod or a long period while not in use, cover the level with the protective vinyl cover.
- Before storing the level in its case for any period of time, brush dirt off of the lens with a lens brush, breathe on the lens to provide some moisture, then clean the lens with a lens cleaning cloth.
- Always remove the battery if storing the level for a long period of time (greater than a week).

- The light on the battery charger will flash when the battery is charging, and turn steady when charging is complete.
- To turn the level on: Press the **PWR** button.
- To turn the level off: Press the **PWR** button and hold it, and press the **backlight button** (to the left of PWR).
- The bar code staff has numbers on one side, and the bar code on the other. When assembling the staff, make sure the segments fit together snugly and create an unbroken series of numbers.
- The bar code staff must be treated with care. Remove any water or dirt, and take care not to soil or scratch the staff.
- Note that extreme temperatures can make the staff expand or contract. The staff is calibrated to 20 °C (68 °F). If temperatures are below 14 °C (57 °F) or above 26 °C (79 °F), the expansion will exceed 0.5 mm over 4 m, and a correction for temperature may be needed (see Operator's Manual, page 24).

Setting up the Tripod and Level

- First set up the tripod so that it is approximately level.
- Mount the level on the tripod, and hand-tighten the mounting screw.
- Using the bubble level on the level for guidance, shift the legs of the tripod until the bubble is inside the central circle of the bubble level. Firmly press the tripod legs into the ground.
- Use the three round foot screws (knobs) on the level to exactly center the bubble in the bubble level.
- Look through the eye piece and adjust the eyepiece outwards (counter-clockwise) so that the reticle is blurry, then inwards until the point where it first becomes sharp.
- With the bar code staff in a stable location, focus on it (with the major focus knob), and shift your eyes slightly up and down, left and right, and make sure that there is no parallax/shifting. The reticle should seem fixed on the bar code, and not shift relative to the bar code staff when you move your eyes slightly.
- Verify settings.
    - When the unit powers on, there will be a letter in the top-right corner of the measurement screen to indicate the measuring mode. Verify that this letter is "*W*" (for "Wave-and-Read"). If not, press **MENU** twice, then ►, then ← twice, select "*Waving*" with the arrow keys, then ← then **ESC**.
- Choose a measurement job to record leveling data.
    - Press **MENU** then ← to get into the Job menu.
    - "*SELECT*" will be highlighted; press ← to choose a job. The level holds 20 different jobs. Choice of different jobs is for convenience; job and point numbers will need to be recorded separately, along with site info and the specific object (datum, staff gage, tape-down) being surveyed for each point.

- Jobs can be renamed by choosing "*EDIT*" from the Job menu.
- When finished, press **ESC** to get to the main menu, press ► to select "*REC*" and press ←. "*Cond.*" will be highlighted; press ← again. Make sure "*Manual*" is highlighted and press ← again. Press **ESC** to return to the main menu.

Taking Measurements

- Use the gun sights on top of the level to aim the level at the bar code staff.
- Look through the eye piece, and adjust the focus using the large focus knob.
- Use the smaller horizontal focus knobs to center the bar code staff in the eye piece. If the bar code staff is in deep shade, a flashlight can be shined on the staff to facilitate measurement.
- The person holding the staff should place it firmly on the benchmark, equipment, or turning point location and wave it front-to-back (in the plane of the level) within 10 degrees of vertical, and at a rate that has the staff passing through vertical about once per second. Moving the staff side-to-side (perpendicular to the level) will result in a measurement error. For wave-and-read measurements to work, the staff must be between 5 and 50 m from the level, and the measurement must be made between 0.5 and 4.0 m on the staff. In other situations, the measurement type can be changed to "*S*" for "single measurement". In this mode, the staff must be held stationary and perpendicular to the ground. To change to "single measurement" mode, follow the procedures above (under "Verify Settings" in "Setting up the Tripod and Level").
- All objects must always be measured from a consistent and marked elevation. For example: the top of a datum bolt or USGS benchmark, the top of a stake pounded firmly into the ground to create a turning point, a marked point on a rock, or a nail or bolt head firmly affixed to a staff gage. Since shifting as little as 2 mm will invalidate the measurement, every precaution must be taken to measure from firm and consistent elevation points.
- Press the **blue button** below the major focus knob to begin the measurement. A single beep will sound. A double beep will sound when the measurement is completed. The staff height (*Rh*) and horizontal distance to the staff (*Hd*) will be displayed. For foresight points, "Δ*H*" will also be displayed.

Testing and Calibrating the Level with a Two Peg Test

The level needs to be checked and adjusted periodically (monthly when it is seeing regular use) by conducting a "Two Peg Test". Find a level area at least 33 m across, and establish two calibration points (A and B) that are 30 m apart. The points will need stable elevation for the test (e.g., rock outcrop, blacktop, tent stakes pounded firmly into the ground) and be clearly marked so that they can be found repeatedly during the test. Follow the procedures in the Operator's Manual, pages 66-70 (reproduced as Appendix S19.A).

Note that it will not be possible to use the "Wave and Read" setting for all measurements during calibration (this method will not work for the 3 m measurements). To change the measurement type, press **MENU** prior to a reading, and select the measurement type ("*Single*" or "*Waving*") and press ←.

Field Procedures

For initial surveying work, height differences must be taken using the double-run (out and back) method between each benchmark datum point, and between each benchmark datum point and the installed equipment. Multiple pieces of equipment that are visible from the same level location can be surveyed together (e.g., from the same turning point, as long as two successive measurements agree on the height difference). If the elevation upon return to the initial datum point (for each double-run) exceeds ±1.5 mm per 90 m of distance or is more than ±5 mm total, conduct a new double-run measurement. Note that if equipment is spread out, the closest equipment can be recorded as an "*IS*" or intermediate sight point.

For follow-up (annual) leveling work, a single-run measurement (from a datum point to the equipment) is acceptable, as long as the elevation of the equipment compared to the previous double-run measurement is within ±1.5 mm per 90 m of distance and no more than ±5 mm total. If the measurement does not agree with previous measurements, then a double run measurement from each datum point to the equipment is needed. If those measurements show an equipment elevation that is within the acceptable error (after accounting for the elevation difference between datum points), there has been a datum shift. If the measurements from separate datum points do not agree, then a complete resurvey is needed to reestablish all datum and equipment elevations.

The detailed measurement procedure is:

1. On the data sheet (Appendix S19.B) or database, record the date, temperature (°C), monitoring site name and code, and the job number (from the level).
2. Set up the level between the datum point and the first turning point or piece of equipment to be leveled.
3. From the main screen (displays "*MEAS*" in the top-left), select **MENU** and use ► or ▼ to scroll to "*Ht-Diff*". Press ←.
4. The left side of the screen should have "Δ*H*", "*BS*" (backsight) and the next 4 digit point number displayed.

a. If an "*" appears to the right of "*BS*", press **MENU**, ► to highlight "*Go*", and then press ←.

5. Focus on the staff held at the backsight and press the **blue button**. The staff height (*Rh*) and distance (*Hd*) will display. If the values look correct, press ← (*Y*); otherwise press ► and then ← (*N*) to start the measurement again.
6. Record the point type (BS Type), point number (BS #), and backsight distance ("*Hd*" to nearest meter; BSD) on the datasheet or database.

a. "*FS*" (foresight) will now be displayed in the middle of the left side of the screen.

7. The person moves to the equipment or turning point, and sets up the staff. It is essential to always measure from a firm/fixed elevation point. If the point is a turning point, choose a

rock or other solid object and clearly mark it. Alternatively, pound a tent stake firmly into the ground and clearly mark it. If you are conducting a double-run measurement you will need to re-use the same turning points to facilitate data quality control checks.

8. If the point is an intermediate sight (e.g., a close-by piece of equipment, when at least one turning point will be needed before reaching other equipment):

a. Press ← and then ► to select "*IS*", then press ← and then **ESC.** Focus on the staff held at the intermediate sight and press the **blue button**.

b. The intermediate sight height (Δ*H*), staff height (Rh) and distance (Hd) will display.

c. If the values look correct, record that this point is an intermediate sight (IS? = "Y"), and also record the point type (FS Type), point number (FS #) and intermediate sight height (ΔH) on the data sheet or database. Record the "*Hd*" to the nearest meter in the FSD column. If you are using a datasheet, calculate 1) the distance (D) as the sum of the BSD and FSD, and 2) the cumulative ΔH (according to the instructions on the data sheet).

d. Press ← (*Y*); otherwise press ► and then ← (*N*) to start the measurement again. NOTE: Use ► as many times as needed to view data that has already been stored, starting with the most recent point. Press **ESC** when done reviewing data.

e. Go to Step 5.

9. Focus on the staff held at the turning point or equipment and press the **blue button**. The turning point or equipment height (Δ*H*), staff height (*Rh*) and distance (*Hd*) will display.

    a. If the values look correct, record whether or not this is a non-terminal foresight measurement (IS? = "Y") or a turning point or other terminal foresight measurement (IS? = "N"), the point type (FS Type), point number (FS #) and height (Δ*H*) on the data sheet or database. Record the "*Hd*" to the nearest meter in the FSD column. If you are using a datasheet, calculate 1) the distance (D) as the sum of the BSD and FSD, and 2) the cumulative ΔH (according to the instructions on the data sheet).

10. Press ← (*Y*); otherwise press ► and then ← (*N*) to start the measurement again. NOTE: Use ► as many times as needed to view data that has already been stored, starting with the most recent point. Press ESC when done reviewing data.

11. If the point is equipment, and there is more equipment to measure, go to Step 5.

12. If the point is a turning point or if you are conducting a double run measurement and have reached the end of your outward run (i.e., all equipment heights have been measured):

    a. Press **MENU** to display "*Turning Point Yes/No?*" and press ← for "*Yes*".

    b. "*BS*" will be displayed in the middle of the left side of the screen, and the same point number will be displayed (since the bar code staff is at the same position).

    c. If you are commencing the return run of a double run measurement, press **MENU** to display "*Go*" and "*Return*", and press ► then ← for "*Return*". An "*" will appear to the left of "*Rh*". The person with the bar code staff should lift if off of the final piece of equipment, then replace it. Go to step 4, and proceed to make all

the measurements you made on the way out in reverse order, including any intermediate sight equipment.

d. If you are measuring a turning point, relocate the level between the turning point and next piece of equipment to measure, and have the person at the turning point carefully rotate the staff so the bar code is facing the level. Take extreme care not to change the elevation of the staff. Go to Step 4.

13. At the end of your survey, calculate Total D (if using a datasheet) as the sum of the D measurements where IS? = "N". Then calculate the allowable error as 1.5 mm if Total D is less than 90 m, 5.0 mm if Total D is greater than 300 m, and (Total D * 1.5) / 90 for other distances. If the final cumulative ΔH exceeds the allowable error, the survey must be conducted again. Reviewing the data sheet should highlight specific leg(s) of a double-run survey where there was more error; start by resurveying these leg(s).

Data Management

Data recorded by the level can theoretically be downloaded via a download cable and "SDL Tool" software. However, this process does not work in practice despite being tested on multiple computers, COM ports, and with various COM settings. Since the data is only needed for QA/QC against the data collected in the field, the comparison can be done manually as follows.

Upon returning from the field, compare the datasheet or database entries to the stored points in the autolevel.

a. Turn on the autolevel and press **Menu**. If you need to change the job, press ← twice, then use the ► key to select the job (note that **Menu** at this point will jump forward to Job 11 then Job 1). Press ← when you have the correct job.

b. Press ► to highlight "*REC*", then ←, then use the ▼ to highlight "*Review*". Press ←.

c. The level will show you the last point first. Scroll through the data using ►, and for each entry verify that the "Δ*H*" shown matches the ΔH recorded on the data sheet. Also verify that the values recorded for "BSD" or "FSD" match. Note that "Δ*H*" will be "*0.0000*" for a backsight.

d. If data were recorded on a paper datasheet, open the leveling database and enter the data into a data form. The database will calculate D, cumulative ΔH, total D, and the allowable error. If any values don't match what was recorded on the data sheet, review the values for BSD, FSD, and ΔH, as appropriate, and check the math on the datasheet, as appropriate.

e. When the data review is complete, press "**ESC**" three times to return to the main screen.

f. When you are certain that the data in the database matches the data on the level, you can delete the job:

    a. Pressing "**MENU**" then "←".

    b. Despite there not being a way to download data, if the level does not think it has downloaded data it will not allow you to delete it. So Use an arrow key to highlight "*Output*" and press ←.

c. Press ←, select the correct job with ►, then press ← and wait for the export to complete.

d. Use an arrow key to highlight "*Delete*" and press ←.

e. Select the job with ► and press ←. Select "*Yes*" with the ► and press ←.

Appendix S19.A. Operator's Manual, pages 66-71

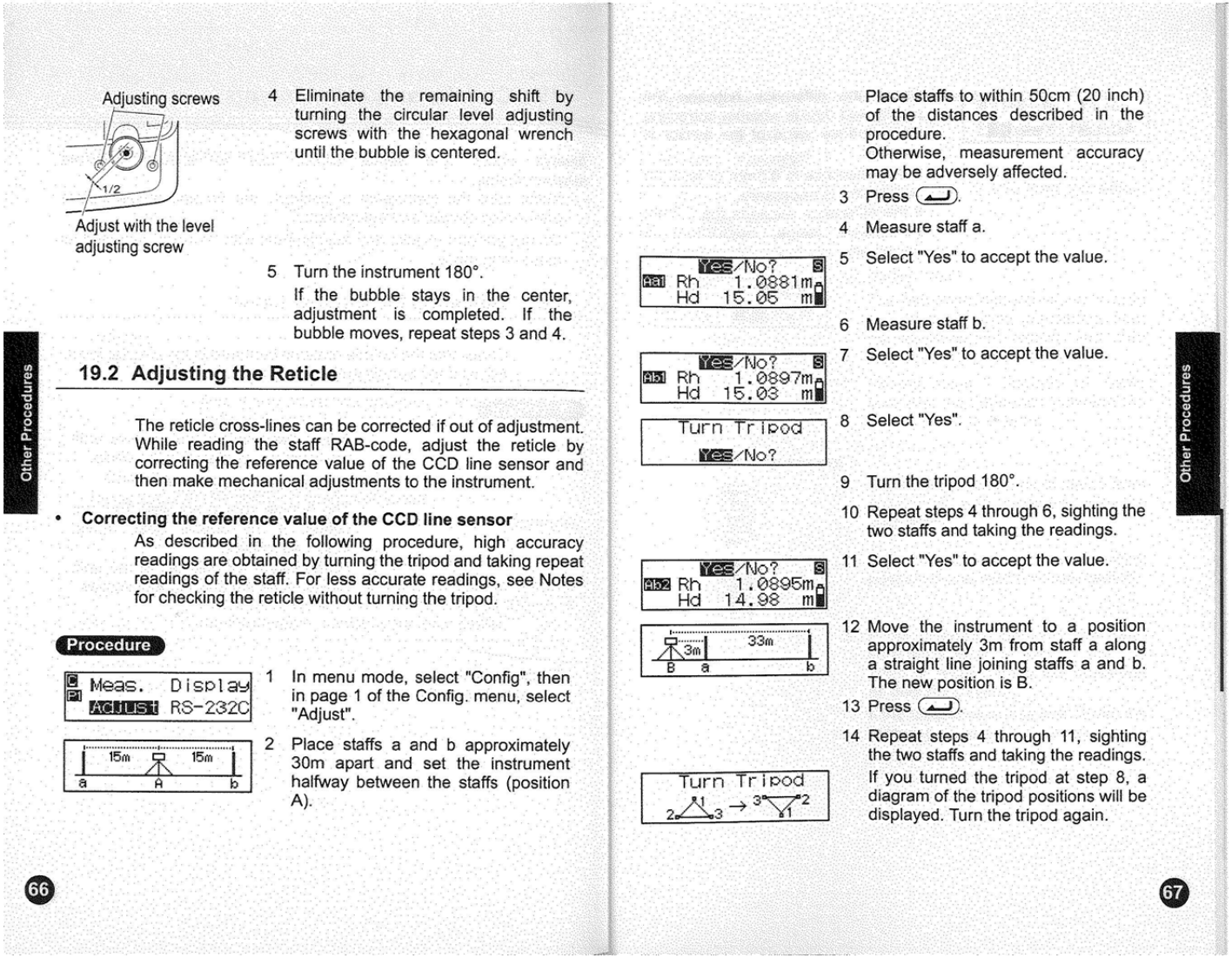


Figure S19.A.13. Sokkia SDL30 Operator's Manual pages 66-67

diff. 0.0017m
Adjust Yes/No?

15 Check the difference between the results and decide whether correcting the reference value of the sensor is required.
If the difference is 0.3mm or less, no adjustment is necessary.
If the difference exceeds the 0.3mm permissible range, adjustment is necessary.

If correcting the reference value is not necessary:

diff. 0.0017m
Adjust Yes/No?

16 Select "No".

Exit Adjust
Yes/No?

17 Select "Yes" to exit from the Adjust menu.

If correcting the reference value is required:

diff. 0.0045m
Adjust Yes/No?

16 Select "Yes".
The instrument calculates and records the required reticle adjustment from the measurement results, and then returns to the menu selection.

17 Repeat steps 1 through 15. Make sure that the difference between the results is within 0.3mm.

- **Mechanical adjustment**



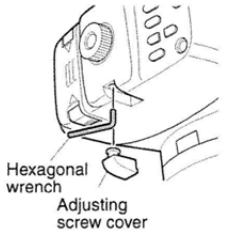
1 Sight the barcode face of staff b from position B and measure with the instrument.



2 Sight the scale face of staff b from position B and take a visual reading.

3 If the difference between the measurements taken at steps 1 and 2 is 2mm or more, adjust the cross-line as described below.
If the difference is less than 2mm, the following steps are not necessary.

Figure S19.A.14. Sokkia SDL30 Operator's Manual pages 68-69



4 Remove the adjusting screw cover and insert a hexagonal wrench in the adjusting screw.

5 Turn the adjusting screw, then repeat steps 1 and 2. Adjust so that the difference between the two measurements is less than 2mm.
If the measurement at step 2 is larger than the measurement at step 1, lower the cross-line by slightly loosening the adjusting screw.
If the measurement at step 2 is smaller than the measurement at step 1, raise the cross-line by slightly tightening the adjusting screw.

6 Replace the adjusting screw cover.

Notes:

- **Saving measurement values during correcting the reference value of the sensor and power off**

• Steps 9, 12 and 14:

Data keep
Yes/No?

"Data keep" screen asks whether or not you want to save the measurement values during setting internal constants.
Select "Yes" to save measurement values and turn power off. When power is turned on again and page 1 of the Config. menu is selected, Screen Status at last power off is displayed.
Select "No" to cancel measurement values and turn power off.

- **Difference calculations:**

• Step 15: If the tripod is turned and repeat measurements taken:

Value at position A = {[(1st reading on staff a) + (1st reading on staff b)] + [(2nd reading on staff a) – (2nd reading on staff b)]} / 2

Value at position B = {[(1st reading on staff a) + (1st reading on staff b)] + [(2nd reading on staff a) – (2nd reading on staff b)]} / 2

Difference = absolute value of [(value at position A) – (value at position B)]

If the tripod is not turned and only one set of measurements are taken:

Value at position A = [(reading on staff a) – (reading on staff b)]

Value at position B = [(reading on staff a) – (reading on staff b)]

Difference = absolute value of [(value at position A) – (value at position B)]

Figure S19.A.15. Sokkia SDL30 Operator's Manual pages 70-71

Appendix S19.B. Leveling Data Sheet

Date (MM/DD/YYYY):

Temp (°C):

Site Leveled (name and code):

Job Number (1 to 20, from autolevel):

BS Type	BS #	BSD	IS?	FS Type	FS #	FSD	D (m)	ΔH (m)	CumΔH (m)	Notes

Total D (m): Allowable Error (mm):

Notes:

Instructions

BS and FS Type: DPN = Datum Point and Number (e.g., DP1), TPN = Turning Point and Number, TDN = Tape-Down Point and Number, SGN = Staff Gage Point and Number, PTN = Pressure Transducer Point and Number

BS and FS #: Backsight and Foresight Point Number from autolevel**BSD and FSD:** Backsight and Foresight Distance (Hd on level) to nearest meter

IS? "Y" if intermediate sight OR not the last foresight point at the current location; otherwise "N"

D: Distance covered by measurement to nearest meter; sum from backsight and foresight

ΔH: to nearest tenth of mm, from autolevel

CumΔH: Most recent ΔH plus the sum of all ΔH measurements where **IS?** = "N"

Total D: The sum of all D measurements where **IS? = "N"**

Allowable Error: If Total D is < 90, allowable error is 1.5 mm. If Total D is > 300, allowable error is 5.0 mm. Otherwise allowable error in mm is (**Total D** * 1.5) / 90

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.3 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

SOP 19 Revision History Log

Version	Date	Revised By	Changes	Justification
1.00	April 2013	Brian Mitchell	New SOP	
1.01	April 2013	Brian Mitchell	Add section “Data Management” Added data sheet Added instructions for recording data to the “Field Procedures” section	Needed to complete the SOP
1.02	June 2013	Bill Gawley	Inserted appendices Minor formatting changes	Needed to complete the SOP

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 962/123879, March 2014

National Park Service
U.S. Department of the Interior

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