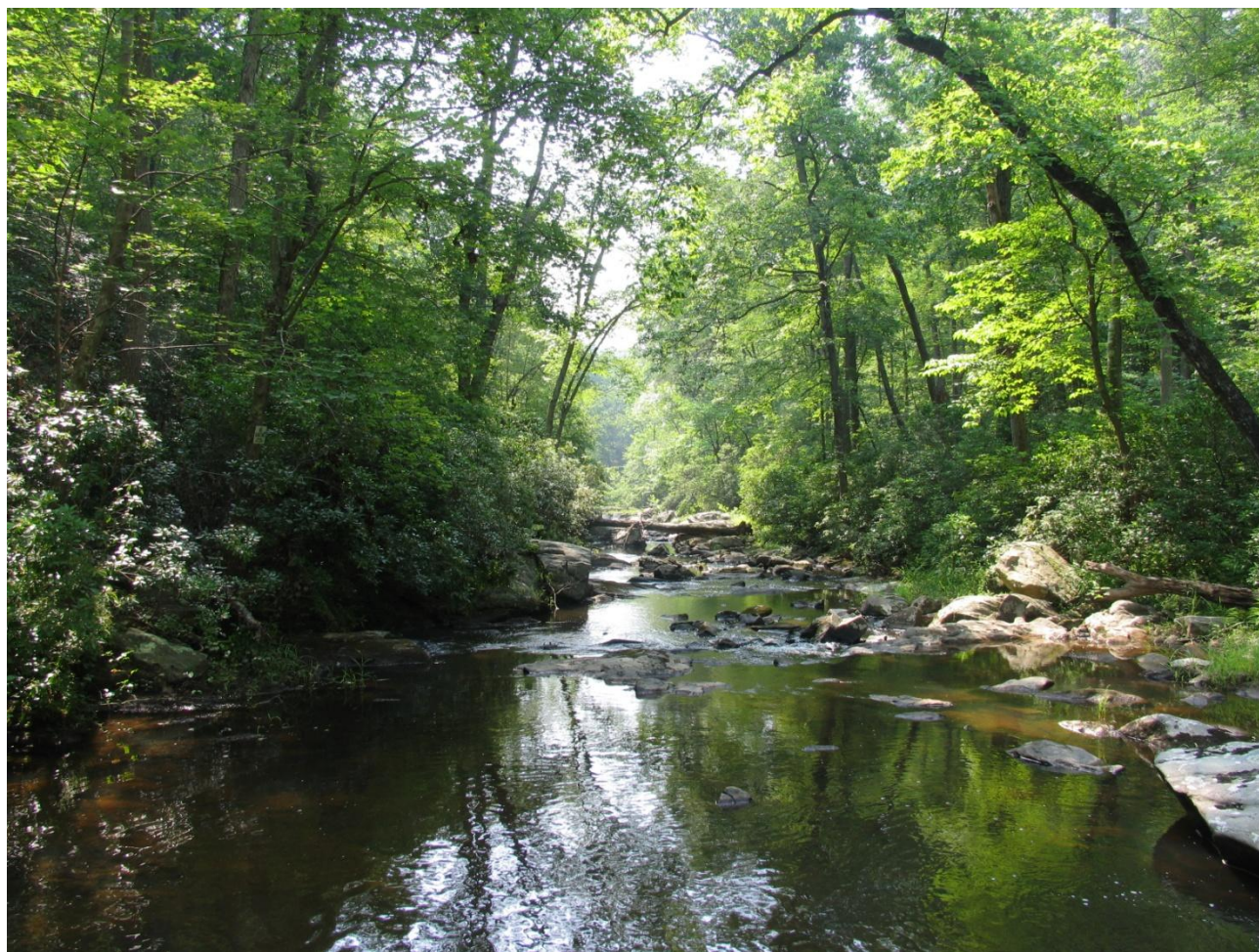




National Capital Region Network Inventory and Monitoring Program Water Chemistry and Quantity Monitoring Protocol Version 2.0

Water chemistry, nutrient dynamics, and surface water dynamics vital signs

Natural Resource Report NPS/NCRN/NRR—2011/423



ON THE COVER

Chopawamsic Creek

Photograph by: Prince William Forest Park Resource Management seasonal staff

National Capital Region Network Inventory and Monitoring Program Water Chemistry and Quantity Monitoring Protocol

Water chemistry, nutrient dynamics, and surface water dynamics vital signs

Natural Resource Report NPS/NCRN/NRR—2011/423

Marian Norris

James Pieper

Tonya Watts

Ali Cattani

National Park Service
Inventory and Monitoring Program
National Capital Region Network
4598 MacArthur Blvd., NW
Washington, DC 20007

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Fort Collins, Colorado

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Executive Summary

The vital sign selection process of the NPS Inventory and Monitoring Program (I&M) identified water chemistry, nutrient dynamics, and surface water dynamics as a critical need for the parks of the National Capital Region Network (NCRN). In 2005, the National Capital Region Inventory and Monitoring Network (NCRN) initiated a long-term water quality and quantity monitoring program, funded in part by the Water Resources Division. The water monitoring portion of the program is carried out through monthly sampling at more than 38 sites within 10 of the NCRN's parks. The data collected using this protocol will provide much needed baseline information on stream water chemistry and quantity in the NCRN. The information will also be used to determine long term trends.

Parks monitored with this protocol include Antietam National Battlefield (ANTI), Catocin Mountain Park (CATO), Harpers Ferry National Historical Park (HAFE), George Washington Memorial Parkway (GWMP), Manassas National Battlefield Park (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap National Park for the Performing Arts (WOTR). The streams monitored are all part of the Potomac River watershed. The Potomac is the second largest drainage of the nine river basins that form the 64,000 square mile Chesapeake Bay watershed.

This protocol includes monitoring of three related vital signs: water chemistry, nutrient dynamics, and surface water dynamics. The protocol is based on guidance from National Park Service Water Resources Division (National Park Service 2002, Penoyer 2003, Tucker 2007, Irwin 2008) and 19 years of field experience on the part of the primary author.

The protocol was revised and expanded in 2010 to include revisions made to the program over the first 5 years as well as respond to review comments from the WRD review panel.

Water chemistry is important to maintaining a healthy habitat for many aquatic organisms, wildlife, and humans. Water quality can provide insights into overall system productivity, shift species abundances and distributions, and alter nutrient cycles. Water quality parameters such as pH, specific conductance, dissolved oxygen, and temperature are good measurements that provide an overview of water quality. Water quality monitoring is required to comply with relevant environmental legislation and NPS mandates and to evaluate potential stressors in NCRN waters.

Acknowledgements

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Background and Objectives

Background and History

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

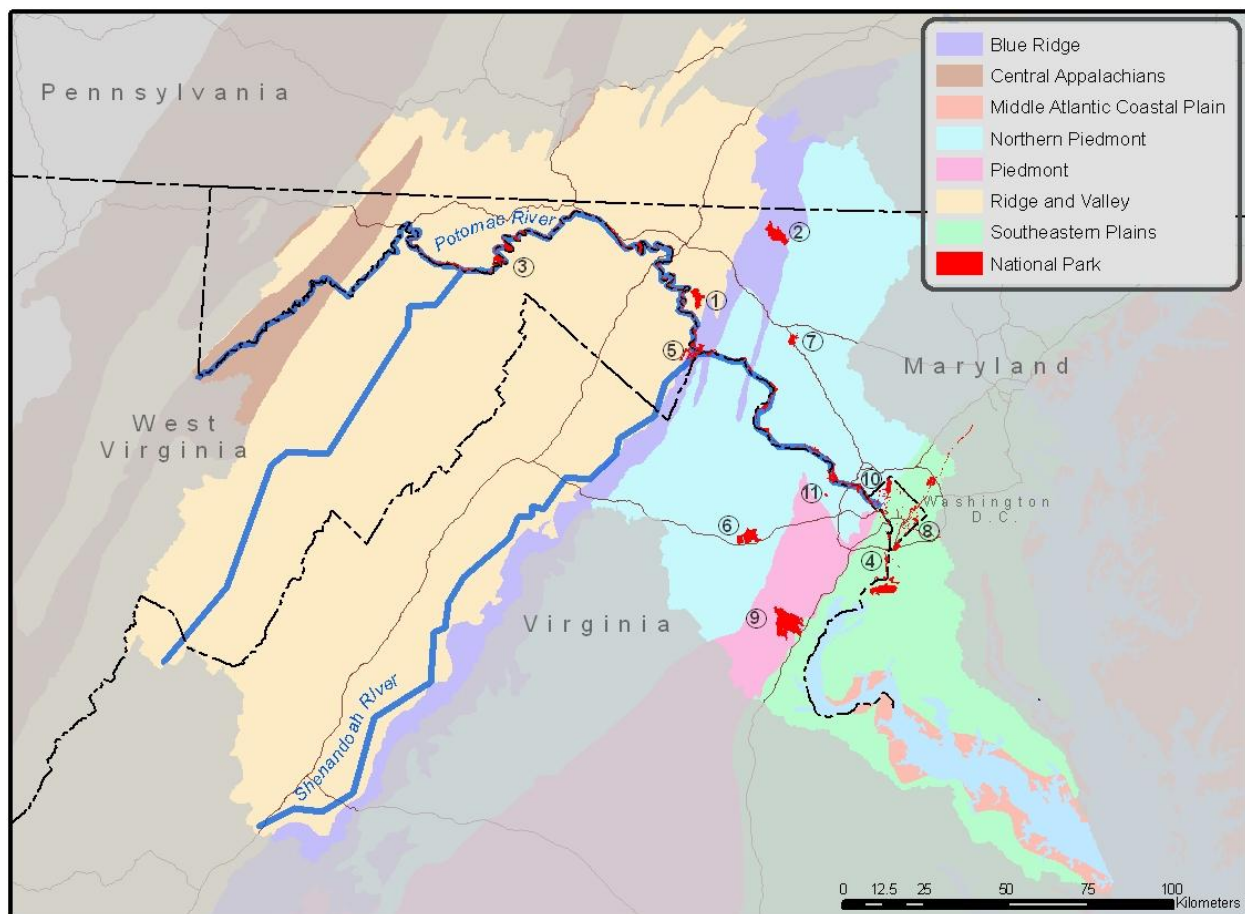


Figure 1: Locations of the National Parks (numbered and in red) in the National Capital Region within the Potomac River watershed (brighter outline within map) and Patuxent River watersheds. The Level III Ecoregions (Woods et al. 1999) are indicated by the pastel areas and listed in the legend. The parks of NCR are:

1. Antietam National Battlefield (ANTI)
2. Catoctin Mountain Park (CATO)
3. Chesapeake & Ohio Canal National Historical Park (CHOH)
4. George Washington Memorial Parkway (GWMP)
5. Harpers Ferry National Historical Park (HAFE)
6. Manassas National Battlefield Park (MANA)
7. Monocacy National Battlefield (MONO)
8. National Capital Parks–East (NACE)
9. Prince William Forest Park (PRWI)
10. Rock Creek Park (ROCR)
11. Wolf Trap National Park for the Performing Arts (WOTR)

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

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

Parks with natural water resources in the region include Antietam National Battlefield (ANTI), Catocin Mountain Park (CATO), Harpers Ferry National Historical Park (HAFE), George Washington Memorial Parkway (GWMP), Manassas National Battlefield Park (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap National Park for the Performing Arts (WOTR). It should be noted that NACE is not an individual park, but rather an administrative unit that manages a variety of small parks (Greenbelt Park, Suitland Parkway, Piscataway Park, etc.) not all of which are monitored.

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

A Water Chemistry Monitoring Protocol (Norris 2005) was developed in-house which includes nutrient dynamics. In collaboration with the USGS, we developed a surface water dynamics protocol (Fisher 2005). In collaboration with researchers from Frostburg State University and The Maryland Department of Natural Resources (Hilderbrand et al. 2005), we worked to adapt the Maryland Biological Stream Survey (MBSS) for use in NCRN parks. The MBSS includes a physical habitat index and indexes of biological integrity for aquatic macroinvertebrates and fish (Norris and Sanders 2009). The NCRN water monitoring program was peer-reviewed by the Water Resources Division in 2008. This protocol revision addresses their comments and changes that occurred as the program evolved from 2005 to 2010. This document combines the water chemistry and surface water dynamics protocols. This protocol is designed for monitoring 1st to 4th order non-tidal streams in 10 parks within the NCRN in the Washington, DC, metropolitan area.

Rationale for Monitoring This Resource

Water resources are a vital component of NPS lands in the National Capital Region (NCR) (Table 1). In parks such as Rock Creek Park, water resources are a dominant landscape feature, and the quality of the visitor experience largely depends on the quality of the resource. On other NCRN lands, aquatic resources play an important role in the visitor experience. The condition of water resources also has direct bearing on public health and safety when waters are degraded or

contaminated. A significant number of NCRN park streams contribute to public drinking water supplies. To this end, the Clean Water Act and other regulatory mandates set minimum water quality standards; standards which are increasingly assessed using aquatic organisms.

Table 1. GPRA Goals and Enabling Legislation Pertaining to Water Monitoring at the Parks

Enabling Legislation	Parks With This Goal										
	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Water quality (prevent water pollution to Anacostia, Potomac, Rock Creek, or Quantico Creek)				X				X	X	X	
GPRA Goal # 1a04: Water quality improvement	X								X		

There are numerous historic or ongoing monitoring projects within the NCRN. Most have been set up by park personnel, previous staff at the Center for Urban Ecology, universities, partner agencies and even volunteer organizations. The I&M program was not designed to replace park based monitoring effort but is in a position to enhance programs that are part of the network's priority vital signs. The monitoring program will attempt to integrate new monitoring protocols with ongoing efforts whenever possible.

Purpose

The purpose of this protocol is to monitor non-tidal freshwater stream resources in the National Capital Region. The National Capital Region Network Inventory and Monitoring program collects data for water chemistry (temperature, dissolved oxygen, specific conductance, pH, acid neutralizing capacity), nutrients (ammonia, nitrate, and total phosphorus), and surface water dynamics (width, depth, flow, and discharge). These parameters provide information that characterize a water body or stream segment, are fundamental components of monitoring and regulatory programs, and are relatively easy to measure with multi-parameter probes or Hach test kits.

Acid Neutralizing Capacity (ANC)

ANC is the prime indicator of a waterbody's susceptibility to acid inputs. ANC is a measure of the amount of carbonate and other compounds in the water that neutralize low pH. The pH of water does not indicate its "buffering capacity", which is controlled by the amounts of alkalinity and acidity present. ANC is typically caused by anions in natural waters that can enter into a chemical reaction with a strong acid. These are primarily the carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions. Dissolution of these species is most typically caused by the partial pressure of CO_2 in the atmosphere but their presence may be further elevated in areas of carbonate rock dissolution where waters are often of a bicarbonate type (elevated in HCO_3^-). Borates, phosphates, silicates, arsenate, ammonium and organic ligands (e.g. acetate and propionate) can also contribute to alkalinity when present. However, except for unusual natural waters or waters significantly impacted by anthropogenic sources, non-carbonate ionized contributors are rarely present in large enough quantities to affect alkalinity or ANC determinations (Wilde and Radtke 1998).

ANC is particularly important to measure in areas where acid mine drainage (e.g. PRWI) or acid precipitation (entire NCRN) is a potential concern. Acid sensitive waters generally have specific conductance below 25 $\mu\text{S}/\text{cm}$, acid neutralizing capacity (ANC) below 100 $\mu\text{eq}/\text{L}$ for episodic acidification (50 $\mu\text{eq}/\text{L}$ for chronic acidification), total base cation (calcium, magnesium, sodium, and potassium) concentration below 100 $\mu\text{eq}/\text{L}$, and pH below 6.0. Schindler (1988) states that surface waters with ANC less than or equal to 200 $\mu\text{eq}/\text{L}$ are considered sensitive to acidification. In karst terrain, ANC below 600 $\mu\text{eq}/\text{L}$ CaCO_3 is cause for concern (Weeks et al. 2007). NPS-WRD (National Park Service 1995, 1996, 1997) indicates that surface waters in three parks—Antietam National Battlefield and Manassas National Battlefield were not susceptible to acidification from atmospheric deposition. However this data ranges in age from 8 to 30 years and circumstances may have changed.

NCRN utilizes Hach Alkalinity Method 8203 (Alkalinity, Phenolphthalein and Total using Sulfuric Acid Method) to determine phenolphthalein and total alkalinity which are used to calculate the acid neutralizing capacity.

Dissolved Oxygen (DO)

DO is a measure of the amount of oxygen in solution. DO enters the water in one of two ways – photosynthesis of plants and directly from the atmosphere via diffusion or mechanical aeration (e.g., waves, waterfalls). The primary losses of DO from water are respiration and biochemical oxygen demand (BOD). Dissolved oxygen (DO) concentration of surface water is dependent on water temperature and air pressure, and, to a lesser extent, the amount of dissolved ions (measured as salinity or conductivity - correction factors for salinity are normally applied after measuring DO). The higher the pressure and cooler the temperature, the more oxygen from the atmosphere can be dissolved into the water until a balance or equilibrium is reached; this is called saturation (Hem 1989). Oxygen has strong daily and seasonal variability. In organically enriched streams, DO is often lowest just before sunrise because plants have not been photosynthesizing and only respiration has been occurring. Conversely, DO increases after sunrise until the sun's angle of incidence is greatest because the rate of photosynthesis is dependent on sunlight. In less enriched streams, this pattern may be less apparent or absent because stream temperatures are lower at night and thus can contain more dissolved oxygen. Therefore it is important to always monitor a particular site at the same time of day (U.S. Geological Survey 1980, Stednick and Gilbert 1998, National Park Service 2002).

DO is necessary in aquatic systems for the survival and growth of many aquatic organisms. The presence and amount of dissolved oxygen in surface water also determines the extent to which many chemical and biological reactions will occur (Wilde and Radtke 1998). Low dissolved oxygen is of greatest concern due to detrimental effects on aquatic life. Conditions that generally contribute to low DO levels include warm temperatures, low flows, water stagnation and shallow gradients (streams), organic matter inputs, and high respiration rates. Decay of excessive organic debris that are in the water column from aquatic plants, municipal or industrial discharges, or storm runoff can also cause dissolved oxygen concentrations to be undersaturated or depleted. Insufficient DO can lead to unsuitable conditions for aquatic life, and its absence can result in the unpleasant odors associated with anaerobic decomposition. Furthermore, the presence of toxic substances such as cyanides and some metals can exacerbate the lethal effects of low concentrations of DO.

It is essential that consideration of the natural regimes of DO be included in applying criteria to specific water bodies. Because oxygen is sparingly soluble, the balance between sources and sinks can be easily upset leading to oxygen extremes of supersaturation or total/near total depletion (U.S. Geological Survey 1980, Stednick and Gilbert 1998, National Park Service 2002). Higher absolute concentrations of dissolved oxygen (mg/L) at saturation are achievable in the natural environment under conditions of higher atmospheric pressure and lower temperature and lower dissolved solids content of the water. Thus, water bodies occurring at higher elevations, subject to a barometric low pressure system, or having warmer temperatures and/or higher dissolved solids content would be expected to contain less dissolved oxygen at saturation. Supersaturation of surface water with respect to dissolved oxygen may also result from turbulence associated with high gradient streams or waterfalls. In rocky, high gradient streams, mechanical aeration is often great enough that even streams with highly elevated oxygen demand are at or near saturation levels. In low gradient coastal plain systems, even moderate oxygen demand (referred to as BOD or biochemical oxygen demand) can result in DO levels that are low enough to harm aquatic biota (U.S. Geological Survey 1980, Stednick and Gilbert 1998, National Park Service 2002).

Minimum required DO concentration to support fish varies because the oxygen requirements of fish vary with a number of factors, including the species and age of the fish, prior acclimatization, temperature, and concentration of other substances in the water. The District of Columbia, the State of Maryland, and the State of West Virginia water quality standards state that the DO concentration may not be less than 5.0 mg/L at any time (District Department of the Environment 2010, State of Maryland 2010, State of West Virginia 2011). The State of Virginia has a 6.0 mg/L DO minimum for natural trout waters (Virginia State Water Control Board 2011).

NCRN utilizes a Yellow Springs Institute (YSI) Professional Plus handheld meter with a polarographic DO probe to measure the percent saturation and concentration of dissolved oxygen.

Nitrogen-Ammonia

Nitrogen in surface water may occur in dissolved or particulate form and result from inorganic or organic sources. The dissolved, inorganic forms of nitrogen are most available for biological uptake and chemical transformation that can lead to eutrophication of water bodies. Inorganic forms of nitrogen are ammonia (NH_3), its more common oxidized form, ammonium ion (NH_4^+), nitrate (NO_3^-), and nitrite (NO_2^-). Nitrite is rare in unpolluted waters. 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. These organically sourced forms of nitrogen occur in various molecular chains of H-N or C-H-N with limited biological uptake (10-20%) potential. However, ammonia (NH_3) is a more toxic form of nitrogen with an aquatic life toxicity that varies with pH and temperature.

Ammonia is typically indicative of agricultural pollution or anaerobic degradation of nitrogen containing compounds. Nitrogen is a major limiting nutrient in most aquatic systems an increase of which may result in eutrophication. It is typically indicative of agricultural pollution or anaerobic degradation of nitrogen containing compounds such as humic matter or urea from animal or human waste. Ammonia is also bioavailable to plants including phytoplankton. When ammonium ions are in high concentration in natural waters containing oxygen, they are oxidized

to nitrate by bacteria in the nitrification process. This microbial facilitated redox reaction consumes oxygen at a ratio of 4.5 mg of O₂ to every 1 mg of NH₄⁺, thus rapidly depleting available oxygen for aquatic organism respiration. At higher pH (above 7.5 or 8.0), the NH₄⁺ ↔ NH₃ equilibrium reaction begins to favor ammonia, which is directly toxic to aquatic life because it may be taken up through membranes, and interferes with cell metabolism. Higher temperatures also favor the uptake of ammonia (movement across membranes, e.g. gills) by aquatic organisms causing the Chronic Concentration Criteria (CCC) for aquatic organisms to be lowered as temperature increases. Ammonia is low in all streams in NCR, which is good because higher levels are associated with sewage spills and septic leaks in developed areas.

The acute criterion for ammonia is dependent on pH and fish species, and the CCC is dependent on pH and temperature. At lower temperatures, the chronic criterion is also dependent on the presence or absence of early life stages (ELS) of fish. The effect of temperature and expected presence of early life stages of fish on the chronic criterion is shown in Table 2. The temperature dependency results in a gradual increase in the criterion as temperature decreases, and a criterion that is more stringent, at temperatures below 15 °C, when early life stages of fish (ELS) are expected to be present. The lowest value for CCC is 0.179 mg/L NH₃, which we use as our threshold (EPA 2000a).

Table 2: Chronic Ammonia Criteria For Waters Where Freshwater Fish Early Life Stages May Be Present (mg nitrogen/L).

	Temperature (°C)									
pH	0	14	16	18	20	22	24	26	28	30
6.5	6.67	6.67	6.06	5.33	4.68	4.12	3.62	3.18	2.8	2.46
6.6	6.57	6.57	5.97	5.25	4.61	4.05	3.56	3.13	2.75	2.42
6.7	6.44	6.44	5.86	5.15	4.52	3.98	3.5	3.07	2.7	2.37
6.8	6.29	6.29	5.72	5.03	4.42	3.89	3.42	3	2.64	2.32
6.9	6.12	6.12	5.56	4.89	4.3	3.78	3.32	2.92	2.57	2.25
7	5.91	5.91	5.37	4.72	4.15	3.65	3.21	2.82	2.48	2.18
7.1	5.67	5.67	5.15	4.53	3.98	3.5	3.08	2.7	2.38	2.09
7.2	5.39	5.39	4.9	4.31	3.78	3.33	2.92	2.57	2.26	1.99
7.3	5.08	5.08	4.61	4.06	3.57	3.13	2.76	2.42	2.13	1.87
7.4	4.73	4.73	4.3	3.78	3.32	2.92	2.57	2.26	1.98	1.74
7.5	4.36	4.36	3.97	3.49	3.06	2.69	2.37	2.08	1.83	1.61
7.6	3.98	3.98	3.61	3.18	2.79	2.45	2.16	1.9	1.67	1.47
7.7	3.58	3.58	3.25	2.86	2.51	2.21	1.94	1.71	1.5	1.32
7.8	3.18	3.18	2.89	2.54	2.23	1.96	1.73	1.52	1.33	1.17
7.9	2.8	2.8	2.54	2.24	1.96	1.73	1.52	1.33	1.17	1.03
8	2.43	2.43	2.21	1.94	1.71	1.5	1.32	1.16	1.02	0.897
8.1	2.1	2.1	1.91	1.68	1.47	1.29	1.14	1	0.879	0.773
8.2	1.79	1.79	1.63	1.43	1.26	1.11	0.973	0.855	0.752	0.661
8.3	1.52	1.52	1.39	1.22	1.07	0.941	0.827	0.727	0.639	0.562
8.4	1.29	1.29	1.17	1.03	0.906	0.796	0.7	0.615	0.541	0.475
8.5	1.09	1.09	0.99	0.87	0.765	0.672	0.591	0.52	0.457	0.401
8.6	0.92	0.92	0.836	0.735	0.646	0.568	0.499	0.439	0.386	0.339

	Temperature (°C)									
pH	0	14	16	18	20	22	24	26	28	30
8.7	0.778	0.778	0.707	0.622	0.547	0.48	0.422	0.371	0.326	0.287
8.8	0.661	0.661	0.601	0.528	0.464	0.408	0.359	0.315	0.277	0.244
8.9	0.565	0.565	0.513	0.451	0.397	0.349	0.306	0.269	0.237	0.208
9	0.486	0.486	0.442	0.389	0.342	0.3	0.264	0.232	0.204	0.179

Table 3: Chronic Ammonia Criteria For Waters Where Freshwater Fish Early Life Stages Are Absent (mg nitrogen/L):

pH	Temperature (°C)									
	0–7	8	9	10	11	12	13	14	15	16
6.5	10.8	10.1	9.51	8.92	8.36	7.84	7.35	6.89	6.46	6.06
6.6	10.7	9.99	9.37	8.79	8.24	7.72	7.24	6.79	6.36	5.97
6.7	10.5	9.81	9.2	8.62	8.08	7.58	7.11	6.66	6.25	5.86
6.8	10.2	9.58	8.98	8.42	7.9	7.4	6.94	6.51	6.1	5.72
6.9	9.93	9.31	8.73	8.19	7.68	7.2	6.75	6.33	5.93	5.56
7	9.6	9	8.43	7.91	7.41	6.95	6.52	6.11	5.73	5.37
7.1	9.2	8.63	8.09	7.58	7.11	6.67	6.25	5.86	5.49	5.15
7.2	8.75	8.2	7.69	7.21	6.76	6.34	5.94	5.57	5.22	4.9
7.3	8.24	7.73	7.25	6.79	6.37	5.97	5.6	5.25	4.92	4.61
7.4	7.69	7.21	6.76	6.33	5.94	5.57	5.22	4.89	4.59	4.3
7.5	7.09	6.64	6.23	5.84	5.48	5.13	4.81	4.51	4.23	3.97
7.6	6.46	6.05	5.67	5.32	4.99	4.68	4.38	4.11	3.85	3.61
7.7	5.81	5.45	5.11	4.79	4.49	4.21	3.95	3.7	3.47	3.25
7.8	5.17	4.84	4.54	4.26	3.99	3.74	3.51	3.29	3.09	2.89
7.9	4.54	4.26	3.99	3.74	3.51	3.29	3.09	2.89	2.71	2.54
8	3.95	3.7	3.47	3.26	3.05	2.86	2.68	2.52	2.36	2.21
8.1	3.41	3.19	2.99	2.81	2.63	2.47	2.31	2.17	2.03	1.91
8.2	2.91	2.73	2.56	2.4	2.25	2.11	1.98	1.85	1.74	1.63
8.3	2.47	2.32	2.18	2.04	1.91	1.79	1.68	1.58	1.48	1.39
8.4	2.09	1.96	1.84	1.73	1.62	1.52	1.42	1.33	1.25	1.17
8.5	1.77	1.66	1.55	1.46	1.37	1.28	1.2	1.13	1.06	0.99
8.6	1.49	1.4	1.31	1.23	1.15	1.08	1.01	0.951	0.892	0.836
8.7	1.26	1.18	1.11	1.04	0.976	0.915	0.858	0.805	0.754	0.707
8.8	1.07	1.01	0.944	0.885	0.829	0.778	0.729	0.684	0.641	0.601
8.9	0.917	0.86	0.806	0.756	0.709	0.664	0.623	0.584	0.548	0.513
9	0.79	0.74	0.694	0.651	0.61	0.572	0.536	0.503	0.471	0.442

NCRN utilizes Hach Method 10200 (Nitrogen, Free Ammonia and Chloramine (Mono) 0-4.50 mg/L Cl₂ and 0–0.50 mg/L NH₃–N) to determine the concentration of ammonia in a sample.

Nitrate-Nitrogen

Nitrogen is a major limiting nutrient in most aquatic systems an increase of which may result in eutrophication. Nitrate is a bioavailable form of nitrogen which aquatic plants can absorb and incorporate into proteins, amino acids, nucleic acids, and other essential molecules. Nitrate is highly mobile in surface and groundwater and may seep into streams, lakes, and estuaries from groundwater enriched by animal or human wastes and commercial fertilizers. High concentrations of nitrate are typically indicative of agricultural pollution and can enhance the growth of algae and aquatic plants in a manner similar to enrichment in phosphorous and thus cause eutrophication of a water body. The drinking water standard for nitrate, which presents human health concerns, particularly for infants, is 10 mg/L (EPA 2011). In most natural waters, inorganic nitrogen such as ammonium or nitrate is not the growth-limiting nutrient unless phosphorous is unusually high. Nitrate is the oxidized form of aqueous nitrogen reported as mg/L NO₃ or mg/L NO₃ - N. Nitrate also travels freely through soil and therefore may pollute ground waters.

Nitrate above 2.0 mg/L can lead to eutrophication of water bodies in Nutrient Ecoregion 9 which includes southeastern CHOH, GWMP, MANA, MONO, NACE, PRWI, ROCR, WOTR (EPA 2000a) and 0.31 mg/L in Nutrient Ecoregion 11 which includes northwestern ANTI, CATO, CHOH, and HAFE (EPA 2000b) (Table 4). Morgan et al (2007), found that the critical thresholds of nitrate between fair and poor stream quality for the Benthic macroinvertebrate Index of Biotic integrity (BIBI) was 0.83 mg/L NO₃-N and for the Fish Index of Biotic Integrity (FIBI) was 0.86 mg/L NO₃-N (Morgan et al. 2007).

Table 4: Nitrate- Nitrogen Management Decision Threshold

Nutrient Ecoregion		Subregion and associated NCRN parks	NO ₃ (mg/l)
IX	Southeastern Temperate Forested Plains and Hills	Southeastern Plains: NACE, GWMP	2.00
		Piedmont: PRWI	
		Northern Piedmont: WOTR, MANA, ROCR, MONO, GWMP	
XI	Central and Eastern Forested Uplands	Ridge & Valley: ANTI	0.31
		Blue Ridge: HAFE, CATO	

NCRN utilizes Hach Method 10020 (Nitrate, Chromotropic Acid Method, Test 'N Tube) to determine the concentration of nitrate in the samples.

pH

The pH of water directly affects physiological functions of plants and animals, and is, therefore, an important indicator of the health of a water system (U.S. Geological Survey 1980, Stednick and Gilbert 1998, National Park Service 2002). pH is measured to determine the acid/base characteristics of water and is controlled by interrelated chemical reactions that produce or consume hydrogen ions (Hem 1989). The term pH literally means “power of hydrogen.” The more hydrogen ions available for reaction, the lower the pH reading. The concentration of these ions is measured on a log scale that most commonly ranges from 0 (acid) to 14 (base / alkaline), so each pH unit increase represents a 10X decrease in hydrogen ion concentration. Pure water

has a pH of 7 (neutral), which means that it is equally able to accept or donate hydrogen ions. At $\text{pH} < 7$, (acid) hydrogen ions are more readily donated (Hem 1989, Stednick and Gilbert 1998).

Generally, dissolution of carbon dioxide to carbonic acid is the most important acidifying factor in extremely fresh natural waters to affect pH ($\sim \text{pH}$ of 6) in the absence of some other site-specific conditions. However, most natural (fresh and salt) waters are slightly basic ($\sim \text{pH}$ of 8) due to the presence of carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-). In freshwater, the $\text{CO}_2 \rightleftharpoons \text{HCO}_3^- \rightleftharpoons \text{CO}_3^{2-}$ equilibrium serves as the primary buffering mechanism. In natural waters, carbonic acid is the main source of hydrogen ions, resulting in a pH of 5.7. Rainwater normally is acidic because of its carbon dioxide content and naturally occurring sulfate. Normally these acids are neutralized as rainwater passes through the soil. In catchments of hard rocks, little buffering capacity, and high surface water (as opposed to groundwater) inputs, stream water will be acidic even if pollution is absent. Organic acids also contribute to low pH values. Industrial activity has contributed to acid precipitation in many areas. Strong inorganic acids H_2SO_4 (sulfuric acid) and HNO_3 (nitric acid), formed in the atmosphere from oxides of sulfur and nitrogen, have dramatically lowered surface water pH in large areas of Europe and North America, especially in granitic drainages with poor buffering capacity (Hem 1989, Stednick and Gilbert 1998).

The pH of water is important in the toxicity and solubility of many constituents. Freshwaters can vary widely in acidity and alkalinity due to natural causes as well as anthropogenic inputs. Extreme pH values, generally those much below 5 or above 9, are harmful to most organisms, and the buffering capacity of water is critical to life. Estimating the toxicity of ammonia, aluminum, and some other contaminants requires accurate pH values. Increases or decreases in pH from their normal range into extreme ranges can result in severe harm to aquatic life (Hem 1989). Changes in pH affect the dissociation of weak acids or bases, which in turn affects the toxicity of many compounds. For example, hydrogen cyanide toxicity to fish increases with lowered pH; rapid increases in pH increase NH_3 concentrations; and the solubilities of metal compounds are affected by pH. The mobility of metals is also enhanced by low pH. This can play a significant factor in impacts to water bodies located in areas contaminated by heavy metals (e.g. mining). The permissible range of pH for fish depends upon many other factors such as temperature, DO, and the content of various anions and cations. The importance of pH as a parameter for monitoring is reflected by potential impacts to the life cycle stages of aquatic macroinvertebrates and certain salmonids that can be adversely affected when pH levels above 9.0 or below 6.5 occur. Temporal causes of variation of pH can range from primary production by fauna and flora (diurnal and seasonal) to fractionation during snowmelt, changes in runoff processes, and changes in atmospheric deposition (monthly and/or seasonal) (MacDonald et al. 1991).

The District of Columbia water quality standards state that the pH should be between 6.0 and 8.5 (District Department of the Environment 2010). The State of Maryland water quality standards state that the pH should be between 6.5 and 8.5 (State of Maryland 2010). The States of Virginia and West Virginia state that the pH should be between 6.0 and 9.0 (State of West Virginia 2011, Virginia State Water Control Board 2011).

NCRN utilizes a Yellow Springs Institute (YSI) Professional Plus handheld meter to measure the pH at each site.

Specific Conductance, Conductivity, and Salinity

Specific conductance is the electrical conductivity of the aqueous solution and is directly related to concentration of ionic species. Conductivity is a measure of the capacity of water to conduct an electrical current and is a function of the types and quantities of dissolved, electrically charged substances (ions) in water (Radtke et al. 1998). The conductivity of solutions of ionic species is highly dependent on temperature and may change as much as 3% for each 1°C change. Thus a significant apparent change in conductivity may simply be a function of the water body's diurnal or seasonal temperature change. In addition, the temperature correction coefficient itself varies with the charge and abundance of the ionic species present (e.g. Na⁺ versus Ca⁺⁺) so no universally applied algorithm will be exact. A raw conductivity value is not temperature compensated making it difficult to compare measurements of the same or different water bodies when not at the same temperature (e.g. conducting trend analysis over time). When the raw conductivity measurement of a substance is normalized to unit length and unit cross-section at a specified temperature (e.g. a compensation temperature of 25 °C), it is called specific conductance (U.S. Geological Survey 1980, Stednick and Gilbert 1998, National Park Service 2002). Specific conductance is dependent upon the types and quantities of dissolved substances and is a good indication of total dissolved solids (TDS) and total ion concentration.

The electrical conductivity of a water body has little or no direct effect on aquatic life but because it is essentially due to the sum of all ionic species, its change (increase) may be detrimental if the particular ionic species or groups of ionic species (e.g. specific salts) causing the change is toxic to aquatic life. Specific conductance is useful in estimating the concentration of dissolved solids in water. Electric current is carried by dissolved inorganic solids such as chloride, carbonate, nitrate, sulfate and phosphate anions (negatively charged particles), as well as sodium, calcium, magnesium, potassium, iron, and aluminum cations (positively charged particles). Common sources of pollution that can affect specific conductance are deicing salts, dust reducing compounds, agriculture (primarily from the liming of fields), and acid mine drainage (AMD) associated with mining operations (U.S. Geological Survey 1980, Stednick and Gilbert 1998, National Park Service 2002). Organic materials such as oils, phenols, alcohols and sugars do not carry electric current. Small quantities of mineral salts are usually contained in natural inland waters, but in waters polluted by brines and various chemical wastes, salt concentrations may rise to levels harmful to living organisms due to the increase in osmotic pressure. Salinity is often expressed as specific electrical conductance in studies of waters used for irrigation and fish production. Collectively, all substances in solution exert osmotic pressure on the organisms living in it, which in turn adapt to the condition imposed upon the water by its dissolved constituents. With excessive salts in solution, osmotic pressure becomes so high that water may be drawn from gills and other delicate external organs resulting in cell damage or death of the organism (U.S. Geological Survey 1980, Stednick and Gilbert 1998, National Park Service 2002). The Maryland Biological Stream Survey has found that fish exhibit stress at specific conductance greater than 400 µS/cm (Morgan and Cushman 2005). In a later analysis of the data, Morgan et al. (2007) found a critical value for conductivity of 247 µS/cm for the BIBI and 171 µS/cm for the FIBI.

Salinity refers to the sum of the concentrations of all dissolved ions. It was originally conceived as a measure of the mass of dissolved salts in a given mass of solution. The only reliable way to determine the true or absolute salinity of natural water is to make a complete chemical analysis. However this method is time-consuming and precision is limited. To determine salinity one

normally uses indirect methods involving the measurement of a physical property such as conductivity, density, sound speed, or refractive index. From an empirical relationship of salinity and the physical property determined for a standard solution it is possible to calculate salinity. The resultant salinity is no more accurate than the empirical relationship. The precision of the measurement of a physical property will determine the precision in salinity. Although conductivity has the greatest precision (± 0.0002), it responds only to ionic solutes. Density, though less precise ($\pm 3 \times 10^{-6} \text{ g/cm}^3$), responds to all dissolved solutes (Eaton et al. 2005).

Salinity is a more inclusive term than total dissolved solids (TDS), although for all practical purposes it is the same quantity. In urban areas, the runoff of salts and other deicing compounds applied to roads can significantly elevate the salinity of receiving waters and cause large fluctuations at short time scales. In the United States, 1-15 million tons of road salt are used each year (Benbow and Merritt 2005), primarily in the Northeast and Midwest, and quantities have increased dramatically since 1950 (Jackson and Jobbágy 2005). Kaushal et al. (2005) report chloride concentrations as high as 25% of seawater in some northeastern streams during winter, and the long-term trend is increasing (Allan and Castillo 2007). Freshwater is defined as 0.5 ppt salinity or less. Water with a salinity above 0.5 ppt is considered brackish (Allan and Castillo 2007).

NCRN utilizes a Yellow Springs Institute (YSI) Professional Plus handheld meter to determine the specific conductance at each site.

Surface Water Quantity

Surface water dynamics such as flow or discharge for flowing waterbodies, and stage or level for non-flowing waterbodies, are critical components of water monitoring. The most fundamental of hydrological measurements, which characterize all river and stream ecosystems, is that of discharge, the volume of water flowing through a cross section of a stream channel per unit time. The amount of water flowing past a given point, when combined with the slope of the stream channel, yields an indication of stream power or the ability of the river to do work. This potential energy is dissipated as frictional heat loss on the stream bed and when the stream picks up and moves material. The work performed by the stream is important because it influences the distribution of suspended sediment, bed material, particulate organic matter, and other nutrients. The distribution of these materials has substantial influence on the distribution of riverine biota (Vannote et al. 1980, Vannote and Minshall 1982, Statzner et al. 1988). In addition, discharge and stream power combine with other basin conditions to influence meander pattern and floodplain dynamics (Leopold et al. 1964, Gore 1996), which are important in providing habitat for flora and fauna.

Streamflow at any point in time is an integration of the streamflow generation and routing mechanisms in the watershed. Streamflow measurements are useful for water quality data comparisons over time, interpretation of water quality data, and calculation of parameter loads. Streamflow monitoring is necessary to calibrate and verify ground-water-flow models. Streamflow measurements are made periodically to define or verify the stage-discharge relation and to define the timing and magnitude of variations in that relation. Understanding the relationship between flow and concentrations and loading helps determine when it is logical to concentrate sampling (Stednick and Gilbert 1998).

Surface water dynamics such as flow are also a key component in calculating chemical and physical loading of a flowing water body for Total Maximum Daily Load (TMDL) studies. Data must be normalized by flow, especially in freshwater streams, because many constituents have strong relationships with flow (trend analysis in running waters is typically difficult unless one calculates flow-adjusted concentrations).

Surface water quantity, or flow regime, can be influenced by human development in and around each park property. A stream or other body of water should have sufficient quantity and quality of water for every day of the year to maintain ecological processes. Height of stream flow varies seasonally under natural conditions, however any extreme variation can be stressful to organisms and damaging to the physical environment (Tarbuck and Lutgens 1984).

Human development can have significant effects upon surface water and hydrologic cycles. Impervious surfaces such as parking lots, streets, sidewalks, and buildings decrease the amount of water that percolates into the soil, thus reducing groundwater recharge and base flow into streams, while simultaneously increasing the velocity and amount of runoff and the likelihood of contaminants and sediment being carried into lakes, rivers, and streams. Lakes, ponds, seeps, and vernal pools are also highly influenced and affected by changes to the hydrologic cycle (Schlosser 1991).

Deforestation disrupts the hydrologic cycle, decreasing the amount of locally available rainfall. Water withdrawal lowers the groundwater table. Impoundments impede flow. It is also possible in an urbanized area to have upstream flow controlled to the point that aquatic systems receive less freshwater (Hackney et al. 1995, Perry and Hershner 1999), which can lead to saltwater incursion in tidal areas. Climate change disrupts weather patterns, either drying the land or not providing precipitation necessary to recharge groundwater. Low flow regime can result in changes in the number, timing, and presence of pools; increase in disease and other pestilence; fish kills; stenothermal:eurythermal changes for fish and herpetofauna; decreased infiltration for groundwater; decreased regeneration for vernal/ ephemeral pools; concentration of solutes and particulates; decreased dissolved oxygen; increased surface water temperature; and decreased water quantity.

High or stormflow can be due to increased runoff over impervious surfaces. Runoff is also increased through deforestation, because trees are no longer using large amounts of water through evapotranspiration. This increased runoff is frequently channeled into combined sewer outflows that empty directly into streams. High flow regime can result in sedimentation, altered stream morphology, scouring, bank instability and mass wasting, decreased buffer / filter capacity for groundwater, increased water quantity, and dilution of solutes and particulates. With greater than 10% impervious surface in a watershed urban streams lose their stability, additional stormwater contribution to annual water level fluctuation passes 20 cm of depth, sensitive macroinvertebrates are replaced by those more tolerant of pollution and hydrologic stress, and the richness of the plant and amphibian communities drop off (Watershed Protection Techniques 1994). Dams may raise the local water table level, alter seasonal water table fluctuation, and flood or saturate normally mesic or xeric soils (Schneider 1988). Roads may also act as dams and influence the level and fluctuation of the water table in nearby ecosystems (Jeglum 1975, Baxter 1977).

The most fundamental hydrological measurement that characterizes all stream ecosystems is discharge, the volume of water flowing through a cross section of a stream channel per unit time.

Wetted Width

Wetted width is measured from water's edge to water's edge of the stream. NCRN has no defined desired value other than >0 feet. Wetted width is used to calculate discharge and determine the number of chemistry readings taken at a site. The NCRN uses a Lufkin fiberglass 50 meter (reverse side in feet and tenths of feet) tape to measure the wetted width.

Depth

Depth is measured for every flow measurement location and averaged for that transect. Desired values are based on equipment requirements. The Sontek Flowtracker requires a minimum of 0.2 feet to function. NCRN uses a Sontek Flowtracker wading rod to measure water depth.

Flow

Flow is used to calculate discharge. NCRN has no defined desired value other than > 0 ft/s. NCRN uses a Sontek Flowtracker to measure the depth, flow and discharge.

Discharge

We currently have no defined desired condition value other than >0 cfs.

NCRN uses a Sontek Flowtracker to measure discharge.

Temperature

Several of the water chemistry parameters are temperature dependent, either in measurement or for the management decision threshold: DO, ammonia, and conductivity. High temperature can also stress aquatic life particularly those adapted to habitats with cooler temperatures such as trout. Maximum permissible temperature according to all states (Table 5), except West Virginia which does not have a standard, is 32°C (District Department of the Environment 2010, State of Maryland 2010, State of West Virginia 2011, Virginia State Water Control Board 2011). Maryland and Virginia specify 20°C for trout waters and/or coldwater aquatic life (State of Maryland 2010, Virginia State Water Control Board 2011).

Table 5: Temperature standards in the District, Maryland, and Virginia by water class

Class of waters	VA Max (°C)	MD Max (°C)	DC Max (°C)
III Nontidal Waters (Coastal and Piedmont Zones) / Recreational water and warmwater aquatic life	32	32	32
IV Mountainous Zones Waters	31		
V Stockable / recreational Trout Waters	21	23.9	
VI Natural Trout Waters /coldwater aquatic life	20	20	

The NCRN utilizes a Yellow Springs Institute (YSI) Professional Plus handheld meter to determine the temperature at each site.

Total Phosphorous

Phosphorus (measured as PO₄) is frequently a limiting nutrient in aquatic systems. A minor increase in phosphorous concentration can significantly affect water quality by changing the

population and community dynamics of algae and diatoms leading to eutrophication (Allan 1995). Phosphorus is singled out as an especially important indicator in the Heinz Center Report (2002) on the state of nation's ecosystems. Sources of phosphorous include sediments, fertilizer application (e.g. irrigation return flow), soaps, and detergents. 0.1 mg/L PO₄ is the published threshold for eutrophication of flowing surface waters for most of the NCRN parks (Table 6).

Table 6: Total Phosphorus Management Decision Threshold (EPA 2002)

Nutrient Ecoregion		Subregion and associated NCR parks	TP (ug/l as P)
IX	Southeastern Temperate Forested Plains and Hills	Southeastern Plains: NACE	36.56
		Piedmont: PRWI	
		Northern Piedmont: WOTR, MANA, ROCR, MONO, CATO	
XI	Central and Eastern Forested Uplands	Ridge & Valley: ANTI	10.00
		Blue Ridge: HAFE, CATO	

EPA has recommended water quality criteria for total nitrogen (TN) and total phosphorus (TP) in different types of habitats and different eco-regions at <http://www.epa.gov/ost/standards/nutrient.html>.

NCRN utilizes Hach Method 8048 (Phosphorus, reactive, PhosVer 3 Method, Low-Range Test 'N Tube) to determine the total phosphorus concentrations for each sample.

Measurable Objectives

The measurable objectives of the stream monitoring described in this protocol are:

1. Assess variance in temperature, specific conductance, pH, dissolved oxygen, nutrients and ANC in priority streams of the NCRN, on a diurnal and seasonal basis as well as over the long term.
2. Assess trends in temperature, specific conductance, pH, dissolved oxygen, nutrients and ANC
3. Assess stream condition by identifying single parameters with values out of bounds (a) biologically (determined through literature search), (b) according to drinking water standards, (c) according to EPA and State designated use standards, or (d) of previous variability.
4. Monitor the flow volume (discharge) of surface water in major streams of the NCRN parks.
5. Assess the availability of sufficient water for ecological, recreational, and aesthetic purposes of the parks.
6. Develop rating curves for a range of environmental conditions, land use, and weather patterns, for each water body (e.g., compare a drought year vs. an El Niño year) in order to gain an overall understanding of hydrologic systems within the NCRN.

Sampling Design

Study Area

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

Site Selection and Justification

As determined by the NCRN's Science Advisory Committee, surface water types in the NCRN parks that are deemed significant or important candidates for long term monitoring include flowing water such as streams, rivers, and groundwater; and still water such as wetlands and vernal pools. The Water Quality Monitoring Program funded by WRD is primarily interested in the set of all 1st to 4th order non-tidal freshwater streams in the parks of the NCRN depicted on current USGS 1:24,000 topographic maps. Due to the broad nature of I&M's monitoring efforts, the remaining surface water types will be monitored as resources are available.

The sample design for streams is based on a map of streams (defined at a scale of 1:24,000) within the parks. Since the water chemistry monitoring sites serve as the pool from which the biological sampling sites are chosen, stream segments in the parks less than 75m in length were eliminated (the length used for BSS sampling). Strahler stream order (Strahler 1952) was calculated for each stream segment in the park. Sampling of streams will focus on those segments of streams that are the furthest downstream and still in park boundaries. Measurements downstream generally reflect conditions in the watershed upstream. Where possible, multiple streams within each watershed will be sampled to provide information at the watershed level.

No sites are monitored in CHOH at this time. The linear nature of the park and the large number of streams that cross it are a challenge for water monitoring. Each individual stream is within the park for only a short distance, and drains only a small portion of the park. Due to these factors the park has little control over the water quality of most of these streams, and each individual stream has a small impact on the park as a whole. Therefore it is difficult to design an appropriate sampling effort that proved both affordable and meaningful. However, the unique orientation of the park and its length may actually be a benefit with respect to water sampling. The state of Maryland's Department of Natural Resources has a comprehensive biological sampling program that is spatially and temporally designed to provide statistically valid estimates of stream health across the state and within specific watersheds based on a stratified random sampling design. One of the biggest advantages of using a modified version of the Maryland Biological Stream Survey to sample waters in the region is that all of the data in the state of Maryland is collected in the same way; the only thing that differs in the parks is the spatial design of the sampling. For example, 169 locations in Allegheny County watersheds draining into the Potomac River have been sampled during the two rounds of MBSS sampling so far, and additional sites are planned for the next round. For more information see the Biological Stream Survey Protocol for the NCRN.

Population Being Monitored

Water bodies or streams were excluded due to one or more of the following:

Ephemeral drainages—any water body that is not a wadeable or perennial stream is automatically not included as a target waterbody. Ephemeral drainages are not typically included since they are only flowing during storm events. These types of drainages are also often hidden in deep brush, located on steep slopes, or otherwise difficult to access.

Streams located primarily off parklands—Water bodies with only small portions on park property are often located in urban areas where volunteer recruitment would be probable or where monitoring activities currently exist. This also includes waterbodies that are located within the park legislative boundary but not managed by the park (and particularly areas where NPS staff access is restricted). This exclusion applies to much of CHOH.

Adequate monitoring by other entities—Water bodies consistently monitored by other entities need not be monitored. It is appropriate and fiscally responsible not to monitor these streams if the parks have access to the data and the data meets the needs of the monitoring program.

It was initially envisioned that once the list of potential monitoring locations was developed; a randomization process would be used to determine which would actually be sampled. However the final list was short enough that it was decided to sample all of them rather than a random subset (Table 7).

Table 7 Water Chemistry Monitoring Sites for 2009 excluding CHOH streams

Site	Watershed	Physiographic Region	State	County	Stream Order
Antietam National Battlefield					
Sharpsburg Creek	Antietam Creek	Ridge and Valley	MD	Washington	1
Catoctin Mountain Park					
Big Hunting Creek	Upper Monocacy River	Blue Ridge	MD	Frederick	2
Owens Creek	Upper Monocacy River	Blue Ridge	MD	Frederick	2
Whiskey Still Creek	Upper Monocacy River	Blue Ridge	MD	Frederick	1
George Washington Memorial Parkway					
Minnehaha Creek	Cabin John	Northern Piedmont	MD	Montgomery	2
Mine Run	Difficult Run	Northern Piedmont	VA	Fairfax	2
Pimmit Run	Rock Creek	Northern Piedmont	VA	Arlington	3
Turkey Run	Difficult Run	Northern Piedmont	VA	Fairfax	2
Harpers Ferry National Historical Park					
Flowing Springs Run	North Fork Shenandoah River	Ridge and Valley	WV	Jefferson	2
Manassas National Battlefield					
Youngs Branch	Bull Run	Northern Piedmont	VA	Prince William	3
Monocacy National Battlefield					
Bush Creek	Lower Monocacy River	Northern Piedmont	MD	Frederick	3
Visitor's Center Creek	Lower Monocacy River	Northern Piedmont	MD	Frederick	2

Site	Watershed	Physiographic Region	State	County	Stream Order
National Capital Parks – East					
Henson Creek	Middle Potomac Tidal	Southeastern Plains	MD	Prince Georges	1
Oxon Run	Middle Potomac Tidal	Southeastern Plains	MD	Prince Georges	1
Still Creek	Anacostia River	Southeastern Plains	MD	Prince Georges	1
Unnamed Tributary to Accokeek Creek	Middle Potomac Tidal	Southeastern Plains	MD	Prince Georges	1
Prince William Forest Park					
Carter's Run	Quantico Creek	Southeastern Plains	VA	Prince William	1
Mawavi Run	Quantico Creek	Piedmont	VA	Prince William	1
Mary Bird Branch	Quantico Creek	Southeastern Plains	VA	Prince William	2
Middle Branch Chopawamsic Creek	Quantico Creek	Piedmont	VA	Prince William	2
North Branch Chopawamsic Creek	Quantico Creek	Piedmont	VA	Prince William	2
North Fork Quantico Creek	Quantico Creek	Southeastern Plains	VA	Prince William	2
Orenda Run	Quantico Creek	Piedmont	VA	Prince William	1
South Fork Quantico Creek	Quantico Creek	Southeastern Plains	VA	Prince William	3
Sow Run	Quantico Creek	Piedmont	VA	Stafford	2
Taylor Run	Quantico Creek	Piedmont	VA	Prince William	1
Rock Creek Park					
Broad Branch	Rock Creek	Northern Piedmont	DC	Washington	2
Dumbarton Oaks	Rock Creek	Northern Piedmont	DC	Washington	1
Fenwick Branch	Rock Creek	Northern Piedmont	DC	Washington	2
Hazen Creek	Rock Creek	Northern Piedmont	DC	Washington	1
Kingle Valley Stream	Rock Creek	Northern Piedmont	DC	Washington	1
Luzon Branch	Rock Creek	Northern Piedmont	DC	Washington	1
Normanstone Creek	Rock Creek	Northern Piedmont	DC	Washington	1
Palisades Creek	Rock Creek	Northern Piedmont	DC	Washington	1
Pinehurst Branch	Rock Creek	Northern Piedmont	DC	Washington	1
Piney Branch	Rock Creek	Northern Piedmont	DC	Washington	1
Rock Creek above Fenwick Branch	Rock Creek	Northern Piedmont	DC	Washington	4
Rock Creek below Dumbarton Oaks	Rock Creek	Northern Piedmont	DC	Washington	4
Soapstone Valley Park Stream	Rock Creek	Southeastern Plains	DC	Washington	1
Wolf Trap National Park for the Performing Arts					
Wolf Trap Creek	Difficult Run	Northern Piedmont	VA	Fairfax	2
Courthouse Creek	Difficult Run	Northern Piedmont	VA	Fairfax	1

Sampling Frequency and Replication

Currently, all parameters are measured on a monthly basis. The *in situ* measurements (temperature, pH, DO, specific conductance, salinity) are determined utilizing handheld instrument(s). For ANC and nutrients (nitrate, total phosphorus, ammonia) water samples are collected and laboratory analysis is conducted.

Flow will be measured monthly concurrently with other sampling. Field investigators are responsible for observing any unusual conditions that may indicate a need for additional water quality sampling outside a scheduled monitoring event. Upon observing an unusual condition, such as an unusual turbidity or odor of the water, excessive algal growth, indications that foreign substances have entered the system (oil slicks, surface films, etc.) or fish kills, water quality samples should be taken to help identify the contaminant source or impacting land use (Stednick and Gilbert 1998).

Field and Laboratory methods

This section presents Standard Operating Procedures (SOP) for implementing water chemistry monitoring and stand alone SOPs for procedures such as permitting and field safety. These SOPs are maintained and updated by the NCRN I&M Program.

Tasks, Project Timeline, and individual responsibilities are described in the following SOPs:

- NCRN WCQ SOP #1 Roles & Responsibilities
- NCRN WCQ SOP #2 Project Timeline
- NCRN WCQ SOP #3 Training Field Personnel
- NCRN WCQ SOP #4 Field Safety

Before leaving for the field site, review the following standard operating procedures related to conducting field work and making site visits:

- NCRN SOP NPS Permits and IARs
- NCRN SOP GPS Specifications
- NCRN SOP GIS
- NCRN SOP Field Safety (T:/I&M/MONITORING/NCRN Field SOPs)
- NCRN SOP Vehicle Fueling and Maintenance (T:/I&M/MONITORING/NCRN Field SOPs)
- NCRN SOP Vehicle Accident Report Form (T:/I&M/MONITORING/NCRN Field SOPs)

Prepare field equipment as described in the following SOPs:

- NCRN WCQ SOP #5 Water Chemistry Laboratory Preparation
- NCRN WCQ SOP #6 Water Chemistry Field Equipment Preparation

Field sites are described in the following SOPs:

- NCRN WCQ SOP #7 Water Site Location

At each field site, collect samples and record data following these SOPs:

- NCRN WCQ SOP #8 Sample Collection for Laboratory Analysis
- NCRN WCQ SOP #9 Air Temperature
- NCRN WCQ SOP #10 YSI ProPlus
- NCRN WCQ SOP #11 Width, Depth, and Discharge
- NCRN WCQ SOP #18 Water Resources Data Management

Upon completing field work, return data, equipment, and samples to the lab and process water samples according to the following SOPs within 48 hours:

- NCRN WCQ SOP #12 Acid Neutralizing Capacity
- NCRN WCQ SOP #13 Nitrate
- NCRN WCQ SOP #14 Total Phosphorus
- NCRN WCQ SOP #15 Chlorine
- NCRN WCQ SOP #16 Free Ammonia and Monochloramine
- NCRN WCQ SOP #17 Hazardous Material Safety & Disposal
- NCRN WCQ SOP #18 Water Resources Data Management

NCRN WCQ SOP #19 Water Resources Data Analysis and Reporting
NCRN WCQ SOP #20 Revising the Protocol

If a spill or leak of tap, sewer, or swimming pool water is suspected at a site Follow NCRN WCQ SOPs 15 and 16 to detect the disinfection products from the water. Free Ammonia should be reported in the Ammonia section of the Tablet PC.

Data Management

The NCRN Water Monitoring Program collects data that are highly valued by parks, the NCRN I&M Network, and the National Capital Region as a whole. These data will be used to justify management actions and inform decision making processes that are ongoing in parks in the NCR. In order to ensure the long-term usefulness of the data, the NCRN must ensure the data are of high quality and maintained in a secure manner that guarantees that the information will be useable and available long into the future. The data management procedures applied to this protocol are in place to make sure that the NCRN goals of quality, security, and usability are met.

One of the first steps to collecting high quality data is to make sure that staff are properly trained on collection procedures and that all of the procedures are clearly outlined. This protocol is accompanied by a number of standard operating procedures (SOPs) that detail all data collection procedures. Specifically, it is imperative that all staff working on this protocol are well versed with NCRN WCQ SOP 3 – SOP 16 which detail data collection and process steps.

In addition to collecting data properly, data need to be recorded in a way that promotes accuracy and stored securely to prevent data loss. The NCRN has employed the use of tablet PCs to record water monitoring data in the field. All data collected during monthly sampling visits, with the exception of discharge which is recorded on the flow meter itself, are entered directly into an MS Access database running on a ruggedized Tablet PC. The database was designed specifically for the NCRN water monitoring program and is based on the NPS-I&M Natural Resource Database Template (NRDT). Recording data in this way increases efficiency and reduces the likelihood of errors (e.g. eliminates the need of transcribing data from paper data sheets to a database back in the office; a step that often yields data entry errors). Refer to the Water Chemistry and Quantity Monitoring Data Management SOP (NCRN WCQ SOP #18) for detailed instructions on how to use the database.

In the event that the tablet PC is not available waterproof paper field sheets or a notebook containing waterproof paper can be used for temporary data entry. All data should be PRINTED clearly in pencil on waterproof paper in the units specified on the data sheets. No write-over is permitted on data sheets—if an incorrect entry is made, a single heavy line should be drawn through the incorrect entry and the correction made in an obvious spot next to the line out. Data sheets for a given site must be consecutively labeled so that the total number of data sheets generated for each site is known. As soon as possible, data should be entered into the Tablet PC data form. Recorded data must be reviewed at the time of entry and the crew leader must review and initial all data sheets prior to departure from the site.

If samples are to be stored, each sample collected will be assigned a sample number. The sample number will contain several unique identifiers to minimize the possibility of misidentification: 4 digit year, 2 digit month, 2 digit day, 4-character park abbreviation, sample site, sample type, and sample number.

Upon return to the water lab, data from laboratory analyses are recorded in a green clothbound US-government issue notebook. Upon completion of the laboratory analyses the data are entered

into Tablet PC database. Data on the tablet PC database are raw field data much in the same way a hard copy field data sheet contains raw data. These data must be secured. Once all of the data are entered into the tablet database, a backup copy of the data file should be made and copied to the following directory on the NCRN file server:

T:\I&M\MONITORING\WaterQual&Quant\Data\Field_Data_Collection_App\Field_Data.

All NCRN water monitoring data must be entered into NPStoret which is the National Park Service's version of the EPA STORET database. Instead of entering data by hand into NPStoret, raw field data can be exported from the NCRN database to an MS Excel spread sheet formatted for direct importing into NPStoret (NCRN WCQ SOP #18 – Data Management provides detailed instructions for this) making the transfer of data from one system to another much less labor intensive. NCRN data manager will work with the NCRN hydrologic technician to ensure that data is well-understood and entered into the proper fields in NPSTORET. This coordination will also help ensure that metadata is complete and accurate. Data will be entered into the NPSTORET database no less than once a month to ensure adequate interpretation of field notes and receipt of proper laboratory QA/QC information. The import file should be stored in the NPStoret Import directory:

T:\I&M\MONITORING\WaterQual&Quant\Data\NPStoret_1.825\Imports.

Once data are transferred to NPStoret, field data from the NCRN water database should be printed onto paper data sheets. The database provides a mechanism for doing this (see NCRN WCQ SOP #18 – Data Management). The data sheets are then used to conduct QA/QC on the data in NPStoret prior to its being archived. Following the completion of the QA/QC steps, the hard copy data sheets are archived to ensure that the Network maintains both hard copy and electronic records of the data.

Data will be reviewed after it has been transferred to NPStoret, ideally within a week after each sampling event. Staff will review the data sheets printed from the field database and compare them to the data in NPStoret. Reviewers should be aware of data that are missing from either the data sheets, NPStoret, or both. This could be an indication that data did not transfer correctly or was never collected in the field. The reviewer should also focus on data that are outside of a normal range. NPStoret will usually flag records that fall outside a defined range. Any issues that are found or changes made to the data should be noted on the data sheets and initialed by the reviewer. Once the review is complete, reviewers should initial the data sheets which should then be filed in the NCRN archive file cabinet.

If errors or issues continue to appear in the data, staff should review all field and data management SOPs to ensure that procedures are being followed. In addition, data loggers used to collected water quantity/quality parameters in the field should be checked and calibrated.

In addition, spatial data will be maintained within a relational database structure in Microsoft Access. This will enable export to databases compatible with the National Park Service and (EPA or NP)STORET, as well as ease the integration with ArcView or other GIS applications and other widely-used software. Within the database, each stream survey will be labeled with its respective stream reach code as identified in the NHD as well as UTM (or NPS designated)

coordinates for the beginning and ending locations of the sample. The stream reach code is unique so that no other stream reach in the United States has the same code. By attaching the NHD stream reach code to survey information in the database, the data can easily be linked to the NHD within ArcView for spatial analysis, queries, or map creation. This will allow construction of GIS coverage maps for sampling points and stream reaches where sampling was conducted.

Data will be scanned upon receipt from laboratory, and during and immediately after field measurements (this is also true of data from data loggers such as turbidity sensor or pressure transducer data). This helps identify potential equipment problems and/or presence of abnormal pollutants. Full data analysis is not necessary until a complete set of data is gathered (annual), but it is essential to preview data as it is gathered. This includes comparing site data to expected results. Therefore, the individual reviewing the data should have a working knowledge of what would be expected for that stream or watershed in different seasons, etc.

Data Analysis and Reporting

NCRN WCQ SOP #19 Water Resources Data Analysis and Reporting

Administration / Implementation of the Monitoring Program

The water monitoring program is administered in house. Roles and responsibilities of NCRN personnel are detailed in NCRN WCQ SOP 1: Roles and Responsibilities.

Schedule

Ideally, water monitoring personnel will work a modified schedule of four (4) 10-hour days per week. This allows both sampling and water analysis to occur on the same day, giving instant alerts to potential problems that may exist. This allows 2 days per week to be dedicated to sampling and 2 days per week to be dedicated for lab maintenance, cleaning dishware, analyzing data, writing reports, etc. Each stream should be visited once a month to ensure each has a total of 12 visits or data points per year.

The general project timeline is outlined in NCRN WCQ SOP 2: Project Timeline.

NOTE: NCRN does not endorse the use of the equipment mentioned in this protocol.

Appendix: Standard Operating Procedures

NCRN Water Chemistry & Quantity Monitoring Roles and Responsibilities Standard Operating Procedure #1

Revision History Log:

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

1 Purpose

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

2 Scope and Applicability

This document applies to all personnel involved in the monitoring protocol for Surface Water Dynamics and Water Chemistry including field crews, cooperators, and network personnel.

3 Reference Documents

NCRN Water Chemistry and Quantity Monitoring Protocol
NCRN Data Management Plan

4 Definitions & Acronyms

NCRN – National Capital Region Network
FGDC – Federal Geographic Data Committee

5 Personnel and Tasks

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

NCRN Water Chemistry & Quantity Monitoring Roles and Responsibilities Standard Operating Procedure #1

Personnel

Table 1-1. List of personnel involved in the NCRN Water Resources Monitoring Project

Title	Name	Role
Water Resources Specialist	Marian Norris	PM
Ecologist	John Paul Schmit	ECO
Data Manager	Geoff Sanders	DM
GIS Specialist	Mark Lehman	GIS
Field Crew	James Pieper Tonya Watts	FC

Responsibilities (Role)

- **Project Manager (PM)** – The project manager is responsible for overseeing the entire project. This does not mean that he/she will play an active role in each task but he/she must have knowledge of each to ensure that they are attended to properly in a timely manner. Responsible for scheduling field work and coordinating the field crew, training them and ensuring that the data are collected properly. Also must ensure that the data is properly entered into the project database (NPStoret), thoroughly checked and validated.
- **Ecologist (ECO)** – Plays an integral role in protocol review/revision, sampling design and data analysis. Can assist in other areas but these are the primary areas of responsibility. The Ecologist will work directly with the Water Resources Specialist to analyze data and prepare summary documents and reports.
- **Data Manager (DM)** – Responsible for coordinating data management throughout the lifespan of the project. Develops data management guidance for the project, and assists and trains project personnel with the use of the project database (NPStoret). Makes sure that all personnel are well versed in the data management guidance and are aware of their role. Conducts specific data queries to assist with data summary and analysis.
- **GIS Specialist (GIS)** – Supports the project's GIS needs especially during the sampling design and site selection stage. The GIS Specialist will also assist with map preparation for all project reports.
- **Field Crew (FC)** – The Field Crew is responsible for the day-to-day operations of the project. This includes handheld meter calibration, field data collection, sample collection, laboratory analysis, data entry, data QA/QC, and equipment/vehicle maintenance. Also responsible for cleaning labware, and maintaining laboratory stock.

NCRN Water Chemistry & Quantity Monitoring Roles and Responsibilities Standard Operating Procedure #1

Tasks

Table 1-2. Task matrix illustrating the list of project tasks and those responsible for each task.

Tasks	SOP	Personnel				
		PM	ECO	DM	GIS	FC
Protocol Review and Revision	WCQ SOP #20	X	X	X		X
Field Season Preparation	WCQ SOPs #3-6	X		X	X	X
Data Collection	WCQ SOPs #7-16	X				X
Data Entry	WCQ SOPs #9-16, 18	X				X
Data QA/QC	WCQ SOPs #5-16, 18	X		X		X
Metadata	WCQ SOPs #18, 19	X		X	X	X
Data Analysis	WCQ SOPs #19	X	X			X
Reporting	WCQ SOPs #19	X				
Budget Tracking		X				
Data Archiving	WCQ SOPs #19			X		
Data Transfer	WCQ SOPs #19	X		X		

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

Field Season Preparation: Ensure that field crews are hired and trained and that all field equipment and data, such as maps are purchased and obtained. Water monitoring is monthly, so this is a continuous task.

Data Collection: Those responsible must ensure that all field data is thoroughly collected in line with the field protocols. Water monitoring is monthly, so this is a continuous task.

Data Entry: Data is entered into the project database in accordance with the specific project data entry requirements. This task primarily falls on the field crew but NCRN staff must (especially the PM and DM) ensure that the field crew are properly trained in using the project database. Water monitoring is monthly, so this is a continuous task.

Data QA/QC: Data is verified and validated in accordance with NCRN QA/QC requirements (see SOP-Data Management). This task is the primary responsibility of the PM and Field Crew but the DM must make sure that all are well versed on the requirements. Water monitoring is monthly, so this is a continuous task. QA/QC occurs at every step of the monitoring process.

Metadata: All data sets (both spatial and non-spatial) must be fully and completely documented with FGDC compliant metadata. This requires completing the proper metadata forms in accordance with NCRN metadata standards. Project staff must complete the metadata but the DM must review and ensure that metadata is completed properly. Metadata should be prepared and / or revised as necessary to support protocols and data products.

NCRN Water Chemistry & Quantity Monitoring Roles and Responsibilities Standard Operating Procedure #1

Data Analysis: Prepare the proper summaries and conduct the necessary analyses as recommended by the protocol. The PM and ECO should work together to analyze and summarize the data.

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

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

Data Archiving: Ensure that data that have been completely verified and validated are stored safely and securely on NCRN servers. Data archiving should take place at least annually once all of the field data have been entered, checked and validated. The PM should work with the DM to ensure that the data is properly archived.

Data Transfer: Water monitoring data should be transferred to the Water Resources Division offices in Fort Collins, CO on an annual basis for upload into the master NPStoret database. The data will receive an extra level of QA/QC prior to transfer to the EPA Storet database. Data should only be transferred after it has been certified.

NCRN Water Chemistry & Quantity Monitoring - Project Timeline

Standard Operating Procedure #2

Revision History Log:

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

1. Purpose

The purpose of this document is to establish a definitive timeline for specific milestones and due dates associated with NCRN Water Resources Monitoring, including Water Chemistry and Surface Water Dynamics monitoring efforts..

2. Scope and Applicability

This document applies to all aspects of the Water Resources Monitoring Project.

3. Reference Documents

WCQ SOP #1- Roles & Responsibilities

4. Procedures and General Requirements

All those involved in the project must be aware of their specific roles and responsibilities and the time table associated with those tasks. Table 1 outlines the tasks associated with the project and the time frame connected to each task. Each task must be completed by the timeframe illustrated in the table below. Any deviations or adjustments to the timeline (especially relating to deliverables) must be agreed upon by the project manager.

NCRN Water Chemistry & Quantity Monitoring - Project Timeline

Standard Operating Procedure #2

Table 2-1. Project Timeline for average year of water resources monitoring. For task descriptions see WCQ SOP #1 Roles & Responsibilities.

	Tasks	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April
Year 1 – Field Season 2007	Protocol Review and Revision																
	Field Season Preparation (Continuous)																
	Data Collection (Continuous)																
	Data Entry and QA/QC (Continuous)																
	Metadata Preparation																
	Data Analysis																
	Annual Reporting																
	Budget Tracking																
	Data Archiving (every three months)																
	Data Transfer (including metadata) to WRD, Fort Collins, CO.																

NCRN Water Chemistry & Quantity Monitoring Training Field Personnel Standard Operating Procedure #3

Revision History Log:

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

1. Purpose

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

2. Scope and Applicability

This SOP applies to the NCRN Water Resources Monitoring protocol when applied to NCRN parks.

3. Reference Documents

CUE Chemical Hygiene Plan

CUE Safety Plan

CUE Emergency Plan

NCRN Water Chemistry and Quantity Monitoring Protocol Version 2.0

First Aid and CPR certification is available from the Red Cross at
<http://www.redcross.org/services/hss/courses/>

Wilderness First Aid courses are also available: www.wfa.net

Chapter A9 of the USGS NFM for information about water quality monitoring field hazards

4. Responsibilities

NCRN management's responsibilities are to support this Plan in order to protect its laboratory employees, integrate safety into all of its activities, and provide authority and adequate time for employees who have laboratory safety responsibilities.

The Chemical Hygiene Officer (CHO)'s responsibilities are to:

- Ensure that proper training in use of emergency equipment has been provided to laboratory workers.
- Arrange for annual training on the Chemical Hygiene Plan for all laboratory workers and maintain records describing content and attendance. Supplementary hazardous materials training materials are available through DOI Learn.

NCRN Water Chemistry & Quantity Monitoring Training Field Personnel Standard Operating Procedure #3

- Provide information on special or unusual hazards in non-routine work.
- Ensure proper storage and disposal of chemicals/waste housed on-site.

The Project Manager's (may also be the CHO) responsibilities are to:

- Instruct and supervise Water Resource Monitoring (WRM) personnel to ensure that sampling and travel at a given site are done in a manner which minimizes health and safety risk and maximizes QA/QC of data.
- Ensure that all members of WRM personnel are fully aware of any potentially hazardous materials used as part of sampling. Examples include preservatives for biological and chemical samples.
- Ensure that all members of WRM personnel are fully aware of any potential hazards that may be encountered during fieldwork. Examples include ticks, snakes, rabid wildlife, etc.

Laboratory personnel responsibilities are to:

- Attend the Center for Urban Ecology's training annually and apply lessons learned.
- Attend First Aid and CPR/AED training annually.
- Attend Operational Leadership training.
- Review protocols at least annually and request clarification or training on any topics that are not fully understood.

5. Procedures and General Requirements

Safety Training and Qualifications

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

- Recent (within 1 year) CPR certification
- Recent (within 1 year) Red Cross First Aid Training
- Complete a satisfactory interview about health and safety aspects with the Project Manager, including routine safety precautions and a discussion of actions to be taken in an emergency.

In addition to the recommendations identified for all survey personnel, the Project Manager and Technician should have adequate field sampling experience under rigorous conditions.

All employees must be trained on the topics listed in [Section 7.1](#) of the Chemical Hygiene Plan (CHP). Training must occur at the time of initial hire and annually through refresher programs. The CHP itself can serve as a training manual. Reading and/or oral presentation of the contents of this Plan may be supplemented by video and slide presentations. Staff will be trained on the details of all applicable general and laboratory-specific SOPs. The level of training, name of trainee, and date of training will be documented on the Training Record. All laboratory personnel will receive training in the general hazardous materials area. The training program will ensure that each employee receives instruction in the following areas:

NCRN Water Chemistry & Quantity Monitoring Training Field Personnel Standard Operating Procedure #3

1. The contents of the OSHA Occupational Exposure to Hazardous Chemicals in Laboratories standard, and its appendices (29 CFR 1910.1450). A copy of this information is located in Appendix A of this Plan.
2. The Center for Urban Ecology's Plan.
3. An in-depth explanation of MSDSs and terms typically used in evaluation of the chemical nature and hazards associated with hazardous materials. These are available in a bin that is mounted on the wall outside the laboratory.
4. Understanding the routes of exposure and the ways in which hazardous materials can affect workers.
5. Understanding the methods commonly used to detect release of and exposure to hazardous substances, including signs and symptoms associated with exposure. Further information about can be found at <http://www.hhmi.org/research/labsafe/overview.html>.
6. Emergency spill procedures/contingency planning and procedures to follow if employees are exposed to hazardous materials.
7. The measures employees can use to protect themselves from these hazards, including specific procedures such as appropriate work practices, personal protective equipment and emergency procedures.
8. An overview of the requirements of the Hazard Communication Regulation, including employee rights under the regulation.
9. Steps NPS has taken to lessen or prevent employee exposure to hazardous substances.

General Training

1. Annual Training Program. The annual training program will be held during the first quarter of the calendar year. The CHO will organize the program.
2. Audience. All employees are required to attend, including administrative, professional and part-time staff, and interns. Training documentation will be combined with Exotic Plant Management Team (EPMT) safety training information and kept in a log.
3. Absentees. Employees may not work in the laboratory until they have had annual training.
4. All-Employee Program. The contents will include a description of the provisions of this Plan and general emergency preparedness.
5. Laboratory Employee Program. The contents will include relevant parts of the federal OSHA standard on chemical hazards in the work place, and of this Plan. Incorporated into the training will be:
 - a. A description of methods for detecting the presence of hazardous chemicals (observation, odor, real-time monitoring, air-sampling);
 - b. The degree of hazard, toxicity, and exposure;
 - c. General principles of good laboratory practices;
 - d. An introduction to toxicological principles;
 - e. An introduction to reading MSDSs;
 - f. Procedures for chemical waste management; and
 - g. A description of control measures and the prior approvals system.

In addition to the training described above, each laboratory supervisor is responsible for ensuring that laboratory employees are provided with training about the hazards of chemicals present in their laboratory work area and methods to control exposure to such chemicals. Such training must be provided at the time of an employee's initial assignment to a work area where hazardous

NCRN Water Chemistry & Quantity Monitoring Training Field Personnel Standard Operating Procedure #3

chemicals are present and prior to assignments involving new potential exposure situations. Refresher training must be provided annually.

Water Chemistry and Quantity Protocol

All water quality personnel collecting data should have had formal training and some period of field apprenticeship in order 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 field sampling tasks are performed safely, achieve the most representative measurements possible, and data is consistent and comparable Servicewide. All Network staff involved in the water quality component of the Vital Signs program and the sampling technicians in particular, should have a thorough understanding of the program objectives

Field personnel should be experienced in the use of the water quality probes and should have become familiar with the manufacturers instructions for calibration and utilization of the specific equipment planned for use in the monitoring/sampling effort. Experience in equipment handling, calibration, and use/field deployment of the sondes/probes is best obtained through a combination of apprenticeship, and through testing of and gaining some familiarity with the equipment at the office prior to entering the field. Becoming familiar with the manufactures equipment operation and maintenance manual is also extremely important

Field personnel must be familiar with the various types of quality-control samples and know how and when to collect them in order to comply with USGS quality-assurance requirements. Personnel are expected to have training and experience prior to hire. On the job training will consist of:

- (1) Employee reads the Regional Monitoring Plan, Water Quality and Quantity Protocol and SOPS, pertinent equipment manuals, and at least one Annual Water report.
- (2) The Program Manager reviews the materials with the Employee. It is the Employee's responsibility to request further clarification of or training on any materials that are not fully understood.
- (3) The employee serves under a 1 year probationary period. For up to the first 6 months it is reasonable that the employee may require close observation to ensure procedures are performed correctly to ensure quality of data. The employee is expected to perform all tasks independently by the end of the first 6 months.

Training to Minimize Ecological Risk

An increasing potential exists for transferring non-native and invasive organisms (including those that cause serious diseases to native stream dwelling fauna) from one stream to another while conducting monitoring. If possible field crew should take the Maryland Biological Stream Sampling training since the Maryland Department of Natural Resources covers the emerging ecological threats in the watershed. If this training is not possible a thorough review of the materials available from <http://dnr.maryland.gov/streams/news.asp>

NCRN Water Chemistry & Quantity Monitoring Field Safety Standard Operating Procedures #4

Revision History Log:

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

1. Purpose

To present the guidelines for Field Safety during water monitoring in the National Capital Region Network (NCRN). Suggested training and qualifications are described, along with general safety procedures, sampling hazards, provision of first aid, and emergency situations. The recommendations in this chapter are non-binding; the ultimate responsibility for health and safety of field crews lies with the parent organization for each field crew.

For laboratory safety see the CUE Chemical Hygiene Plan.

2. Scope and Applicability

This Standard Operating Procedure (SOP) applies to all fieldwork performed following the NCRN BSS Protocol. The methods outlined in this SOP are applicable to all water sampling performed or managed by Network staff or cooperators.

3. Reference Documents

CUE Chemical Hygiene Plan

CUE Safety Plan

CUE Emergency Plan

First Aid and CPR certification is available from the Red Cross at <http://www.redcross.org/services/hss/courses/>

Wilderness First Aid courses are also available: www.wfa.net

Chapter A9 of the USGS NFM for information about water monitoring field hazards

NCRN SOP Motor Vehicle Accident Report

4. Responsibilities

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

NCRN Water Chemistry & Quantity Monitoring Field Safety Standard Operating Procedures #4

Project Manager - The Project Manager has overall responsibility for health and safety aspects of the monitoring and for ensuring that day-to-day activities of the field crew are conducted in as safe a manner as possible. Recommended health and safety responsibilities include:

- instruction and supervision of WRM personnel such that sampling and travel at a given site are done in a manner which minimizes health and safety risks;
- reporting any unusual health and safety conditions, emergencies, or accidents encountered during sampling;
- ensuring that vehicles and sampling equipment are in safe operating condition prior to and during field deployments;
- ensuring that all members of the survey team are fully aware of any potentially hazardous materials used as part of sampling. Examples include preservatives for biological and chemical samples;
- determining whether sampling conditions are safe and appropriate;
- informing the survey team of any situation-specific dangers involved at a given site;
- ensuring that vehicles are operated in a safe manner; and
- ensuring that samples and sampling equipment are safely stored prior to vehicle operations.

Project Staff (NPS or cooperator/contractor) – All personnel involved in field sampling or field observations (e.g., QA/QC inspections) should be aware of the risks involved with the routine aspects of sampling. When unsafe or hazardous conditions are observed, crew members should inform the Project Manager at the earliest opportunity. For immediate assistance on site the NCRN Coordinator or Chief should be notified. In addition, crew members should notify the Project Manager if, for any reason, they cannot perform an assigned task in a safe manner.

Examples include sickness, physical limitations, or uncertainty about proper operation of the sampling equipment.

5. Safety Equipment

Each field crew is required to carry the following equipment:

- Cellular phone
- First-aid kit
- Each vehicle must have a flashlight, safety triangles, spare tire and tools

Recommended Personal Gear

- Water bottles
- Snacks
- Hat
- Pocket knife
- Long-sleeved shirt and light-colored, long pants
- Sunscreen
- Insect repellent
- Lint roller and tweezers (for tick removal)
- Leather work gloves (if needed)

NCRN Water Chemistry & Quantity Monitoring Field Safety Standard Operating Procedures #4

- Solid, lug-soled footwear
- Compass and map or handheld GPS unit
- Backpack
- Rain poncho
- Special medications if necessary (e.g., EpiPen)
- Snow / rain pants
- Crampons (snow and ice)
- Waterproof insulated gloves
- Waterproof insulated boots
- Waterproof coat
- Hat with ear cover and face mask
- Polarized sunglasses

6. Procedures and General Requirements

Training and Qualifications

To minimize any potential health and safety risks related to field sampling, Water Resource Monitoring (WRM) personnel need to be physically able to conduct fieldwork under demanding conditions and be well prepared to handle contingencies or emergencies. The following are suggested for all WRM personnel:

- Recent (within 1 year) physician's approval to conduct rigorous physical work
- Recent (within 1 year) CPR certification
- Recent (within 1 year) Red Cross First Aid Training
- Complete a satisfactory interview about health and safety aspects with the Project Manager, including routine safety precautions and a discussion of actions to be taken in an emergency.
- Ability to swim in chest waders

In addition to the recommendations identified for all survey personnel, the Project Manager and Technician should have adequate field sampling experience under rigorous conditions.

Sampling Hazards and Procedures for Minimizing Risk

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

Vehicle Accident

To minimize the risk of a vehicular accident, the following measures should be taken:

- an inspection of the sampling vehicle should be performed by WRM personnel or a designee prior to sampling departure. This inspection should include tire condition and operability of wipers, defroster, etc.;
- during sampling activities, any potentially unsafe vehicle condition should be reported to the Project Manager and corrected as soon as is practical;

NCRN Water Chemistry & Quantity Monitoring Field Safety Standard Operating Procedures #4

- if the sampling vehicle is not safe to operate, the vehicle should not be operated until the condition is rectified; and
- vehicles should not be operated by WRM personnel who are incapable of safely operating them. No sampling vehicle should be operated by a person not holding a valid driver's license.

If an accident should occur, consult the Accident Instructions envelope in the vehicle's glove compartment and NCRN SOP Motor Vehicle Accident Report.

Hazardous Terrain

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

- when necessary, the Project Manager will make a determination that access to the sampling site is not possible and the site will be deemed unsampleable;
- equipment should be distributed equitably among WRM personnel for transport from the vehicle to the site;
- to the greatest extent possible, travel between the vehicle and the sample site should occur during daylight hours.

Fast or Deep Water

During sampling, some sampling sites may be visited which have fast and/or deep water in them. Sampling in locations which are too deep or too fast for wading could result in injury or drowning. To minimize health and safety risks associated with sampling in fast and/or deep waters, the following steps should be taken:

- prior to sampling, the Project Manager should ensure that all crew members who are to enter the stream are physically fit to do so and are aware of any specific sampling risks at the site;
- prior to sampling, WRM personnel should make a determination as to whether the site can be sampled by wading without undue risks. If a negative determination is reached, the site should be sampled with a sampling arm. If sampling is still not safe, the site should not be sampled.
- all WRM personnel should wear chest waders outfitted with waist belts and lugged soles should be used in rocky areas. Felt soles are not allowed in the state of Maryland.

Slippery Substrate

Sampling at some sites will be hazardous due to slippery substrate. Examples of stream types which may have treacherous substrates include those affected by acid mine with high silt loads or heavy periphyton biomass. To minimize the risks associated with slippery substrates, the WRM personnel should factor the degree of slipperiness of the substrate into decisions as to whether a site can be sampled and any extra precautions to be taken by the field crew; and all wading gear should have lugged soles. Felt soles are not allowed in the state of Maryland.

Dangerous Animals or Plants.

Sampling at some sites will include risks associated with dangerous animals and/or plants. Poison ivy is likely to be common along many travel routes used by the sampling crew, as well as in

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riparian vegetation. Poison ivy roots on tree trunks offer particular risks since they are often unnoticed. Poison sumac is another plant which occurs in boggy areas and should be avoided. Contact with bees, wasps, and certain caterpillars can cause allergic reactions and should also be avoided. A number of other animals also present serious risks including: northern copperheads, timber rattlesnakes, free-ranging domestic dogs, rabid animals of any mammal species, and ticks. To minimize the risks associated with dangerous animals and plants, the following measures are recommended:

- all field survey personnel should receive training in field identification, avoidance of, and first aid for dangerous plants and animals which may be encountered;
- WRM personnel should inform the Project Manager of any known allergies and keep appropriate medical relief in the field first aid kit;
- the Project Manager should make all crew members aware of site- or situation-specific dangers as they are noted; and
- All WRM personnel should be informed of the risks of lyme disease and should check thoroughly after conducting field work for ticks that may have become attached to the body.

High Bacteria Levels

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

- WRM personnel should make note of any evidence of high bacteria levels;
- gloves should be used during the sampling process;
- open wounds should not be exposed to contact with stream water; and
- after exposure to stream water, all WRM personnel should wash their hands with anti-microbial skin cleanser (Vionex is kept in the center console of the field vehicle) and clean water prior to consuming any food or drink.
- Showering and change to clean clothes upon completion of fieldwork is highly recommended. Showers and laundry facilities are available in the Center for Urban Ecology.

Lightning Strike

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

- WRM personnel are responsible for monitoring weather conditions, adjusting sampling schedules as appropriate to minimize the chance of a field crew being exposed to an electrical storm while in a remote location; and
- in the event of an electrical storm while sampling, sampling activities should be halted and WRM personnel should determine whether to return to the vehicle or seek local shelter.

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Dehydration and Heat Exhaustion

Potable water should be kept with sampling crews at all times and crew members should be encouraged to drink plenty of water. In the event that a crew member suffers from dehydration or heat related illness, all possible attempts should be made to cool and hydrate the person. If heat exhaustion or stroke is suspected, seek immediate medical attention.

Winter Weather Safety

Winter weather conditions are defined as temperature during the day at or below freezing with overnight conditions well below freezing. Many of the sites sampled will be in remote locations. At these locations, the potential for stranding and prolonged exposure to extreme weather conditions is of concern, especially when sampling is conducted during cold weather. There is also a potential for prolonged exposure to cold water in the case of accidents, emergencies or other unusual conditions. Recommended precautions to reduce the possibility of hypothermia or related illnesses include:

- WRM personnel are responsible for monitoring weather conditions and adjusting or postponing sampling plans as appropriate;
- prior to leaving the vehicle for a sampling site, crew members should be properly clothed and take any necessary emergency supplies to the site.
- Dress Properly - Wear several layers of thick, loose-fitting clothing to insulate your body by trapping warm, dry air inside. Loosely woven cotton and wool clothes best trap air and resist dampness. The head and neck lose heat faster than any other part of the body. Hats, scarves, and/or balaclavas are recommended winter field clothing. Cheeks, earlobes, nose, fingertips, and toes are the most prone to frostbite. Early warnings of frostbite include tingling, pain, and numbness to the extremities.
- Avoid overexertion - Cold weather itself, without any physical exertion, puts an extra strain on the heart.
- Take Frequent Breaks - Limit the amount of time outdoors: take frequent short breaks in warm dry shelters to allow the body to warm up. Eat regularly to provide the body with energy for producing its own heat. Keep the body replenished with fluids such as warm broth or juices to prevent dehydration.

When ambient air temperature within the vicinity of a park is at or below freezing and overnight conditions have been below freezing, it is safe to assume that most 1st order streams are frozen, due to their shallow and narrow character.

When the substrate is freezing / frozen:

Probes cannot be used (Table 4-1)

Samples cannot always be taken

Fluids used to rinse and protect meters between sites freeze.

After three pH probes cracked in a row one winter, the YSI technical representative recommended NOT transporting the probes at a temperature much different from the ambient temperature, because that was the most likely cause of the breakage. The glass ball probe technology used by YSI is the standard for field pH equipment.

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The technical representative also pointed out the operational /storage temperatures are for both water and air temperature and are under ideal conditions when the probe is dry (ie short term storage). In our humid climate if the air temperature is below freezing, the stream water will freeze on the probes as soon as they are removed from the water, unlike in a drier climate such as the Rockies where they would dry before they could freeze. There are also the issues of rinsing the probe between sites to remove contamination and fouling. Since we do multiple sites in one day, we have to rinse the probe between sites to avoid cross contamination, invasives spread, maintain the health and well-being of the probe, etc. At air temperatures below freezing the rinse water freezes in the bottle or on the probe.

In the event of freezing site conditions, 1L samples will be taken from each site and processed in the lab for all measurements. Air temperature and physical conditions at the site should be noted in the tablet's database as well as a note indicating samples were collected for all measurements in the lab. When processing in the lab record the water temperature of the sample in the lab, since this influences the rest of the measurements with the meter.

In the event the site is frozen and/or it is unsafe to collect samples, either for people or the equipment, note this on the drop down box of Site Condition and record as much of the site data as possible but do not take samples.

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Table 4-1: Operational Ranges of Water Monitoring Field Equipment with specific attention to cold weather conditions

Equipment	Measurement Range	operational temperature	Storage temperature	Comments
Tablet PC		-20°C to 60°C (-4°F to 140°F)	-40°C to 75°C (-40°F to 167°F)	
YSI Pro Plus		-10°C to 60°C (14°F to 140°F)	-20°C to 70°C (-4°F to 158°F)	Cannot be deployed in icy conditions because the sensors may be physically damaged
DO, Temp & SC		-5°C to 70°C (23°F to 158°F)	-5°C to 70°C (23°F to 158°F)	
pH / ORP probes		0°C to 30°C (32°F to 86°F)	0°C to 30°C (32°F to 86°F)	
YSI 85	-5°C to 65°C (23°F to 149°F)	-5°C to 65°C (23°F to 149°F) SC algorithm operation range: 2°C to 39°C (35.6°F to 102.2°F)		Cannot be deployed in icy conditions because the sensors may be physically damaged
YSI 63	-5°C to 75°C (23°F to 167°F)	-5°C to 45°C (23°F to 113°F) SC algorithm operation range: 2°C to 39°C (35.6°F to 102.2°F)		Personal experience pH probe ambient operational range above -0.5°C Cannot be deployed in icy conditions because the sensors may be physically damaged
YSI 690	-5°C to 50°C (23°F to 122°F)	-5°C to 50°C (23°F to 122°F) SC algorithm operation range: 2°C to 39°C (35.6°F to 102.2°F)	-10°C to 60°C (14°F to 140°F)	Cannot be deployed in icy conditions because the sensors may be physically damaged
Hydrolab MS5a	-5°C to 50°C (23°F to 122°F)	-5°C to 45°C (23°F to 113°F)		Cannot be deployed in icy conditions because the sensors may be physically damaged
Sontek Flowtracker		-20°C to 50°C (-4°F to 122°F)	-20°C to 50°C (-4°F to 122°F)	Personal experience, we have received errors in air temperatures just below freezing that the salesperson stated were due to the air temperature, since everything else checked out
Digital Thermometer		0°C to 50°C (32°F to 122°F)	0°C to 50°C (32°F to 122°F)	

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7. Emergencies

In the event of a medical or other emergency, take all appropriate immediate actions and send for appropriate assistance using the fastest available means.

In the event the emergency occurs at a remote location, all necessary information to guide assistance personnel (Park contacts listed below in Table 4-2) should be provided, including map coordinates if known and appropriate.

TABLE 4-2. Emergency contact numbers for each park

Park	Facility	Number
ANTI	National Park Service Emergency Dispatch National Capital Region Communications Center Local Emergency Dispatch	1-866-677-6677 (toll free) 301-714-2235 or <u>911</u>
CATO	National Park Service Emergency Dispatch National Capital Region Communications Center Local Emergency Dispatch	1-866-677-6677 (toll free) 301-714-2235 or <u>911</u>
CHOH	East of Great Falls : United States Park Police District #2 - USPP Emergency Dispatch - USPP Non-emergency Communication West of Great Falls : NPS Emergency Dispatch - NCR Communications Center - Local Emergency Dispatch	703-285-1000 202-619-7300 202-619-7105 1-866-677-6677 (toll free) 301-714-2235 or <u>911</u>
GWMP	USPP District #2 USPP Emergency Dispatch USPP Non-emergency Communications Local Emergency Dispatch	703-285-1000 202-619-7300 202-619-7105 911
HAFE	National Park Service Emergency Dispatch National Capital Region Communications Center HAFE Law Enforcement Office Local Emergency Dispatch	1-866-677-6677 (toll free) 301-714-2235 304-535-6455 911
MANA	National Park Service Emergency Dispatch National Capital Region Communications Center Local Emergency Dispatch	1-866-677-6677 (toll free) 301-714-2235 or <u>911</u>
MONO	National Park Service Emergency Dispatch National Capital Region Communications Center Local Emergency Dispatch	1-866-677-6677 (toll free) 301-714-2235 or <u>911</u>
NACC	United States Park Police District #1 USPP Emergency Dispatch USPP Non-emergency Communications Local Emergency Dispatch	202-426-6710 202-619-7300 202-619-7105 911
NACE	Greenbelt Park, BW Parkway USPP District #4 Anacostia, all other NACE USPP District #5 USPP Emergency Dispatch USPP Non-emergency Communications Local Emergency Dispatch	301-344-4250 202-610-8703 202-619-7300 202-619-7105 911
PRWI	National Park Service Emergency Dispatch National Capital Region Communications Center PRWI Law Enforcement Office	1-866-677-6677 (toll free) 301-714-2235 703-221-2192

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Park	Facility	Number
	Local Emergency Dispatch	911
ROCR	United States Park Police District #3	202-426-7716
	USPP Emergency Dispatch	202-619-7300
	USPP Non-emergency Communications	202-619-7105
	Local Emergency Dispatch	911
	Water Quality Division for DDOE , Jacob Zangrilli:	cell-202-497-4351, office-202-535-2645
	Water Quality Division for DDOE, Teamrat Gebremedhin:	cell-202-359-3319
	Bill Yeaman	cell # 202-359-1704
	DC 24 hour water and sewer emergency	202-612-3400
WOTR	Local Emergency Dispatch	911

8. Precautions for Minimizing Ecological Risk

An increasing potential exists for transferring non-native and invasive organisms (including those that cause serious diseases to native stream dwelling fauna) from one stream to another while conducting monitoring. Whirling disease (a protist, *Myxobolus cerebralis*), rock snot (an alga , *Didymosphenia geminata*), and amphibian-infecting chytrid fungus (*Batrachochytrium dendrobatidis*) are examples of such organisms.

The risks described above require that WRM personnel take precautions to minimize, to the greatest extent possible, the transfer of any disease organisms from one place to another.

Beginning in June 2007, the State of Maryland requires all field crews to disinfect all field equipment and waders that come in contact with stream or wetland (e.g. vernal pool) water following sampling at each stream site. This procedure should also be applied to all equipment that comes in contact with chicken litter.

The disinfection procedure consists of soaking or rinsing all equipment that has come in contact with water (or chicken litter) in a 10% bleach solution for at least one minute. Equipment with a smooth surface (e.g. buckets, sides – but not soles - of waders) can be scrubbed with a scrub brush using a 10% bleach solution. After soaking and scrubbing have been completed, all equipment must be rinsed with freshwater to remove the bleach solution. Bleach cannot be used on the YSIs. If contamination of the probes or meters are suspected, they should be returned to the lab and cleaned following manufacturer's guidelines as detailed in WCQ SOP #6 Water Chemistry Field Equipment Preparation.

Avoid skin and eye contact with bleach solution as it can be severely irritating. Thoroughly rinsing all equipment with freshwater also minimizes risk of skin and eye irritation.

NCRN Water Chemistry & Quantity Monitoring

Water Chemistry Laboratory Preparation

Standard Operating Procedure #5

Revision History Log:

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

1. Purpose

Preparation of lab materials so that samples can be processed immediately on return from the field.

2. Scope and Applicability

This procedure applies to all Hach-kit-based analysis of water samples, which currently includes ANC, nutrients, and water treatment by-products. If additional parameters are analyzed the pertinent supplies need to be added to the table.

3. Reference Documents

HACH. 2004. DR4000U Handbook. HACH Company, Loveland CO.

4. Procedures and General Requirements

Table 5-1. Required chemicals and equipment for water chemistry analysis.

Nitrate, Chromotropic	Nitrate Pretreatment Solution Vials NitraVer X Reagent B Powder Pillows De-ionized Water Nitrate Nitrogen Standard Solution, 15- mg/L NO ₃ -N Nitrate Nitrogen Standard Solution, 1000-mg/L NO ₃ -N HACH DR/4000 DR/4000 Test Tube adapter Test Tube Rack TenSette Pipet, 1.00 mL Kimwipes
Phosphorus, Total, (PhosVer 3 Method with Acid Persulfate Digestion)	PhosVer 3 Phosphate Reagent Powder Pillows Potassium Persulfate Powder Pillow Sodium Hydroxide Solution, 1.54 N Total and Acid Hydrolyzable Test N tube vials De-ionized water HACH COD Reactor HACH DR/4000 DR/4000 Test Tube Adapter Test Tube Rack Kimwipes
ANC	0.1600 or 1.600 Sulfuric Acid Cartridges Phenolphthalein Powder Pillows Bromocresol Green- Methyl Red Powder Pillows Digital Titrator and delivery tubes

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Table 5-2. Chemicals and equipment for optional water chemistry analysis, if a leak is suspected.

Chlorine	DPD Total Chlorine Powder Pillows De-ionized Water HACH DR/4000 Sample Cell DR/4000 Sample cell adapter TenSette Pipet, Kimwipes
Free Ammonia, Monochloramine	Free Ammonia Reagent Set Free Ammonia Reagent Solution Monochlor F Reagent Pillows De-ionized Water HACH DR/4000 Sample Cell DR/4000 Accu Vac Sample cell adapter Kimwipes

Produce distilled water for instruments and parks:

Distilled water is the minimum purity required for preparing analytical blanks and cleaning the glassware. Deionized water is preferred. Unfortunately the still for producing distilled water and the deionizer (for producing deionized water or DI) are not located in the same room due to infrastructure constraints. Therefore water is distilled in room 120, where the still is located on the back wall on the left. Carboys with spouts are filled from the still and then transferred to the Water Lab where they are attached via tubing to the deionizer, located on the back wall on the right.

The still is located in Room 120 to the right of the Water Laboratory. **DO NOT OPERATE THE STILL AND THE AUTOCLAVE OR WASHER AND DRYER SIMULTANEOUSLY!**

Check that the Drain Lever is in the closed position and turn on the Water Supply Valve (should be nearly parallel to the piping).

Flip the power switch on the wall box on.

Adjust CLD (see diagram on wall next to the still for location) drips to a constant slow drip by turning the CLD Regulator, the black knob at the end of the CLD. See illustration posted on wall beside still for location of CLD.

Wait 5 minutes then check for puffs of steam coming out of the Condenser Vent.

Adjust the steam to constant, barely visible puffs by increasing or decreasing the water supply: Gushing puffs – increase the water flow, No puffs – decrease the water flow.

Drain off the water recovered in the beginning of the process. It may contain impurities.

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When enough distilled water has been made, turn off the power switch on the wall

Wait 3-5 minutes then turn off the water supply

Be sure to turn the still off before leaving for the day.

Fill containers for parks and field work with distilled water. Top-off the carboy for the de-ionizer when necessary.

To replace the carboy attached to the De-Ionizer

Fill a carboy for the De-Ionizer with distilled water from the still.

Take the carboy into the Water Lab, Place it on the top shelf of the center island above the Hand-Washing Sink. The height is necessary to encourage water flow into the NANOpure Deionizer.

Insert the water hose for the Deionizer into the carboy spigot. Turn on the carboy spigot. Loosen the lid on the carboy, to prevent creating a negative pressure.

Sample Bottles

125 mL acid-washed and 500 mL non-acid washed Disposable high-density polyethylene (HDPE) plastic bottles will be used for analytical sample collections.

All sample bottles, new or used, must be cleaned before each use. Water sample bottles should be employed for water samples only. Bottles that have been used for other purposes, such as storing concentrated reagents should not be used as sample containers.

Mixing the 3:1 HCl acid bath

Using 6N HCl, mix 3 parts DI water to 1 part HCl (1.5L HCL and 4.5L DI water).

A total of 6L of the acid bath will fill the green Tupperware up to the indentation. The indentation provides a nice reference for adding more water as it evaporates.

The acid bath should remain in the hood at all times.

Cleaning Glassware and sample bottles for nutrients and monochloramine analysis

Table 3. Acid-washed glassware for water chemistry analysis.

Nitrate, Chromotropic	Micro funnel, poly Pipet tips
Phosphorus, Total (PhosVer Method)	Micro funnel, poly

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	Pipet tips
Free Ammonia, Monochloramine	2 sample cells with cap (1 cm / 10mL) Glass sample bottles

Rinse the glassware well with tapwater.

If there is any analytical residue on the glass, clean it with laboratory detergent (nitrate and phosphate-free detergent is recommended) by hand or run it through the dishwasher located in the Soils Annex. Rinse the glassware again with deionized water.

Leach in 3:1 HCl acid bath (for nutrients) for at least 24 hours.

Rinse well with deionized water. Place in drying racks to dry. Once dry, put away with openings down when possible to prevent contamination.

Cleaning ANC and chlorine sample bottles

Table 4. Glassware and hardware for chlorine and ANC

Chlorine	2 glass sample cells Pipet tips
ANC	125 mL Erlenmeyer Flask (for each sample) graduated cylinder

Containers to be used for ANC (acid neutralizing capacity = alkalinity for an unfiltered sample) and chlorine analyses should be either hand-washed with soap or run through the dishwasher in the Soils Annex with detergent.

The containers shall be rinsed three times with deionized water, filled with deionized water, and allowed to stand for at least 48 hours, then emptied and rinsed with sample water in the field.

Air dry.

Reagents, Standards, and Equipment

Check to make sure that all required equipment and chemicals listed in tables 1 and 2 are available in sufficient amounts, that the equipment has been properly cleaned, and that the chemicals are not expired. If any chemicals or equipment are not available, submit an order using a DI-1 (according to NCRN purchasing procedures) and ordering information available at <http://www.hach.com/>.

Cleaning the Hood and its Contents

Dump the DI water bath down the sink drain next to the deionizer. Wash the container with soap and DI water. Rinse well and refill with DI water to the line, approximately 6 L.

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Neutralize the acid bath with Sodium Hydroxide, using no more than 1.5L.

Once the sodium hydroxide is mixed in, verify a neutral pH with the pHdriion paper found in cabinet #2. Tear off a piece and dip it in the bath. The paper should turn green or blue. Dump the acid bath contents down the sink drain next to the deionizer. Wash the container with soap and DI water. Rinse well and refill with DI water half way to the line.

Change the absorbent liner and wipe down the glass sash.

Return the acid bath to the hood. Carefully add a 1L bottle of 6N hydrochloric acid (found in the acid cabinet). Fill the empty acid bottle with DI water and add to the bath until the liquid is above the line. If the acid bottle is glass, put it in the glass waste box. If it is plastic, tightly cap it and put it in the trash can.

NCRN Water Chemistry & Quantity Monitoring: Field Equipment Preparation Standard Operating Procedures #6

Revision History Log:

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

1. Purpose

The purpose of this Standard Operating Procedure (SOP) is to collect and prepare water chemistry field equipment for use.

2. Scope and Applicability

This Standard Operating Procedure (SOP) applies only for the field portion of the Water Chemistry and Quantity Protocol and the equipment described. If new equipment is obtained by the lab, this SOP must be updated.

3. Reference Documents

YSI Incorporated. 2010. Professional Plus Calibration Tips. YSI Incorporated, Yellow Springs, OH.

YSI Incorporated. 2008. Professional Plus User Manual. YSI Incorporated, Yellow Springs, OH.

SonTek/YSI Inc. 2007. FlowTracker Handheld ADV Technical Manual, Firmware Version 3.3, Software Version 2.20. SonTek/YSI Inc., Yellow Springs, OH.

NCRN SOP - Vehicle Fueling and Maintenance

NCRN SOP - Vehicle Accident Report Form

NCRN WCQ SOP 04– Field Safety

4. Procedures and General Requirements

Inspect Vehicle

Four-wheel drive vehicles should be used when possible for Water Resources sampling and are generally necessary during weather that is anything other than warm, dry, and sunny for access on the fire roads in PRWI and the tow path in CHOH.

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Prior to use each day, Field Personnel will visually inspect the sampling vehicle for any evidence of safety or mechanical problems. See NCRN SOP: Vehicle Fueling and Maintenance for further information. Also carry a copy of NCRN SOP: Motor Vehicle Accident Report in the vehicle with you at all times.

If a vehicle other than the water lab truck is required, sign out the vehicle as far in advance as possible. It is best to check the vehicle and obtain the keys the evening before, in case another vehicle is required.

Collect Equipment

Ensure that the laboratory is ready to receive water samples. See NCRN WCQ SOP 05: Water Chemistry Laboratory Preparation. Prior to each field sampling trip, the Field Personnel should ensure that all necessary equipment and supplies are in working order (Be especially certain that the batteries are fully charged), calibrated, and loaded into the sampling vehicle, including spare or back-up equipment, extra data sheets, etc. Depart for sampling only after the equipment inventory is verified. Equipment for sampling is listed below (Table 6-1). These items must be transported and handled with care. Even though some have been designed for field use, they are subject to damage from shock, dust, and moisture. Any equipment problems that develop during sampling should be recorded in the Notes section of the field data form and addressed upon return from the field. In no case should faulty equipment continue to be used for sampling.

At least one person on the field crew should carry their valid DOI ID for entry into the parks.

Table 6-1. List of items for stream sampling.

Keys for, MONO, ROCR, or PRWI fire roads / access roads
Road Maps, Itinerary, Site List, Site Maps, &/or GPS, if necessary
Tablet PC, in the case
Fully charged Spare Tablet battery
Spare stylus for Tablet
Clipboard and waterproof paper data sheets
Field notebook
Pencils, Permanent Markers
Strips of water proof paper to label sample bottles
Digital Camera, Extra Batteries, & memory card(s)
Blaze orange field vests
Backpacks
Pruners or machete
Waders and boots
Cell phone or radio calibrated for Park, if cellular service is not available
Freshwater for Crew Consumption
Lunch & snacks
First Aid Kit
Foul Weather Gear
Wader Repair Kit
Disinfectant Lotion
Sunscreen, insect repellent
Tech-nu ivy block & after-wipes
Discharge measurement equipment (Sontek FlowTracker, tape, etc.)

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YSI Pro Plus
Distilled water (squeeze bottle for meters, larger container for the parks)
Tool box, including appropriate screw drivers for meters and spare batteries
Meter tape and chaining pins
Thermometer
Cooler
Cool packs
Sample bottles (a 125mL and a 500 mL HDPE sample bottles per stream), labeled w/ 4 letter site code, second labeled 500mL for each site if suspect freezing conditions on site
Lint Roller
Sampling permit(s), if necessary
DOI Identification Card
Yellow sampling pole and attached bottle

Equipment Assembly and Setup

YSI

YSI Pro Plus Battery Installation

The Pro Plus requires (2) alkaline C-cell batteries. Replace the batteries every month. To install or replace the batteries:

1. Turn the instrument over to view the battery cover on the back.
2. Unscrew the four battery cover screws.
3. Remove the battery cover and install the new batteries, ensuring correct polarity alignment on the instrument or the removed cover.
4. Replace the battery cover on the back of the instrument and tighten the four screws. Do NOT over-tighten.

You will have approximately 2 minutes to change the batteries before the clock resets. Once the batteries are installed, power on the unit, the instrument will automatically bring up the Date/Time menu the next time it is powered on in order to update this information. If it does not go to Set up>system>date/time. This is important, especially if you intend to log data!

YSI Pro Plus Main Display Setup

Press the Power key to turn the instrument on. The instrument will briefly display the splash screen with the YSI logo then go directly to the main run screen. The first time the instrument is powered up or if the instrument has had a battery change (with batteries removed for more than 2 minutes), you will need to set the date and time.

Press System (the button at the upper left with the ProPlus icon) to access any of the following: Date/Time, GLP, Language, Radix Point, Logging, Auto-Shutoff, Backlight, SW (Software) Version, Serial #, and Unit ID.

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Any item with [brackets] shows the current setting inside the brackets. The brackets will also give a quick visual clue as to what items can be changed.

Changing YSI Professional Plus Date & Time:

Highlight **Date/Time** from the System menu. Press **Enter** to select.

Highlight **Date Format** and press **Enter** to open a sub menu for selecting the preferred date format: YY/MM/DD, MM/DD/YY, DD/MM/YY, or YY/DD/MM.

Highlight **Date** and press **Enter** to use the numeric entry screen to set the correct date.

Highlight **Time Format** and press **Enter** to open a submenu to select the preferred time format from 12-hour or 24-hour.

Highlight **Time** and press **Enter** to use the numeric entry screen to set the correct time.

Sensor Installation

Quatro (4 sensor) bulkhead ports are labeled 1, 2, DO, and C/T. ports 1 and 2 are for a pH, ORP, or and ISE sensor. A sensor must be installed in port 1 for port 2 to operate correctly. If you install a pH/ORP combo sensor into port 1 or port 2, ORP will not be measured. The DO port is either for a Polarographic or Galvanic dissolved oxygen sensor. The C/T port is for the Conductivity/Temperature sensor. For ease of installation, YSI recommends that you install a sensor into port 1 first, followed by DO installation, then a plug or optional sensor into port 2 and lastly C/T.

YSI Pro Plus pH Sensor Installation

Insert pH probe into ISE slot 1

Press the **Sensor** icon, highlight **Setup**, press **Enter**. Highlight **ISE1** if the pH sensor is installed in port 1 or highlight **ISE2** if the pH sensor is installed in port 2 (a sensor must be installed in port 1 for port 2 to operate). Press **Enter**.

Highlight **Enabled** and press **Enter** to enable. After enabling the ISE function, ensure that it is set to pH as shown in the left screen shot. If necessary, highlight pH and press enter to set the ISE to pH. Highlighting pH[USA] and pressing enter will also allow you to select the values for auto buffer recognition which are used during calibration. The buffer options are USA (4, 7,10), NIST (4.01, 6.86, 9.18), and User-Defined.

The selected option will be displayed in [brackets].

Note: If a sensor is Enabled that isn't connected to the instrument, the display will show an unstable false reading, "?????", or "-----" next to the units.

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Press the **Sensor** icon, highlight **Display** and press **Enter**. Highlight ISE (pH) and press enter. You will not be able to Display the sensor unless it is Enabled in the Sensor Setup menu. Highlight pH and/or pH mV, press enter to enable or disable. Both can be reported at the same time.

YSI Pro Plus ISE 2 Cap Installation

Insert a port plug into ISE slot 2. This will protect the bulkhead from water damage. Port plugs and a tube of o-ring lubricant are included with all Quattro cables. These items can be ordered separately if needed. Apply a thin coat of o-ring lubricant to the two o-rings on the port plug. After application there should be a thin coat of lubricant on the o-ring. Remove any excess o-ring lubricant from the o-ring and / or port plug with a lens cleaning tissue. Insert the plug into an empty port on the bulkhead and press firmly until seated. Then turn the plug counterclockwise to engage the threads and finger-tighten until the plug is installed completely. Do not use a tool to tighten the plug.

YSI Pro Plus DO Sensor installation

Warning: before installing either dissolved oxygen sensor, the instrument **MUST** be configured for the sensor being installed. Failure to do this may result in damage not covered under warranty.

Hold the cable with bulkhead in one hand, and the DO sensor in the other hand. Notice the two o-rings on the sensor. O-ring lubricant is applied to these o-rings prior to shipment from YSI. There is no need to apply o-ring lubricant.

Align the pin in the bulkhead and the sensor connector and push together until it is properly seated and only one o-ring is visible. Do not begin threading before the sensor is firmly seated and only one o-ring is visible. Failure to fully seat the sensor may damage the sensor and bulkhead threads.

Once the sensor is firmly seated in the bulkhead and only one o-ring is visible, twist the sensor clockwise to engage the threads. Finger tighten until the sensor is flush with the bulkhead. Do NOT use a tool to tighten sensor. Once installed, the sensor guard will protect the sensor during sampling.

YSI Pro Plus DO Cap Membrane Installation & Configuration

The dissolved oxygen sensor is shipped with a dry, protective red cap that will need to be removed before using. It is very important to put a new membrane with electrolyte solution on the sensor after removing the red cap. Prepare the membrane solution according to the instructions on the bottle. Ensure you are using the correct electrolyte solution for the correct sensor. Galvanic sensors utilize electrolyte with a light blue label and Polarographic sensors utilize electrolyte with a white label. The dissolved oxygen sensor is supplied with cap membranes specific to the sensor type ordered (Polarographic or Galvanic). The 5906, 5908, and 5909 membrane kits are for

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Polarographic sensors. The sensor currently used by the I&M water monitoring personnel is Polarographic.

Remove the sensor guard to access the probe tip. The DO sensor is shipped dry with a protective red plastic cap on the electrode. A new cap membrane must be installed before first use. Prepare the O₂ probe solution, after mixing allow the solution to sit for 1 hour. This will help prevent air bubbles from later developing under the membrane. Remove and store the red protective cap. Thoroughly rinse the sensor tip with distilled or deionized water. Fill a new membrane cap with probe solution. Avoid touching the membrane portion of the cap. Be very careful not to touch the membrane surface. Lightly tap the side of the cap membrane to release bubbles that maybe trapped.

Thread the membrane cap onto the sensor, moderately tight. A small amount of electrolyte will overflow. Screw the sensor guard on moderately tight.

For accurate dissolved oxygen readings, the membrane type must be configured in the instrument. Users who are primarily interested in a fast response from their dissolved oxygen sensor should consider a change of the default time constant setting is that field pH readings may appear somewhat noisy if the cable is in motion. To accomplish this task, from the main menu, enter the “System Setup” menu. Highlight “Data Filter” and press Enter. Change the time constant and threshold to the desired value.

Press the Sensor icon, highlight Setup and press enter. Next, highlight DO and press enter. Enabled allows you to enable or disable the Dissolved Oxygen function. Highlight Enabled and press enter to activate (check mark) or deactivate (not check) dissolved oxygen. Disable dissolved oxygen if you do not have a dissolved oxygen sensor connected to the instrument. Note: If a sensor is Enabled that isn't connected to the instrument, the display will show an unstable, false reading, with “?????” or “-----” displayed next to the units.

Sensor Type sets the type of oxygen sensor being used: either Polarographic (black) or Galvanic (grey). Highlight Sensor Type (Polarographic) and press enter. Highlight the correct sensor type installed on the cable and press enter to confirm.

IMPORTANT – The instrument default setting is Galvanic. Change the Sensor Type to Polarographic. If you observe readings very close to 0 or extremely high readings (i.e. 600%), your Sensor Type setting (Polarographic or Galvanic) may be set incorrectly and you should immediately change it to Polarographic.

Membrane sets the type of membrane used on the dissolved oxygen sensor.

Highlight Membrane and press enter.

Highlight the correct membrane type installed on the sensor and press enter to confirm. The DO sensor is supplied with color coded membranes specific to the sensor type. . The Polarographic membrane kit that corresponds to the ProPlus used by the I&M water monitoring personnel is: #5908, Yellow, 1.25 mil polyethylene .

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Press the Sensor icon, highlight Display and press enter.

Highlight DO and press enter. All DO units can be displayed simultaneously. Highlight the unit(s) and press enter to activate or deactivate units from the run screen.

DO % will show DO readings in a percent scale from 0 to 500%.

DO mg/L will show DO readings in milligrams per liter (equivalent to ppm) on a scale from 0 to 50 mg/L.

DO ppm will show DO readings in parts per million (equivalent to mg/L) on a scale from 0 to 50 ppm.

YSI Pro Plus Conductivity/Temperature (C/T) Sensor Installation

Insert conductivity/temperature into C/T slot. For ease of installation, YSI recommends installing the conductivity/temperature sensor on the Quatro cable after the other 3 sensors are already installed. If installing for the first time, remove the protective dust cover from the bulkhead. If replacing the sensor, remove the probe guard by unscrewing counter clockwise and dry the cable/sensor assembly completely. Locate the C/T port and, if replacing, remove the old sensor using the installation tool to loosen the stainless steel retaining nut. Once the stainless steel retaining nut has been completely unscrewed from the bulkhead, remove the old sensor from the bulkhead by pulling the sensor straight out of the bulkhead. Apply a thin coat of the o-ring lubricant (supplied in the maintenance kit with the sensor) to the o-rings on the connector side of the new sensor.

WARNING: visually inspect the port for moisture. If moisture is found, it must be completely dried prior to sensor installation. The cable/sensor may be permanently damaged if moisture is not removed prior to sensor installation. Insert the new sensor into the correct port. Gently rotate the sensor until the two connectors align. Align the connectors of the new sensor and the port. Push the sensor in towards the bulkhead until you feel the sensor seat in its port. You will experience some resistance as you push the sensor inward, this is normal. Once you feel the sensor seat into the port, gently rotate the stainless steel sensor nut clockwise with your fingers, **DO NOT USE THE TOOL.**

The nut must be screwed in by hand. If the nut is difficult to turn **STOP** as this may cause cross-threading. If you feel resistance or cross threading at any point, unscrew the nut and try again until you are able to screw the nut down completely without feeling any resistance/. Damage to your cable/sensor may occur if you force the parts together.

Once completely installed, the nut will seat flat against the bulkhead. At this point, use the tool to turn the nut an additional $\frac{1}{4}$ to $\frac{1}{2}$ turn so it cannot come loose. **DO NOT OVER TIGHTEN.** **WARNING:** do not cross thread the sensor nut. Seat nut on face of bulkhead. Do not over tighten.

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YSI Pro Plus Conductivity Set up

Press the Sensor icon, highlight Setup, and press enter. Highlight Conductivity, press enter. Enabled allows you to enable or disable the conductivity measurement. Highlight Enabled and press enter to activate or deactivate conductivity. Disable conductivity if you do not have a conductivity sensor connected to the instrument.

Press Sensor, highlight Display and press enter. Highlight Conductivity and press enter. Highlight Sp. Conductance (Specific Conductance), Conductivity, Salinity and press enter to select the reporting units for each parameter. One reporting unit per parameter may be enabled. To disable a parameter, select None. You will not be able to display any of these parameters unless the Conductivity sensor is Enabled in the Sensor Setup menu first. Sp. Conductance can be displayed in $\mu\text{S}/\text{cm}$ or mS/cm . Specific conductance is temperature compensated conductivity.

Conductivity can be displayed in $\mu\text{S}/\text{cm}$ or mS/cm . Conductivity is the measure of a solution's ability to conduct an electrical current. Unlike specific conductance, conductivity is a direct reading without any temperature compensation.

Salinity can be displayed in ppt (parts per thousand) or PSU (practical salinity units).

The units are equivalent as both use the Practical Salinity Scale for calculation.

YSI Pro Plus Temperature Set up

To set the units, press the Sensor icon, highlight Display and press enter. Highlight Temperature and press enter. Highlight the desired temperature units of $^{\circ}\text{F}$, $^{\circ}\text{C}$, or K and press enter to confirm the selection. Only one temperature unit may be displayed at a time. You may also choose not to display temperature. If you choose not to display temperature, other parameters that require a temperature reading will still be temperature compensated.

Maintain and Calibrate Meters

Field work is scheduled so there is a "free" week between sampling "months". During this week all labware and field gear should be cleaned and field equipment checked and calibrated. Equipment should also be calibrated if suspicious readings are taken in the field. **IN NO CASE SHOULD WATER QUALITY INSTRUMENTS BE USED IF THEY HAVE NOT PASSED CALIBRATION OR GIVE UNSTABLE CALIBRATIONS.**

The following information should be recorded in the Instrument Logbook each time calibration occurs:

- METER – record Instrument manufacturer and model number
- PAGE NUMBER – record next page number in sequence; pages numbered sequentially from first use of letter identifier.
- DATE – record date with year as a four digit field and month and day as two digit fields each.
- TIME – record time in 24 hr military format with hours as two digit field and minutes as two digit field.

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- LOCATION – record place where work performed
- PROJECT – record project(s) on which instrument is intended to be used.
- CHECKED BY – record initials of person(s) performing work; each person's initials are a three-digit field. Separate individual fields with slash.

On the YSI Professional Plus the GLP or 'Good Laboratory Practice' file saves detailed information about calibrations. It also includes diagnostic information about the sensors. Calibrations are logged into a file, the GLP, for later review as needed. On the YSI Pro Plus go to File>View GLP and write down the contents in the calibration log.

YSI

General Maintenance for YSI Pro Plus Sensor Ports

It is important that the entire sensor connector end be dry when installing, removing or replacing. This will prevent water from entering the port. Once a sensor is removed, examine the connector inside the port. If any moisture is present, use compressed air to completely dry the connector or place directly in front of a steady flow of fresh air. If the connector is corroded, return the cable to your dealer or directly to an YSI Repair Center.

*Note: Remove sensors upside down (facing the ground) to help prevent water from entering the port upon removal.

General Maintenance for YSI Pro Plus O-rings

The instrument utilizes o-rings as seals to prevent water from entering the battery compartment and sensor ports. Following the recommended procedures will help keep your instrument functioning properly. If the o-rings and sealing surfaces are not maintained properly, it is possible that water can enter the battery compartment and/or sensor ports of the instrument. If water enters these areas, it can severely damage the battery terminals or sensor ports causing loss of battery power, false readings, and corrosion to the sensors or battery terminals. Therefore, when the battery compartment lid is removed, the o-ring that provides the seal should be carefully inspected for contamination (e.g. debris, grit, etc.) and cleaned if necessary. The same inspection should be made of the o-rings associated with the sensor connectors when they are removed. If no dirt or damage to the o-rings is evident, then they should be lightly greased without removal from their groove. However, if there is any indication of damage, the o-ring should be replaced with an identical o-ring. At the time of o-ring replacement, the entire o-ring assembly should be cleaned.

To remove the o-rings use a small, flat-bladed screwdriver or similar blunt-tipped tool to remove the o-ring from its groove. Check the o-ring and the groove for any excess grease or contamination. If contamination is evident, clean the o-ring and nearby plastic parts with lens cleaning tissue or equivalent lint-free cloth. Alcohol can be used to clean the plastic parts, but use only water and mild detergent on the o-ring itself. Using alcohol on o-rings may cause a loss of elasticity and may promote cracking. Do not use a sharp object to remove the o-rings. Damage to the o-ring or the groove may result.

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Inspect the o-rings for nicks and imperfections. Before re-installing the o-rings, make sure to use a clean workspace, clean hands, and avoid contact with anything that may leave fibers on the o-ring or grooves. Even a very small amount of contamination may cause a leak.

To re-install the o-rings place a small amount of o-ring grease between your thumb and index finger. Draw the o-ring through the grease while pressing the fingers together to place a very light covering of grease to the o-ring. Do not over-grease the o-rings. The excess grease may collect grit particles that can compromise the seal. Excess grease can also cause the waterproofing capabilities of the o-ring to diminish, potentially causing leaks. If excess grease is present, remove it using a lens cloth or lint-free cloth.

Place the o-ring into its groove making sure that it does not twist or roll. Use your grease-coated finger to once again lightly go over the mating surface of the o-ring.

Updating YSI Professional Plus Firmware

The instrument's firmware can be updated via www.ysi.com. There you will find the new firmware file and instructions on how to update the instrument. There is no need to send the instrument back to the factory for upgrades.

YSI Pro Plus pH Calibration and Maintenance

Calibrate the ProPlus approximately once a month with regular field use. The pH calibration uses a three point calibration (4, 7, 10). Calibration can be accomplished in any buffer order.

Press the Cal icon. Highlight ISE (pH) and press enter. The message line will show the instrument is "Ready for point 1". Place the sensor in a traceable pH buffer solution.

The instrument should automatically recognize the buffer value and display it at the top of the calibration screen. If the calibration value is incorrect, the auto buffer recognition setting in the Sensor Setup menu may be incorrect. If necessary, highlight the Calibration Value and press enter to input the correct buffer value. *Note: The calibration value may differ slightly due to temperature compensation (see Table 6-1).

Table 6-1: pH calibration values at temperatures from 0 to 40, according to Fisher as printed on their 10 L containers, serial number below pH value.

°C	pH 10.00	pH 7.00	pH 4.00
0	10.34	7.13	4.01
5	10.26	7.10	3.99
10	10.19	7.07	4.00
15	10.12	7.05	3.99
20	10.06	7.02	4.00
25	10.00	7.00	4.00
30	9.94	6.99	4.01
35	9.90	6.98	4.02
40	9.85	6.97	4.03

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Once the pH and temperature readings stabilize, highlight Accept Calibration and press enter to accept the first calibration point. The message line will then display “Ready for point 2”. Place the sensor in the second buffer solution. The instrument should automatically recognize the second buffer value and display it at the top of the screen. Once the pH and temperature readings stabilize, highlight Accept Calibration and press enter to confirm the second calibration point.

The message line will then display ‘Ready for point 3’ and you can continue with the 3rd calibration point. Press **Cal** to finalize the calibration and to allow the instrument to update the pH offset and slope. The actual readings displayed during the calibration will NOT reflect the updated calibration information. These values will not change until Cal is pressed to finalize the calibration and to update the instrument.

Record the pH millivolts for each calibration point. The acceptable mV outputs for each buffer are shown below.

pH 7 mV value = 0 mV +/- 50 mV

pH 4 mV value = +165 to +180 from 7 buffer mV value

pH 10 mV value = -165 to -180 from 7 buffer mV value

A value of +50 or -50 mVs in buffer 7 does not indicate a bad sensor.

The mV span between pH 4 and 7 and 7 and 10 mV values should be $\approx$ 165 to 180 mV. 177 is the ideal distance. The slope can be 55 to 60 mV per pH unit with an ideal of 59 mV per pH unit.

If the mV span between pH 4 and 7 or 7 and 10 drops below 160, clean the sensor and try to recalibrate.

For each calibration point, record: Calibration value, Actual Value & Temperature.

After accepting a good calibration, navigate to the GLP file and check the pH Slope and Slope % of ideal. A good slope should be between 55 and 60 mVs while the ideal is 59 mV. If the slope drops below 53, the sensor should be reconditioned and recalibrated.

Rinse the probe several times with deionized water.

Typical working life for pH sensors is approximately 12-24 months depending on usage, storage, and maintenance. Proper storage and maintenance generally extends the sensor's working life. Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces or when the sensor's response slows. BE VERY CAREFUL – the glass bulb is fragile. The cleaning can be chemical and/or mechanical. Periodically, if necessary, removing the sensor from the cable may make cleaning easier. Initially, use clean water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb and/or platinum button. Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor. When using a cotton swab, be careful NOT to

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wedge the swab between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress. You can also use a pipe cleaner for this operation if more convenient.

If good pH and/or ORP response is not restored, perform the following additional procedure:

1. Soak the sensor 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 sensor in clean water, wipe with a cotton swab saturated with clean water, and then rerinse with clean water.

If good pH and/or ORP response is still not restored, perform the following additional procedure:

1. Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). Be sure to follow the safety instructions included with the acid.
2. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water (not DI water), and then rerinse with clean water.

To be certain that all traces of the acid are removed from the sensor crevices, soak the sensor in clean water for about an hour with occasional stirring.

If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the sensor for approximately 1 hour in a 1:1 dilution of commercially-available chlorine bleach.
2. Rinse the sensor with clean water and then soak for at least 1 hour in clean water with occasional stirring to remove residual bleach from the junction. (If possible, soak the sensor for a period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then rerinse the sensor with clean water and retest.

Dry the port and sensor connector with compressed air and apply a very thin coat of o-ring lubricant to all o-rings before reinstallation.

YSI Pro Plus DO Calibration and Maintenance

Change the membrane and calibrate the DO sensor and approximately once a month with regular field use.

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For both ease of use and accuracy, YSI recommends performing the following 1-point DO % water saturated air calibration. It is not necessary to calibrate in both % and mg/L or ppm. Calibrating in % will simultaneously calibrate mg/L and ppm and vice versa.

The supplied sensor storage container (screw on plastic cup for the dual-port and Quatro cables) can be used for DO calibration purposes.

Moisten the sponge in the storage sleeve or plastic cup with a small amount of clean water. The sponge should be clean since bacterial growth may consume oxygen and interfere with the calibration. If using the cup and you no longer have the sponge, place a small amount of clean water (1/8 inch) in the plastic storage cup instead.

Make sure there are no water droplets on the DO membrane or temperature sensor. Then install plastic cup over the sensors. If using the cup, screw it on the cable and then disengage one or two threads to ensure atmospheric venting. Make sure the DO and temperature sensors are not immersed in water. Turn the instrument on and wait approximately 5 to 15 minutes for the storage container to become completely saturated and to allow the sensors to stabilize.

Press the CaL icon. Highlight DO % and press enter to confirm. The instrument will use the internal barometer during calibration and will display this value in brackets at the top of the display. Highlight Barometer and press enter to adjust it if needed. If the barometer reading is incorrect, it is recommended that you calibrate the barometer. Note - the barometer should be reading “true” barometric pressure (see Barometer section for more information on “true” barometric pressure). If the value is acceptable, there is no need to change it or perform a barometer calibration.

The Salinity value displayed near the top of the screen is either the salinity correction value entered in the Sensor menu or the Salinity value as measured by the conductivity sensor in use and enabled. If you are not using a conductivity sensor, the Salinity correction value should be the salinity of the water you will be testing. Highlight Salinity and press enter to modify this setting if necessary. See the Salinity Correction section of the user manual for more information.

Wait for the temperature and DO% values under “Actual Readings” to stabilize, then highlight Accept Calibration and press enter to calibrate. Or, press Esc to cancel the calibration. Press the CaL icon to complete the calibration. The message line at the bottom of the screen will display “Calibrating Channel...” and then “Saving Configuration...”. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select ‘No’ and investigate what is causing the questionable results. If you accept a questionable calibration, your DO readings will be erroneous. Typical causes of a calibration error message include: incorrect sensor, membrane or port setup in the instrument, incorrect barometric pressure information, a bad membrane or a sensor that needs reconditioned. Figure 6-1 can be used to determine what the dissolved oxygen saturation should be at a given temperature.

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Nomogram for Determining Saturation of Oxygen at Different Temperatures

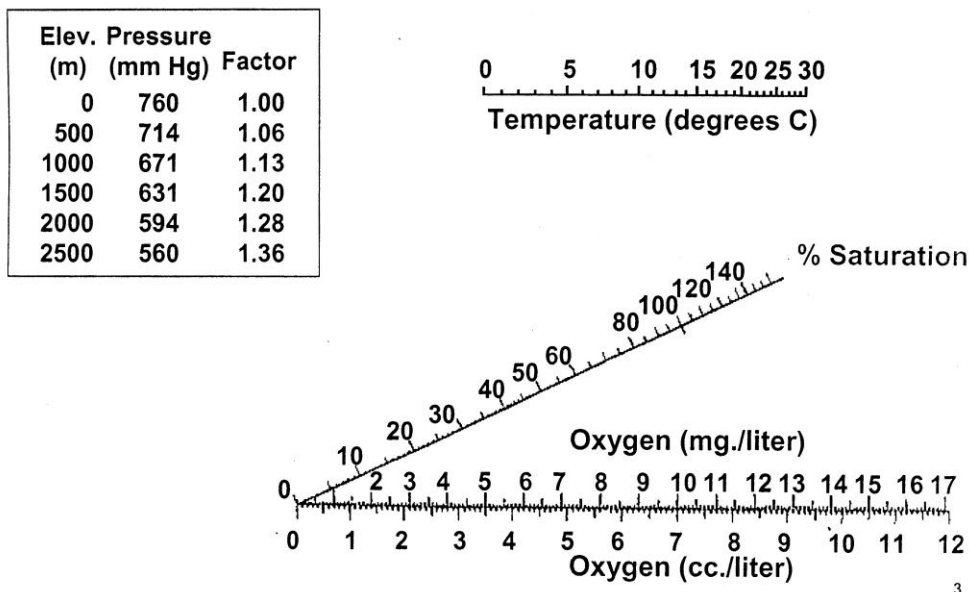


Figure 6-1: Dissolved Oxygen Nomogram

After accepting the calibration, navigate to the GLP menu and record the DO sensor's value (sensor current in uA). The acceptable sensor currents when calibration is performed at 25°C, in a 100% saturated air environment at 760 mmHg are:

1.25 mil PE membrane (yellow membrane): Average 6.15 uA (min. 4.31 uA, max. 8.00 uA)

Rinse the probe several times with deionized water.

Maintenance of YSI Pro Plus Polarographic Sensors - Model # 605203

The KCl (potassium chloride) solution and the membrane cap should be changed at least once every 30 days during regular use. In addition, the KCl solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible on the membrane; and (c) if the sensor shows unstable readings or other sensor-related symptoms.

During membrane changes, examine the gold cathode at the tip of the sensor and the silver anode along the shaft of the sensor. If either the silver anode is black in color or the gold cathode is dull,

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the sensor may need resurfaced using the fine sanding disks included in the membrane kit. Do not sand the electrode every membrane change as this is not routine maintenance. In fact, visually, the anode may appear tarnished and operate just fine. YSI recommends using the 400 grit wet/dry sanding disks to resurface the electrodes if the sensor has difficulty stabilizing or calibrating after a membrane change. To resurface the sensor using the fine sanding disk, follow the instructions below.

For correct sensor operation, the gold cathode must be textured properly. It can become tarnished or plated with silver after extended use. Never use chemicals or abrasives not recommended or supplied by YSI. First dry the sensor tip completely with lens cleaning tissue. Wet a sanding disk with a small amount of clean water and place it face up in the palm of your hand. Next, with your free hand, hold the sensor in a vertical position, tip down. Place the sensor tip directly down on the sanding disk and twist it in a circular motion to sand the gold cathode. The goal is to sand off any build-up and to lightly scratch the cathode to provide a larger surface area for the O₂ solution under the membrane. Usually, 3 to 4 twists of the sanding disk are sufficient to remove deposits and for the gold to appear to have a matte finish. Rinse thoroughly and wipe the gold cathode with a wet paper towel before putting on a new membrane cap. If the cathode remains tarnished, contact YSI Technical Support or the Authorized dealer where you purchased the instrument.

After extended use, a thick layer of Silver Chloride (AgCl) builds up on the silver anode reducing the sensitivity of the sensor. The anode must be cleaned to remove this layer and restore proper performance.

Chemical cleaning: Chemical cleaning should be performed as infrequently as possible. First attempt a membrane change and recalibrate. If a new membrane does not resolve the problem, then proceed with cleaning. Remove the membrane cap and rinse the electrodes with deionized or distilled water. Soak the sensing anode section of the sensor in a 14% ammonium hydroxide solution for 2 to 3 minutes or in a 3% ammonia solution overnight for 8-12 hours (most household ammonia cleaners are typically around 3%). Rinse heavily in cool tap water followed by a thorough rinsing with distilled or deionized water. The anode should then be thoroughly wiped with a wet paper towel to remove the residual layer from the anode. You can smell the tip of the sensor to help ensure all the ammonia has been rinsed off. Trapping residual ammonia under the new membrane cap can quickly tarnish the electrode and/or give false readings.

Mechanical cleaning: In order to sand the silver anode along the shaft of the sensor, simply hold the sensor in a vertical position. Wet the sanding disk with a small amount of clean water then gently wrap it around the sensor shaft and twist it a few times to lightly sand the anode (the goal is to simply sand off any build-up without scratching or removing layers of the anode itself). Usually, 3 to 4 twists of the sanding disk are sufficient to remove deposits. However, in extreme cases, more sanding may be required to regenerate the original silver surface.

After completing the sanding procedure, repeatedly rinse the electrode with clean water and wipe with lens cleaning tissue to remove any grit left by the sanding disk. Thoroughly rinse the entire tip of the sensor with distilled or deionized water and install a new membrane.

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IMPORTANT: Be sure to: (1) Use only the fine sanding disks provided and (2) Sand as mentioned in the above procedures. Not adhering to either of these instructions can damage the electrodes. If this procedure is unsuccessful, as indicated by improper electrode performance, contact YSI Technical Support or the Authorized dealer where you purchased the instrument.

To change the membrane, remove the old yellow membrane cap. Thoroughly rinse the sensor tip with distilled or deionized water. Fill a new membrane cap with KCl probe solution. Avoid touching the membrane portion of the cap. Be very careful not to touch the membrane surface. Lightly tap the side of the cap membrane to release bubbles that maybe trapped. Thread the membrane cap onto the sensor, moderately tight. A small amount of electrolyte will overflow.

Be sure there are no air bubbles in the newly installed membrane cap. Screw the sensor guard on moderately tight being careful not to screw it on too tightly. The membrane sensor maintenance requires that this procedure will need to be done approximately every 30 days with regular use, during the calibration schedule if convenient.

YSI Pro Plus Conductivity / Salinity Calibration and Maintenance

Calibrate the Conductivity/Salinity sensor approximately once a month with regular field use. Press the **Cal** icon. Highlight **Conductivity** and press **Enter**. Highlight **Sp. Conductance** and press **Enter**. When calibrating in Sp. Conductance there is no need to change the reference temperature. Place the sensor into a fresh, traceable conductivity calibration solution. The solution must cover the holes of the conductivity sensor that are closest to the cable. Ensure the entire conductivity sensor is submerged in the solution or the instrument will read approximately of half the expected value.

Choose the units in **SPC-us/cm**. If the calibration value does not match the conductivity standard solution value, highlight **Calibration Value** and press **Enter** to input the value of the calibration standard.

If calibrating Specific Conductance, enter the value of the conductivity solution as it is listed for 25°C. Make sure you are entering the correct units: 1 mS = 1,000 uS.

If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your conductivity readings (and your DO mg/L readings) will be erroneous. Typical causes for this error message include: incorrect entries (entering 1000 uS/cm instead of 1.0 mS/cm), not using enough solution to cover the vent holes, air bubbles trapped in the sensor, calibrating in conductivity instead of specific conductance, dirty conductivity electrodes, and/or bad calibration solution.

Then, once the temperature and conductivity readings stabilize, highlight **Accept Calibration** and press **Enter**. Or, press **Esc** to cancel the calibration.

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Press the **Cal** icon to complete the calibration. After completing the calibration, the message line at the bottom of the screen will display “Calibrating Channel...” and then “Saving Configuration...”.

Record the data for: Calibration Value, Actual Value & Temperature

After accepting a good calibration, navigate to the GLP file and check the conductivity cell constant for the calibration. For highest accuracy, the cell constant should be 5.0 ± 0.5 . However, the acceptable range is 5 ± 1.0 . A cell constant outside of this range indicates that a questionable calibration was accepted

Rinse the probe several times with deionized water.

The openings that allow sample access to the conductivity electrodes should be cleaned regularly. The small cleaning brush included in the Maintenance Kit is ideal for this purpose. Dip the brush in clean water and insert it into each hole 10 to 12 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent (laboratory grade soap or bathroom foaming tile cleaner) with the brush. Rinse thoroughly with clean water, then check the response and accuracy of the conductivity cell with a calibration standard. If this procedure is unsuccessful, as indicated by improper electrode performance, contact YSI Technical Support or the Authorized dealer where you purchased the instrument.

YSI Pro Plus Temperature Calibration and Maintenance

Temperature calibration is not required nor is it available. Check the temperature-display thermistor against a certified thermometer over the normal operating range of the instrument, at least three times per year, and note the date checked, findings, and any actions taken (see Table 6-2 for recommendations) in the Meter Log Book. Make the comparison in a water bath to eliminate erratic readings. A NIST-traceable thermometer should have divisions in 0.1 degrees C. In a water bath that is > 5 degrees different than room temperature; all temperature sensors should be close together and at the same depth when checking measurements. This is because a temperature gradient can develop across the bath and can cause a few tenths of a degree difference that is real and not due to temperature sensor error.

If a thermistor reading is off by more than 0.5°C , return the instrument to the manufacturer for repair.

Do not use the automatic temperature compensating function of a pH meter if it has not been checked within the past four months.

Fill in the Temperature box as follows:

- THERMISTOR TEMPERATURE – record temperature in degrees centigrade as displayed on the instrument.

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- CALIBRATION THERMOMETER TEMP °C – record temperature displayed on an NIST certified Thermometer.
- ADJUSTED – circle yes or no if calibration setting was changed or not changed, respectively.
- MAINTENANCE – list any maintenance tasks performed, the date they were performed, and the initials of the person performing them.

Table 6-2. YSI Pro Plus Thermometer Troubleshooting

Symptom	Possible Cause and Corrective Action
Liquid-in-glass thermometer does not read accurately	Check thermometer for separation of liquid – if liquid has separated, take back to the office to reunite the column
Thermistor thermometer does not read accurately	Dirty sensor – remove dirt and oil film Weak batteries – replace with new batteries
Erratic thermistor thermometer readings	Bad or dirty connection at meter or sensor – tighten or clean connections Break in the cables – replace cables Weak batteries – replace with new batteries
Thermistor thermometer slow to stabilize	Dirty sensor – clean sensor to remove dirt and oily film Check the voltage of the batteries - Start with good batteries in instruments and carry spares

The temperature portion of the sensor must be kept free of build up. Otherwise, the sensor requires no maintenance. The conductivity cleaning brush can be used to scrub the temperature sensor if needed. Alternatively, you can use a toothbrush to clean the sensor.

Sontek FLOWTRACKER Calibration and Maintenance

To turn the unit on, hold the yellow button for one second; to turn off, hold the yellow button for four seconds.

Before any extended field trip, you should run a system diagnostics test using the Beam Check module. At the first site, before the first measurement is taken, run the beam check. This software should show signal amplitude plots on top of each other. If not, it is possible the probe may be damaged. A complete description of Beam Check can be found in the manual. Use Recorder to download all files from the recorder and to format it before deployment.

Storage

YSI Professional Plus Short term storage:

The cable assembly is supplied with a storage container, or sleeve, that installs on to the cable. The container is used for short-term storage (less than 30 days). Be sure to keep a small amount of moisture (tap water) in the container during storage. This is done to maintain a 100% saturated air environment which is ideal for short-term sensor storage (see Care, Maintenance, and Storage for more detailed information). Do not submerge the sensors in an aqueous solution. The intent is to create a humid air storage environment.

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YSI Professional Plus Long term storage:

When the ProPlus is not in use for longer than 30 days be sure to remove the batteries to prevent possible corrosion. For long term storage details for specific sensors see individual parameter/sensor type sections in this document.

Long Term Storage of YSI Pro Plus DO Sensors

Dissolved oxygen sensors (Polarographic and Galvanic) should be stored in a dry state for long term storage. First, remove the membrane cap and thoroughly rinse the sensor with clean water. Next, either blow it dry with compressed air or allow to air dry completely. Install a clean, dry new membrane cap over the sensor to keep it dry and to protect the electrodes.

After storing the sensor for a long period of time, it is necessary to “condition” the sensor by putting a new membrane with electrolyte solution on the sensor and then turning the instrument on to allow the sensor sufficient time to stabilize.

Recommended Long-term Storage Temperature: -5 to 70°C (23 to 158°F)

YSI Pro Plus Conductivity Sensor Long Term Storage

No special storage is required. Sensors can be stored dry or wet as long as solutions in contact with conductivity electrodes are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to and after long term storage.

Long-term Storage Temperature: -5 to 70°C (23 to 158°F)

YSI Pro Plus Thermistor Long Term Storage

No special storage is required. The temperature sensor can be stored dry or wet as long as solutions in contact with the thermistor are not corrosive (for example, chlorine bleach).

Recommended Long-term Storage Temperature: -5 to 70°C (23 to 158°F)

Long Term Storage of pH sensors:

To store the sensor, remove it from the cable and seal the vacant port with a port plug (black with white O rings). Fill the original shipping/storage vessel (plastic boot or small bottle provided) with buffer4 solution and then submerge the sensor into the solution. The sensor should remain submerged in the solution during the storage period; therefore, make certain that the vessel is sealed to prevent evaporation and periodically check the vessel to ensure the sensor does not dry out.

1. Unscrew the grey pH probe from the unit.
2. Plug the vacant port with a port Plug (black with white O rings).

NCRN Water Chemistry & Quantity Monitoring: Field Equipment Preparation Standard Operating Procedures #6

3. Fill the bottle with pH 4 buffer solution, unless it is already filled with fairly fresh solution.
4. Hold the grey pH sensor upright with glass globe facing upward. Place the white cap (with hole in it) on the sensor face down. Place the black O ring into the cap.
5. Push the cap down the sensor midway.
6. Turn the probe over and submerge into the plastic bottle with pH4 solution.
7. Screw on tightly, preventing evaporation.
8. Check it periodically to be sure the solution is not evaporating.

The key to pH sensor storage, short or long-term, is to make certain that the sensor does not dry out. Sensors which have been allowed to dry out due to improper storage procedures may be irreparably damaged by the dehydration and will require replacement. You can try to rehydrate the sensor by soaking it (preferably overnight) in a potassium chloride solution or a pH 4 buffer before attempting to calibrate.

Recommended Long-term Storage Temperature: 0 to 30°C (32 to 86°F)

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

Revision History Log:

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

1. Purpose

The purpose of this Standard Operating Procedure (SOP) is to locate water sampling sites on maps and in the field, and then document their locations.

2. Scope and Applicability

This procedure can be used to locate sampling sites for all surface water protocols.

3. Reference Documents

SOP- GPS Specifications
SOP – GIS Specifications
NCRN Inventory and Monitoring Sampling Design

4. Procedures and General Requirements

Locate stream reaches (using geographic information system [GIS] maps).

Select segments to be sampled from the selected reaches and provide the following:

- list of primary and alternate sites with topographic map showing those sites
- directions to closest road to the sites
- order in which stream reaches are to be sampled
- description of probable difficulty of access
- time/distance between sample sites and number to be sampled in a day

Visit the site and determine safety and sample-ability of the segment, avoiding:

- a dry stream bed
- obvious tidal influence
- unsafe velocities/depths, road culverts, etc., or other dangerous flow condition
- if the site is inaccessible during parts of the year
- sites directly above or below confluences or point sources to minimize problems with backwater or poorly mixed flows

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

Determine station coordinates using a GPS receiver (see SOP - GPS Specifications) - Station/sampling site coordinates in degrees, minutes, seconds, and fractions of seconds of latitude and longitude should be determined as accurately as practically feasible using topographic quadrangles or by digitizing from maps using GIS.

Record on the field data sheet the stream width at the upstream and downstream boundaries and site location information.

Current sampling locations are listed in Table 1-1. For route classification purposes (and simplification) Minnehaha Creek (formerly under the GWMP route) and Palisades Creek (formerly under the ROCR route) have been incorporated under the CHOH domain. This reclassification is due to the fact neither stream shares a direct interaction with their previous assignments. Minnehaha Creek lies in Montgomery County, MD across the Potomac River from all other GWMP sites. Palisades Creek is the only ROCR site that has no interaction with Rock Creek. However, both of these streams share interaction with the Chesapeake and Ohio Canal (CHOH) and thusly have been incorporated under this domain.

Table 1-1: Sampling Locations by Park and 4-letter stream identification code.

ANTI	Sharpsburg Creek (shck)
CATO	Big Hunting Creek (bghc) Owens Creek (owck) Whiskey Still Creek (whst)
“CHOH”	Minnehaha Creek (micr) Battery Kemble (bake) [formerly Palisades Creek (pacr)]
GWMP	Mine Run (miru) Pimmit Run (piru) Turkey Run (turu)
HAFE	Flowing Springs Run (flsp)
MANA	Young’s Branch (yobr)
MONO	Bush Creek (buck) Gambrill Mill (gami) [formerly Visitor Center Creek (vcck)]
NACE	Accokeek Creek (acck) Henson Creek (hecr) Oxon Run (oxru) Still Creek (stck)
PRWI	Carter’s Run (caru) Mary Bird Branch (mbbr) Mawavi Run (maru) Middle Branch Chopawamsic Creek (mbch) New Site 1 (new1) (to be renamed later) North Branch Chopawamsic Creek (nobr) North Fork Quantico Creek (nfqc) Orenda Run (orru) South Fork Quantico Creek (sfqc) Sow Run (soru) Taylor Run (tafs)
ROCR	Broad Branch (brbr) Dumbarton Oaks Park Stream (duoa)

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	Fenwick Branch (febr) Hazen Creek (hacr) Klinge Valley (klva) Luzon Branch (lubr) Normanstone Creek (nost) Pinehurst Branch (phbr) Piney Branch (pybr) Rock Creek (below Dumbarton Oaks) (roc3) Soapstone Valley Park Stream (svps)
WOTR	Courthouse Creek (chck) Wolf Trap Creek (wotr)

5. Sampling Routes

The following sampling routes have been established. They are monitored on the same day to streamline the sampling process and due to connections that exist.

ROCR – Rock Creek Park stands alone as it possesses the most sites (10)

MANA/PRWI – This association was created due to the close proximity these parks have to one another.

NACE – National Capital Parks – East stands alone due to large distances that are traveled in between sampling sites

GWMP/WOTR – This route was created due to the close proximity these parks have to one another, and due to the fact all sites at Wolf Trap lie within the Difficult Run Watershed, as do 2 sites at GWMP (miru & turu).

MONO/CATO/HAFE/ANTI/CHOH – This route was created to limit the number of times traveling the I-270/I-70 corridors. It creates a really long day.

6. Directions

ROCR (Rock Creek Park - HQ – 3545 Williamsburg Lane NW, Washington, DC 20008)

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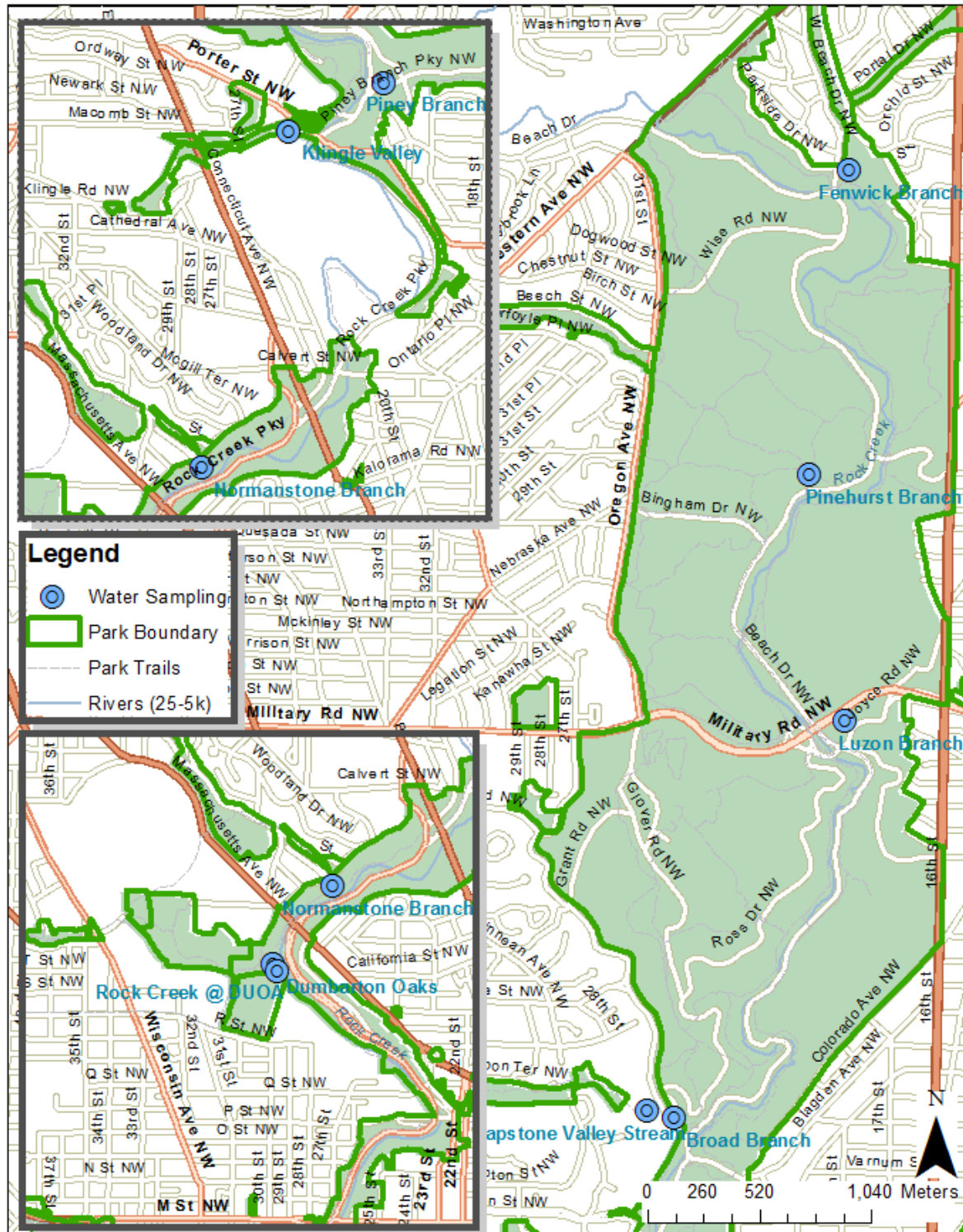


Figure 7-1: Sampling Site Locations in Rock Creek Park

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

To Fenwick Branch (febr)

Make a left onto MacArthur Boulevard NW
At the light, make a left to continue along MacArthur Blvd
Make a right just past the firehouse onto Whitehaven Parkway NW
At the light, make a left onto Foxhall Road NW
At the end of the road, make a right onto Nebraska Avenue NW
Continue straight through Ward Circle and Tenley Circle
At the end of the road, make a left onto Oregon Avenue NW
Make a right onto Wise Road NW
At the stop sign, make a left onto Beach Drive NW
Merge right onto West Beach Drive NW
Pull off just past the stop sign
Hike down the trail and cut through the woods
Site is located at the beginning of straightaway in the stream

To Pinehurst Branch (phbr)

Make a left onto West Beach Drive NW
At the stop sign, make a left onto Beach Drive NW
Make a left into Picnic Area 8
Hike along Beach Drive to culvert
Take trail back into woods
Site is located at the horse trail crossing

To Luzon Branch (lubr)

Exit Picnic Area 8, making a left onto Beach Drive NW
At the stop sign, make a left onto Joyce Road NW
At the large patch of green to your left, make a U-turn into it and park
Site is located just downstream of storm drain, next to Military Road NW

To Soapstone Valley Park Stream (svps)

Continue along Joyce Road NW
At the stop sign, make a left onto Beach Drive NW
At the next stop sign, make a right onto Broad Branch Road NW
Immediately make a right onto Ridge Road NW
Park in parking area to the right
Cross Broad Branch Road NW to Soapstone Valley Trail
Site is located downstream of trail crossing, at the start of the concrete retaining wall

To Broad Branch (brbr)

Backtrack down Soapstone Valley Trail
Enter creek just downstream of confluence with Soapstone Valley Creek
Site is located ~ 25 meters upstream of Ridge Road bridge crossing

To Hazen Creek (hacr) [Melvin Hazen Valley Branch]

Make a U-turn to head back along Ridge Road NW
At the stop sign, make a left onto Broad Branch Road NW

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

Merge right onto Beach Drive NW
Stay right to continue along Beach Drive
At the light, make a right onto Tilden Street NW
After crossing the bridge, make a left onto Shoemaker Street NW
Immediately make a left into the parking lot for Picnic Grove 1
Hike along the path to the bridge
Site is located just downstream of footbridge

To Piney Branch (pybr)

Exit the parking lot, making a right onto Shoemaker Street NW
At the stop sign, make a right onto Tilden Street NW
At the light, make a right onto Beach Drive NW
At the stop sign, make a left onto Piney Branch Parkway NW
Pull off to the right, just before the clearing to your left
Site is located at the break in the trees (end of clearing, start of trees)

To Picnic Grove 29

Return to road from pull off
Continue along Piney Branch Parkway NW
Picnic Grove will be to your left before you reach 16th Street overpass
Make a u-turn and park along picnic grove parking area
Site is located about 50 meter to the North-Northwest from parking area, surrounded by fencing

To Klinge Valley (klva)

Return to road from parking area
Continue along Piney Branch Parkway NW towards Beach Drive
At the stop sign, make a left onto Beach Drive
Merge right onto Klinge Road NW, and stay left
Pass under Porter Street NW, and continue to end of road
Make a u-turn, and stay to the right onto access road
Park halfway down the access road
Site is located directly next to the vehicle (look for large tree stump to step down)

To Normanstone Creek (nost)

Continue along access road and pass under Klinge Road NW
Make an illegal left turn onto the Porter Street NW exit ramp
At the stop sign, merge left onto Porter Street NW
Move into the left lane as you approach the two (2) consecutive stop lights
Make a left onto Connecticut Avenue NW (after the gas station light)
Continue along Connecticut Ave past the National Zoo
Make a right onto Calvert Street NW
Make a left at the second (2nd) intersection, onto 28th Street NW
Continue around the sharp right curve
At the fork in the road, take the left fork onto Rock Creek Drive NW
Make the sharp right onto Normanstone Drive NW
Park along the row of hedges

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

Follow the trail (on your left) down to the bridge
Site is located just upstream of the bridge

To Dumbarton Oaks (duoa) and Rock Creek (roc3)

Continue along Normanstone Drive NW to the stop sign
Make a left onto Rock Creek Drive NW
Continue around the sharp curve to the right, along Rock Creek Drive NW
At the stop light, make a left onto Massachusetts Avenue NW
(Lane assignments will vary along this stretch due to the concentrated presence of foreign embassies, so it is best to simply remain in the left lane, even though you'll need to be in the right lane)
As you approach Sheridan Circle, try to maneuver into the right lane
Travel one-quarter (1/4) the way around the circle and exit right onto 23rd Street NW
At the stop light, make a right onto Q Street NW (the bridge to the left of the buffalo)
Continue through the first stop sign
At the second (2nd) stop sign, make a right onto 28th Street NW (retarded isn't it)
At the stop sign, make the left onto R Street NW
Continue through a couple of stop sign
Make a right just past the tennis courts onto the access road (it's gated, so stop)
Continue down the road to the parking area where the road runs out
Travel down the trail toward Rock Creek
Site duoa is located ~ 20 meters upstream of its confluence with Rock Creek
Site roc3 is located ~ 50 meters downstream of its confluence with Dumbarton Oaks (logjam)

To CUE

Backtrack along the access road to the gate (please lock if lock is present)
Make a right onto R Street NW
At the stop light, make a left onto Wisconsin Avenue NW
At the stop light, make a right onto Reservoir Road NW
Continue along Reservoir Road NW past Georgetown University Hospital
At the stop light, make a left onto Foxhall Road NW
Just past Jetties (get to know it) make a right onto Q Street NW (again, retarded)
At the stop light, make a right onto MacArthur Boulevard NW
Just before the large opening, make a left onto Eliot Place NW
Make an immediate right onto CUE's driveway

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

MANA (Manassas National Battlefield Park)

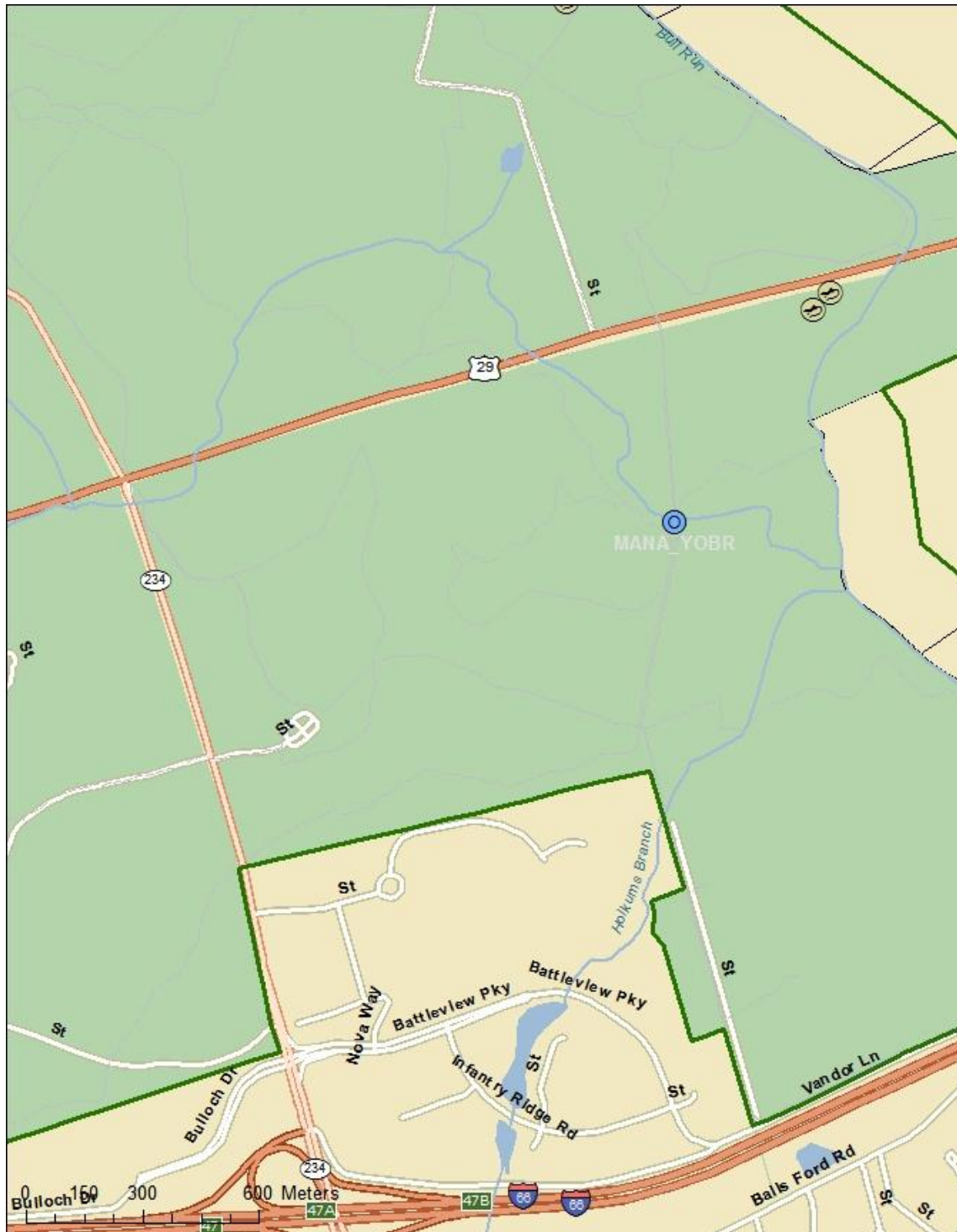


Figure 7-2: Sampling Site Location in Manassas National Battlefield Park

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To I-66 West from CUE

Right on MacArthur Blvd.
On Canal Road, stay in Left Lane
Turn right onto Key Bridge, stay in right lane
Turn right onto Lee Highway (US-29) northbound (right at 2nd light)
Get in the left lane and continue
Merge left onto 66 West

To Youngs Branch (yobr)

Continue to Exit 47B, Route 234 Business North
Merge onto Sudley Road (Rt. 234 B) and travel in the center lane through the light
Continue past NVCC-Manassas and the MANA visitor Center
Turn right onto Lee Highway/Warrenton Turnpike (US-29)
Continue for approximately 1.5 miles, past the sign for MANA Law Enforcement
Pull off of US-29 onto large graveled area just past this sign
Hike along the First Manassas Trail
Site is located just upstream of road crossing

PRWI (Prince William Forest Park)

Important information: Call Base Scheduling/Range Control before leaving out if accessing mbch/nobr

To PRWI from MANA

Make a left onto US Route 29 from the parking area (blind corner, be careful)
Continue straight through the stoplight
Make a left onto Groveton Road (2nd left past large pond to our left)
Continue over Interstate 66
At the stop sign, make a right onto Balls Ford Road
At the stop light, make a left onto the Route 234 Bypass, Ronald Wilson Reagan Memorial Highway
Continue along here for a number of miles, it will turn into Dumfries Road
As you pass the landscaping company to your left, get into the right lane
At the stop light, make a right onto Independent Hill Road
At the stop sign, make a left onto Dumfries Road (soon to be renamed)
Before the Citgo Station, make a right onto Joplin Road
Continue straight through the stop sign, past Independent Hill (PRWI land is to your left)

To Middle Branch Chopawamsic Creek (mbch) (MB key) (Call Range Control)

Continue south along Rt. 619 (Joplin Road)
Continue past Mawavi Road (to the right) and Cabin Camps 2 & 5
Make the 1st left onto the Bellefaire Crossroads (large locked gates)
Proceed through gate, ensuring it is locked properly
At the stop sign, make a left onto MCB-1 South
Pull off at the 1st right you come to (Blackrock Road) and park
Site is located across the road, just downstream of the road crossing

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To North Branch Chopawamsic Creek (nabr)

Make U-turn and head northbound on MCB-1

Continue for approximately .5 miles

Pull off road just past the USGS Gauging Station

Site is located just downstream of the road crossing

To Mawavi Run (maru) (NB key)

Continue northbound on MCB-1

Veer right at fork, towards gate at Bellefair Crossroads

Proceed through gate, ensuring it is locked properly

Make right onto Joplin Road (Rt. 619) southbound

Make a left onto Mawavi Road, towards Cabin Camp #2

Merge left at the fork in the road

Stay left at the next fork in the road and proceed through the gate (closed during winter)

Site is located at the first bridge you come to (a water tower is just past this site)

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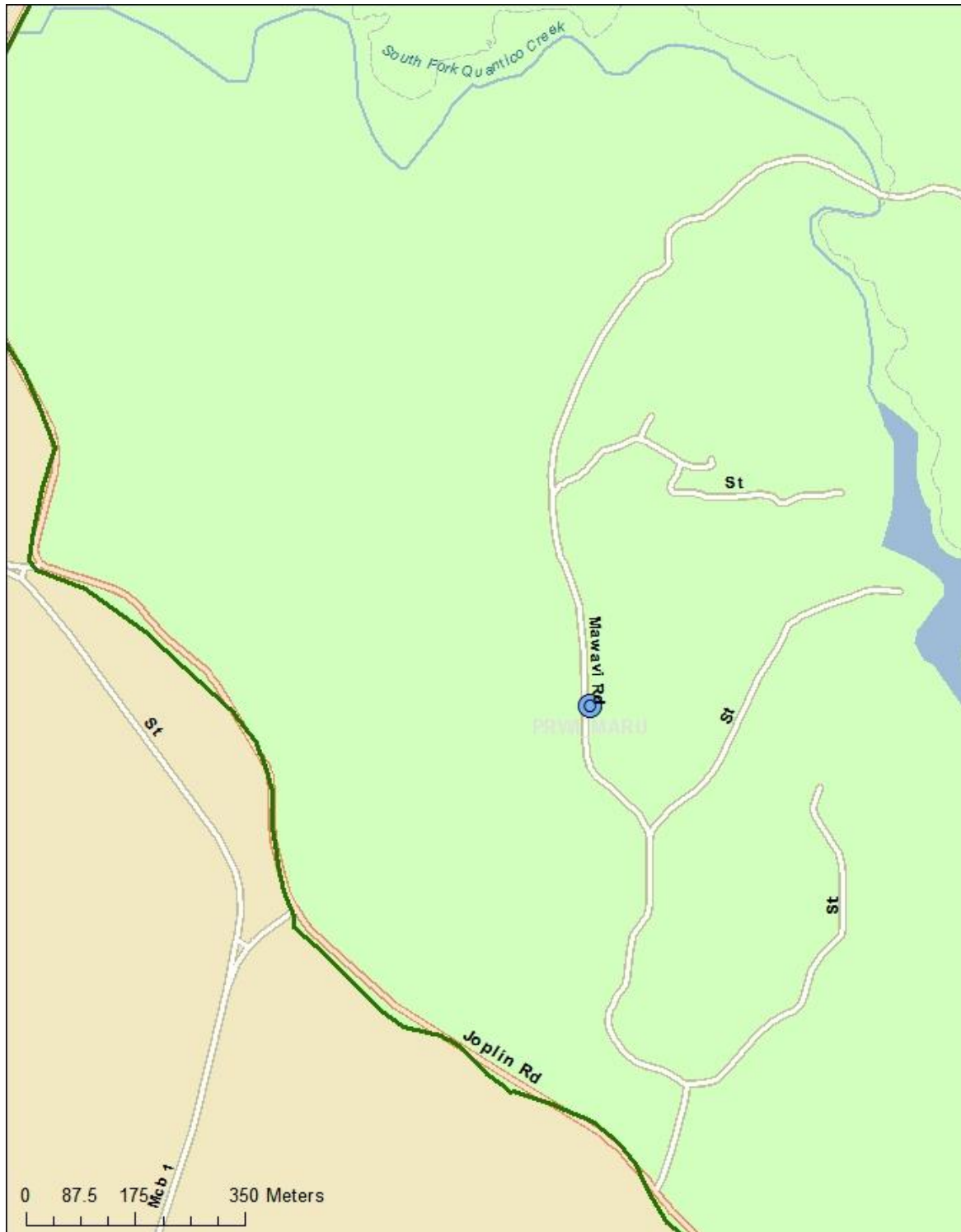


Figure 7-3: Mawavi Run Sampling Site Location in Prince William Forest Park

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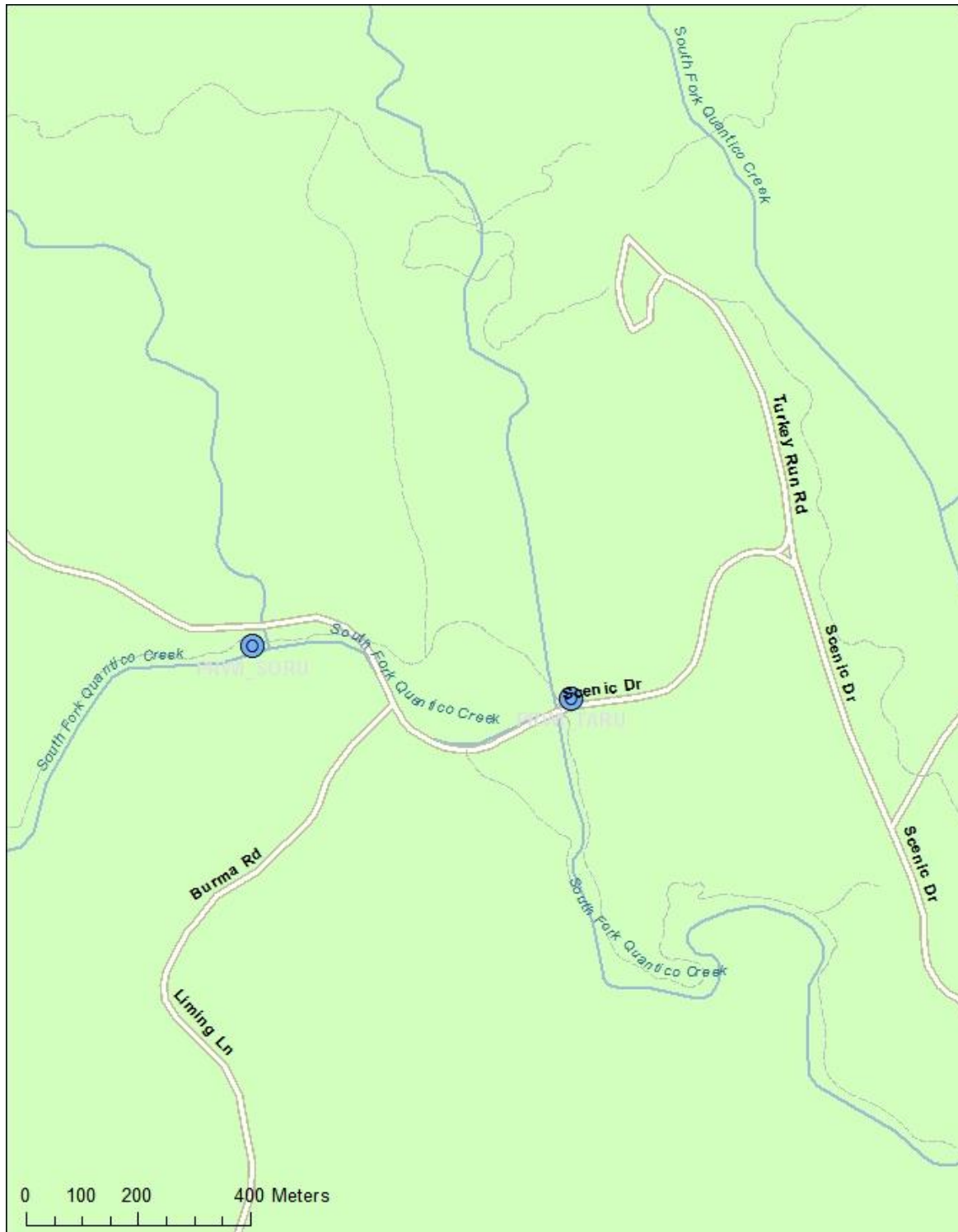


Figure 7-4: Taylor Run and Sow Run Sampling Site Locations in Prince William Forest Park

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

Taylor Run (taru)

Turn around at the entrance to the water tower and head south along Mawavi Road
Proceed through the gate and stay right at the fork
Merge right at the next fork in the road
Make a left onto Joplin Road (Rt. 619) southbound
Continue for approximately 4 miles
Make a left onto Park Headquarters Road
Merge right at the fork in the road
Merge left at the next fork in the road
Make a left at the stop sign
Make a left at intersection of Scenic and Scenic (just past Parking Lot C)
Pull off after passing South Fork Quantico Creek at a suitable location
Hike back up the road and down the steep hill to South Valley Trail on river left side
Site is just before stream enters culvert

To Sow Run (soru)

Return to road
Continue along Scenic Drive passing South Fork Quantico Creek a second time
Pull off the road just before the large incline

To North Fork Quantico Creek (nfqc) (NB key)

Make a U-turn to head back the direction you came
Continue along Scenic Drive until stop sign
Make a left onto Scenic Drive
Continue along past 1st right turn and Parking Lot D
Make a right onto Pyrite Mine Road (just past Parking Lot D)
Continue down road for 1.1 miles
Park just before trailhead for South Valley Trail (50 meters before bridge)
Site is located under the bridge

To South Fork Quantico Creek (sfqc)

Hike down South Valley Trail from trailhead where parked
Continue for 0.1 miles
Site is located where numerous large bedrocks emerge from the stream

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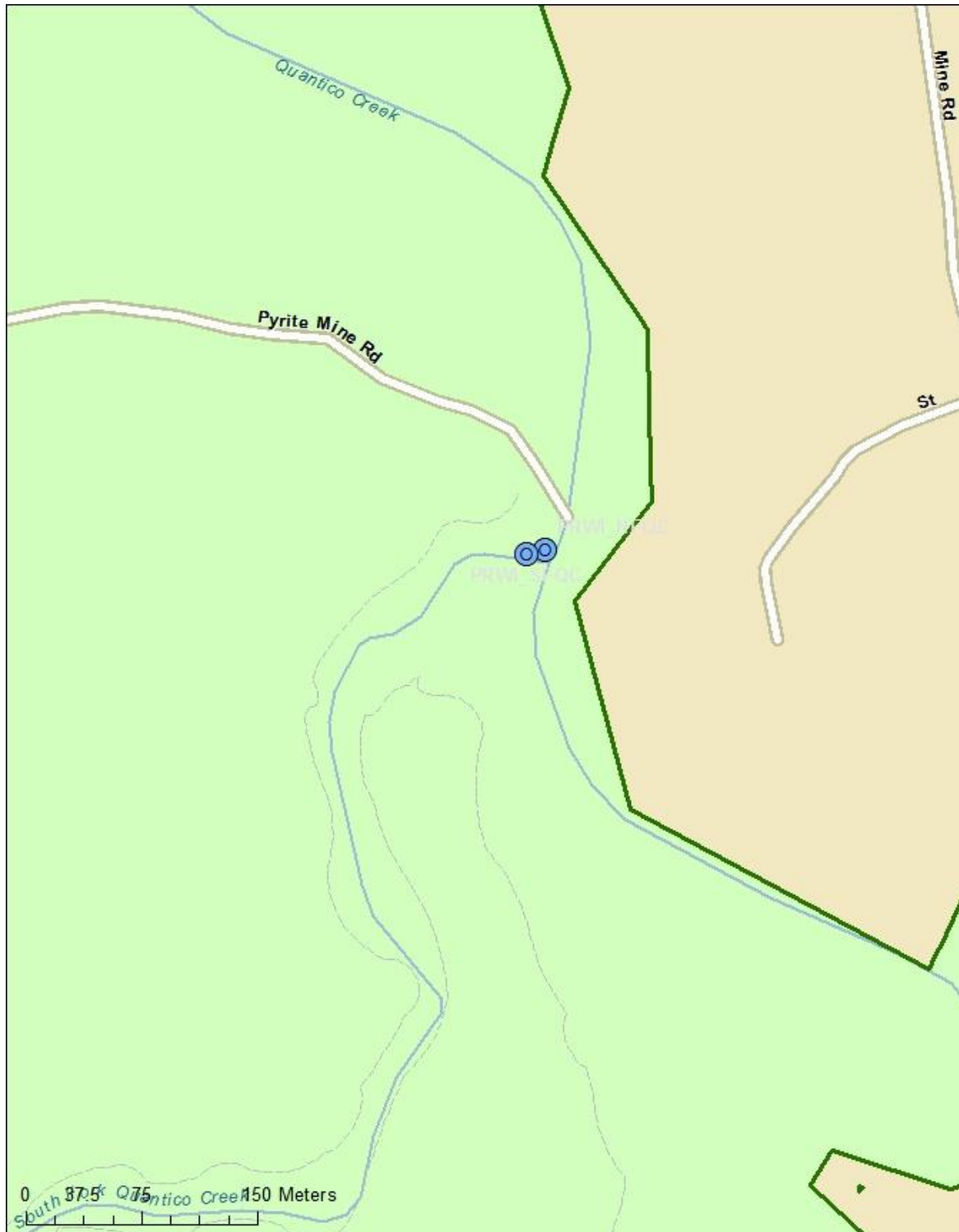


Figure 7-5: South Fork Quantico Creek and North Fork Quantico Creek Sampling Site

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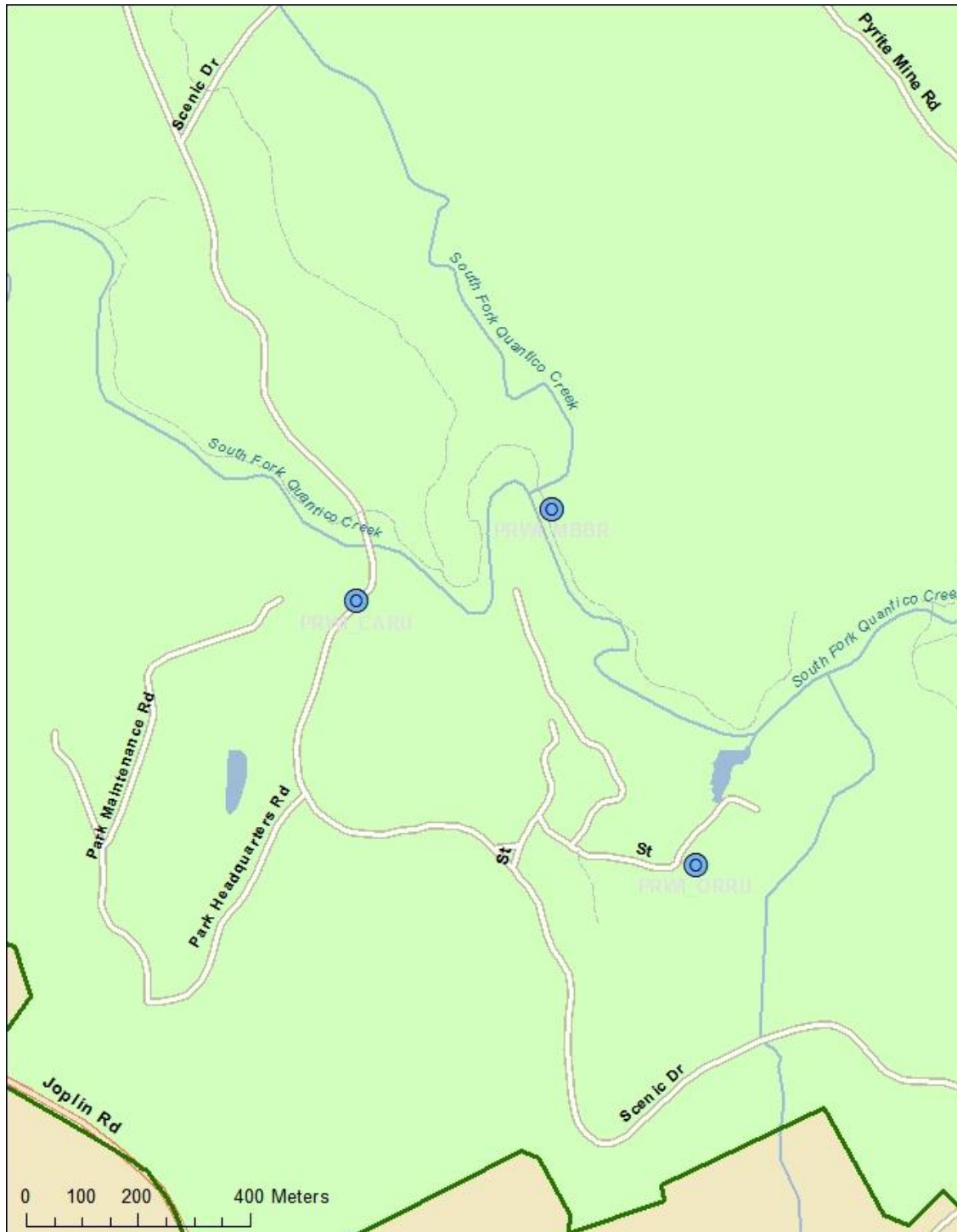


Figure 7-6: Mary Bird Branch, Carter's Run, New Site1 and Orenda Run Sampling Site Locations in Prince William Forest Park

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

To Mary Bird Branch (mbbr)

Return to vehicle

Reverse up the hill

At the top of the hill there is an area to turn around in (Mine shaft vent and cap is here)

Continue along Pyrite Mine Road to Scenic Drive

At intersection with Scenic Drive make left turn onto Scenic (though illegal)

Continue along Scenic Drive for approximately 1 mile

Park in Parking Lot A (on right side of road)

Travel down towards the Scenic Bridge and take South Valley Trail to the left

Hike along the trail for about 0.5 miles, climbing a large incline

On the other side of the incline, Mary Bird Branch should be in field of view

The site is located about 30 meters upstream of the bridge on the trail

To Carters Run (caru)

Return to Scenic Drive, hiking back along South Valley Trail

Cross the Scenic Bridge

Carter's Run flows along roadside to the right (south) side

Site is located 100 meter upstream of confluence with South Fork

To New Site 1 (new1)

Cross over Scenic Drive heading in a Northeasterly direction

Follow the stream down to the site, which is approx. 100 meters away from the road

To Orenda Run (orru) (MB key – 1st gate; NB key – 2nd gate)

Return to vehicle at Parking Lot A and head towards exit

Continue along Scenic Drive, merging right at the fork in the road

Make the 2nd or 3rd right you come to, into Cabin Camp #3 (1st gate)

Continue through the gate and make a left into the parking lot

Continue through the parking lot and head towards the left (2nd gate)

Continue through the gate and merge right at the fork in the road

Site is located just downstream of the sediment house

To CUE from PRWI

Return to Scenic Drive (lock gates behind you if you unlocked them)

Make a right onto Scenic Drive

Merge left at the fork in the road

Merge left at the next fork in the road

Make a left at the stop sign onto Park Headquarters Road

Make a left at the stop sign onto Joplin Road (Rte. 619)

Head along Scenic Drive making a right out of Parking Lot A

Travel under Interstate 95 and make an immediate left onto the northbound ramp

Continue along I95 North to the Springfield Interchange

At the interchange, be in either the center or center-right lane to continue heading north

Merge (stay in these lanes) onto Interstate 395

Take Exit 8B for Rt. 27 (Washington Boulevard)

Stay left through two forks in the road

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Merge right briefly onto Memorial Drive
Merge immediately right onto the Arlington Memorial Bridge
Merge right briefly onto Lincoln Memorial Circle SW
Merge immediately right onto entrance ramp to Ohio Drive SW
Merge onto Ohio Drive SW and remain in the right lane
Take the middle of the fork onto the Potomac River Freeway N
Make way to second from the right lane
Take the left exit for the Whitehurst Freeway (K Street NW)
Pass under the Key Bridge
Make a left onto Canal Road NW
Continue straight onto Foxhall Road NW
Make a left onto MacArthur Boulevard NW

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

NACE (National Capital Parks – East)

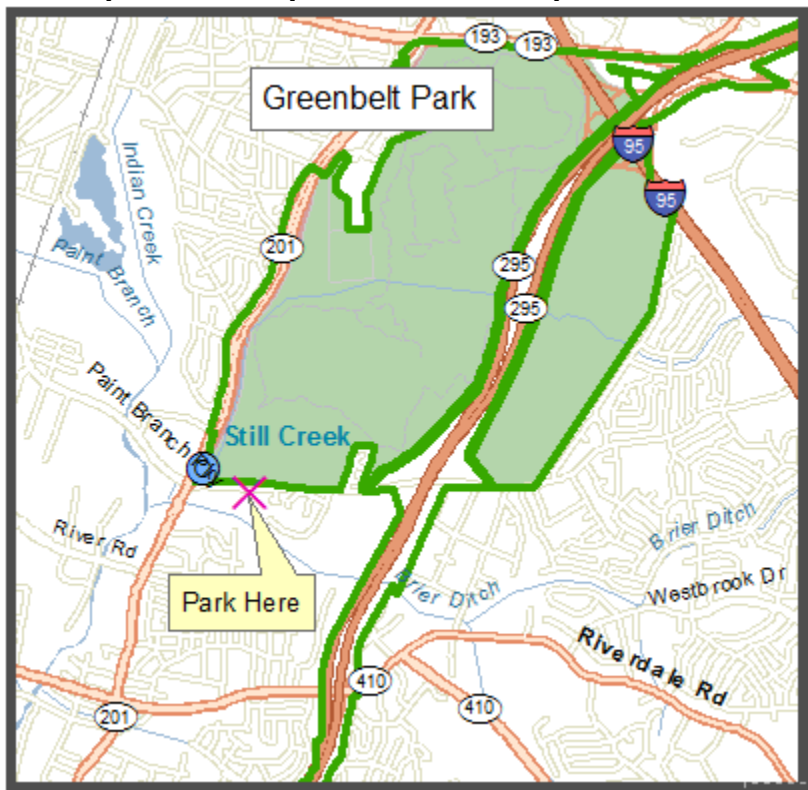


Figure 7-7: Still Creek sampling site location in Greenbelt Park, NACE

To Still Creek (stck) from CUE

Make a right onto MacArthur Boulevard NW
 At the 2nd light, make a right onto Foxhall Road NW
 Continue straight through the next light onto Canal Road NW, and make way into right lane
 Exit right onto Rt. 29 (Whitehurst Freeway)
 Exit right onto Potomac River Freeway S
 At the stop sign, continue straight onto Ohio Drive SW
 Merge left onto Independence Avenue SW, at the fork in the road
 Continue along Independence and make way into right or center lane
 Exit right onto Maine Avenue SW
 Exit left onto Interstate 395 (Southwest Freeway)
 Stay left and merge onto Interstate 295 (Southeast Freeway)
 Continue along SE Freeway in the center lane to end
 Merge right onto Pennsylvania Avenue SE
 Cross John Philip Sousa Birdge and make way to far left lane
 At the light, make a left and merge onto Rt. 295 (Anacostia Freeway)
 Anacostia Freeway turns into Kenilworth Avenue NE
 Stay left and merge left onto the Baltimore-Washington Parkway (Rt. 295)

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Continue along the BW Parkway
Take the exit for Rt. 410 (Riverdale Road)
Make a left at the light onto Riverdale Rd
Make a right onto Rt. 201 (Kenilworth Avenue)
Make a right onto Good Luck Road
Make a right into the church parking lot
Sprint across the six (6) lanes into Greenbelt Park
Hike along the creek heading upstream
Site is located just downstream of gabion wall and massive erosion

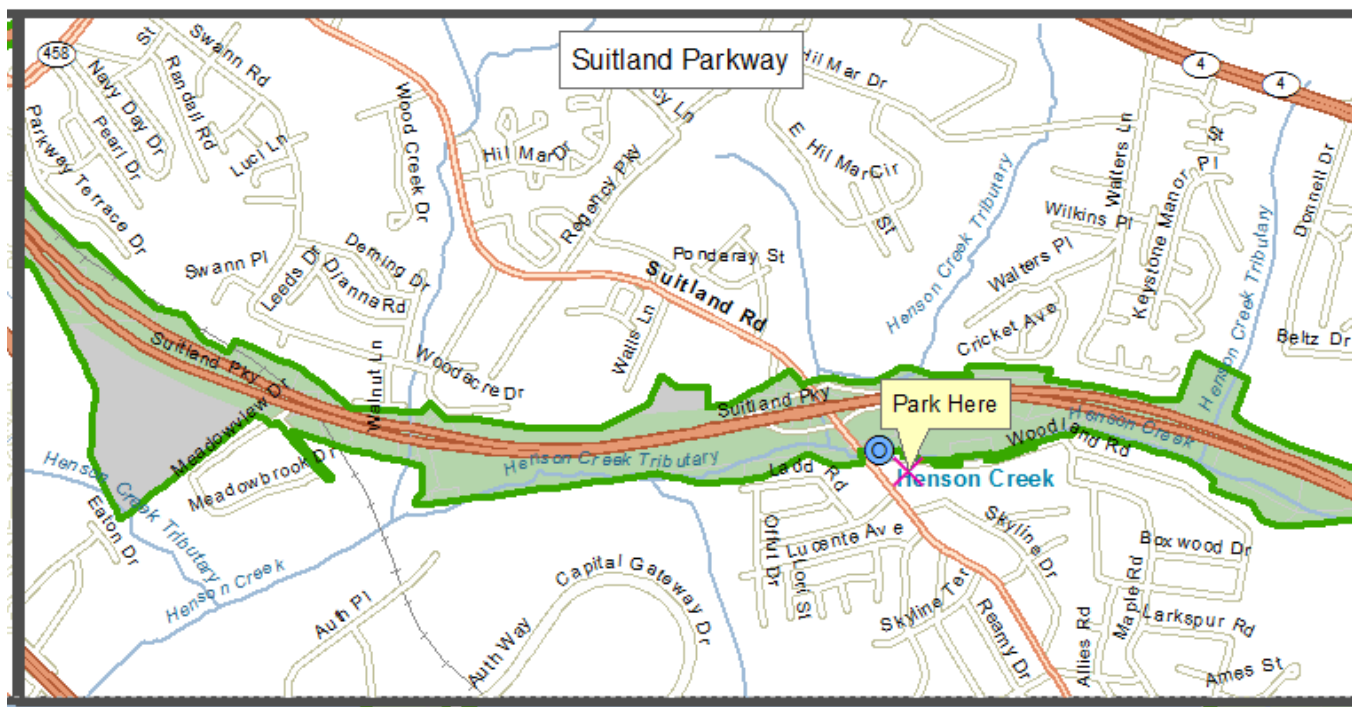


Figure 7-8: Henson Creek sampling site location on Suitland Parkway, NACE

To Henson Creek (hecr)

Make a left out of the church parking lot onto Good Luck Road
At the light, make a left onto Rt. 201 (Kenilworth Avenue)
Make a left onto Riverdale Road
Make a right onto the entrance ramp for the Baltimore-Washington Parkway (Rt. 295)
Stay right and merge onto Kenilworth Avenue
Merge left onto Kenilworth and move into the left lanes
Merge left onto the Anacostia Freeway (Rt. 295)
Anacostia Freeway turns into Interstate 295 Southbound
Take the exit for the Suitland Parkway SE (towards Suitland, MD)
Continue along the Suitland Parkway

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Take exit for Suitland Road
Make a right onto Suitland Road
Make an immediate left onto Woodland Road
Make an immediate right into the parking lot for the firehouse
Site is located across the road (Woodland) and just next to the storm drain

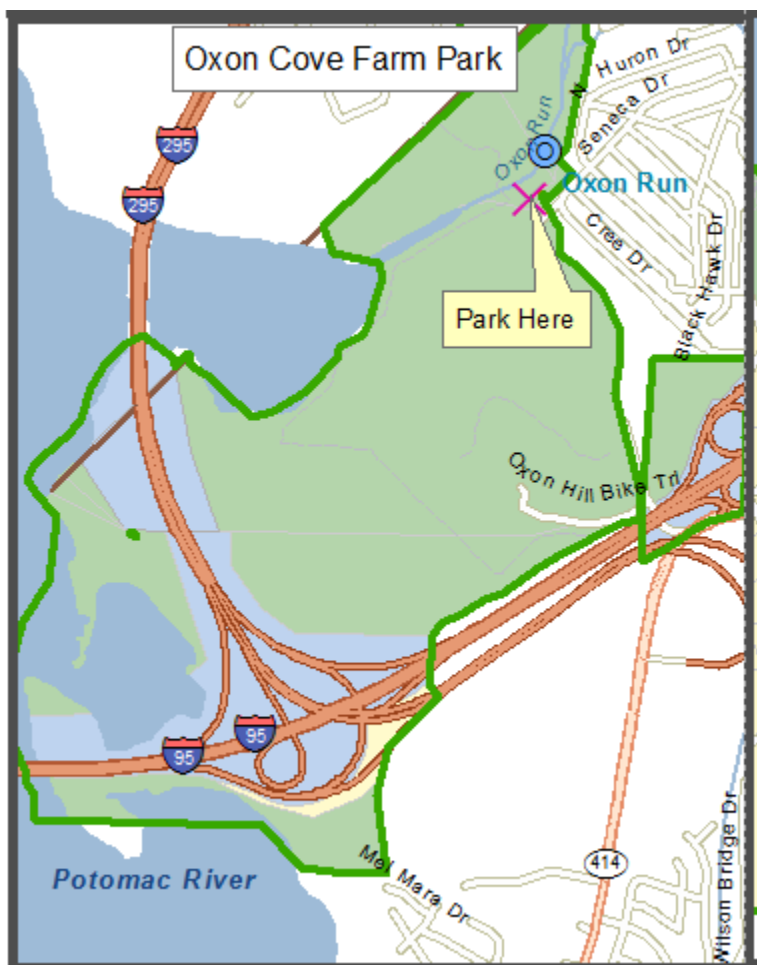


Figure 7-9: Oxon Run sampling site location in Oxon Cove Farm Park, NACE

To Oxon Run (oxru)

Make a right out of the firehouse parking lot onto Suitland Road (lot is one way)
Cross under the parkway and make a left at the light onto the entrance ramp
Merge left onto the Suitland Parkway
Continue along the Suitland Parkway towards Interstate 295)
Make a left onto Firth Sterling Avenue SE
At the light (across from the Anacostia Naval Station) make a left onto South Capitol Street SE

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Merge left to stay on South Capitol St SE
 Merge right (briefly) onto Overlook Avenue SW
 Merge left immediately onto Interstate 295 (Anacostia Freeway)
 Stay left to remain on I-295
 Merge left onto the access road for Rt. 210 (Indian Head Highway)
 Take the first exit to the right, that you come to, onto Harborview Avenue
 Make a right at the light onto Rt. 414 (Oxon Hill Road)
 Make a left at the next light onto Oxon Hill Farm Road
 Cut through the parking lot and take the middle gravel road to the Contact Station (inform them)
 Follow winding dirt road
 Make a right onto the park tour road
 Make a right onto the paved running path
 At the bridge, take the right path across the stream to the 2nd portion of paved pathway
 Site is located at last riffle not influenced by tide



Figure 7-10: Unnamed tributary of Accokeek Creek sampling site location in Piscataway Park, NACE

To Accokeek Creek tributary (acck)

Travel back along the paved running path
 Make a left onto the park tour road
 Make a left onto the winding dirt road
 Cut through the parking lot onto Oxon Hill Farm Road

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At the light, proceed straight and merge onto Rt. 210 (Indian Head Highway)
Continue along Rt. 210 for some time
Make a right onto Livingston Road
Make a right onto Biddle Road
Make a left onto Bryan Point Road
Make a right into the parking lot for Piscataway Park
Hike along the trail to the right, before the boardwalk
Site is located just downstream of the footbridge, alongside the planks

To CUE

Exit Piscataway Park parking lot by making a left onto Bryan Point Road
Make a left onto Farmington Road W
At the light, make a left onto Rt. 210 (Indian Head Highway)
Merge right onto the I-95/I-495 entrance ramp
Immediately merge left onto Interstate 95/Interstate 495 Southbound (towards Washington)
Gradually merge right onto Interstate 295 (Anacostia Freeway)
Cross the 11th Street Bridge
Anacostia Freeway turns into Southeast Freeway
Merge onto Interstate 395 (Southwest Freeway) and make way into second from right lane
Take right exit for Maine Avenue SW
Continue straight along Maine Ave
Maine Avenue turns into Independence Avenue SW
Independence Avenue turns into Ohio Drive SW
Continue past the Lincoln Memorial in the right lane
Take the middle of the fork onto the Potomac River Freeway N
Make way to second from the right lane
Take the left exit for the Whitehurst Freeway (K Street NW)
Pass under the Key Bridge
Make a left onto Canal Road NW
Continue straight onto Foxhall Road NW
Make a left onto MacArthur Boulevard NW

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GWMP (George Washington Memorial Parkway)

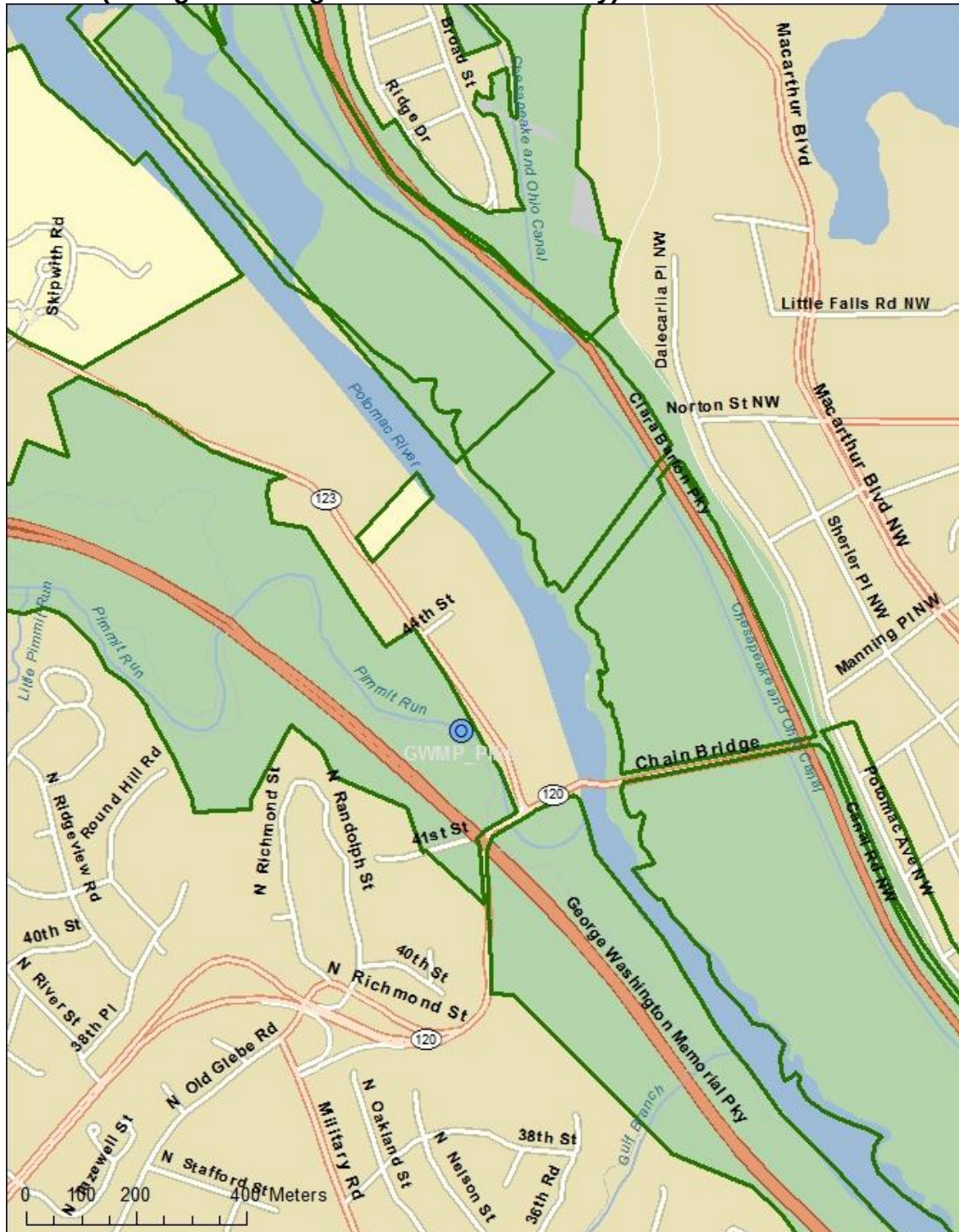


Figure 7-11: Pimmit Run sampling site location on George Washington Memorial Parkway

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To Pimmit Run (piru) from CUE

Left onto MacArthur Boulevard NW

Make a left at the light to continue along MacArthur Blvd

Make a left onto Arizona Avenue NW

Make a right at the light onto Canal Road NW (single lane traffic flow from 6:15am to 10:30am)

Make a left at the light onto North Glebe Road and cross the Chain Bridge

Continue straight through the next light

Make an immediate right on 41st Street N and park in the gravel lot

Hike along the Potomac Heritage Trail until you reach access site where a pipe is sticking out of the ground

Site is located in the pool, just downstream of large rock in the center

To Turkey Run (turu)

Make a left onto North Glebe Road

At the light, make a left onto Rt. 123 (Chain Bridge Road)

Merge left onto the entrance ramp to the George Washington Memorial Parkway

Continue and exit onto ramp for Turkey Run Park (unnamed park road)

Continue straight along road until under GW Parkway

Make a U turn and park next to bridge abutment

Cross the road and climb down the hill under the GW Parkway

Site is located directly under Parkway crossing

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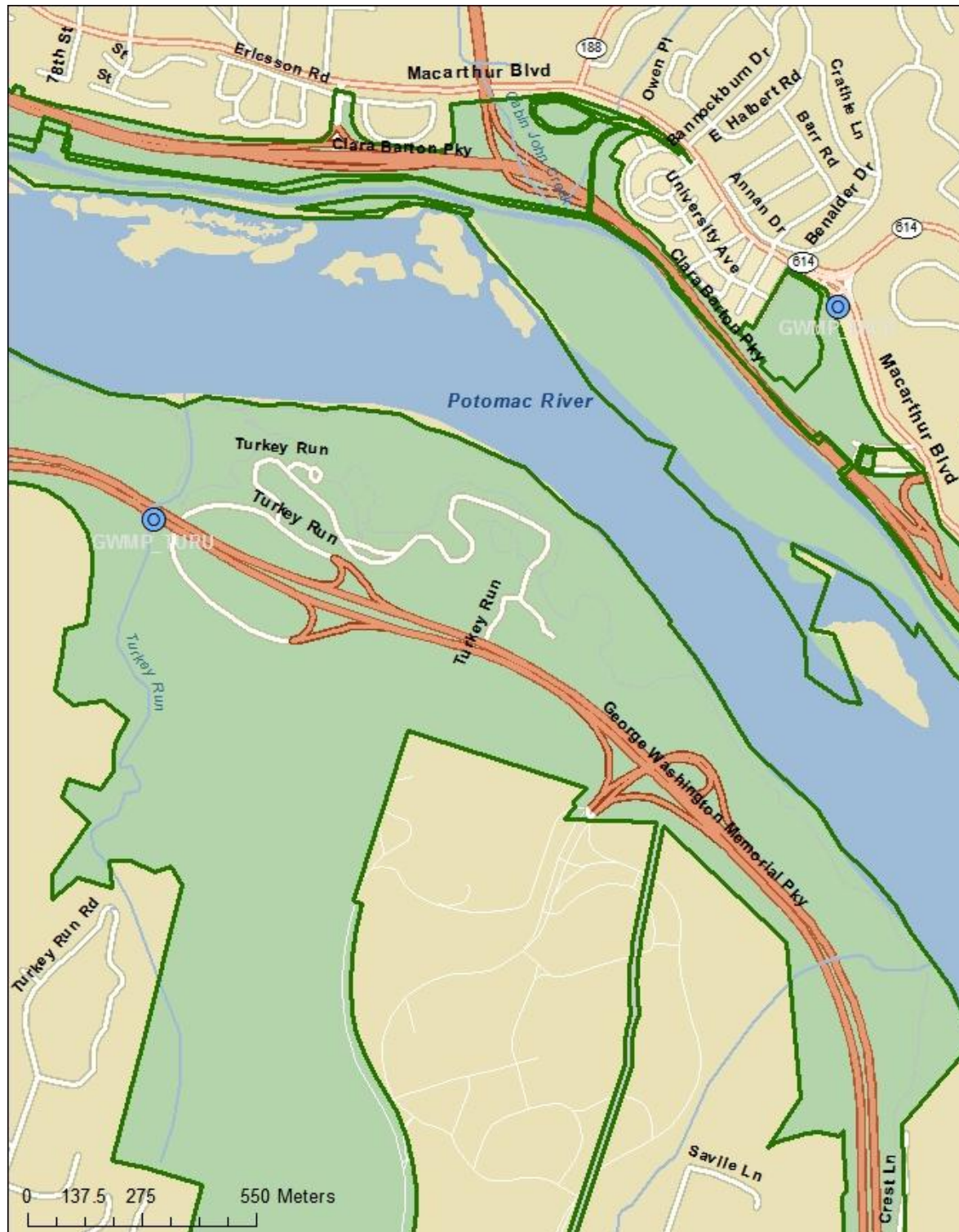


Figure 7-12: Turkey Run sampling site location on George Washington Memorial Parkway

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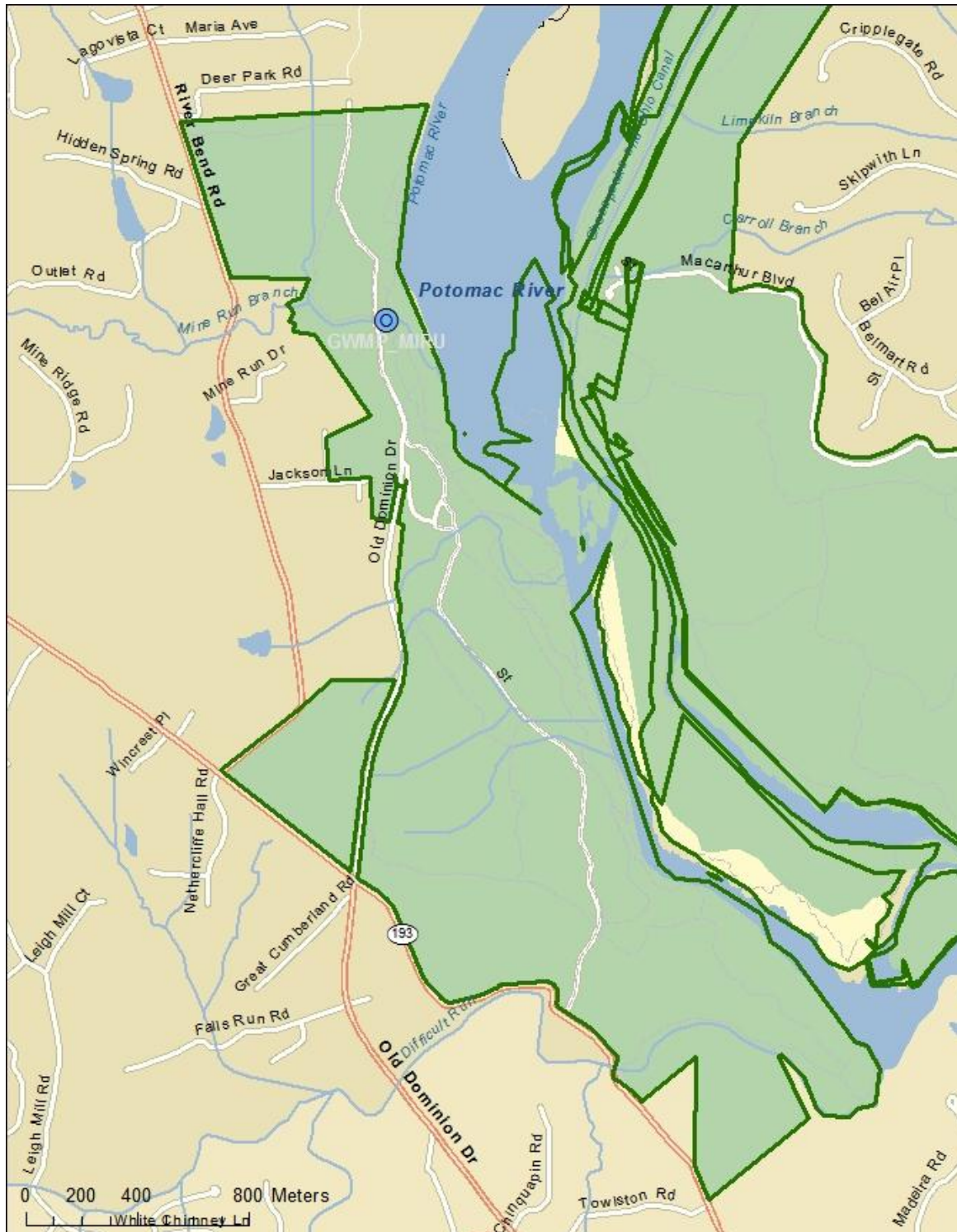


Figure 7-13: Mine Run sampling site location on George Washington Memorial Parkway

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To Mine Run (miru)

Return to vehicle and to northbound George Washington Memorial Parkway
Continue along in the right lane, but DO NOT take exit for Maryland
Exit GW Parkway onto Interstate 495 towards Virginia, remain in right lane
Exit onto Route 193 (Georgetown Pike) towards Great Fall
Merge right at the light
Continue straight along the winding route
Make a right at the light onto Rt. 738 (Old Dominion Drive)
At the gate, inform park staff of your purpose and provide identification
Park in the lot after the Visitor's Center, at the opposite end from the VC, closest to Potomac River
Walk along park trail to the foot bridge
Site is located just upstream of said bridge

WOTR (Wolf Trap National Park for the Performing Arts)

To Wolf Trap Creek (wotr)

Exit park onto Route 738 (Old Dominion Drive)
Continue straight through the light
Make first (1st) right after passing over Difficult Run, onto Peacock Station Road
Make a right at the stop sign onto Towlston Road
Continue straight through a couple of stop signs
Continue straight through stop light at Route 7
Towlston Road turns into Trap Road when the road becomes temporarily undivided
Pull into the parking lot near the maintenance building (on the right)
Walk through the grassy area to the stream
Site is located at the end of the large pool

To Courthouse Creek (chck)

Make a right out of the parking lot onto Trap Road
Turn left nearly immediately onto Trap Road
Continue into park towards the circle
Veer right (avoiding circle) and travel around the Filene Center
Continue to end of road and park in the back of the parking lot
Hike along trail, cross bridge and continue hiking past the Theater-In-The-Woods
Continue straight (off trail) as trail turns right, towards a footbridge over Courthouse Creek
Site is located approximately 30 meters downstream of footbridge

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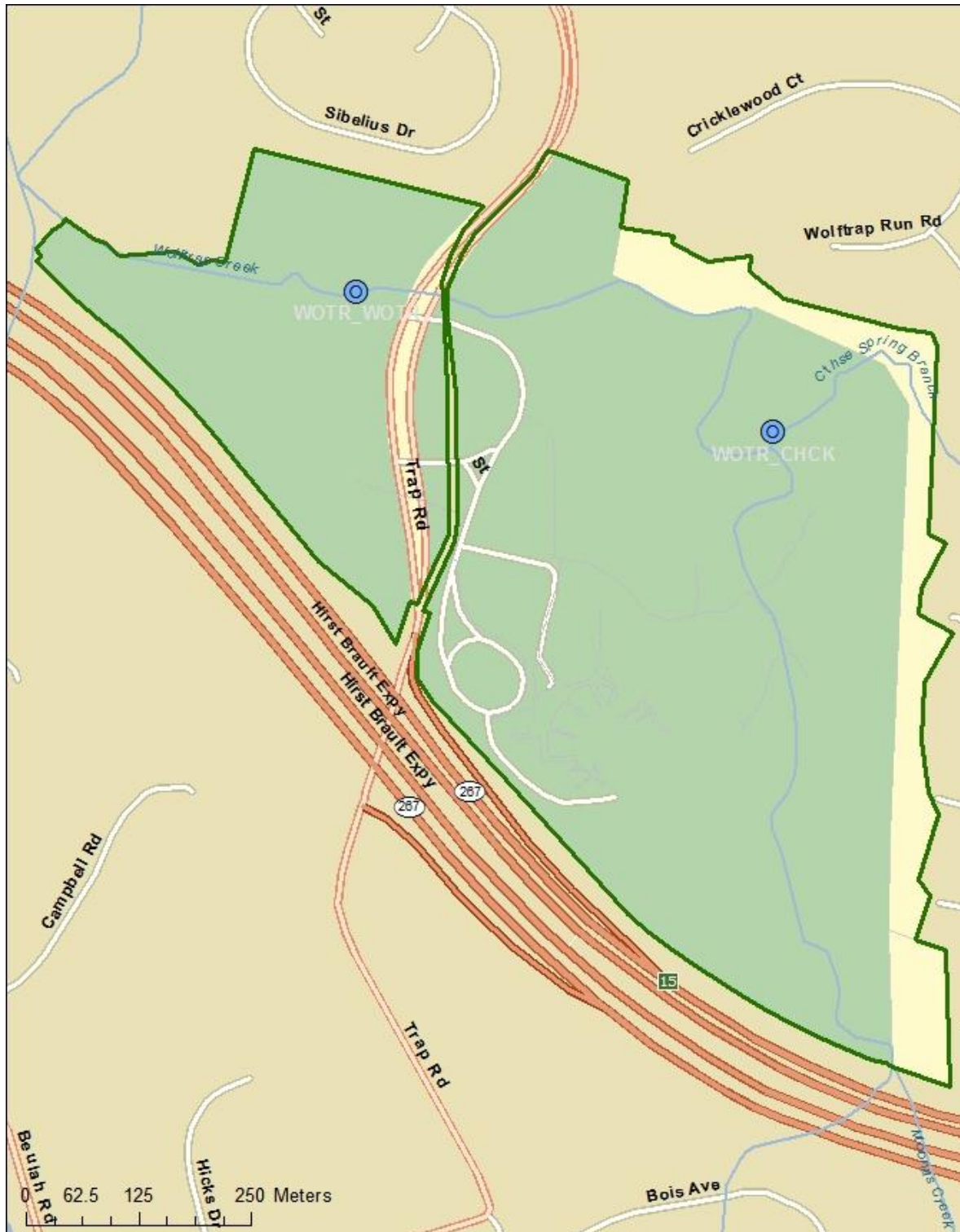


Figure 7-14: Sampling site location in Wolf Trap Farm Park for the Performing Arts

NCRN Water Chemistry & Quantity Monitoring Site Location Standard Operating Procedure #7

To CUE

Exit the park and make a right onto Trap Road
Trap Road turns into Towlston Road when the road becomes temporarily undivided
Continue on Towlston Road straight through the light
Make a right at the stop sign onto Bellevue Road
Continue along Bellevue Road
At the stop sign, make a right onto Old Dominion Drive
Continue straight through the light
Make a left at the next light onto Swinks Mill Road
At the stop sign, make a right onto Georgetown Pike (Rte. 193)
Continue straight through the first light in the left lane
At the next light, make the left onto the I-495 ramp
Merge onto Interstate 495 (Capital Beltway) and remain in the right lane (not the exit lane)
Continue past the GW Parkway exit
While crossing the American Legion Bridge, get into the far right lane (exit lane)
Take Exit 41 Clara Barton Parkway
Merge right at the fork in the road
Merge onto the Clara Barton Parkway
(If before 2:00pm, follow these directions)
Continue straight on the Clara Barton Parkway and stay in the right lane
Continue straight along Clara Barton and cross into DC
Clara Barton Parkway will turn into Canal Road
Continue through the first light
Make a left at the 2nd light onto Arizona Avenue NW
At the light, make a right onto MacArthur Boulevard NW
Follow past the Georgetown Reservoir, and make a right onto Elliot Place NW
Make an immediate right onto CUE's driveway
(If after 2:00pm, follow these directions)
Take the Cabin John exit from the Clara Barton Parkway
At the stop sign (end of ramp), make a left onto the Clara Barton Access Road
At the stop sign, make a right onto MacArthur Boulevard
Follow half-way (1/2) around the traffic circle to continue straight along MacArthur
Continue straight through the stop sign and into DC
MacArthur Boulevard will turn into MacArthur Boulevard NW
Continue past Arizona Avenue (but perhaps stop at the Starbucks)
Continue Along MacArthur Boulevard NW and get in the right lane
At the Georgetown Reservoir, make a right to continue along MacArthur
Just after the Reservoir, make a right onto Eliot Place NW
Make an immediate right onto CUE's driveway

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MONO (Monocacy National Battlefield - 4801 Urbana Pike, Frederick, MD 21704)

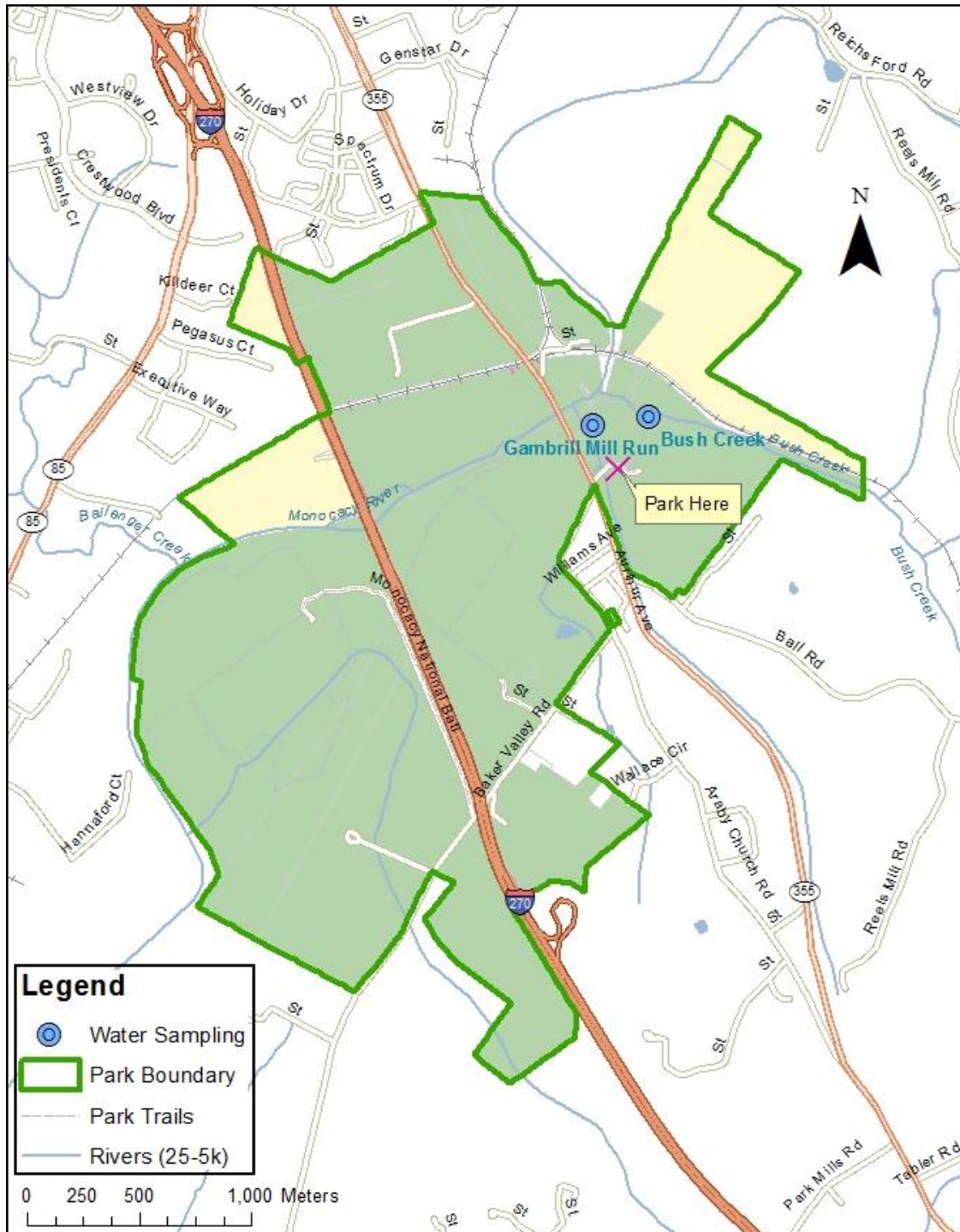


Figure 7-15: Sampling Site Locations in Monocacy National Battlefield

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To Bush Creek (buck)

Make a left onto MacArthur Boulevard NW
At the light, make a left to continue on MacArthur Blvd NW
MacArthur Boulevard NW turns into MacArthur Boulevard (4 lanes to 2)
At the stop sign, make a left onto the entrance ramp for the Clara Barton Parkway
Merge onto the Clara Barton Parkway and remain in the right lane
Merge right onto the Cabin John Parkway (not labeled) toward I-495, remain in the left lane
Merge left onto Interstate 495 Northbound (Inner-loop Capital Beltway)
Make your way over into the left two (2) lanes
Merge left onto Interstate 270 Northbound
Continue along I-270 N towards Frederick, MD
Take exit 26 (Rt. 355) towards Urbana
Take a left off the exit ramp heading north on Rte. 355 (Fingerboard Road)
Follow three-quarters ($\frac{3}{4}$) the way around the traffic circle to the light, make a left on to 355 north
Make a right into the parking lot for the Gambrill Mill
Hike down the trail behind the mill (between two fenced areas) to Bush Creek
Site is located where the pathway enters the creek

*** Alternate Route = better

Make the first left onto Urbana Church Pass
Make a right onto Urbana Church Road
Make a left onto Rte. 355 (Urbana Pike) ***

To Gambrill Mill (gami) [formerly Visitor Center Creek (vcck)]

Return to the path and take the trail to the right (larger field)
Hike along the fence line until reaching the boardwalk
Traverse the boardwalk past the first footbridge you encounter
Site is located a few meters upstream from the footbridge

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CATO (Catoclin Mountain Park)



Figure 7-16: Big Hunting Creek and Whiskey Still Creek sampling site locations in Catoclin Mountain Park

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To Big Hunting Creek (bghc)

Make a right out of Gambrill Mill parking lot, heading north on Route 355 (Urbana Pike)
Urbana Pike turns into South Market Street
Just after passing over Interstate 70, make a right at the stoplight onto Monocacy Blvd
Make a right onto South East Street
Merge onto I-70, staying to the right
Take exit 53B onto Interstate 270 North (Baltimore National Pike)
I-270 turns into Route 15/Route 40 (Baltimore National Pike)
Route 15/Route 40 turns into Route 15 (Catoclin Mountain Highway)
Take the exit for Route 77 (West Main Street) just past the town of Thurmont
West Main Street turns into Foxville Road
Make a right into the parking lot for the Park Headquarters
Site is located downstream of the bridge, next to the collapsing wall

To Whiskey Still Creek (whst)

Make a right out of the parking lot, onto Rt. 77 Northbound
Make the next available right onto Park Central Road
Make an immediate right into the parking lot for the Visitor's Center
Hike along Park Central Road and cross Rt. 77
Site is located just downstream of culvert

To Owens Creek (owck)

From Visitor Center parking lot make right onto Park Central Road
Make a right onto Foxville-Deerfield Road (follow signs for Owens Creek Campground)
Make a left onto road to Owens Creek Campground and park along guardrail
Site is located just downstream of the bridge
(If Park Central Road is closed)
From Visitor Center parking Lot, make left onto Park Central Road
Make a right onto 77 north
Make a right onto Foxville-Deerfield Road
Stay right at Foxville Church Road, follow signs for Owens Creek Campground
Make a left onto road to Owens Creek Campground and park along guardrail
Site is located just downstream of the bridge

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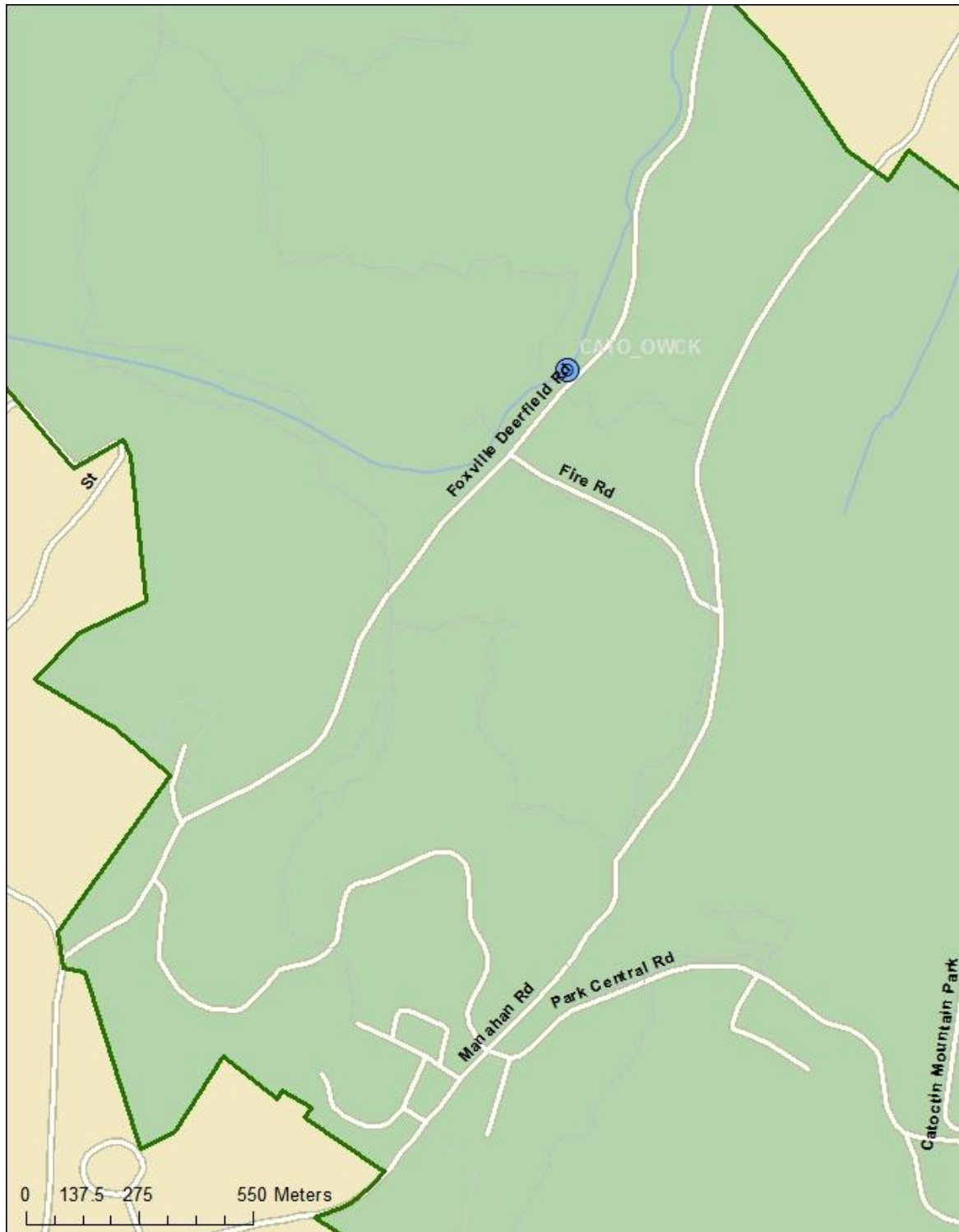


Figure 7-17: Owens Creek sampling site location in Catoclin Mountain Park

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ANTI (Antietam National Battlefield)

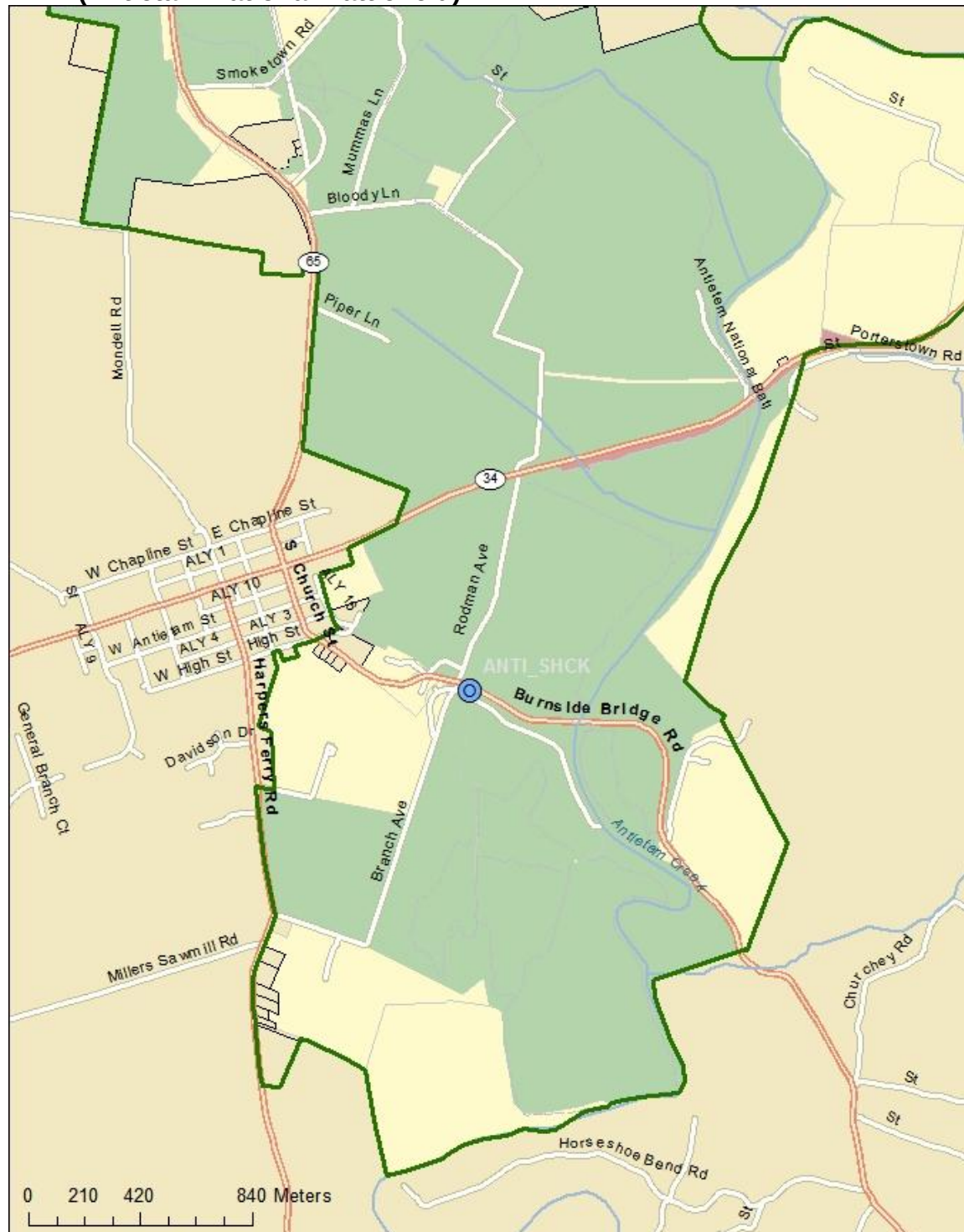


Figure 7-18: Sampling Site Locations in Antietam National Battlefield Park

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To Sharpsburg Creek (shck)

Make a right out of the Owens Creek Campground onto Foxville-Deerfield Road
At the stop sign, take the left fork to continue along Foxville-Deerfield Road
At the next stop sign, make a right onto Rt. 77 (Foxville Road)
Continue along the windy mountain road for several miles, passing the Appalachia Trail along the way
Make a left at the first stop light onto Rt. 64 (Jefferson Blvd)
Continue along Jefferson Blvd for a mile, making a left at the first stoplight onto Rt. 66 (Mapleville Rd.)
Continue along Mapleville Road, travelling straight through a round traffic circle
About a mile after the traffic circle, merge onto I-70, Travel on I-70 for 6 miles
Take Exit 29 (Sharpsburg Pike) and remain in the left lane
Make a left onto Rt. 65 (Sharpsburg Pike)
Stop at Wendy's for lunch
Continue along Sharpsburg Pike for some time
Sharpsburg Pike will turn into North Church Street in the Town of Sharpsburg
Continue straight through the stop sign onto South Church Street
Continue straight through a second stop sign
South Church Street turns into Burnside Bridge Road
Pass under Rodman Avenue (park tour road) and make a right into the 1st driveway
Site is located just downstream of the culvert

HAFE (Harper's Ferry National Historical Park)

To Flowing Springs Run (flsp)

Make a left out of the driveway onto Burnside Bridge Road
Burnside Bridge Road turns into South Church Street
Continue straight through the first stop sign
At the next stop sign, make a left onto Rt. 34 (East Main Street)
East Main Street turns into West Main Street, West Main Street turns into Shepherdstown Pike
Cross over the Potomac River
Rt. 34 (Shepherdstown Pike) will turn into Rt. 480 (North Duke Street)
Continue straight through the stop sign
North Duke Street will turn into South Duke Street
Make a right onto West Washington Street, Continue straight through the stop sign
West Washington Street will turn into East Washington Street
East Washington Street will turn into Rt. 230 (Shepherdstown Pike)
Continue along Shepherdstown Pike, merging left to continue towards Harpers Ferry, WV
At the stop sign, follow left to continue on Shepherdstown Pike
Follow right to the stoplight
Make a right (on green only) onto Rt. 340 (Jefferson Pike) and get into the left lane
Continue along Rt. 340 in the left lane, watching for sign for Blair Road
Make a left onto Blair Road
Make a left onto Quarry Lane, just past the entrance to the Quarry Mill
Park at the end of the street and hike to the right, along the railroad tracks,
Site is down the hill at the end of the road

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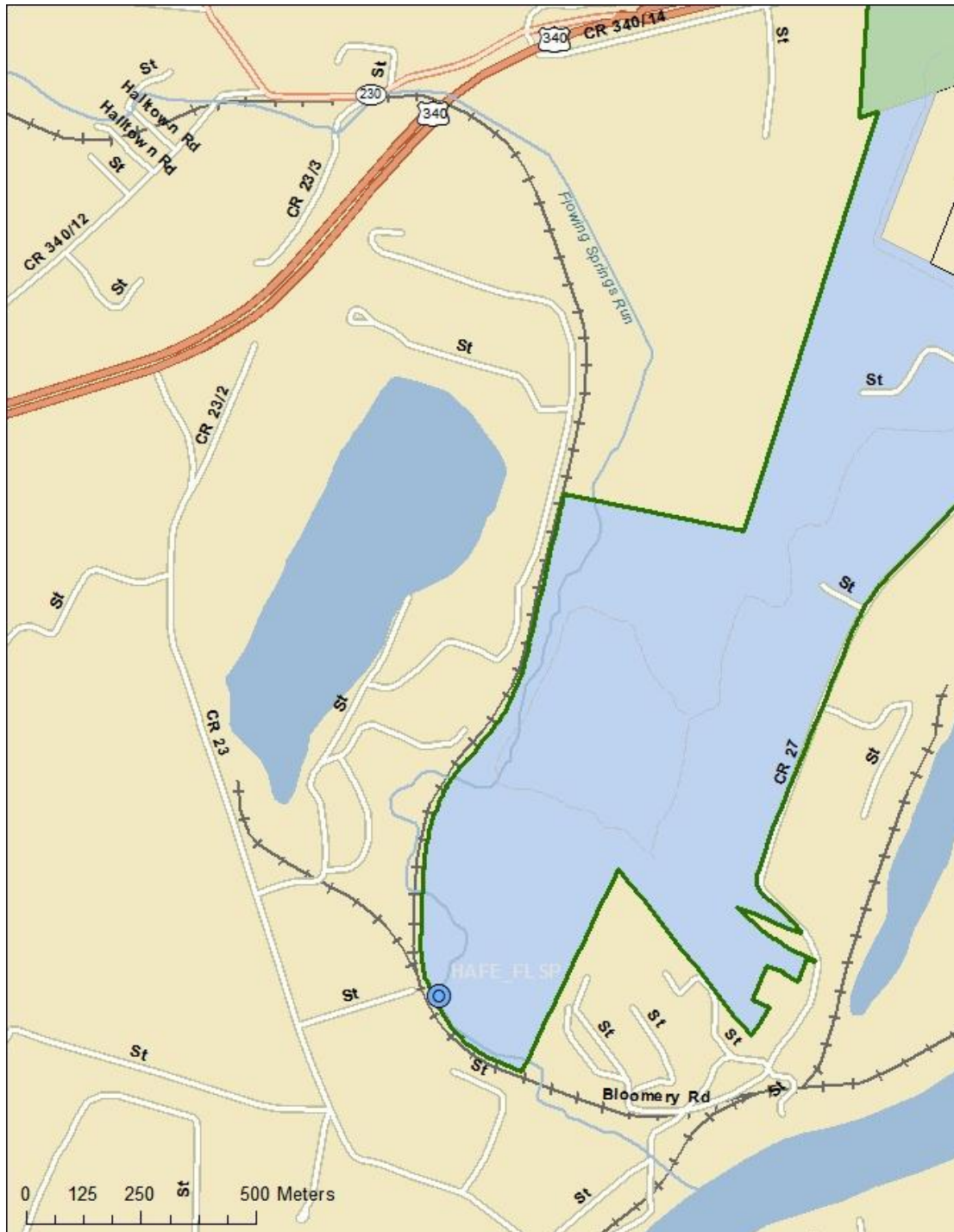


Figure 7-19: Sampling Site Locations in Harpers Ferry National Historic Site

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Sites along MacArthur Blvd

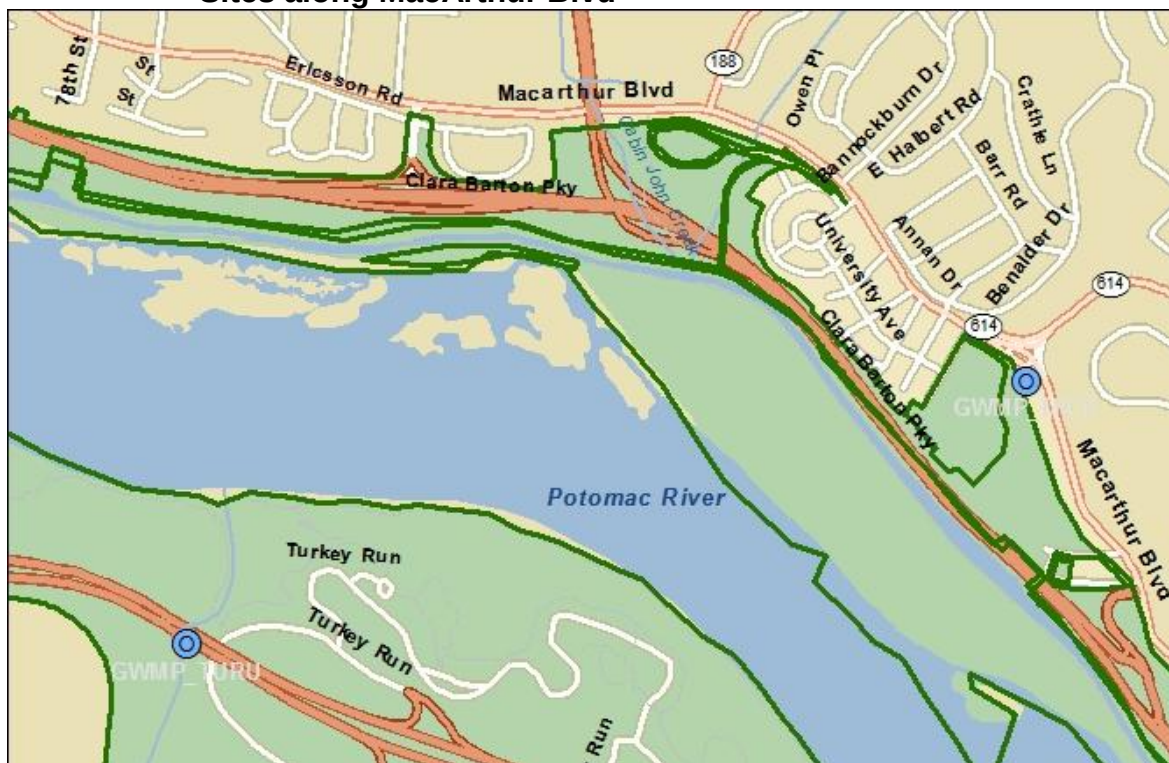


Figure 7-20: Minnehaha Creek sampling site location in Glen Echo Park, GWMP

To Minnehaha Creek (micr) (GWMP)

Return to vehicle, and travel along Quarry Lane
 Make a right onto Blair Road
 Make a right onto Rt. 340 (Jefferson Pike/Washington Heritage Trail)
 Continue along Jefferson Pike and cross over the Shenandoah River, into Virginia
 Continue along Jefferson Pike and cross over the Potomac River, into Maryland
 Jefferson Pike will turn into US-340, US-340 will turn into US-15/US-340
 Merge right onto I-70 remaining in the two right lanes
 Merge right onto I-270
 Merge onto Interstate 495 Southbound (Outerloop Capital Beltway) second to the right lane
 ****Take Exit 40 Cabin John Parkway
 Merge onto Clara Barton Parkway and get in the left lane
 At the yield sign, merge when traffic allows, and get in the right lane
 Make a left at the stop sign onto MacArthur Boulevard
 Follow half-way (1/2) around the traffic circle to continue straight on MacArthur
 Make the first (1st) left after the circle onto Oxford Road****
 Continue through the stop sign and make a left into the parking lot for Glen Echo Park
 Park near stone wall and bridge, Take the trail to left of stone wall and down to the creek
 Site is located just downstream of the culvert and pool

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**** Alternate directions

Take Exit 39 River Road

Merge onto River Road and stay in the right lane

Make a right onto Wilson Lane

At the stop sign, make a left onto MacArthur Blvd

Make a left onto Oxford Road, before you get to the traffic circle****

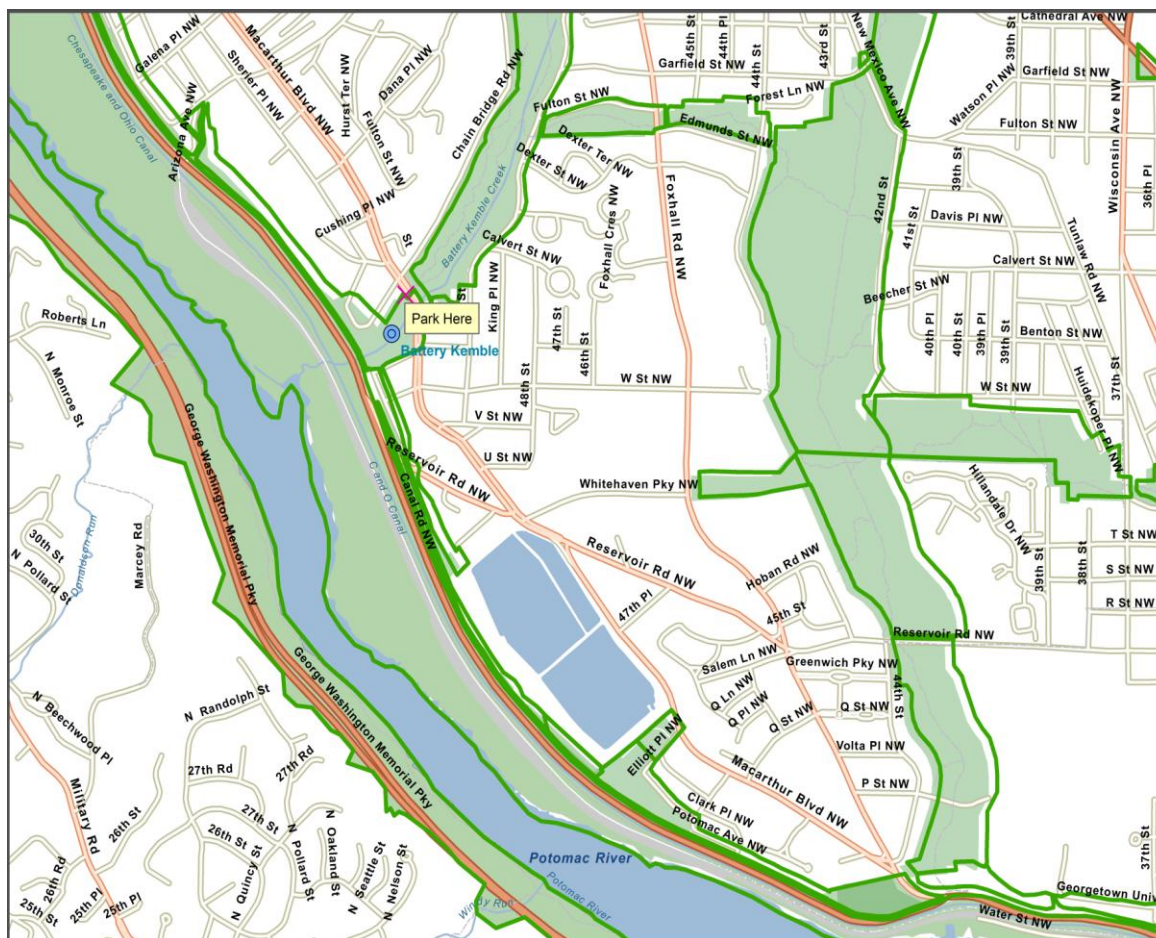


Figure 7-21: Battery Kemble Creek sampling site location in Battery Kemble Park, ROCR

To Battery Kemble (bake) [formerly Palisades Creek (pacr)] (ROCR)

Exit parking lot

Make a right at the stop sign onto Oxford Lane

Make a right at the stop sign onto MacArthur Boulevard

Follow half-way (1/2) around the traffic circle to continue straight along MacArthur

Continue straight through the stop sign and into DC

MacArthur Boulevard will turn into MacArthur Boulevard NW

Continue past Arizona Avenue (but perhaps stop at the Starbucks)

After the next stop light you encounter, get into the right lane

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Keep an eye out for the red building
Park on MacArthur Boulevard NW in front of Discovery Creek
Take the trail to the left of the school, and then the left fork of the trail down to the creek
Site is located at the end of the trail

To CUE

Continue Along MacArthur Boulevard NW and get in the right lane
At the Georgetown Reservoir, make a right to continue along MacArthur
Just after the Reservoir, make a right onto Eliot Place NW
Make an immediate right onto CUE's driveway

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Retired Sampling Locations

ROCR - Rock Creek above Fenwick Branch (rocr)

To Rock Creek above Fenwick Branch (rocr) from Fenwick Branch
Continue on trail from Fenwick Branch, passing under West Beach Drive NW
Site is located just upstream of overpass

ROCR -Rock Creek at Edgewater Stables (egwa)

To Rock Creek below Edgewater Stables (edge) from Piney Branch
Continue south on Beach Drive
Left into Park Police parking lot
From there continue south to the Whitehurst Freeway and back to CUE

MANA - Holkums Branch (hobr) (MANA)

To Holkums Branch from Interstate 66
Continue to Exit 47B, Route 234 Business North
Merge onto Sudley Road (Rt. 234 B) and travel in the center lane through the light
Continue past NVCC-Manassas and the MANA visitor Center
Turn left onto Lee Highway/Warrenton Turnpike (US-29)
Continue for approximately 1.5 miles, past the sign for MANA Law Enforcement
Pull off of US-29 onto large graveled area just past this sign
Hike along the First Manassas Trail
Cross over Youngs Branch and continue on First Manassas Trail (icy death march in winter)
At junction, take the left hand hiking trail (grassy road) toward Portici
Site is where road runs into stream

MANA - Dogan Branch (dobr) from Youngs Branch (MANA)

Return to vehicle
Make a U-turn and continue on US-29 southbound
Pass through the intersection of Rt. 234 (Sudley)
Turn left onto New York Avenue, just past the private inholding (house with lake)
Park in one of the first few spaces in the parking lot
Hike along roadside to where Dogan Branch passes under US-29
Site is located midway between culvert and private lake

MANA - Chinn Branch (chbr) from Dogan Branch (MANA)

Return to vehicle
Turn right out of parking lot onto US-29 North
At the light (intersection), turn right onto Rt. 234 B (Sudley Road)
Pull off onto shoulder immediately after guard rail ends
Hike along Young Branch to confluence with Chinn Branch
Site is 5 meters upstream of confluence

NACE - Fort DuPont stream (ftdu) from Still Creek

Make a left out of the church parking lot onto Good Luck Road
At the light, make a left onto Rt. 201 (Kenilworth Avenue)
Make a left onto Riverdale Road

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Make a right onto the entrance ramp for the Baltimore-Washington Parkway (Rt. 295)
Stay right and merge onto Kenilworth Avenue
Take the exit for Minnesota Avenue
Make a left onto Burroughs Avenue
Cross under Rt. 295 (Kenilworth Avenue) straight through the 1st light
At the next light, make a right onto Minnesota Avenue NE/SE
Make a left onto F Street SE
Make a right onto the gravel road for the theater
Park just behind the theater
Site is located just downstream

MONO - Hardings Run (haru) from Visitor Center Creek/Gambrill Mill (MONO)

From the Gambrill Mill, shoot straight across Rt. 355 onto Araby Church Road
Make a right onto Baker Valley Road
Cross under I-270 and make an immediate right onto the driveway for the Worthington Farm
Continue to the house and park between the house and the woodline
Take the trail to the left of the house
Site is located just upstream of the foot bridge

GWMP - Difficult Run (diru) from Wolf Trap

Exit the park and make a right onto Trap Road
Trap Road turns into Towlston Road when the road becomes temporarily undivided
Continue on Towlston Road straight through the light
Make a right at the stop sign onto Bellevue Road
Continue along Bellevue Road straight through the stop sign
At the Madeira School make a left onto Rt. 193 (Georgetown Pike) toward Great Falls
Cross the bridge over Difficult Run and immediately pull off to the right at a gate
Follow trail until stream is easily accessible (currently across from the trash cans on the trail)
This stream channel is also pretty mobile, sampling the exact same place not be possible

GWMP - Gulf Branch

Make a right out of the parking lot onto Glebe Road
Follow signs to Military Road
Left on 36th street (at Gulf Branch Park sign, but opposite way)
Park at trash can and take trail to where trail leads to water

GWMP - Donaldson Run

Continue on Military Road
Left on Marcey Road, to it's end (yes, through the gate marked "Authorized vehicles only", but yield to pedestrians)
Park on the right with all the other cars and continue on foot
Trail goes off to the left, follow signs for Donaldson Run / Potomac Heritage Trail
Sample where the trail crosses the water

GWMP - Spout Run (on the way back from MANA)

Pull of on divider at Spout Run exit

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Walk down embankment where guard rail starts
Left to get to first site
To get back:
Spout Run Parkway
Lorcam Lane
Right on Military Road
Left at Nellie Rd. to continue on Military
Follow signs for Chain Bridge Road

NCRN Water Chemistry & Quantity Monitoring Sample Collection for Laboratory Analysis Standard Operating Procedure #8

Revision History Log:

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

1. Purpose

Collection of water samples for analysis of ammonia, acid neutralizing capacity, chlorine, free ammonia / monochloramine, nitrate, and total phosphorus.

2. Scope and Applicability

This Standard Operating Procedure (SOP) is applicable to samples collection for any surface water.

3. Reference Documents

Hem, J.D. 1989. Study and interpretation of the chemical characteristics of natural water, 3rd ed. U.S. Geological Survey Water-Supply Paper 2253. Government Printing Office. Available from the Distribution Branch, Text Products Section, USGS, Alexandria, VA, 263 pp.

NCRN WCQ SOP 04: Field Safety

NCRN WCQ SOP 05: Water Chemistry Lab Preparation

NCRN WCQ SOP 07: Water Site Location

NCRN WCQ SOP 18: Water Resources Data Management

4. Procedures and General Requirements

Determine Sampleability

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

Do not walk on, or in any way disturb, the stream bottom upstream from the sampling site.

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

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stream widths downstream should be adequate). After sampleability of a segment has been determined (see Water Site Location SOP), the crew member responsible for water quality sampling should move to the upstream boundary of the sample segment, carefully locating an undisturbed area for sampling. Collect the sample where the water is well mixed, immediately downstream from a point of hydraulic turbulence such as a knickpoint or flume or where streamflow appears laminar (nonturbulent, no cross currents, eddies, or swirls).

Field investigators are responsible for observing any unusual conditions which may indicate a need for additional water quality sampling outside a scheduled monitoring event. Upon observing an unusual condition, such as an unusual turbidity or odor of the water, excessive algal growth, indications that foreign substances have entered the system (oil slicks, surface films, etc.) or fish kills, water quality samples should be taken to help identify the contaminant source or impacting land use. Investigators should also notify Project Manager and Park Natural Resource staff as soon as possible.

Sample collection method is determined by water depth:

Grab Samples (for water < 2 feet deep)

A grab sample is defined as a discrete sample taken at a selected location, depth and time and analyzed for the constituents of interest.

Grab samples are often used for small streams where depth integration is not possible.

Wide shallow streams should be sampled at several points, at least once for every additional 10 feet, for example a 9 foot stretch would be sampled once, a 12 foot stretch would be sampled twice, a 25 foot stretch would be sampled 3 times) and analyzed as composite samples.

Depth-Integrated Sample (for water >2 feet deep)

A depth integrated sample is defined as a sample collected over a predetermined part or the entire depth of the water column at a selected location and time in a particular water body and then analyzed for the constituents of interest.

The trip from the surface to near the bottom and back to the surface must be at a uniform rate.

Each point at which the sampling device is lowered to the bottom and hauled back is called a "vertical".

Samples should be taken at several verticals, at least once for every 2 feet of depth, in the cross-section to allow for the vertical and lateral variations in water quality that frequently exist in slowly moving waters.

The number of verticals sampled is largely a matter of intuition; large variations in the water quality in the cross section will require sampling at more verticals than little variation.

Label the container

The sample container should already be labeled on the outside with the site's 4 letter code. If it is not, write in pencil on a strip of water proof paper. Once full, the label should be placed in the sample bottle. The sample container label and date form should contain:

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Sample identification composed of the date, park, and site identification as recorded on a tablet computer.

Time

Date of collection

Name of the person collecting the sample

Sample treatment (preservation)

Discharge (ft³/s or gal./min.)

Fill sample bottle

Using care to avoid potential sample contamination from handling; fill the sample bottle, then rinse the bottle and discard the water. Repeat the process twice.

Submerge the sample container below the water surface to the appropriate depth. To avoid contaminating the sample, collect samples with the mouth of the sample bottle or collection container pointed upstream. Keep hands and other potential contaminants away from the mouth of the collection container. In a well-mixed stream, collect the sample in the center of the channel using depth integrated sampling techniques, avoiding the inadvertent collection of part of the stream bottom or top-floating materials.

Fill bottle to neck.

Collect sufficient sample volume (which will depend on container size) to allow duplicate analyses and quality assurance testing.

Preserve the sample

Preserve the sample if necessary (only if analysis will not be performed within 48 hours) following standards shown in Table 8-1. All preservatives must be included in field blanks for identification of potential contamination. Samples must never be permitted to stand in the sun. Samples should be stored in the upright position at 4°C in a cool place, ice chest or equivalent.

If chlorine is known to be present, the ammonia sample must be treated immediately with sodium thiosulfate. Add one drop of Sodium Thiosulfate Standard Solution, 0.1 N (Cat. No. 323-32), for each 0.3 mg of chlorine present in a one-liter sample.

Secure the cap tightly. Check to ensure that the seals on sample bottles are tight.

Rinse the container's outside surface with clean water and dry with a paper towel. Verify the sample label is correct and complete.

Place samples on wet or blue ice (e.g., Kool Paks) to maintain samples at 4°C until laboratory analysis is performed.

NCRN Water Chemistry & Quantity Monitoring Sample Collection for Laboratory Analysis Standard Operating Procedure #8

Table 8-1. Sample preservation and holding times for required measurements

Parameter	Container	Preservative	Holding Time
Acid neutralizing capacity	Polyethylene Fill completely Cap tightly	Refrigerate 4°C Avoid excessive agitation or prolonged exposure to air	24 hours
Chlorine, Free Ammonia, Monochloramine	Polyethylene	NONE	NONE
Nitrate	Polyethylene	Refrigerate 4°C No Mercury compounds	48 hours
Total phosphorus	Polyethylene	pH<2 H ₂ SO ₄ , 4°C about 2 mL per liter	28 days

Fill out all data sheets and labels

After sample collections are completed, the sample data and chain-of-custody forms should be completed and checked by the field crew for completeness and accuracy. Complete chain-of-custody documents if required and record them in the field logbook. Maintain an up-to-date field book in which to note setting, personnel, equipment used, environmental conditions, and problem areas. Chain of custody (COC) documentation is intended to provide information regarding transport of the sampling equipment from the laboratory to the field sampling event and return to the laboratory. COC documentation is built into the Tablet PC dataform.

Rinse sampling and analytical equipment with DI water before leaving each sampling location. Move to next sampling location and repeat procedures.

Upon completion of sampling and field-data recording, the samples should be transported to the laboratory in an ice chest. The acid-preserved samples may also be stored in the ice chest as a matter of convenience.

NCRN Water Chemistry & Quantity Monitoring

Air Temperature

Standard Operating Procedure #9

Revision History Log:

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

1. Purpose

This Standard Operating Procedure (SOP) outlines how to measure air temperature. Air temperature influences water temperature and also can influence water quality meter performance. Air temperature reflects the surrounding groundcover and land-use conditions: urban heat island, tempering effects of vegetation canopy, etc.

2. Scope and Applicability

These analytical methods can be applied to any location where air temperature is of interest.

3. Reference Documents

NCRN WCQ SOP 18 – Water Resources Data Management

NCRN WCQ SOP 19 – Water Resources Data Analysis and Reporting

4. Procedures and General Requirements

Keep thermometers clean. Thermometers can easily become damaged or lose calibration. Carry thermometers in protective cases; thermometers and cases must be free of sand and debris. Mercury-filled thermometers are prohibited in the field. To eliminate the problem of column separation, it is best to use a thermometer with a gas-filled capillary. Store the liquid-filled thermometers in a bulb-down position and in a cool place away from direct sunlight.

If using a traditional liquid-in-glass thermometer, check thermometer for liquid-column separation. Inspect liquid-in-glass thermometers to be certain liquid columns have not separated. Inspect bulbs to be sure they are clean. Inspect protective cases to be sure they are free of sand or debris.

Place a dry, calibrated thermometer 5 feet above the ground in a shaded area, protected from strong winds, but open to air circulation, for example, tie to a tree branch with a twist tie. Avoid areas of possible radiant heat effects, such as metal walls, rock exposures, or sides of vehicles.

Allow 3 to 5 minutes for the thermometer to equilibrate, then record the temperature to the nearest 0.5°C for liquid-in-glass or 0.1°C for digital on the field data sheet. Measure the air temperature as close as possible to the time when the water temperature is measured. The digital thermometer is only accurate down to 0°C. If temperatures at or below freezing are anticipated, be sure to pack a liquid-in-glass thermometer as well.

NCRN Water Chemistry & Quantity Monitoring YSI ProPlus (DO, Specific Conductance, Salinity, pH, & Temperature) Standard Operating Procedure #10

Revision History Log:

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

1. Purpose

Standard water chemistry measurements include collection of pH, dissolved oxygen (DO), specific conductance, conductivity, salinity, and temperature. This SOP describes how to take these measurements with the YSI Professional Plus.

2. Scope and Applicability

These analytical methods can be applied to all surface waters. Data interpretation will need to take into account the water body type and local conditions.

3. History of NCRN in situ Chemistry Measurement

From 2005 to 2009 a YSI 85 was used to measure dissolved oxygen (DO), specific conductance, conductivity, salinity, and temperature. The unit uses similar technology to the YSI Pro Plus, including the polarographic DO probe and temperature compensation of all measurements. A YSI 100 was used for pH measurements. Due to the fragile nature of the YSI 100 it was replaced with a YSI 63 for pH measurements in 2007. The YSI 63 uses similar technology to the YSI Pro Plus and also measures specific conductance, conductivity, salinity, and temperature. In 2009 the YSI Pro Plus was purchased for the monthly water monitoring and the YSI 63 and 85 were used for other projects such as the amphibian monitoring at MANA and the climate change monitoring at Piscataway and Dyke Marsh.

4. Reference Documents

NCRN WCQ SOP 04- Field Safety

NCRN WCQ SOP 07- Water Site Location

NCRN WCQ SOP 06- Water Chemistry Field Equipment Preparation

NCRN Water Chemistry & Quantity Monitoring YSI ProPlus (DO, Specific Conductance, Salinity, pH, & Temperature) Standard Operating Procedure #10

5. Procedures and General Requirements

How the Meter Works

Specific conductance and dissolved oxygen measurements are temperature compensated (adjusted to a standard temperature such as 25°C). An internal algorithm does this adjustment automatically. Accurate temperature measurements are thus very important because any temperature error compounds the measurement error for the temperature compensated parameters. The measurement of dissolved oxygen is affected by temperature in yet another way. The amount of dissolved oxygen that water can contain at saturation varies inversely with temperature so the maximum dissolved oxygen concentration at saturation (mg/L) is higher in colder waters.

Conductivity measurements are based on the premise that when current (AC voltage) flows through two electrodes separated by an aqueous sample, the current level will have a direct relationship with the conductivity of the solution. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed. The instrument output should be in uS/cm for both conductivity and specific conductance. The multiplication of cell constant by conductance is carried out automatically by the software.

The DO sensor on the YSI Professional Plus utilizes an oxygen-permeable, 1 mm thick, Teflon membrane that covers an electrolytic cell consisting of a gold cathode and a porous silver anode in KCl solution. This membrane acts as a diffusion barrier and an isolation barrier preventing fouling of the cathode surface by impurities in the environment. A voltage (0.8 volts) is applied to the cathode/anode causing all oxygen to be consumed in the solution near the cathode. Depletion of the DO in the KCl solution causes diffusion of DO across the Teflon. After a few minutes the electrochemical reactions occurring at the anode and cathode reach a steady state and generate a potential directly related to the diffusion rate of molecular oxygen across the Teflon membrane. Because the diffusion rate is a function of the concentration of DO in the sample, the DO may be determined by the voltage output generated by the sensor. The reduction current at the cathode is directly proportional to the partial pressure of oxygen in liquid (expressed as %-air saturation) that is proportional to the concentration of dissolved oxygen (in mg/L) at a particular temperature. Thus the same partial pressure of oxygen (% air-saturation) in liquid gives different concentrations of dissolved oxygen (mg/L) at different temperatures because of the different solubilities of oxygen at different temperatures.

Field Measurements of Dissolved Oxygen

Measure the wetted width of the stream. Take 1 reading per 10 ft. for each parameter (<10ft.= 1 reading, <20 ft.=2 readings, <30ft.=3 readings etc.). Immerse the probe in the stream, making sure it is covered with water. When the sensors equilibrate to water conditions and the readings become stable record the data for temperature, pH, DO%, DO mg/L, conductivity, specific conductance and salinity. Rinse the probe with deionized water and store in the grey plastic sleeve.

NCRN Water Chemistry & Quantity Monitoring YSI ProPlus (DO, Specific Conductance, Salinity, pH, & Temperature) Standard Operating Procedure #10

Dissolved oxygen (DO) should be measured in-situ, or in the field, as concentrations may show a large change in a short time if the sample is not adequately preserved. It is important to remember that the dissolved oxygen probe is stirring dependent. This is due to the consumption of oxygen at the sensor tip during measurement. When taking DO measurements the probe must be moved through the sample at a rate of 1 foot per second to provide adequate stirring.

Turn the instrument on and wait 5-15 minutes for readings to stabilise.

Place the probe fully in the water but do not rest the end on the substrate. After the instrument reading has stabilized (allow 1 to 2 minutes and ± 0.3 mg/L), record DO concentration in mg/L and percentage. Take the measurement at each point in the cross-section, completely removing the probe from the water in between each measurement and re-stabilizing the probe after return to the water. This will provide field replicates of measurements, to counteract any false variability produced by the meter.

Place the probe in the sample to be measured and give the probe a quick shake to release any air bubbles. Allow the temperature readings to stabilize. Next, stir the probe in the sample to overcome the stirring dependence of the dissolved oxygen sensor. You must provide at least 12 inches per second for the Teflon membranes of the polarographic sensor. Once the values plateau and stabilize, you may record the measurement and/or log the data set. The dissolved oxygen reading will drop over time if stirring is ceased. Too low a velocity (< 1 ft./sec) can deplete DO at the sensor membrane boundary resulting in an erroneously low DO reading, to avoid this manually move the probe through the water (up and down).

If placing the DO sensor into a stream or fast flowing waters it is best to place it perpendicular to the flow and NOT facing into the flow. Too high a water velocity or turbulence can cause a streaming effect at the sensor membrane boundary and result in an erroneously low DO reading - finding another cross-section profile location to inserting the sonde in a section of screened pipe to reduce water velocity past the sensor.

Measurements should be reported to the nearest 0.1 mg/L for amperometrically (probe/sensor) determined DO values that fall within the range of 0.1 to 20 mg/L. Under some conditions of extreme supersaturation, DO measurements may exceed 20 mg/L. In such situations and where DO values are exceedingly low (< 0.1 mg/L), WRD recommends defaulting to the NAWQA protocol and simply reporting these results as > 20 mg/L and 0.0 mg/L, respectively.

Field Measurement of Specific Conductance / Conductivity

To obtain the most accurate readings, be sure the instrument is calibrated before taking measurements. The conductivity sensor will provide quick readings as long as the entire sensor is submerged and no air bubbles are trapped in the sensor area. Immerse the probe into the sample so the sensors are completely submerged and then shake the probe to release any air bubbles. Occasional cleaning of the sensor may be necessary to maintain accuracy and increase the responsiveness.

**NCRN Water Chemistry & Quantity Monitoring
YSI ProPlus (DO, Specific Conductance, Salinity, pH, & Temperature)
Standard Operating Procedure #10**

Immerse the conductivity and temperature sensors in the water to completely cover the probe and hold there (no less than 60 seconds) until the sensors equilibrate to water conditions and the temperature reading becomes stable.

If the readings do not meet the stability criterion after extending the measurement period, record this difficulty in the field notes along with the fluctuation range and the median value of the last five or more readings. Concentrations of suspended material may be interfering with obtaining a stable measurement.

Record the specific conductance, conductivity, salinity and temperature readings without removing the sensors from water.

Field Measurement of pH

pH readings are typically quick and accurate. However, it may take the sensors a little longer to stabilize if they become coated or fouled. To improve the response time of a sensor, follow the cleaning steps in the Maintenance.

Cleaning

When measurements for the stream have been completed, remove the sensor from the water, rinse the probe thoroughly with deionized water, and store it in the grey plastic sleeve.

NCRN Water Chemistry & Quantity Monitoring Width, Depth and Discharge Standard Operating Procedure #11

Revision History Log:

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

1. Purpose

This standard operating procedure (SOP) provides instruction on how to take width, depth and discharge measurements for determination of surface water dynamics.

2. Scope and Applicability

This standard operating procedure (SOP) applies to wadeable flowing waters of National Capital Region Network (NCRN) parks.

This SOP applies to using various instruments to determine stream cross section. The detailed Surface Water Dynamics Protocol has been discarded in favor of a simpler SOP included within the Water Chemistry Monitoring Protocol.

3. Reference Documents

Buchanan, T.J., and Somers, W.P., 1969, Discharge measurements at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A8, p. 37-42.

Gore, James A., 1996, Chapter 3: Discharge measurements and streamflow analysis: p.53-74, in Hauer, Richard, and Lamberti, Gary A., Methods in Stream Ecology, New York, Academic Press. 674 p.

Rantz, S.E., and others, 1982, Measurements and computation of streamflow, volumes 1 and 2: U.S. Geological Survey, 631 p.

SonTek/YSI Inc. 2007. FlowTracker Handheld ADV Technical Manual, Firmware Version 3.3, Software Version 2.20. SonTek/YSI Inc., Yellow Springs, OH.

4. Equipment

- Sontek Flowtracker
- Tape measure
- Surveying pins - for anchoring tape measure to stream banks (can also use a long screwdriver, garden trowel, shovel, tree, etc.)

NCRN Water Chemistry & Quantity Monitoring Width, Depth and Discharge Standard Operating Procedure #11

- Waders - hip or chest
- Pencils, markers, and labels

5. Procedures and General Requirements

Quantitative flow/discharge data should be acquired at most monitoring stations. Stream discharge is defined as the unit volume of water passing a given point on a stream or river over a given time. Stream discharge is typically expressed in cubic feet per second (cfs) or cubic meters per second (cms) and is based on the continuity equation or velocity-area method $Q = A * V$, where A is the cross sectional area of the stream at the measurement point and V is the average velocity of water at that point (Stednick and Gilbert 1998).

The Sontek FlowTracker is operated from a simple keypad interface, with instructions and real-time data displayed on an LCD screen. No PC is required for data collection.

- The system collects data for a fixed length of time at each location.
- For each location, you enter a few parameters to document the data set (e.g., location, water depth, measurement depth).
- For river discharge applications, these parameters are used with velocity data to compute discharge in real-time.
- All data are stored on an internal recorder. Later, you can download the data to a PC for additional processing, display, and archiving.

The FlowTracker Handheld ADV is a single-point Doppler current meter designed for field velocity measurements. The FlowTracker uses the Doppler technology of the SonTek/YSI Acoustic Doppler Velocimeter (ADV). ADV technology provides several advantages.

When needed, install AA batteries in the compartment in the back of the unit by unscrewing the plate, be sure that the crevasse is free of moisture, dirt or corrosion. Keep the unit clean and free of build up. It is not necessary to clean the acoustic beam.

Download all data from previous site measurements before / after each field day (see SOP#18).

Area is accurately calculated by measuring depths at several increments along the cross-section or stream transect while a current meter is used to measure velocity at the same location as each depth measurement (Harrelson et al. 1994). Initially, several discharges are computed at various stages at a frequency that enables definition of the station/discharge rating curve for the site. The stage-discharge relationship may be simple or complex depending on several factors indigenous to the stream and the rate of change of stage.

NCRN Water Chemistry & Quantity Monitoring Width, Depth and Discharge Standard Operating Procedure #11

Site Selection

The first step in streamflow measurement is selecting a cross section across the total width of the stream. Select a straight reach where the streambed is uniform and relatively free of boulders and aquatic growth. The flow should be uniform and free of eddies, dead water near banks, and excessive turbulence.

Select a reach of stream matching as close as possible to the following characteristics:

A straight reach with the threads of velocity parallel to each other.

Stable streambed free of large rocks, weeds, and protruding obstructions such as piers, which would create turbulence.

A flat streambed profile to eliminate vertical components of velocity.

Select a representative cross section within the reach where the discharge measurement will be made. For wading measurements, the ideal cross section should be at least 10 ft wide and no shallower than 0.3 ft.

Use a wading rod to determine the range of water depths in the cross section

The top-setting rod has a hexagonal main rod for measuring depth and a sliding round rod for setting the position of the current velocity meter. The rod is placed in the stream so the base plate rests on the streambed. The depth of water is read on the hexagonal rod to the 0.1 feet. Single marks on the hex rod indicate one tenth of a foot, double marks are one half of a foot, and a triple mark indicates a whole foot.

When the water is less than 1.5 feet, only the 60% depth (from the water surface) measurement is taken. When the water is deeper than 1.5 ft, both the 20% and 80% depths measurements are taken. Neither the Flowtracker nor its top-setting rods work below water depths of 0.2 feet.

One Point Method in water less than 1.5 feet depth

To take the 60% measurement, you want the foot reading of your water depth on the round rod to line up with the tenths reading of your water depth on the scale on the handle. If, say, your water is 1.3 feet deep, the 1 mark on the round rod would be lined up with the 3 mark on the handle. Now your meter is positioned at the 60% depth from the water surface.

Two Point Method in water more than 1.5 feet depth

The top-setting wading rod allows the user to easily set the sensor at 0.8 and 0.2 of the total depth by using the markings on the rod. To take the 20% measurement, measure your water depth using the hex rod. Multiply the total depth by 2. Take this value and line up the foot measure on the

NCRN Water Chemistry & Quantity Monitoring Width, Depth and Discharge Standard Operating Procedure #11

round rod to the tenth measure on the handle scale. If the total depth is 3.1 ft, the rod would be set at 6.2. Line up the 6 mark on the round rod with the 2 mark on the handle scale.

To take the 80% measurement, take your water depth from the hex rod. Divide the total depth by 2. Use this value to line up the foot mark on the round rod to the tenth mark on the handle scale. Using the total depth example of 3.1 ft., the rod would be set at 1.55. Line up the 1 mark on the round rod in between the 5 and the 6 mark on the handle scale.

Preparing to Make the Discharge Measurement

Measure and record flow after recording visual observations. Do not collect water samples in the area disturbed during a flow measurement.

Determine the width of the stream at the measurement cross section as follows: String measuring tape for measurements. String the tape at right angles to the direction of flow to avoid horizontal angles in the cross section. Select verticals (at the center of a cell) to best represent the distribution of discharge in the cross section.. Next, determine the spacing or width of the verticals. If the stream width is less than 5 ft, use vertical spacing widths of 0.5 ft. If the stream width is greater than 5 ft, the minimum number of verticals is 10. If there are any hydraulic irregularities (protruding boulders, cascades, pools, etc.) across the transect, a new cell should be designated at the point where the irregularity begins and a new cell designated where more uniform conditions resume.

Several measurements of mean velocity must be taken across the stream, because flow is unevenly distributed across the stream channel. However, if the flow is very irregular, say on a meander bend or where undercut banks and boulders obstruct or alter flow, the entire velocity distribution must be measured and plotted to determine a mean. In general, stream ecologists and hydrologists try to avoid these situations because of the relative difficulty in obtaining accurate measurements at these sites. Between entering tributaries, discharge should be fairly constant, but may vary with gains or losses to the stream channel (particularly in alluvial, gravel-bed streams where a significant amount of water may be lost to or gained from the hyporheic zone along an unconfined stream reach).

Identify the stream bank by either LEW or REW (left edge of water or right edge of water, respectively, when facing downstream).

The velocity measurements are made in the stream while wading, when the depth and velocity of water permit safe crossing of the stream. The individual taking depth and velocity measurements will stand downstream of the measurement point and in a position that least affects the velocity of the water passing the current meter (obtained by standing behind the meter facing upstream).

. The wading rod is held at the tape in a vertical position with the meter parallel to the direction of flow while the velocity is being observed. The wading rod should be kept vertical and the flow sensor kept perpendicular to the tape rather than perpendicular to the flow while measuring velocity with an electronic flowmeter. The velocity measurements will be taken by setting the

NCRN Water Chemistry & Quantity Monitoring Width, Depth and Discharge Standard Operating Procedure #11

current meter on the wading rod to the proper depth. Repeat the velocity measurement at each increment of the cross-section.

Making the Discharge Measurement

Turn the Flowtracker on using the yellow button. Press hard and hold until the text is displayed. Press 3 to **Start Data Run** and display the **Data File Name**. Press 1 and enter a filename ex caru0411 is Carter's Run April 2011. Press 9 to accept the name.

In the Starting Edge screen, enter the location, depth, correction factor and starting edge using the marked buttons on the keypad (note that LEW/REW stands for Left/Right Edge Water. Press Next Station to continue.

For each vertical measure the mean velocity: Enter the location and depth and press the Measure button. An updating display will show the measured velocity and SNR values. Keep the probe as steady as possible (the level bubble in the center). On completion of the averaging time, a summary will be displayed. Press 1 to accept and go to the next station or depth, or press 2 to repeat this measurement. These steps will be repeated for all stations until End Section is pressed.

When End Section is pressed, the ending-edge information is displayed. Enter the information for this edge. The Previous Station and Next Station buttons can also be pressed to review completed stations. Press Calc Discharge to compute the total cross-sectional discharge for all completed stations. Press 0 to return to the Main Menu. You must always return to the main menu to make sure that all data is saved.

Qualitative Estimate of flow/discharge for Flowing Water Bodies (e.g., stream/river)

In recognition of cost, effort level, equipment, and expertise required to quantitatively measure flow/discharge, WRD requires that only a qualitative estimate or assessment of flow be obtained at all monitoring stations. In the absence of a quantitative flow measurement at/near the monitoring site (preferred but not required), a qualitative assessment of flow/discharge (low, medium, high, flood stage, etc.) should also be documented (or a quantitative flow estimate be approximated) at all flowing freshwater monitoring sites in the program.

At a minimum, a qualitative estimation of flow will be made based on visual estimation of relative % of bank full at the sampling site as follows:

- Low / Base flow when < 25% of bank full condition

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- Intermediate from 25% to 75% of bank full,
- High, 75% to 100% of bank full
- Flood/Overbank > 100% of bank full

or a similar percent estimation based on the stream hydrograph from the nearest gauging station that is too distant for an accurate quantitative measurement of flow for the monitoring site.

Off load data from the Flowtracker to:

T:\I&M\MONITORING\WaterQual&Quant\Data\Hydrology\Sontek_Data_Files

See SOP # 19 for the flow data management procedures.

NCRN Water Chemistry & Quantity Monitoring Acid Neutralizing Capacity Standard Operating Procedure #12

Revision History Log:

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

1. Purpose

This standard operating procedure describes how to analyze water samples for acid neutralizing capacity (ANC). Alkalinity is filtered water's ability to neutralize acid, whereas ANC is the alkalinity of an unfiltered water sample (i.e., alkalinity due to both dissolved and suspended matter). The pH of water does not indicate its "buffering capacity," which is controlled by the amounts of alkalinity and acidity present. ANC is typically caused by anions in natural waters that can enter into a chemical reaction with a strong acid. These are primarily the carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions. ANC is the prime indicator of a water body's susceptibility to acid inputs. It is particularly important to measure in areas where acid mine drainage (PRWI) or acid precipitation (entire NCRN) is a potential concern.

2. Scope and Applicability

These analytical procedures can be used for all water resources.

3. History of NCRN Acid Neutralizing Capacity Analysis

Hach Method 8203 (Alkalinity, Phenolphthalein and Total using Sulfuric Acid Method) is currently utilized as the active methodology for determining Acid Neutralizing Capacity and has been since May 2005.

For the month of July 2007, NCRN utilized Phenolphthalein Indicator solution and Bromcresol Green-Methyl Red Indicator solution after all reagents were lost to a refrigeration malfunction and resulting mold infestation.

4. Reference Documents

NCRN WCQ SOP 05 – Water Chemistry Lab Preparation
 NCRN WCQ SOP 07 – Water Site Selection
 NCRN WCQ SOP 08 – Water Chemistry Sample Collection for Lab Analysis
 NCRN WCQ SOP 18 – Haz Mat Disposal
 NCRN WCQ SOP 19 – Water Resources Data Management
 NCRN WCQ SOP 20 – Water Resources Data Analysis & Reporting
 HACH. 2008. The Water Analysis Handbook. 5th edition. HACH Company; Loveland, CO.
 Rounds, S. A. 2006. 6.6 Alkalinity and acid neutralizing capacity. *in* USGS, editor. USGS.

NCRN Water Chemistry & Quantity Monitoring Acid Neutralizing Capacity Standard Operating Procedure #12

5. Active Procedure and Requirements

Table 12-1 Equipment and reagents for ANC analysis

Reagents	Sulfuric Acid Cartridges 0.1600 or 1.600 Phenolphthalein Powder Pillows Bromcresol Green- Methyl Red Powder Pillows De-ionized Water Alkalinity Standard Solution Voluette Ampule 0.500 N Na ₂ CO ₃ , 10-mL Buffer Powder Pillows, pH 4.5 Buffer Powder Pillows, pH 8.3
Equipment	Digital Titrator and delivery tubes 125 mL Erlenmeyer Flask graduated cylinder

ANC will be analyzed for all sites every month. ANC will be determined in the laboratory by titrating a water sample with a standard solution of sulfuric acid and monitoring the pH change as the acid is added to the sample.

Table 12-2. Expected Range of ANC values at NCRN parks.

Note that 1meq/L ANC = 1 mg/L CaCO₃ ÷ 50, 1 meq/L = 1000 ueq/L, therefore 1 mg/L CaCO₃ = 20 ueq/L ANC

PARK	Karst / Limestone?	ANC (mg/L CaCO ₃)	ANC (ueq/L)	Conductivity (µS/cm)	Recommended Titration Range (mg/L CaCO ₃)
ANTI	Yes	105-334	2100 – 6680		100 – 400
CATO	No	14.0 – 52.9	280 – 1058		0 – 40
GWMP	No	10-169	200 - 3376		40 – 160
HAFE	No/Yes	140 – 312	2800 – 6240		100 – 400
MANA	No	30 – 196	600 – 3912		40 – 160
MONO	Yes	29 – 208	576 – 4152		40 – 160
NACE	No	14 – 116	278 – 2328		0 – 40
PRWI	No	10 – 47	200 – 932		0 – 40
ROCR	No	28 – 161	552 - 3224		40 – 160
WOTR	No	11-115	222 - 2296		0 – 40

Interferences to ANC Determination

Water color, turbidity or the presence of chlorine can interfere with ANC determination. Table 12-3 describes steps to eliminate the interference under these conditions.

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Table 12-3 Interfering Substances

Interfering Substance	Interference Level and Corrections
Chlorine	> 3.5 mg/L may cause a yellow-brown color when the Bromcresol Green-Methyl Red Powder Pillow is added. Add one drop of 0.1 N Sodium Thiosulfate to the sample to remove chlorine before starting the test.
Color or Turbidity	Can mask the color change of the end point. Use a pH meter instead of the color indicators and titrate to a pH of 8.3 for phenolphthalein alkalinity. For total alkalinity see Table 12-5 for the correct endpoint pH.

Verifying Technique

Whenever new equipment is used, new personnel are in the lab, or the analysis has not been performed in awhile, it is helpful to run a sample of known concentration. This technique will confirm the operator is following the procedure correctly and the new equipment is working properly. Perform a calibration check on the digital titrator at least annually. If results show an equipment calibration problem, contact the manufacturer for repair or replacement.

Use Standard 0.500 N Na₂CO₃ catalog# 14278-10 as the “sample”

For 0.1 mL of standard use 0.1600 N H₂SO₄ Catalog # 14388-01.

For 1.0 mL standard use 1.600 N H₂SO₄ Catalog# 14389-01.

In both cases the expected Digits are 250.

Snap the neck off an Alkalinity Voluette Ampule Standard, 0.500N.

Use a TenSette Pipet to add 0.1 mL of standard to the sample. Resume titration back to the same end point. Record the number of digits needed.

Repeat, using two more additions of 0.1 mL. Titrate to the end point after each addition.

Each 0.1 mL addition of standard should require 25 additional digits of 1.600 N titrant or 250 digits of 0.1600 N titrant. If these uniform increases do not occur, evaluate possible interferences or errors.

End Point Confirmation

A solution of one pH 8.3 Buffer Powder Pillow and one Phenolphthalein Powder Pillow in 50 mL of De-ionized water is recommended as a comparison for determining the proper end point color.

A solution of one Bromcresol Green-Methyl Red Powder Pillow and one pH 4.5 Buffer Powder Pillow in 50 mL of de-ionized water is recommended as a comparison for judging the pH 4.5 end point color.

NCRN Water Chemistry & Quantity Monitoring

Acid Neutralizing Capacity

Standard Operating Procedure #12

Sample analysis (Alkalinity (10-4000 mg/L as CaCO₃); Phenolphthalein alkalinity and Total alkalinity using sulfuric acid with a digital titrator HACH Method 8203)

The sample is titrated with sulfuric acid to a colorimetric end point corresponding to a specific pH. Phenolphthalein alkalinity is determined by titration to a pH of 8.3, as evidenced by the color change of phenolphthalein indicator, and includes the total hydroxide and one half the carbonate present. Methyl orange or Total alkalinity is determined by titration to a pH between 3.7 and 5.1, and includes all carbonate, bicarbonate, and hydroxide. Alternatively, total alkalinity end may be determined by using a pH meter and titrating to the specific pH required for the sample composition.

Warm the sample to room temperature before analyzing.

Table 12-4. Analysis parameters for expected ANC concentrations

Range (mg/L as CaCO ₃)	Sample Volume (mL)	Titration Cartridge (H ₂ SO ₄)	Catalog #	Digit Multiplier
0-40*	100	0.1600	14388-01	0.1
40-160	25	0.1600	14388-01	0.4
100-400	100	1.600	14389-01	1.0
200-800	50	1.600	14389-01	2.0
500-2000	20	1.600	14389-01	5.0
1000-4000	10	1.600	14389-01	10.0

* In the method published by Hach they give the lower limit as 10 mg/L but it is entirely possible to measure 0 if the Bromocresol Green - Methyl red turns any color other than teal on contact with the sample. Since this is a titration, values between 0 and 10 mg/L are also possible to measure, though USGS recommends a titration with 0.016 H₂SO₄ below 10 mg/L. USGS also recommends the Gran Function Plot Method for water in which the alkalinity or ANC is expected to be less than about 20 mg/L or in which conductivity is less than 100 µS/cm, or if there are appreciable noncarbonated contributors or measurable concentrations of organic acids (Rounds 2006)

Select the sample volume and Sulfuric Acid (H₂SO₄) Titration Cartridge from Table 12-3 corresponding to the expected alkalinity concentration as mg/L calcium carbonate (CaCO₃) from Table 12-2 and record on the sample data sheet. Place a clean, dry stir bar into the beaker before transferring the sample to the beaker. Do not use a magnetic stirrer if the sample conductivity < 100 µS/cm.

Remove the polyethylene cap and insert a clean delivery tube into the end of the cartridge until it is tight. Do not insert the tube past the cartridge neck. It might be necessary to remove a small burr on the leading edge of the tube before insertion.

Slide the cartridge into the titrator receptacle and lock into position with a slight turn.

NCRN Water Chemistry & Quantity Monitoring Acid Neutralizing Capacity Standard Operating Procedure #12

To start titrant flowing and flush the delivery tube, hold the tip of the cartridge up. Advance the plunger release button to engage the piston with the cartridge (push the button in and toward the cartridge).

Turn the delivery knob until air is expelled and several drops of solution flow from the tip; as you turn the knob a drive screw pushes a piston against the cartridge seal and forces liquid out through the delivery tube.

Use the counter reset knob to turn the digital counter back to zero and wipe the tip.

Use the smallest appropriate graduated cylinder or pipet to measure the sample volume from Table 12-4 above. Transfer the sample into a clean 250 mL Erlenmeyer flask. Dilute to the 100 mL mark with deionized water, if necessary. Sample volume measurements and dilutions must be made accurately. However, final total volume of titrated solution is not critical.

Add the contents of one Phenolphthalein Indicator Powder Pillow (4 drops of Phenolphthalein Indicator Solution may be substituted for the Phenolphthalein Indicator powder Pillow). If using a magnetic stirrer, stir the sample slowly and continuously. Avoid creating a vortex and large streaming potentials.

If the solution is colorless before titrating with Sulfuric Acid, the Phenolphthalein (P) alkalinity is 0, proceed to the Bromcresol Green Methyl Red titration.

If the solution turns pink, titrate to a colorless endpoint. A solution of one pH 8.3 Buffer Powder Pillow and one Phenolphthalein Powder Pillow in 50 mL of deionized water is recommended as a comparison for determining the proper end-point color.

Place the delivery tube tip into the solution and swirl the flask while titrating with Sulfuric Acid. Keep the tip of the delivery tube away from the stir bar to avoid bleeding acid from the tube between titrant additions. Allow sufficient time between titrant additions for the pH value displayed on the instrument to equilibrate (approximately 15-30 seconds). Record the number of digits required.

Calculate the P Alkalinity of the sample as follows: Digits Required x Digit Multiplier = mg/L CaCO_3 P Alkalinity where Digits Required = the # in the digital counter window, Digital Multiplier = # from Table 12-4. It takes into account the sample dilution and titrant strength.

Add the contents of one **Bromcresol Green-Methyl Red Indicator Pillow** to the flask and swirl to mix. (4 drops of Methyl Purple Indicator Solution may be substituted for the Bromcresol Green-Methyl Red Indicator Powder Pillow, in which case titrate from a green to a gray endpoint (pH 5.1). 4 drops of Bromcresol Green-Methyl Red Indicator Solution can also be substituted for the Bromcresol Green-Methyl Red Indicator Powder Pillow.)

Continue the titration with **Sulfuric Acid** to a light pink color, as required by the solution composition (Table 12-5). A solution of one Bromcresol Green-Methyl Red Powder Pillow and

NCRN Water Chemistry & Quantity Monitoring Acid Neutralizing Capacity Standard Operating Procedure #12

one pillow of the appropriate pH buffer in 50 mL of deionized water is recommended as a comparison for judging the proper end-point color.

Calculate Digits Required $\times$ Digit Multiplier = mg/L as CaCO_3 Total Alkalinity.

Total alkalinity primarily includes hydroxide, carbonate, and bicarbonate alkalinities. The concentration of these alkalinities in a sample may be determined when the phenolphthalein (**P**) and total alkalinities are known (Table 12-6). Fill in row 3, **Final Calculations** on data form.

Table 12-5. Bromcresol Green- Methyl Red Titration endpoints based on sample concentration

Sample Composition	End Point	Phenolphthalein Alkalinity
Alkalinity ~ 30 mg/L	4.9	pH 8.3
Alkalinity ~ 150 mg/L	4.6	pH 8.3
Alkalinity ~ 500 mg/L	4.3	pH 8.3
Silicates or phosphates present	4.5	pH 8.3

Table 12-6. Alkalinity relationship, where P = phenolphthalein alkalinity

Row	Result of Titration	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Alkalinity
1	P = 0	0	0	Total Alkalinity
2	P = Total Alkalinity	Total Alkalinity	0	0
3	P < ½ Total Alkalinity	0	2 x P	Total alkalinity
4	P = ½ Total Alkalinity	0	Total Alkalinity	0
5	P > ½ Total Alkalinity	2 (P-total Alkalinity)	2 x difference b/t P and Total Alkalinity	0

This analysis yields a measurement of mg/L CaCO_3 . To convert this to ueq/L ANC, multiply the value by 20. On the Tablet PC select the Lab Data tab. Under ANC select the tab for the expected range of the site and enter the number of digits for Phenol and Bromcresol. The calculations for alkalinity will be performed automatically. If the sample alkalinity is outside the expected range, adjust the water sample dilution &/or sulfuric acid concentration and repeat the titration for the appropriate range. Enter the digits in the tab for that range. **DO NOT ERASE THE PREVIOUS RANGE DATA.** Be sure to select the appropriate data range for the final titration before leaving this section of the data form.

After completing testing for the day, press the plunger release button and manually retract the plunger into the body of the titrator. Remove the cartridge. Remove the delivery tube and reseal the cartridge with the polyethylene cap.

Discard or clean the delivery tube immediately after use. To clean, force water, then air, into the tube opening with a syringe or wash bottle.

Clean Up

Add sample to the flask until the color returns to blue-green, neutralizing the pH. The waste can then be poured down the sink with the tap running.

NCRN Water Chemistry & Quantity Monitoring

Nitrate

Standard Operating Procedure #13

Revision History Log:

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

1. Purpose

The purpose of this SOP is to measure the concentration of nitrate (NO₃) in non-tidal, freshwater streams.

2. Scope and Applicability

This analytical method is applicable to all surface water samples. Data interpretation must take into account local conditions. In Nitrate High Range (0-30.0 mg/L), Chromotropic Acid Method, Test 'N Tube, Hach Method 10020, nitrate in the sample reacts with chromotropic acid under strongly acidic conditions to yield a yellow product with a maximum absorbance at 410 nm.

3. History of NCRN Nitrate Analysis

Hach Method 10020 (Nitrate, Chromotropic Acid Method, Test 'N Tube) is currently utilized to determine nitrate levels and has been since July 2007.

During the month of July 2007, NCRN utilized Hach Method 8171 (Nitrate, Cadmium Reduction Method, Mid-Range AccuVac ampuls) to determine nitrate levels after all reagents were lost to a refrigeration malfunction and resulting mold infestation.

NCRN previously utilized Hach Methods 8039 (Nitrate, Cadmium Reduction Method, High-Range powder pillows), 8171 (Nitrate, Cadmium Reduction Method, Mid-Range powder pillows), and 8192 (Nitrate, Cadmium Reduction Method, Low-Range powder pillows) to determine nitrate levels from May 2005 until July 2007

4. Reference Documents

NCRN WCQ SOP 5– Water Chemistry Lab Preparation

NCRN WCQ SOP 7 – Water Site Location

NCRN WCQ SOP 8 – Water Chemistry Sample Collection for Lab Analysis

NCRN WCQ SOP 17 – Haz Mat Disposal

NCRN Water Chemistry & Quantity Monitoring Nitrate Standard Operating Procedure #13

NCRN WCQ SOP 18 – Water Resources Data Management

NCRN WCQ SOP 19 – Water Resources Data Analysis

HACH. 2004. DR4000U Handbook. 4th edition. HACH Company; Loveland, CO

5. Active Procedure and Requirements

Table 13-1 Equipment and reagents for nitrate analysis

Reagents	Nitrate Pretreatment Solution Vials NitraVer X Reagent B Powder Pillows De-ionized Water Nitrate Nitrogen Standard Solution, 15- mg/L NO ₃ -N Nitrate Nitrogen Standard Solution, 1000-mg/L NO ₃ -N
Equipment	HACH DR/4000 DR/4000 Test Tube adapter Micro funnel, poly Test Tube Rack Pipet tips TenSette Pipet, 1.00 mL

Sample Collection, Storage and Preservation

Collect samples in clean plastic or glass bottles. Store at 4 °C (39 °F) or lower if the sample is to be analyzed within 24 to 48 hours. Warm to room temperature before running the test. For longer storage periods (up to 14 days), adjust sample pH to 2 or less with concentrated sulfuric acid, ACS (about 2 mL per liter). Do not use mercury compounds as preservatives. Sample refrigeration is still required. Before testing the stored sample, warm to room temperature and neutralize with 5.0 N Sodium Hydroxide Standard Solution. Record the volume used to adjust pH on the Sample Data Sheet.

Correct the test result for volume additions. Determine the volume of the initial sample, the volume of acid and base added, and the total final volume of the sample. Divide the total volume by the initial volume. Record this factor on the Sample Data Sheet. After sample analysis, multiply the test result by this factor

Turn the spectrophotometer on. The machine will run through a series of self tests and calibrations. Keep the lid closed during this sequence.

Reagent Blank QA/QC

All QA/QC procedures should be run with each new lot of reagent. For the Reagent Blank repeat the test procedures below using deionized water as a sample.

Record in Lab Log.

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Correct for the reagent blank by pressing the soft keys under **OPTIONS, (MORE)**, and then **BLANK:OFF**. Enter the reagent blank value and press **ENTER**. Repeat for each new lot of reagent.

If it is not the beginning of a new reagent lot, check the Lab Log for the applicable value to record on the Lab Data Sheet. Subtract this value from each result obtained with this lot of reagent.

Standard Additions (Sample Spike) QA/QC

Leave the reagent blank in the sample compartment. Verify that the units displayed are in mg/L. Select standard additions mode by pressing the soft keys under **OPTIONS, (MORE)** and then **STD ADD**.

Press **ENTER** to accept the default sample volume (mL), 25.0.

Press **ENTER** to accept the default standard concentration (mg/L), 500.0.

Press the soft key under **ENTRY DONE**.

Snap the neck off a High Range Nitrate Nitrogen Voluette Ampule Standard, 500-mg/L $\text{NO}_3\text{-N}$.

Use the TenSette Pipet to add 0.1, 0.2, and 0.3 mL of standard, respectively, to three 25-mL samples and mix each thoroughly.

Analyze each standard addition sample as described below. Accept the standard additions reading by pressing the soft key under **READ** each time. Each addition should reflect approximately 100% recovery.

After completing the sequence, the display will show the extrapolated concentration value and the “best-fit” line through the standard additions data points, accounting for matrix interferences.

Standard Calibration QA/QC

To perform a nitrate calibration using the Test ‘N Tube Chromotropic Acid method, prepare calibration standards containing 4, 14, and 30 mg/L $\text{NO}_3\text{-N}$ as follows:

Into three different 500-mL Class A volumetric flasks, pipet 2.00, 7.00, and 15.00 mL of a 1000mg/L Nitrate Nitrogen Standard Solution using Class A glassware.

Dilute to the mark with deionized water. Mix thoroughly.

Using the Test ‘N Tube Chromotropic Acid method and the calibration procedure described in the *User-Entered Program* section of the *DR/4000 Spectrophotometer Instrument Manual*, generate a calibration curve from the standards prepared above.

NCRN Water Chemistry & Quantity Monitoring Nitrate Standard Operating Procedure #13

Potential Interferences and Mitigation

Barium interferes at concentrations greater than 1 mg/L, resulting in lower than expected readings.

Chloride interferes at concentrations greater than 1000mg/L. No mitigation exists.

Hardness does not interfere at any concentration.

Nitrite interferes at concentrations greater than 12 mg/L, resulting in higher than expected readings. Remove nitrite interference up to 100 mg/L by adding 400 mg of urea (one full 0.5 gram Hach measuring spoon) to 10 mL of sample. Swirl to dissolve. Proceed with the nitrate test as usual.

Sample Analysis

Press the soft key under HACH PROGRAM. Select the stored program number for Nitrate, Test 'N Tube method, by pressing 2511 with numeric keys, then press ENTER.

The display will show: HACH PROGRAM: 2511 N, Nitrate HR TNT. The wavelength 410 nm is automatically selected.

Insert the Test Tube Adapter into the sample cell module by sliding it under the thumb screw and into the alignment grooves. Fasten with the thumb screw.

Remove the cap from a Nitrate Pretreatment Solution Test 'N Tube vial and add 1.00 mL of sample (this will be the sample blank). Use a different pipet tip for each sample.

Cap the tube and invert 10 times to mix. (note: This test is technique sensitive. If these instructions are not followed, low results may occur.) Hold the tube in a vertical position with the cap pointing up. Invert the vial so the cap now points down. Wait for all of the solution to flow to the cap end. Pause. Return the vial to the original upright position. Wait for all the solution to flow to the vial bottom. This process equals one inversion. Do this 10 times.

Clean the outside of the vial with a Kimwipe.

Place the sample blank into the cell holder and close the light shield.

Press the soft key under ZERO. The display will show: 0.0 mg/L NO₃--N.

Remove the vial from the instrument. Remove the cap from the vial

Using a funnel, add the contents of one NitraVer X Reagent B Powder Pillow to the vial. Cap and invert 10 times to mix. (this will be the prepared sample.)

NCRN Water Chemistry & Quantity Monitoring Nitrate Standard Operating Procedure #13

Press the soft key under START TIMER. A 5-minute reaction period will begin. Do not invert the vial again.

When the timer beeps, clean the outside of the vial with a towel.

Place the prepared sample into the cell holder and close the light shield. The result in mg/L nitrate nitrogen (or chosen units) will be displayed.

Clean Up

The Chromotropic reagent is highly acidic. Dispose of the waste in the container marked Nitrogen TNT ACID. Do not dispose of the waste in a container marked BASE.

NCRN Water Chemistry & Quantity Monitoring Total Phosphorus as P Standard Operating Procedure #14

Revision History Log:

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

1. Purpose

Phosphorous is frequently a limiting nutrient in aquatic systems. Potential sources of phosphorous include: sediments, fertilizer application (e.g., irrigation return flow), cleaning and laundry soaps and detergents. When phosphorus is not limiting eutrophication occurs. Total phosphorus will be monitored because phosphorus is bioavailable in so many different forms, it is not useful to monitor them individually. Phosphorus will be measured with a Hach spectrophotometer and reagents using Method 8190 Phosphorus, Total, TNT PhosVer 3 Method with Acid Persulfate Digestion, , (0.06 to 3.50 mg/L PO₄³⁻). Samples will be analyzed in the CUE water lab.

2. Scope and Applicability

This SOP can be applied to all surface waters. Location should be considered during data analysis.

Phosphorus occurs in natural waters and wastewaters almost solely as phosphates (Eaton, Clesceri et al. 2005). Phosphorus occurs in streamwater as orthophosphate (PO₄³⁻) dissolved in water and attached to inorganic particles in suspension; as dissolved organic molecules; and in particulate organic form, mainly in bacteria and detrital particles. Total P (TP) is determined by analyzing unfiltered samples and includes all forms of P; including those present in organisms, detritus, and absorbed to inorganic complexes such as clays and carbonate (Wetzel 2001 in Allan and Castillo 2007). The various P fractions can be analyzed using filtration and digestion to separate its various forms, followed by measurement using colorimetry and additional reactions (Eaton, Clesceri et al. 2005; Allan and Castillo 2007).

Phosphates that respond to colorimetric tests without preliminary hydrolysis or oxidative digestion of the sample are termed “reactive phosphorus” (Eaton, Clesceri et al. 2005). In common usage, orthophosphate, phosphate, SRP (soluble reactive phosphorus) and dissolved inorganic P are interchangeable terms that refer to the form of P available for organisms to take up. Reactive P is considered to be the best indicator of what is immediately available for uptake, but because P cycles so quickly through its various states, TP is a better overall measure of available P (Allan and Castillo 2007). Total phosphorus analyses embody two general; procedural steps: (1) conversion of the P to dissolved orthophosphate, and (2) colorimetric determination of dissolved orthophosphate (Eaton, Clesceri et al. 2005). In this test

NCRN Water Chemistry & Quantity Monitoring Total Phosphorus as P Standard Operating Procedure #14

Orthophosphate reacts with molybdate in an acid medium to produce a Phosphomolybdate complex. Ascorbic acid then reduces the complex, giving an intense molybdenum blue color.

3. History of NCRN Phosphorus Analysis

Hach Method 8190 (Phosphorus, total, PhosVer 3 with Acid Persulfate Digestion, Low-Range Test 'N Tube) has been used for determining phosphorus levels since January 2009.

Hach Method 8048 (Phosphorus, reactive, PhosVer 3 Method, Low-Range Test 'N Tube) is currently being discontinued as the utilized methodology for determining phosphorus levels. This test will continue to be used for QA/QC purposes until all stocks are depleted. This test has been used since March 2007. Data collection with the two methods (PhosVer3 and Amino Acid) overlapped from March through July 2007. Data from both tests are located on the data sheets.

For the month of July 2007, NCRN utilized AccuVac ampuls (Hach method 8048) after all reagents were lost to a refrigeration malfunction and resulting water and microbe contamination.

NCRN previously utilized Hach Method 8190 (Phosphorus, total digestion, Organic and Acid Hydrolyzable, Acid Persulfate Digestion Method) and Hach Method 8178 (Phosphorus, reactive, Orthophosphate, Amino Acid Method) to determine phosphorus levels from May 2005 until July 2007. In January 2007, glassware maintenance changed from acid triple rinse and the reuse of analytical values to >48 hour leaching and the one-time-use of disposable analytical vials.

4. Reference Documents

NCRN WCQ SOP 5– Water Chemistry Lab Preparation

NCRN WCQ SOP 7 – Water Site Location

NCRN WCQ SOP 8 – Water Chemistry Sample Collection for Lab Analysis

NCRN WCQ SOP 17 – Haz Mat Disposal

NCRN WCQ SOP 18 – Water Resources Data Management

NCRN WCQ SOP 19 – Water Resources Data Analysis

Eaton, A. D., L. S. Clesceri, E. W. Rice, and A. E. Greenberg, editors. 2005. Standard Methods for the Examination of Water and Wastewater. 21st / Centennial edition. American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC.

HACH. 2004. DR4000U Handbook. 4th edition. HACH Company; Loveland, CO

Hach. "Method 10127 Phosphorus, Total Molybdovanadate Method With Acid Persulfate Digestion HR (0.00to 100.0 Mg/L PO43-)." DR/4000 Procedure. 11th Edition ed. Hach, 2003.

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---. "Method 8048 PHOSPHORUS, Reactive (Orthophosphate) PhosVer 3 (Ascorbic Acid) Method for Powder Pillows or AccuVac® Ampuls (0 to 2.500 Mg/L PO43-)." DR/4000 Procedure. 11th Edition ed. Hach, 2003.

---. "Method 8048 PHOSPHORUS, Reactive (Orthophosphate) PhosVer 3 (Ascorbic Acid) Method for Test'N'Tube Vials (0 to 5.00 Mg/L PO43-)." DR/4000 Procedure. 11th Edition ed. Hach, 2003.

---. "Method 8178 Phosphorus, Reactive (Orthophosphate) Amino Acid Method (0.00 to 30.0 Mg/L PO43-)." DR/4000 Procedure. 11th Edition ed. H, 2003.

---. "Method 8190 Phosphorus, Total, PhosVer3 Method With Acid Persulfate Digestion (0.00 to 3.5.0 Mg/L PO43-)." DR/4000 Procedure. 11th Edition ed. Hach, 2003.

5. Active Procedures and Requirements

Table 14-1 Equipment Needed

Reagents	1 mg/L Phosphate Standard Solution 50 mg/L Phosphate 2-mL Ampule Standard PhosVer 3 Phosphate Reagent Powder Pillow Total and Acid Hydrolyzable Phosphorus Test 'N Tube Dilution Vials Sodium Hydroxide Solution, 1.54N Potassium Persulfate Powder Pillows
Equipment, supplies, glassware, etc.	HACH DR/4000 DR/4000 Test Tube Adapter Test Tube Rack TenSette Pipet Pipet tips Micro funnel Safety Shield, lab bench COD Reactor, 115/230 VAC

Sample Collection, Storage and Preservation

Collect samples in plastic or glass bottles that have been acid washed with 1:1 Hydrochloric Acid Solution and rinsed with deionized water. Do not use commercial detergents containing phosphate for cleaning glassware used in this test. Analyze samples immediately after collection for best results. If prompt analysis is impossible, preserve samples up to 28 days by adjusting the pH to 2 or less with H₂SO₄ (2 mL per L) and storing at 4 °C. Before analyzing samples, warm to room temperature and neutralize with 5.0 N Sodium Hydroxide Standard Solution. Record the volume used to adjust pH on the Sample Data Sheet.

Correct the test result for volume additions. Determine the volume of the initial sample, the volume of acid and base added, and the total final volume of the sample. Divide the total volume by the initial volume. Record this factor on the Sample Data Sheet. After sample analysis,

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multiply the test result by this factor. Turn the spectrophotometer on. The machine will run through a series of self tests and calibrations. Keep the lid closed during this sequence.

Reagent Blank QA/QC

The QA/QC analyses should be run with each new lot of reagent. For the Reagent Blank repeat the test procedures below using deionized water as a sample.

Record in Lab Log.

Correct for the reagent blank by pressing the soft keys under OPTIONS, (MORE), and then Blank:OFF. Enter the reagent blank value and press ENTER. Repeat for each new lot of reagent.

If it is not the beginning of a new reagent lot, check the Lab Log for the applicable value to record on the Lab

Standard Additions QA/QC (Sample Spike)

Leave the unspiked sample in the sample compartment. Verify that the units are displayed in mg/L. Select standard additions mode by pressing the soft keys under OPTIONS, (MORE) and then STD ADD.

Press ENTER to accept the default sample volume (mL), 25.0.

Press ENTER to accept the default standard concentration (mg/L), 50.00.

Press the soft key under ENTRY DONE.

Snap the neck off a Phosphate 2.mL Ampule Standard, 50-mg/L as PO_4^{3-} .

Use the TenSette Pipet to add 0.1 mL, 0.2 mL and 0.3 mL of standard, respectively to three 25-mL samples and mix each thoroughly.

Analyze each standard addition sample as described above (use a 5-mL aliquot of the spiked sample as the sample). Accept the standard additions reading by pressing the soft key under READ each time. Each addition should reflect approximately 100% recovery.

After completing the sequence, the display will show the extrapolated concentration value and the “best-fit” line through the standard additions data points, accounting for matrix interferences.

If you do not get about 100% recovery, repeat the standard additions with deionized water. If you then get about 100% recovery, there is an interference. See Table 14-2(Potential Interferences and Mitigation) to address any interference.

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If there is still not 100% recovery, retry with fresh reagents. Check the performance of the instrument following the Maintenance protocols. If nothing else is wrong, the standards are bad. Call Hach to arrange replacement.

Standard Calibration

To perform a phosphate calibration using the Test 'N Tube method, prepare standards containing 0.5, 1.0, 1.5, 2.0, 2.5 mg/L phosphate as follows:

Into five different 100-mL volumetric flasks, pipet 1.0, 2.0, 3.0, 4.0, and 5.0 mL of a 50-mg/L Phosphate Standard Solution using Class A glassware.

Dilute to the mark with de-ionized water and mix thoroughly.

Analyze as described below.

To adjust the calibration curve using the reading obtained with the standard solutions, press the soft keys under **OPTIONS, MORE** then **STD: OFF**. Press **ENTER** to accept the displayed concentration, the value of which depends on the selected units. If an alternate concentration is used, enter the actual concentration and press **ENTER** to return to the read screen.

Table 14-2 Potential Interferences and Mitigation

Compound	Interfering Concentration	Mitigation
Aluminum	> 200 mg/L	None
Arsenate	all concentrations	None
Chromium	> 100 mg/L	None
Copper	> 10 mg/L	None
Iron	> 100 mg/L	None
Nickel	> 300 mg/L	None
Silica	> 50 mg/L	None
Silicate	> 10 mg/L	None
Sulfide	> 90 mg/L	None
Highly turbid	inconsistent results in the test because the acid present in the powder pillows may dissolve some of the suspended particles and because of variable desorption of orthophosphate from the particles.	Filter
Zinc	>80 mg/L	none
pH	Highly buffered samples or extreme sample pH may exceed the buffering capacity of the reagents and require sample pretreatment	Adjust to neutral

Sample Analysis Methodology

Put the COD Reactor in the fume hood. Turn on the COD Reactor. When it has initialized it will beep.

Set the COD Reactor timer to 30 minutes as follows: select arrow key/ 150° / 30' / OK .

Select Start to heat the unit to 150°C. The unit will beep when it has reached 150°C.

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Meanwhile, Use a TenSette Pipet to add 5.0 mL of sample to a Test Vial. **Use a different pipet tip for each sample.**

Using a funnel, add the contents of one Potassium Persulfate Powder Pillow for Phosphonate to the vial.

Cap tightly and shake to mix.

Place the vial in the COD Reactor, and start a 30 minute heating period by pressing the soft key under START TIMER.

Carefully remove the vial from the reactor. Place it in a test tube rack and allow to cool to room temperature. (Tubes will be hot).

Using a TenSette Pipet, add 2mL of 1.54 N Sodium Hydroxide Standard Solution to the vial. Cap and mix.

On the Spectrophotometer, press the soft key under HACH PROGRAM. Select the stored program number for Test 'N Tube reactive phosphorus by pressing 3036 with the numeric keys. Press: ENTER.

The display will show: **HACH PROGRAM: 3036 P React. As. TNT.** The wavelength, 890 nm, is automatically selected.

Insert the Test Tube Adapter into the sample cell module by sliding it under the thumb screw and into the alignment grooves. Fasten with the thumb screw.

Clean the outside of the vial with a kimwipe.

Place the vial into the cell holder and close the light shield.

Press the soft key under ZERO. The display will show: 0.00 mg/L PO_4^{3-}

Using a funnel, add the contents of one PhosVer 3 Phosphate Powder Pillow to the vial.

Cap the vial tightly and shake for 10-15 seconds

Press the soft key under START TIMER. A 2-minute reaction time will begin

After the timer beeps, clean the outside of the vial with a kimwipe. Place the prepared sample vial into the cell holder and close the light shield. The results in mg/L PO_4^{3-} will be displayed. (Also record the results as phosphorus, P).

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Clean Up

Final samples will contain molybdenum. In addition, final samples will have a pH less than 2 and are considered corrosive (D002) by the Federal RCRA. Only dispose of Total Phosphorus Waste in containers marked Total Phosphorus and ACID. DO NOT dispose in BASE container

**NCRN Water Chemistry & Quantity Monitoring
Total Phosphorus as P
Standard Operating Procedure #14**

NCRN Water Chemistry & Quantity Monitoring Chlorine Standard Operating Procedure #15

Revision History Log:

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

1. Purpose

Chlorine can be present in water as free chlorine and as combined chlorine. Both forms can exist in the same water and be determined together as the total chlorine. Free chlorine is present as hypochlorous acid or hypochlorite ion. Combined chlorine exists as monochloramine, dichloramine, nitrogen trichloride and other chloro derivatives. The combined chlorine oxidizes iodide in the reagent to iodine. The iodine and free chlorine reacts with DPD (N,N-diethyl-p-phenylenediamine) along with the free chlorine to form a red color which is proportional to the total chlorine concentration. To determine the concentration of combined chlorine, run a free chlorine test. Subtract the results of the free chlorine test from the total chlorine test to obtain the combined chlorine concentration.

2. Scope and Applicability

This method is for testing residual chlorine and chloramines in water, wastewater, estuary water and seawater. It is USEPA-accepted for reporting for drinking and wastewater analyses. Procedure is equivalent to USEPA method 330.5 and Standard Method 4500-Cl G for drinking water and wastewater analyses. This analytical method is applicable to all surface water samples. Data interpretation must take into account local conditions. The estimated detection limit for program numbers 1450 and 1460 is 0.01 mg/L Cl₂.

3. History of NCRN Chlorine Analysis

Hach Method 81671 (Chlorine, total, DPD method 0-2.00 mg/L) is currently utilized to determine chlorine levels and has been since 2010.

4. Reference Documents

NCRN WCQ SOP 05 – Water Chemistry Lab Preparation
 NCRN WCQ SOP 08 – Water Chemistry Sample Collection for Lab Analysis
 NCRN WCQ SOP 17 – Haz Mat Disposal
 NCRN WCQ SOP 18 – Water Resources Data Management
 NCRN WCQ SOP 19 – Water Resources Data Analysis & Reporting
 HACH. 2008. The Water Analysis Handbook. 5th edition. HACH Company; Loveland, CO.
 HACH. 2004. DR4000U Handbook. 4th edition. HACH Company; Loveland, CO3.2

NCRN Water Chemistry & Quantity Monitoring Chlorine Standard Operating Procedure #15

5. Procedure and General Requirements

Table 15-1: Equipment for Chlorine, Total (0 to 2.00 mg/L) DPD Method 8167

Reagents	DPD Total Chlorine Powder Pillows De-ionized Water
Equipment	HACH DR/4000 DR/4000 Sample cell adapter 2 glass sample cells Pipet tips TenSette Pipet

Sample Collection, Storage and Preservation

Samples must be analyzed immediately and cannot be preserved for later analysis. Free chlorine is a strong oxidizing agent and it is unstable in natural waters. It reacts rapidly with various inorganic compounds and more slowly oxidizes organic compounds. Many factors, including reactant concentrations, sunlight, pH, temperature and salinity influence decomposition of free chlorine in water.

Avoid plastic containers since these may absorb chlorine (have a large chlorine demand). Pre-treat glass sample containers to remove any chlorine demand by soaking in a dilute bleach solution (1 mL commercial bleach to 1 liter of deionized water) for at least 1 hour.

Rinse thoroughly with deionized or distilled water. If sample containers are rinsed thoroughly with deionized or distilled water after use, only occasional pretreatment is necessary.

Do not use the same sample cells for free and total chlorine. If trace iodide from the total chlorine reagent is carried over into the free chlorine determination, monochloramine will interfere. It is best to use separate, dedicated sample cells for free and total chlorine determinations.

A common difficulty in testing for chlorine is obtaining a representative sample. If sampling from a tap, let the water flow for at least 5 minutes to ensure a representative sample. Let the container overflow with the sample several times, then cap the sample containers so there is no headspace (air) above the sample.

If sampling with a sample cell, rinse the cell several times with the sample, then carefully fill to the 10-mL mark. Perform the chlorine analysis immediately.

Reagent Blank QA/QC

A reagent blank should be run with each new lot of reagent. Repeat the test procedures below using deionized water as a sample. Zero the instrument on deionized water by pressing the soft key under **ZERO**. Insert the reagent blank and the blank value will be displayed. Correct for the reagent blank by pressing the soft keys under **OPTIONS, (MORE)**, and then **BLANK:OFF**. Enter the reagent blank value and press **ENTER**. Record in Lab Log.

If it is not the beginning of a new reagent lot, check the Lab Log for the applicable value to record on the Lab Data Sheet. And subtract this value from each result obtained with this lot of reagent.

NCRN Water Chemistry & Quantity Monitoring Chlorine Standard Operating Procedure #15

Standard Additions (Sample Spike) QA/QC Using Powder Pillows

Run a standard addition with each new lot of reagents. Equipment sensitivity and precision as determined by Hach are shown in tables 15-3 and 15-2.

Verify that the units displayed are in mg/L. Select standard additions mode by pressing the soft keys under **OPTIONS**, **(MORE)** and then **STD ADD**

Press **ENTER** to accept the default sample volume (mL), 10.0.

Locate the average chlorine concentration shown on the certificate enclosed with the LR Voluette Ampules.

When prompted for the standard concentration, use the numeric keys to enter the certificate value. Press **ENTER** to accept the default standard concentration (mg/L), 500.0. Press **ENTER**.

Press the soft key under **ENTRY DONE**.

Snap the neck off a LR Chlorine Voluette Ampule Standard, 25-30 mg/L Cl₂.

Use the TenSette Pipet to add 0.1, 0.2, and 0.3 mL of standard, respectively, to three 10-mL samples and mix each thoroughly.

Analyze each standard addition sample as described above. Accept the standard additions reading by pressing the soft key under READ each time. Each addition should reflect approximately 100% recovery.

After completing the sequence, the display will show the extrapolated concentration value and the “best-fit” line through the standard additions data points, accounting for matrix interferences.

Table15-2: Precision for a standard: 1.00 mg/L Cl₂

Program	95% Confidence Limits	Estimated Detection Limit (EDL)
1450	0.99-1.01 mg/L Cl ₂	0.01 mg/L Cl ₂
1460	0.99-1.01 mg/L Cl ₂	0.01 mg/L Cl ₂

Table 15-3: Sensitivity Program Number: 1450

Portion of Curve	ΔAbs	ΔConcentration
Entire Range	0.010	0.018 mg/L
Entire Range	0.010	0.020 mg/L

NCRN Water Chemistry & Quantity Monitoring Chlorine Standard Operating Procedure #15

Sample Analysis

If necessary, turn the spectrophotometer on. The machine will run through a series of self tests and calibrations. Keep the lid closed during this sequence.

Press the soft key under HACH PROGRAM. Select the stored program number for free chlorine (Cl_2) by pressing **1450** with the numeric keys. Press: **ENTER**

The display will show: **HACH PROGRAM: 1450 Chlorine, F&T** The wavelength (λ), **530 nm**, is automatically selected.

Fill a sample cell with 10 mL of sample. For expected interferences, make the corrections listed below in table 15-4.

Table 15-4: Potential Interferences and Mitigation

Interfering Substance	Interference Levels	Treatments
Acidity	≥ 150 mg/L CaCO_3	May not develop full color or color may fade instantly. Neutralize to pH 6–7 with 1 N sodium hydroxide. Determine amount to be added on separate sample aliquot, then add the same amount to the sample being tested. Correct for volume addition (See Section 1.2.2 <i>Correcting for Volume Additions</i>).
Alkalinity	≥ 300 mg/L CaCO_3	May not develop full color or color may fade instantly. Neutralize to pH 6–7 with 1 N sulfuric acid. Determine amount to be added on separate sample aliquot, then add the same amount to the sample being tested. Correct for volume addition
Bromine, Br_2	Interferes at all levels	
Chlorine Dioxide	Interferes at all levels	
Chloramines, organic	May interfere	
Hardness	$\geq 1,000$ mg/L as CaCO_3	
Iodine, I_2	Interferes at all levels	
Manganese, Oxidized (Mn_4^+ , Mn_7^+) or Chromium, Oxidized (Cr_6^+)		1. Adjust sample pH to 6–7 2. Add 3 drops potassium iodide (30-g/L) to a 25-mL sample 3. Mix and wait one minute 4. Add 3 drops sodium arsenite (5-g/L) and mix 5. Analyze 10 mL of the treated sample as described in the procedure 6. Subtract the result from this test from the original analysis to obtain the correct chlorine concentration
Ozone	Interferes at all levels	
Peroxides	May interfere	
Extreme sample pH	Adjust to pH 6–7	
Highly Buffered Sample	Adjust to pH 6–7	

Add the contents of one DPD Total Chlorine Powder Pillow to the sample cell (the prepared sample). Swirl the sample cell for 20 seconds to mix. A pink color will develop if chlorine is present.

NCRN Water Chemistry & Quantity Monitoring Chlorine Standard Operating Procedure #15

Press the soft key under **START TIMER**. A 3-minute reaction period will begin.

Fill another sample cell (the blank) with 10 mL of sample. Place it into the cell holder. Close the light shield.

Press the soft key under **ZERO**. The display will show: **0.00 mg/L Cl₂**. If you are using a reagent blank correction, the display will show the correction. For alternate concentration units press the soft key under **OPTIONS**. Then press the soft key under **UNITS** to scroll through the available options. Press **ENTER** to return to the read screen.

Within 3 minutes after the timer beeps, place the prepared sample into the cell holder. Close the light shield. Results in **mg/L chlorine** (or chosen units) will be displayed. If the sample temporarily turns yellow after reagent addition, or the display shows **OVER!**, dilute a fresh sample and repeat the test. A slight loss of chlorine may occur because of the dilution. Multiply the result by the appropriate dilution factor.

Record the data.

Clean Up

Samples treated with sodium arsenite for manganese or chromium interferences will be hazardous wastes as regulated by the Federal RCRA for arsenic (D004).

NCRN Water Chemistry & Quantity Monitoring Free Ammonia & Monochloramine Standard Operating Procedure #16

Revision History Log:

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

1. Purpose

Monochloramine (NH_2Cl) and “free ammonia” (NH_3 and NH_4^+) can exist in the same water sample. Added hypochlorite combines with free ammonia to form more monochloramine. In the presence of a cyanoferrate catalyst, monochloramine in the sample reacts with a substituted phenol to form an intermediate monoamine compound. The intermediate couples with excess substituted phenol to form a green-colored indophenol, which is proportional to the amount of monochloramine present in the sample. Free ammonia is determined by comparing the color intensities, with and without added hypochlorite.

2. Scope and Applicability

This method is intended for NCRN stream water samples that are suspected to contain ammonia or monochloramine from an anthropogenic source such as sewer or tap water.

3. History of NCRN Monochloramine Analysis

Hach Method 10200 (Nitrogen, Free Ammonia and Chloramine (Mono) 0-4.50 mg/L Cl_2 and 0–0.50 mg/L $\text{NH}_3\text{-N}$) is currently utilized to determine monochloramine and ammonia levels and has been since 2010. Prior to 2010 monochloramine was not measured.

Hach Methods 10023 (Nitrogen, Ammonia, Salicylate Method, Low-Range Test’n’Tube) and 10031 (nitrogen, ammonia, Salicylate Method, High-range Test’n’Tube) were used to determine ammonia level from 2007 to 2010. NCRN previously utilized Hach Method 8155 (Nitrogen, ammonia, Salicylate method powder pillows) from May 2005 until 2007.

4. Reference Documents

NCRN WCQ SOP 05 – Water Chemistry Lab Preparation
 NCRN WCQ SOP 08 – Water Chemistry Sample Collection for Lab Analysis
 NCRN WCQ SOP 17– Haz Mat Disposal
 NCRN WCQ SOP 18– Water Resources Data Management
 NCRN WCQ SOP 19– Water Resources Data Analysis & Reporting
 HACH. 2008. The Water Analysis Handbook. 5th edition. HACH Company; Loveland, CO.

NCRN Water Chemistry & Quantity Monitoring Free Ammonia & Monochloramine Standard Operating Procedure #16

5. Procedures and General Requirements

Table 16-1 Equipment and reagents for Free Ammonia & Monochloramine analysis

Reagents	Free Ammonia Reagent Set Free Ammonia Reagent Solution Monochlor F Reagent Pillows De-ionized Water
Equipment, supplies, glassware, etc.	HACH DR/4000 DR/4000 Accu Vac Sample cell adapter 2 s ample cells with cap (1 cm / 10mL)

Sample Collection and Pretreatment

Collect samples in clean glass bottles. Most reliable results are obtained when samples are analyzed immediately after collection. Preservation is not recommended. Rinse the sample container several times with sample, letting the container overflow each time. If sampling from a tap, let the water flow for at least 5 minutes before sampling. Then cap the container so that there is no head space (air) above the sample.

Reagent Blank QA/QC

QA/QC samples should be run with each new lot of reagent.

If necessary, turn the spectrophotometer on. The machine will run through a series of self tests and calibrations. Keep the lid closed during this sequence.

A reagent blank should be run with each new lot of reagent. Repeat the test procedures below using deionized water as a sample. Record in Lab Log.

Correct for the reagent blank by pressing the soft keys under **OPTIONS, (MORE)**, and then **BLANK:OFF**. Enter the reagent blank value and press **ENTER**. Repeat for each new lot of reagent.

If it is not the beginning of a new reagent lot, check the Lab Log for the applicable value to record on the Lab Data Sheet. And subtract this value from each result obtained with this lot of reagent.

NCRN Water Chemistry & Quantity Monitoring Free Ammonia & Monochloramine Standard Operating Procedure #16

Standard Solution QA/QC

Monochloramine

Prepare the Monochloramine standard fresh before use. Add the contents of one Buffer Powder Pillow, pH 8.3 to about 50-mL of organic-free water in a clean 100-mL Class A volumetric flask. Swirl to dissolve the powder.

Using a Class A volumetric pipet, transfer 2.00 mL of Nitrogen, Ammonia Standard Solution, 100 mg/L as $\text{NH}_3\text{-N}$ into the flask.

Dilute to volume with organic-free water, cap and mix thoroughly. This is a 2.00 mg/L buffered ammonia standard.

Pipet 50.0 mL of the buffered ammonia standard into a clean 100-mL beaker. Add a stir bar.

Obtain a recent lot of Chlorine Solution Ampules, 50–75 mg/L, and note the actual free chlorine concentration for this lot.

Calculate the amount of Chlorine Solution to be added to the ammonia standard using the following equation:

$$\text{mL chlorine solution required} = \frac{455}{\text{free chlorine concentration}}$$

Open an ampule and, using a glass Mohr pipet, add the calculated amount of Chlorine Solution slowly to the ammonia standard, while mixing at medium speed on a stir plate.

Allow the monochloramine solution to mix for 1 minute after all the Chlorine Solution is added.

Quantitatively transfer the monochloramine solution to a clean 100-mL Class A volumetric flask. Dilute to the mark with organic-free water, cap, and mix thoroughly. This is a nominal 4.5 mg/L (as Cl_2) monochloramine standard. Use this standard within 1 hour of preparation.

Free Ammonia Standard Additions Method

Measure 50 mL of sample into three 50-mL mixing cylinders. Use the TenSette Pipet to add 0.3, 0.6, and 1.0 mL of Ammonium Nitrogen Standard, 10 mg/L as $\text{NH}_3\text{-N}$ to the three samples. Mix well. Analyze each spiked sample following all the steps of the Monochloramine and Free Ammonia procedure. The ammonia nitrogen concentration should increase 0.02 mg/L for each 0.1 mL of standard added.

NCRN Water Chemistry & Quantity Monitoring Free Ammonia & Monochloramine Standard Operating Procedure #16

Free Ammonia Standard Solution Method

Prepare a 0.20 mg/L ammonia nitrogen standard by diluting 2.00 mL of the Ammonia Nitrogen Standard Solution, 10 mg/L, to 100 mL with deionized water. Or, using the TenSette Pipet, prepare a 0.20 mg/L ammonia nitrogen standard by diluting 0.4 mL of a Ammonia Nitrogen Voluette Standard Solution, 50 mg/L as $\text{NH}_3\text{-N}$, to 100 mL with dilution water. Analyze the standard solution following every step of the Monochloramine and Free Ammonia procedure.

Sample Analysis

Press the soft key under **HACH PROGRAM**. Enter **2475**, the stored program number for Monochloramine, LR, with the numeric keys.

Press: **ENTER**. The display will show: **HACH PROGRAM 2475 Chloramine, Mono LR**. The wavelength (λ), **655 nm**, is automatically selected.

Insert the AccuVac adapter into the sample cell module by sliding it under the thumbscrew and into the alignment grooves. Fasten with the thumbscrew.

Fill two 10-mL/1-cm cell (Labelled M for Monochloramine) to the 10-mL line with sample. Label one cell "Free Ammonia" and one cell "Monochloramine". Place the Monochloramine cell into the cell holder so that the locking ridge on the cell is oriented to the left. Press the top rim of the cell on the right side to lock it in place. Close the light shield

Press the **ZERO** soft key. The display will show: **mg/L Cl_2** .

Remove the cell from the instrument. Add the contents of one Monochlor F pillow to the cell for the Monochloramine measurement. Cap the cell and shake for 20 seconds to dissolve the reagent. A green color will form if monochloramine is present.

Add one drop of Free Ammonia Reagent Solution to the cell for Free Ammonia measurement. Cap the reagent bottle to maintain reagent performance and stability. Cap the cell and mix.

Note: If the sample becomes cloudy by the end of the reaction period, pretreat the sample according to Table 16-2 and retest. Samples containing high levels of both Total Hardness and Alkalinity may become cloudy after the addition of the Free Ammonia Reagent Solution. If this occurs by the end of the first reaction period, the sample for Free Ammonia measurement must be pretreated: Measure 10 mL of sample into the cell for Free Ammonia measurement. Add the contents of one Hardness Treatment Reagent Powder Pillow (Cat. No. 28823-46) to the sample. Cap the cell and invert until the reagent is dissolved. Remove the cap. Continue with the analysis using the pretreated sample as the Free Ammonia cell.

NCRN Water Chemistry & Quantity Monitoring Free Ammonia & Monochloramine Standard Operating Procedure #16

Table 16-2 Interfering Substances for Monochloramine and Recommended Treatment

Interfering Substance	Effect	Interference Level	Recommended Treatment
Magnesium	+	Above 400 mg/L CaCO ₃	Add 5 drops Rochelle Salt Solution prior to testing. OR: use the high range (HR) test.
Manganese (+7)	–	Above 3 mg/L	Use the HR test; it will tolerate up to 10 mg/L.
Ozone	–	Above 1 mg/L	Usually doesn't coexist with monochloramine.
Sulfide	+	Turns a "rust" color if present.	Usually doesn't coexist with monochloramine.
Thiocyanate	–	Above 0.5 mg/L	Use the HR test; it will tolerate up to 2 mg/L.

Press the **START TIMER** soft key. A 5-minute reaction period will begin. Note: Color development time depends on sample temperature, See Table 16-3 for recommended reaction periods. For accurate results allow the full reaction period to occur. The reaction periods indicated in the procedure are for a sample temperature of 18–20 °C (64–68 °F).

Table 16-3 Reaction Period

Sample Temperature		Reaction Periods (minutes)
°C	°F	
5	41	10
7	45	9
9	48	8
10	50	8
12	54	7
14	57	7
16	61	6
18	64	5
20	68	5
23	73	2.5
25	77	2
>25	>77	2

After the color has developed fully, place the Monochloramine cell into the cell holder so the locking ridge on the cell is oriented to the left. Press the top rim of the cell on the right side to lock it in place.

Close the light shield and read the result. The result in mg/L Monochloramine (as Cl₂) will be displayed. Leave the cell in the instrument. Note: Results may be expressed as NH₂Cl or N. Press the soft keys under **OPTIONS (MORE)** and then **FORM** to scroll through the available options. Press **ENTER** to return to the read screen.

Press **EXIT**, then **YES** to return to the main menu. Press **HACH PROGRAMS** then **2746** for software versions 2.42 and higher. Press the **USER PROGRAM** soft key. Use the **UP** or **DOWN** arrow keys to scroll to the *user-entered program* for N, Ammonia Free, or key in the program number with the numeric keypad. Press: **ENTER**. The display will show: **USER PROGRAM XXX N, Ammonia Free** where XXX is the User Program number assigned to the Free Ammonia test. With the Monochloramine sample still in the adapter, press the **ZERO** soft key. The display will show: **NH₃-N f**.

NCRN Water Chemistry & Quantity Monitoring Free Ammonia & Monochloramine Standard Operating Procedure #16

Remove the cell from the cell holder. Add the contents of one pillow of Monochlor- F to the cell for the Free Ammonia measurement. **Note:** *The reaction period must be complete before the addition of Monochlor F to the cell for free ammonia measurement.* Cap and shake the cell about 20 seconds to dissolve. A green color will form if Monochloramine or Ammonia is present. Press the **START TIMER** soft key. A 5-minute reaction period will begin. **Note:** *Color development time depends on sample temperature. See Table 16-4 above.* After the timer expires, place the Free Ammonia cell into the cell holder so the locking ridge on the cell is oriented to the left. Press the top rim of the cell on the right side to lock it in place. Close the light shield. The result in mg/L Free Ammonia as Nitrogen (NH₃-N) will be displayed. **Note:** *Press the **OPTIONS (MORE)** soft keys and then **FORM:** to scroll through the available options. Press **ENTER** to return to the read screen.*

Clean Up

The monochloramine reagent contains a cyanoferrate catalyst. Cyanide solutions are regulated as hazardous wastes by the Federal RCRA. Collect cyanide solutions for disposal as reactive waste (D001). Be sure cyanide solutions are stored in a caustic solution with pH>11 to prevent release of hydrogen cyanide gas. DO NOT mix the waste from this test with any waste labeled ACID. Only dispose of the ammonia test waste in the container labeled Monochloramine /Ammonia.

NCRN Water Chemistry & Quantity Monitoring: Hazardous Material Safety & Disposal Standard Operating Procedures #17

Revision History Log:

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

1. Purpose

To present the guidelines for disposing of hazardous chemicals in the National Capital Region Network (NCRN).

2. Scope and Applicability

This Standard Operating Procedure (SOP) applies to all hazardous chemical waste generated during the water chemistry and surface water dynamics protocols.

3. Reference Documents

MSDS sheets are kept in a box outside the water lab.

Haz Mat Disposal Records are maintained in the black filing cabinet drawer labeled **Property**.

4. Procedures and General Requirements

All expired reagents that do not have to be stored in the Flammables or Acid Cabinets, should be placed under the sink in the Soils Annex. Those stored in the Flammables or Acid cabinets go on the bottom shelves. All bottles must be labeled "For Disposal."

The contents of all bottles and their locations must be entered into a spreadsheet. A waste generator fee must be paid annually to the DC Treasurer to maintain our Handler ID (DCR000502880). Produce a Purchase Request and fax it to Brenda Thompson, Contracting Officer, Catocin Mountain Park along with a memo explaining that you are requesting a Courtesy Check for DDOE Annual Hazardous Waste Generator Fee for the Center for Urban Ecology.

As needed (but before the cabinets are full or containers show wear from age) make an appointment with Bishop & Associates Inc. The primary point of contact is Mark Shearer

NCRN Water Chemistry & Quantity Monitoring: Hazardous Material Safety & Disposal Standard Operating Procedures #17

at m.shearer@hotmail.com , 410-468-0400, or his cell at 410-808-4469, and fax at 410-468-0006.

If you have any questions regarding the contract you may contact the NCRN Hazardous Materials coordinator, Julia Hewitt at (202) 619-7083. Any deviations from the bid schedule will require a modification (ie. disposal of an item not on the bid schedule) - you will need to notify Julia Hewitt. If you have any concerns regarding the quote contact Julia Hewitt and she will discuss them with the contractor.

Send all requests for bid to the contractor – not to Julia Hewitt.

The park or program responsible for storing the waste is responsible for payment to the contractor.

Make sure you receive and maintain your manifests and obtain a certificate of disposal from the contractor.

When preparing your inventory please make sure you provide the type of material, if it is contaminated, and how it is presently contained. This will make pricing accurate. If you add items at the day of pick up, that were not on your original inventory, your pricing will be higher.

Bishop & Associates Inc. will assess the items in the cabinet. An NPS person with HazWOPER training must be present during collection of materials by Bishop & Associates Inc and sign off on the manifests. Copies of the manifests must be kept on file at CUE, preferably in the Water Lab. Copies should also be sent to ROCR since the building is park property.

Check the RCRA Subtitle C Site Identification Form in the Haz Mat folder in the Purchases & Property Drawer of the Water Lab filing cabinets. If the compounds intended for disposal are not listed on it, an addendum (a new copy of the form with the complete chemical listing) must be submitted to Joyce Milson of the DC Dept. of Health, 51 N St., NE, 3rd floor (near the Rhode Island Ave. metro). Joyce can be contacted at (202) 535-1906.

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Important Numbers in case of spill

Maryland:

Maryland Department of Environmental Waste Management Administration
Hazardous Waste Division
2500 Broening Hwy
Baltimore, MD 21224
(410) 537-3304

OSHA Area Office
Baltimore, MD
(410) 865-2055
OSHA Area Office
(410) 865-2056

Washington, DC:

DC Hazardous Waste
Environmental Health Administration
Toxic Substance Division
51 N Street, NE, 3rd Floor
Washington, DC 20020
(202) 535-2299

Virginia:

Virginia Department of Environmental Quality Waste; Division of Air Waste and Water
629 E Main Street
Richmond, VA 23219
(804) 698-4000

OSHA Area Office
Norfolk, VA
(757) 441-3820

West Virginia:

West Virginia Division of Environmental Protection; Office of Waste Management
601 57th Street
Charleston, WV 25304
(304) 926-0465

OSHA Area Office
Charleston, WV
(304) 347-5937

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Important Numbers in case of spill, cont.

National:

US Consumer Product Safety Commission
National Injury Information Clearing House
(Statistics Regarding Injury, etc.)
Washington, DC 25301
(800) 638-2772

Department of Health and Human Services
Parking and Metro Information
330 Independence Ave, SW
Washington, DC 20201
(202) 619-0257

National Institute of Occupational Safety and Health
Technical Information (CDC – requesting forms) 1-800-356-4674
Substance ID (CAS Assigning registry) 1-800-848-6538

Center for Hazardous Materials
(412) 334-2467

National Response Center (Oil & Chemical)
24 Hours for EPA reportable quantities
1-800-424-8802

NCRN Water Chemistry & Quantity Monitoring: Data Management Standard Operating Procedures #18

Revision History Log:

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

1. Purpose

This Standard Operating Procedure (SOP) is used to define the data management guidelines and procedures (including but not limited to collection, verification, transfer, storage, archiving, and dissemination) that apply to all data collected under the National Capital Region Network's (NCRN) Water Chemistry and Quantity Monitoring Protocols.

2. Scope and Applicability

This SOP applies to all data collected for the Water Chemistry, Nutrient Dynamics and Surface Water Dynamics vital signs. This includes data collected on the tablet PCs as well as data retrieved from flow meters, water level loggers and water chemistry loggers. This document details how these data will be managed and stored. The following procedures describe how data collected under these protocols will be managed. More specific guidance may appear in other documents such as the steps to take when entering data into the project database. This document does not in any way dictate how data should be collected in the field. Those procedures are outlined in separate field methodology SOPs.

3. Reference Documents

NCRN Data Management Plan
NCRN Water Chemistry & Quantity Protocol

4. Roles and Responsibilities

Water Resources Specialist:

- Ensure that all technicians are trained in using the Water Resources Data Collection Application as well as NPStoret. Make sure that technicians are exporting and uploading the field data in a timely fashion as outlined in this document.
- Ensure that data undergo the proper QA/QC procedures.
- Ensure that all members of the field crew are aware of the procedures outlining how data should be entered into the project database, verified and validated.
- Ensure that new data are copied from the tablet PC to the NCRN file server prior to taking the tablet back into the field.
- Communicate with the network Data Manager regarding project issues relating to data management or GIS.

Water Resources Technicians:

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- Follow all data management guidance.
- Save field data to back-up file and copy to I&M file server.
- Export data from data collection application and upload data into NPStoret in a timely fashion.
- Print completed data sheets from data collection application for data checking and archiving.
- Conduct data verification and validation checks.
- Transfer daily data sets to the NCRN file server.
- Import data into NPStoret and copy import files to the appropriate directory.
- Document in the project database as well as on the data sheets who was involved in the data entry and QA/QC process and when each took place.
- Conduct data verification and validation checks.

Data Manager:

- Provide training and/or assistance with project databases.
- Develop database tools to assist with data entry and data QA/QC procedures.
- Develop data management guidance and ensure that all those involved in the project are aware of the standards required.
- Archive data files and data sheets.
- Develop database tools to assist with data entry and data QA/QC procedures.
- Archive data files and data sheets.
- Transfer the NCRN NPStoret back-end to the Water Resources Division annually for upload to STORET.

5. Procedures and General Requirements

Field Data Collection

Tablet PCs are used as the primary tool for recording field data. A database designed specifically for the NCRN Water Resources vital signs is deployed on the tablet PC and used as a data entry application. All water chemistry data are entered into this system in the field. Additionally, data derived from water samples collected in the field are also entered into this database after the samples have been analyzed in the lab. In case of emergency the YSI Pro Plus will record chemistry data from the sonde at a site, however it will not record air temperature or other environmental observations. There should always be a waterproof notebook and pencils in the backpack in case of tablet failure in the field.

Logging Data on the YSI Pro Plus

Data is generally logged in the Tablet PC, but it is possible to save data files in the ProPlus. The instrument will be in *Run* mode when turned on.

Log One Sample is already highlighted in *Run* mode. Press *Enter* to open a submenu. If *Use Site List* and/or *Use Folder List* are enabled in the *Logging Setup* menu, you will have the option to select these two items before the data point is logged. If necessary, use

NCRN Water Chemistry & Quantity Monitoring: Data Management Standard Operating Procedures #18

the keypad to create a new *Site* or *Folder* name. If *Site List* and *Folder List* are disabled in the *System* menu, you will not see these options when logging a sample.

Once the *Site* and/or *Folder* name is selected, highlight *Log Now* and press *Enter*. The instrument will confirm that the data point was successfully logged.

If you would like to log at a specific interval vs. logging one sample at a time or vice versa, press *System*, then highlight *Logging* and press *Enter*. Select *Continuous Mode* and adjust the *Time Interval* if necessary. On the *Run* screen, the option to log will change from *Log One Sample* to *Start Logging* based on the time interval entered in the *Logging Menu*. During a continuous log, the *Start Logging* dialog box on the *Run* screen will change to *Stop Logging*. Press *Enter* to stop continuous logging.

Logging Data on the FlowTracker

All stream flow and depth data used to calculate stream discharge are collected and stored using a SonTec FlowTracker Handheld ADV (Acoustic Doppler Velocimeter). Data sets collected on the FlowTracker logger should be named using the following naming convention: PARKMMYY

EXAMPLE: ACCK0808

Depth and flow data are collected at consistent intervals across the width of a stream. The unit automatically calculates and stores a discharge value for that stream. The discharge value is also entered into the tablet database application in the field. Refer to SOP #11 for information on the methods behind this field data collection.

Field Data Verification – Flow Data

The Flow Tracker Handheld device incorporates data verification into the data collection process. The unit checks for consistency as the user collects data across a stream width. For instance, if a user is collecting data every foot across a stream and then suddenly jumps to collecting data every 5 ft, the unit will alert the user. Similarly, if the depth of the stream drastically changes from one point to the next the user will be notified. Additional data verification can be done once the data has been downloaded from the device and incorporated into the Flow Tracker software.

Data validation or identifying records that are unreasonably out of bounds (i.e. outliers) is an essential step to ensuring data quality. A good portion of data validation is built into the database structure as well as into the SonTek Flow Tracker system.

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Data Entry into the Tablet

Upon opening the application “Water”, the database will check to see if it is properly linked to the back-end data table. If it cannot find the appropriate data table, the user will be prompted to browse for the data file and re-link the back-end. A folder called “Water” exists on the desktop of the tablet pc where all of the data files exist. The current back-end data model will be named as follows: NCRN_Water_Field_Data_BE_Ver_X.XX

On the Tablet, create a new backend (BE) file for that week. Copy and paste a blank backend file and rename at the end with the date of the first day of the sampling week: NCRN_water_field_data_BE_(date: YYYYMMDD)

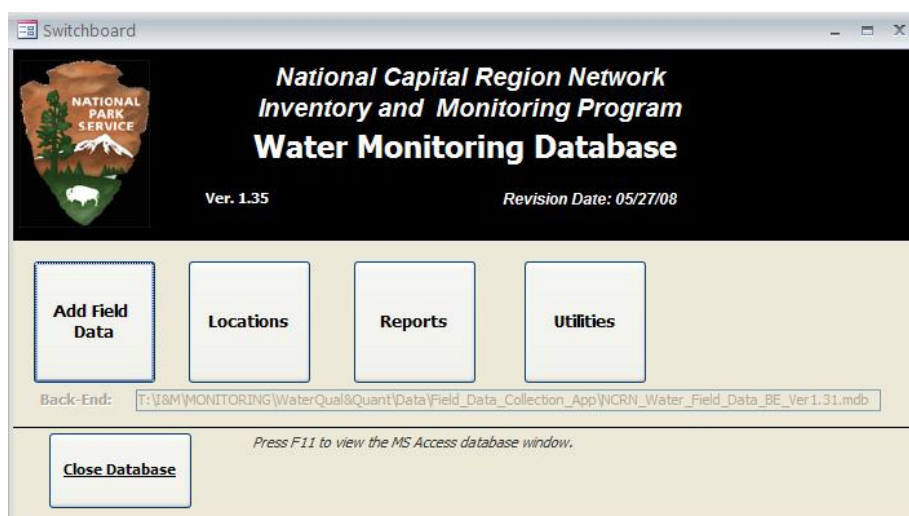


Figure 18-1. NCRN water field data collection form

Once the re-linking procedure is complete the user will be presented with the application “Switchboard” (Figure 18-1). The user is presented with a number of options but the first button, “Add Field Data”, will be the primary selection when collecting field data. Note that the box underneath the buttons provides a description of the back-end file that the database is currently linked to.

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Figure 18-2. Main data entry form.

Clicking the “Add Field Data” button opens the field data collection form (Figure 18-2). The data entry form allows the user to browse events that have already taken place or to enter new data.

The main data entry form will automatically open to a new (blank) data record but if the form is already open and populated with existing data, the user must click “Create New Event” to create a new data record on the form. The tabbed section of the form is completely disabled until the user completes the required fields (Location and Date) in the top portion of the form.

Select a park unit and then select a station from the list (the list of stations will be filtered by the park selected in the Park Unit box). The system date and time are automatically added for the survey date and time but these values can be changed by the user if need be.

Once the required fields are completed the ‘Event Information’ tab (and only this tab) will be activated. The user must identify the “Sampleability” conditions. If anything other than “Actively Sampled” is selected the other data tabs will remain disabled preventing any data entry.

Other information such as weather conditions, air temp and field crew participants should still be entered. The inactive fields are automatically populated based on the chosen sampleability condition (see Table 18-1). If the user selects “Actively Sampled” the data tabs are activated and further data entry can take place.

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Table 18-1. Default Data Values by Sampleability

Parameter	Dry Default Data Value	Frozen Default Data Value	Not accessible Default Data Value
Stream Condition	Dry	Not Reported	Not Reported
Algae	Absent	Not Reported	Not Reported
Flow Condition	Dry	Not Reported	Not Reported
Width	0	Not Reported	Not Reported
Depth	0	Not Reported	Not Reported
Discharge	0	Not Reported	Not Reported
Flow	0	Not Reported	Not Reported
pH	Absent	Not Reported	Not Reported
Water Temperature	Absent	Not Reported	Not Reported
Dissolved Oxygen	Absent	Not Reported	Not Reported
Specific Conductance	Absent	Not Reported	Not Reported
Conductivity	V	Not Reported	Not Reported
Salinity	Absent	Not Reported	Not Reported
Nitrate	Absent	Not Reported	Not Reported
Total Phosphorus	Absent	Not Reported	Not Reported
Ammonia	Absent	Not Reported	Not Reported
Chlorine	Absent	Not Reported	Not Reported
Monochloramine	Absent	Not Reported	Not Reported

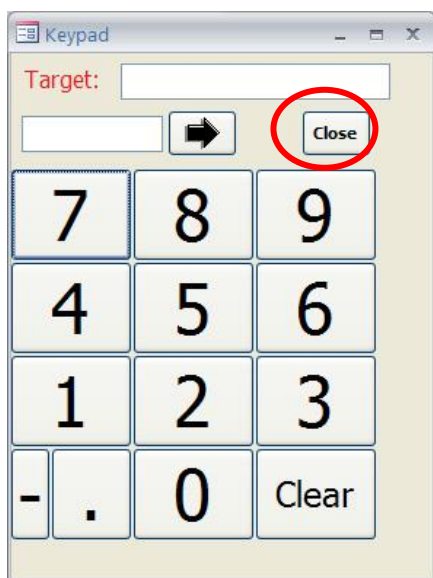


Figure 18-3. Number pad

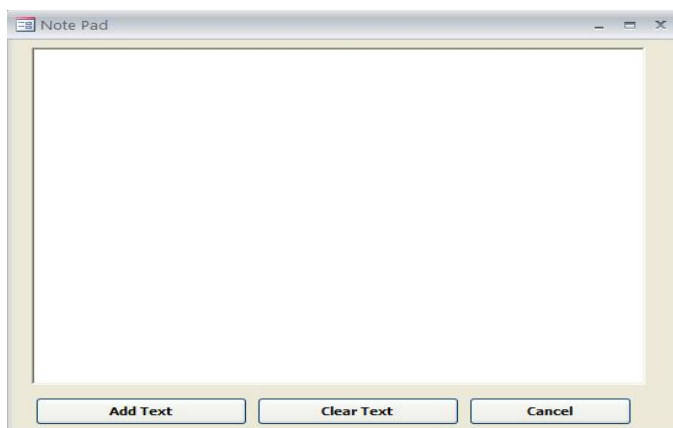


Figure 18-4. Note pad

Some of the field data are entered using selection lists but other data require the entry of numerical values. Some tools are provided to help with the entry of such data in the field. A number pad utility is available for entering numerical values into data fields (Figure 18-3). The number pad is opened by clicking on the button on the data entry form. The number pad will always remain on top of the field form while it is open regardless of where the user clicks on the screen. To enter a numerical value, the user first must select the 'target' cell (e.g. Wetted Width or Discharge). The current target cell will be displayed at the top of the Number Pad. The user types in the numerical value

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and then clicks the 'Arrow' button to send the data to the 'Target' field. This can be used for all numerical fields on the data entry form.

Stream "Wetted Width" is measured in feet and inches but field data are recorded as tenths of feet (e.g. 6.1 = six and one tenth feet). Using the previous example, users can enter the data as either 6.1 or 6.01 (both re interpreted as 6 and 1/10 feet) and the database applies the appropriate conversion to convert the data to decimal feet.

Other fields require a lengthy text description such as 'Event Notes'. Users can utilize the keyboard or stylus utilities provided by the tablet OS or can open a large "Note Pad" window by double tapping on the target box on the data form that the user can use to scribe notes with the stylus (Figure 18-4). The text recognition is pretty good but not perfect. After "inking" something on the Note Pad it will take the computer a few seconds to process the "ink" into text.

Field Data Verification - Water Chemistry

The database was designed to incorporate certain QA/QC controls that include pick lists and defined data ranges (e.g. you would not be able to enter a pH value of 50.5). These built in mechanisms are not able to prevent all data entry errors, additional QA/QC is required, and described later in this SOP.

After the data have been entered into the project database it should be reviewed. The purpose of this step is to catch errors that were incorrectly entered into the database. Field crews must take care to ensure that they are entering data properly. At times, data are collected quickly and numbers are dictated rapidly from one member of the field crew to another. It is imperative that field crews take time to review the data they have entered to make sure that it is correct. This may entail the data entry person repeating the number back to the crew member collecting the data to ensure that the data recorded was what was observed. Because data are entered directly into the database in the field, almost all of the data verification checks must take place at the sampling site.

Data for water chemistry parameters such as Ammonia (NH₄), Nitrate (NO₃), Phosphate (PO₄), and Acid Neutralizing Capacity (ANC) are calculated from water samples collected at the site and analyzed in the office. It is important that lab personnel make sure that data are entered properly into the database.

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

Lab Data Collection

Initially, all laboratory data are entered into green notebooks, analytical data in one and calibration and QA/QC data in another. At the end of the day chemistry results from the lab analyses on the water samples are also entered into the tablet application. Lab data is entered into an existing event so the user is, in essence, editing an existing event. The 'Current Mode – BROWSE ONLY- Click to Edit' button must be clicked prior to being able to enter any lab data.

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The user can browse and access existing data in the database by selecting an event from the 'Existing Events' selection box. The data will open on the form but is protected from editing to help prevent inadvertent changes. The data form contains a button indicating the current state of the form. After existing data is loaded the button will become active and the caption will update to indicate that the form is currently in "Browse Mode" (Figure 18-5).

The screenshot shows a web-based form titled "Sampling Events". At the top, there is a "Browse Existing Events ->" dropdown menu, a "Create New Event" button, and a "Close Form" button. Below these, there are fields for "Select Park Unit" (set to "ANTI"), "Station ID" (set to "NCRN_ANTI_SHCK"), "Survey Date" (set to "6/11/2009"), and "Start Time (24 hr.)" (set to "12:44"). An "Add Location" button is also present. A red banner across the form states "Current Mode: BROWSE ONLY -- Click to Edit". The main form area is divided into several sections: "Sampleability" (set to "Actively Sampled"), "Air Temp. (C)" (set to "25"), "Weather Conditions" (set to "Cloudless"), and a checkbox for "Photographs". There is a large text area for "Event Notes". On the right side, there is a "Data Collected By:" section with a list containing "Sanders" and "Schmit", and an "Add Contact" button.

Figure 18-5. Events form in browse mode.

Clicking the button will prompt a message warning the user that all edits will be permanent. After acknowledging the warning the form will be in "Edit Mode" and the button's caption is updated to reflect the change in the form's edit status. Clicking the button again will return the form to Browse Mode. Users can browse through all of the tabs to view the data but will be unable to make any changes.

Clicking on the "Lab Data" tab provides fields for entering acid neutralizing capacity (ANC) and nutrient data into the database (Figure 18-6). Basic information such as the date and time of the analysis as well as who ran the analysis should be entered.

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Field Data Lab Data

☐ Check if you would like to use the system date/time.

Data Analyzed By: *

Date of Analysis: Time of Analysis: Lab Location: CUE

ANC

Expected Range: 10 - 40 mg/L Expected Range: 40 - 160 mg/L Expected Range: 100 - 400 mg/L

Sample Volume	Titration Cartridge	Digit Multiplier	# of Digits for Phenol	Bromcresol Endpoint	# of Digits for Bromcresol
100 mL	0.1600	0.1		4.9 (light pink)	

ANC Calculations

Phenolphthalein Alkalinity:	Total Alkalinity:	Hydroxide Alkalinity:	Carbonate Alkalinity:	Bicarbonate Alkalinity:	Microequivalents /L Alkalinity:
0	0	0	0	0	0

Select the data you would like to use to export ANC to NPStoret.

☐ 10 - 40 mg/L ☐ 40 - 160 mg/L ☐ 100 - 400 mg/L

NUTRIENTS

Analytical Method:	Sample Reading (mg/L):
Ammonia, LR TNT:	0
Reactive Phosphorus, LR TNT:	0
Nitrate, HR TNT:	0

Lab Notes:

Figure 18-6. Data tab for entering chemistry data calculated in the lab.

One of three “ranges” can be used for entering ANC data. To determine which range is best for a park, see SOP #12 Table 12-2.

IMPORTANT: the user must select which range was used on the check boxes below the tabbed section so that the ANC data are properly exported to NPStoret.

Data Transfer/Export to NPSTORET

After completion of laboratory analyses all data need to be transferred from the field devices, tablet PC and Flow Tracker, to the NCRN file server.

Once all data have been entered into the tablet database and all necessary data checks have been performed, the data need to be transferred from the tablet PC to the network file server. The tablet should not go back into the field with data that has not been backed-up onto the NCRN file server. It is not necessary to remove all data from the tablet database at the end of each field trip but a copy of the back-end file should be made and transferred to the NCRN file server in the event that the tablet suffers some sort of catastrophic failure.

Open the Water Database on the Tablet PC.

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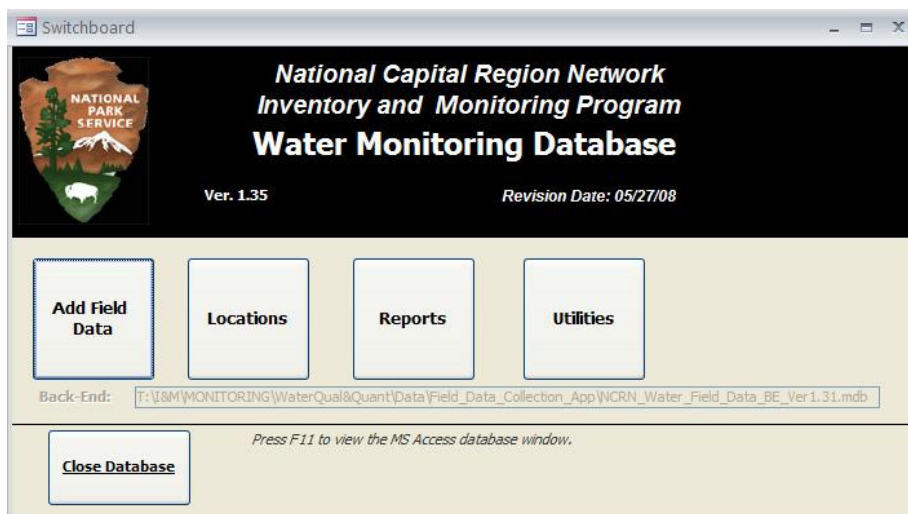


Figure 18-7: NCRN water field data collection form – Main Switchboard

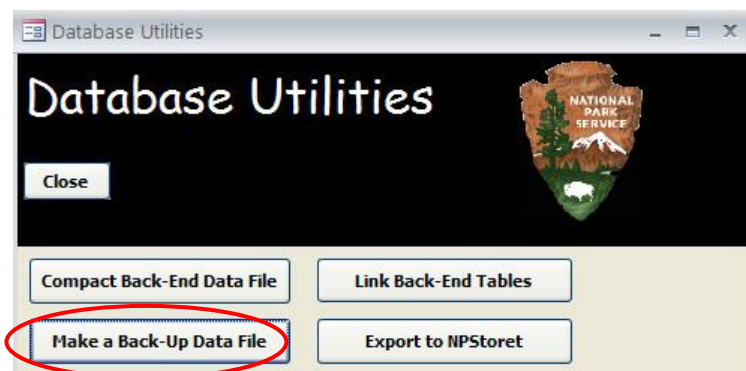


Figure 18-8: Database utilities form

From the Switchboard the user should click on 'Utilities' (Figure 18-7). The new field data should be renamed and tagged with a specific date identifier referring to when the data was transferred. Select 'Make a Back-Up Data File' (Figure 18-8). This function creates a back-up data file with a date and time stamp in the file name.

The data file will be given a default name:

Example: NCRN_Water_Field_Data_BE_Ver.X.XX_YYYYMMDD_HHMM

Save the backup file to a USB drive for transfer to a networked computer, and move the Tablet copy to Water / Downloaded for later archiving from the tablet. The renamed file(s) should then be transferred to the file server. Navigate and place the file in the following directory:

T:\I&M\MONITORING\WaterQual&Quant\Data\Field_Data_Collection_App\Field_Data

Open the Water Database found at

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T:\I&M\MONITORING\WaterQual&Quant\Data\Field_Data_Collection_App

on a networked computer and link to the data file in the **Field_Data_Collection_App** \Field_Data directory containing the data to be imported into NPStoret. From the Main Switchboard:

Click 'Utilities' from the Main Switchboard.

Click 'Link Back-End Tables

Browse to the back-end data set to link to (Figure 18-9).

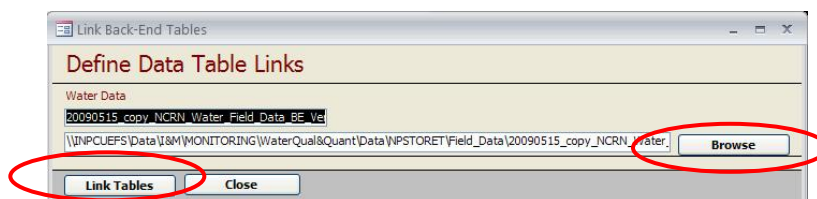


Figure 18-9: Box for linking Back-end Table

Click 'Link Tables'. The database will prompt when linking is complete.

Once the Application is linked to the appropriate back-end data file, data export to NPStoret can proceed. Close the Define Data Table Links window (Figure 18-9). Click the 'Export to NPStoret' button (Figure 18-10) on the utilities form which opens the "Export" form (Figure 18-11).

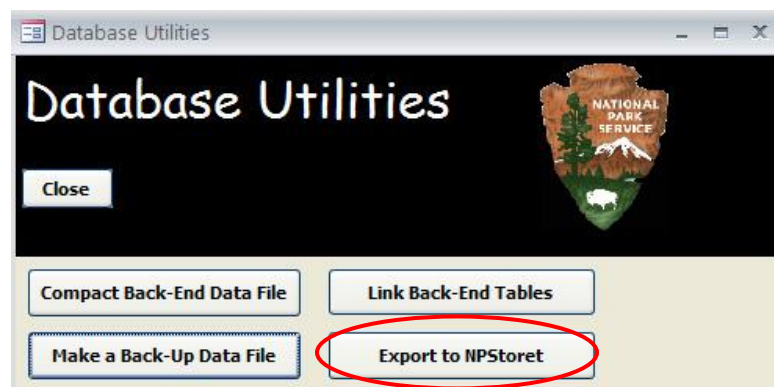


Figure 18-10: Database Utilities form - Export to NPStoret selected

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Figure 18-11: Data export form

The data can be exported by selecting a single event, all events from a single day or all events from a series of dates. Once the export parameters are selected, a preview of the file can be viewed. If additional water chemistry QA samples were collected and need to be exported make sure to check the box to include those data in the export.

Data files can be exported as either MS Excel files (recommended) or comma separated (csv) files. If the user intends to export QA data along with the field data, the MS Excel export option **MUST** be used. If QA data is exported along with the standard event data, the Excel Workbook file will contain two worksheets (one for the standard event data and one for the QA data). Note that if no format is selected, the export format will default to comma delimited.

The user can browse for the appropriate location to save the export file. The default directory should be the 'Import' directory located under the 'NPStoret' directory on the file server.

T:\I&M\MONITORING\WaterQual&Quant\Data\NPSTORET\Imports

The file should be named in a way that describes what data it contains (e.g. NPStoret_import_5_7_2008-5_10_2008 for data collected from 5/7 to 5/10/2008). Select "Preview Export File" and verify that all records have complete data sets. Pay particular attention to ANC values. If ANC values are "0", either the data was entered in the wrong tab or the wrong range was checked. After identifying a storage location for the export file, click 'Export'.

The database will review the survey events selected for export and compare them to events that have already been exported. If an event has already been exported the user will be notified (Figure 18-12).

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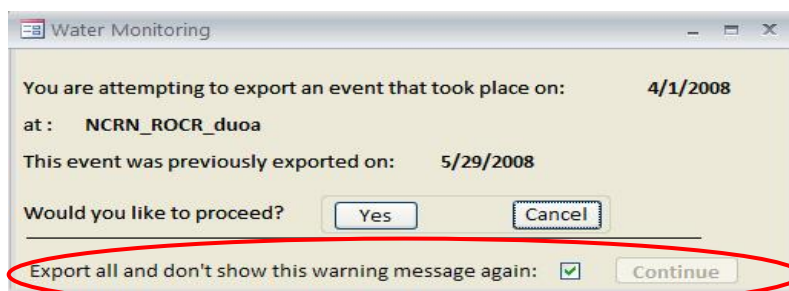


Figure 18-12: Export message box

This is to help avoid the possibility of importing the same event into NPStoret multiple times. The user can either cancel out of the process and review the export parameters, acknowledge the warning and continue by clicking 'Yes' or skip all future warnings and export everything (click the check box at the bottom of the notification form and then click 'Continue'). Close Database Utilities Box.

In addition to exporting the data, paper data sheets should be printed from the field database as part of the QA/QC data review process and to be archived separately. From the main Switchboard in the Tablet application (Figure 18-7) click on the 'Reports' button and the 'Reports' form will open (Figure 18-13). The user should select an Event from the list and click 'Summary' to open the report for the selected event and then print it. When all data sheets are printed, close the NCRN Water Resources Monitoring Database. Set the datasheets aside for use during data verification.

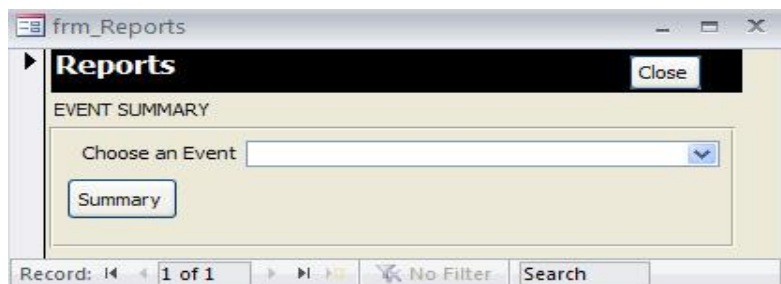


Figure 18-13: Reports form used to print completed data sheets

Import into NPStoret.

Open NPStoret:

T:\I&M\MONITORING\WaterQual&Quant\Data\NPSTORET\NPSTORET.mdb
or from the shortcut on your desktop, if you have one. Select yourself under "Available Log In ID". The data is exported from the field database in a format that NPStoret will readily accept. To import the data into NPStoret the user must select 'Import' from the main Switchboard in NPStoret (Figure 18-14).

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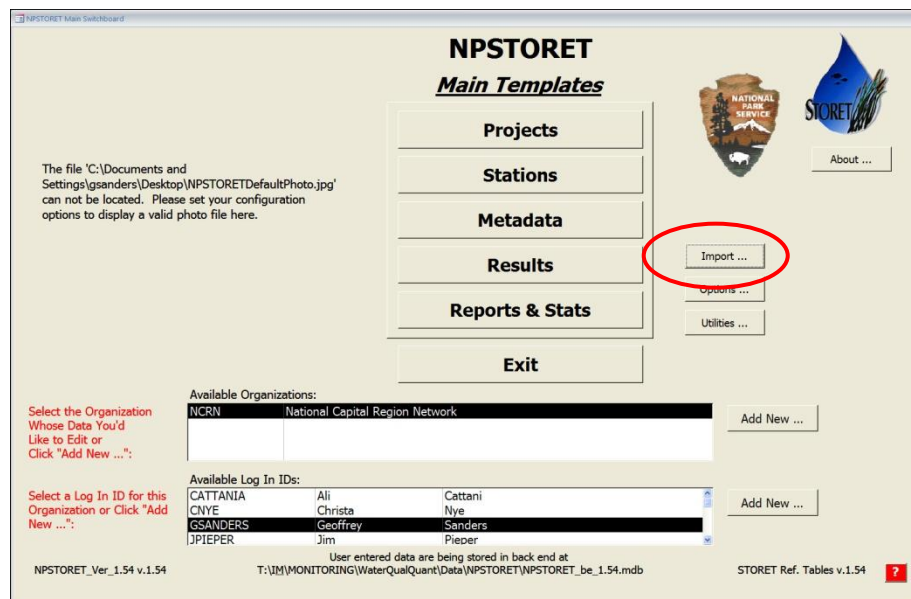


Figure 18-14: NPStoret main switchboard

Then select 'Import Results' on the next form (Figure 18-15).

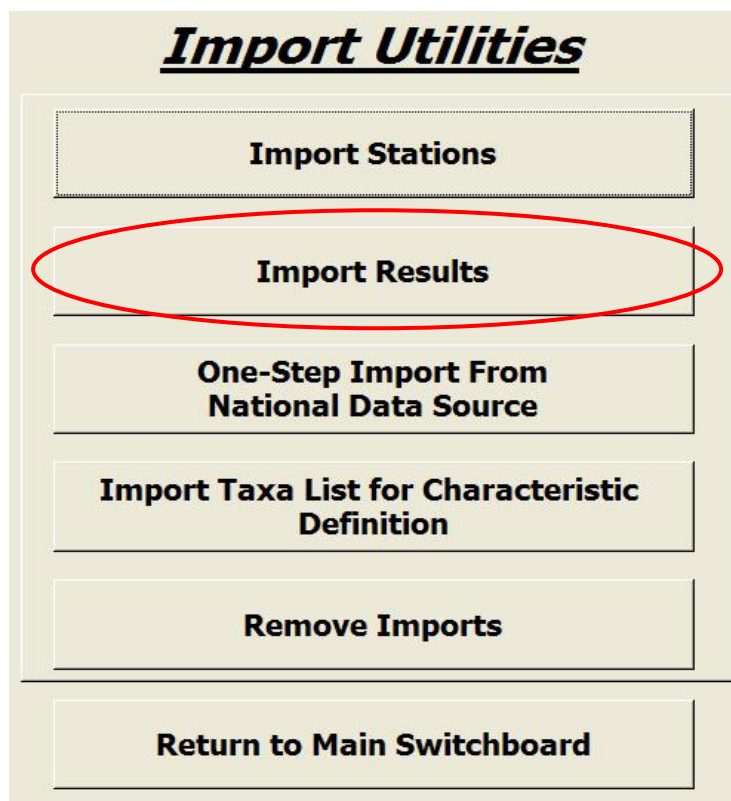
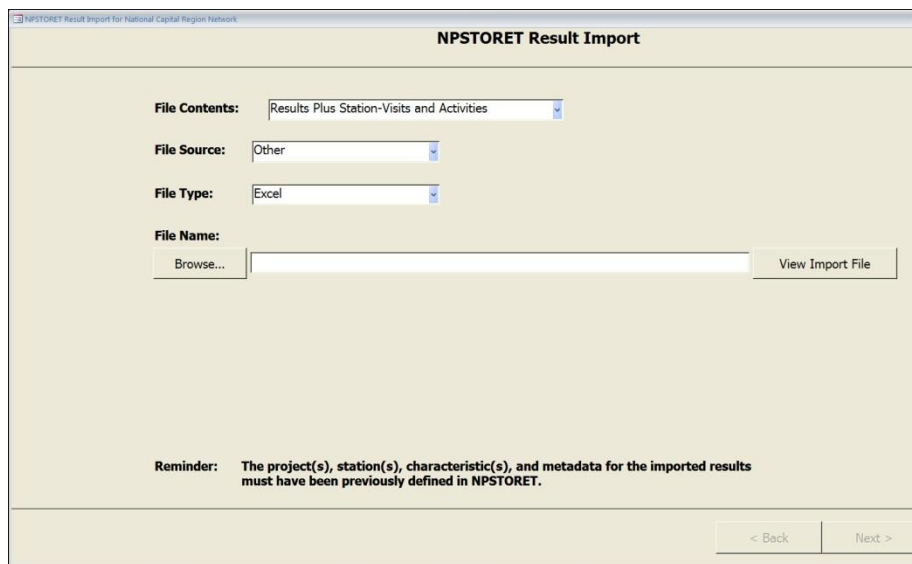


Figure 18-15 NPStoret Import Utilities options

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NPStoret will then prompt you to select the type of file you want to import and to select the file you wish to import (Figure 18-16). The only parameter that will likely ever have to change on this form is File Type depending on whether you are importing a CSV file or Excel file. All else should remain as the default. After completing this, click Next.

The image shows a screenshot of the 'NPSTORET Result Import' window. The window has a title bar that says 'NPSTORET Result Import for National Capital Region Network'. The main area contains several fields: 'File Contents' with a dropdown menu showing 'Results Plus Station-Visits and Activities'; 'File Source' with a dropdown menu showing 'Other'; 'File Type' with a dropdown menu showing 'Excel'; and 'File Name' with a text box and a 'Browse...' button. To the right of the 'File Name' text box is a 'View Import File' button. At the bottom of the window, there is a 'Reminder' section with text: 'The project(s), station(s), characteristic(s), and metadata for the imported results must have been previously defined in NPSTORET.' Below the reminder are two buttons: '< Back' and 'Next >'.

NPSTORET Result Import

File Contents: Results Plus Station-Visits and Activities

File Source: Other

File Type: Excel

File Name: Browse... View Import File

Reminder: The project(s), station(s), characteristic(s), and metadata for the imported results must have been previously defined in NPSTORET.

< Back Next >

Figure 18-16: NPStoret import file selection form.

Browse to

T:\I&M\MONITORING\WaterQual&Quant\Data\NPSTORET\Imports\CurrentFilename

If the import file you selected is an Excel file with more than one Worksheet you will be prompted to select the worksheet containing the data you wish to import. This will occur if QA/QC data was also exported. The QA/QC data is a second worksheet in the export workbook and must be imported separately.

The user must select how they wish the data to be formatted during the import process (Figure 18-17). **The default is Row Major but this must be changed to Column Major. Click Next.**

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NPSTORET Result Report for National Capital Region Network

**Import Results from 'qry_Export_Single_Date' in
T:\IM\MONITORING\WaterQualQuant\Data\NPSTORET\Imports\Export_to_Storet_5_8_2008.xls**

NPSTORET can use entries in the first row of worksheet 'qry_Export_Single_Date' as field/column headings. Does the first row contain field/column headings?

☒ First Row Contains Column Headings

File format is ...

- ☒ Row major. Each row is a separate characteristic result so it takes multiple rows to comprise the station visit/activity.
- ☐ Column major. Columns in row contain results for each characteristic measured during one station visit/activity.

Sample data for worksheet 'qry_Export_Single_Date'

Event_ID	Visit	St	Station	Visit	St	Visit	C	Air	Ter	Weath	Flow	Chl	DO	(DO _{mg})	Water	Specific	Salinity	Algae	Algae	Stream	Discha	Wetted	Nitrogen	PO4	NO3	ANC	rm
20080508095843-70554	5/8/20	NCRN	9:58:4	21	5	LOW	7.05	87.07	7.73	17.32	44.95	0	100%	Dead	4.TEA-1.34	20.25	0.023	0.17	0.7	0							
2008050812206-61449	5/8/20	NCRN	10:27:58	20	5	NORM	7.3	95.9	8.85	17	52.55	0	1	-20"	hairy	4.TEA-1.37	8	0.026	0.19	0.9	398						
20080508113017-53504	5/8/20	NCRN	11:30:36	22	5	NORM	7.4	79.7	7.5	16.4	21.96	0	0			4.TEA-0.98	5.5	0.036	0.15	0.8	302						
20080508115336-82980	5/8/20	NCRN	11:53:36	SAV	or	21	5	NORM	7.35	93.2	9.19	15.65	56.05	0	81	-95	Dead	4.TEA-0.18	5.75	0.019	0.18	0.9	434				
20080508122301-69511	5/8/20	NCRN	12:23:36	stream	22	5	LOW	7.09	91.9	8.66	18.4	97.4	0	61	-8	Scum	4.TEA-3.37	7.5	0.021	0.16	0.6	430					
20080508124559-15703	5/8/20	NCRN	12:46:16	Could	20	6	NORM	7.44	87.43	8.15	17.52	62.57	0	61	-8	Dead	4.TEA-	17.5	0.02	0.14	1	432					
20080508133258-70554	5/8/20	NCRN	1:32:58	Discha	20	2	NORM	7.51	95	9.17	16	52.1	0	0			1.CLEA	7	0.025	0.26	0.8	390					
20080508133550-81449	5/8/20	NCRN	1:55:50	Discha	24	2	NORM	6.43	90.3	8.71	16.5	104.15	0.1	0			1.CLEA	4.85	0.02	0.14	0.5	196					

< Back Next > Cancel

Figure 18-17: NPStoret import file format form

A field mapping specification (Figure 18-18) was created to identify where all of the data should be mapped. Click Load Spec and select ‘NCRN Chemistry Import’ (Figure 19-19). All of the import fields will be mapped to the appropriate database fields. Click next and proceed with the import.

NPSTORET Import for National Capital Region Network

Import Results From 'qry_Export_Single_Event_QA' In T:\IM\Temporary\Export_to_Storet.xls

NPSTORET was not able to map any of your import file field names to NPSTORET field names. Please complete the specification.

Station Visit/Activity Info

NPSTORET Field Name	Data Type	Import File Field Name	OR	Constant Value
* ProjectID	Text (8)		▼	▼
* StationID	Text (15)	StationID		▼
* Visit Start Date	Date/Time	Visit Start Date	▼	
Visit Start Time	Date/Time	Visit Start Time	▼	
Start Time Zone	Text (4)		▼	▼
Visit End Date	Date/Time		▼	
Visit End Time	Date/Time		▼	
End Time Zone	Text (4)		▼	▼
Visit Comment	Memo	Visit Comment	▼	

Save Spec...

Load Spec...

NPSTORET Local Char Name	STORET Display Name	Result/Detection Condition Import File Field Name
Adjacent Land Cover	RBP2, Watershed, Predominant Surrounding La	▼
Air Temperature	Temperature, air	▼
Alderfly larvae	Sialidae	▼
Algae	Algae, substrate rock/bank cover (choice list)	▼
ANC	Acid Neutralizing Capacity (ANC)	▼
Aquatic worms	Oligochaeta	▼
Atherix	Athericidae	▼
Beetle larvae	Coleoptera	▼
Blackfly larvae	Simuliidae	▼

< Back

Next >

Cancel

Figure 18-18: Field Mapping interface

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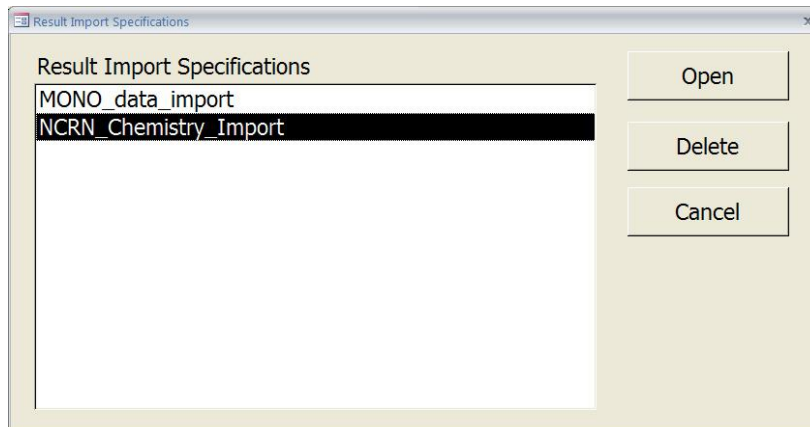


Figure 18-19: NPStoret result import specifications

Once the fields are mapped click NEXT and proceed with the import.

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Select how you wish the import to be treated. You will be prompted to indicate whether you are importing new station visits and results or just results. Make sure that the first option (“Always create new station visits and activities to house import data”) is selected (Figure 18-20).



Figure 18-20: Create New Station Visits

NPStoret will review all of the data that have been selected for import and provide any warnings or errors that might occur as a result of importing the data.

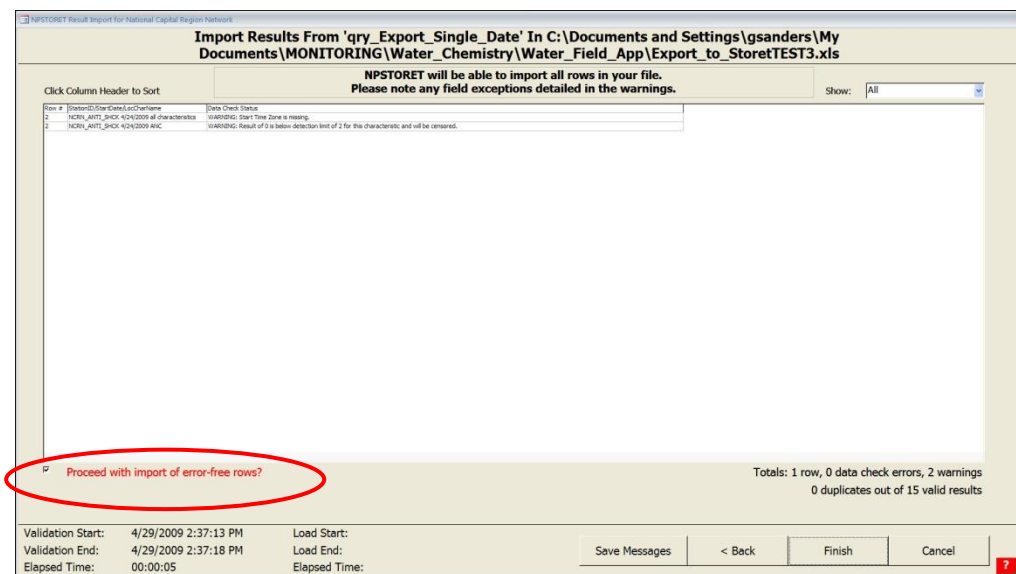


Figure 18-21: Import Review

The review may produce some warnings but should not produce errors. If errors are noted the import should be canceled until the errors are resolved. Otherwise, Check the box ‘Proceed with Import of error free row?’ and click: FINISH (Figure 18-21). NPStoret

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will review all of the data that have been selected for import and provide any warnings or errors that might occur as a result of importing the data.

If additional QA data are collected and need to be imported into NPStoret, follow the previous instruction and Click the Load Spec button again but this time select “NCRN_Chemistry_Import_QA” (Figure 18-22).

Select the QA field mapping specification.



Figure 18-22: Import Specification Options

Once the fields are mapped click NEXT and proceed with the import.

Select how the imported QA data should be treated. When indicating how the imported data should be treated, make sure that the SECOND option (“Add the import data to existing station visits....”) is selected and select the following sub-option: “Generate a QA activity replicate and store the data there” (Figure 18-23).

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NPSTORET Result Import for National Capital Region Network

Import Results From 'qry_Export_Single_Event_QA' In T:\IM\Temporary\Export_to_Storet.xls

When importing results ...

- ☐ Always create new station visits and activities to house the import data.
- ☒ Add the import data on existing station visits. Create new station visits if the station visits don't already exist.

If an activity matches one that already exists on station visit ...

- ☐ Replace entire visit activity and all of its results. This will delete any results that do not appear in import data.
- ☐ Update existing characteristic results. Append new characteristic results.
- ☐ Only update existing characteristic results if value was "Not Reported". Append new characteristic results.
- ☒ Generate a QC activity replicate and store the results there.
- ☐ Generate a new activity and store the results there.
- ☐ Don't import any information for that visit activity.

Figure 18-23: QA Import Options

NPStoret will, once again, review all of the data that have been selected for import and provide any warnings or errors that might occur as a result of importing the data. Review and complete the QA import

NPSTORET Result Import for National Capital Region Network

Import Results From 'qry_Export_Single_Event_QA' In T:\IM\Temporary\Export_to_Storet.xls

NPSTORET will be able to import all rows in your file.
Please note any field exceptions detailed in the warnings.

Click Column Header to Sort

Row #	StationID/StartDate/LocCharName	Data Check Status
2	NCRN_ANTL_SHCK 4/24/2009 all characteristics	WARNING: Start Time Zone is missing.
2	NCRN_ANTL_SHCK 4/24/2009 all characteristics	NOTE: Matching activity exists for station visit on this date in NPSTORET. QC Activity re

☒ Proceed with import of error-free rows?

Totals: 1 row, 0 data check errors, 1 warning
0 duplicates out of 6 valid results

Validation Start: 5/1/2009 12:52:00 PM Load Start:
 Validation End: 5/1/2009 12:52:10 PM Load End:
 Elapsed Time: 00:00:10 Elapsed Time:

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Figure 18-24: Import Review Display

A note will be added to the Import Warning form indicating that a new QC activity will be created. As long as no errors are identified, click FINISH to complete the import of the QA data (Figure 18-24). Return to Main Switchboard.

After importing files into NPStoret: Put the excel file from “to be imported” into:
T:\I&M\MONITORING\WaterQual&Quant\Data\NPSTORET_1.81\Imports (This version (1.81) is subject to change). Change the file name to match the others (Export_to_...) with corresponding date at the end. Put the access file from “to be imported” into:
T:\I&M\MONITORING\WaterQual&Quant\Data\Field_Data_Collection_App\Field_Data (Name stays the same). Then the files can be moved from “to be imported” to “to be deleted” on desktop

Flow Data Download

Connect the FlowTracker data logger to the PC serial port.

Turn the FlowTracker on, if it does not turn on itself.

Open the Flowtracker software: Start / All Programs / Sontek Software / FlowTracker and choose Connect to FlowTracker

Should get a message that the “FlowTracker Was Found On COM1”

In case the FlowTracker software cannot find the data logger take the following steps:

In Active Sync / Connection Settings uncheck Allow Connections to COM1 (this setting should stay set – USB peripherals should not need COM1)

Connect FlowTracker to serial port

Reboot computer

When computer restarts, FlowTracker logger should start up and display FlowTracker 3.5 Under External Control

If you still cannot connect to FlowTracker logger start SonUtils program and send the Flowtracker logger the <BREAK> command

Choose Recorder, select all files for download and click the download button. FlowTracker data files should be stored in the following directory:

T:\I&M\MONITORING\WaterQual&Quant\Data\Hydrology\Sontek_Discharge

Close the Recorder menu. Select “Open a FlowTracker file”. Navigate to the folder listed above. Using the Shift key, select all downloaded data and click “Open”. Verify

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that a complete data set is present for each file and print each file in color. Set data sheets aside for Data Verification and Data Archiving.

Choose “Recorder”. Delete files by selecting FORMAT. This will delete all files on the data card, so it is very important that the files are verified on the T drive first. When “Done” is displayed, close the Recorder menu. Choose “disconnect from a FlowTracker” and close the software. Disconnect the FlowTracker, turn it off, and return it to its storage location on the by the door countertop.

YSI Pro Plus data download

Make sure *Data Manager* and the USB drivers are installed on the PC. The USB drivers will be installed during the Data Manager installation

Connect the *Communications Saddle* to the back of the Pro Plus instrument and use the USB cable to connect the saddle to the USB port of the PC.

If connecting for the first time, Windows may prompt you through a “New Hardware Found” Wizard in order to complete the USB driver installation.

Open *Data Manager* on the PC and turn on the Pro Plus.

Click on the correct instrument in *Data Manager* under the *Select Instrument* heading. Once you’ve highlighted the correct instrument, click the *Retrieve Instrument Data* tab and check **Data, GLP, Site List, Configuration or Select All** options to retrieve data. Click **Start**.

After the file transfer is complete, the data is available for viewing, printing, and exporting in *Data Manager* and files can be deleted from the Pro Plus if desired.

Select the **File Hot Key** on the key pad and choose **Delete Data** if you no longer need the data on the Pro Plus

Data Verification in NPSTORET

After the data import is complete users should review all imported data with the field data sheets and printouts of the Flow Meter to ensure that all was imported correctly.

Data sheets printed from the field application containing all of the data collected in the field can be compared to the data imported into NPStoret to the data collected in the field. After the data has been imported into NPStoret, the data sheets should be compared to the data in NPStoret to ensure that the import functions worked properly. Any errors should be immediately addressed and the network data manager should be notified of the problem.

Compile the Discharge Measurement Summary sheets (Flowtracker printouts) with the Field Data sheets for each site.

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Open NPSTORET:

T:\I&M\MONITORING\WaterQual&Quant\Data\NPSTORET\NPSTORET.mdb

Select your name under “Available Log In IDs:”. Select the Results tab. Click OK on the dialog box, you should not have to change any selections here. The form will take awhile to load.

Use the “Visit:” arrow buttons to navigate to the first site visit in the stack of field data sheets. Note the Visit number from the NPSTORET Result Entry Template Screen in the upper right corner of the Field Data Sheet. Review all data on the sheet. IF a record in NPSTORET has a text entry such as “Not Reported” or Below Detection Limit”, write that in on the data sheet. These will most commonly occur for discharge and ammonia. Other non-numeric data may be:

Not Reported – Indicates that at the time of the site visit the conditions were adequate for collecting data but for some reason, data for this parameter was not collected. This might be used if attempts were made to get to a sample site but due to a fallen tree along the road access to the site was impeded.

Non-Detect – Indicates that attempts were made to detect the data but it was present below the detection limit of the gear.

Absent – This is mostly used during drought periods when a site is visited but the stream is either dry or so low that no samples can be taken.

Present<QL – the test indicates that something is there but some of these tests have defined detection ranges. If the result falls below the limit it is classified as “Present < quantification limit”

From the Discharge Measurement Summary sheet, enter Mean Depth as Water Depth in the NPSTORET record and Mean Velocity as Flow.

Once all data have been checked the data sheets should be initialed and dated by the staff member who performed the data checks. Data sheets should then be archived in the proper file cabinet.

Verification of data continuity and outliers

After each month’s park visit, a Time Series Graph of all of that park’s data should be examined for any outliers or other erroneous appearing data. From the Main Switchboard (Figure X) select “Reports & Stats.” Select the “3. Graphs” tab.

Available Graphs: Time Series

File Name: T:\I&M\MONITORING\WATERQUAL&QUANT\REPORTS\Park\Park-
GraphTSMMDYYYY

X-axis: Sample Date

Plot for Each: Characteristic

Censored Data Handling: Exclusion

Projects: Subset

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Stations: Subset of Stations (select the stations corresponding to the park
All other parameters should be set to the default value of “All”
Select “Generate Graphs”. Once the Excel Workbook is displayed review each
parameter (which is on a separate tab) for anomalies in the most recent data points. Make
note of any anomalies found and check the calibration of the equipment involved.

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“Dean Tucker’s Import / Export Data Check”

An additional data check recommended by Dean Tucker, WRD, is that the recently imported data be exported back out of NPStoret as another means of ensuring that all of the data imported properly. Click ‘Reports & Stats’ from the NPStoret Main Menu. Click on the ‘Export’ tab.

Indicate how you would like the export file formatted and where the file should be stored (Figure 18-25). All files exported from NPStoret should be stored in the following directory: T:\I&M\MONITORING\WaterQual&Quant\Data\NPSTORET\Exports and named: “Export_Results” followed by the date range of the exported data.

EXAMPLE: Export_Results_ YYYYMMDD- YYYYMMDD

Filter the data by selecting the appropriate subsets of information:

Project: NCRNWX01 – Perennial Stream Monitoring

Stations: Select the subset of stations to be included in the export

Date Range: Select the date range for the sampling events to be included in the export.

Click ‘Export Data’

NPSTORE Reports and Statistics

1. Reports 2. Statistics 3. Graphs 4. Export 5. Google Earth

Data Type: Results New Row for Each: Characteristic Include a Header Record: ☒ Fields: All

File Type: Excel Memo Fields: Truncate to 255 characters

File Name: T:\I&M\Temporary\Export_Results_05012009 Open Export on Completion: ☒ Substitute Detection or Quant for Result Value/Text for Filtered Data: ☐

Select export location

Choose how you want the export formatted.

Filter Options: Load Filter Save Filter Analytical Groups Scroll down to access all filter options

Organizations: All Projects: Subset Stations: Subset of Stations Date Ranges: Subset

Selected Projects: NCRNWX01: NCRN Perennial Nontid Selected Stations: NCRN_LANTL_SHOK: Sharpsburg Cree

Activities: All Activity Types: All Detection Cond: All Allowed Remarks: All

Filter the data to limit the amount of information exported.

Export Data Export Analysis Data Set Close Reports & Statistics Options ...

Figure 18-25: Dialog box for Dean's Export Check

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Photographs

Water program photograph management follows the NCRN Photo Management SOP EXCEPT in the naming of data photographs:

PARKsiteYYYYMMDD (#)

Data photographs are always kept with the project. Copies may be placed in Photo Library with naming and metadata following the NCRN SOP.

Literature Management

The Water monitoring program follows the Network SOP Literature Naming and Referencing.

File Naming

The Water monitoring program follows the Network SOP NCRN File Naming Convention.

Archiving

Update the metadata in NPSTORET as needed following Tucker 2004.

Upon review of a Fiscal Year's data and completion of the annual report and IARs the NPSTORET backend will be archived by the Data Manager. The NPSTORET backend will also be archived prior to each version upgrade of the front end database (naming convention and storage location?)

Data Dissemination

Data should be transferred to the Water Resources Division offices in Fort Collins, CO at least annually for upload into the master NPSTORET Database and eventual upload into EPA STORET. This transfer should not take place until all data have been verified, validated and certified as complete.

Additionally, annual data products (including data and reports) should be posted to the NPS Data Store for dissemination to the public as well as to the Integration and Application Network's (IAN) Data Portal website.

Individual data requests will be handled by the Data Manager and Program Manager as needed, for example the biannual water quality reports generated by the States.

Prior to delivery of data to WRD in Ft. Collins please complete the following checklist to certify that products have been completed and received and that those products meet the standards required by the NCRN. Please provide comments in RED when necessary especially if the box labeled “N/A” is marked. Once completed, this sheet should be archived with other project materials.

Project Title					
Date Range					
Ye s	N o	N/A	Data Review		
☐	☐		Field data reviewed for proper formatting and completeness?		
			Yes: ☐	No: ☐	Revisions necessary? If ‘Yes’, please describe:
☐	☐		Metadata complete and current in NPSTORET?		
☐	☐	☐	IARs produced?		
☐	☐		Data set contains sensitive information? If so, describe:		
		☐	Yes: ☐	No: ☐	If data is considered sensitive has metadata been updated?
☐	☐		Data set certified?		
☐	☐		Annual data set archived?		
☐	☐		Master data set updated?		
☐	☐	☐	Draft report completed?		
		☐	Yes: ☐	No: ☐	Report reviewed and comments incorporated?
☐	☐	☐	Peer review required?		
			Yes: ☐	No: ☐	Peer review comments addressed?
☐	☐	☐	Report contains sensitive information? If so, describe:		
			Yes: ☐	No: ☐	If document contains sensitive information has disclaimer been added.
☐	☐	☐	NRTR report number received and added to report?		
☐	☐	☐	TIC number received and added to report?		
☐	☐	☐	Final report received and approved?		
☐	☐	☐	Annual report archived?		
☐	☐	☐	Report citation added to NatureBib and report uploaded?		
			Yes: ☐	No: ☐	NatureBib citation reflects sensitivity level?
☐	☐		Data/report posted to Network Internet site?		
☐	☐		Data/report posted to Network Intranet site?		
☐	☐		Final data bundle uploaded to national data repository (NPStoret)?		
☐	☐		NCRN Project Management System updated?		
Certified By:					
Certified Date					

NCRN Water Chemistry & Quantity Monitoring Data Analysis and Reporting Standard Operating Procedure #19

Revision History Log:

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

1. Purpose

The purpose of this SOP is to document the data analysis and reporting procedures for all of the water quality vital signs. The current version of the SOP (1.0) focuses on analysis to be used for the annual reports of water chemistry, nutrient dynamics, and surface water dynamics vital signs; 6 year review of all water vital signs including BSS; QA/QC reporting, data sharing, and suggestions for special reports.

As data accumulates, it will be possible to analyze the data to identify trends in water quality and quantity. It is anticipated that methods to analyze trends may change as more data becomes available. For example, with one or two years of data it will not be possible to estimate seasonal effects, but this will be possible with five or more years of data (hence the 6 year review).

This reporting follows the templates established in the Natural Resource Reporting Series. Three types of reports are described in this series: Natural Resource Reports (NRR), Natural Resource Technical Reports (NRTR), and Natural Resource Data Series (NRDS).

2. Scope and Applicability

This data analysis procedure is intended to be applicable to all data collected by the Water Quality Monitoring Program. This Standard Operating Procedure (SOP) is used to describe the procedures used to format and disseminate data collected from NCRN vital sign projects. This document is intended to only provide a broad overview of the requirements. Additional documents and websites exist to provide contributors with very detailed information on how to prepare reports for these reporting series.

3. Roles and Responsibilities

NPS Project Manager

- Completing data analysis is the responsibility of the project manager but may be conducted in house or by cooperators.
- Ensure that all members of the field crew are aware of the procedures outlining how data should be entered into project database, verified and validated; and are doing so.
- Ensure that data undergo the proper QA/QC procedures.
- Produce IARS and annual reports.
- Work with the Quantitative Ecologist on 6 year review and specialized topic reports.

Field Crews

- Follow all data collection procedures.

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- Enter/upload data into project databases in a timely fashion.
- Conduct data verification and validation checks.
- Review reports.
- Report unusual field conditions to the Project Manager for inclusion in the IARs and annual reports.

NPS Quantitative Ecologist

- Assist Project Manager with 6 year review and special topic reports.

4. Reference Documents

Griffith, L.M., R.C. Ward, G.B. McBride, and J.C. Loftis. 2001. Data Analysis Considerations in Producing 'Comparable' Information for Water Quality Management Purposes. National Water Quality Monitoring Council Technical Report 01-01. White Paper of the National Water Quality Monitoring Council, Co-sponsored by USGS, Web:

<http://water.usgs.gov/wicp/acwi/monitoring/CouncilPrior6-Mar00.html>.

Irwin, R. J. 2008. Draft Part B lite QA/QC Review Checklist for Aquatic Vital Sign Monitoring Protocols and SOPs. National Park Service, Water Resources Division, Ft. Collins, CO.

Kayzak, Paul F. 2001. MARYLAND BIOLOGICAL STREAM SURVEY SAMPLING MANUAL. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division: Annapolis, MD.

Lenz, B.N., Robertson, D.M., Fallon, J.D., and Ferrin, R. 2001. Nutrient and suspended-sediment loads and benthic invertebrate data for tributaries to the St. Croix River, Wisconsin and Minnesota, 1997-99: U.S. Geological Survey Water-Resources Investigations Report 01-4162. 57 pp.

Maryland, G. S. 1968. Maryland Geological Survey bulletin 19: geography and geology of Maryland. Maryland Geological Survey.

[National Park Service. 2006. Instructions to Authors – Natural Resource Reports and Natural Resources Technical Report. Natural Resource Report NPS/NRPC/NRR – 2006/001. National Park Service, Fort Collins, Colorado.](#)

(www.nature.nps.gov/publications/NRPM/docs/Instructions_to_Authors.pdf)

Natural Resource Publications Management Website

www.nature.nps.gov/publications/NRPM/index.cfm

NCRN Data Management Plan

NRInfo Reference Application on the NRInfo data portal

<http://nrinfo.nps.gov/ReferenceDomain.mvc/Welcome>

Omernik, J. M. 1987. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers 77:118-125.

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Research Permit and Reporting System <https://science.nature.nps.gov/research/ac/ResearchIndex>

Roth, N. E., M. T. Southerland, G. Mercurio, J. C. Chaillou, P. F. Kazyak, S. S. Stranko, A. P. Prochaska, D. G. Heimbuch, and J. C. Seibel. 1999. State of the Streams: 1995-1997 Maryland Biological Stream Survey Results. ea-99-6, Maryland Department of Natural Resources.

Stednick, Dr. John D., and Gilbert, David M. 1998. Water Quality Inventory Protocol: Riverine Environments. National Park Service, Water Resources Division and Servicewide Inventory and Monitoring Program. Fort Collins, CO. Technical Report NPS/NRWRD/NRTR-98/177

5. Procedures and General Requirements

Reports produced by the NCRN should be formatted using one of the standard reporting templates (<http://www.nature.nps.gov/publications/NRPM/>). Report citations should be added to the NRInfo Reference Application on the NRInfo data portal (<http://nrinfo.nps.gov/ReferenceDomain.mvc/Welcome>). Once the citation record is completed an electronic copy of the reference should be uploaded and attached to the reference data record. Posting the report on the NRInfo portal makes it discoverable by a wide range of users.

The report must also be posted on the Network's website. A link to the report should be posted on the protocol-specific web page as well as on the Monitoring Products page.

Reporting Schedule

Table 19-1: Reporting Schedule

Report	Frequency	Due Date
AARWP	Annually	November 8 th
NRDS	Annually	March 30 th
IARs	Annually	March 30 th
NRTR of Trends	6 years	March 30 th 2014
QA/QC, other periodic reports	Periodically	As needed

AARWP (Annual Administrative Reports and Work Plans)

The AARWP will be submitted with I&M and also to WRD. The Network Annual Administrative Report and Work Plan for Inventories and Monitoring (AARWP) is due to Inventory and Monitoring Program Division Chief by November 8 to allow consolidation into the Report to Congress. The intended audience is the Park Superintendents, network staff, regional coordinators, and Servicewide program managers. The AARWP uses a standardized simple format for tracking accomplishments, planned activities, and budgets that summarizes last year's accomplishments and expenditures, and this year's planned activities. The data are consolidated Service-wide into a Report to Congress for accountability purposes.

Annual Data Series Report and upload to STORET

An annual Natural Resource Data Series (NRDS) Report of the water chemistry, nutrient dynamics, and surface water dynamics vital signs for the previous fiscal year's data will be published by the end of March every year. The NRDS is intended for timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial

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analyses of data in these reports are provisional and subject to change. This series is intended to provide data sets or data summaries that will be compiled, analyzed, and interpreted once enough data has been collected to do so adequately.

Water quality parameters at a site will be compared by plotting analyte concentration through time to identify if there is no slope (no change), positive slope (concentration increasing through time), or a negative slope (concentration decreasing through time). Concentrations will also be compared against threshold values that are indicators of degradation. The annual report will focus on the status of the streams in that year. The report will cover the status of the following indicators: air and water temperature, ANC, DO, NH₃, NO₃, pH, and SC, conductivity, salinity, monochloramine and chlorine if measured, width, depth, flow, and discharge.

In order to produce an annual summary report that is most useful to management and provides adequate monitoring of potential anomalies and long-term trends, a standardized format should be used to record, list, and display all data. A Standardized layout can be found in the annual reports beginning with 2009. Annual summaries of water chemistry and quantity data collected for the monitoring program are reported in the NRDS format and internally reviewed.

The “Instructions to Authors” document found on the Natural Resources Publications Management website provides detailed instructions on preparing Natural Resource Data Series Reports including formatting guidance on typing and page formatting and figures and table preparation and documentation. The following describes the basic content required for these reports:

Front Cover – Should include the title of the report “National Capital Region Network YYYY Water Resources Monitoring Data Report: Water Chemistry, Nutrient Dynamics, and Surface Water Dynamics Vital Signs” along with a picture that is representative of the project. The following page (inside front cover) should contain the photo credits for the cover photo.

Title Page – Should include: title, report date, and authors as well as the report number. Also include complete current mailing address (including zip + four), email, phone and fax number of the person to whom correspondence should be sent.

Table of Contents

List of Figures, Tables and Abbreviations & Acronyms

Executive Summary –Should be a “stand alone” section of the document that summarizes the important points of the document. This section requires revision every year.

Keywords - Below the abstract, provide 5-6 keywords that describe the subject of the paper; these need not duplicate words in the title.

Acknowledgements (optional)

Introduction – Describes the NCRN water monitoring program including the study area. This section does not require revision unless details of the program change.

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Methods – Describes the NCRN water monitoring protocol but does not repeat it. This section does not require revision unless details of the program change.

Parameters - This section does not require revision unless details of the program change. The thresholds used in the parameter descriptions may need to be revised every three years as the states revise their water quality standards. The next state revision is due in 2013.

Discussion of Findings – Data are presented graphically with summary statistics in tables in alphabetical order by park and then by parameter. Speculation on the significance of the data should be minimal since detailed statistical analysis is not performed at this time. That is part of the 6 year review and trends report process. This section requires revision every year.

The majority of the work for the Annual NRDS is the preparation of the graphs. Open NPSTORET. Select your Login ID and select **Reports & Stats**. Select Tab 3. Graphs. Fill in the following selections, the others do not matter:

- Available Graphs: Time Series.
- File Name:
T:\I&M\MONITORING\WaterQual&Quant\Reports\Regional\yyyy\PARK_FYyyyy_TSGraph.xls
- Projects: Subset, Selected Projects NCRNWQ01: NCRN Perennial Nontidal Streams
- Stations: Subset of Stations, Selected Stations those of the park
- Date Ranges either all or a subset, depending on purpose of the graph
- Characteristics: Subset is recommended though if All is chosen, the file will simply not include the non-qualitative data.

Click **Generate Graphs**. The Excel Workbook will eventually appear, this is already saved and does not require re-saving. The spreadsheets produced are read-only. To manipulate the graph, under the **Review** tab select **Unprotect Sheet**. *Save file between each step*

Open Excel workbook ex: T:\I&M\MONITORING\WaterQual&Quant\Reports\Regional\YYYY

Example: CATO_FYYYYY_TSGraph.xls

Review > Unprotect Sheet

Change Chart Type to Scatter w/o lines

Edit Date Range to 1October YYYY-1 to 30 September YYYY

Name the streams

Change Legend to 10 point font

Edit vertical axes:

- Adjust vertical axes so they cross the x-axis at 0,
- pH Y-axis 0 to 14, delete units
- water temperature Y-axis at least 0 to 25 C

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Edit Graphs to the following:

Table 19-2: Standardized units of measure and current management decision thresholds.

Graph Titles	Axis Titles	Management Decision Thresholds
Acid Neutralizing Capacity (ANC) as CaCO₃	µeq/L	karst = 600 µeq/L, non-karst = 200 µeq/L
Ammonia (NH₃)	mg/L	0.179 mg/L
Dissolved Oxygen (DO)	mg/L	6.0 mg/L trout streams, 5.0 mg/L all others
Nitrate (NO₃)	mg/L	Ecoregion IX 2.0 mg/L Ecoregion XI 0.31 mg/L
pH	pH	6.0 and 9.0
Phosphorus as PO₄	mg/L	Ecoregion IX 0.037 mg/L Ecoregion XI 0.01 mg/L
Salinity	ppt	0.5
Specific Conductance	µS/cm	171
Water Temperature	°C	20 coldwater streams 32 warmwater streams
Discharge	cfs	>0
Flow	ft/s	>0
Average Water Depth	feet	0.20
Wetted Width	feet	>0

All water resources data will be analyzed to determine if parameters fall above or below Program-defined Management Decision Thresholds (see Table 19-2). The Clean Water Act requires the states to establish water quality standards. Results necessary to trigger management decisions are based on these standards where available. Where State or Federal standards are not available the relationship between the measurements and observations to be made and the value(s) to be protected (or the desired future outcome) is drawn from the literature. The States review they're water quality standards every three years. The last review occurred in 2010, the next is due in 2013. The States also publish integrated reports of surface water quality every two years, the last was published in 2010, and the next is due in 2012. These reports should be reviewed for updated information on thresholds and water quality status as they are available. For references and explanations of the thresholds see the Parameters section of the Protocol narrative.

Draw Thresholds: Insert > Shape > line

Start at Y-axis and extend to other side, select and Format Shape > width = 1.5, line color = red

Select line and graph and Group

Copy graph above appropriate heading in report

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Descriptive Statistics can be generated from NPSTORET. Open NPSTORET. Select your Login ID and select **Reports & Stats**. Select **Tab 2. Statistics**. Presumably you are producing statistics for the same set of data and do not need to change any of the settings. Click **Generate Statistics**. A Text file will eventually appear. This must be saved, preferably as a Word document: T:\I&M\MONITORING\WaterQual&Quant\Reports\Regional\YYYY

Example: CATO_FYYYYY_SumStats.doc

Literature Cited - List literature citations alphabetically by the first author's last name in a literature cited section following the acknowledgments. Literature cited entries should use a consistent format and follow the format used by the journal Ecology. Carefully double-check citations against citations in the text. See Exhibit K in the “Instructions to Authors” document for examples.

Back Cover – The NPS TIC Number and report date are the only pieces of information that need to be added to the back cover of the report. These will be provided by Fort Collins.

Refer to [Appendix 1](#) for a report preparation checklist to help ensure that all reporting sections are included in the final product.

Document Submission:

Upon the completion of the draft report, all documents should be submitted to the NPS Key Official for review. At the time of submission of the draft report, the project lead should inform the NPS Key Official of whether the report contains information relating to sensitive resources (e.g. rare, threatened or endangered species, or specific sensitive habitat types). If the report does contain sensitive material it should be marked as such on the inside of the cover page.

The NPS Key Official will review and circulate the document for “peer review”. Reviewers may include park managers, network level, regional level or national level NPS staff, or colleagues from other agencies or academia. The level of peer review required will be determined by the NPS Key Official and choice of reviewers may also be affected by whether the report contains information on sensitive resources. All review comments will be forwarded to the project lead who then should address the comments as necessary.

Once all of the review comments have been addressed, the NPS Key Official will obtain the appropriate series number and Technical Information Center (TIC) number for the report and provide these numbers to the project lead.

The project lead will ensure that all comments are addressed and that report numbers are added to the final document in the proper locations (cover page and title page). An electronic copy of the report will be submitted to the NPS Key Official as an MS Word file (preferably accompanied by a Adobe PDF version as well). The NPS Key Official will ensure that the document is properly posted for dissemination and added into the NatureBib database.

Investigator Annual Reports (IARs)

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Concurrently with the Annual Water Resource NRDS, Investigator Annual Reports will be prepared for those parks requiring permits (GWMP, HAFE, NACE, PRWI, ROCR, WOTR) and permits will be renewed as necessary through the Research Permit and Reporting System (<https://science.nature.nps.gov/research/ac/ResearchIndex>).

6 year review for Status and Trends

Every 6 years, upon completion of a full round of Biological Stream survey sampling, the Network will produce a synthesis report of all water resource vital signs: water chemistry, nutrient dynamics, surface water dynamics, fish, benthic macroinvertebrates, physical habitat index, and amphibians. This report will be prepared in the Natural Resources Technical Reports (NRTR) format. The next report is due in 2014. NRTRs are used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. The NRTR typically follows the "Introduction - Methods - Results - Discussion" type organization that is standard for many scientific journal publications and technical reports. A formal statistical test for trends can be conducted using simple linear regression with the analyte concentration as the dependent variable and time as the independent variable. As trend data becomes available we anticipate that it will become incorporated into the report as well. The main purpose of the synthesis report is trend analyses.

Points to consider when determining data analysis techniques:

USGS recommends the following analyses for Surface Water Dynamics:

- trend estimation (seasonal Kendall test and related slope estimators),
- methods for analysis of water-quality data with multiple detection limits,
- record extension techniques (MOVE.1)
- hydrograph plotting,
- Piper and Stiff diagrams,
- subseries plots for seasonal data
- USGS-style boxplots
- Peak flow data
- 7 and 30 day low and high flows
- Daily, monthly and yearly means, minimums and highs
- 20 standard n-day high and low flows
- Flow duration plot

Adjust data for measurement uncertainty and/or flow

In flowing water systems, many water column parameters are strongly correlated with discharge. Analysis of trends can be virtually impossible without first removing the influence of discharge on the variable. There are lots of ways to do this, including "normalizing" for discharge, evaluating changes in the Q v. parameter relationship, etc. In standing water systems, sequential measurements may not be independent of the previous measurement. In these cases, time series analysis of trend may be more applicable (Bill Jackson, NPS, Personal Communication, 2002).

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Flow-adjusted concentrations are often used in USGS and flow-adjustment of concentrations is appropriate for analyses of trends IF there is a strong correlation between the concentrations and flow (Griffith et al. 2001). However, keep in mind that sometimes correlations between concentrations and flow appear to good in synoptic studies and later prove inconsistent or perhaps not as generically helpful as first thought when studied in long term monitoring (Lenz et al. 2001)

Spatial Scale

Many park resources vary along three spatial scales: (1) regional scale variation caused by large scale phenomenon, (2) meso-scale variation in attributes correlated with topography for example elevation, slope, aspect, individual site history, and (3) micro-scale variation in small scale gradients for example microtopography and within site soil fertility. Parks should be examined within the context of these three scales.

Physiographic Region

In analysis of MD-DNR MBSS data, Three distinct geographic strata, corresponding to physiographic region and river basin boundaries, were identified as having statistically (cluster analysis and MANOVA) different naturally occurring species assemblages that corresponded with physiographic region and river basin boundaries: the Coastal Plain, Eastern Piedmont, and Highlands regions. These geographic strata are coincident with aggregations of ecoregions (Omernik 1987) and the physiographic provinces (Maryland Geological Survey) developed for Maryland. The Coastal Plain fish species are to a large degree distinct from those found in the higher gradient Highlands. The Eastern Piedmont appears to be a more speciose region, able to support many of the fishes found in the Highlands, but also a number of species rarely or not found in the Highlands. The Coastal Plain includes nearly all of Maryland's eastern shore plus portions of the western shore basins below the fall line. The Eastern Piedmont stratum includes the central Maryland basins above the fall line that drain to the Chesapeake Bay and tidal Potomac. Within the Potomac Washington Metro basin, the boundary reflects the division of Potomac tributaries above Great Falls (Highlands) and below it (Eastern Piedmont), a distinction noted when cluster analysis groups were mapped. The Highlands stratum includes the remainder of central and western Maryland, including the Appalachian Plateau, Valley and Ridge, Blue Ridge, and westernmost part of the Piedmont physiographic region. The cluster analysis did not support further subdivision of these site groupings into finer geographic strata. Although coldwater and coolwater stream systems in Maryland frequently differ in species abundance and composition from warmwater systems, a separate stratum of cold/coolwater sites was not clearly distinguishable in this analysis, but is worth considering since some brook trout sites showed a slight tendency to group (Roth et al. 1999). NCRN crosses the Coastal Plain, Piedmont, Blue Ridge, Valley & Ridge, and Appalachian Plateau in MD, DC, VA, and eastern WV. The underlying bedrock of the regions can also cause differences in baseline chemistry of the streams (Kayzak 2001). Sampling sites also differ in their soils, groundwater, and landuse.

Additional Points to Consider in Determining Data Analysis Techniques

Non-parametric statistical tests are more valid for non-normal data and are used to describe distributions in water quality data. The median and interquartile range (IQR) (middle 50% of data points) can be used instead of the mean and standard deviation typically used for normally distributed data. The median is particularly useful for water quality data since it is less sensitive to outliers than the mean. Confidence intervals (95%) should be used to bound uncertainties in

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means and medians (Irwin 2004). Summary statistics and correlation techniques will be used to determine (quantify) relationships between variables (water quality parameters).

For general trend analyses Stednick and Gilbert (1998) suggest the **Seasonal Kendall Test for trends**, unless an alternative approach is justified. The Seasonal Kendall Test (a seasonal extension of the nonparametric Mann-Kendall test) was found to be the most frequently used trend analysis method in water quality work, especially in USGS analyses (Griffith et al. 2001). Using the same method will provide some consistency across NPS.

To limit seasonal variability, statistical tests can be performed on each of the different seasons, summing the test statistics and summing their expectations and variances. The overall test for trends is then carried out by using the summed test statistics with its expectation and variance. The Seasonal-Kendall test makes use of this approach (Irwin 2004).

QA/QC Reporting

A periodic summary of QA/QC results for field meter and analytical chemistry sampling will be prepared and maintained on file.

Assessment of data quality will be conducted to determine the overall performance of the Water Quality Monitoring program, identify potential limitations to use and interpretation of the data, and to provide information for other data users regarding usability of the data for other purposes. Precision and bias associated with important elements of the sampling and measurement process for each variable measured will be evaluated using results from replicate sampling and performance evaluation studies. Information about precision, bias, and completeness will be used to determine the comparability of data acquired during each sampling year (Stednick and Gilbert 1998).

Data Dissemination

Water quality monitoring results will be submitted to the Water Resources Division at least once per year for upload into the NPS' STORET database. At this time the data will also be provided to the Parks, partners and other interested parties, such as the Maryland Water Monitoring Council and the Virginia Water Monitoring Council for inclusion in their databases of statewide monitoring. Share data with state and local groups for TMDL and other regulatory decision purposes.

Network Storage and Archiving

The following sections detail how and where data will be stored in the NCRN file structure and when and where data are to be archived. All data and project materials will be maintained on the NCRN file server under a project specific directory.

Protocols and SOPs

All currently active protocols and SOPs will be maintained in the 'Protocol' Directory under the 'MONITORING\WaterQual&Quant' directory. Copies of the currently active protocol and SOPs will also be stored under the appropriate 'ARCHIVE' folder in case the 'Active' files are inadvertently altered.

Field Data

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All field data will remain under the 'MONITORING\WaterQual&Quant\Data' data folder until the field season has been completed and the project manager certifies that all data products have been received and have undergone the proper level of QA/QC. Once the project manager is confident that the data are in good order, the data files should be archived under the project's ARCHIVE directory. The data should be appended to the master NCRN BSS database located in the ARCHIVE directory.

All data sheets will be archived in the NCRN archive fire cabinets. Copies will be maintained separately.

Reports

Annual reports are stored in the project's 'MONITORING\WaterQual&Quant\Reports' folder until they have undergone review. Network staff should review reports for completeness and compliance with standards. The project manager should circulate the reports to network parks for review. All comments should be provided back to the contractor to be addressed. Once the report has been finalized and approved, a copy is archived and entered into NatureBib.

Archiving

Project materials should be archived periodically throughout the annual project cycle as a means of increasing data security. Project milestones that define the appropriate times to archive file materials in addition to the seasonal close-out milestone when all materials are received and finalized: at the completion of the Spring sampling data entry and the completion of the Summer sampling data entry. Once the data are sent to I&M and entered in the database, the data should be archived. The project manager should advise the data manager that materials are ready for archiving.

Providing well-documented data in a timely manner is a primary goal of the I&M Program, and is essential to program success. The NCRN will share and disseminate quality natural resource data, information, and products from vital signs monitoring projects to a broad audience including park managers, researchers, educators, and the general public.

Timeframe – When will data be released?

It is the goal of the NCRN I&M Program to make data and data products available in a timely fashion. Timelines for sharing and disseminating data and information will vary depending on the vital sign or project but the NCRN will generally aim to disseminate data within two years of the completion of data collection.

Prior to release, it is imperative that the NCRN I&M Program ensures that the data are accurate and do not contain information that might endanger park resources. Accomplishing this takes time and should involve a carefully coordinated effort between all those involved with the project including network staff and cooperators and contractors, and park managers. No data or information will be released until a formal, detailed review has been completed and the data are deemed accurate and certified.

The timeframe for data release may hinge on the completion of associated reports and/or publications. Depending on the content of the report and/or the journal or report series peer

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review may be required. In cases like this, data can be *shared* internally with park managers and other staff once the data set has been certified. Data sets should be posted on intranet sites and files uploaded to the NRInfo portal should be limited to internal NPS viewers only. Following the publication of reports the data should then be *disseminated* to the public assuming the data are not sensitive. Data products should then also be posted on internet sites and made publically available on the NRInfo portal.

What is disseminated/shared?

In addition to reviewing the data to ensure quality and accuracy, staff must also make sure that the data set and associated data products do not contain sensitive information. The content of information that is released will sometimes depend on the audience and the status of the data.

Publicly Available

All non-sensitive, fully certified data will be released to the public. This means that the data have undergone numerous QA/QC checks and are consistent with associated data products (e.g. reports), if they exist. This also includes data that have been thoroughly reviewed and were found not to contain any information that might endanger sensitive resources (cultural or natural). The format in which the data are released (e.g. raw or summarized to a certain degree) will depend on the protocol.

Internal/Restricted

Data and/or data products that are deemed to contain sensitive information that, if released to the public, could endanger park resources will not be disseminated to the public. These data and products will be available to an internal audience only including park managers and other NPS staff. However, these data will not be shared internally until all QA/QC checks are completed and the data set and data products are certified as final. Internal data are shared through the NCRN Intranet website and the posted on the NRInfo portal with data access restricted to NPS users only.

Metadata

Regardless of whether data are released to internal or external audiences all data files must be accompanied by a FGDC compliant metadata file. Refer to the program or protocol specific Metadata SOP for more information about creating and formatting project metadata.

Formatting of Disseminated Data

All NCRN monitoring protocols are accompanied by a protocol-specific MS Access database where data are entered, stored, and managed. Certain protocols are supported by national or regional databases that function as a master data center and dissemination point. (e.g. NPStoret). In these cases, data are periodically (annually) uploaded to these master systems where data are integrated and become discoverable. Details on upload schedules and procedures can be found in protocol specific documents.

Many of the NCRN monitoring protocols are not supported by larger enterprise level data systems. In these cases, the Network is responsible for determining the most appropriate format for distributing data. Some of these databases are relatively complicated applications that may

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not necessarily be an appropriate means of packaging data for dissemination. In these cases, data will be exported from the databases and organized in MS Excel workbooks. Data will be organized by worksheets but how the worksheets are organized will depend on the protocol (e.g. worksheets for parks versus worksheets for data type).

Regardless of how the data are packaged when released the data must contain certain valuable pieces of information including:

Location where data were collected

- **Park and/or Park Code**
- **Sub-Unit Code (if applicable)**
- **Plot or Site Name**

The GPS (X/Y) coordinates for monitoring sites/plots *should not* be included in the standard data that are released to public facing sites. This information is not necessarily sensitive and can be released to both internal and external users upon request. Limiting the release of this information reduces the possibility of having monitoring sites impacted by user groups. Making this information only available upon request allows network staff to keep track of those users who have the actual location information for monitoring sites in case we find that a monitoring site is impacted by data users.

Event information

- **Date**
- **Time (Start and End Times if applicable).**
- **Event details such as weather conditions.**

Field Data

Field data will be distributed differently depending on the protocol. The data collected for some protocols is fairly basic and can be distributed in raw form. Other protocols collect data that are quite complex and the raw data are often not very helpful. In these cases, the raw data should be summarized or aggregated and distributed in that form. A good example of this would be distributing tree basal area numbers instead of distributing the DBH data for each tree stem. Details on how protocol data should be formatted for distribution can be found in protocol specific documentation.

NCRN Water Chemistry and Quantity Revising the Protocol Standard Operating Procedure #20

Revision History Log:

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

1. Purpose

The Standard Operating Procedure (SOP) explains how to make changes to the Water Chemistry and Quantity Protocol narrative for the National Capital Region. Persons editing the protocol narrative or any of the SOPs need to follow this outlined procedure to avoid confusion in how the data are collected and analyzed. Note: this SOP follows directly from the example provided for the bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas written by Peitz et al. (2002).

2. Scope and Applicability

This SOP applies to the Water Chemistry and Quantity Protocol when applied to NCRN parks.

3. Procedures and General Requirements

The Water Chemistry and Quantity Protocol narrative and the accompanying SOPs have attempted to include the most sound methodologies for analyzing and collecting aquatic monitoring data. However, all protocols, regardless of how sound, require editing as new and different information becomes available. Edits should be made in a timely manner and appropriate reviews undertaken.

All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by National Capital Region Inventory and Monitoring staff. However, if a complete change in methods is sought, than an outside review is required. Regional and National staff of the National Park Service with familiarity in aquatic research and data analysis will be used as reviewers. Also, experts in aquatic research and statistical methodologies outside of the Park Service will be used in the review process.

Document edits and protocol versioning in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.

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Revising the Protocol
Standard Operating Procedure #20**

Inform the Data Manager about changes to the Protocol Narrative or SOP so the new version number can be incorporated in the Metadata of the project database. The database may have to be edited by the Data Manager to accompany changes in the Protocol Narrative and SOPs.

Post new versions on the internet and forward copies to all individuals with a previous version of the effected Protocol Narrative or SOP.

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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.

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National Park Service
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Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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