National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Upper Columbia Basin Network
Integrated Water Quality Monitoring Protocol

Standard Operation Procedures Version 1.9

Natural Resource Report NPS/UCBN/NRR—2016/1231.1





ON THIS PAGE
Photograph of NPS UCBN staff reviewing data collected during a cross-section survey at Big Hole National Battlefield.
Photograph courtesy of the National Park Service

ON THE COVER
Photograph of NPS UCBN staff conducting a cross-section survey at Big Hole National Battlefield.
Photograph courtesy of the National Park Service

Upper Columbia Basin Network
Integrated Water Quality Monitoring Protocol

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Natural Resource Report NPS/UCBN/NRR—2016/1231.1

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July 2016

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Starkey, E. N., G. H. Dicus, L. K. Garrett, M. K. Lonneker, T. J. Rodhouse, K. R. Sherrill, and R. K. Steinhorst. 2016. Upper Columbia Basin Network integrated water quality monitoring protocol: Standard operating procedures version 1.9. Natural Resource Report NPS/UCBN/NRR—2016/1231.1. National Park Service, Fort Collins, Colorado.

NPS 963/133000, July 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	March 2013	UCBN	Macroinvertebrate sampling techniques/site selection is now covered in the stream channel characteristics monitoring protocol. Minor revisions to state water quality thresholds. No changes were made to objectives or water quality techniques. In 2008, the timing of water quality sampling was shifted from May-October to June-November. This change is documented in this version.	Additional details and revisions needed following 5 years of implementation. Integration of macoinvertebrate sampling with stream channel characteristics protocol due to collaboration with USFS-PIBO program.	1.8
1.8	February 2016	UCBN	Updated training SOP. Revised data management SOP due to updated water quality database and changes to Aquarius Time-Series Software. Removed SOP #3 Finding GPS Waypoints and SOP #4 Drawing GRTS Sample. No changes were made to objectives, analysis or core water quality techniques. Initial site visit procedures have been combined into a single new SOP. Expanded final field visit and end of season procedures SOP.	Updates made to bring SOPs in line with revised protocol narrative. Removed SOPs not being used.	1.9

NOTE: Monitoring data collected 2008 – 2009 were collected under SOP version 1.0. Data collected 2010-2014 used version 1.8, and data collected in 2015 used version 1.9.

1. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, …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.
2. Notify the UCBN Data Manager of any changes to the Protocol Narrative or SOP so that the new version number can be incorporated in the Metadata of the project database.
3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOP.

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Executive Summary

The mission of the National Park Service is “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The Upper Columbia Basin Network (UCBN) consists of nine widely separated NPS units located in western Montana, Idaho, eastern Washington, and central Oregon. One unit of the Nez Perce National Historical Park (NEPE), Bear Paw Battlefield, is actually located outside the Network boundary in eastern Montana. This unit and one other park, Big Hole National Battlefield (BIHO), lie outside the Columbia River Basin, although administratively speaking they are part of the Network. UCBN parks vary in size from 30 ha (74 ac) to more than 188,197 ha (465,046 ac), and all but two are less than 6,000 ha (14,826 ac). These park units operate with limited budgets and few staff, and are not able to provide personnel and funds for many of the natural resource concerns they face. The resources available at the network level greatly increase their capacity to meet increasingly complex resource management issues. While the parks have been identified as having significant natural resources, the majority were actually established to protect cultural and paleontological resources. The upper Columbia Basin holds a rich and fascinating cultural history, and several UCBN parks provide the nationally significant service of chronicling the pre-contact and contact cultures of the Nez Perce and Cayuse people, early pioneer and mission culture, and the tragic conflicts that arose between them. Two parks also protect and interpret globally significant fossil localities. Most also have some level of natural resource protection language included in enabling legislation or other guidance documents.

Parks of the Upper Columbia Basin Network include: Big Hole National Battlefield (BIHO), City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), John Day Fossil Beds National Monument (JODA), Lake Roosevelt National Recreation Area (LARO), Minidoka Internment National Monument (MIIN), Nez Perce National Historical Park (NEPE), and Whitman Mission National Historic Site (WHMI).

The Upper Columbia Basin Network (UCBN) has identified 14 priority park vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Our intent has been to come up with a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Water quality is a particularly high priority vital sign for six of the nine UCBN parks. The UCBN contains more than 34 rivers, streams, ponds and reservoirs located in nine park units spread over four large western states. Unlike many National Parks that are large and often encompass entire watersheds, most UCBN parks and water bodies are

small and embedded in large watersheds with diverse land use. Water quality in most UCBN water bodies has not been directly assessed within park units for regulatory compliance, though most streams are listed as impaired by states for at least one parameter.This protocol details the why, where, how, and when of the UCBN's water quality monitoring program. As recommended by Oakley et al. (2003), it consists of a protocol narrative (see Starkey et al. 2016) and a set of standard operating procedures (SOPs), which detail the steps required to collect, manage, and disseminate the data representing the status and trend of water quality parameters in the Network. This monitoring protocol combines two approaches: 1) collection of water chemistry data for "core parameters" from UCBN stream sites using continuous water quality monitors, and 2) macroinvertebrate biomonitoring using the United States Forest Service (USFS)- PACFISH/INFISH Biological Opinion (PIBO) sampling protocols. These data in combination with other vital signs monitoring, will provide a context for the interpretation of status and trends in water resources within the network.

The protocol is a "living" document in the sense that it is continually updated as new information acquired through monitoring and evaluation leads to a refinement of program objectives and methodologies. Changes to the protocol are carefully documented in a revision history log. The intent of the protocol is to ensure that a seamless and scientifically credible story about water quality conditions over time can be told to park visitors and managers alike. The next few years of monitoring results are eagerly awaited, as outstanding questions related to site variability, inter-annual variability, and the current water quality of park water bodies can finally be described. From there, the focus will shift toward trend analysis, in which biologically meaningful declines or increases will be detected, and appropriate management strategies can be developed.

Acknowledgments

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Servicewide Inventory and Monitoring Program. We thank the staff of Nez Perce National Historical Park and Whitman Mission National Historic Site for their contributions in field testing these standard operating procedures and assistance during field reconnaissance. We also thank Chris Caudill, Ph.D. for his initial contributions to the draft standard operating procedures produced in 2007.

List of Acronyms and Abbreviations

BIHO Big Hole National Battlefield
CIRO City of Rocks National Reserve
CRMO Craters of the Moon National Monument and Preserve
DEQ Department of Environmental Quality
EPT Ephemeroptera, Plecoptera, Trichoptera aquatic macroinvertebrate index
EPA United States Environmental Protection Agency
GPRA Government Performance Results Act
GRTS Generalized Random Tessellation Stratified
HAFO Hagerman Fossil Beds National Monument
JODA John Day Fossil Beds National Monument
LARO Lake Roosevelt National Recreation Area
LULC Land use – land cover
MIIN Minidoka Interment National Monument
NAWQA National Ambient Water Quality Assessment (USGS)
NEPE Nez Perce National Historical Park
NOAA National Oceanographic and Atmospheric Administration
NWIS National Water Information System (USGS)
ONRW Outstanding Natural Resource Waters
PIBO PACFISH/INFISH Biological Opinion (USFS)
QA/QC Quality Assurance/Quality Control
SOP Standard Operating Procedure
STORET data STOrage and RETrieval (EPA)
T&E Threatened and Endangered
TMDL Total Maximum Daily Load
UCBN Upper Columbia Basin Network
USGCRP United States Global Change Research Program
USFS United States Forest Service
USGS United States Geological Survey
WHMI Whitman Mission National Historic Site
WQX Water Quality eXchange (EPA)
WRD Water Resources Division of NPS.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 1: Preparations and Equipment Set-up Prior to the Field Season

Version 1.9 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2013	UCBN-Aquatic Biologist	Updates to multiprobe housing construction. Changes to macroinvertebrate site selection/setup. Addition of external power source directions. Updated safety section.	Updates reflect changes to procedures	1.1
1.1	February 2016	UCBN-Aquatic Biologist	Minor updates housing installation section. Removal of macroinvertebrate sample reach selection and field work preparation sections. These sections were removed because the UCBN now implements macroinvertebrate sampling along with stream channel monitoring. Details of macroinvertebrate field prep. are now in Starkey et al. 2016.	Updates reflect changes to procedures and protocol narrative.	1.9

Note: This SOP describes the step-by-step procedures for preparing for field work and for constructing, preparing, and organizing field equipment prior to the initiation of personnel training and entry into the field. Field time is expensive and adequate field and equipment preparation is crucial to a successful monitoring program.

Suggested Reading

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Starkey, E. N., T. J. Rodhouse, G. H. Dicus, K. M. Irvine, and E. K. Archer. 2016 (in preparation) Upper Columbia Basin Network stream channel characteristics monitoring protocol: Narrative version 1.2. Natural Resource Report NPS/UCBN/NRR—2016/XXX. National Park Service, Fort Collins, CO.

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Annual Review

Key network and park staff should conduct an annual review of the protocol and SOPs prior to spring preparations. This is a central element to season close-out procedures. Review should include training and field procedures, data management, analysis, and reporting, as well as fundamental design issues. Most importantly, careful consideration should be made of the resulting analyses and the overall confidence in results. The adequacy of sampling effort must be evaluated. Any necessary changes should be made to the protocol and SOPs with enough time to circulate updated material to key staff.

Procedures

Scheduling and Organizing Field Work

The UCBN and its constituent parks are unable to maintain a large field staff for financial and logistical reasons. This combined with the remote and widely dispersed nature of the network, as well as the demands from other vital signs monitoring efforts, requires that the field portion of the integrated water quality monitoring program be sustained by the project lead, UCBN staff, and park resource managers. This fact mandates that field work should be scheduled well in advance of the June-November sampling window, and scheduling efforts should begin no later than the previous January. The project lead will coordinate this planning with park resource managers and UCBN staff. The UCBN Aquatic Biologist and field technician will assume primary responsibility for multiprobe calibration, maintenance, and data retrieval. However, park natural resource staff may be called upon to provide additional support during multiprobe installation/removal and cross-section survey data collection. A minimum of two people are necessary to safely complete multiprobe installation and cross-section surveys. Two people are also advisable, although not required, for monthly calibration and maintenance site visits. The UCBN Aquatic Biologist will make arrangements with the Network Program Manager to hire seasonal help as needed.

Water Quality Monitoring Site Selection –Preliminary reconnaissance

Water quality monitoring site selection will be determined using the criteria established by Wagner et al. (2006) and White (1999). In preparation for the field season, it is necessary to adequately search for prime multiprobe installation locations. This reconnaissance should be conducted during base flow conditions, the prior to the scheduled monitoring. Overall, the UCBN seeks to balance the need for a representative location within each stream, with factors such as stream stages, channel morphology, water velocity, potential for debris damage, and logistics. Site selection is discussed in more detail in SOP #3.

Supplies for Construction and Preparation

The following equipment should be assembled each spring, and sufficient time allowed to construct and/or order replacement equipment. Water quality field equipment will be checked out/in of the UCBN office by the protocol lead. Each water quality monitoring station will require one continuous monitor (multiprobe), housing, power source, and calibration supplies. Necessary calibration supplies are given in SOP #5.

Macroinvertebrate supplies and field season preparation is covered in the UCBN Stream Channel Characteristics Protocol (Starkey et al. 2016).

- Initial installation/housing construction
  - ½-inch rebar, 5’ (3) Or depending on configuration 5’ T-posts (4)
  - Cable padlock –for locking the housing(1)
  - Padlock - for attaching security cable (2)
  - Security cable – 1/8-inch (1)
  - PVC pipe 5’ section (4” diameter, schedule 40) (1)
  - PVC flanged end cap (4” diameter, schedule 40) (1)
  - 5-inch long ½-inch carriage bolt (1)
  - Flat washers (2) inside diameter ¼-inch, (2) inside diameter ½-inch
  - 2 ½” long, ¼-inch stainless steel eyebolt (1)
  - Stainless steel bolt snap (1)
  - Stainless steel band clamps (3)
  - 5/16-inch drill bit
  - ½-inch drill bit
  - 2-inch hole-saw drill bit
  - Flathead screwdriver to adjust band clamp
  - T-Post driver/3 pound sledge hammer
  - Drill
  - Handsaw
  - Recommended for construction of housing extension (for use in deep pools)
    - In addition to PVC above, PVC pipe 5’ section (4” diameter, schedule 40) (1)
    - PVC straight connectors 4” diameter (1)
- Initial installation/external power source construction
  - Adapter (Hach Company Cat. No. 011530HY) (1)
  - External Power Adapter Cable (Hach Company Cat. No. 013170HY) (1)
  - Detachable calibration cable (15 m preferred) (Hach Company Cat. No. 015XXX) (1)
  - PVC pipe 8’ section (¾” diameter)
  - PVC pipe (2” diameter) length depends on distance between battery box and multiprobe housing.
  - PVC electrical conduit 8’ (2” diameter, schedule 80) (1)
  - PCV connectors ¾-inch
    - 90° corners (4)
    - Ts (3)

        - 45° (1)
    - PVC cleaner and glue
    - Battery box (8 gallon, ActionPacker® Cargo Box / Bin Rubbermaid) (1)
    - Deep cycle battery (1)
    - Solar 12V battery trickle charger such as http://www.northerntool.com/shop/tools/product_200578631_200578631 (accessed 02/02/2016)
    - Alligator clips (2)- one black (-) one red (+)
    - Camouflage green paint (1 spray can)
    - ¼ -inch wing nuts (4)
    - 2 ½-inch long ¼ -inch machine screws, Philips head (2)
    - ¼ -inch flat washers (4)
    - T-post (1)
    - T-post driver (1)
    - 2 padlocks-same key (for battery box)
    - Copper scrub pads
- Maintenance / Data retrieval
    - Chimney Sweep or Toilet Brush (1)
    - Dish soap
    - New AA batteries (8)
    - Cotton swabs
    - Lint free towels
    - Deionized water
    - Wash bottle
    - Laptop computer or PDA
    - Ruggedized tablet loaded with the water quality station and instrumentation Access database
    - Detachable calibration cable
    - MS5 calibration cup
- Calibration (See the Water Quality Monitoring Site Revisit SOP #5).

Multiprobe Housing Construction and Preparation

The methods for housing construction outlined below are based on construction techniques used by the Southeast Coast Inventory and Monitoring Network (DiDonato, et al. 2006), and information provided in the Hydrolab MS5 User Manual (HACH Environmental 2006).

The housing containing the Hydrolab MS5 water quality multiprobe is made from 4-inch diameter schedule 40 PVC pipe, which will be attached to metal posts within the stream channel or on the bank. Typically multiprobes are attached to bridges or other permanent structures to help prevent theft, washouts or damage from drifting debris. However, very few of these structures exist in UCBN parks and water quality information taken near permanent structures may not be representative of overall stream conditions. As a result, multiprobe housings will be attached to metal posts in a location found to be representative of water chemistry within the reach. The multiprobe, will be suspended such that the sensors are ≈ 30.5 cm (1 ft) from the bottom of the housing to prevent contact with sediment. At most locations the multiprobe cannot be higher in the water column, because aerial exposure may occur during low flow conditions. Each multiprobe housing is capped with a PVC flanged end-cap and locked with a cable padlock. The entire housing is also affixed to a permanent or semi-permanent location on the bank using a cable and lock.

PVC pipe can be purchased from most hardware stores in 3.05 m (10 ft) sections and will need to be cut into 1.52 m (5 ft) sections. Generally a handsaw works best to cut PVC pipe. Drill one ½" hole through the entire pipe 30.5 cm (1 ft) from one end. A 5-inch stainless steel carriage bolt will be inserted through this hole to serve as the rest for the multiprobe so it will remain 30.5 cm (1 ft) from the sediment. Next, with a 2-inch hole-saw drill bit, drill a series of 2 inch diameter holes around the pipe and extending 46 cm (1.5 ft) above the carriage bolt (Figure 1). These holes will allow water to mix easily and pass through the pipe. Several other ½-inch holes should be drilled throughout the rest of the pipe to ensure the mixing of water. Place the end cap on and drill a ½-inch hole through the end cap and the pipe, across the diameter of the pipe, so that the end cap can be locked with a cable padlock. If using an external power source, a notch should be cut in the pipe and flanged end cap to allow the calibration/power cable to enter the housing (Figure 2).

The Southeast Coast Network operating procedure suggests the use of a flanged end-cap because it is easy to remove and provides a good location for an eye bolt from which to hang the multiprobe (note that the eye bolt is only used with a multiprobe operated by internal AA batteries). Drill a 5/16-inch hole in the cap, just off center, to prevent interference with the locking mechanism. Then, insert a ¼-inch stainless steel eye bolt and washer from the bottom of the cap (Figures 3 and 4). It is advisable to damage the threads to prevent the nut from being removed and subsequent multiprobe loss. An eye bolt should also be inserted into the multiprobes mooring fixture (Figure 5). This eyebolt will allow the multiprobe to be suspended from a cable attached to the cap (internal power option). The cable should be made from braided nylon line, which has had the ends melted to prevent fraying. The line should be tied to a long bolt stainless steel snap hook, with a clinch knot. This end will be attached to the multiprobe and will allow for easy removal during calibration. It is advisable to paint the housing a non-descript color to prevent vandalism (Figures 1-6). In addition, a white line should be painted on the housing that indicates when the sensors are in danger of drying out.

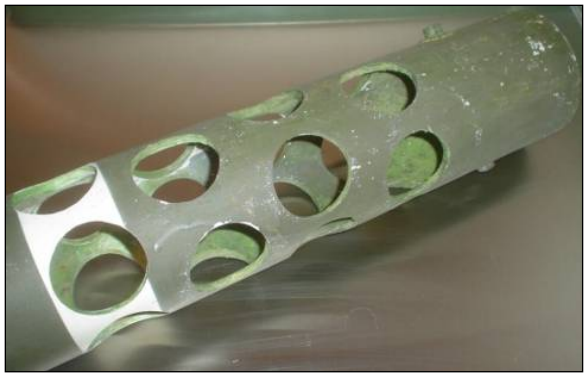


Figure 1. Photo of the series of holes drilled in the multiprobe housing to allow water to mix easily.



Figure 2. Flanged end cap and housing with notch to accommodate external power source cable.



Figure 3. Flanged end cap top view. (DiDonato, et al. 2006)



Figure 4. Flanged end cap bottom view. (DiDonato, et al. 2006)

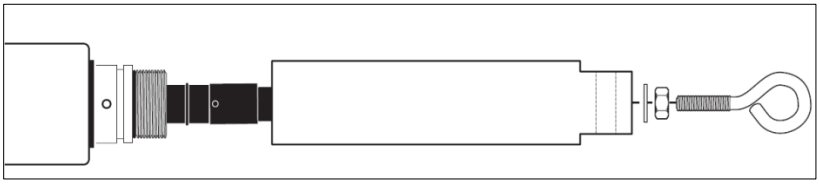


Figure 5. Mooring fixture with eye bolt (HACH 2006).



Figure 6. Housing extension for deep water/high flow configuration.

Recommended Multiprobe Housing Options

External power source

In addition to the standard multiprobe housing setup above, the UCBN recommends the use of an external power source for multiprobes that are to be deployed longer than 20 days. Deployment intervals over 20 days usually result in the depletion of internal battery power (8-AA) and reduction of data quality and utility. One external power source that has been reliably used since 2010 is a deep cycle battery maintained by a solar trickle charger (Figures 6 and 7). Initial costs of setup are quickly recovered by avoiding the purchase of AA batteries and additional site visits/travel time. Note that if vandalism is a concern this design may need to be modified.



Figure 7. External power source/multiprobe configuration.

Solar trickle charger frame

A PVC frame should be constructed to fit the solar trickle charger. The exact design may differ slightly due to varying types of solar trickle chargers; however, it is important that the frame provides adequate support even during high winds. After dry fitting, all PVC connections should be cleaned and glued. Following construction of the frame and attachment of the trickle charger, 2- ¼-inch holes should be drilled in the stem of the frame so that it can be attached to the vertical support using 2 ½-inch long ¼ -inch machine screws and wing nuts (Figure 8).



Figure 8. Solar trickle charger and PVC frame attached to vertical support. Note placement of PVC connectors and bolts.

Vertical support

The vertical support is constructed of PVC electrical conduit (2” diameter, schedule 80). A 1 inch hole should be drilled near the base of the vertical support such that wiring from the solar panel can be fed down the top end of the conduit and exit the hole near the battery box (Figures 7 and 8). This electrical conduit is placed over a T-post driven into the ground (Figure 7).

Electrical connections

A small hole (2.5 cm X 1.9 cm) should be cut in the battery box (Figure 7), just below the handles. The position and diameter of the hole are important in order to limit the entry of rain water, rodents and insects.

During pre-season preparations, all electrical connections should be made in order to assure that there are no connectivity issues during the initial site visit. The trickle charger cable should pass from the vertical support, through the hole in the battery box and be connected to the posts on the deep cycle battery. The battery adapter cable (Figure 9) should be modified such that it can be connected to the battery using alligator clips. As shown in Figure 9, the battery adapter cable should be connected to the external power adapter cable, which should subsequently be connected to the detachable calibration cable.

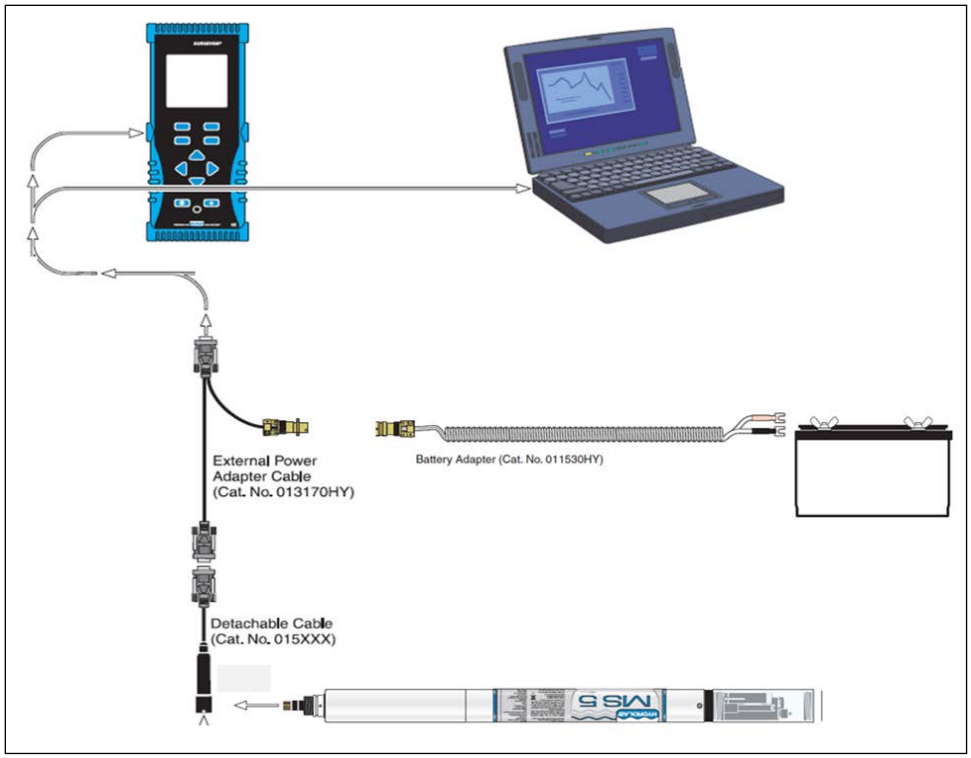


Figure 9. Cables required to connect a Hach brand Hydrolab MS-5 to an external power source. Modified from Hach Environmental 2006.

Multiprobe Housing Extension

If the multiprobe is to be deployed in a deep pool, or where access may be limited due to high flow, it may be necessary to extend the length of the housing from 1.5 m (5 foot) to 3.1 m (10 feet) (Figures 6 and 7). This extension can be made by using a 1.52 m (5 ft) section of 4-inch schedule 40 PVC, a straight coupling and PVC glue. The coupling should be glued to the new section of PVC such that it can be joined with the 5foot long housing as constructed above. In addition, new holes should be drilled in the PVC pipe so that the flanged end cap can be locked and a notch should be cut to accommodate an external power source. DO NOT glue the PVC coupling to both the extension and the housing. The extension will only be dry fitted to the existing housing. This arrangement makes transport to the site easier and allows the housing to be used as a 5 or 10 foot segment depending upon site requirements.

Datasheet and Database Preparations

Calibration and Maintenance Logbook

In version 1.0 of this protocol, maintenance and calibration events were tracked in a logbook. All aspects of the logbook have been incorporated into the water quality monitoring station and instrumentation Access database (Figure 10). As a result, the paper logbook is no longer a critical component of water quality data management; however, duirng site visits it is advissable to carry a logbook that can serve as a backup to the digital database. The logbook (1-inch or larger, 3-ring notebook) should include all paper forms and tables necessary to complete a field visit. Contents should include:

- General workflow for a water quality site revisit
- List of standard solutions and calibration criteria for each parameter
- UCBN Calibration and Maintenance Log Sheets
- UCBN Cross Section Survey datasheets
- Multiprobe and Sensors User Manuals
- Dissolved Oxygen Solubility Table
- MSDS – for calibration standard solutions

Water Quality Monitoring Station and Instrumentation Database

Prior to water quality site visits, the water quality monitoring station and instrumentation database (Figure 10) should be loaded onto a ruggedized tablet capable of running Microsoft Access (such as the Trimble Yuma). After loading the database onto the tablet, it should be tested for functionality prior to leaving the UCBN office.

During site visits the database will be used to enter data associated with:
1) Calibration and maintenance events
2) Cross section surveys

Post data entry the database will be used to:
1) Evaluate data quality via the site inspection summary form
2) Evaluate data quality indicators (QA/QC)

Multiprobe Pre-deployment Calibration/Error Check

Prior to the field season each spring, the multiprobe should be prepared for deployment. These pre-deployment activities involve general maintenance, calibration and error checks that will help ensure quality data collection. General pre-deployment activities are outlined below and are more fully outlined in SOP #5 Multiprobe Site Revisit. The procedures for pre-deployment calibration are the same as the calibration procedures in the field but instead are conducted in the lab/office. Note that all calibrations and error checks should be recorded in the Calibration and Maintenance form, and the Data Quality Indicators QA/QC form in the water quality monitoring station and instrumentation Access database (Figure 10). Paper Calibration and Maintenance forms can be found in Appendix F.

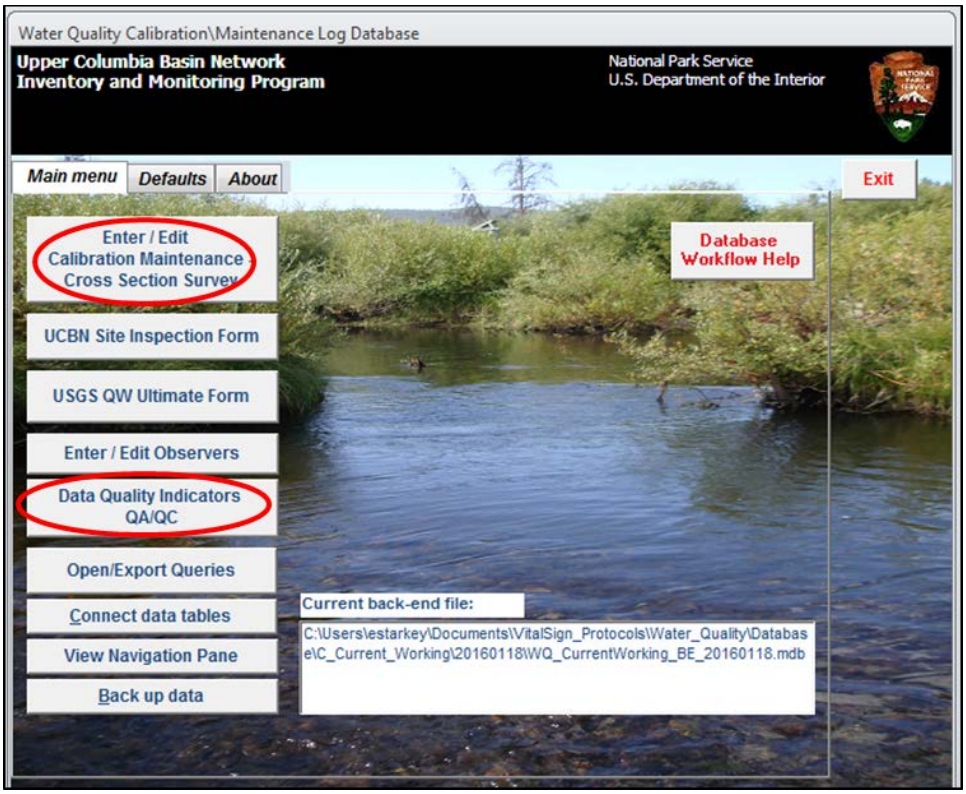


Figure 10. Location of Calibration and Maintenance and Data Quality Indicators QA/QC forms in the water quality monitoring station and instrumentation Access database.

1. Clean the sensors and multiprobe with soapy water as outlined in the "Cleaning" section of SOP #5.
2. Conduct other maintenance as outlined in the "Other Maintenance" section of SOP #5
   a. Install new batteries
   b. Lubricate all O-rings
3. Calibrate each sensor as outlined in the "Calibration" section of SOP #5 - Calibration failure likely indicates a faulty sensor. If the problem persists contact Hach Technical Assistance (1-800-949-3766). Record calibration in the water quality monitoring station and instrumentation Access database **Calibration/Maintenance form** (Figure 10)**.** Make sure to check the pre-deployment box (Figure 11).
   a. Specific Conductance
   b. Dissolved Oxygen
   c. pH
   d. Turbidity

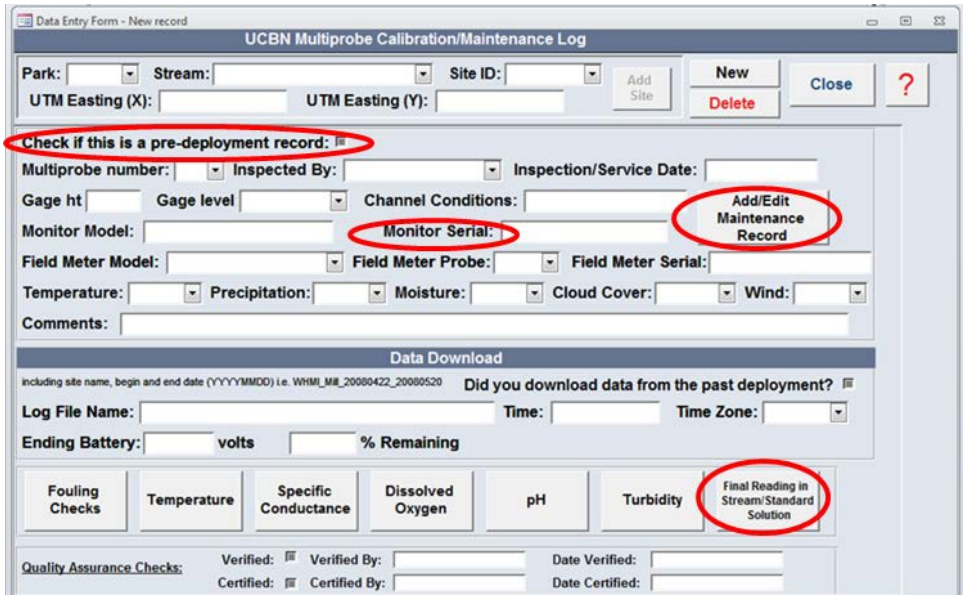


Figure 11. Calibration and Maintenance form in the water quality monitoring station and instrumentation Access database.

4. Pre-deployment error check - this error check should be performed in the same manner as the "Final Readings in Stream/Standard Solution" in the Water Quality Site Revisit SOP #5. Make sure that all standard solution readings fall within the calibration criteria given in Table 2 of SOP #5. If standard solutions measurements do not fall within the accepted criteria the faulty sensor should be re-calibrated and checked again. If the sensor fails a second time call Hach Technical Assistance.
5. Each multiprobe (monitor) and each sensor on that monitor have a unique serial number. All serial numbers should be entered/double checked in the **Calibration/Maintenance form-Add/Edit Maintenance Record** (Figure 11)**.**
6. Note that dissolved oxygen will need to be re-calibrated at the deployment location due to differences in barometric pressure caused by change in altitude.
7. Determine Pre-deployment **Data Quality Indicators (QA/QC)** (Figure 10).
    a. Fill a sink or 5 gallon bucket with water. Let the water sit for several hours so that it equilibrates to the ambient temperature.
    b. Place a calibrated multiprobe with sensor guard in the water.
    c. Every minute for seven minutes record Temperature, pH, Specific Conductance, Dissolved Oxygen and Turbidity values on the **Pre-Deployment Values from Tap Water QAQC form** (Figure 12) in the water quality monitoring station and instrumentation Access database.
    d. After all fields are populated, the form will auto calculate:
        i. Method Detection Limit (MDL) – Turbidity
        ii. Minimum Level of quantitation (ML) – Turbidity
        iii. Alternative Measurement Sensitivity (AMS)- Temperature, pH, Specific Conductance, Dissolved Oxygen and Turbidity
        iv. See QA/QC SOP #10 for more details.

8. Note that after the Cross Section Surveys have been completed during the first site visit (SOP #3) some of those values will be pulled into the **Beginning of Season and End of Season QA/QC** form (Figure 12). Those values will be used to calculate AMS+ and Precision+ (relative percent difference). **No pre-deployment action is necessary in the Beginning of Season and End of Season QA/QC form.**

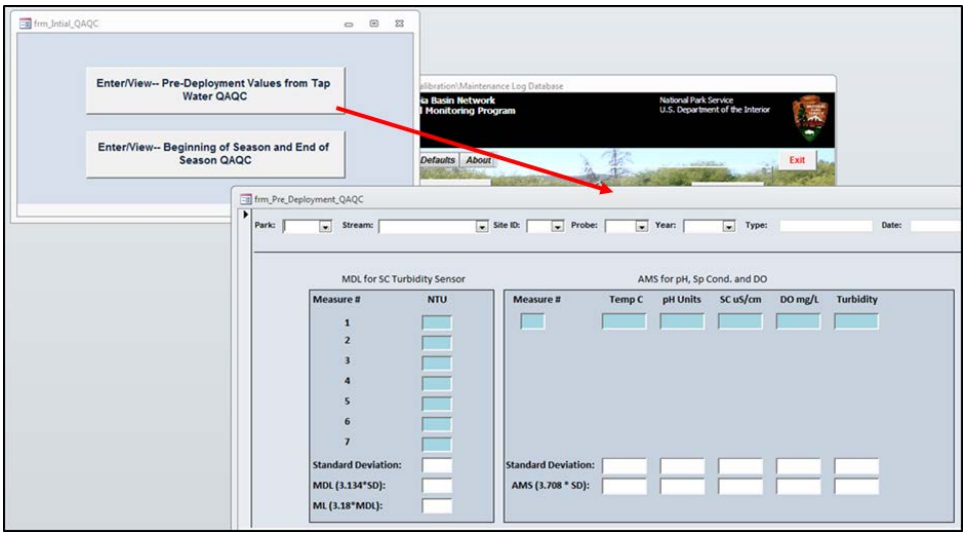


Figure 12. Pre-Deployment QA/QC form in the water quality monitoring station and instrumentation Access database.

Safety Preparations

Safety is an important, but easily overlooked consideration. The safety SOP (#11) should be reviewed before any field activity occurs. All information in the field safety notebook should be updated and reviewed. This includes appropriate Job Hazard Analysis, contact phone numbers, Chemical Material Safety Data Sheet (MSDS), and the Medical Information for Office Personnel form. Make sure all persons in the field know where vehicle keys are to be stored during field operations, the location of the nearest pay phone and/or cellular phone coverage opportunity, and emergency contact and operation procedures for NPS staff.

In addition, prior to the start of each field season, certain safety documents must be reviewed, signed, and returned to the park contact and the network coordinator. These documents include: an official travel checklist, fieldwork itinerary forms that outline when and where field operations will take place, readiness review documents that detail necessary safety topics that have been prepared for the field season, and job hazard analyses (JHAs) that highlight some of the individual risks associated with fieldwork and ways to mitigate those risks. A CRMO specific backcountry travel SOP is required for anyone performing fieldwork in CRMO. These documents are included in the appendices

Literature Cited

DiDonato, E.M., C. Wright, and B. Huston. 2006. Core Parameter Fixed-Station Water Quality Monitoring (Draft). Natural Resource Report NPS/SER/SECN/NRR—2007/xxx. National Park Service, Southeast Coast Network, Atlanta, Georgia.

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Starkey, E. N., T. J. Rodhouse, G. H. Dicus, K. M. Irvine, and E. K. Archer. 2016 (in preparation) Upper Columbia Basin Network stream channel characteristics monitoring protocol: Narrative version 1.2. Natural Resource Report NPS/UCBN/NRR—2016/XXX. National Park Service, Fort Collins, CO.

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

White, E.T.1999, Automated water quality monitoring field manual: British Columbia, Canada, Ministry of the Environment Lands and Parks, Water Management Branch for the Aquatic Inventory Task Force Resources Inventory Committee, version 1.0 [June 8, 1999], 73 p.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 2: Training Field Personnel

Version 1.9 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2013	UCBN-Aquatic Biologist	Addition of safety section	Updates to SOP 13 and changes in procedures necessitated updates.	1.1
1.1	February 2016	UCBN-Aquatic Biologist	Removed macroinvertebrate section to reflect collaboration with USFS-PIBO program and inclusion in the UCBN stream channel protocol.. Finding GPS waypoint training is now covered here instead of a separate SOP. Added a section for record computation.	Updates reflect changes to procedures and protocol narrative.	1.9

Note: This SOP describes the step-by-step procedures for organizing and training field personnel. Note that none of these SOPs are meant to be stand-alone training manuals replacing the thorough documentation available for GPS, PDA and multiprobe hardware and software. Training personnel should refer to these SOPs as a guide, and seek out additional information in the suggested references and through hands-on training courses provided by NPS and outside vendors.

Suggested Reading

Garmin. 2011. GPSmap 62 series owner's manuel. Garmin International, Olathe, KS. Available online at http://static.garmin.com/pumac/GPSMAP62_OM_EN.pdf

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Procedures

Safety

All field crews and park staff should have completed first aid/CPR training (Red Cross or similar) and NPS Operational Leadership prior to any field work. Staff that will assist with monitoring will be briefed on safety procedures and hazards prior to field work. Briefings will occur in the office and during tailgate safety talks each site visit. Required reading is the job hazard analysis and other potential hazards listed on the field description form in Appendix E, and the Safety SOP #11.

The primary safety training message is the following:

Safety is the number one priority! Data collection is secondary to all safety concerns.

Finding GPS Waypoints

When water quality monitoring stations are established, GPS waypoints are recorded. Returning to a monitoring station in subsequent monitoring years may require GPS navigation back to an existing waypoint. The user manual for the GPS to be used in the field should be consulted for details about upload of waypoints to the unit and for navigation methods. The UCBN water quality program currently uses the GPSmap 62st. The user manual can be found online at: http://static.garmin.com/pumac/GPSMAP62_OM_EN.pdf (Accessed 9 February 2016). Field crews should practice waypoint upload and navigation before fieldwork begins.

Water Quality Station Operation

Required reading for the UCBN water quality monitoring project leader prior to the field season is Wagner et al. 2006. This publication provides the guidance and techniques necessary for continuous monitoring station establishment, operation and record computation. In addition, it is advisable that the project lead attend an in person USGS training course based on the Wagner et al. 2006 publication. This course offering may be found via DOI Learn.

Initial installation and multiprobe calibration will be conducted by the UCBN Integrated Water Quality Monitoring project leader and temporary field staff. Subsequent data retrieval and multiprobe calibration/maintenance will be performed by the UCBN Integrated Water Quality Project Leader, NPS resource managers, and/or other temporary field staff. As a result it's necessary to annually train resource managers and other field personnel in proper calibration and maintenance methods. In general the most effective technique for multiprobe calibration training is a hands-on demonstration. This demonstration will follow the procedures outlined in the Hach Hydrolab MS5 user manual and the Water Quality Site Revisit SOP #5. A copy of this manual and SOPs will be kept with calibration supplies and can serve as a quick reference if difficulties are encountered during multiprobe operation. During training, field personnel will perform calibration techniques with the water quality project leader to address any issues or questions. Training will occur each spring prior to multiprobe deployment. Each year, field personnel that are responsible for calibration and data retrieval will be updated on procedures. Training is a critical aspect of the UCBN's water quality monitoring program because a well trained staff helps ensure the collection of quality data, and is part of QA/QC.

Topics to be covered by training include:

- Multiprobe housing maintenance
- Data retrieval
- Multiprobe calibration of five core parameters: dissolved oxygen, pH, turbidity, conductivity, and temperature
- Use of the UCBN water quality monitoring station and instrumentation Access database
- Use of Hydras 3 LT software

Continuous Water Quality Record Computation

Once continuous water quality data has been collected it must be processed (corrections applied, outliers removed, grades applied, etc.). Data processing tasks will generally be completed by the UCBN water quality monitoring project lead. As indicated in the section above, Wagner et al. 2006 should be reviewed prior to working with continuous water quality data. Due to the UCBNs reliance on Aquarius Time-Series Software to process continuous data, the project lead should also read the Aquarius Time-Series software user manual and view online training videos found by logging into the Aquarius support portal at http://aquaticinformatics.com/support/. A username and password may be requested on the same page.

Site Photographs

Site photographs will be taken during each monthly site visit. As a result, all field going personnel should be familiar with the operation of a digital camera and should review the user manual for the UCBN digital camera a necessary.

Literature Cited

Garmin. 2011. GPSmap 62 series owner's manuel. Garmin International, Olathe, KS. Available online at http://static.garmin.com/pumac/GPSMAP62_OM_EN.pdf

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 3: Continuous Water Quality Site Selection and Cross Section Survey

Version 1.5 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2016	UCBN-Aquatic Biologist	Minor edits and additions to reflect the use of an Access database to manage cross-section survey data. Inclusion of example R code.	Updates reflect changes to workflow due to database design.	1.5

Note: This SOP describes the step-by-step procedures for determining if the water quality monitoring location is representative of the stream segment within the UCBN Park.

Suggested Reading

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Overview

Continuous water quality monitoring site selection is an important aspect of the monitoring protocol in that it determines if water chemistry data is representative of the entire stream segment within each UCBN Park. Without proper placement of the multiprobe the data collected has limited value for assessment of status and trend of water quality within UCBN Parks.

Multiprobe site selection is determined using the criteria established by Wagner et al. (2006) and White (1999). Overall, the UCBN seeks to balance the need for a representative location within each stream, with factors such as stream stages, channel morphology, water velocity, potential for debris damage, and logistics (Table 1).

Table 1. Factors for consideration in the placement and installation of continuous water quality monitoring stations (Wagner et al. 2006).

Category	Factors
Site characteristics	Potential for water quality measurements at the site to be representative of the location being monitored.
	Degree of cross-section variation and vertical stratification.
	A channel configuration that may pose unique constraints.
	Range of stream stage (from low flow to flood) that can be expected.
	Water velocity.
	Presence of turbulence that will affect water quality measurements.
	Conditions that may enhance the rate of fouling, such as excessive fine sediments, algae, or invertebrates.
	Range of values for water quality field parameters.
	Need for protection from high-water debris damage.
	Need for protection from vandalism.
Monitor installation	Type of state or local permits required before installation can begin.
	Safety hazards relevant to monitor construction and installation.
	Optimal type and design of installation.
	Consideration of unique difficulties or costs of installation.
Logistics (maintenance requirements)	Accessibility of site, including parking or boat access.
	Safe and adequate space in which to perform maintenance.
	Presence of conditions that increase the frequency of servicing intervals needed to meet data-quality objectives.
	For stream sites, proximity to an adequate location for making cross-section measurements.
	Accessibility and safety of the site during extreme events (for example, floods or high winds).
	Availability of electrical power or telephone service.
	Need for real-time reporting.

Within the area immediately up and downstream of the proposed multiprobe site, the factors in Table 1 will be assessed to determine the sites suitability for water quality monitoring. Assessment of

cross-section and stream segment variation will be determined using a survey of water quality parameters. This survey will consist of measurements taken at the proposed multiprobe site, across a transect at the proposed multiprobe site, and at three subsequent transects up or downstream (Figure 13). The direction (up or downstream) that transects will be laid out is determined by site characteristics.

The distance between the proposed multiprobe site and the most upstream transect will be 40 times the mean wetted width. Therefore, the distance between transects is the total reach length divided by 3. Each transect will be subdivided into 10 equal-width increments. The core water chemistry parameters will be recorded once a minute for 10 minutes at the proposed multiprobe site and once at each equal-width increment along transects during the cross section survey.

Note that the UCBN is using a modified Equal-Width Increment Method. The parameter values and associated variability among transects will be compared to the proposed multiprobe site with an ANOVA or a Kruskal-Wallis test. If the proposed multiprobe site is not significantly different from the other transects it will be assumed that the multiprobe site is reasonably representative of the stream segment within the park.

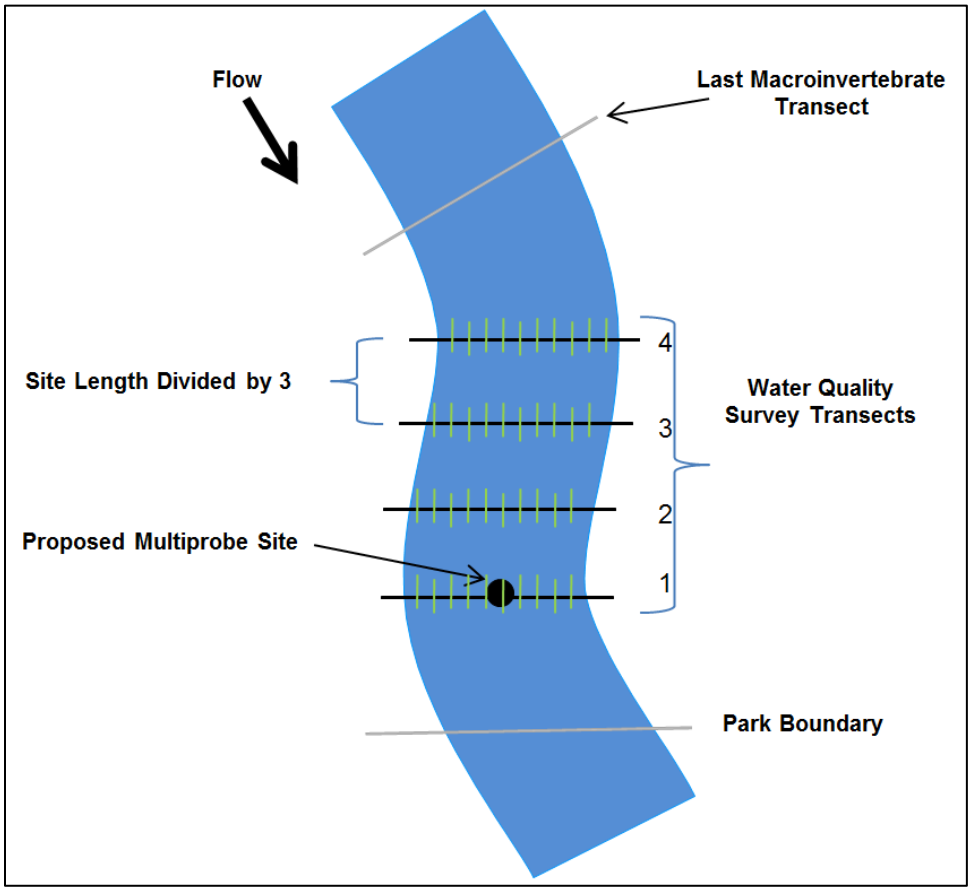


Figure 13. Multiprobe site selection survey transects. Measurements will be recorded using a modified Equal-Width Increments Method and data will be recorded at 10 locations across each transect. (Wagner et al. 2006).

Procedures

Site Selection

Initially, a location for deployment of the water quality multiprobe should be determined by visual assessment of the factors listed in Table 1. These factors include the need for a representative location within each stream, stream stages, channel morphology, water velocity, potential for debris damage, and logistics. In general, a location that would be ideal for measuring stream discharge is an ideal location for the placement of a multiprobe. Overall, an appropriate site will have easy access, smooth flowing water, water deep enough for multiprobe sensor submersion, and stable substrate. In most streams selected for monitoring, pools deep enough for deployment of the multiprobe are limited. When a site has been selected it will be checked for representativeness with a Cross-Section Survey.

Cross-Section Survey

Cross-Section Surveys will help the UCBN determine if the conditions at the multiprobe site are representative of conditions throughout a park's stream segment. The UCBN will use a modified Equal-Width Increments survey design. The USGS uses the Equal-Width Increments design but calculates an area-weighted value for each parameter at each measurement location (Wagner et al. 2006, Wilde and Radtke 2005). For simplicity and comparison with one fixed site (the proposed multiprobe site) the UCBN will not be calculating area-weighted values.

Data for the cross section survey method outline below should be recorded on a paper UCBN Cross-Section Survey Form (Appendix F) and later entered into the UCBN water quality monitoring station and instrumentation database.

Modified Equal-Width Increment Design

1. **Wetted Width:** Initially the average wetted width should be determined (use a reel tape or range finder). The average wetted width times 40 will determine the length of the Cross-Section Survey (site). The distance between transects will be the site length divided by 3. Record these values on the UCBN Cross-Section Survey Form (Appendix 5). Use pin flags to temporarily mark the position of each transect.
2. **Proposed Multiprobe Site**: Next, the multiprobe should be deployed at the proposed site for 10 minutes. During this time period the multiprobe should be connected to the Archer unit and Hydras 3 Pocket PC. Values for each parameter should be recorded each minute on the UCBN Cross-Section Survey Form.
3. **Transect 1:** Transect 1 is located perpendicular to the flow at the proposed multiprobe site (Figure 13).
    a. Stretch the reel tape from the left bank to the right bank and stake it using rebar.
    b. The wetted width should be determined and divided into 10 equal-width increments (record these on the datasheet).
    c. Starting from the left bank (facing downstream)go to the first of 10 equal increments and measure the total depth. Divide the total depth in half to determine where the water

chemistry measurement should be taken. Record both of these values under the “Total Depth” and “Depth of Measurement (50% of total)” columns.

d. The multiprobe should be lowered to 50% of the total depth and held in the water for one minute to equilibrate. At the end of one minute a reading should be recorded for each parameter (see the Cross-Section Survey Form in Appendix F).

e. Repeat c and d for the remaining 9 increments along transect 1.

4. **Transects 2-4**: Move to the next transect and stretch the reel tape from the left bank to the right bank. Record core parameter values at each of the 10 increments in the same way as transect 1 (step 3).

5. Evaluation of the Cross-Section Survey:

   a. All data collected on the paper UCBN Cross-Section Survey Form should be entered into the UCBN water quality monitoring station and instrumentation database (Figure 14).

   b. After data has been entered into the database, it can be exported for analysis using the Open/Export Queries button accessed from the main menu (Figure 15).

   c. Data should be statistically analyzed to determine if the multiprobe site is representative of conditions upstream (± 10%). An ANOVA or a Kruskal-Wallace Test are likely the best methods for this analysis. Specific Conductance (µS/cm) should be the primary parameter used to evaluate cross-section surveys since it is less variable than other core parameters and should accurately reflect stream mixing. Secondary parameters such as pH and dissolved oxygen are important, but due to their inherent variability will not be the primary means of evaluating the Cross-Section Survey. Example R code for analysis and visualization of specific conductance data is shown below. This example can be copied and saved directly into the R script text editor, modified as necessary, and executed by highlighting desired sections of code, and keying “ctrl-shift” and then “r” on the computer keyboard.

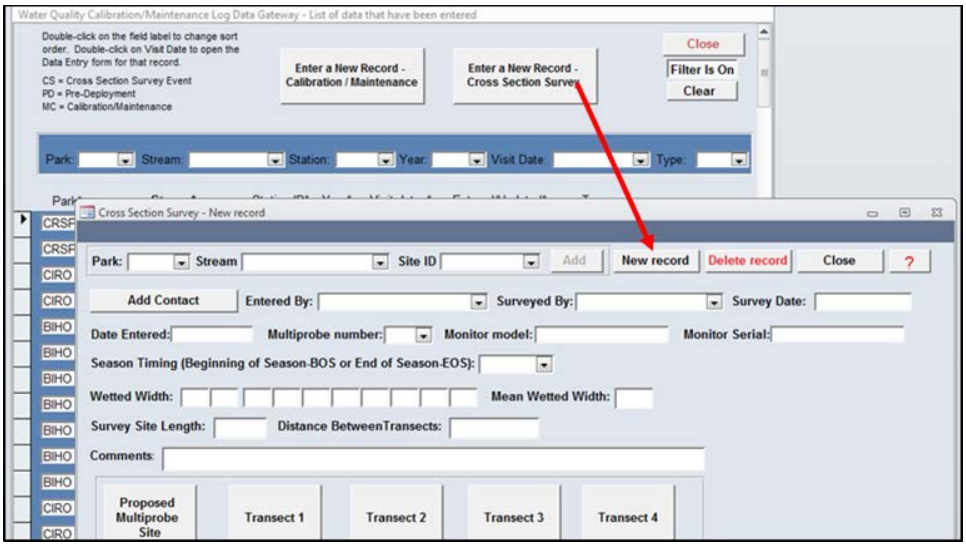


Figure 14. Cross section summary data entry form in the water quality station and instrumentation database.

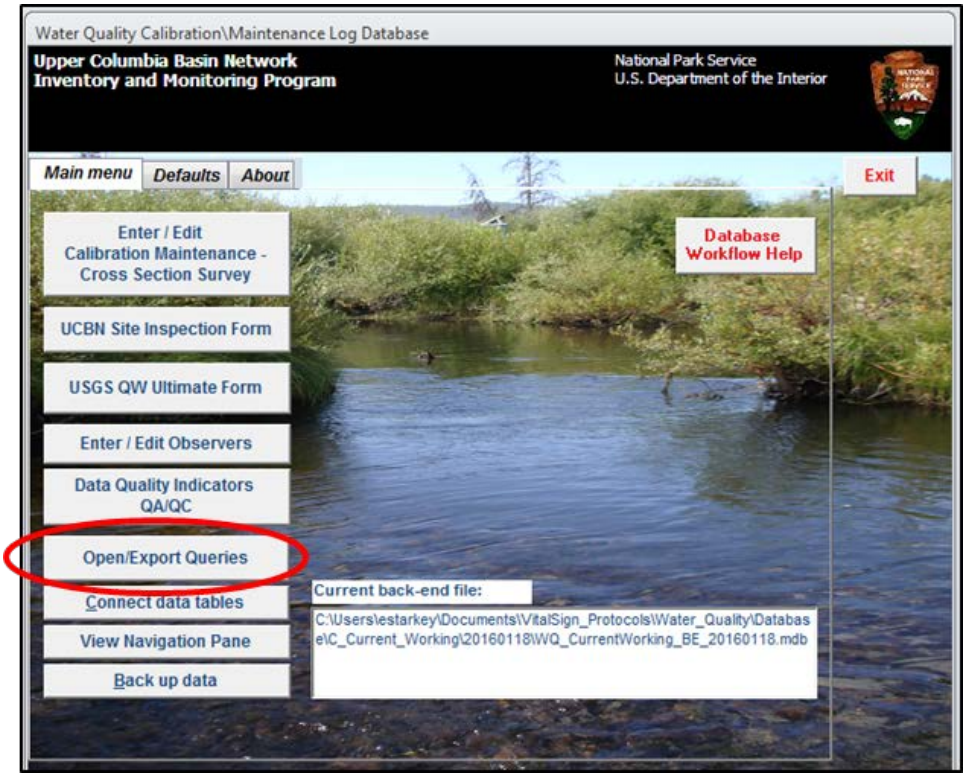


Figure 15. Open/Export Queries button in the UCBN water quality monitoring station and instrumentation database.

If the proposed multiprobe site is found to be representative, the multiprobe housing can be installed. If the proposed site is found to be un-representative, the results of the survey may help indicate a more appropriate location for the multiprobe. Once a new proposed site is found a new Cross-Section Survey should be conducted. It is important to note that data from the monitoring site will not be

corrected based on data gathered during the Cross-Section Survey. The variability of streams in time and space precludes such corrections and is not suggested by the USGS.

The USGS advocates at least two Cross-Section Surveys per year. Given that most UCBN streams are small and relatively stable, it is likely that two surveys per year will be adequate (June and November). However, if changes in stream morphology are noted that could change the representativeness of the multiprobe site, a new Cross-Section Survey should be conducted.

Example R Code for Analysis of Cross Section Survey Data

```
**************************************************************
# Purpose: Analysis of Variance and Box Plot for Specific
Conductance data collected  # during cross section survey at BIHO
2015.
# Contact: Eric Starkey, UCBN Aquatic Biologist,
Eric_Starkey@nps.gov
# Date: July 16, 2015

## Read in data##
CrossSection = read.csv(file.choose(),header=T)
##Check data####
head(CrossSection); dim(CrossSection)

## Run ANOVA ##
library(multcomp, pos=4)
library(abind, pos=4)
AnovaModel.1 <- aov(SP_Cond ~ Location, data=CrossSection)
summary(AnovaModel.1)
#numSummary(CrossSection$SP_Cond , groups=CrossSection$Location, ###numSummary is a
function in Rcmdr#
           #statistics=c("mean", "sd"))
.Pairs <- glht(AnovaModel.1, linfct = mcp(Location = "Tukey"))
summary(.Pairs) # pairwise tests
confint(.Pairs) # confidence intervals
cld(.Pairs) # compact letter display
old.oma <- par(oma=c(0,7,0,0))
plot(confint(.Pairs))##95% family wise confidence level plot##
par(old.oma)
remove(.Pairs)

##Boxplot##
par(oma=c(0,1,0,0))
boxplot(SP_Cond~Location, main="BIHO North Fork Big Hole River 07/16/2015
        Cross Section Survey Results: Specific Conductance", ylab="Sp.Cond. µS/cm",
xlab="Location", data=CrossSection)

###################################################################
### Export the 95% family-wise confidence level plot to a file###
#### AFTER RUNNING ABOVE CODE                                  ###
###################################################################
## Specify filepath on your computer here (note the double backwards slashes that are
unique to R
filepath =
"C:\\Users\\estarkey\\Documents\\VitalSign_Protocols\\Water_Quality\\Analysis\\Hydrola
b_Cross-section_Survey\\Z_Graph_Output\\BIHO_NFBigHole_XSection_fam_20150716.tif"
## Make a .tiff image
tiff(filepath,width=8, height=7, units="in", res=250)

.Pairs <- glht(AnovaModel.1, linfct = mcp(Location = "Tukey"))
summary(.Pairs) # pairwise tests
```

```
confint(.Pairs) # confidence intervals
cld(.Pairs) # compact letter display
old.oma <- par(oma=c(0,7,0,0))
plot(confint(.Pairs)) ##95% family wise confidence level plot##
par(old.oma)
remove(.Pairs)

dev.off()

#######################################################
#### Export the boxplot image to a specified file###
#######################################################

## Specify filepath on your computer here (note the double
backwards slashes that are unique to R
filepath =
"C:\\Users\\estarkey\\Documents\\VitalSign_Protocols\\Water_Quality
\\Analysis\\Hydrolab_Cross-
section_Survey\\Z_Graph_Output\\BIHO_NFBigHole_XSection_BPlot_20150
716.tif"
## Make a .tiff image
tiff(filepath,width=8, height=7, units="in", res=250)

par(oma=c(0,1,0,0))
boxplot(SP_Cond~Location, main="BIHO North Fork Big Hole River
07/16/2015
        Cross Section Survey Results: Specific Conductance",
ylab="Sp.Cond. µS/cm", xlab="Location", data=CrossSection)

dev.off()
*******************************************************
```

Literature Cited

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Wilde, F.D., and Radtke, D.B., 2005, General information and guidelines: U.S. Geological Survey Techniques of Water Resources Investigations, book 9, chap. A6, section 6.0, 36 p.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 4: Initial Water Quality Site Visit

Version 1.0 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	2/16/2016	UCBN	New SOP for initial water quality site visit.	In previous protocol versions, initial site visit information were spread among other SOPs and created confusion. Initial site information is now centralized in one SOP	1.0

Note: This SOP describes the step-by-step procedures for the initial water quality site visit (first visit of the field season).

Suggested Reading

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Overview

The initial water quality monitoring site visit will occur in mid-June. If the site has been monitored in the past, the timing of the first visit should be consistent with previous years. During this initial visit, the monitoring site will be selected (or returned to if already established), a cross section survey will be completed, monitoring equipment setup, and the water quality multiprobe will be deployed

General Workflow

1. Return to or establish new monitoring site
2. Recalibrate dissolved oxygen sensor
3. Conduct cross section survey to assess representativeness of monitoring site
4. Install multiprobe housing and external power source
5. Take site photos
6. Setup Log file
7. Deploy multiprobe

Materials Required for Initial Site Visit

- Multiprobe housing suitable for site (see SOP 1 for construction)
  - Deep water/high flow configuration **OR**
  - Shallow/low flow configuration
- External power source (see SOP 1 for construction)
- Zip ties and 6-8" hose/band clamps
- Calibration cable long enough to run between external power source and multiprobe (10-15 m)
- All keys and locks for housing and external power setup
- Multiprobe (one MS-5 Hydrolab) for each site
- Work gloves
- T-post driver and 3-pound sledge
- 5 T-posts for deep water/high flow configuration **OR** 6 (4 ft sections) rebar depending on site characteristics.
- Equipment for cross section survey
  - Reel tape
  - Range finder
  - Pin flags
  - Datasheet and UCBN water quality monitoring station and instrumentation database.
- For Log file setup/multiprobe deployment.
  - PDA with 9 pin port or laptop computer
  - Tablet PC capable of running MS Access database
  - UCBN Water Quality Monitoring Station and Instrumentation Access database
  - Hydras 3 or Hydras for PDA's
  - Detachable calibration cable
- Calibration standards (see SOP 5)

Procedures

Return To / Establish New Monitoring Site

As of the writing of this SOP in 2016, all primary water quality monitoring stations have been established. The maps presented in Appendix A and B and the GPS waypoints presented in Appendix C should facilitate return to monitoring sties/stations. If new monitoring sites need to be established due to changes in stream channel or park needs, follow procedures outline in SOP #3-Continuous Water Quality Site Selection and Cross Section Survey.

Recalibrate Dissolved Oxygen Sensor

The water quality multiprobe should have been calibrated in the office; however, due to changes in altitude between the office and the deployment location it is advisable to recalibrate the dissolved oxygen sensor once you have arrived at the monitoring site. See the site revisit and calibration maintenance SOP #5 for calibration directions.

Conduct Cross Section Survey

After calibration of the dissolved oxygen sensor you should evaluate the proposed monitoring site to see if it is relatively representative of conditions within the park's stream segment. This evaluation is done via the cross section survey outlined in SOP #3-Continuous Water Quality Site Selection and Cross Section Survey.

Install Multiprobe Housing and External Power Source

<u>Deep Water/High Flow Configuration</u>

(Recommended for most sites)

Once a representative location has been established (SOP 3), two T-posts should be driven into the bank near the water's edge so that they will support the PVC housing (Figures 13 and 14). The two sections of the 3.1 m (10ft) housing should be joined by dry fitting the housing with the extension. Use a mallet and board to tap the two segments together. Two additional T-Posts should be fastened to each side of the housing so that the ends of the posts extend approximately 47 cm (1.5 ft) from the end of the pipe. (Figures 13 and 14). Three band clamps should be used to fasten the T-posts to the housing.

The housing should then be positioned in between the T-posts driven into the bank. The housing should be hit with a mallet to drive the lower T-posts into the stream substrate. Once in position, the upper portion of the housing should be affixed to the T-posts on the bank using band clamps.

In areas that are expected to experience high flows, the T-Posts positioned in the stream may need to be driven directly into the substrate.

This design will allow the housing and multiprobe to be accessed from the bank, even in deep pools or high flows. An example of this design is shown in Figures 16 and 18). In addition, this configuration is ideal for a multiprobe powered by an external power source.

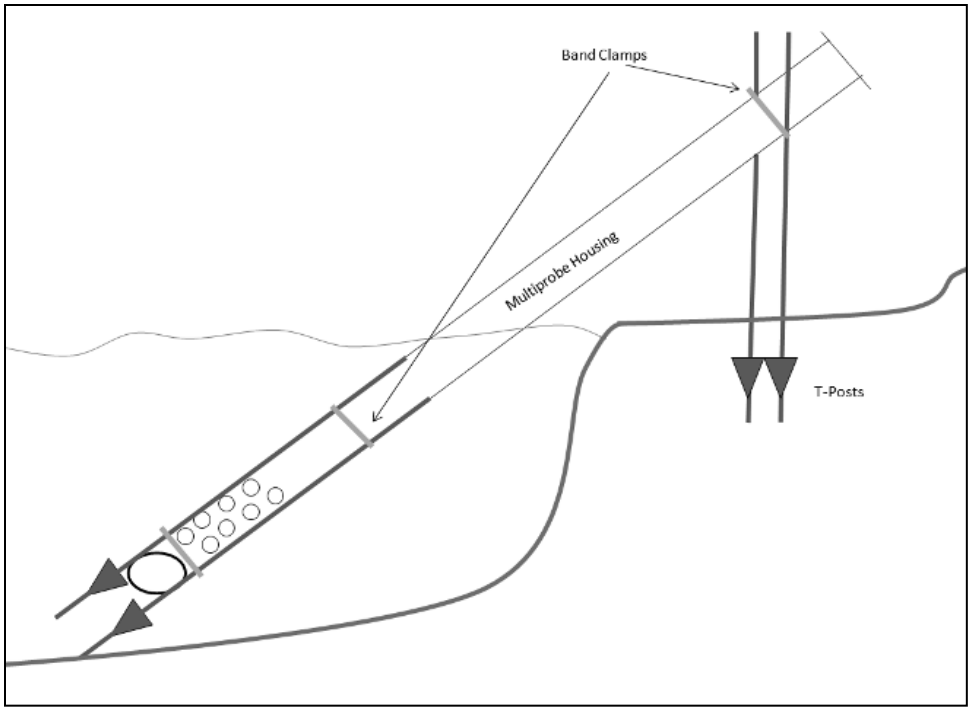


Figure 16. Deep water multiprobe housing configuration.



Figure 17. T-Posts being fastened to each side of the housing.



Figure 18. Multiprobe housing with extension deployed in a deep pool. Note the position of T-posts on the bank and attached to the housing.



Figure 19. Multiprobe housing with extension and external power source.

Shallow/Low Flow Configuration

(Optional)

Once a representative location has been established (SOP 3), three 1.5 m (5 ft) ½-inch rebar posts should be driven at least 30.5 cm (1 ft) into the substrate, so that when they are pulled together they form a tripod of three supports for the 1.5 m (5 ft) PVC housing (Figures 20-22). Three band clamps should be used to fasten the pipe to the rebar posts. This design should allow the housing to "break away" from the installation location during high flow events, yet remain attached to the bank via a security cable. In addition, this design is easily reconfigured to accommodate extreme low flow conditions (Figure 22). It is best to use rebar in gravel to coble substrates and 2 T-posts in soft silty or clay substrates (Figure 23). Note that this configuration is not recommended for a multiprobe powered by an external power source.



Figure 20. Rebar posts for multiprobe housing support.



Figure 21. Multiprobe housing attached to rebar posts. Note the security cable attached to the bank.

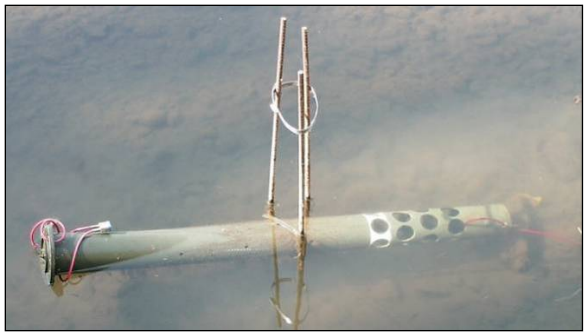


Figure 22. Alternative configuration of the multiprobe housing during extreme low flow conditions.



Figure 23. Multiprobe housing attached to T-posts. Soft substrate is not optimal for rebar supports.

External Power Source

As indicated in SOP #1 Preparations and Equipment Set-up Prior to the Field Season, an external power source is preferred over internal multiprobe batteries. The following is a guide to setting up the external power source and supplying power to the multiprobe. Figure 24 shows how the external power source should be sited relative to the housing.



Figure 24. External power source/multiprobe configuration.

1. Attach the Solar trickle charger/frame to the vertical support as shown in Figure 25. Tighten the wing nuts.

2. Feed the solar panel wiring down the vertical support and out the hole located ~ 1ft from the end.



Figure 25. Solar trickle charger and PVC frame attached to vertical support.

1. Decide where you will place the battery box and solar panel. Make sure the location is far enough from the water's edge that the battery will not be submerged during high flows; yet near enough that the calibration/power cable will reach between the battery box and the housing.
2. Drive a T-post into the ground. Leave ~ 3.5 feet exposed.
3. Place the vertical support over the T-Post.
4. Place the battery box next to the vertical support and pass the solar panel cable from the vertical support, through the hole in the battery box and connect it to the posts on the deep cycle battery (Figure 26).
5. Un-coil the multiprobe detachable calibration/power cable and run the 9-pin side through the same hole used in the step above.
6. Connect the battery adapter cable to the posts on the deep cycle battery (Figure 26).
7. Connect the 9-pin multiprobe detachable calibration/power cable to the battery adapter cable (Figure 27).
8. After these connections have been made, the calibration cable should be fed from the battery box down a PVC pipe (2" diameter) towards the multiprobe housing. This step will help avoid damage to the calibration cable by rodents as it runs between the battery box and multiprobe housing.
9. The ends of the PVC pipe should be blocked with copper scrub pads.
10. If there is exposed cable between the battery box and the PVC pipe it should be wrapped with copper mesh.
11. Connect the calibration cable to the multiprobe. If it beeps, it is receiving power.

12. Close and lock the lid to the battery box prior to deployment.



Figure 26. External power source batter box configuration.

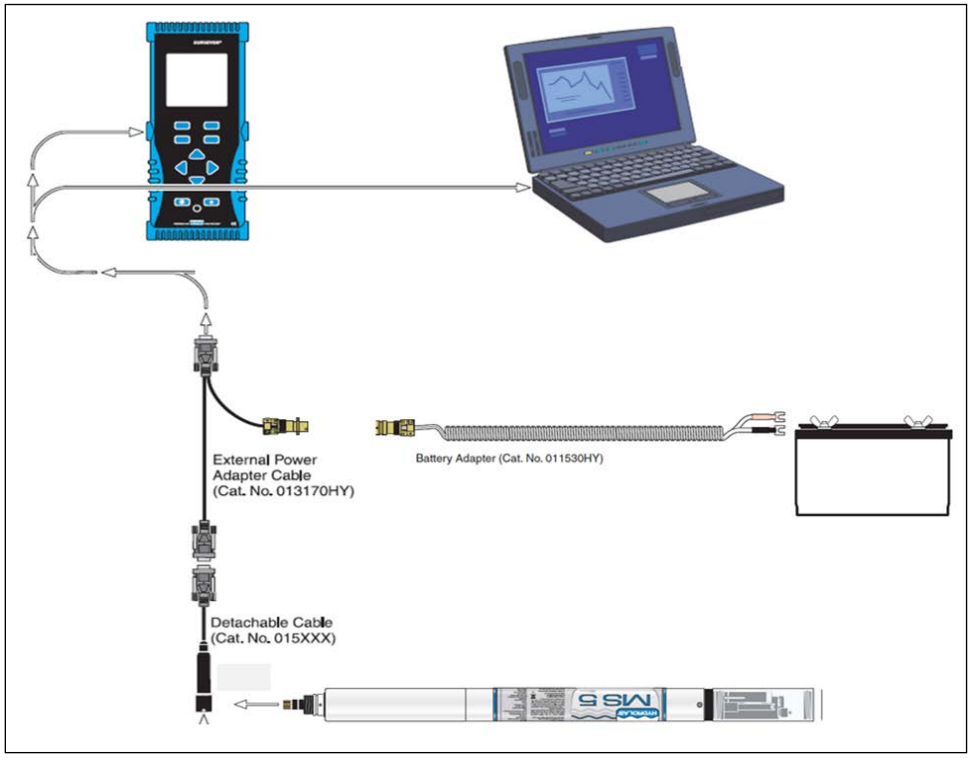


Figure 27. Cables required to connect a Hach brand Hydrolab MS-5 to an external power source. Modified from Hach Environmental 2006.

Take Site Photos

Site photos should be taken from the deployment housing looking upstream and downstream, and of the housing/external power source. Similar photos should be taken during site revisits. All site photos should be downloaded and named according to standard UCBN photo naming convention.

Setup Log File and Deploy Multiprobe

Log file setup and deployment steps are the same as those outline in SOP #5 (Water Quality Site Revisit- Calibration and Maintenance) re-deployment section.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 5: Water Quality Site Revisit- Calibration and Maintenance

Version 1.5 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	June 2011	UCBN Aquatic Biologist	Revisions to recovery of multiprobe and fouling check due to the use of an external power source. Additional step in the calibration of turbidity (use of 20 NTU standard)	Necessary for cooperators and park staff that service water quality instrumentation.	1.1
1.1	February 2016	UCBN Aquatic Biologist	Minor edits and additions to reflect the use of an Access database to manage monitoring station and instrumentation metadata generated during calibration and maintenance site visits.	Updates reflect changes to workflow due to database design.	1.5

Note: This SOP describes the step-by-step procedures to download data, error check, calibrate and re-deploy the integrated water quality multiprobe. This SOP should be evaluated frequently to determine if updates are necessary due to changes in best practices suggested by field experience, the Hach Company and USGS.

Suggested Reading

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Overview

Continuous water quality monitors or multiprobes are complex instruments that require maintenance and calibration on a regular basis. Despite the need for frequent visits, the exact timing of maintenance and calibration is varies due to field conditions. Factors affecting the timing of site revisits include; sensor fouling, water levels, battery life and data storage capacity. The UCBN has established that it is optimal to schedule a site revisit every 30-35 days if using an external power source such as a solar panel/battery. If the multiprobe is being powered by internal batteries, return site visits should occur as frequent as every 20 days. In addition to extending the site revisit interval, the solar panel/battery combination has eliminated data gaps caused by low battery power. These revisit intervals should serve as a guide to servicing multiprobes, but site specific conditions may warrant deviations from this schedule in any given year. With this in mind, the following is a guide to the proper procedures for each water quality monitoring site revisit.

Procedures

Materials Required for Site Revisit

Each time the multiprobe is serviced it will require a substantial amount of supplies and equipment, for data download, cleaning and calibration. These supplies will be provided by UCBN and stored in a clear plastic container in the network or park office. When supplies run low the person responsible for multiprobe maintenance should notify UCBN personnel that more supplies are needed.

- Multiprobe retrieval
  - Keys for cable lock and battery box (if applicable)
  - Hammer
- Data retrieval
  - PDA with 9 pin port or laptop computer
  - Tablet PC capable of running MS Access database
  - UCBN Water Quality Monitoring Station and Instrumentation Access database
  - Hydras 3 or Hydras for PDA's
  - Detachable calibration cable
- Maintenance
  - Rollup table
  - Calibration stand with clamp
  - Soft brush (1)
  - Dish soap
  - Spray bottle with soapy water
  - New AA batteries (16)
  - Cotton swabs
  - Deionized water
  - MS5 calibration cup
- Calibration
  - Bucket
  - Calibration stand with clamp
  - Container for waste standard solutions

- Standard solutions
  - Conductivity
    - 100 µS/cm
    - 1412 µS/cm
  - pH
    - 4 pH Units
    - 7 pH Units
    - 10 pH Units
  - pH Reference Electrolyte
  - pH small Teflon junction
  - Turbidity
    - Deinoized water
    - 20 NTU
    - 100 NTU
- NIST traceable thermometer
- Handheld barometer
- Handheld multiparameter water chemistry meter equipped at minimum with Temperature, Dissolved oxygen, Conductivity, and pH sensors (i.e. additional Hach MS-5 Hydrolab or YSI #556).
- Watch
- PDA with 9 pin port or laptop computer
- Tablet PC capable of running MS Access database
- UCBN Water Quality Monitoring Station and Instrumentation Access database
- Hydras 3 or Hydras for PDA's
- Detachable calibration cable
- Multiprobe Maintenance/Calibration Log Book (as a backup to Access database)
- Paper- Maintenance/Calibration Log Sheet (as a backup to Access database)
- Hach Hydrolab User Manual and Calibration Instructions
- Pencil

- Miscellaneous Field Equipment
  - Park Radio
  - Sattelite locator beacon (e.g. Delorme inReach)
  - Topographic map of park and aerial imagery
  - First Aid Kit
  - Water Jug
  - Sun screen
  - Field safety notebook
  - Bug repellent

General Workflow

1. Recovery of Multiprobe
2. Attachment of Calibration Cable / Connection to Archer Unit
3. Populate site details on Calibration Maintenance Form
4. Data Download
5. Fouling Check
6. General Maintenance
7. Calibration Drift Check
8. Calibration (if necessary)
9. Final Readings
10. Log File Setup
11. Re-Deployment

Recovery of Multiprobe

The water quality multiprobe will have been deployed for approximately one month prior to the site revisit. On the previous deployment the instrument will have been locked in the housing with a cable padlock. Each park will be supplied with the keys for the cable padlock, security cable, and external battery box. An extra set of keys will be kept in the UCBN office. As you approach the housing please take note of any debris on the housing or vandalism. The UCBN requests pictures of anything that might have affected data collection or the security of the multiprobe.

Multiprobe with External Power Source

When using an external power source such as a solar panel and battery it is possible to connect to the multiprobe without removing it from the housing. This prevents the removal of algae and sediment from the sensors prior to the assessment of fouling error. As a result, the use of an external power source provides the most accurate assessment of data quality.

Note that the calibration cable is already connected to the multiprobe and to the battery via an External Power Adapter Cable (Hach Company Cat. No. 013170HY) and Battery Adapter (Hach Company Cat. No. 011530HY). The external power adapter cable has a 9 pin connection to which the Archer Field PC can be connected (see Figure 28 and the “Connecting to Hydras” section below).

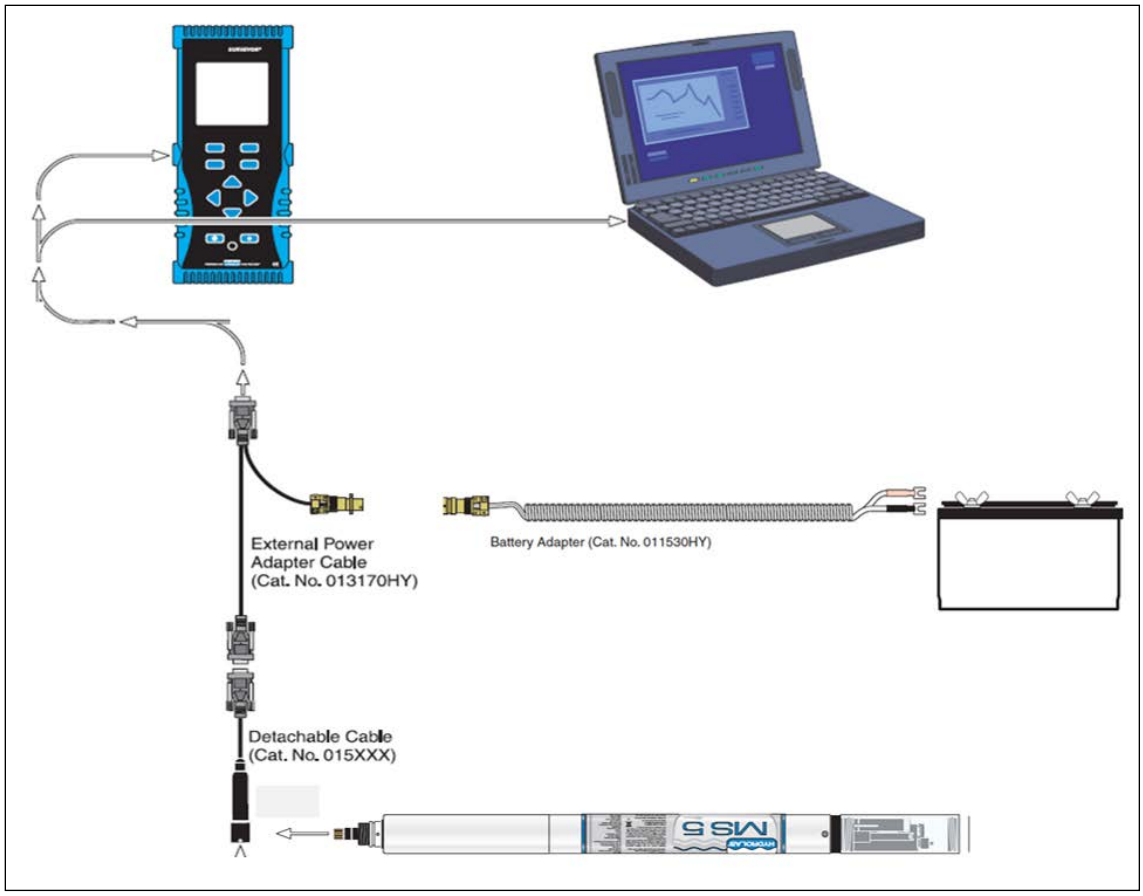


Figure 28. Cables required to connect a Hach brand Hydrolab MS-5 to an external power source. Modified from Hach Environmental 2006.

Multiprobe with Internal Power Source

If the multiprobe is powered with internal batteries, it is necessary to remove the multiprobe from the housing in order to attach the calibration cable. Make sure to gently remove the instrument from the water/housing and connect the calibration cable. It is important to minimize disturbance of the fouling on the sensors. If fouling is removed it will greatly affect the assessment of the fouling error. To remove the multiprobe from the housing gently tap upwards on the flange until the cap becomes loose. The multiprobe is suspended from the cap by a cable or rope, after the multiprobe has been removed unclip the snap hook and remove the mooring fixture. Make sure to keep the mooring fixture in a safe place until you re-deploy the multiprobe. Attach the calibration cable and prepare for the fouling and calibration drift error checks.

Attachment of the Calibration Cable

Remove the connector cap (Figure 29) and attach the calibration cable. Note that the connector cap may be difficult to remove. Pull straight up and the cap will come off, do not twist. Make sure the calibration cable is fastened securely and sealed properly, if not water may leak into the connection and damage the Hydrolab. When the calibration cable is connected, gently lower the multiprobe back

into the housing, being careful not to disturb any fouling. This will not harm the cable or the multiprobe as long as you have connected it and tightened it properly.



Figure 29. Remove the connector cap before attaching the calibration cable.

Connecting to Hydras

Hydras is the program provided by the Hach Company that allows for data download and calibration. Hydras comes in two formats, one for standard PC computers and the other for PDA's equipped with a 9-pin connection. The PC version of Hydras has more capabilities than the PDA version and should be used for setup and lab calibrations. In the field the UCBN will be using an Archer unit to download data and calibrate the multiprobe. After the multiprobe is connected to the calibration cable it should be plugged into the Archer unit. The 9-pin connection is located on the side of the Archer unit just below the buttons (Figure 30). When the calibration cable is connected, the multiprobe will beep once. Make sure to secure the 9-pin connection by tightening the screws. Once you have connected the multiprobe, follow the steps below for successful multiprobe operation.



Figure 30. The Archer Field PC with 9-pin communication port.

1. Turn on the Archer unit by pressing the button with this symbol (**φ**) in the lower right hand corner of the Archer unit.
2. Remove stylus from upper left hand back corner of Archer unit.
3. Use stylus to tap on upper left hand corner of screen on windows icon.
4. Scroll down pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
5. Click **"Connect"** on Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
6. Prior to conducting the fouling check and downloading data, you should check to see if there is enough battery power to complete the fouling check (>5% internal battery power). Click on **"Online Monitoring"** and then **"Start"** the internal battery power should be displayed in the statistics window. See Figures 36 and 37. If there is insufficient battery power, replace them according to the instructions given in the general maintenance section of this SOP.

Calibration and Maintenance Form

The UCBN uses the Water Quality Monitoring Station and Instrumentation Microsoft Access database to track all multiprobe calibration and maintenance events. This database and the calibration and maintenance form should be open and ready to populate with information prior to the steps outlined in subsequent sections of this SOP.

1. On the Tablet PC (not the Archer PDA), Open the UCBN Water Quality Monitoring Station and Instrumentation database (Figure 31).
2. From the main menu, click on **"Enter/Edit Calibration Maintenance-Cross Section Survey"** (Figure 31).
3. From the water quality calibration/maintenance log data gateway, click on **"Enter a New Record- Calibration / Maintenance"** (Figure 32).

4. When the **UCBN Multiprobe Calibration/Maintenance Log form** opens, populate all site and instrumentation fields for this site visit (Figure 33).

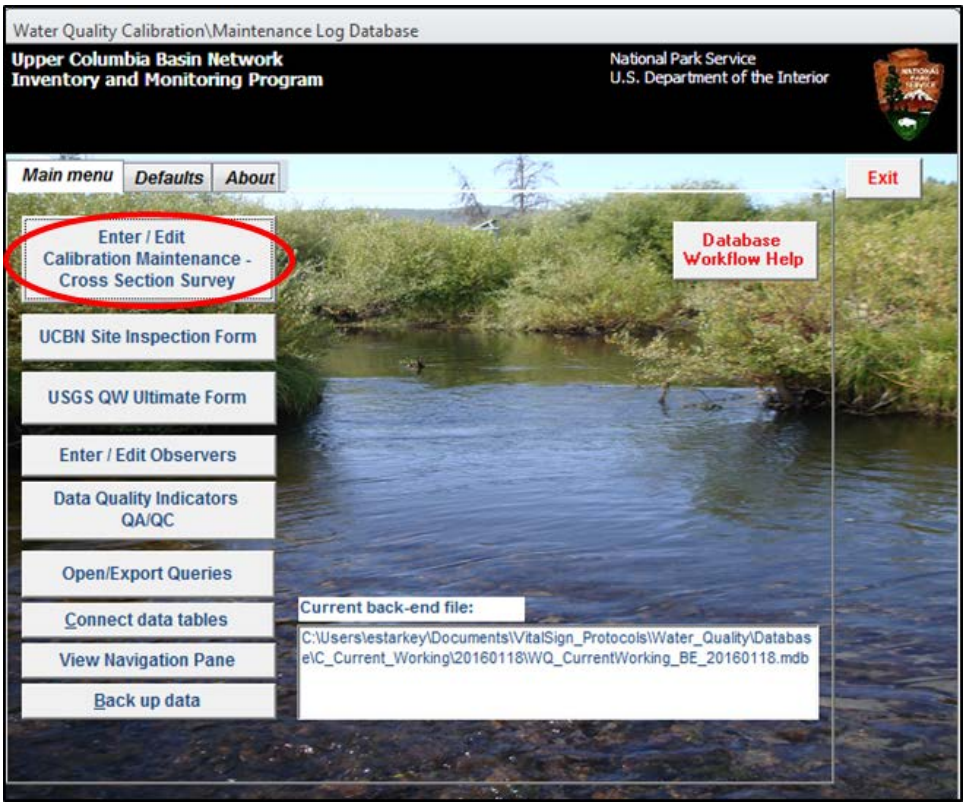


Figure 31. Enter/Edit Calibration Maintenance- Cross Section Survey button in the UCBN water quality monitoring station and instrumentation database.

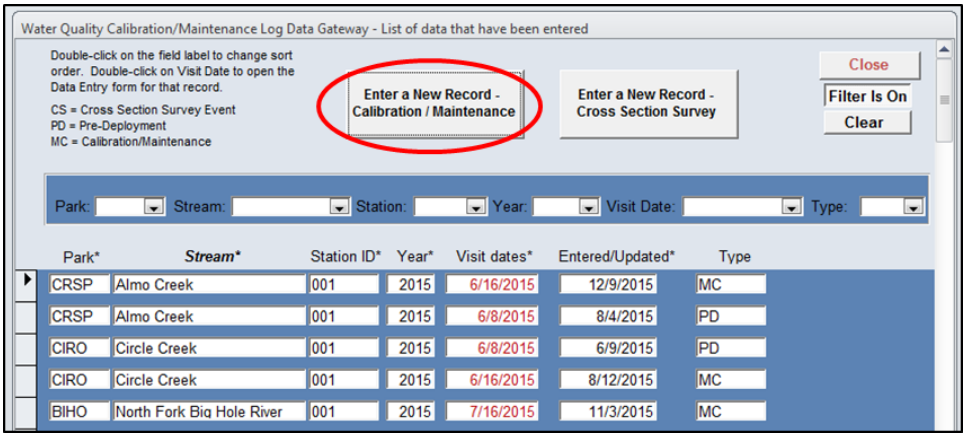


Figure 32. Water quality calibration/maintenance log data gateway in the UCBN water quality monitoring station and instrumentation database.

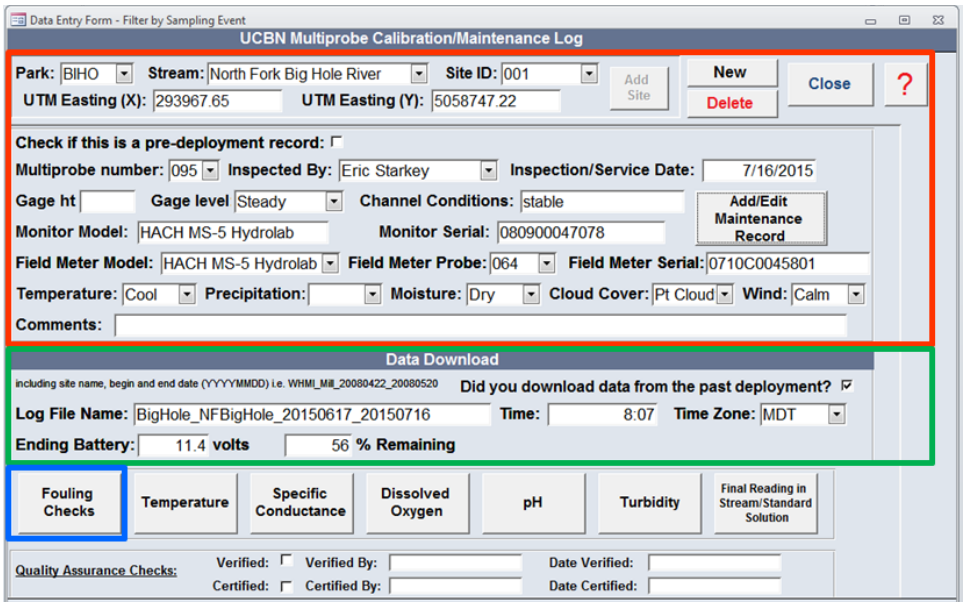


Figure 33. UCBN Multiprobe Calibration/Maintenance Log form in the UCBN water quality monitoring station and instrumentation database. Site and instrumentation fields outlined in red. Data download fields outlined in green. Fouling checks button outlined in blue.

Data Download

The recovery of data from prior deployments is a critical step to help the UCBN determine the status and trends of water quality. The calibration cable and Archer Unit should still be attached to the multiprobe. If the Archer unit is not connected see the "Attachment of the Calibration Cable" and "Connecting to Hydras" section in this SOP.

Saving the file

1. On the main Hydras screen click on **"Log Files."** A list of log files should appear.
2. Select the log file with the most recent date and for the stream in which the multiprobe has been deployed.
3. After selecting the log file, the download and disable option should be available from the buttons near the bottom of the screen. Click "**To Disable"** (same location as "To "Enable") then click **"Download"** (Figure 34).

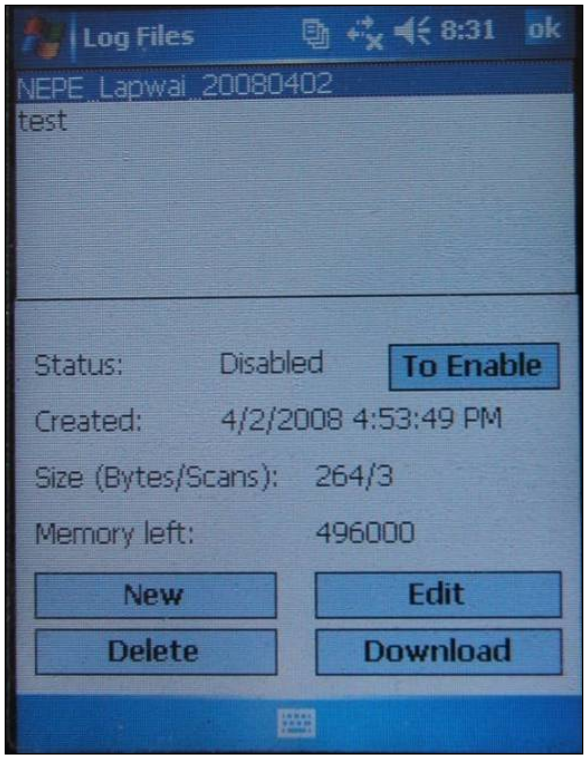


Figure 34. Selection of a log file in Hydras.

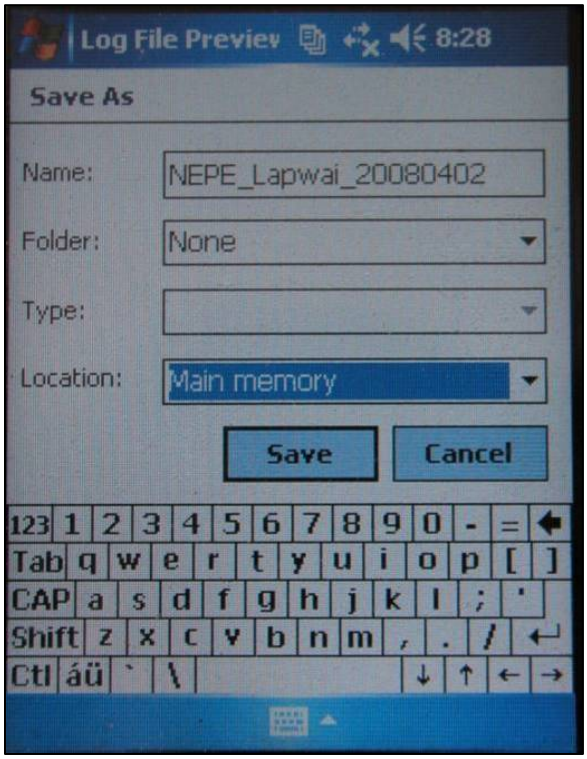


Figure 35. Screen to save a log file.

4. A new window will appear with a preview of the log file. Click **"Save"** at the bottom of the screen.
5. The next screen will have the current name for the log file (Figure 35). This name should be modified to reflect when the log period ended. For example the file name might read NEPE_Lapwai_20080402. The file name should include the park abbreviation, the stream and the beginning date. During the data download, the file name should be modified to reflect the end of the deployment. If the log period ended on April 18, 2008 the file name would be, NEPE_Lapwai_20080402_20080418. **Adding the end date is critical!** Please remember to complete this step. **Make sure to record the log file name in the "Data Download" section in the "UCBN Multiprobe Calibration/Maintenance Log" in the database** (Figure 33)
6. On the same Hydras screen under the **"Folders"** pull down menu, select Water_Quality_Log-Files.
7. Under **"Location"** make sure **"Main Memory"** is selected.
8. When finished click **"Save."** You will be directed back to the log file preview. Click **"OK"** in the upper right hand corner.
9. To ensure the file has been saved, click the Windows **"Start"** menu and click the icon for **"File Explorer."**
10. Click the **"Water_Quality_Log-Files"** folder and check for the new log file.
11. If the log file has been saved correctly click the **X** to close the File Explorer window. You should now be back to the **"Log Files"** screen. The most recent log file should be maintained in the internal memory on the multiprobe. Select older log files and click **"Delete"** to remove them. Click **"OK"** to return to the main Hydras menu.
12. It is advisable to make a backup copy of the log file to an SD card or other external memory.

Fouling Check

Fouling error is the error in measurements caused by biological growth and/or sediments on the sensors. You will need to obtain current readings from the stream before and after you have cleaned the sensors. While it seems repetitive to take stream measurements before cleaning and after cleaning, these measures allow for the calculation of fouling error. "The observed difference between the initial sensor reading and the cleaned-sensor readings (in stream water) is a result of fouling" (Wagner et al. 2006). The fouling error will be used for data corrections and for the assessment of data quality.

<u>Stream Reading Before Cleaning</u>

1. In the database, from the UCBN Multiprobe Calibration/Maintenance Log form click on **"Fouling Checks"**(Figures 33). The Fouling Check form will open (Figure 38).
2. If you have removed the multiprobe from the housing, make sure it has been gently placed back into the housing, being careful not to disturb any fouling.
3. Place the handheld multiparameter field meter (Temperature, dissolved oxygen, pH, and specific conductance sensors) in the water near the multiprobe housing.
    a. A field meter is used to evaluate the amount of environmental change that has occurred in between the time "before cleaning" measures are recorded and "after cleaning." Ideally a

handheld multiparameter field meter should be used as it allows for more accurate assessment of data quality and correction for fouling.

4. The Hydras program should still be open on the Archer unit. If not open Hydras and connect to the multiprobe.
5. On the main Hydras menu click **“Monitor.”**
6. A new screen will appear with three tabs along the bottom: (Figure 36) **“Time Series”** **“Depth Profile”** and **“Manual Mode.”**

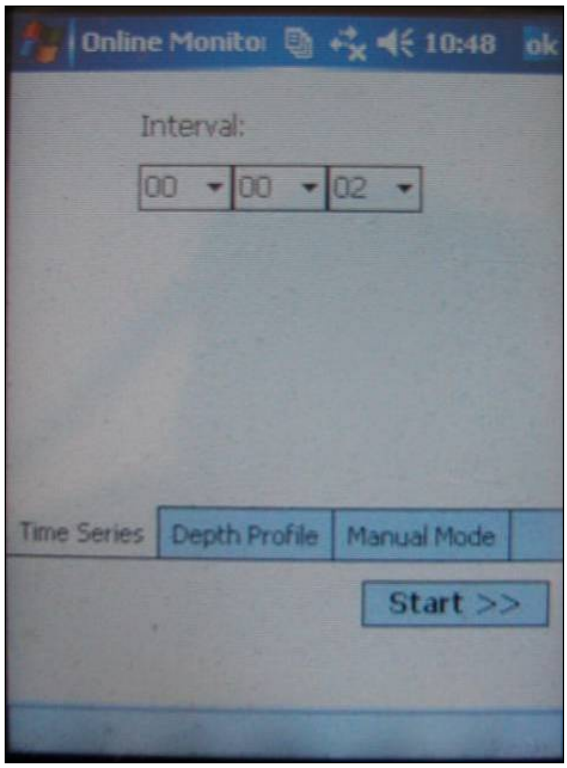


Figure 36. Online Monitoring Screen).

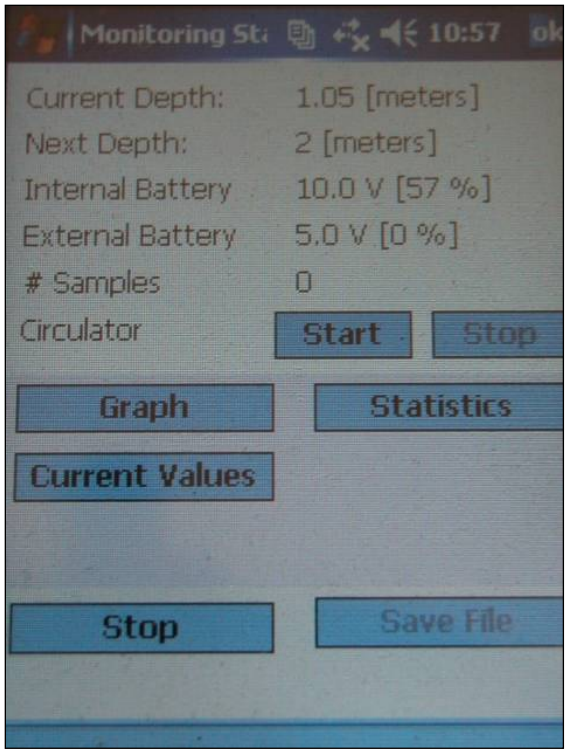


Figure 37. Monitoring Statistics Screen.

7. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button (Figure 36).
8. In the Monitoring Statistics Screen you will press the **"Current Values"** button (Figure 37).
9. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add."** There should be five parameters; Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the calibration/maintenance log (Figure 38).
10. Wait for the readings to stabilize (~2 min). Record the value for each parameter in the **"Before Cleaning" – "Recorded/Live Monitor Reading"** column (Figure 38).
11. Check the field meter and record the values for each parameter in the **"Before Cleaning" – "Field Meter Reading"** column.
12. In the Dissolved Oxygen field make sure to record the barometric pressure.
    a. If a handheld barometer is available, record the current absolute barometric pressure **(ABS)** "inHg." In the database, this value will automatically be converted to mmHg using the following equation:

$$\frac{\boldsymbol{ABS}\ \text{inHg}}{\mathbf{0.0393701}} = \boldsymbol{ABS}\ \text{mmHg}$$

Where:
ABS inHG = The absolute barometric pressure from the handheld barometer (inHg)

ABS mmHg = The absolute barometric pressure (mmHg)

Do not use sea level barometric pressure (SEA) also shown on the handheld barometer.

b. If no barometer is available check the nearest weather station before you service the instrument for barometric pressure in mbar (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/). You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

Weather stations report a corrected barometric pressure, which is barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5(\frac{A_{ft}}{100})$$

Where:
BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

13. You will need to stop monitoring after recording parameter values by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."**

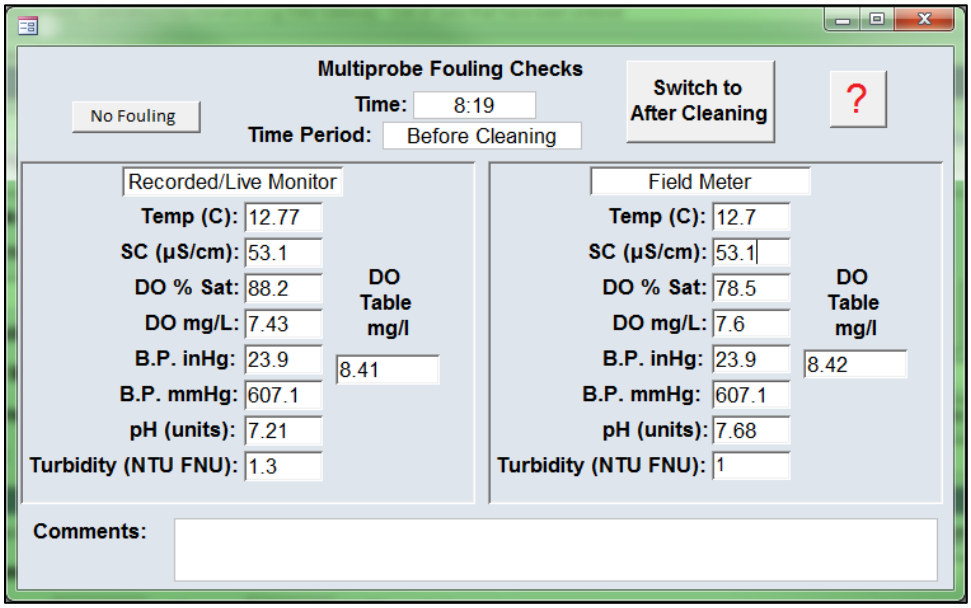


Figure 38. Multiprobe fouling checks form.

Cleaning

1. Remove the multiprobe from the housing and place it in the calibration stand with the sensors pointing up.
2. Carefully remove the sensor guard.
3. In the database, navigate to the **"Add/Edit Maintenance Record"** form (Figure 39). Record the type and degree of fouling found on the sensors and sensor guard (Figure 40).
4. Spray the multiprobe case and sensors with the soap and water from the spray bottle.
5. Gently scrub the sensors with a soft brush to loosen any fouling. Be careful not to scrub the L.D.O. sensor or the pH sensor use a cotton swab instead of the brush. These components are especially easy to damage. If fouling will not loosen on the sensors try using a cotton swab. After the sensors have been scrubbed, clean the outside of the multiprobe with a soft brush.
6. Rinse the entire multiprobe with clean tap water or stream water. Use a cup or the bucket to pour stream water over the multiprobe while it is in the calibration stand. Make sure to rinse the sensors thoroughly.
7. After rinsing with stream water, gently rinse the sensors with de-ionized water.
8. Replace the sensor guard and remove the multiprobe from the calibration stand.
9. Prior to placing the multiprobe back in the housing make sure has been scrubbed inside and out with the brush. It will take a minute for the debris and turbidity to clear the housing.

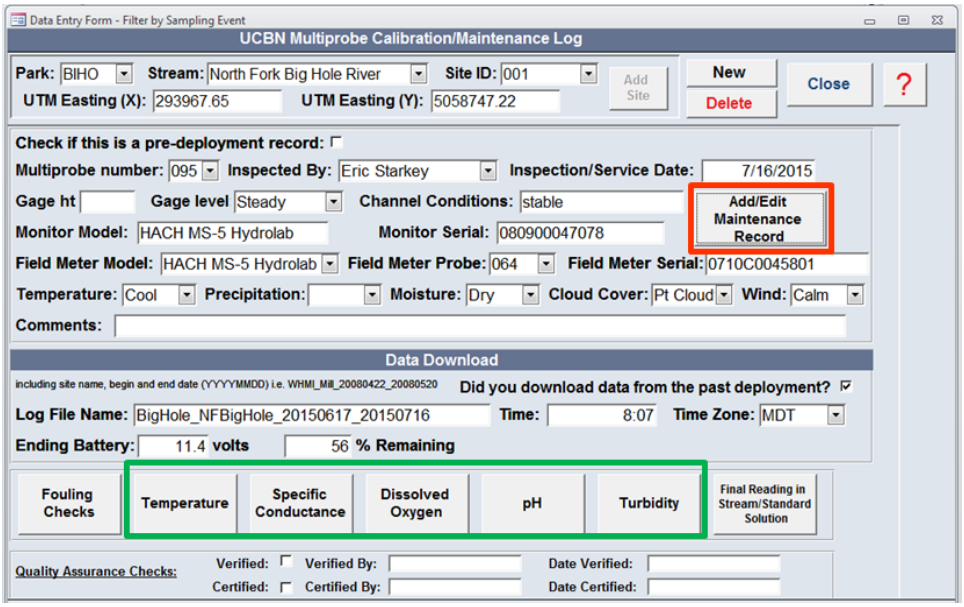


Figure 39. UCBN Multiprobe Calibration/Maintenance Log Form - Add/Edit Maintenance Record button outlined in red, forms to be used during calibration drift assessment and calibration are outline in green.

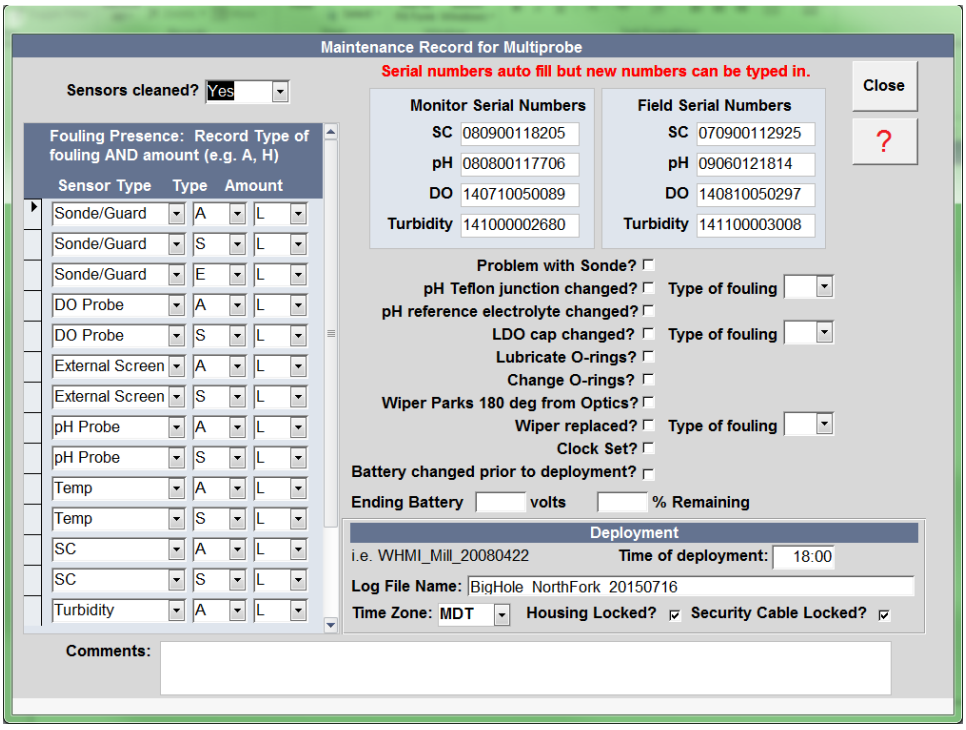


Figure 40. Add/Edit Maintenance Record form.

Stream Reading After Cleaning

1. Lower the multiprobe into the housing by holding onto the calibration cable, this will not harm the cable or the multiprobe as long as you have connected it and tightened it properly.
2. The Hydras program should still be open on the Archer unit. If it is not, open Hydras and connect to the multiprobe.
3. On the main Hydras menu click **"Monitor."**
4. A new screen will appear with three tabs along the bottom: (Figure 36) **"Time Series" "Depth Profile"** and **"Manual Mode."**
5. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
6. In the Monitoring Statistics Screen you will press the **"Current Values"** button (Figure 37).
7. (Skip if parameters are already listed.) Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add."** There should be 5 parameters, Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log Sheet.
8. In the database on the tablet PC navigate back to the **"Fouling Checks"** form (Figure 33). Click **"Switch to After Cleaning"** button (Figure 38).
9. Wait for the readings to stabilize. Record the value for each parameter in the **"After Cleaning" – "Recorded/Live Monitor Reading"** column.
10. Check the field meter and record the values for each parameter in the **"After Cleaning" – "Field Meter Reading"** column.

11. You will need to stop monitoring after recording parameter values by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."**
12. After recording the stream measurements before and after cleaning you can proceed with other maintenance and the calibration drift checks.

Other Maintenance

After the fouling error checks you will need to prepare for the calibration drift error check and calibration of each sensor. In most cases, if using internal batteries, they will be very low after the deployment period and should be replaced before the fouling check and calibration. In addition, it is important to make sure the multiprobe battery compartment is water tight. All O-rings need to be lubricated before the battery compartment is closed. Record maintenance information on the **"Add/Edit Maintenance Record"** form (Figure 40)

Battery Replacement (only if using internal batteries)

1. Grasp the middle of the multiprobe with your left hand (near the Hydrolab label) and grasp the upper portion of the multiprobe above the label with your right.
2. You should be able to twist the upper portion counter clockwise to open the battery compartment.
3. Remove all batteries and replace with new NON-RECHARGABLE AA batteries of the same brand.
4. Make sure to **INSTALL THE BATTERIES CORRECTLY!** There is a diagram inside the battery compartment. If the batteries are not replaced correctly the multiprobe will be **DAMAGED!!!** You should double check the orientation of each battery as you replace them. This is **VERY IMPORTANT!!**
5.

O-Ring Maintenance/Replacement of Battery Compartment Cover

1. When all batteries have been replaced you should lubricate the four O-rings that seal the housing. Two O-rings are located near the cable attachment and two are located near the Hydrolab label. O-rings should be lubricated with the silicon grease (Figure 41).
2. Replace the battery compartment cover by placing it back into position and pushing down slightly until the cover slides just past the first O-ring (you may need to push down rather hard to clear the first O-ring).
3. After clearing the first O-ring you should be able to tighten the cover by twisting it clockwise until it is seated against the lowest O-ring.



Figure 41. Water quality multiprobe with open battery compartment. Note the O-rings located at the red arrows.

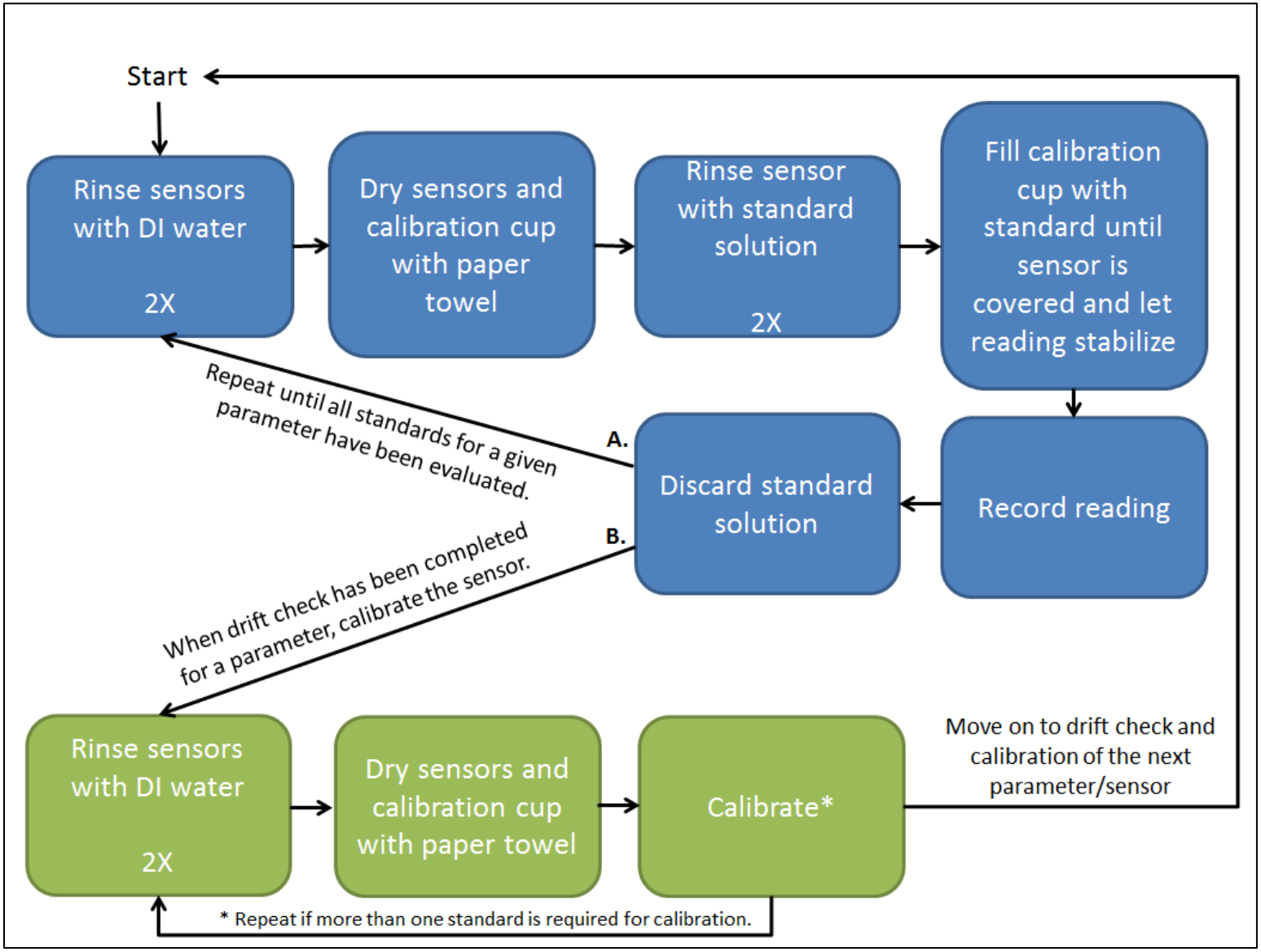


Figure 42. Calibration drift check and calibration workflow. Drift check process shown in blue boxes, calibration process shown in green.

Calibration Drift Check

Calibration drift error is the error in measurements caused by changes in the sensors due to electronic drift over time. You will need to obtain readings of standard solutions (solutions of a known value) for each parameter. Some parameters require readings from multiple standard solutions. These measures allow for the calculation of calibration drift error. "The difference between the cleaned-sensor readings in calibration standard solutions and the expected reading in these solutions is the result of sensor calibration drift error" (Wagner et al. 2006). Calibration drift error values will be used for data correction, assessment of data quality, and sensor trouble shooting. In addition, the amount of calibration drift will determine if re-calibration is necessary. **If drift is under the calibration criteria, no calibration will be necessary.**

Standard Solution Readings

During the process of recording standard solution readings you will evaluate one parameter at a time starting with Temperature (Table 2). As you evaluate each parameter, and if it is found to be outside of the calibration criteria, it will need to be recalibrated before checking subsequent parameters. Figure 42 shows the general workflow for calibration drift checks and calibration.

1. Remove the multiprobe from the housing and place it in the calibration stand with the sensors pointing up.
2. Carefully remove the sensor guard and replace it with the calibration cup.
3. Fill the calibration cup with 2 inches of de-ionized water. Replace the calibration cup top and tighten.
4. Gently swirl the de-ionized water around to rinse the sensors of all stream water. Make sure the water comes in contact with each sensor. Empty and repeat step 3.
5. Empty the de-ionized water from the calibration cup, remove the cup and dry the sensors with a paper towel, and/or a cotton swab. Make sure not to damage the L.D.O. or the pH sensor. Replace the calibration cup.
6. Fill the calibration cup ¼ of the way with one of the standards listed in Table 2. **Make sure to follow the order of parameters in Table 2 and in the maintenance log.** Place the cap on the calibration cup and tighten.
7. Gently swirl the standard around to ensure that the sensors are rinsed with the standard solution.
8. Empty the calibration cup. (Repeat steps 7 and 8 twice). **Steps 3-7 are critical for an accurate assessment of sensor drift.**

Table 2. Calibration Drift Checks. Standard solutions that should be measured to determine calibration drift. Note the calibration criteria for each parameter.

Parameter	Checked against	Parameters to select on Archer	Calibration Criteria	Maximum allowable limits for WQ sensor values
Temp	NIST Thermometer	Temp[°C]	> ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.	± 2.0 °C
Specific Cond.	100 µS/cm	SpCond [µS/cm]	± 5 µS/cm or ± 3%	± 30 %
	1412 µS/cm std.	SpCond [µS/cm]	± 5 µS/cm or ± 3%	± 30 %
D.O.	Air Sat. Water 100%	LDO%[SAT]	> ± 0.3 mg/L	The greater of ± 2.0 mg/L or 20%
pH	4.0	pH [Units]	>0.2 pH units	± 2 pH units
	7.0	pH [Units]	>0.2 pH units	± 2 pH units
	10.0	pH [Units]	>0.2 pH units	± 2 pH units
Turbidity	De-ionized water, 100% Saturation	Turbidity [NTU]	The greater of ± 0.5 turbidity units or ±5%	The greater of 3.0 TU or ± 30 %
	20 NTU	Turbidity [NTU]	The greater of ± 0.5 turbidity units or ±5%	The greater of 3.0 TU or ± 30 %
	100 NTU	Turbidity [NTU	The greater of ± 0.5 turbidity units or ±5%	The greater of 3.0 TU or ± 30 %
Battery	N/A	Internal-Battery [%Left]	Must be replaced before Calibration	-

9. Now fill the calibration cup with the appropriate calibration standard (i.e. the same as used in step 7) so that the sensor is covered. Loosely cap the calibration cup for each standard except for dissolved oxygen.
    a. For dissolved oxygen you should place the cap upside down on the calibration cup. In addition, make sure to follow the procedures for saturating the water with dissolved oxygen. This procedure is outlined in the Calibration section of this SOP.
    b. For the DO drift check, record the barometric pressure and the current water temperature. This will allow for calculation of the DO saturation value from the DO Solubility Table**.** This DO table reading will be auto calculated in the database.
10. On the main Hydras (PDA) menu click **"Monitor."**
11. A new screen will appear with three tabs along the bottom (Figure 36) **"Time Series," "Depth Profile"** and **"Manual Mode."**
12. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
13. In the next window you will press the **"Current Values"** button (Figure 37).
14. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add"**. There should be five parameters, Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log.

15. After readings have stabilized (approx. 1 min.) you will need to record the reading for the parameter/standard being evaluated in the Multiprobe Calibration/Maintenance Log (in the database). Note that each parameter has a data entry form (Figure 39). Calibration drift check values should be recorded in the **"Check"** column (Figure 43).

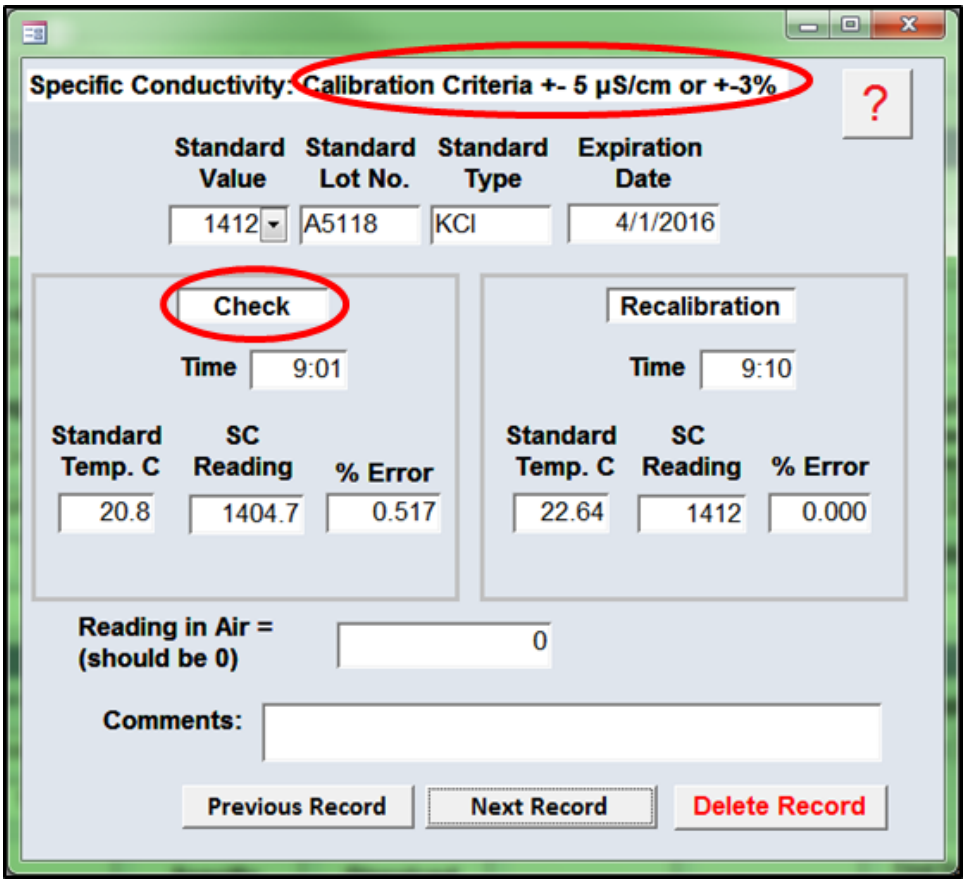


Figure 43. Specific conductance data entry form for calibration drift check and calibration.

16. Check if the readings are outside of the calibration criteria listed in Table 2 and in the UCBN Multiprobe Calibration/Maintenance Log for each parameter (Figure 43). If they are outside the range you will need to re-calibrate that parameter. The recalibration of the parameter should be conducted immediately after the calibration drift check for the individual parameter. For example, if the calibration check in a standard solution of pH 7.0 measures 7.3 it is outside of the calibration criteria (> 0.2 pH units). Therefore, the sensor will need to be calibrated before you can proceed with the calibration drift checks for other parameters (i.e., Turbidity, DO, etc.) To conduct the calibration of each parameter see the "Calibration" section in this SOP. The workflow in Figure 42 shows this process.
17. Steps 3-16 will need to be repeated until all standards for a given parameter (Table 2) have been evaluated and recalibrated if necessary (Figure 42).
18. For dissolved oxygen, make sure to record the barometric pressure during the drift check. This is the same value you will use to re-calibrate the sensor.

a. If a handheld barometer is available, record the current absolute barometric pressure **(ABS)** "inHg." In the database, this value will automatically be converted to mmHg using the following equation:

$$\frac{\boldsymbol{ABS}\ \text{inHg}}{\mathbf{0.0393701}} = \boldsymbol{ABS}\ \text{mmHg}$$

Where:
ABS inHG = The absolute barometric pressure from the handheld barometer (inHg)
ABS mmHg = The absolute barometric pressure (mmHg)

Do not use sea level barometric pressure (SEA) also shown on the handheld barometer.

b. If no barometer is available check the nearest weather station before you service the instrument for barometric pressure in mbar (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/). You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

Weather stations report a corrected barometric pressure, which is barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5(\frac{A_{ft}}{100})$$

Where:
BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

Calibration

The process of calibration is one of the most important steps during the multiprobe site revisit in that it ensures that the data collected during the deployment period represents actual conditions. Quality calibration depends on following the calibration guidelines established by the Hach Company. Much of the information contained in this section comes directly from the Hach Hydrolab MS5 User Manual (HACH Environmental. 2006) and the HACH Calibration Video Transcripts (https://www.youtube.com/playlist?list=PLF68B70D7F26A3B6D Accessed on February 12, 2016). The calibration videos on the Hach website are an invaluable tool for anyone that will be conducting calibrations. Each video contains information not found in the user manual.

All sensors must be calibrated separately, with different standard solutions. In some cases multiple standard solutions are used to generate calibration points for a single parameter. This is done so that the sensor is calibrated for both high and low concentrations. For example, the pH calibration uses a standard solution of 7 pH units to establish the first calibration point and a standard solution of 10 pH units to establish the second point.

Each calibration requires that the sensor be clean and free from any contaminates. If the sensor is cleaned properly the calibration will generally be successful. If cleaning procedures are not followed, erroneous readings and calibration failure may occur. Proper cleaning and rinsing is described in the following sections.

Make sure to calibrate the sensors in the same order as they are listed in the database and in this SOP. The order has been predetermined to help reduce the possibility of cross contaminations caused by standard solutions.

After calibration of each sensor/parameter, post-calibration values ("Recalibration" Figure 45) should be recorded in the Multiprobe Calibration/Maintenance log for each parameter (Figures 44 and 45)**.**

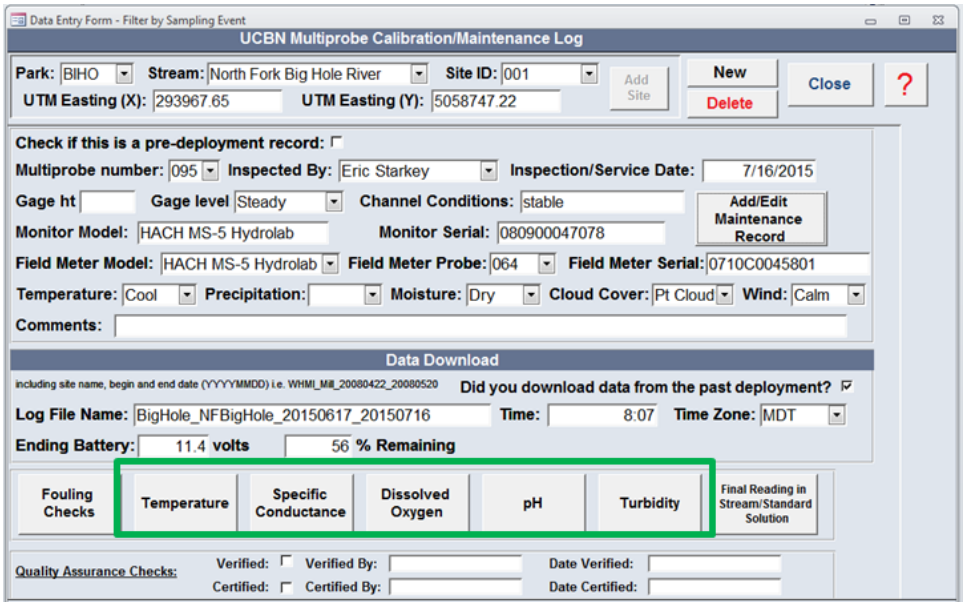


Figure 44. UCBN Multiprobe Calibration/Maintenance Log Form - forms to be used during calibration are outline in green.

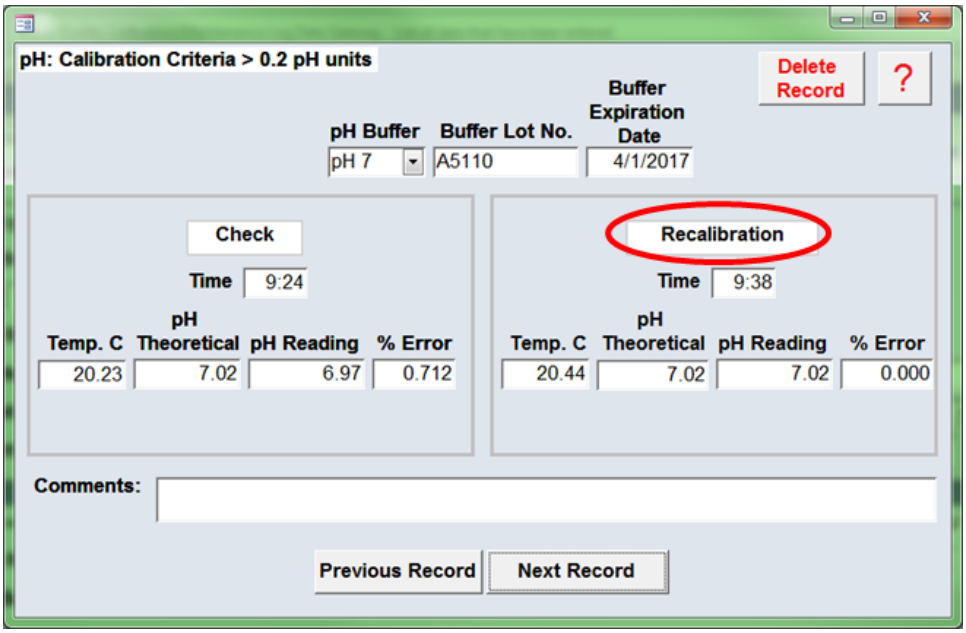


Figure 45. pH data entry form for calibration drift check and calibration. Note the recalibration section.

Temperature Sensor

The temperature sensor is factory-set and does not require recalibration. However, if this sensor does malfunction it will have a negative impact on all of the other sensors because they adjust readings based on the temperature. If any discrepancy between the NIST traceable thermometer and the temperature sensor are noted during the drift check, the multiprobe will need to be serviced by the Hach company.

Specific Conductance

Modified from the HACH Calibration Video Transcript

"The conductivity sensor measures the ability of water to conduct electricity across a set distance between graphite conductors of a known size. When the conductivity is known, the salinity and total dissolved solids can be calculated and displayed (Hach Environmental 2006)."

"The only maintenance required is cleaning of the probe's cell and body. Debris, organisms, and other contaminants in the sensor cell will have a negative impact on the accuracy and stability of the readings. The inside of the cell should be cleaned out after every deployment with a cotton swab or small brush. Additionally, prior to calibration of conductivity, all sensors should be cleaned. Any residue or debris on the sensors may contaminate the conductivity standards and change their value, resulting in an inaccurate calibration (Hach Environmental 2006)."

Note that the specific conductance sensor is calibrated at 0 and 1412 µS/cm. The 100 µS/cm standard is only used during the calibration drift check.

1. Attach the Hydrolab to the Archer unit using the cable provided with a 9-pin connector.
2. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.

3. Remove the stylus from upper left hand back corner of Archer unit.
4. Use the stylus to tap on upper left hand corner of screen on the Windows **"Start"** icon.
5. Scroll down the pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
6. Click on **"Connect"** on the Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
7. When the Hydrolab finishes its initialization, click the **"Calibration"** tab, then click the **"SpCond [µS/cm]"** tab.
8. You will see the current conductivity reading and the current temperature.
9. The first calibration point is done with a dry sensor to establish a zero point. Rinse the sensors with de-ionized water and dry them thoroughly. Be sure the inside of the conductivity cell is dry. It is best to use cotton swabs to do this.
10. Replace the calibration cup.
11. In the box on the Hydras screen, type a value of **"0"** and click **"Calibrate"**. A **"Calibration successful"** message will appear.
12. Fill the storage cup about 25% with a conductivity standard higher than the highest expected value of the water at your deployment site. For the UCBN we will use a 1412 µS/cm standard.
13. Screw the cap on and shake vigorously for six seconds. Discard the standard.
14. Fill the cup with the calibration standard again, this time so the conductivity cell is completely submerged.
15. Wait one minute for the readings to stabilize.
16. When the readings are stable, type the labeled value of the standard into the box and click the **"Calibrate"** button. This labeled value is on the bottle of calibration standard.
17. A **"Calibration successful"** message will appear.
18. Pour the used standard solution into the "Waste Calibration Standard" bottle that was provided by the UCBN. When this bottle is full please let UCBN know so it can be picked up and disposed of properly.

Congratulations you have calibrated the first sensor!

<u>Luminescent Dissolved Oxygen (LDO)</u>

Modified from the HACH Calibration Video Transcript

"The Hach LDO probe measures the oxygen dissolved in water by flashing a blue light on the sensor cap coated with a luminescent material and measuring the time it takes for the sensor to return red light. More oxygen in the water causes a shorter time delay" (Hach Environmental 2006).

"The Hach LDO probe is nearly maintenance free. To ensure accurate readings and long sensor life, the probe should be kept clean. After each deployment, the sensor should be cleaned with a cotton swab or soft brush and soapy water to remove any oils or organisms. Organisms living on the sensor will consume or produce oxygen and change the readings. Hard scrubbing will remove the black coating from the outside of the sensor cap. If more than half of the coating is removed, the cap must be replaced. If deposits on the sensor are difficult to remove, soak the sensor in warm fresh water

until the deposits soften. NEVER use organic solvents such as acetone or methanol on any part of the sensor or cap. When the sensors are clean, the LDO is ready to calibrate" (Hach Environmental 2006).

"The LDO sensor compensates for the temperature of the water. **To perform an accurate calibration it is important that the temperature of the water remain constant during the procedure. The easiest way to do this is to allow the water used for calibration to sit overnight in an open container until it equilibrates to room temperature.** If the temperature changes by more than 0.5 °C during calibration, dissolved oxygen measurements may be inaccurate and the sensor will need to be recalibrated when the temperature of the water stabilizes. For this reason, the calibration should also not be done in direct sunlight" (Hach Environmental 2006).

1. Make sure the sensor has been cleaned with a soft brush or cotton swab.
2. Use a handheld barometer or local weather station to determine the barometric pressure at the deployment site. This barometric pressure will be used to re-calibrate the LDO sensor.
   a. If a handheld barometer is available, record the current absolute barometric pressure **(ABS)** "inHg." In the database, this value will automatically be converted to mmHg using the following equation:

$$\frac{\boldsymbol{ABS}\ \text{inHg}}{\mathbf{0.0393701}} = \boldsymbol{ABS}\ \text{mmHg}$$

   Where:
   ABS inHG = The absolute barometric pressure from the handheld barometer (inHg)
   ABS mmHg = The absolute barometric pressure (mmHg)

   Do not use sea level barometric pressure (SEA) also shown on the handheld barometer.

   b. If no barometer is available check the nearest weather station before you service the instrument for barometric pressure in mbar (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/). You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

   Weather stations report a corrected barometric pressure, which is barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5(\frac{A_{ft}}{100})$$

   Where:
   BP' = Barometric pressure at altitude mmHg
   BP = Barometric pressure at sea level mmHg
   A_{ft} = Altitude in feet

3. Attach the Hydrolab to Archer Unit using cable provided with 9-pin connector.
4. Stand the Hydrolab so the sensors are pointed upwards with the storage cup attached.

5. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
6. Remove stylus from upper left hand back corner of Archer unit.
7. Use stylus to tap on upper left hand corner of screen on **Windows start icon**.
8. Scroll down the pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
9. Click on **"Connect"** on the Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
10. Add about one liter of **room temperature** de-ionized water (or clean tap water with a conductivity of less than 500 µS/cm) to a clean one gallon jug. Shake the jug very vigorously for 40 seconds.
11. Fill the storage cup over the sensors to the bottom of the threads and place the storage cap on upside-down. **Do not screw the cap on.**
12. When the sonde is ready to operate, click the **"Calibration"** tab.
13. Select the **"LDO (%Sat)"** tab.
14. Wait for the current value and temperature readings to stabilize. If the LDO cap was stored wet this should happen very quickly. A dry cap may take several minutes to stabilize.
15. Enter the current absolute barometric pressure in mm/Hg in the box.
16. Click **"Calibrate"**.
17. A **"Calibration Successful"** message will be displayed.
18. Record the temperature and barometric pressure (mmHg) in the calibration and maintenance log DO form. The DO saturation value from the DO Solubility Table will be auto calculated. This is the same value used to determine if the instrument exceeds the calibration criteria (Figure 46).

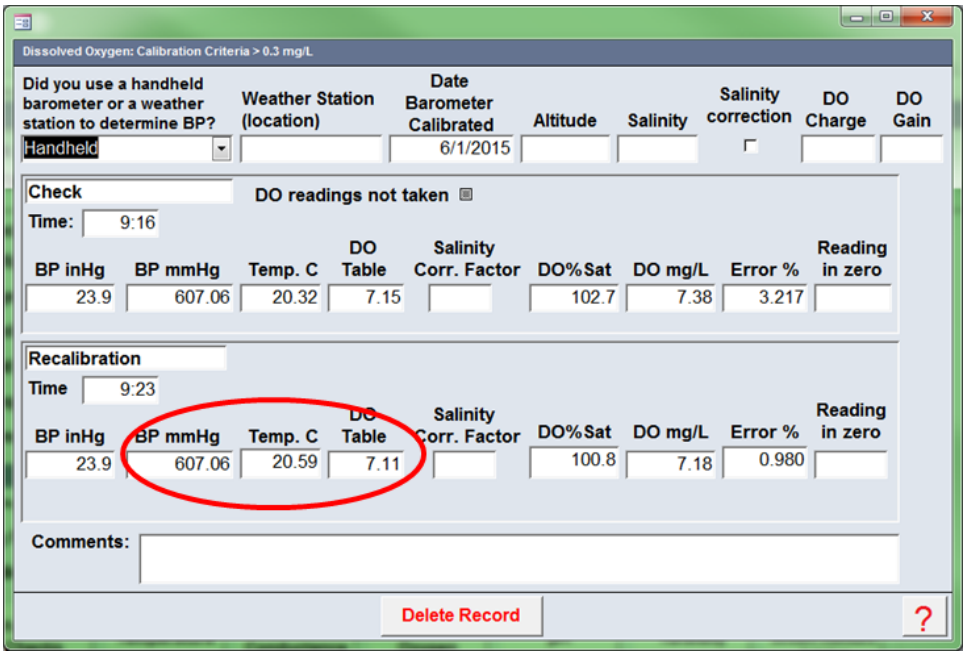


Figure 46. Dissolved oxygen data entry form for calibration drift check and calibration.

Verification of LDO Calibration: If LDO calibration is conducted with a PC instead of an Archer Unit it is possible to verify the success of the calibration by following the next set of steps. **If calibration was conducted with an Archer Unit move on to the next parameter. Note that the symbols < and > designate commands to be pressed on the keyboard.**

1. Click the red **"X"** in the upper right corner and close the calibration window.
2. In the Connection window click the button labeled **"Terminal mode."**
3. Using the arrow keys, highlight **"Login"** and press <**Enter>.**
4. Highlight **"Level 3"** and press <**Enter>.**
5. Type the password and press **<Enter>.** The default is **"Hydrolab"** and it is case sensitive.
6. Use the arrow keys to highlight **"Setup"** and press <**Enter**>.
7. Highlight **"Sensors"** and press **<Enter>.**
8. Highlight **"LDO"** and press **<Enter>.**
9. Highlight **"LDO % SAT"** and press **<Enter>.**
10. Read the Scale Factor. A valid calibration will produce a Scale Factor between 0.5 and 1.5. Values outside of these parameters may indicate a problem with the sensor or electronics. DO NOT type a new value for the Scale Factor. This will invalidate the calibration and cause the sensor to take incorrect readings!
11. Press **<Esc>** after you have verified that the Scale Factor is acceptable.
12. Your LDO is now calibrated and ready to deploy.

pH

Modified from the HACH Calibration Video Transcript

"The pH sensor consists of two electrodes: The Measuring Electrode is surrounded by a glass bulb, The Reference Electrode is surrounded by an electrolyte solution and is separated from the water sample by a porous junction. By measuring the electrical potential between these two electrodes, the sensor can determine the Hydrogen ion activity and calculate the pH for a given water sample" (Hach Environmental 2006).

"In order to give consistently accurate readings, the pH sensor should be maintained on a regular basis. Oils, sediment, and biological contaminants on the bulb or reference junction will result in errant readings or a very slow response. Leaching or dilution of the electrolyte solution in the reference will cause the readings to drift over time" (Hach Environmental 2006).

"The glass bulb is very thin and fragile. Care should always be taken not to damage it when servicing the instrument. The sensor should be cleaned with a cotton swab or soft brush and soapy water.

The reference junction is a threaded cap with a sleeve of porous Teflon in the center. The Teflon allows the reference electrolyte to make an electrical connection to the sample water while preventing them from mixing freely. If it becomes clogged or dirty, replace it" (Hach Environmental 2006).

1. **VERY CAREFULLY** clean the glass bulb with a cotton swab and a mild soap. The bulb is made from extremely thin glass and is very fragile.

2. Replace the reference junction if it is visibly fouled. Water with strong biological activity tends to foul the junction more rapidly.
3. Replace the electrolyte solution regularly. Water with very low levels of dissolved solids or high flow rates will leach the salts out of the solution and dilute it more quickly. Your specific water conditions will determine how frequently this should be done.
4. Use of the salt tablets from the maintenance kit will keep the electrolyte solution saturated for longer periods of time.
5. The pH sensor should not be allowed to dry out for extended periods. When not in use, store the sensor in clear pH 4 buffer, or alternatively, clean tap water.
6. **DO NOT store the sensor in de-ionized water or sample water.** DI water will damage the sensor bulb, and the organisms in sample water will foul the bulb and junction.

Replacing the Teflon Reference Junction

1. Turn the junction counter clock-wise to unscrew it from the base; you will need a flat screwdriver to do this.
2. With the junction off, pour the old electrolyte solution out and replace it with fresh solution.
   a. ***Make sure the new electrolyte solution is clear!** If it is grey or milky-looking, it is bad and should not be used. Re-deployment is acceptable but will have a negative impact on the pH data quality. Reorder the solution as soon as possible.*
3. Add a salt tablet to the reference electrolyte in the sensor . This will maintain the saturation level of the electrolyte as the salt slowly leaches through the Teflon junction.
4. Fill the reference until the electrolyte forms a slight dome over the top.
5. Gently place the new junction into the top of the reference tube so that no air remains inside, and turn it clock-wise until the O-ring is sealed tightly. As you tighten you will see a small amount of electrolyte and possibly bubbles being forced out of the junction. This is the air being purged from inside the junction. If this purging effect does not occur, the junction may be clogged and must be replaced.
6. The pH sensor is now ready to be calibrated.

Calibration of the pH sensor

1. Attach the Hydrolab to the Archer unit using cable provided with 9-pin connector.
2. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
3. Remove stylus from upper left hand back corner of Archer unit.
4. Use stylus to tap on upper left hand corner of screen on the **Windows start icon**.
5. Scroll down the pop-up window menu and tap on **“Hydras 3 Pocket for Hydrolab”** to open program.
6. Click on **“Connect”** on the Hydras 3 program screen. You will hear a “beep” that indicates that the Hydrolab is connected and receiving information from the Archer unit.
7. When the Hydrolab finishes its initialization, click the **“Calibration”** tab, then select pH units and click **“Select”** near the bottom of the screen.
8. You will see the current pH value, the date and time, and the current temperature.

9. **Rinse and dry the sensors (Very important!)** and attach the storage/calibration cup. Fill the cup about 25% with pH buffer 7 and screw on the storage cap. Shake for 6 seconds.
10. Remove the storage cap and pour the buffer 7 out.
11. Fill the cup with buffer 7 again, this time over the top of the pH sensor.
12. Wait one minute for the readings to stabilize.
13. When the readings are stable, type the temperature adjusted standard value* and click **"Calibrate"**. ***The temperature corrected pH (pH theoretical) values are auto calculated in the calibration and maintenance log pH form (Figure 45).**
14. A **"Calibration Successful"** message will appear. If the pH readings continue to drift for an extended period of time, or jump up and down, the sensor may need to be cleaned or replaced.
15. Pour the buffer 7 out, rinse the sensors with deionized water, and dry them.
16. Fill the cup about 25% with pH 10 buffer solution.
17. Screw on the storage cap and shake for 6 seconds. Remove the storage cap and pour the buffer 10 solution out.
18. Fill the cup with pH 10 buffer solution again, this time over the top of the pH sensor.
19. Wait one minute for the readings to stabilize.
20. When the reading stabilizes, type the temperature adjusted standard value into the box, and click **"Calibrate"**. A **"Calibration Successful"** message will appear. If the pH readings continue to drift for an extended period of time or jump up and down, the sensor may need to be cleaned or replaced.
21. The pH sensor is now calibrated.

"If desired, a linearity test may be performed with a buffer opposite that used for pH slope calibration. For example, if pH 10 was used to calibrate, check with pH 4, or if pH 4 was used to calibrate, check with pH 10. Repeat the process used for the previous calibration with the opposing buffer solution, but **do not** click the calibrate button again" (Hach Environmental 2006).

Self-cleaning Turbidity

Modified from the HACH Calibration Video Transcript

"The Hydrolab Self Cleaning Turbidity sensor measures the intensity of light scattered by particles in the water sample at 90 degrees from an infrared light source and reports that value in NTUs. In order to take an accurate measurement of the scattered light, the sensor requires an unobstructed view of the water extending approximately 1 inch (25.4 mm) from the end of the sensor. To keep the optics clean there is a motorized pad that can be set to wipe from 1 to 9 times before taking a measurement depending on the degree of sensor fouling expected. The 'X' version also features an extended brush for removing debris from the other sensors" (Hach Environmental 2006).

"The Self Cleaning Turbidity sensor is almost completely maintenance free. When the cleaning pad becomes fouled, simply replace it using the hex wrench provided. The cleaning pad set screw should be tightened against the flat side of the shaft. **DO NOT rotate the wiper by hand or operate the wiper when the sensor is dry**. Both of these actions can damage the gear assembly inside the motor" (Hach Environmental 2006).

The Self Cleaning Turbidity sensor uses scattered light to report the concentration of suspended particles in water, so it is important to clean the instrument as thoroughly as possible prior to calibration.

Note that the turbidity sensor is calibrated at 0 and 100 NTU the 20 NTU standard is only used during the assessment of calibration drift.

1. Use a soft brush and mild soap to remove dirt and debris from all of the sensors and the inside of the storage cup. Rinse the storage cup and sensors until they are free of soap and dirt, then **dry with lint free towels**.
2. Change the wiper if necessary. Use the supplied Allen wrench to remove the set screw holding the wiper onto the motor shaft. Position a new wiper on the motor shaft and tighten the set screw. More details are provided in the Hach Self Cleaning Turbidity manual.
3. Attach the Hydrolab to the Archer unit using the cable provided with a 9-pin connector.
4. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
5. **Zero Point Calibration** – With the sensors pointed upwards, fill the storage cup approximately 75% with de-ionized water or <0.1 NTU StablCal and screw the storage cap on tightly.
6. Slowly turn the Hydrolab over so the sensors point downwards.
7. Remove stylus from upper left hand back corner of Archer unit.
8. Use the stylus to tap on upper left hand corner of the screen on the Windows start icon.
9. Scroll down the pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
10. Click on **"Connect"** on the Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
11. When the Hydrolab finishes its initialization, click the **"Calibration"** tab, then select **"Turbidity [rev]"**
12. Verify that the value in the box is **"1"** and click the **"Calibrate"** button.
13. The wiper should make one complete revolution, removing any air bubbles from the optics.
14. Click the **"OK"** button in the **"Calibration Successful"** window.
15. Click the **"Calibration"** tab, then select **"Turbidity [NTU]."** There are two boxes on this page.
16. In the box labeled **"Turbidity [Point]"** enter a **"1."**
17. In the box labeled **"Turbidity [NTU]"** enter a value of 0.3 to 0.6 depending on the cleanliness of the sensors.
18. When the readings at the top of the page are stable, click **"Calibrate."**
19. Click the **"OK"** button in the **"Calibration Successful"** window.
20. **High-End Calibration** – The high-end calibration point should be a value higher than the highest value anticipated at the deployment site. The standard factory high point is 100 NTU.
21. Pour the de-ionized water out of the storage cup and dry the sensors again.

22. Gently swirl or invert the bottle of 100NTU StablCal for two to three minutes to mix the suspension. **DO NOT shake the bottle of StablCal!** This will suspend air bubbles in the solution and change the turbidity of the standard.
23. Pour the StablCal into the storage cup until it is about 25% filled. Screw the cap on tightly and shake the Hydrolab. Remove the cap and pour the solution out.
24. Gently pour StablCal into the storage cup again, this time filling the cup to 75%. Screw the cap on and gently turn the sonde over so the sensors are pointing downward. The end of the Self Cleaning Turbidity sensor should be fully submerged.
25. Again, in Hydras, click on the **"Calibration"** tab, and then click on **"Turbidity [rev]."** Verify that the value in the box is **"1"** and click the **"Calibrate"** button. The wiper should make one complete revolution, removing any air bubbles from the optics.
26. Click the **"OK"** button in the **"Calibration Successful"** window.
27. From the main Hydras menu click the **"Calibration"** tab, and then select **"Turbidity [NTU.]"** There are two boxes on this page.
28. In the box labeled **"Turbidity [Point]"** enter a **"2."**
29. In the box labeled **"Turbidity [NTU]"** enter a value of **"100".**
30. When the readings at the top of the page are stable, click **"Calibrate"**.
31. Click the **"OK"** button in the **"Calibration Successful"** window.
32. The Self Cleaning Turbidity sensor is now calibrated.

Post-Calibration Final Readings

After the calibration drift error check and/or calibration of all sensors, the multiprobe should be deployed briefly in the stream next to a field meter or checked against standard solutions. The final readings allow the multiprobe to be "double checked" before it is re-deployed. Ideally the multiprobe will be checked against a field meter of the same make/model and not in standard solutions. A field meter is a meter that was calibrated in lab conditions and is used to verify that multiprobe measurements reflect actual stream conditions. The final readings should be recorded in the **"Final Readings in Stream/Standard Solution"** form in the database. **If a field meter is not available final readings should be determined by placing the sensors in standard solutions**, **in the same manner as when they were assessed for calibration drift**. A list of standards that you should use for final readings is provided in Table 3. The concentration of standard used for the final readings should be recorded next to the multiprobe (monitor) readings in the **"Final Readings in Stream/Standard Solution"** form in the database. Using the drop down field, make sure to note if final readings were taken in the stream or with standard solutions.

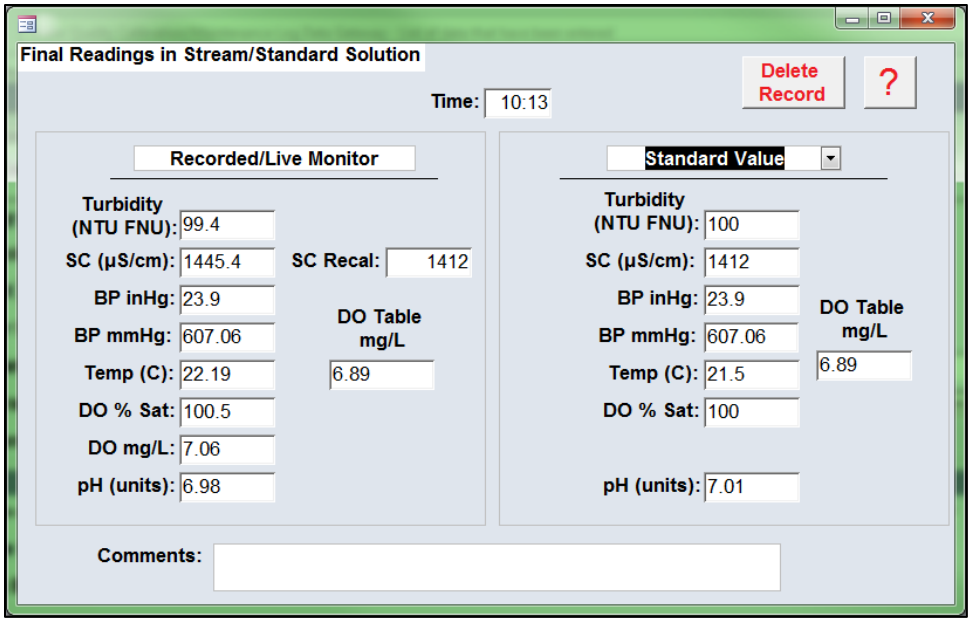


Figure 47. Final readings in stream/standard solution form.

Final Readings in the Stream

If a field meter is available, the multiprobe should be placed in the stream next to the field meter. After values on the multiprobe and field meter have stabilized the values for each parameter should be recorded on the UCBN Multiprobe Calibration/Maintenance Log in the "Final Readings" section. Readings should be recorded for both the field meter and the multiprobe.

1. Do not disconnect the calibration cable/Archer unit from the multiprobe.
2. Remove the calibration cup from the multiprobe and attach the sensor guard.
3. Place the multiprobe in the stream adjacent to the field meter.
4. Wait several minutes for the readings on the multiprobe to stabilize.
5. On the main Hydras menu click **"Monitor."**
6. A new screen will appear with three tabs along the bottom: (Figure 36) **"Time Series," "Depth Profile,"** and **"Manual Mode."**
7. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
8. In the next window you will press the **"Current Values"** button.
9. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add"**. There should be five parameters: Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log Sheet.
10. Wait for the readings to stabilize. Record the value for each parameter in the appropriate blank in the "Final Readings in Stream/Standard Solution" form (Figure 47). You should also record the readings for each value from the field meter. After you have recorded all of the parameters look at the calibration criteria listed in Table 3. The values recorded by the

multiprobe should be very close to the field meter. If the readings are not within the limits, the sensor should be re-calibrated again or the sensor may be faulty and should be replaced.

11. You will need to stop monitoring after each parameter by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."**

Final Readings in Standard Solutions

If no field meter is available, final readings should be taken in standard solutions. While this is not the preferred method it, will serve the same function as a double check using a field meter. It is important to note in the Calibration/Maintenance log database that the final readings were taken in standard solutions. In addition, the type of standards used for the comparison should also be recorded.

1. Fill the calibration cup with 2 inches of de-ionized water. Replace the calibration cup top and tighten.
2. Gently swirl the de-ionized water around to rinse the sensors of all stream water. Make sure the water comes in contact with each sensor.
3. Empty the de-ionized water from the calibration cup, remove the cup and dry the sensors with a paper towel and/or a cotton swab. Make sure not to damage the L.D.O. or the pH sensor. Replace the calibration cup.
4. Fill the calibration cup ¼ of the way with one of the standards listed in Table 3. Place the cap on the calibration cup and tighten.

Table 3. List of standard solutions for final readings after calibration.

Parameter	Checked against	Parameters to select on Archer	Calibration Criteria	Maximum allowable limits for WQ sensor values
Temp	NIST Thermometer	Temp[°C]	> ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.	± 2.0 °C
Specific Cond.	1412 µS/cm	SpCond [µS/cm]	± 5 µS/cm or ± 3%	± 30 %
pH	7.0	pH [Units]	>0.2 pH units	± 2 pH units
D.O.	Air Sat. Water 100%	LDO%[SAT]	> ± 0.3 mg/L	The greater of ± 2.0 mg/L or 20%
Turbidity	100 NTU	Turbidity [NTU]	The greater of ± 0.5 turbidity units or ±5%	The greater of 3.0 TU or ± 30 %
Battery	N/A	Internal-Battery [%Left]	Should have ≈ 95% remaining	-

5. Gently swirl the standard around to ensure that the sensors are rinsed with the standard solution.
6. Empty the calibration cup.
7. Now fill the calibration cup with the appropriate calibration standard so that the sensor is covered. Loosely cap the calibration cup for each standard except for dissolved oxygen. For dissolved oxygen you should place the cap upside down on the calibration cup.
8. On the main Hydras menu click **"Monitor."**
9. A new screen will appear with three tabs along the bottom: (Figure 36) **"Time Series," "Depth Profile,"** and **"Manual Mode."**
10. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
11. In the next window you will press the **"Current Values"** button.
12. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add."** There should be five parameters: Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log Sheet.
13. Wait for the readings to stabilize. Record the value for the parameter in the appropriate blank in the **"Final Readings in Stream/Standard Solution" form** (Figure 47). After you have recorded all of the parameters look at the calibration criteria listed in Table 3. The values recorded by the multiprobe should be very close to the standard solution value. If the readings are not within the limits, the sensor should be re-calibrated again or the sensor may be faulty.
14. As in the calibration check, make sure to record the barometric pressure and temperature during the dissolved oxygen check.

15. You will need to stop monitoring after each parameter by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."**
16. Repeat steps #1-13 until all 5 parameters have been recorded for the final readings.

If values are observed outside of the acceptable range during the final readings the sensor may have been fouled during the calibration procedure, may be low on batteries or requires maintenance. The first step in trouble shooting should be to check the batteries. If the batteries have been replaced or have ≥ 95 % remaining then you should try re-calibrating the suspect sensor. If neither of these two options works to fix erroneous readings you should contact the UCBN Water Quality Project Lead (208-885-3010) and/or Hach Technical Assistance (1-800-949-3766).

Re-deployment

After the multiprobe has been error checked it will need to be set up to collect data during the next deployment period. To do this, a new log file will need to be created.

Creating/Enabling a Log File

1. **Quickly double check the amount of battery remaining. If the batteries are less than 95%, replace them.**
    a. To check battery power, go to the main Hydras screen and click "Monitoring."
    b. Set the interval for 2 seconds. Click "Start"
    c. Check the **"Internal Battery"** reading (Volts and %) Record these values on **"Add/Edit Maintenance Record"** form in the database.
2. From the main Hydras menu click **"Log Files."**
3. The next screen will allow you to create a new log file. Make sure not to delete the templates for each park (Figure 48). Click **"New."**

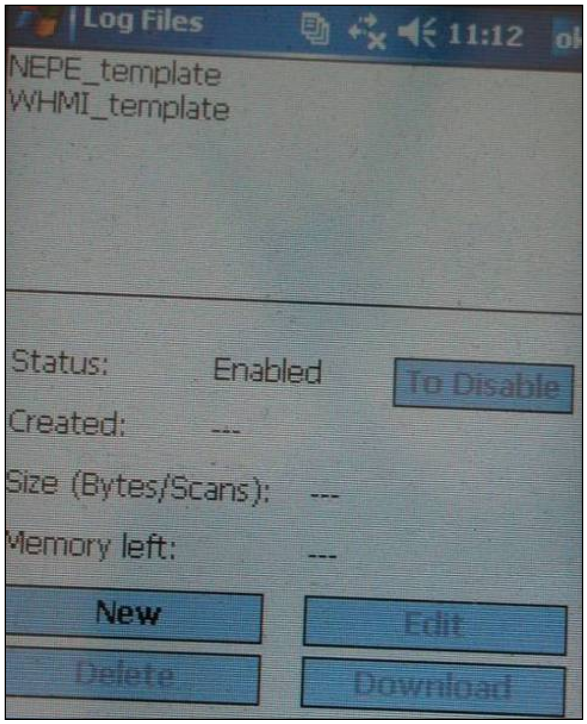


Figure 48. The Log Files screen allows the user to create a new log file for the next deployment period.

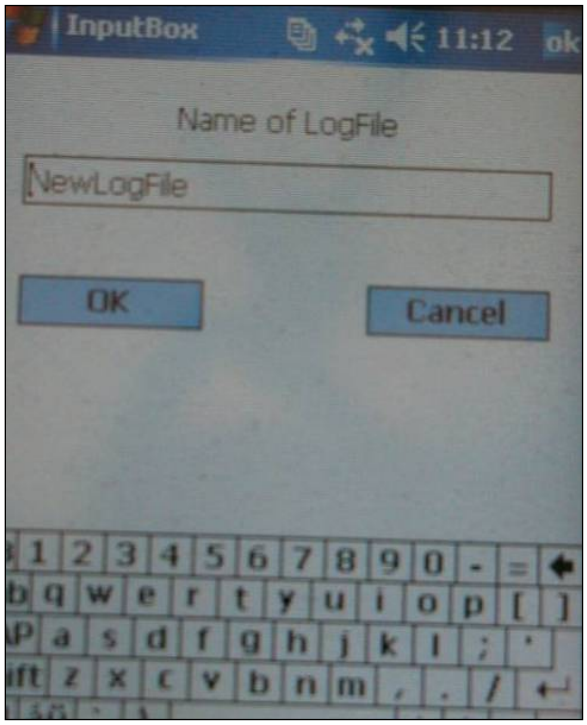


Figure 49. The Input Box screen is used to name the new log file.

4. On the Input Box screen (Figure 49) enter the new file name for the log file. Remember the file naming convention used when you downloaded the data from the previous deployment.

For example the file name might read NEPE_Lapwai_20080402. The file name should include the park abbreviation, the stream and the beginning date. During the next data download the file name will be modified to reflect the end of the deployment. Make sure to record the new log files name in the "Deployment" section of the "UCBN Multiprobe Calibration/Maintenance Log." This is important in case a different person services the multiprobe on the next visit.

5. After you name the file click **"OK."**
6. After a few seconds the Log File Setup screen will appear. This screen allows the user to specify the sensors start and stop times, measuring interval, sensor warm up period, and the measured parameters.
7. To avoid confusion about what parameters and intervals to select a template has been created and pre-loaded on each Archer unit.
8. On the bottom of the Log File Setup screen click **"Templates", "Load"** and then the appropriate template for the applicable multiprobe number (UCBN label on the instrument) (Figure 50).

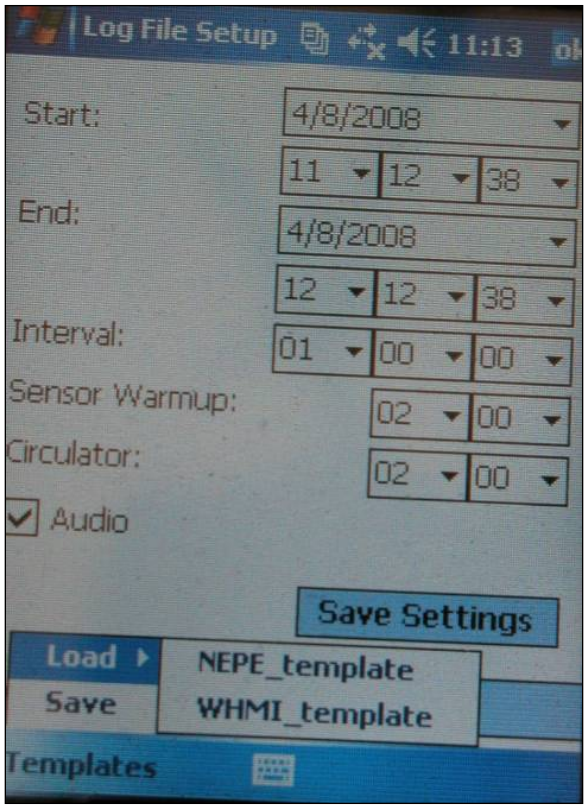


Figure 50. Log File Setup Screen "General" tab.

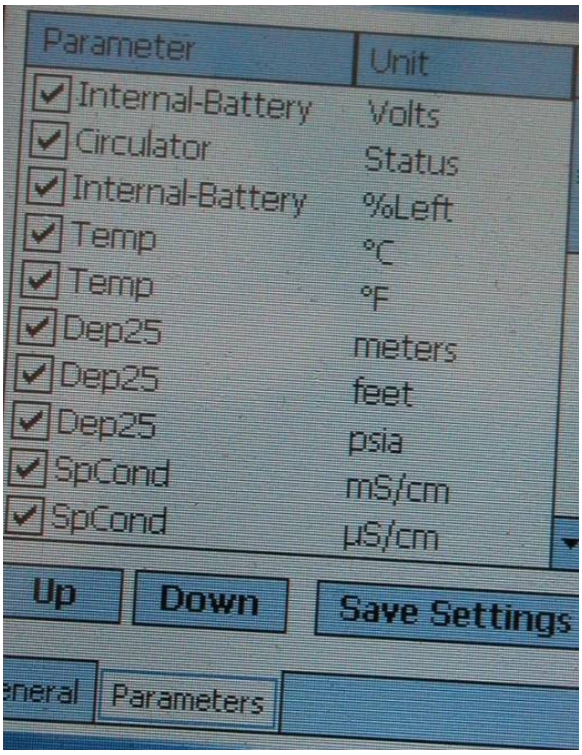


Figure 51. Log File Setup Screen "Parameters" tab.

9. The template will automatically populate the Parameters, Interval, Sensor Warm Up and Circulator fields with the correct values; however, you will need to update the start and end dates and times. **Note that if you are using an external power source you may need to manually select "External Battery- Volts" and "External Battery- %Left" from the "Parameters" tab.**
10. On the **"General"** tab in the **"Start"** field enter the current date.
11. In the **"Start"** field enter the time you want the multiprobe to begin taking measurements. Make sure to set this time for when the multiprobe will be secured in the housing and when you will no longer be in the stream. **When in doubt add at least 30 minutes to the current time. Make sure to record the deployment time in "Add/Edit Maintenance Record" form in the database.**
12. In the **"End"** field enter the expected return date. You should enter a date at least two months away from the current date. The reason for this is that if field conditions do not allow you to revisit the site, data will be collected until the batteries run out.
13. Double check that the following is correctly entered on the Log File Setup **"General"** tab:
    a. Interval: 1 hour
    b. Sensor Warm-up: 2 minutes
    c. Circulator: 2 minutes
    d. Audio: Off or Un-checked
14. Click on the **"Parameters"** tab (Figure 51).
15. Double check that the following parameters are selected:
    a. Internal Battery –Volts (if applicable)

b. External Battery- Volts (if applicable)
c. Circulator - Status
d. Internal Battery - %Left (if applicable)
e. External Battery- %Left (if applicable)
f. Temp - °C
g. Temp - °F
h. Dep25 – meters (Hydrolab 064 only)
i. Dep25 – feet (Hydrolab 064 only)
j. Dep25 – psia (Hydrolab 064 only)
k. SpCond – mS/cm
l. SpCond - µS/cm
m. Res – KÛ-cm
n. Sal – ppt
o. TDS – g/l
p. pH – units
q. ORP – mV
r. Turbidity – Rev
s. Turbidity – NTU
t. Turbidity – Volts
u. LDO% - Sat
v. LDO – mg/l
w. LDO _BP – mmHg
x. Date-Time – seconds

16. **The following should NOT be selected.**
    a. Temp - °K
    b. DepthX – volts
    c. DepthY - mvolts
17. When you have double checked all parameters, dates and times click **"Save Settings."** After saving there will be a short delay before you are returned to the Log File Screen.
18. Select the newly created log file. Make sure to double check the name and enter it in the **"Add/Edit Maintenance Record"** form in the database.
19. **Click "To Enable."**
20. The multiprobe log file has been created and should actively monitor data beginning at the time you specified. **Make sure to deploy the multiprobe and exit the stream before monitoring begins.**
21. **Double check that the ENTIRE UCBN multiprobe calibration/maintenance log form in the database is complete.**
22. Go to the main Hydras menu and select **"Disconnect."** You will be asked if you really want to disconnect click **"Yes."**

Deployment

External Power Source:

1. The calibration cable should remain attached to the multiprobe and battery.
2. Disconnect the Archer unit from the external power adapter cable.
3. Double check all connections and look for signs of rodent damage to the calibration cable.
4. Lower the multiprobe into the housing by holding onto the calibration cable.
5. Align the security cable holes in the cap with the holes in the housing.
6. Gently tap the top of the cap until it is seated against the top of the multiprobe housing or the cable lock holes are aligned.
7. Fasten the cable lock as shown in Figures 54(a) and 54(b).
8. Double check that the security cable is locked.
9. Coil extra calibration cable into the battery box.
10. Replace the lid on the battery box and secure it with locks.

Internal Power Source:

1. Disconnect the calibration cable from the multiprobe and the Archer unit. Loosely coil the cable so it is no smaller than 15” in diameter.
2. Re-attach the 9 pin connector cap. Make sure to purge all air from the cap by pressing in on the rubber sleeve near the multiprobe (Figure 52).



Figure 52. Replace the connection cap before attaching the mooring fixture.

3. Re-attach the mooring fixture, making sure that it is seated against the O-ring.
4. Attach the snap hook located under the housing cap to the mooring fixture.

5. Grasp the multiprobe in your left hand and the housing cap in your right and slowly lower the multiprobe into the housing (Figure 53).



Figure 53. Proper arrangement of the multiprobe cap, snap hook, mooring fixture, multiprobe and multiprobe housing.

6. Align the security cable holes in the cap with the holes in the housing.
7. Gently tap the top of the cap until it is seated against the top of the multiprobe housing or the cable lock holes are aligned.
8. Fasten the cable lock as shown in Figures 54(a) and 54(b).
9. Double check that the security cable is locked.



Figure 54a. Proper arrangement of the cable lock. Note that the cable passes through the housing and cap.



Figure 54b. Proper arrangement of the cable lock. Note that the cable passes through the housing and cap.

Transfer of Files to UCBN

After maintenance, calibration, and re-deployment, the downloaded data should be transferred from the Archer unit onto a PC that is capable of printing and has an internet connection. In addition, the

PC must have Microsoft Active Sync version 4.5 or higher. Microsoft Active Sync can be provided by the UCBN.

1. Connect the Archer unit to the PC by attaching the USB cable to port B on the side of the unit just below the buttons. Port B is on the left side of the 9-pin connection (Figure 30). Plug the other side into the computer's USB slot. When the connection has been made, Microsoft Active Sync will automatically detect the unit.
2. When Active Sync is connected, click **"Explore."** This will open the Mobile Device window which will allow you to navigate to different folders on the Archer unit (Figure 55).

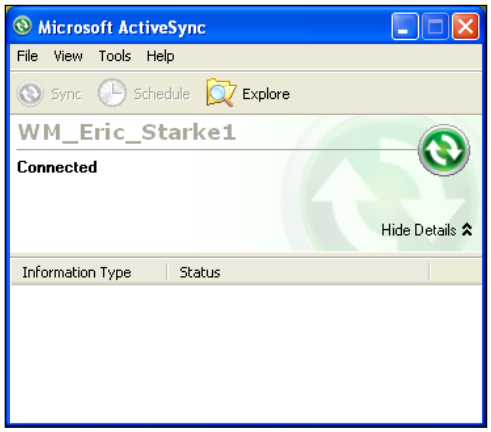


Figure 55. Microsoft Active Sync window.

3. Navigate to the correct folder containing the downloaded data.
4. Copy the correct file to your computer. Make sure the data remains on the Archer unit. Only UCBN personnel should remove deployment records from the Archer unit at the end of the monitoring season.
5. Attach the electronic file to an email and send it to the UCBN water quality project lead as soon as possible.

Post Revisit

1. Transfer all datasheets and a copy of the water quality monitoring station and instrumentation database to the UCBN.
    a. After the multiprobe has been re-deployed it is up to the Integrated Water Quality Protocol cooperator and UCBN staff to ensure that all datasheets, electronic or paper, are transferred to the UCBN Water Quality Project Lead. All log files and datasheets should be transferred via email or ground mail within a week of the multiprobe site revisit. **It is critical to transfer data to UCBN staff as soon as possible so any problems with the multiprobe can be fixed!**
2. Notify the UCBN if any standard solutions are running low

a. To avoid costly gaps in data, it is crucial that the UCBN be aware of standard solution levels. If you are low on standard solutions let the UCBN Project Lead know immediately so more can be ordered.

3. Check on the Water Quality Multiprobe
   a. UCBN Cooperators should check on the multiprobe at least once a week. The multiprobe sensors are very fragile and susceptible to desiccation. **IF THE SENSORS DRY OUT THEY MAY NEED TO BE REPLACED! Please check on the multiprobe at least once a week to avoid the cost of replacing the sensors. IF THE WATER IS NEAR THE WHITE LINE ON THE HOUSING THE HYDROLAB SHOULD BE REMOVED OR RECONFIGURED** (Figure 56).
   b. If you are in doubt about water levels, remove the sensor from the stream, conduct fouling and drift error checks and download the data from the last deployment. Place the multiprobe in its calibration/storage cup with ¼ inch of clear pH 4 standard and store it in the office. Call the Integrated Water Quality Project Lead to discuss relocating the multiprobe.



Figure 56. Multiprobe housing. The white line indicates low water. If the water level reaches the white line, the sensors have one inch of water covering them. Remove the multiprobe if water reaches this line.

Storage/End of Season Procedures

If the multiprobe is removed for storage during low water or at the end of the sampling season it should undergo routine maintenance and error checks. In addition, it should be prepared as follows before it is stored in a hard-sided case.

1. Scrubbed clean with a brush and soap and water
2. All O-rings lubricated
3. Batteries removed
4. The storage cup filled with ¼ inch of pH 4 buffer solution
5. The communication cable should be scrubbed with soap and water and rinsed
6. Coil the communication cable in a coil greater than 15" in diameter

If the multiprobe has been operated using an external power source such as a solar panel and battery, these items should be serviced before storage.

1. Remove any debris found in the battery box (grass, soil, etc.)
2. Disconnect the external power adapter and battery adapter from the calibration cable and battery. Coil all 3 cables and leave them in the same box.
3. Place the locks inside of the box
4. Remove the solar panel from the PVC post.
5. Wipe the dust off of the solar panel and coil the cable. (Keep the battery clips attached to the cable)

Conclusion

By the time you have made it to this point in the SOP you have successfully serviced and re-deployed the UCBN water quality multiprobe. Thanks for taking the time to download data, error check and calibrate. The long term data gained by continuous monitoring helps to determine the status and trend of water quality in each park. You have directly contributed to a better understanding of surface water in the National Park system. Thanks for your help! Keep up the good work!

Literature Cited

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 6: Decontamination of Equipment for Aquatic Invasive Species

Version 1.0 January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0

Note: This SOP describes the step-by-step procedures for decontamination of all water quality monitoring equipment. Decontamination will help prevent the spread of aquatic invasive species from one sample location to another. Procedures have been modified from the Great Lakes Network Large Rivers Water Quality Monitoring Protocol (2005). This SOP does not address terrestrial invasive species that may be encountered in the riparian areas.

Suggested Reading

Elias, J. 2005. Standard operating procedure #5, Decontamination of equipment to remove exotic species. in Magdalene S., D.R. Engstrom, and J. Elias. 2007. Large rivers water quality monitoring protocol, Version 1.0. National Park Service, Great Lakes Network, Ashland, Wisconsin.

Idaho Invasive Species Council Technical Committee. 2007. Idaho Aquatic Nuisance Species Plan. http://www.anstaskforce.gov/State%20Plans/Idaho_ANS_Plan_2007.pdf (Accessed 17 February 2016).

Meacham, P. 2001. Washington State Aquatic Nuisance Species Management Plan. http://wdfw.wa.gov/publications/00105/wdfw00105.pdf (Accessed 17 February 2016).

Montana Aquatic Nuisance Species (ANS) Technical Committee. 2002. Montana Aquatic Nuisance Species Management Plan. http://www.anstaskforce.gov/Montana-FINAL_PLAN.pdf (Accessed 17 February 2016).

Overview

Aquatic invasive species (AIS) are an issue of concern throughout the United States and within the Upper Columbia Basin Network. The UCBN will be monitoring water quality in diverse watersheds across 4 states; therefore, it is important to take a pro-active approach to preventing the spread of AIS between waterbodies.

Aquatic invasive species threaten aquatic ecosystems by disrupting community composition, outcompeting native species, and altering food chains. The ecologic and economic damages caused by the most serious aquatic invasive species top $8.9 billion/year and this cost continues to rise (Pimentel 2003). The states of Idaho, Montana, Oregon, and Washington all have distinct aquatic invasive species issues which are outlined in their respective Aquatic Nuisance Species Management Plan. These plans are listed under the Suggested Readings heading on the first page of this SOP. The Water Quality Project Leader is responsible for reviewing each state's Aquatic Nuisance Species Management Plan and educating the field crew about threats in each region. This SOP identifies the most likely AIS threats and addresses general decontamination procedures. In the future, if an explicit species threat develops, more specific procedures will be implemented.

Existing and Potential Aquatic Invasive Species Threats

Idaho

Idaho has fewer known invasive species than many other western states, yet it faces a serious threat of invasion due to interstate travel from one waterbody to another. The primary concern for invasive introduction comes from recreational use by anglers and boaters who frequent multiple waterbodies. Another, more specific source for invasion is barge traffic on the Snake River, near the port of Lewiston. The port of Lewiston is 465 miles upstream from the Pacific Ocean, which makes it the farthest inland sea port on the west coast. As a result, traffic entering this area has the potential to bring invasive species from miles downstream. Other threats to Idaho state waters include fish culture and aquarists.

Table 4 lists high priority aquatic nuisance species currently known to be in the state of Idaho and Table 5 lists the high priority aquatic nuisance species not currently found in Idaho. These lists serve as a general guide for AIS that may be encountered during work in Idaho but may not be all inclusive. For this reason the Water Quality Project Lead should be aware of changes in AIS status in and around UCBN parks.

Parks affected in Idaho include: City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), and Nez Perce National Historical Park (NEPE).

Table 4. High priority aquatic nuisance species known to be in Idaho (Idaho Invasive Species Council Technical Committee 2007).

Kingdom	Scientific Name	Common Name
Animal	*Corbicula fluminea*	Asian clam
	Potamopyrgus antipodarum	New Zealand mudsnail
	Myxobolus cerebralis	Whirling disease
Plant	*Potamogeton crispus*	Curly leaf pondweed
	Myriophyllum spicatum	Eurasian watermilfoil
	Myriophyllum aquaticum	Parrot feather milfoil
	Lythrum salicaria	Purple loosestrife
	Tamaricaceae spp.	Saltcedar
	Iris pseudacorus	Yellow flag iris

Table 5. High priority aquatic nuisance species not currently found in the state of Idaho, but likely to have a detrimental effect if introduced (Idaho Invasive Species Council Technical Committee 2007).

Kingdom	Scientific Name	Common Name
Animal	*Rhinogobius brunneus*	Amur goby
	Mylopharyngodon piceus, Hypophthalmichthys molitrix, H.nobilis, Ctenopharyngodon idella	Asian Carp (black, silver, bighead, grass (fertile variety))
	Gymnocephalus cernuus	Eurasian ruffe
	Myocastor coypus	Nutria
	Neogobius melanostomus	Round goby
	Orconectes rusticus	Rusty crayfish
	Channa argus, C. maculata, C. marulius, C. micropeltes	Snakehead fish, sp.
	Bythotrephes cederstroemii / Bythotrephes longimanus	Spiney/fishhook water flea
	-	Viral hemorrhagic septicemia
	Dreissena polymorpha / Dreissena rostriformis bugensis	Zebra mussel/Quagga mussel
Plant	*Egeria sp.*	Brazilian elodea
	Cabomba sp.	Carolina fanwort
	Hydrocharis morsus-ranae	Frog's bit / European frogbit
	Hydrilla verticillata	Hydrilla
	Eichhornia sp.	Water hyacinth
	Trapa natans	Water-chestnut

Montana

In Montana the primary vector for introduction and transport of aquatic invasive species (AIS) is recreational anglers and boat users. Another potential source of introductions are fish culture and aquarists. In addition, water diversions increase the connectivity of waterbodies and raise the likelihood of spreading AIS once they are established. Montana classifies AIS threats into 4 distinct classes depending on if they are currently established within the state and the degree to which management actions can control AIS. Tables 6 and 7 list and explain the classification of AIS. These lists serve as a general guide for AIS that may be encountered during work in Montana but may not be all inclusive. For this reason, the Water Quality Project Lead should be aware of changes in AIS status in and around UCBN parks.

Parks affected in Montana include Big Hole National Battlefield (BIHO).

Table 6. Priority Class 2* and Class 4** AIS for Montana

Kingdom	Scientific Name	Common Name	Class
Animal	*Rana catesbeiana*	Bullfrog	4
	Aeromonas salmonicida	Furunculosis (Bacteria)	4
	Potamopyrgus antipodarum	New Zealand mudsnail	2
	Oncorhynchus mykiss, Salvelinus fontinalis, Salvelinus namaycush, Salmo trutta, Micropterus spp., Sander vitreus, Esox lucius, etc.	Non-indigenous fishes (i.e., rainbow, brook, lake and brown trout, bass, walleye, Northern pike, and other warmwater fish species)	4
	Myxobolus cerebralis	Whirling disease	2
Plant	*Potamogeton crispus*	Curly leaf pondweed	4
	Butomus umbellatus	Flowering rush	4
	Lythrum salicaria	Purple loosestrife	4
	Tamaricaceae spp.	Saltcedar	4
	Iris pseudacorus	Yellow flag iris	4

***** Priority Class 2 species are **present and established in Montana and have the potential to spread in Montana** and there are limited or no known management strategies for these species (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

** Priority Class 4 species are **present and have the potential to spread in Montana,** but there are management strategies available for these species (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

Table 7. Priority Class 1* and Class 3** AIS for Montana.

Kingdom	Scientific Name	Common Name	Class
Animal	*Mylopharyngodon piceus, Hypophthalmichthys molitrix, H.nobilis, Ctenopharyngodon idella*	Asian Carp (black, silver, bighead, grass (fertile variety))	1
	Gymnocephalus cernuus	Eurasian ruffe	1
	None Specified	Hematopoietic Necrosis (IHN)Virus	1
	None Specified	Heterosporosis (Parasite)	1
	Myocastor coypus	Nutria	1
	Neogobius melanostomus	Round goby	1
	Orconectes rusticus	Rusty crayfish	1
	Bythotrephes cederstroemii	Spiney water flea	1
	Tinca tinca	Tench	1
	Stizostedion lucioperca	Zander	1
	Dreissena polymorpha	Zebra mussel	1
	Bothriocephalus acheilognathi	Asian tapeworm	3
Plant	*Egeria sp.*	Brazilian elodea	1
	Myriophyllum spicatum	Eurasian watermilfoil	3
	Hydrilla verticillata	Hydrilla	1

*Priority Class 1 species are **not known to be present in Montana, but have a high potential to invade** and there are limited or no known management strategies for these species (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

Priority Class 3 species are **not known to be established in Montana and have a high potential for invasion and appropriate management techniques are available (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

Oregon

The Oregon Aquatic Nuisance Species Plan does not designate specific threats to aquatic resources but rather lists all non-indigenous species existing in Oregon, Oregon species introduced outside of their historic range, and non-indigenous species prohibited by state programs. Many of the AIS listed by Idaho's Aquatic Nuisance Species Plan are the same as those listed as non-indigenous by Oregon. For this reason the UCBN will operate on the premise that threats to freshwater are similar to those found in Idaho. These threats can be found in Tables 4 and 5 under the Idaho section of this SOP.

Parks affected in Oregon include: John Day Fossil Beds National Monument (JODA).

Washington

The primary mechanisms of AIS introduction in the state of Washington are: aquarium trade, biological control, transport via vessel fouling and ballast water discharge, recreational boating and fishing, research activities, and movement of nonnative species through channels, canals and locks. Washington classifies AIS threats into 4 distinct classes depending on if they are currently established within the state and the degree to which management actions can control AIS. Tables 8 and 9 list and explain the classification of AIS. These lists serve as a general guide for AIS that may be encountered during work in Washington but may not be all inclusive. For this reason, the Water Quality Project Lead should be aware of changes in AIS status in and around UCBN parks.

Parks affected in Washington include: Whitman Mission National Historical Site (WHMI), and Lake Roosevelt National Recreational Area (LARO).

Table 8. Includes freshwater class1* and class 4** aquatic invasive species.

Kingdom	Scientific Name	Common Name	Class
Animal	*Gymnocephalus cernuus*	Eurasian ruffe	1
	Eriocheir spp.	Mitten crab	1
	Neogobius melanostomus	Round goby	1
	Bythotrephes cederstroemi	Spiny water flea	1
	Dreissena polymorpha	Zebra mussel	1
Plant	*Salvinia molesta*	Giant salvinia	4
	Hydrilla verticillata	Hydrilla	1
	Eichornia crassipes	Water hyacinth	1
	Trapa natans	Water-chestnut	1

* Management Class 1 - Management activities focus on preventing the introduction and eradicating pioneering populations of nonnative plant and animal species that currently **are not present in the state, or that have limited populations within state waters**.

** Management Class 4 - This group consists of nonnative species that **are not present in Washington** for which we lack adequate information to understand their potential to be invasive, or their interaction and effects on native species. These species warrant further evaluation and research to ascertain the potential for impact and control. Until information is available that would place them in management class two or three, they are treated as management class 1 species.

Table 9. Freshwater class 2* and 3* aquatic invasive species.

Kingdom	Scientific Name	Common Name	Class
Animal	*Procambarus clarkii*	Louisiana red swamp crayfish	2
	Potamopyrgus antipodarum	New Zealand mudsnail	2
	Corbicula fluminea	Asian clam	3
	-	Nonnative amphibians	3
	-	Nonnative fish	3
Plant	*Egeria densa*	Brazilian elodea	2
	Phragmites australis	Common reed	2
	Myriophyllum spicatum	Eurasian watermilfoil	2
	Myriophyllum aquaticum	Parrot feather milfoil	2
	Lythrum salicaria	Purple loosestrife	2
	Tamarix ramosissima	Saltcedar	2

* Management Class 2 - Management activities focus on mitigating the impact, controlling population size and preventing dispersal to other water bodies of nonnative plant or animal species that are present and established in Washington. This class **includes nonnative species approved for import and managed under other regulations** - such as aquacultural species.

** Management Class 3 **- Includes nonnative species that are established throughout Washington and that have an impact, but for which there are no available or appropriate management techniques.** These species warrant further evaluation and research to ascertain the potential for impact and control, and to prevent establishment in new waterbodies.

Procedures

Before any waterbody can be entered for sampling purposes all equipment must be decontaminated to remove exotic species. Decontamination should be conducted as soon as a waterbody has been sampled, and before sampling occurs in another waterbody. These procedures are to be followed in all waters, not only those with current AIS issues. To prevent any introductions/dispersal of aquatic invasive species (AIS) all UCBN waterbodies are assumed to be infested.

The following procedures have been directly taken or modified from the Great Lakes Network Standard operating procedure #5, Decontamination of Equipment to Remove Exotic Species (Elias 2005).

1.0 Procedure at non-remote locations, when tap water is available

1.1 When finished at a segment of river that is known or suspected to be infested with exotic species:

- remove or rinse mud, plant material, mussels, and other visible organic material from boat/canoe, paddles/oars, waders, boots, and all sampling equipment;
- soak all nets, waders, and boots in a 2% Sparquat 256 solution for 10 minutes or spray a 10% Sparquat 256 solution on equipment and let stand for 5 minutes; Sparquat is preferred over bleach since it is less harsh on nets and wader material.
- thoroughly rinse disinfectant solution off sampling equipment;

- let equipment dry for 10 days. If it is not possible to let equipment dry, follow the procedure outlined in section 1.2.

1.2 Before entering a new segment of the river that is not known to contain exotic species:

- on vegetated land, use hose with spray nozzle and scrub brush to rinse and scrub with tap water and scrub-brush all sampling equipment, boat/canoe, paddles/oars, boots; discard water on land, away from the bank of the river, avoiding impervious surfaces and slopes where rinse water might run directly into the river;
- use a bottle or toilet brush to clean the inside of the continuous water quality monitor housing;
- pay particular attention to ropes, cracks, and crevices in equipment, and rinse well;
- visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed.

2.0 Procedure at remote locations, when tap water is not available

2.1 When finished at a segment of river that is known or suspected to be infested with exotic species:

- remove and rinse mud, plant material, mussels, and other visible organic material; boat/canoe, paddles/oars, waders, boots, and all sampling equipment;
- run hand up and down ropes attached to all equipment and anchor to dislodge mud, plant material, and organisms;
- pay particular attention to cracks and crevices in equipment when rinsing;
- visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed;
- let equipment dry for 10 days. If it is not possible to let equipment dry, follow the procedure outlined in section 2.2.

2.2 Before entering a new segment of the river that is not known to contain exotic species:

- use a clean and dry container, such as a bucket to collect river water;
- on vegetated land away from the bank of the river, rinse and scrub with (clean) scrub-brush all sampling equipment, boat/canoe, paddles/oars, boots, etc. Avoid rinsing on impervious surfaces or slopes where rinse water might run directly into the river;
- use a bottle or toilet brush to clean the inside of the continuous water quality monitor housing;
- pay particular attention to ropes, cracks, and crevices in equipment, and rinse well;
- visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed.

3.0 Regardless of Remoteness

- When possible, avoid using boats and other equipment on both infested and un-infested waters. Designate a set of equipment for both types of waters.
- Always begin sampling with waterbodies not known to harbor exotic species; sample waterbodies known or suspected to contain exotic species last.
- Thoroughly clean or disinfect all equipment between use in infested and un-infested waters.

- Use a 2-10% Sparquat 256 or bleach solution as a disinfectant. Sparquat is preferred as it is less harsh on equipment. Sparquat is available as a commercial cleaner manufactured by the Spartan Chemical Company, Inc.
- When possible, allow boat/canoe and paddles/oars to dry for five days and all other sampling equipment such as nets, waders, and boots to dry for 10 days after sampling a water body known to be infested with AIS.

Literature Cited

Elias, J. 2005. Standard operating procedure #5, Decontamination of equipment to remove exotic species. *in* Magdalene S., D.R. Engstrom, and J. Elias. 2007. Large rivers water quality monitoring protocol, Version 1.0. National Park Service, Great Lakes Network, Ashland, Wisconsin.

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Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 7: Continuous Water Quality Record Processing

Version 1.9 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	June 2011	UCBN Aquatic Biologist	Updates to site inspection summary worksheet section. These changes reflect the use of a field meter during the assessment of sensor fouling. Updates to workflow and AQUARIUS toolbox arrangement.	New methods insure better evaluation of data quality and record maintenance within AQUARIUS software.	1.1
1.1	February 2016	UCBN Aquatic Biologist	Update to site inspection summary worksheet section to reflect the use of an Access database. Update to record processing in Aquarius. Added overview of Aquarius software, new citations and links to NPS-WRD guidance docs.	The UCBN now uses an updated database that auto populates the site inspection worksheet. The UCBN now uses a server based Aquarius Time-Series interface instead of a standalone instance.	1.9

Note: This SOP describes the step-by-step procedures for processing continuous water quality monitoring log files (records) after they have been successfully downloaded from the multiprobe and transferred to the UCBN with the accompanying Access Calibration/Maintenance Log. The UCBN has successfully used Aquarius Time-Series Software to meet its water quality record processing needs but its use does not constitute an endorsement by the U.S. Government.

Required Reading/Training

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

USGS training “Guidelines and Standard Procedures Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting. In person course found via DOI Learn.

Recommended Training

AQUARIUS Time-Series 101, Water Quality Record Computation Training. Offered by Aquatic Informatics.

Overview

This SOP is meant to be a guide for processing records (log files) from continuous water quality monitoring stations within the UCBN. Currently all water quality monitoring in the UCBN is conducted with Hach MS5 Hydrolabs also referred to as multiprobes. It is important that all

multiprobe calibration and maintenance procedures be followed from SOP #5. Processing of log files that have been improperly configured or downloaded from incorrectly serviced multiprobes will not be covered by this SOP. In addition, it is not advisable to process water quality log files without knowledge of monitoring locations and general knowledge of water chemistry daily cycles and parameter relationships. At a minimum it is required that personnel read the Record Computation section of Wagner et al. 2006 (pages 22-35) prior to processing water quality records. This guidance document provides an excellent introduction to data corrections for fouling and calibration drift.

In June 2008, the UCBN worked closely with the National Park Service-Water Resource Division to purchase and pilot test Aquarius Time-Series Software produced by the Aquatic Informatics Company in Vancouver, British Columbia. During pilot testing this software greatly streamlined record processing and allowed the UCBN to apply and track data corrections, deletions, and data quality. Between 2008 and 2014, the UCBN used Aquarius Time-Series Software-Workstation (Whiteboard) installed as a standalone instance on a local computer. As more networks began to use Aquarius Time-Series, the Inventory and Monitoring central office in Fort Collins CO began to host Aquarius Springboard and Aquarius Server. The server based instance of Aquarius began to serve as a central repository for UCBN continuous monitoring data beginning in 2015. All data 2008-2014 were migrated onto the server in 2015. Aquarius Server and the Springboard interface have further streamlined the efficiency of continuous water quality data management.

It should be noted that Aquarius time series software may not directly meet every need but the data can be easily exported for subsequent analysis in other programs. The UCBN has successfully used Aquarius to meet its water quality record processing needs but its use does not constitute an endorsement by the U.S. Government.

Pre-Processing Requirements

After UCBN personnel have completed a multiprobe site revisit the Water Quality Project Lead should have the following prior to record processing:

- Access to discharge information from the nearest United States Geological Survey (USGS) gage (See Appendix D for sources of water quality/quantity data).
- Access to weather information from the nearest National Weather Service station.
- Log file from the multiprobe deployment (Comma delimited text file) with appropriate naming convention and parameters (see SOP #5).
- Completed Calibration and Maintenance Log in the UCBN Water Quality Monitoring Station and Instrumentation database for the same deployment period as the log file. (See SOP #5).
- Site Inspection Summary Form generated from the UCBN Water Quality Monitoring Station and Instrumentation database (See directions below).
- Access to the Inventory and Monitoring Central Office Aquarius Time Series Software instance on the GETT1 server. If you haven't used the NPS servicewide Aquarius licenses previously, you must first request access from Water Resources Division (Dean Tucker).
    - Using the NPS servicewide Aquarius licenses (including the Workstation/Whiteboard and Springboard interfaces and associated database access) requires that a user:
        1. be included in the Aquarius Active Directory group,

2. be added as a valid user of the Aquarius system, and
3. make a remote desktop connection to the server in Fort Collins, CO that hosts Aquarius.

General Workflow

1. Complete Calibration and Maintenance record in the UCBN Water Quality Monitoring Station and Instrumentation database
2. Generate Site Inspection Summary Worksheet in the UCBN Water Quality Monitoring Station and Instrumentation database
3. Upload data log file (Aquarius Springboard Procedure)
4. Data correction/deletion of erroneous data (Aquarius Springboard Procedure)
5. Data grading (Aquarius Springboard Procedure)
6. Descriptive Statistics (Aquarius Whiteboard Procedure)
7. Graphing (Aquarius Whiteboard Procedure)
8. Reporting (Aquarius Springboard or Whiteboard Procedure)
9. Export (Aquarius Springboard or Whiteboard Procedure)

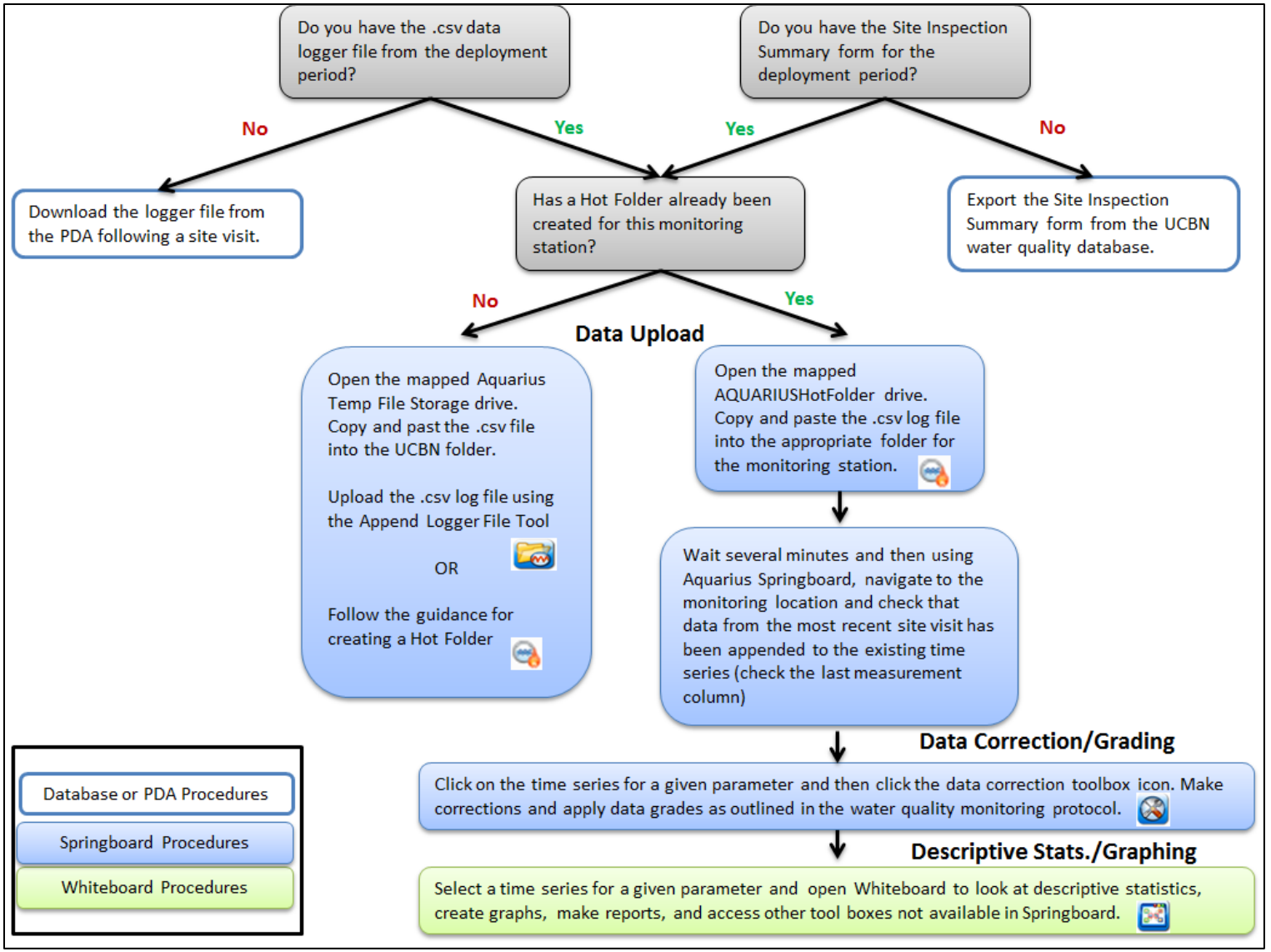


Figure 57. General data processing workflow.

Generation of Site Inspection Summary Worksheet

The site inspection summary worksheet was developed to aid in the assessment of data quality and corrections for calibration drift and fouling. The UCBN is using data correction and grading criteria established and used by the United States Geological Survey (USGS) (Wagner et al. 2006). The site inspection summary worksheet follows the general design of the USGS - QW Ultimate Worksheet v.2.51.

Procedure

1. User Input

The site inspection summary form can be accessed by opening the UCBN Water Quality Station and Instrumentation database and clicking on the **"UCBN Site Inspection Form"** button from the main menu. In the next window, select the correct **park, stream, site ID, and date of revisit** (Figure 58). From the field meter drop down, select if a field meter was used (Figure 58). The instrument serial number will auto populate for the site/date of revisit. After all selections are made, the full site inspection form will open and the white cells will populate with data originally entered during the site revisit (Multiprobe Calibration/Maintenance Log in the database). The remaining cells (blue, red, and green) are calculated values (Figure 59). **Double check all data shown in the fouling and calibration drift sections (Figure 59). If changes need to be made, you will need to open the existing calibration/maintenance log record via the main menu. After any changes are made, re-open the site inspection summary.**

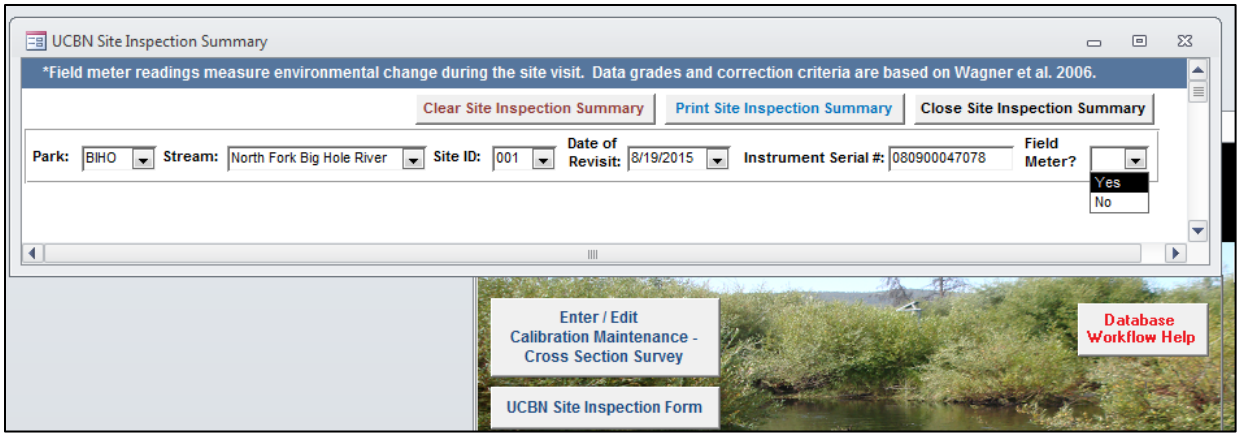


Figure 58. UCBN Site Inspection Summary user input.

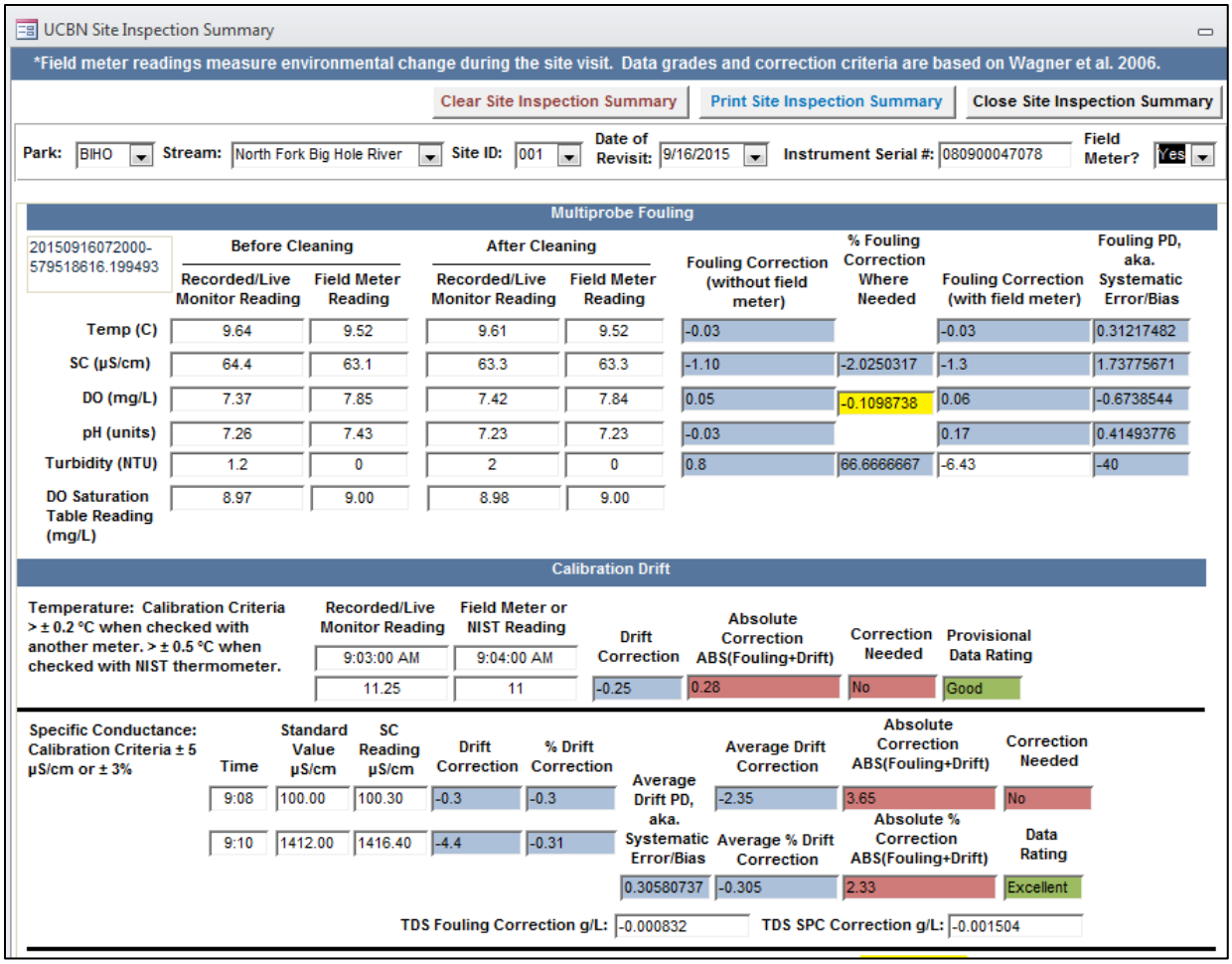


Figure 59. Populated UCBN Site Inspection Summary.

2. Assessment of Fouling Error

Fouling error is the error in measurements caused by biological growth and/or sediments on the sensors. "The observed difference between the initial sensor reading and the cleaned-sensor readings (in stream water) is a result of fouling" (Wagner et al. 2006). **The amount of fouling is indicated in the "Multiprobe Fouling" section (blue cells) of the UCBN Site Inspection Summary (Figure 59).** It is important to note that these values will only be applied as a correction if the absolute value of fouling and drift error exceeds the calibration criteria listed in Table 10. Double check all fouling correction values to make sure they reflect the original Calibration and Maintenance Log. It is especially important to check the degree of fouling reported on each sensor (Multiprobe Calibration/Maintenance Log- Maintenance Record, Figure 60). If very little fouling was indicated yet fouling error is high, it may indicate that the sensor is faulty. The calibration drift error will also reflect problematic sensors. Note that the "Fouling Correction (with field meter)" cells will remain the same as those in the "Fouling Correction (without field meter)" if no field meter is used to evaluate changes in environmental conditions during fouling assessment (SOP#5).

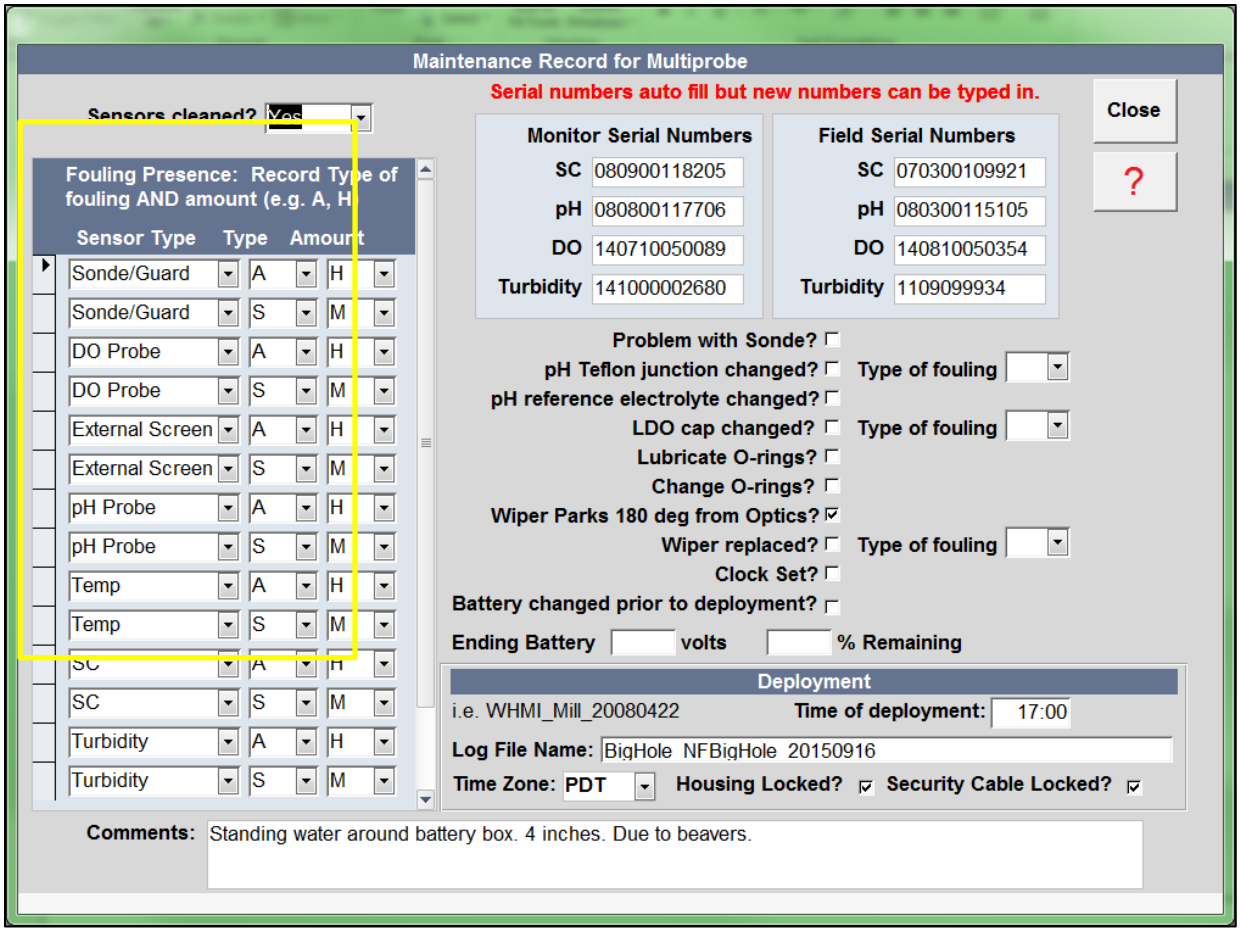


Figure 60. Multiprobe Maintenance Record. Fouling Presence outlined in yellow.

Table 10. Criteria for water-quality data corrections, modified from Wagner et al. 2006.

Parameter	**Data Correction Criteria** (Apply correction when the sum of the absolute values for fouling and calibration drift error exceeds the value listed.)
Temperature	± 0.2 °C when checked with another meter ± 0.5 °C when checked with NIST thermometer
Specific Conductance	± 5 µS/cm or ± 3% of the measured value, whichever is greater
Dissolved Oxygen	± 0.3 mg/L
pH	0.2 pH units
Turbidity	± 0.5 turbidity units or ±5% of the measured value, whichever is greater

3. Assessment of Calibration Drift Error

Calibration drift error is the error in measurements caused by changes in the sensors due to electronic drift over time. “The difference between the cleaned-sensor readings in calibration standard solutions and the expected reading in these solutions is the result of sensor calibration drift error” (Wagner et al. 2006). The degree of calibration drift is indicated in **the “Calibration Drift” section (blue cells) of the UCBN Site Inspection Summary** (Figure 61). The “Average Drift Correction” field is

important since it is used to determine if a correction needs to be applied (Figure 61). **Note that the UCBN will be applying a correction if the combined absolute value of the fouling and the average drift correction error exceed the calibration criteria.** It is also important to quickly check the "Absolute Correction" field against the data correction criteria given in Table 10. If the summary worksheet indicates it is necessary (red cells), corrections will be applied within the Aquarius software package.

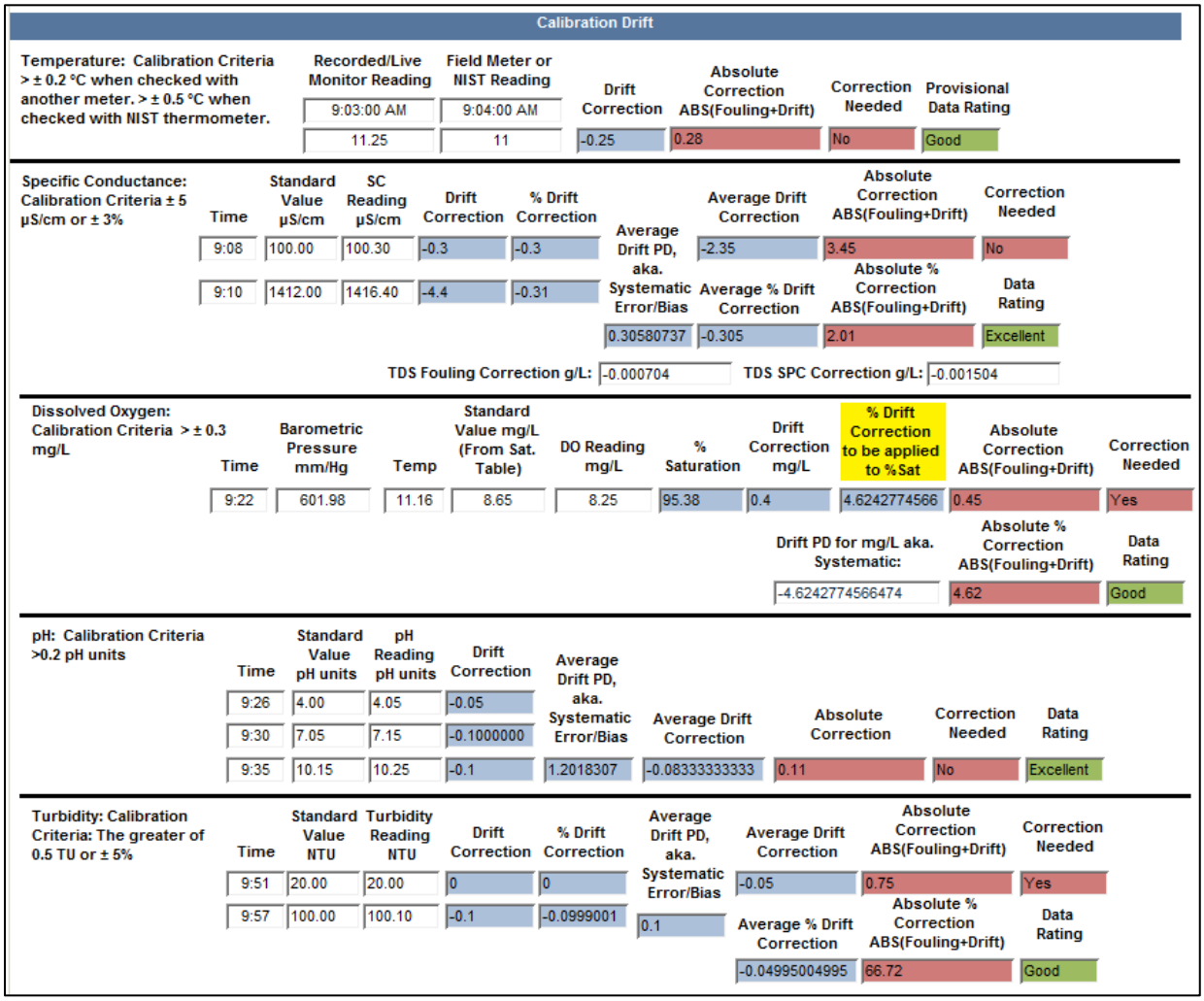


Figure 61. UCBN Site Inspection Summary-Calibration Drift Section

4. Data Grading

Green cells in the UCBN Site Inspection Summary (Figure 61) will indicate, data ratings/grades based on the absolute correction mentioned in the previous section and a standard set of accuracy ratings developed by the USGS (Table 11).

It is important to review data grades relative to notes recorded in the Calibration and Maintenance Log (Notes and Comments recorded during site visits are automatically shown at the bottom of the Site Inspection Summary). This is an important step because these ratings, on occasion, may not

accurately portray the quality of data due to specific field conditions. For example, if actual water temperature changes during the fouling error check procedure, it might cause an artificially high fouling error. As a result, the data rating may be reported as "poor" when, in fact, the rating should have been "good." This data rating may need to be adjusted based on professional judgment. This simple example highlights several important points. First, it shows the importance of a field meter or at a minimum, a NIST thermometer to track actual conditions during calibration. Second, it highlights the importance of the professional judgment needed to process water quality records. Data ratings (grades) will be applied to the data within the Aquarius software package as described in the next section. **If a data rating is suspected of being incorrect and will be recorded in Aquarius differently than the generated rating (in the site inspection summary worksheet), the modification should be noted in the comments filed (calibration and maintenance log) and within Aquarius when the data grade is applied.**

Table 11. USGS accuracy ratings of continuous water-quality records or "data grade" (modified from Wagner et al. 2006).

Measured field parameter	**Rating of accuracy (data grade)** (Based on combined fouling and calibration drift corrections applied to the record) **Excellent**	**Good**	**Fair**	**Poor**
Water Temperature	≤ ± 0.2 °C	>± 0.2-0.5 °C	>± 0.5-0.8 °C	>± 0.8 °C
Specific Conductance	≤ ± 3%	>± 3-10%	>± 10-15%	>± 15%
Dissolved Oxygen	≤ ± 0.3 mg/L or ≤ ± 5%, whichever is greater	>±0.3-0.5 mg/L or >±5-10%, whichever is greater	>± 0.5-0.8 mg/L or >± 10-15%, whichever is greater	>± 0.8 mg/L or >± 15%, whichever is greater
pH	≤ ± 0.2 units	>± 0.2-0.5 units	>± 0.5-0.8 units	>± 0.8 units
Turbidity	≤ ± 0.5 NTU or ≤ ± 5%, whichever is greater	>± 0.5-1.0 NTU or >± 5-10%, whichever is greater	>± 1.0-1.5 NTU or >± 10-15%, whichever is greater	>± 1.5 NTU or >± 15%, whichever is greater

5. Print the Site Inspection Summary

After the Site Inspection Summary has been carefully reviewed, it should be printed as a PDF using the "Print Site Inspection Summary" button at the top of the Site Inspection Summary Form (Figure 61). PDF versions of the site inspection summary will be automatically saved in the folder associated with the database and will be used during data entry in Aquarius. In addition, the summaries provide a concise record of data quality, outside of the Aquarius interface, that may be referred to months or years after the initial processing of data.

Introduction to Aquarius Time-Series Software System

Aquarius Time-Series software (product of Aquatic Informatics) facilitates the management of continuous water quality data and consists of several distinct systems/interfaces including:

1. **Aquarius Server and Database**
    - Aquarius Server (not to be confused with the server hardware – GETT1 – that runs the Aquarius system) is a component of the Aquarius software system that is 'middleware'

between Aquarius Workstation and the Aquarius Database. It connects Workstation Whiteboards to the Aquarius Database through the 'Read from Server' and 'Write to Server' tools. The database is a central repository for all NPS I&M continuous water quality data.

2. **Aquarius Springboard**
   - Springboard is a production-oriented interface, which simplifies Aquarius usage by taking a location-centric view of time series data. It provides a means to manage projects, locations, field visits, and time series as well as to save all that data in the Aquarius Database. Springboard does not include all the analytical toolboxes available in Workstation/Whiteboard – just the basic toolboxes for importing/appending time series, managing folders, locations, and field visits; Quick View; Data Correction; Exporting, and Reporting (Modified from NPS Water Resource Division (WRD) Aquarius Guidance). More information on this interface is given in the Records Processing in Aquarius Springboard section below.
3. **Aquarius Time-Series Workstation/Whiteboard**
   - Can be installed locally or used via connection to the central office server. Contains toolboxes for data processing, corrections, visualization, reporting, and statistics. This interface offers processing/analysis tools not available in Aquarius Springboard. Workstation/Whiteboard can be used to read and write data to Aquarius Server/Database. (Modified from WRD Aquarius Guidance)More information on this interface is given in the Records Processing in Aquarius Whiteboard section below.
4. **Aquarius Web Portal**
   - Aquarius Web Portal is a public facing website that allows data stored in the Aquarius database to be visualized and downloaded on demand. Data is only available to the public if the appropriate permissions have been set in Aquarius Springboard. Aquarius software is not required to view the data. https://irma.nps.gov/aqwebportal/

This SOP is concerned with record processing and will focus on the first 3 bullets shown above. Data processing procedures are accomplished in both the Aquarius Springboard and Aquarius Whiteboard interfaces.

As mentioned in the Overview section above, the UCBN has transitioned from using a standalone workstation instance of Aquarius (Whiteboard) to a NPS service wide Aquarius licenses hosted on a central server. This license includes the Workstation/Whiteboard and Springboard interfaces and associated database access.

NPS Water Resource Division offers guidance on connecting to and interface with the server, Springboard, and Whiteboard. Guidance documents are stored on the UCBN internal server in the integrated water quality folder (Figure 62) and should be updated as new versions become available. Documents in this folder have been placed in the order in which they will generally be needed for data processing. These documents will be referred to throughout this SOP. The original source for these is documents was http://nrdata.nps.gov/Programs/Water/Aquarius/AquariusVideos.htm (Accessed 03/02/2016) future updates will likely be posted to the same site.

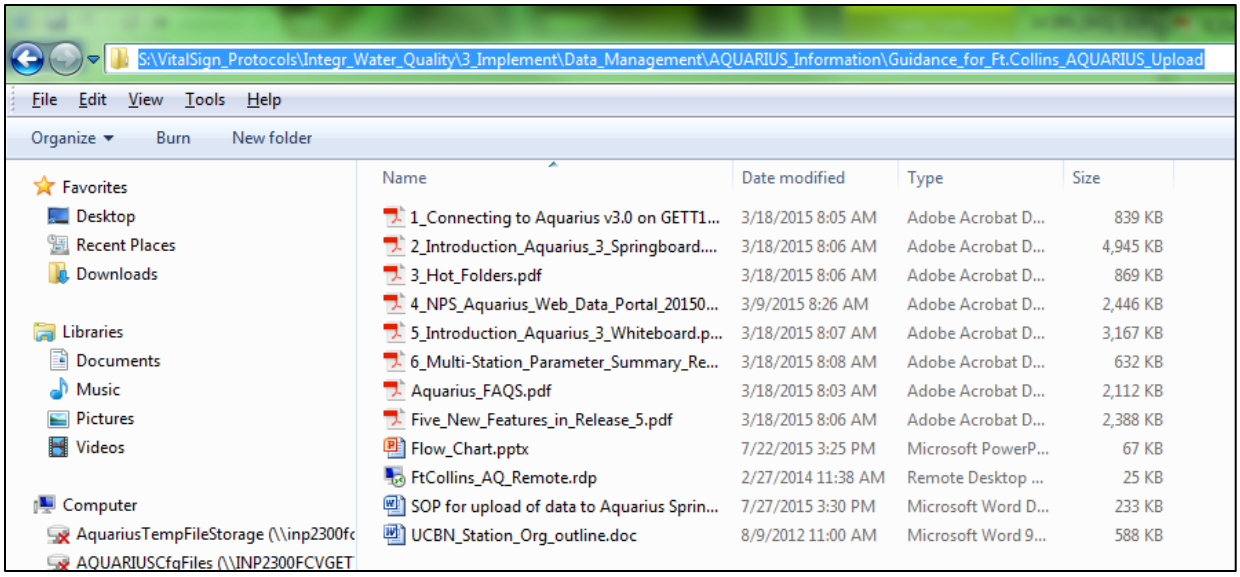


Figure 62. NPS Water Resource Division (WRD) Aquarius guidance documents on UCBN server. (S:\VitalSign_Protocols\Integr_Water_Quality\3_Implement\Data_Management).

Record Processing in Aquarius Springboard/Whiteboard

Monitoring Locations (Station) Overview

All projects and locations have already been created in the Aquarius Database for established UCBN water quality monitoring stations. Within Aquarius Springboard, UCBN locations can be found within the Upper Columbia Basin project folder (left pane, Figure 63). When the UCBN folder has been selected, all locations are visible in the Locations pane (right pane, Figure 63). Location identifiers are Park Code_Stream_Station Number. Note that monitoring stations that have been moved or relocated will need a new station number and a new location defined within Aquarius. An example can be seen in Figure 63, NEPE_Lapwai_001 and 002. Managing locations and establishing new locations are covered in WRD guidance document "Aquarius v.3.0 Release 5 Springboard Introduction." Once a location has been selected, available data sets can be viewed by clicking on "Go To Data Sets" icon .

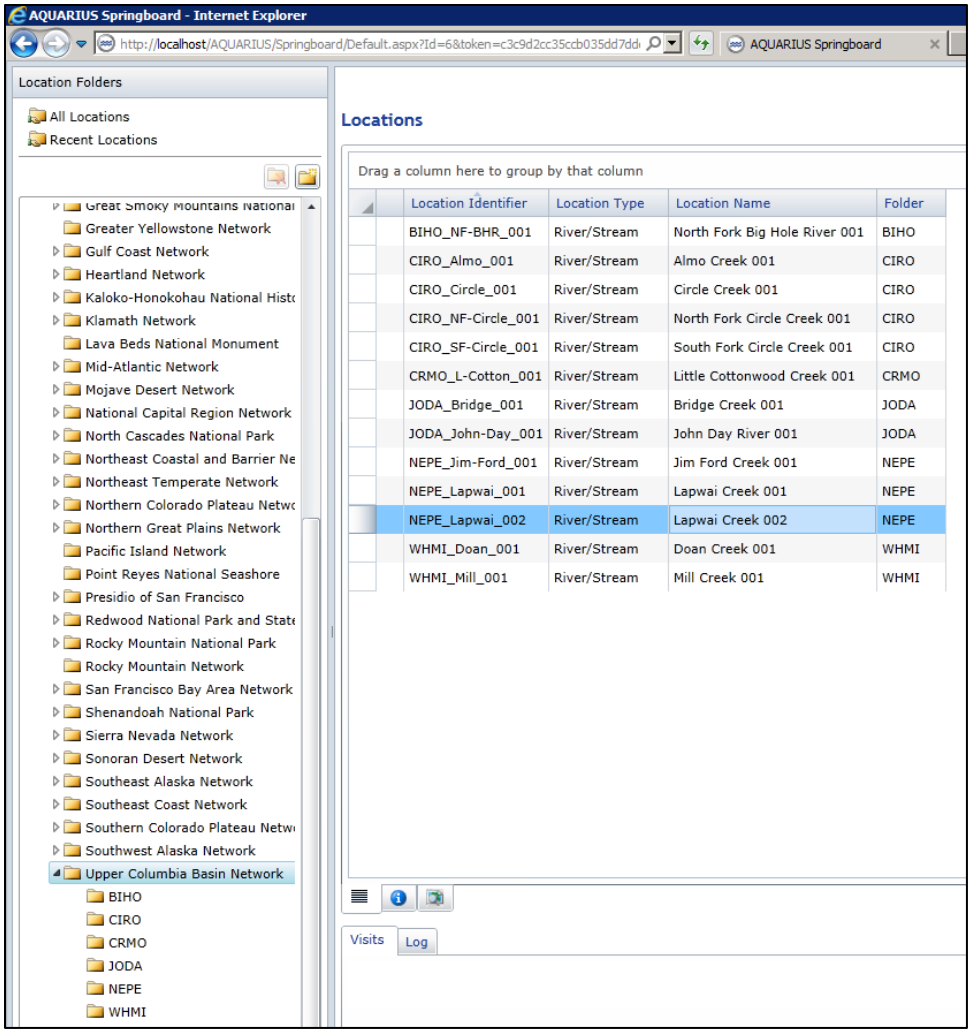


Figure 63. Locations screen in Aquarius Springboard.

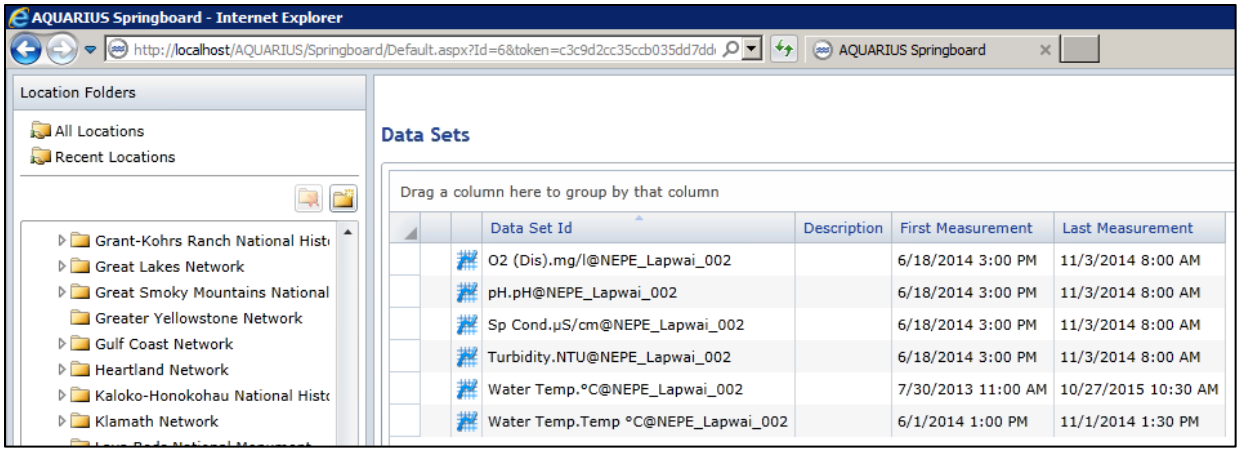


Figure 64. Data sets screen for NEPE_Lapwai_002.

Springboard Procedures

The following are procedures for upload of continuous water quality data to the Aquarius database, and data processing via the Aquarius Springboard interface. **In order to complete all procedures, the following are required:**

1) Review WRD guidance document "Aquarius v.3.0 Release 5 Springboard Introduction." For a video demonstration, see: http://nrdata.nps.gov/Programs/Water/Aquarius/Videos/Introduction_Aquarius_3_Springboard_R5/Introduction_Aquarius_3_Springboard_R5.html (Accessed 02/29/2016).

2) Establish a remote desktop connection to the server in Fort Collins, CO that hosts Aquarius. See WRD guidance document "Accessing Aquarius 3.0 on GETT1." For a video demonstration, see: http://nrdata.nps.gov/Programs/Water/Aquarius/Videos/Accessing_Aquarius_Whiteboard_and_Springboard_on_GETT1/Accessing_Aquarius_Whiteboard_and_Springboard_on_GETT1.html (Accessed 02/29/2016)

3) Once you have remotely connected, map the following drives:
   a. \\INP2300FCVGETT1\AquariusTempFileStorage
   b. \\INP2300FCVGETT1\AQUARIUSHotFolders
   c. \\INP2300FCVGETT1\AQUARIUSCfgFiles

4) Launch Springboard from the AQUARIUS Assistant (remote) icon located in the Windows Task Bar in the lower right corner of the screen.

Data Upload

Prior to completion of these steps place the log file (.csv) in the UCBN folder found on the Aquarius Temp File Storage mapped drive listed above. Within Springboard, navigate to the location for which you wish to upload data. The following are 2 methods for upload of time series logger files to the Aquarius Database via Springboard.

1) Append Logger File tool:  This method is recommended for non-reoccurring or infrequent uploads (e.g. infrequently collected temperature data for a station). In addition, uploads will need to be completed using this tool for the first site visit each season (to define the configuration of the logger file). This tool also can also be used to configure hot folders.

   Details of Append Logger File tool can be found in the WRD guidance document "Aquarius v.3.0 Release 5 Springboard Introduction" page 8.

   Important note:

   Make sure to save the configuration file created in this step as it can be used again for future uploads and during creation of a Hot Folder.
   - Name the configuration file something that will be useful to future users. For example, the Hydrolab deployed at Nez Perce National Historical Park (NEPE) is number #054 so its configuration file name is NEPE_054_Configuration.txt.cfg.
   - Save configuration files to the mapped AQUARIUSCfgFiles drive.

2) Hot Folder:  Hot folders are used for uploading reoccurring consistently formatted data from a single monitoring station (i.e. monthly site visits). These folders allow for "drag and drop" upload and append to an existing time series. Given that hot folders are configured to receive data in a consistent format and append that data to an existing time series, they must be reconfigured each season for a given monitoring station and instrument.

   Details about how to use hot folders can be found in the WRD guidance document "Aquarius Hot Folders". For a video demonstration see: http://nrdata.nps.gov/programs/water/aquarius/Videos/HotFolders/HotFolders.html (Accessed 02/29/2016).

   Existing hot folders are located on the mapped AQUARIUSHotFolders drive.

After data has been successfully uploaded and appended to data sets for a given location, you can proceed with data corrections and grading outlined below.

Data Corrections

Data correction and data grading are completed using the data correction toolbox (Figure 65). For information on data grading refer to the next section. To complete data corrections you should have prior knowledge about the deployment location (i.e., discharge, weather, basin geology, etc.). This knowledge will allow you to interpret the data and look for false spikes/outliners versus real spikes.

Some parameters may be interpreted more easily by looking at several parameters simultaneously (i.e., dissolved oxygen, water temperature). Removal of false spikes and corrections relies on professional judgment. **To complete data corrections, you will need to refer back to the site inspection summary form generated from the UCBN Water Quality Monitoring Station and Instrumentation Database (see above).**

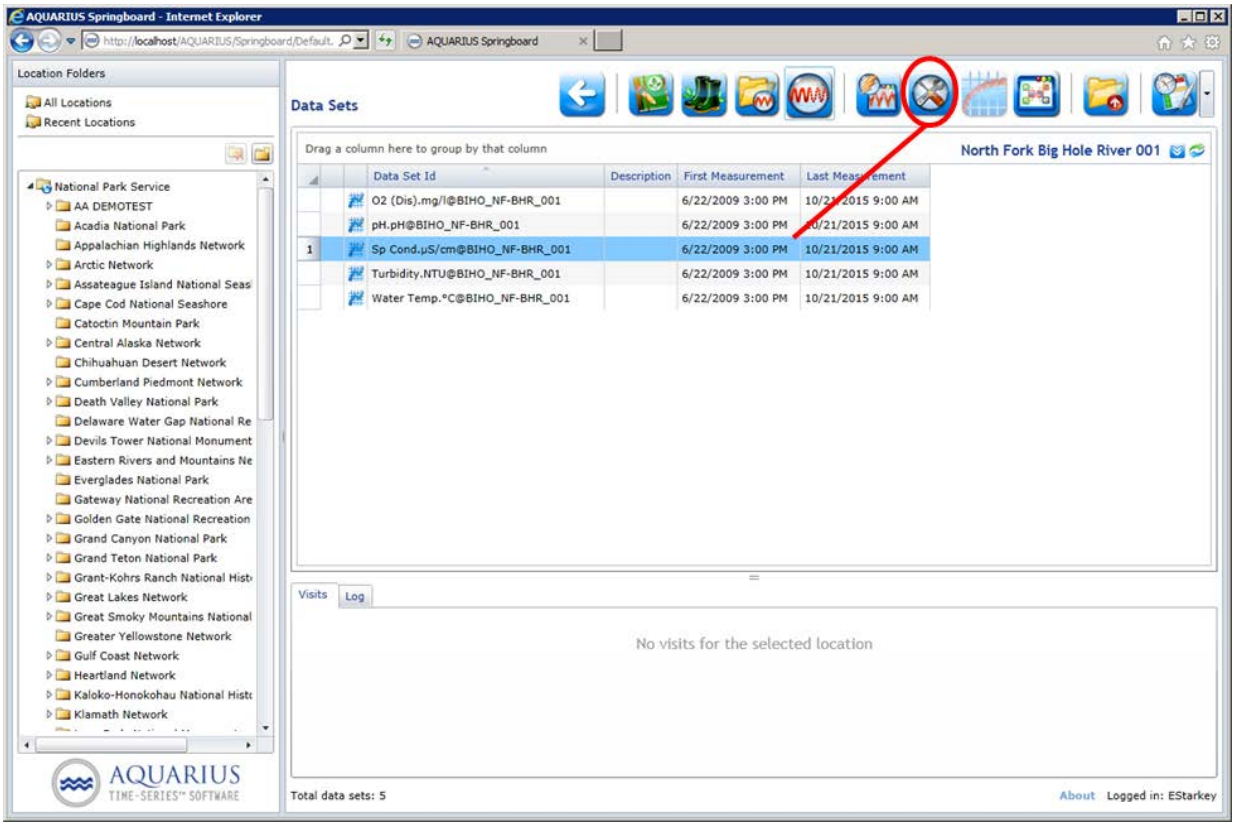


Figure 65. Data sets view in Aquarius Springboard. After selecting a dataset, the data correction toolbox becomes active (highlighted in red).

1. Select the parameter to which you would like to apply data corrections. After selecting a dataset, the data correction toolbox becomes active (Figure 65). Also make sure to select any other parameters of interest as the surrogate signal. Multiple selections can be made by holding Ctrl. on the keyboard Surrogate signals can aid in the interpretation of data. Several examples of when surrogate signals are useful include:
    a. Data for a specific parameter may show erratic readings near the end of a deployment but the cause may be unknown. If you look at the time series for the parameter and % battery power (surrogate signal) you may be able to tell if the erratic readings are associated with low battery power.
    b. If you notice a large spike in turbidity that you suspect might be erroneous, you might want to view specific conductance or stream discharge as surrogate signals. The surrogate signals may help determine if the spike was due to actual conditions in the stream or sensor fouling.

2. Click on the **“Data Correction”** Toolbox  to open the data correction window. You will see the data correction window open with a graph of the parameter you loaded (Figure 66). If you selected a surrogate signal, it will be graphed below the main time series. Next, you should look at your data and visually determine which values are suspected outliers or erroneous data.

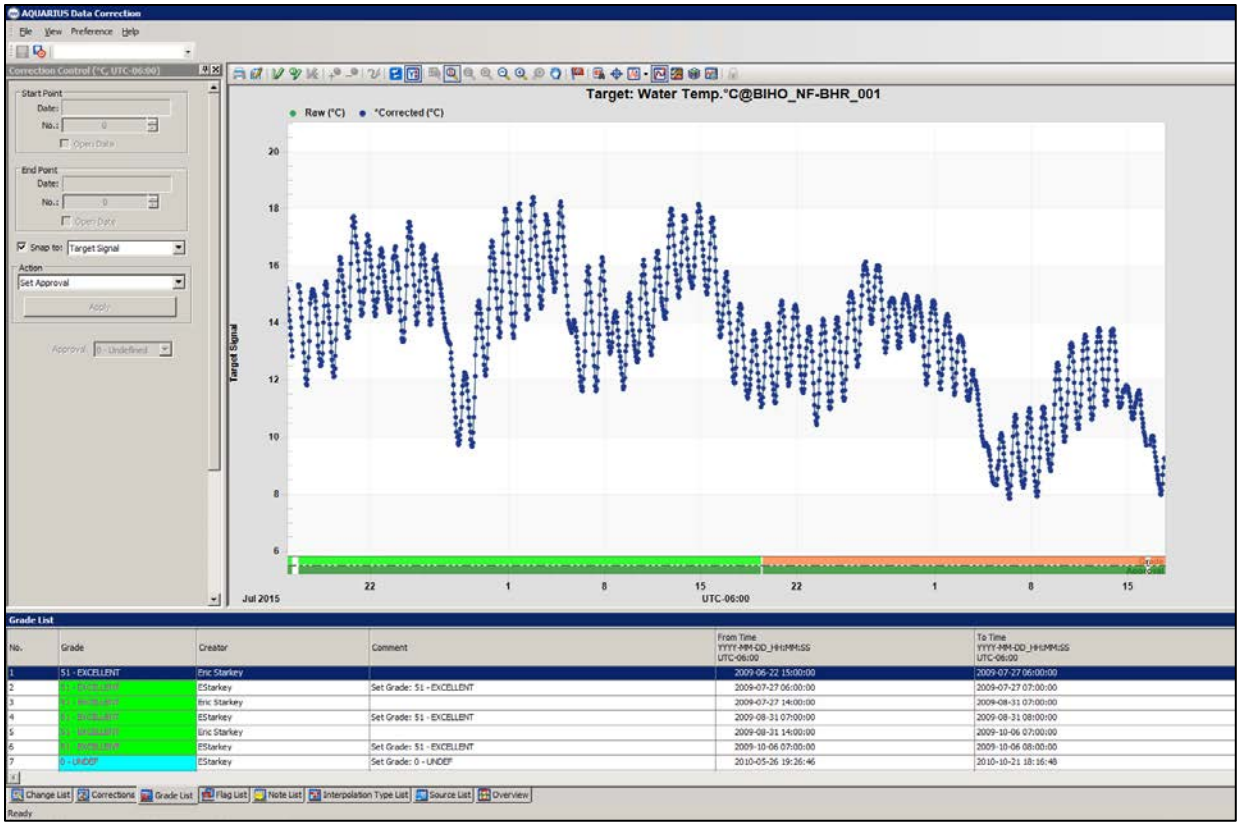


Figure 66. Data Correction toolbox. Graph of raw temperature data.

Delete Region

Note: within Aquarius the data is never permanently deleted, it is removed from the working or “Corrected” copy of the data. A correction history log tracks all changes made to the corrected data.

3. To remove data points (outliers, erroneous data, etc.) click the **“Mark Region”**  tool from the toolbar and **highlight the section of data you wish to remove. Double check you have selected the correct region.** It is useful to zoom in on the specific segment you want to remove. You can also make sure you have selected the correct data by checking the time series grid on the right side of the window. **Click the drop down menu under “Action”** (left side in the Correction Control pane). **Select “Delete Region” then click “Apply”** under the drop down menu**.** An “Apply Correction” window will open (Figure 67).
4. Fill out the **“Apply Correction”** window (Figure 67). Make sure to add a comment describing the reason you have removed the data. This comment can be saved to the list for

future use. If you have already added comments to the list they can be selected from the "Saved Comments" box. All deletions/corrections are logged in the correction history manager. If you have made an error these deletions can be un-done from the correction history tab at the bottom of the data correction window. Reasons for deletion might include a low battery, sensor spikes, etc.

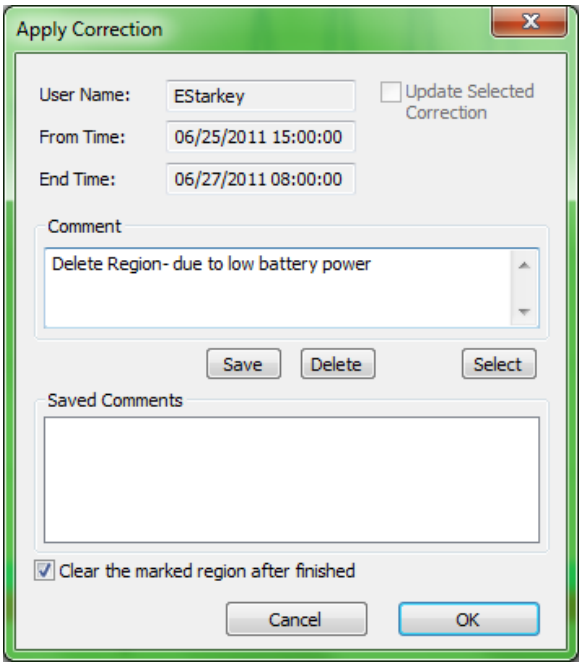


Figure 67. Apply Correction window.

5. Other useful actions to remove outliers, erroneous data, etc. are also available from the "Action" drop down in the Correction Control pane. Some useful actions include:
    a. Adjustable Trim Correction
    b. Threshold Correction/Flagging
    c. Trim Flagged Values
    d. Delete Specific Values

Fouling and Drift Corrections

6. **Skip this step if no correction is necessary** (see the Site Inspection Summary Worksheet generated from the UCBN database). Applying drift and fouling corrections is done by highlighting the entire data region of interest. Note that the UCBN is applying a pro-rated correction for the entire deployment period (back to the previous calibration). Click the **"Mark Region"**  tool from the toolbar and **highlight the section of data you wish to correct**. Next, **click the drop down menu under "Action"** (left side in the Correction Control pane). **Select "Drift Correction."** If needed, enter the **calibration drift** (aka sensor drift) and **fouling drift**. These can be found on the site inspection summary worksheet. Make sure to **include a negative sign if necessary.** C**lick "Apply"** under the drop down

menu**.** The “Apply Correction” window will appear. The amount of correction applied will automatically be listed in the comment field. Make sure to **add additional comments if necessary** (Figure 67). Click **“OK.”** You will now see a second signal within the graph, this is the corrected data.

7. Note that this toolbox is also the place to make other corrections such as: offset, percent, multi-point, and clock drift. These types of corrections are described in the Aquarius data correction toolbox manual. This manual can be found by going to the Help menu within the Data Correction toolbox.
8. After double checking that all corrections have been made you should continue with data grading (see next section). Do not close the “Data Correction” toolbox.

Data Grading

The ability to grade or assign a quality rating to data is built into the “Data Correction” toolbox. Data grades are indicated by the color below the time series graph and by the “Grade” column in the time series grid (Figure 68).

1. The **“Data Correction”** toolbox should still be open following data corrections. If the “Data Correction” toolbox is not open, follow steps 1 and 2 from the Data Correction section above.
2. Note that the UCBN is applying a data grade for the entire deployment period (back to the previous calibration). Click the **“Mark Region”**  tool from the toolbar and **highlight the section of data you wish to grade**. Next, **click the drop down menu under “Action”** (left side in the Correction Control pane). **Select “Set Grade.”**
3. Next, **select the appropriate data grade from the “Grade” drop down menu.** These data grades are listed on the Site Inspection Summary Worksheet and are based on the USGS rating criteria found in Wagner et al. 2006 and in Table 11 in this SOP. **Click “Apply.”**
4. The “Set Grade” window will appear (Figure 69). Add any necessary comments in the comments field. **Click “OK.”**
5. After double checking that all corrections have been made you should continue by setting the approval code (see next section). Do not close the “Data Correction” toolbox.

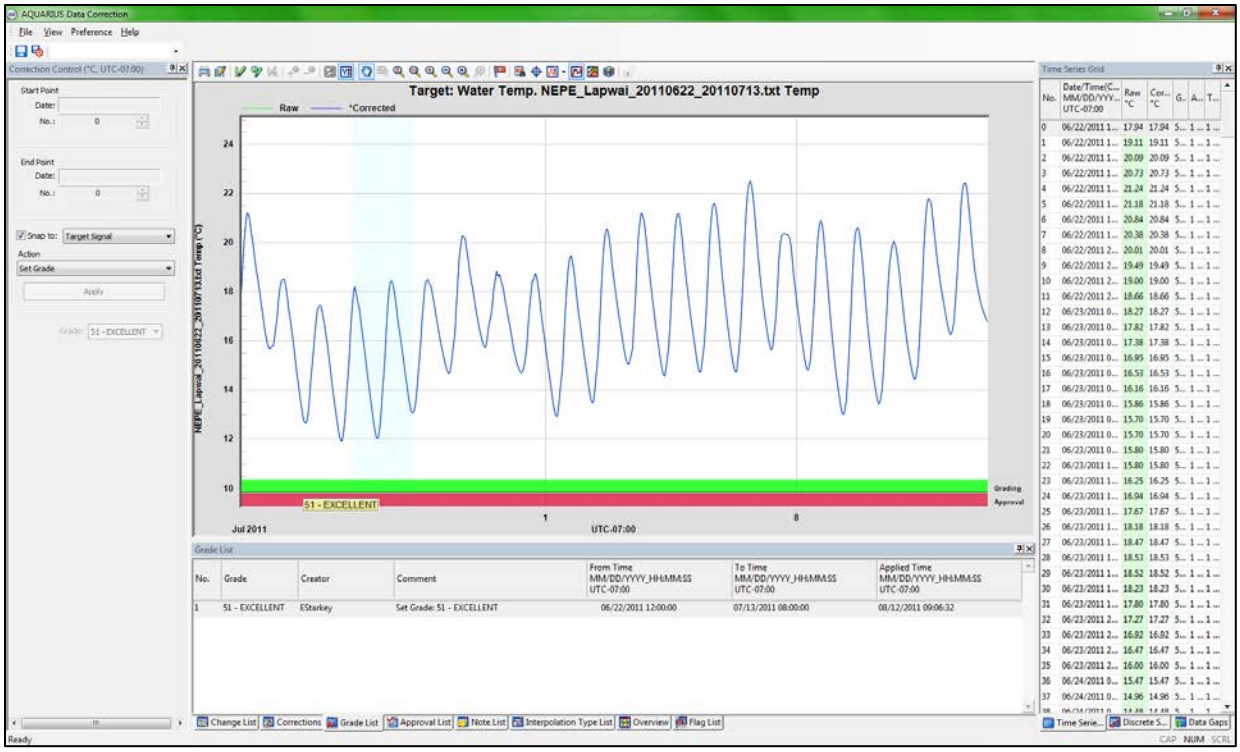


Figure 68. Data Correction Toolbox indicating the data grade for temperature data collected at Nez Perce National Historical Park (NEPE).

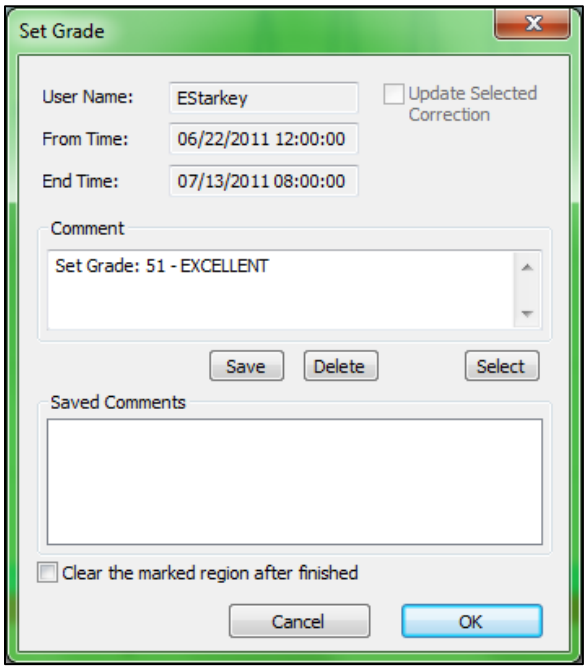


Figure 69. Set Grade window.

Approval Codes

Approval codes help define the status of the data relative to data processing. In other words, is the data "working", "in review", or "approved." These categories help with quality assurance and are especially important if multiple users will be reviewing and processing the data. For example a hydrologic technician could enter and process the data in Aquarius and set the approval code as "in review." After the data has been checked by a supervisor the approval code could be switch to "approved." Note that the approval codes can be changed to meet individual user needs. For instance, rather than "working" the user might want the approval code to read "provisional." The process for changing the approval codes can be found in the Aquarius Help Manual under the heading "Aquarius Local Data Manager." The help manual is available from the Help menu.

1. The **"Data Correction"** toolbox should still be open following data grading. If the "Data Correction" toolbox is not open, follow steps 1 and 2 from the Data Correction section above.
2. Click the **"Mark Region"**  tool from the toolbar and **highlight the section of data to which you would like to set the approval code.** Next, **click the drop down menu under "Action"** (left side in the Correction Control pane). **Select "Set Approval."**
3. Next, **select the appropriate approval code from the "Approval" drop down menu.** The assigned approval code depends on the data's status. Use the following as a guide to choosing an approval code.
   a. Working = Data have been imported to Aquarius but have not been reviewed, error checked, corrected, or graded.
   b. In Review = Data are being processed and checked for errors and outliers. The data may have been corrected and graded but have not been double checked by a supervisor or subsequent analysis.
   c. Approved = Data have been corrected, graded, and error checked. The data is certified and ready for export and analysis.
4. After double checking the approval code, data grade, and data corrections click the **"Save data to output ports and exit"** icon  .
5. If you re-open the data correction toolbox, all corrections, grades and approvals should remain.

Optional Procedures in Springboard

Quick View Graphing

The Quick View toolbox  allows for production of basic graphs. These graphs can be useful to double check that corrections were applied as desired in the Data Correction toolbox. Graphs for annual reports should be created in the Charting toolbox in Whiteboard (see below). The Charting toolbox offers more flexibility in graph design and layout.

Reporting

The reporting toolbox  can be used to develop and automate standard reports. More information on this feature is offered in the Aquarius user manual.

Whiteboard Procedures

After completing the data correction and grading procedures in Springboard, remaining data processing is accomplished via the Whiteboard interface. Processing in Whiteboard is generally done parameter by parameter, although multiple data sets can be opened in Whiteboard. **Other than generating descriptive statistics following each month's deployment, most of the processing that occurs in Whiteboard relates to generation of summary statistics and graphs to be included in annual reports.**

On rare occasion, other toolboxes might be used to alter the corrected data series (e.g. signal trimming, auto QA/QC, data correction, etc.) all changes must be written back to the server (write to server toolbox). Situations where this might be necessary are: 1) trimming data ranges not of interest, 2) Flagging and auto removal of data that does not meet certain thresholds and rates of change. These toolboxes are discussed below in the optional Whiteboard procedures section.

Whiteboard is a unique workspace in that it relies on a series of toolboxes that can be dragged onto the workspace (whiteboard) and connected to each other or wired together in a variety of ways. While this system sounds complex, it adds great flexibility to the ways data can be processed and viewed. WRD guidance document "Whiteboard Introduction" is a useful guide to learning how to use this interface. A video demonstration can be found at http://nrdata.nps.gov/Programs/Water/Aquarius/Videos/Introduction_Aquarius_3_Whiteboard_R5/Introduction_Aquarius_3_Whiteboard_R5.html (Accessed 03/04/2016).

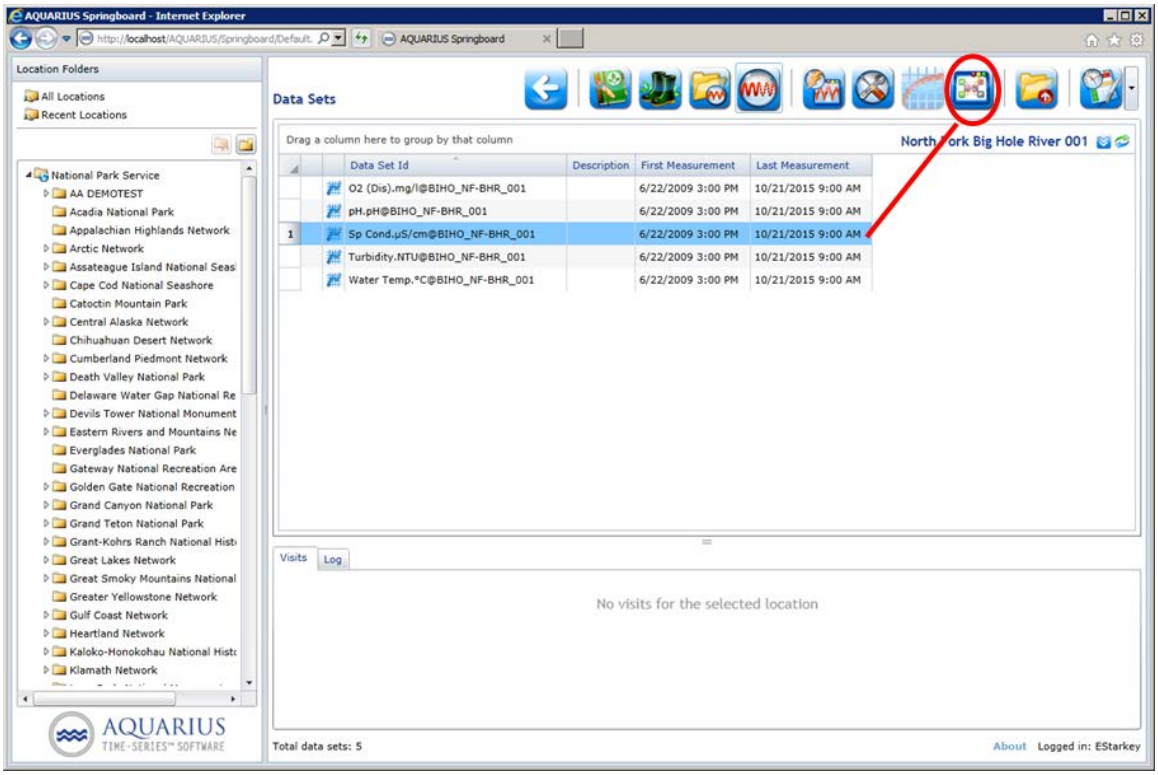


Figure 70. Data sets view in Aquarius Springboard. After selecting a dataset, the Whiteboard toolbox becomes active (highlighted in red).

1. In Springboard, select the parameter (data set) you would like to open in Whiteboard. After selecting a dataset, the Whiteboard toolbox becomes active (Figure 70). Multiple data set selections can be made by holding Ctrl. on the keyboard.
2. Click the **"Whiteboard"** toolbox.  . The Whiteboard interface will appear (Figure 71).
3. With the Whiteboard open, you can click and drag other toolboxes from the toolbox pane onto the workspace. Those toolboxes can then be wired together (connect the output port from one toolbox to the input of another).

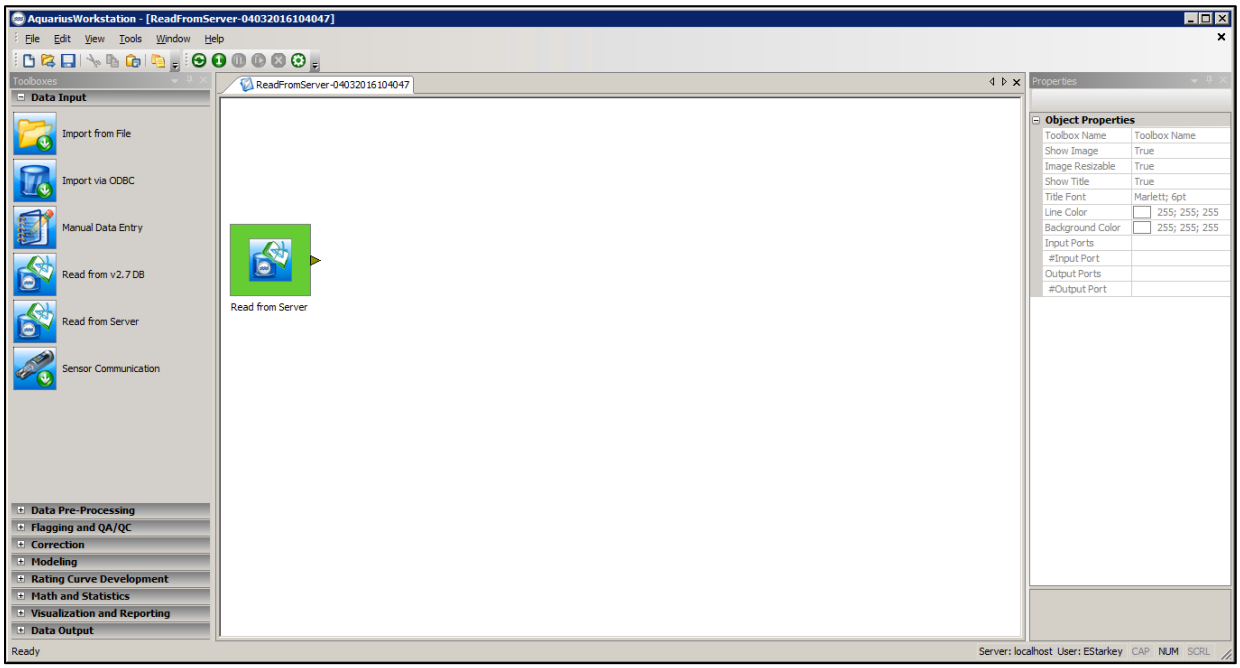


Figure 71. Aquarius Workstation Whiteboard interface. Note the Read from Server toolbox.

Descriptive Statistics

1. Connect the "Read from Server" toolbox to the "Descriptive Statistics Toolbox."

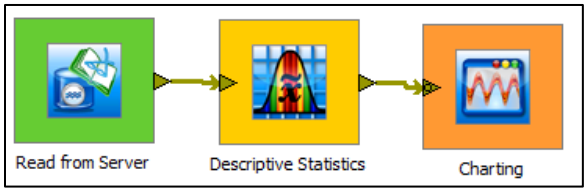


Figure 72. Read from Server toolbox connected to Descriptive Statistics toolbox.

2. Specify the time period and the types of statistics you would like to report by filling in the appropriate fields and by checking the appropriate boxes in the "Input Time-Series Binning Control" and "Descriptive Stats Control" panes. Note that by checking the left box next to each statistic you will generate an output port. For example, if both boxes were checked next to mean, minimum and maximum, and the time period was set at "daily," it would generate

three output ports. These output ports would contain the daily mean, minimum and maximum. This is important because those values could then be graphed using the “Quick View” or the “Charting Toolbox.”

3. It is also possible to specify thresholds within this toolbox and calculate the “number of days” the parameter exceeded the threshold (Figure 73). It is important to note that the “Days Above” and “Days Below” values are calculated based on the number of hours the parameter exceeded the threshold and not the actual number of days the parameter peaked above or below that threshold. For example, if dissolved oxygen was below 6.0 mg/L during 8 samples (1 sample/hour) Aquarius would say that it was below the threshold 0.333 days (8-hourly samples/24hrs). Dissolved oxygen was actually below the threshold on 4 separate days. This is important to take into account when compiling annual reports.
4. Within the “Input Time Series Binning Control” pane it is also possible to specify that you would like run statistics on days with a specific grade and data coverage. **It is advisable to have at least 80% data coverage to be included in summary stats for annual reports.** These settings are described in detail in the Aquarius user manual. This manual can be accessed by clicking on the Help menu and selecting “Descriptive Statistics Toolbox Manual.”
5. Click “Compute” and the results will be displayed within the same window.
6. If you wish to save the results to the output port click the icon “Save Data to Output Ports and Exit”  .

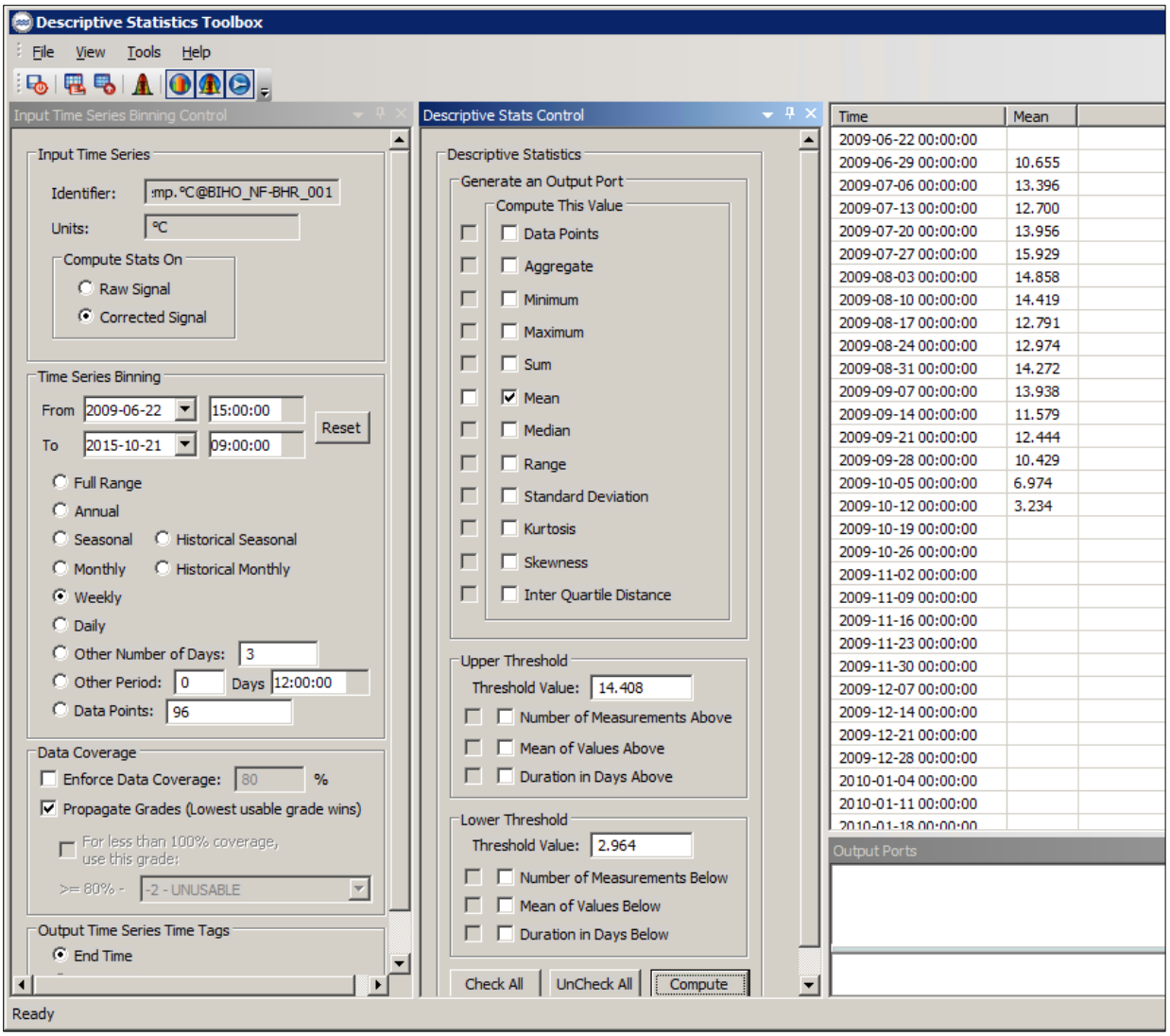


Figure 73. Descriptive Statistics Toolbox.

Graphing

There are two toolboxes that allow the user to produce a graph suitable for export to a publication. The "Quick View" toolbox is the easiest to use, yet it does not have the flexibility of the "Charting" toolbox. The user can decide which toolbox best meets his/her graphical needs. It is important to note that a user can either graph the entire set of raw or corrected data, or can analyze the data with the "Descriptive Statistics" toolbox first and subsequently graph summarized data (i.e., daily max, min, mean). The order of operations depends on the user's specific needs. **Graphs for annual reports should be created using the Charting toolbox.**

Quick View:

1. **Connect an input signal to the "Quick View" toolbox,** OR **right click the output on any toolbox, and select "Quick View"** (if you choose this option skip to step 3)**.**
2. Double click the **"Quick View"** toolbox.

3. The “Quick View” graphing window should open. You can zoom to specific dates or graph the entire time period. Graph options can be edited by going to the **Charting menu**, then by clicking **“Properties.”**
4. To export the graph go to the **“File” menu** and select **“Save Chart Image.”**

Charting:

1. **Connect an input signal to the “Charting” toolbox.**
2. Double click the **“Charting” toolbox.**
3. The “Charting” window should open. It will automatically graph both the raw and corrected data. The raw or corrected the signals can be turned on and off by going to the **“Chart” menu** and selecting **“Show/Hide Series.”**
4. To customize the chart, go to the **“View” menu** and select **“Chart Options”**
5. If you want to add an additional Y axis, go to the “Chart” menu and select **“Multiple Y-Axis.”**
6. After you have formatted the graph, you can save the settings as a template for future use. This will help you produce standardized looking graphs for each parameter. To save the template go to the **“File” menu** and select **“Save as Template.” Templates for annual reports are usually created for each parameter and saved on the mapped AQUARIUScfgFiles drive (UCBN, charting_templates folders).**
7. To export the graph go to the **“File” menu** and select **“Save Chart Image.”**
8. **NOTE: If you close the Charting toolbox without saving, you will lose your graph!**

Reporting

The reporting toolbox  can be used to develop and automate standard reports. More information on this feature is offered in the Aquarius user manual.

Export

At the end of each season, the following should be exported and saved on the UCBN server:

1. AOP file for each parameter – Aquarius specific file (carries all data corrections and grading)
2. Corrected data file (will include all parameters) – CSV format
3. Correction history file for each parameter – CSV format
4. Data grade/rating file for each parameter- CSV format

The reason for exporting these is so that all time-series with corrections and data grades can be re-constructed if necessary.

The procedure for exporting the AOP and corrected data files listed above is:

1. From the Springboard interface, select all data sets for a given location (hold Ctrl. to select multiple data sets). Open Whiteboard by clicking the active **"Whiteboard"** toolbox.
2. Wire the **"Read from Server"** toolbox for each parameter to the **"Export to File"** toolbox. Adjust the number of input ports on the "Export to File" toolbox by right clicking the toolbox and selecting **"Properties Pane."** Once this pane opens, change the number of input ports to match the number of parameters on your whiteboard.

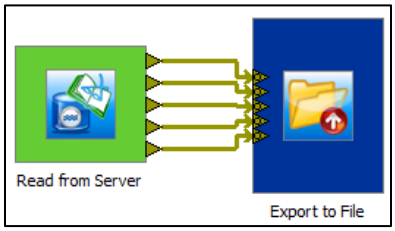


Figure 74. Read from Server toolbox wired to Export to File toolbox.

3. Double click the **"Export to File"** toolbox. The Export to File window will open (Figures 74 and 75).

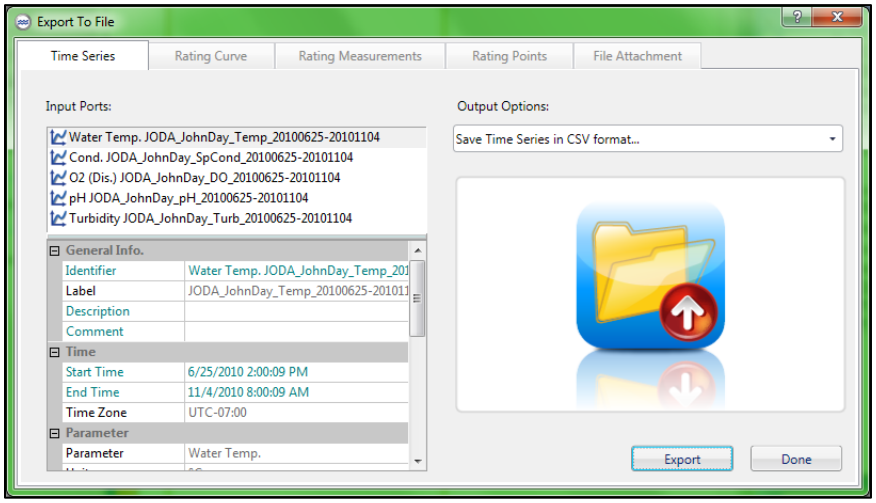


Figure 75. Export to File Toolbox.

4. Make sure all of the parameters are listed in the "Input Ports" box.
5. **Click on the first, second,… parameter in the list of input ports.**

AOP File:

6. To export the AOP file select **"Save Selected Time Series in AOP Format"** from the drop down menu under **"Output Options."** Then click **"Export."** Save the AOP file using established naming conventions (e.g. Water Temp. JODA_BridgeCreek_Temp_20100626-20101103). **Files saved on the mapped AquariusTempFilesStorage drive will need to be copied and saved locally to the UCBN server.**
7. Repeat steps 5 and 6 for each parameter until all AOP files have been exported.

Corrected/Raw Data File:

8. To export the corrected/raw data file select **"Save Time Series in CSV Format"** from the drop down menu under **"Output Options."** Then click **"Export."** The "Export to CSV" window will appear (Figure 76).
9. Select the radio button for **"Entire Range.**
10. **If a configuration file has already been created, load it and skip to step 18.**
11. **Select the first parameter from the list on the left**. When you have selected the first parameter, the "Available Columns" box should be populated.
12. **Select each column under the "Raw Data" tab and click "Add."** This column will become part of the data that will be exported.
13. **Click the "Corrected Data" tab**
14. Again, select the first parameter from the list on the left. When you have selected the first parameter the "Available Columns" box should again be populated. This time with the corrected data.
15. **Select each column under the "Corrected Data" tab and click "Add".** This column will become part of the exported data.
16. When all columns for both raw and corrected data have been added, Click the checkboxes next to **"Append Time Series Statistics" and "Append Metadata Glossary."**
17. To avoid this process in the future, save these settings as a configuration file by clicking **"Save Config." These configuration files should be saved on the mapped AQUARIUScfgFiles drive.**
18. Next, click **"Export"** and save the CSV file using established naming conventions (e.g. JODA_BridgeCreek_Output_All_Data_2010). **Files saved on the mapped AquariusTempFilesStorage drive will need to be copied and saved locally to the UCBN server.**
19. When finished, Click **"Done"**

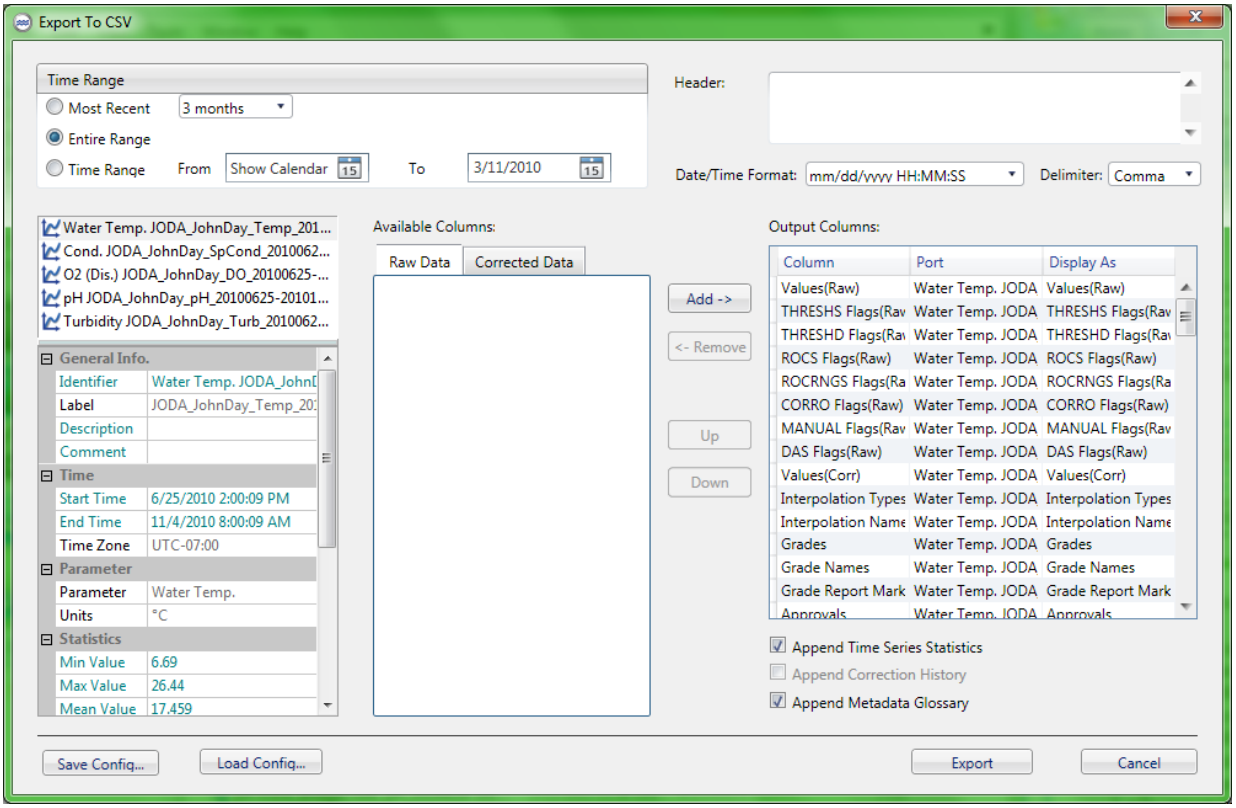


Figure 76. Export to CSV window.

Correction History File:

1. Connect the signal for a single parameter from the **"Read from Server"** toolbox to a new **"Data Correction"** toolbox.

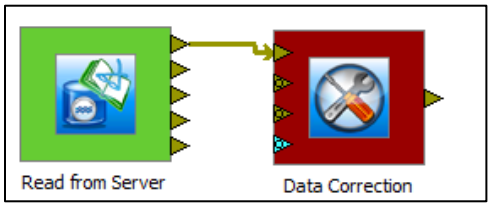


Figure 77. Read from Server toolbox wired to a Data Correction toolbox.

2. Double click the **"Data Correction"** toolbox (Figure 77). The data correction window should open.
3. Check that the entire season's worth of data is displayed in the graph. Below the graph should be a series of colors indicating each deployment periods data grade.
4. Go to the "File" menu. Select **"Export Corrections List."** Save the file using established naming conventions (e.g.JODA_JohnDay_001_Correction_history_of_SpCond_2010). **Files saved on the mapped AquariusTempFilesStorage drive will need to be copied and saved locally to the UCBN server.**
5. Repeat steps 1-4 for each parameter.

6. Do not close this toolbox. Continue by exporting the data grade/rating file.

Data Grade/Rating File:

1. After exporting the correction history file, you should still be within the **"Data Correction"** toolbox for a given parameter
2. Go to the "File" menu. Select **"Export Grade List."** Save the file using established naming conventions (e.g. JODA_JohnDay_001_Grade_List_SpCond_2010)
3. Repeat steps 1 and 2 for each parameter. **Files saved on the mapped AquariusTempFilesStorage drive will need to be copied and saved locally to the UCBN server.**
4. When finished, click the icon **"Save Data to Output Ports and Exit"**  .

Optional Procedures in Whiteboard

The following are procedures that are infrequently used or only used in special circumstances.

Signal Trimming

The Signal Trimming toolbox allows you to remove outliers, trim dates, interpolate small gaps, etc. This toolbox is very helpful in some situations and can greatly speed up the processing of a record (Figure 78 and 79). The "Signal Trimming Toolbox" should be placed before the "Auto QA/QC" and "Data Correction" Toolboxes.

Note the following about the signal trimming toolbox: "The Signal Trimming Toolbox performs special corrections on one or more input signals and creates a new output signal for each one. It works as follows: Corrected data from input + new corrections = New raw data in output. **The original raw data and correction history are not preserved, so using this toolbox on previously corrected signals in not recommended."** For this reason, this toolbox should always immediately follow the input from file or read from server toolboxes.

1. After successfully loading one parameter, your "Import from File" toolbox or "Read from Server" toolbox should have two triangular output ports. **Click on the first output port (►) and drag a wire to the input port on the "Signal Trimming" toolbox** (Figure 78). The data you imported is now connected to the signal trimming toolbox.

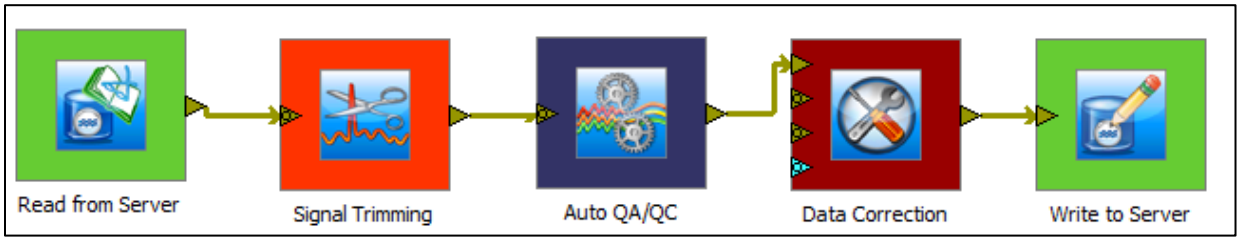


Figure 78. Read from Server toolbox connected to Signal Trimming toolbox.

2. Double click the **"Signal Trimming"** toolbox.

3. If the data requires trimming, **enter the values and/or date range you wish to keep.** Everything outside of the range you specify will be trimmed.
4. Click **"Apply"** then click **"Run"** and to return to the whiteboard click **"OK."**
5. You should now have an active output port on the "Signal Trimming" toolbox.

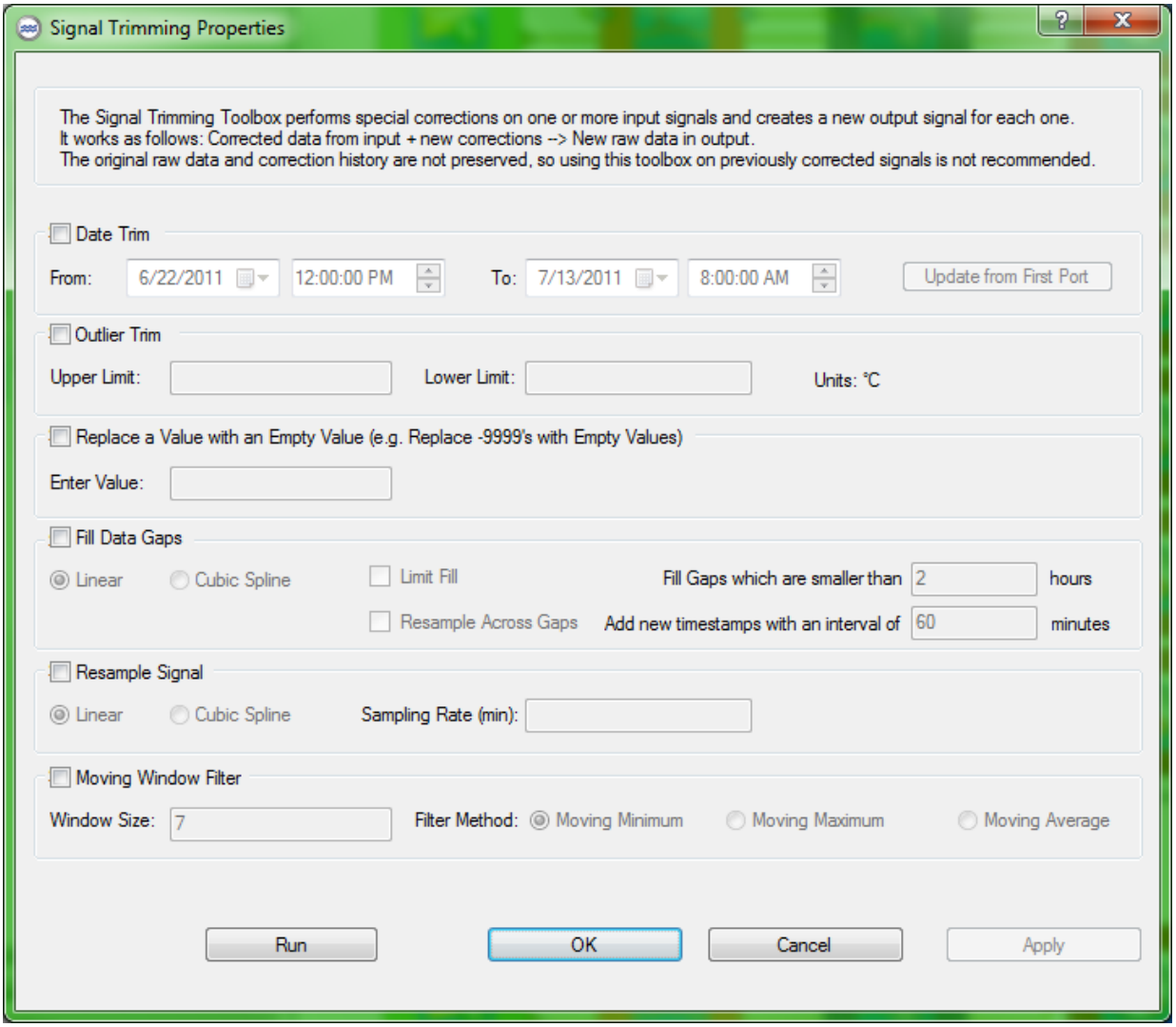


Figure 79. Signal Trimming toolbox – Properties window.

Auto QA/QC

The "Auto QA/QC" toolbox allows the user to automatically flag data that exceeds a specified threshold or rate of change (Figure 80). Individual data points that have been flagged using this toolbox can be viewed in the "Quick View" toolbox and the "Data Correction" toolbox. In addition, options under the "Correctives" tab allow for the automatic removal and correction of flagged data. This toolbox can also be used to assist in the identification of outliers. Basic steps for running data through this toolbox are:

1. Wire the **"Signal Trimming"** toolbox to the auto QA/QC input port.

2. Double click the **“Auto QA/QC”** toolbox.
3. When the toolbox first opens you will notice that the fields in the **“Input Port View”** (left column in Figure 80) are populated with data. The **“Output Port View”** will remain empty until you run the toolbox.
   Enter any data flagging thresholds or correctives (center column Figure 80). Exact thresholds depend on the parameter, time of year, and monitoring station. For this reason, professional judgment should be used to determine appropriate thresholds and corrective measures. Threshold flagging allows the user to input values that should be flagged for review or that exceed a specified criteria. This function is especially useful for indicating values that fall above state DEQ regulatory thresholds.

   When in doubt, it may be easier to visually identify outliers and other data anomalies in the subsequent “Data Correction” toolbox.

4. Once all thresholds and correctives have been input, click the **“Run Toolbox”**  button. The **“Output Port View”** should now be populated (right column Figure 80). This view allows you to quickly see how many flags have been applied and other summary information about the output signal.

5. Click the **“Save Output Port and Exit”** button  to exit the “Auto QA/QC” toolbox.

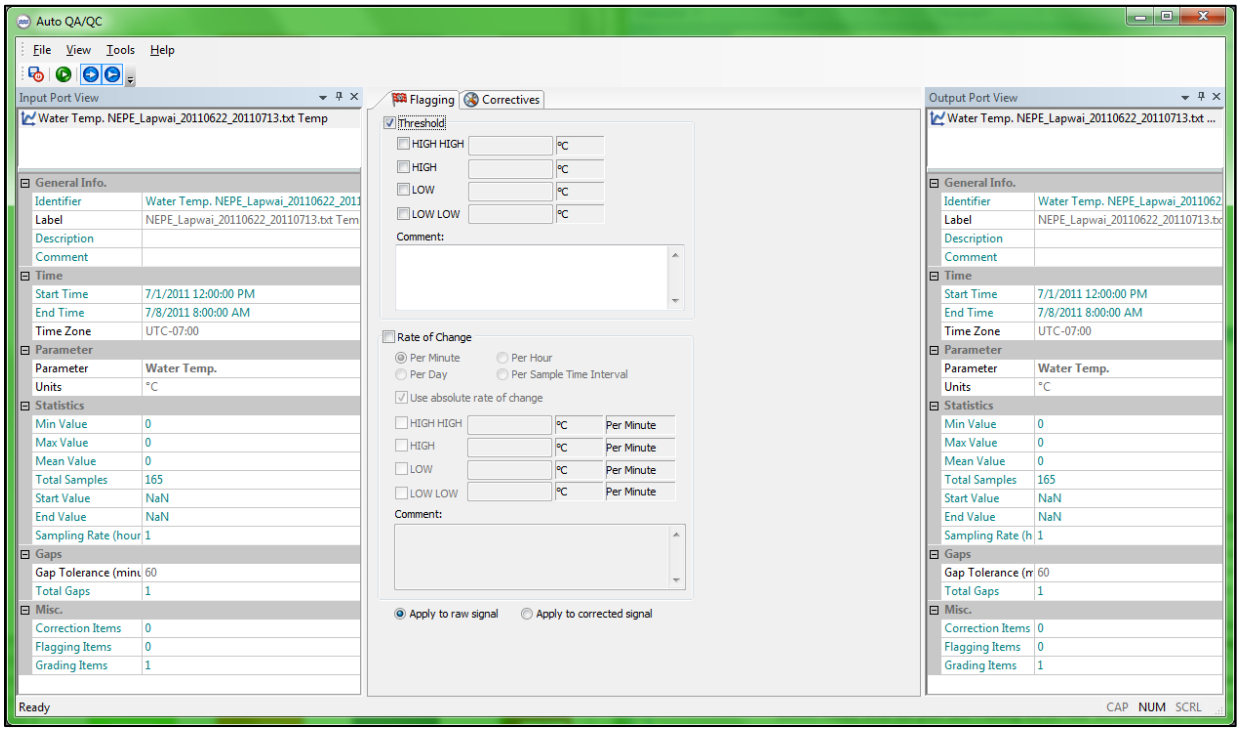


Figure 80. The “Auto QA/QC” toolbox – Flagging tab.

Signal Joining

In some cases you may need to join time series (same parameter) from multiple deployments or years, this task can be accomplished using the "Signal Joining" toolbox. You must have multiple data signals loaded in Whiteboard via the "Read from Server" or "Import from File" toolbox.

1. **Connect multiple signals to the signal joining input ports.** If you need additional input ports, right click on the "Signal Joining" toolbox and select **"Properties Pane."** Change the number of input ports. If you have more input ports than signals the toolbox will not function.
2. Double click the **"Signal Joining" t**oolbox.
3. The "Signal Joining" window will appear (Figure 81). Each signal (deployment period) will appear as a different color on the graph. Make sure the check boxes are selected under **"Include Corrections?"** in the "Signal Joining Properties" section of the Time Series Manager pane.
4. Click the **"Save data to output ports and exit"** icon  on the toolbar. You should now have one active output port on the "Signal Joining" toolbox.

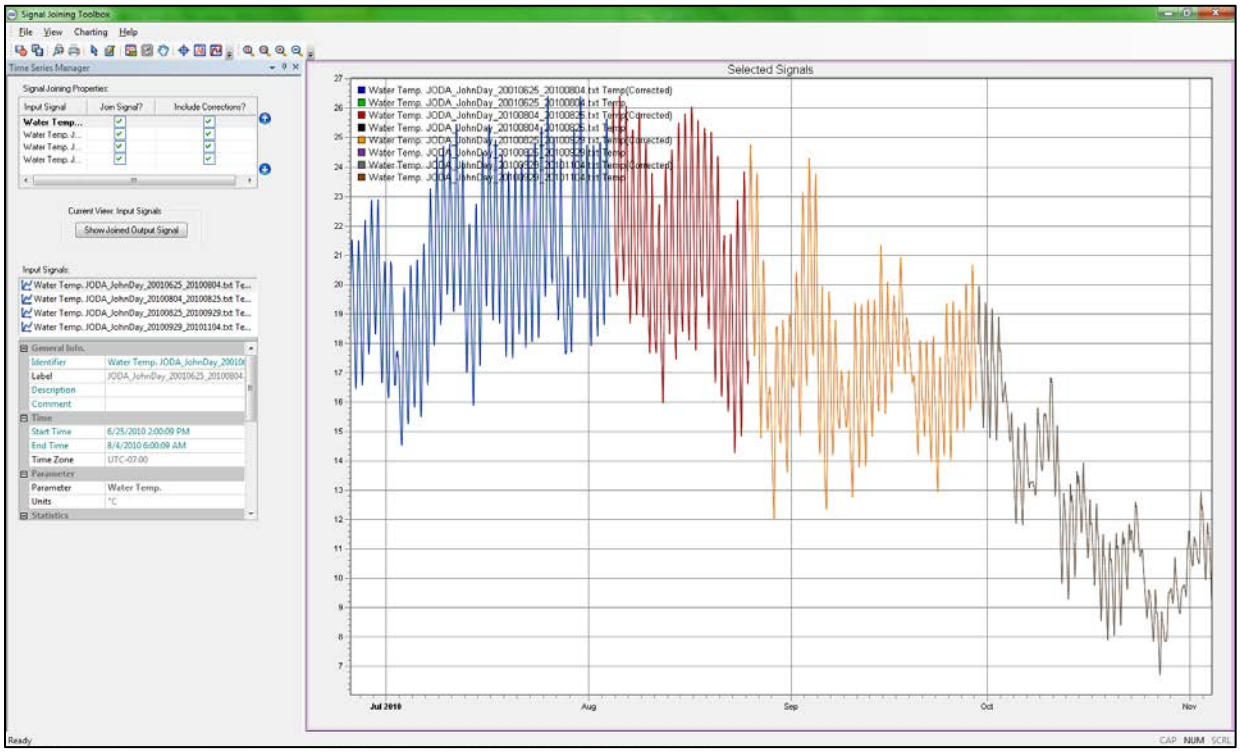


Figure 81. Signal Joining Toolbox-multiple (monthly) temperature signals.

Write to Server (only if changes to the dataset occurred)

Data must be written back to the server if changes occurred due to signal trimming, auto QA/QC, or data correction.

1. Wire the **“Write to Server”** toolbox to output port of the toolbox that made the latest modification to the data set (Figure 78).
2. See the WRD guidance “Whiteboard Introduction” for procedures to write data back to the server. A video demonstration can be found at http://nrdata.nps.gov/Programs/Water/Aquarius/Videos/Introduction_Aquarius_3_Whiteboard_R5/Introduction_Aquarius_3_Whiteboard_R5.html (Accessed 03/04/2016).

Literature Cited

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 8: Data Management

Version 1.9 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.1	February 2016	UCBN Aquatic Biologist and Data Manager	Updates to reflect new database design and data management workflow. Expanded details about metadata.	Updated UCBN database and extensive use of Aquarius Server/Springboard	1.9

Note: This SOP provides documentation for the integrated water quality monitoring project database and provides instructions for the development, maintenance, archiving, and distribution of the database or datasets.

Suggested Reading

Dicus, G. H. and L. K. Garrett. 2007. Upper Columbia Basin Network Data Management Plan. National Park Service Upper Columbia Basin Network Inventory and Monitoring Program. Moscow, ID

Garrett, L. K., T. J. Rodhouse, G. H. Dicus, C. C. Caudill, and M. R. Shardlow. 2007. Upper Columbia Basin Network vital signs monitoring plan. Natural Resource Report NPS/ UCBN/NRR—2007/002. National Park Service, Fort Collins, CO.

National Park Service. 2006. Natural Resource Database Template Version 3.1 documentation. Natural Resource Program Center, Office of Inventory, Monitoring, and Evaluation, Fort Collins, CO.

Overview

The Water quality monitoring process results in the collection of three distinct datasets: 1) continuous water quality monitoring time series data, 2) monitoring station cross section surveys, and 3) multiprobe calibration and maintenance metadata. While being distinct the datasets are inter-related and are created from monitoring efforts with concurrent workflows (Figure 82). Continuous water quality data is transferred from multiprobe collection devices to comma separated value (.csv) tabular data which is then imported into Aquarius Time-Series software. Cross section survey and multiprobe calibration and maintenance metadata are entered and stored in the water quality monitoring station and instrumentation Access database.

Water quality data (continuous) is collected using multiprobes which are installed at sampling locations (Multiprobe Site Selection – Cross Section Survey SOP 3) at the beginning of the field season. At the initial site or second site visit and the season closeout visit (2 total per season) site cross sectional data is entered into the water quality monitoring station and instrumentation database (see SOP 3 for cross section survey data entry details).

For revisits and season closeout site visits water quality monitoring data is downloaded from the multiprobe devices and stored in tabular format (see SOP 5 for details on water quality site revisits). Additionally at revisit and season closeout visits multiprobe calibration and maintenance data is collected and entered to the water quality monitoring station and instrumentation database (see SOPs 3 & 5). Post field visit, continuous water quality data (tabular format) is uploaded to the Aquarius Time-Series platform following processing steps defined in the Continuous Water Quality Record Processing SOP 7. Quality assurance and quality control processes are subsequently performed on the continuous data within the Aquarius platform as explained in SOP 7 and the QA/QC SOP 10.

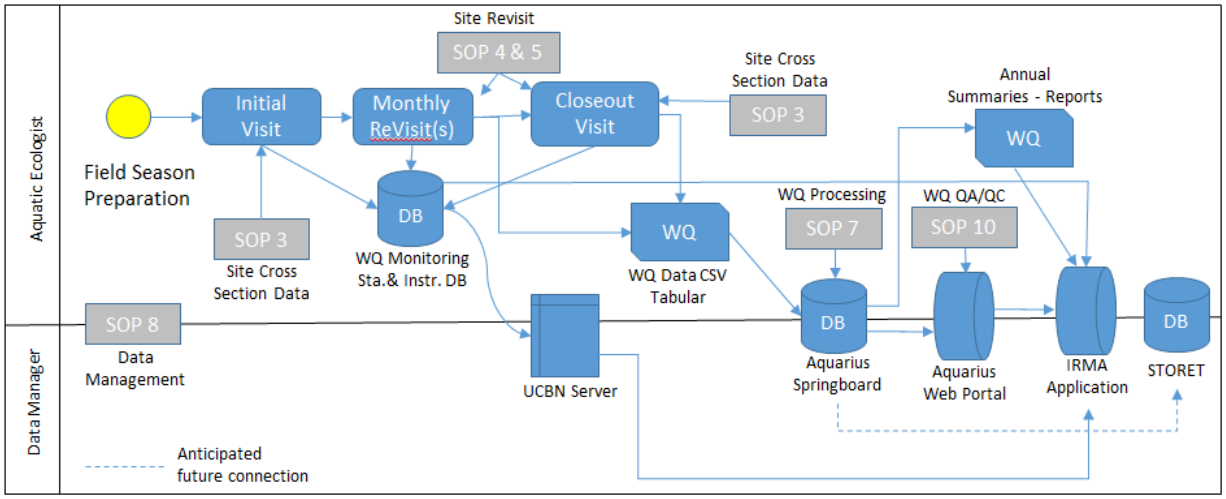


Figure 82. Generalized data management annual work flow for water quality monitoring, cross section data and calibration and maintenance metadata collection.

Database Model

The database used by the UCBN integrated water quality monitoring protocol has been developed within Microsoft Access and conforms to the standard version 3.2 of the Natural Resource Database Template (NRDT).

The database consists of a user interface front-end (holding user forms for data entry, review, and export) that is linked to a back-end database file (holding the core protocol data tables). The general data management strategy employs a “working copy” of the database (used to enter the current season’s data, conduct error-checking, and perform validation) and a “master version” of the database, which stores all validated data and facilitates multi-year analyses by providing specific data summaries and export formats. A physical data model for the UCBN water quality monitoring station and instrumentation database shows the relationships among the core data tables, lookup tables, and cross reference tables (Figure 83).

The user interface front-end contains data entry forms for monitoring station cross section surveys, multiprobe calibration and maintenance metadata, data quality indicators and site inspection summaries for the USGS and UCBN.

The core tables in the UCBN water quality monitoring station and instrumentation database are the tbl_Sites, tbl_Locations, tbl_Stations, tbl_Events, and tbl_Event_Details. These core tables store the unique attributes, physical locations and detailed information for each visit (e.g. stream name, station coordinates, type of visit, date and time) There are three tables related to maintenance data (tbl_Maintenance, tbl_Sensor_Record and tbl_Fouling_Presence). The tables for calibration consist of three tables for each measured water quality parameter (tbl_Calibration_SpCond, tbl_Readings_Spcond, tbl_Readings_SpCond_recal, tbl_Calibration_DO, tbl_Readings_DO, tbl_Readings_DO_recal, tbl_Calibration_Turbidity, tbl_Readings_Turbidity, tbl_Readings_Turbidity_recal, tbl_Calibration_pH, tbl_Readings_pH, tbl_Readings_pH_recal) excluding temperature (tbl_Calibration_temp). The tables for cross section survey data and fouling checks include (tbl_Cross_Section_Survey, tbl_Cross_Section_Transect_Data, tbl_Fouling_Checks, tbl_Fouling_Checks_Live and tbl_Fouling_Checks_Values). The data quality indicator tables include permanent and temporary tables drawn from the cross section survey tables for calculations (tbl_AMS, tbl_AMS_CRMO_CIRO, and tbl_BOS_NTU). The support tables include lookup tables for contacts, standard code values, probes and sensor serial numbers (tlu_Contacts, xref_Event_Contacts and tlu_Enumerations). Revisions to the database are captured in two metadata tables, tbl_Db_Meta and tbl_Db_Revisions.

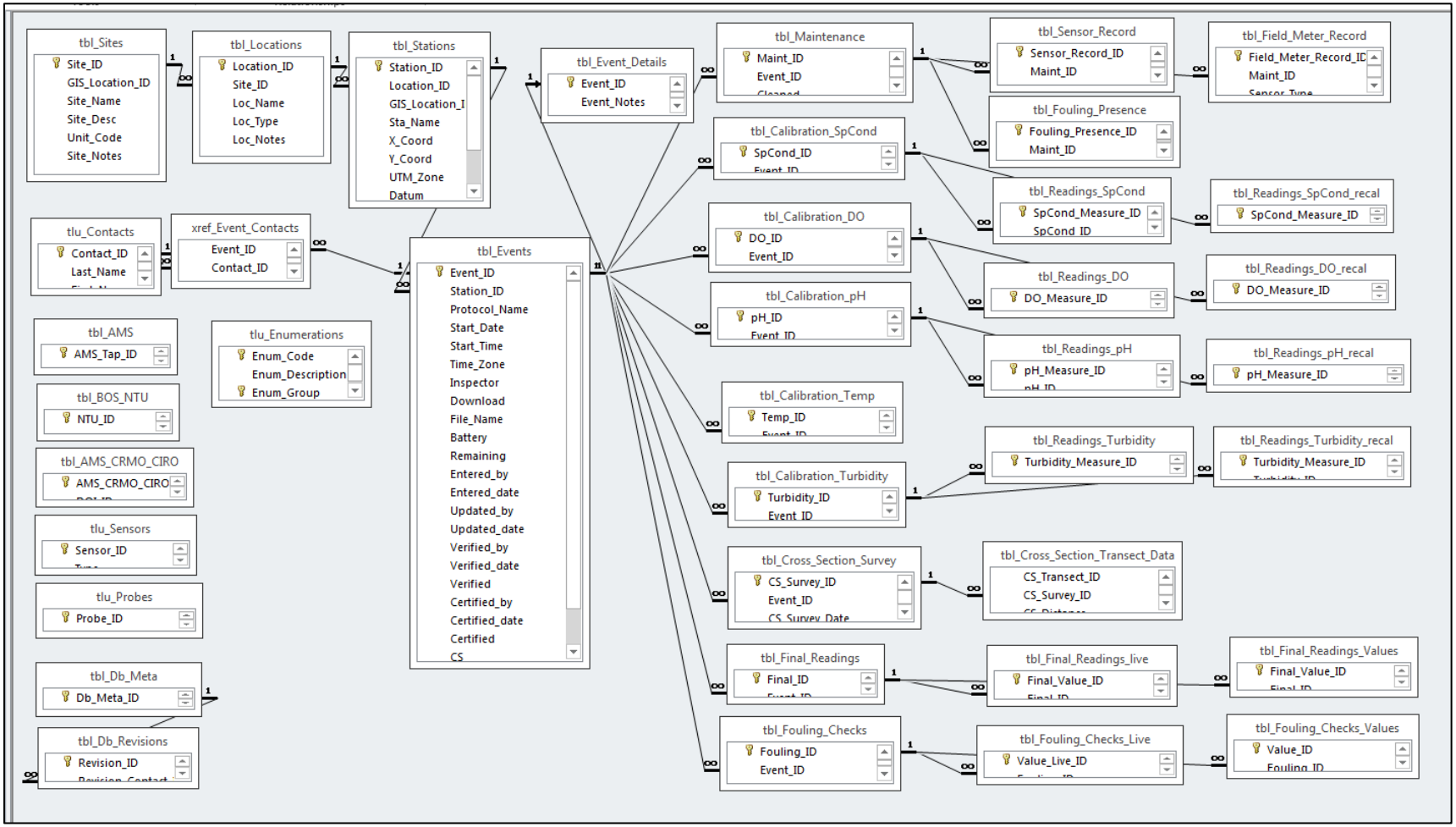


Figure 83. A logical data model for the UCBN water quality monitoring station and instrumentation database.

Data Dictionary

The data dictionary (Appendix G) provides a description for every table contained in the UCBN water quality monitoring station and instrumentation database back-end file, and, for each table, provides each field name, the field type, the field size, and the field description.

Data Import

The process by which 1) continuous water quality monitoring time series data, 2) monitoring station cross section surveys, and 3) multiprobe calibration and maintenance metadata are imported into the respective database for subsequent QA/QC, data certification and eventual archival is explained in this section.

I. Continuous Water Quality Data

After the initial water quality site visit it is necessary to download monitoring data that has been collected since the previous site visit. Collected data must be transferred from the multiprobe onto a hand held Archer personal digital assistant (PDA) device and saved in a comma separated value (.csv) tabular format. The .csv data files will then be transferred from the PDA devices onto a personal computer where monitoring files (.csv) are then transferred to the UCBN server. Monitoring .csv files are archive by park, site (i.e. stream) and year on the UCBN server at:

VitalSign_Protocols\Integr_Water_Quality\4_Close\Certified_Data_GIS_Metadata\HydroLab-DataLogger_Files (Figure 84).

Lastly the monitoring data on the UCBN server is uploaded to the NRSS Aquarius platform via the Aquarius Springboard interface (Figure 85). Additional information on data import steps to be performed during multiprobe site revisists is found in SOP 5, while SOP 7 further documents processes for upload of continuous water quality data (i.e. .csv files) into Aquarius. A data import workflow for continuous water quality data is shown in Figure 86.

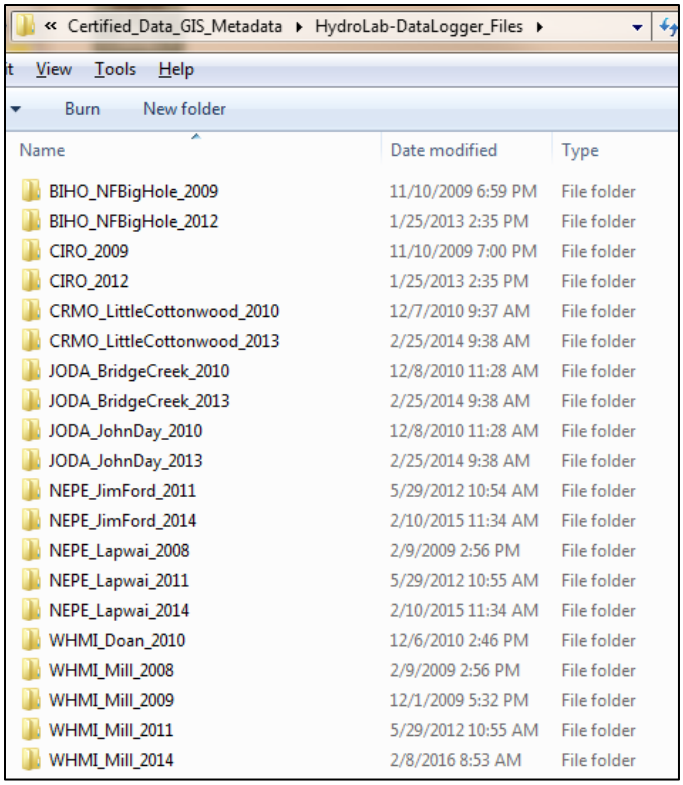


Figure 84. UCBN server location for archival of raw continuous water quality monitoring .csv data files.

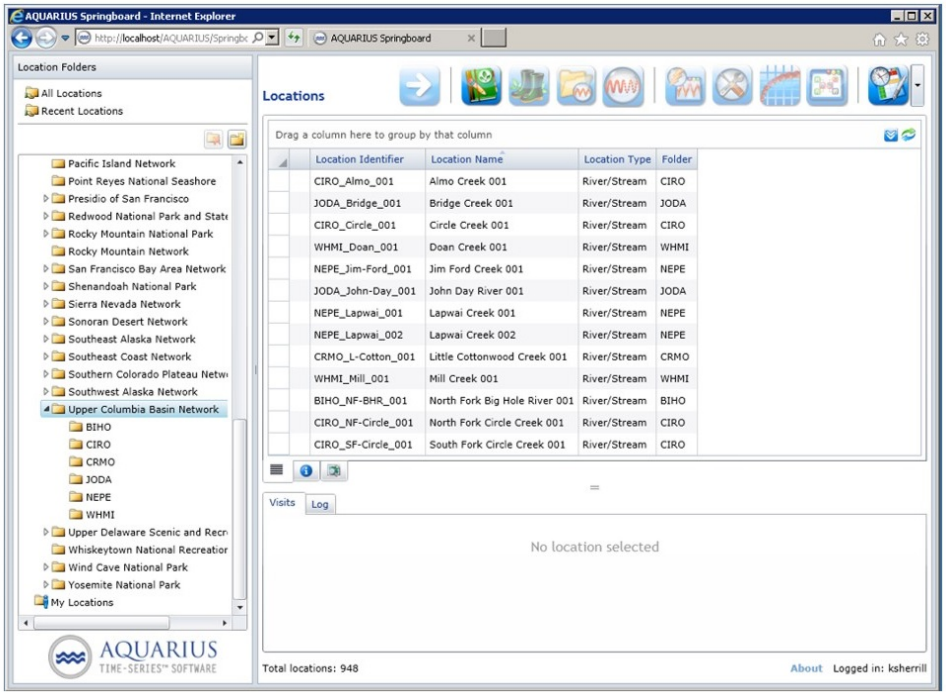


Figure 85. Aquarius Springboard interface, used to transfer raw tabular .csv continuous water quality data to Aquarius.

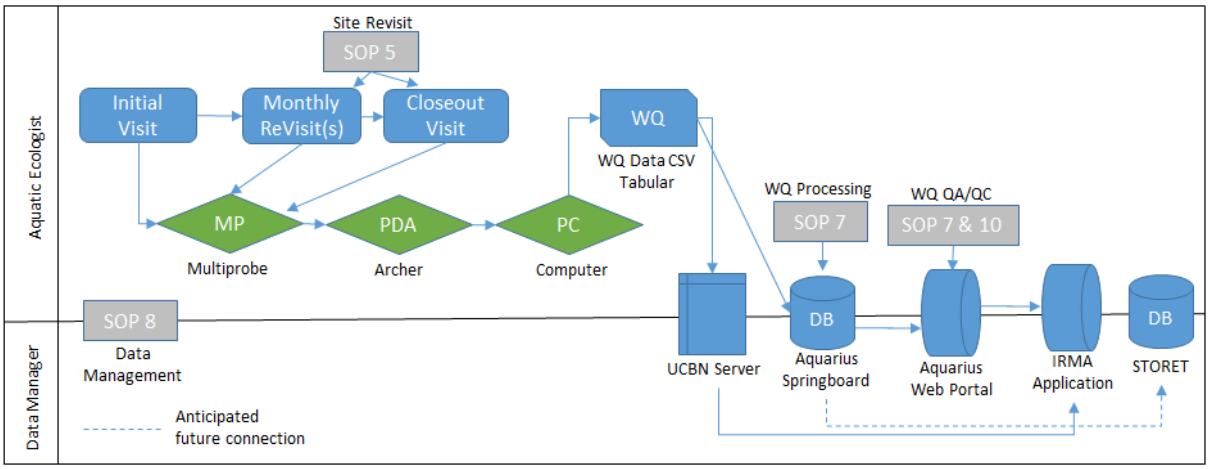


Figure 86. Data import workflow for continuous water quality monitoring data.

II. Monitoring station cross section surveys

Cross section surveys of water quality monitoring sites are performed at initial and season close out visits. Cross section data is initially collected on a paper data form and then entered into the water quality monitoring station and instrumentation database using a Tremble Yuma hand held tablet computer (see SOP 3 for cross section survey data entry details). Forms within the database used to enter the cross section survey are shown in Figure 87. Cross section data in the database are archived by field season (one database per year) on the UCBN server and within the NPS IRMA application. The data import workflow for cross section survey data is shown in Figure 88.

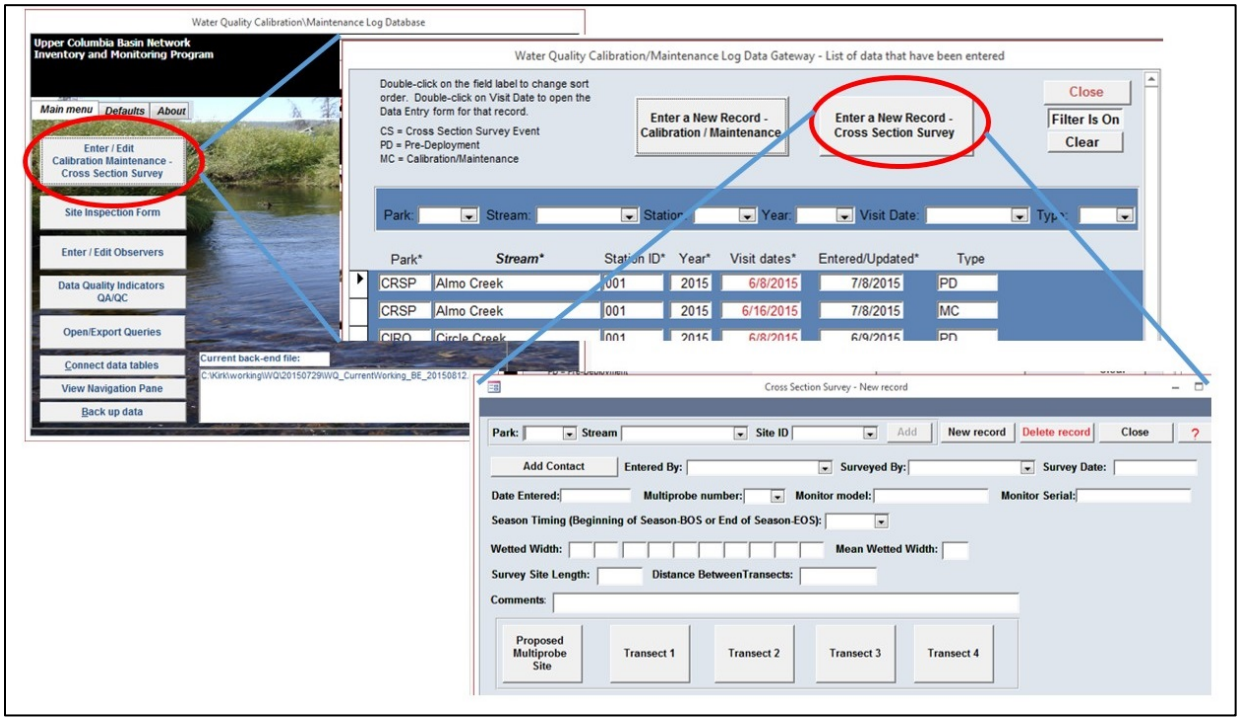


Figure 87. WQ monitoring station and instrumentation DB forms used for data entry of monitoring site cross sectional surveys.

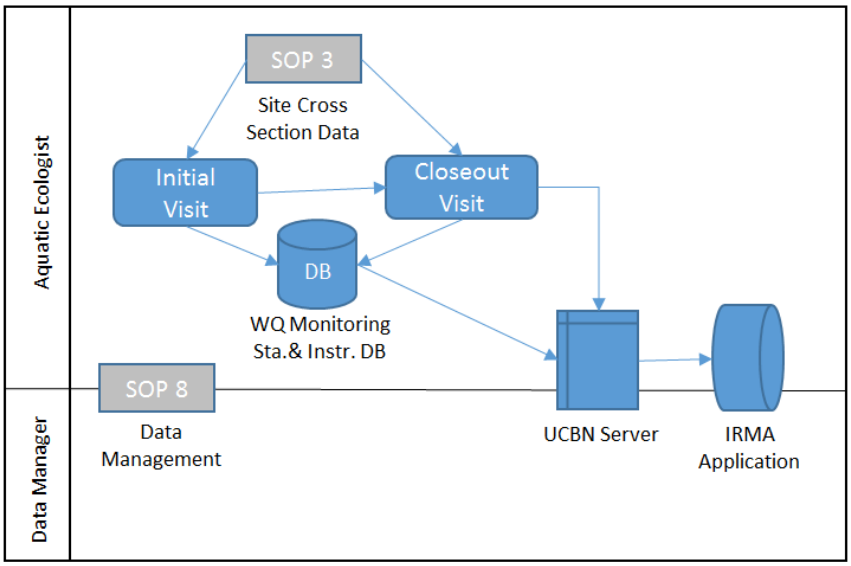


Figure 88. Data import workflow for cross section survey data.

III. Multiprobe calibration and maintenance metadata

Multiprobe calibration and maintenance metadata is collected at revisit and season closeout site visits. As with the cross section surveys, multiprobe metadata information is entered in the field to the water quality monitoring station and instrumentation database using a Tremble Yuma hand held tablet computer (see SOP 5 site visit and multiprobe metadata entry details). Forms within the database used to enter the calibration and maintenance data are shown in Figure 89. Calibration and maintenance data in the database are archived by field season (one database per year) on the UCBN server and within the NPS IRMA application. The data import workflow for multiprobe calibration and maintenance data is shown in Figure 90.

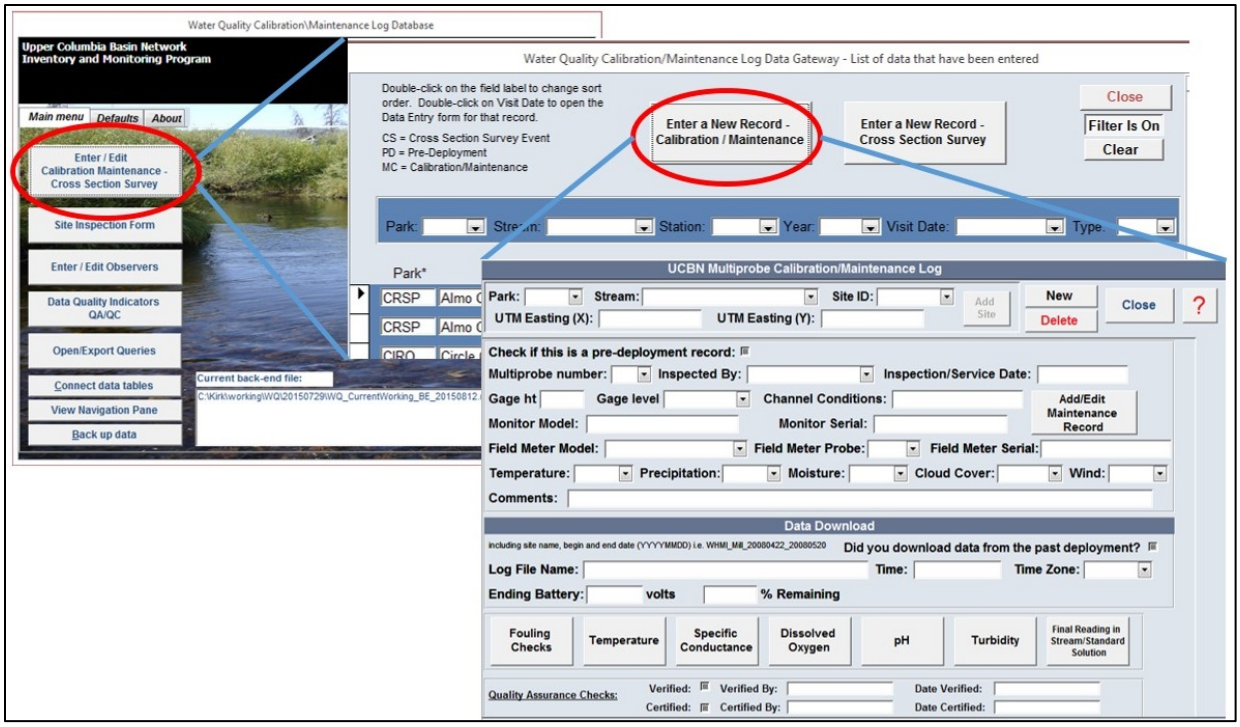


Figure 89. WQ monitoring station and instrumentation DB forms used for data entry of multiprobe calibration and maintenance metadata.

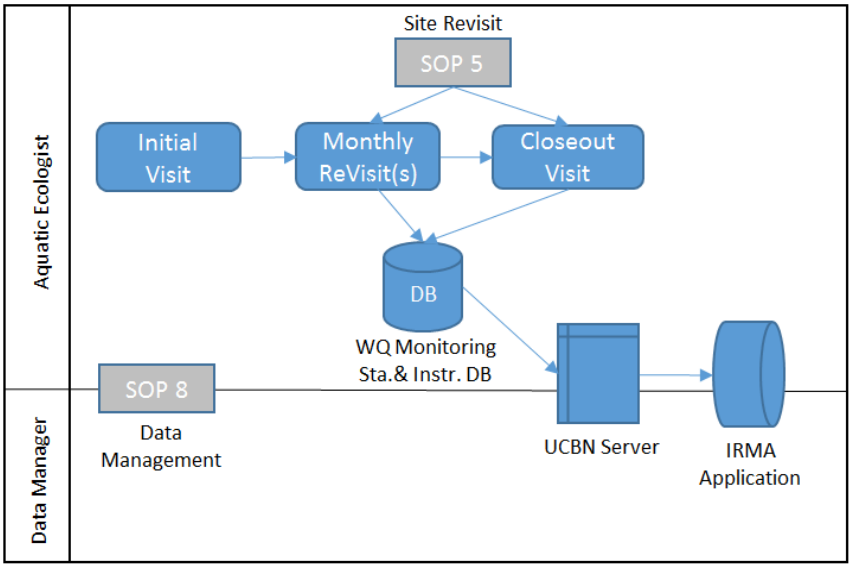


Figure 90. Data import workflow for calibration and maintenance data.

Data Management QA/QC

After monitoring data (site cross section data, instrumentation metadata, and continuous water quality data) has been collected and imported to an archival database, they need to be reviewed by the Project Lead for quality, completeness, and logical consistency. The QA/QC reviewer will then address problems and document any applied corrections. Documentation of corrections occurs within

the Site Inspection Form found in the Water Quality Monitoring Station and Instrumentation database and in Aquarius. If all errors and inconsistencies cannot be addressed, these errors will be documented and included in the metadata and season certification report.

1) Continuous water quality data QA/QC is performed within the NRSS instance of the Aquarius Time-Series platform. The Project Lead performs a data review to verify data integrity, and identify any potential data outliers, missing values, and illogical values. This process of QA/QC is further defined within the continuous water quality record processing SOP 7 (see “Signal Trimming”, “Auto QA/QC”, “Data Corrections”, and “Data Grading” subsections of the “Record Processing” section).

2) The Water Quality Monitoring Station and Instrumentation database and associated data facilitates the quality assessment of data integrity for the collected continuous monitoring data (Temperature, specific conductance, pH, dissolved oxygen and turbidity). Numerous data quality objectives are evaluated using information from both the site cross section survey and multiprobe instrumentation metadata information. Data quality objectives deal with site representativeness, data completeness (spatially and temporally), data comparability (i.e. transferability elsewhere), measurement sensitivity and detection limits, measurement precision/repeatability, and measurement error and biases (Figure 91). The in depth process by which this data evaluation is defined and performed is explained in the QA/QC SOP 10.

In summary, the monitoring station cross section survey(s) and multiprobe instrumentation metadata (within the Water Quality Monitoring Station and Instrumentation database) are used to holistically evaluate and insure data integrity and standards are meet for the continuous water quality data.

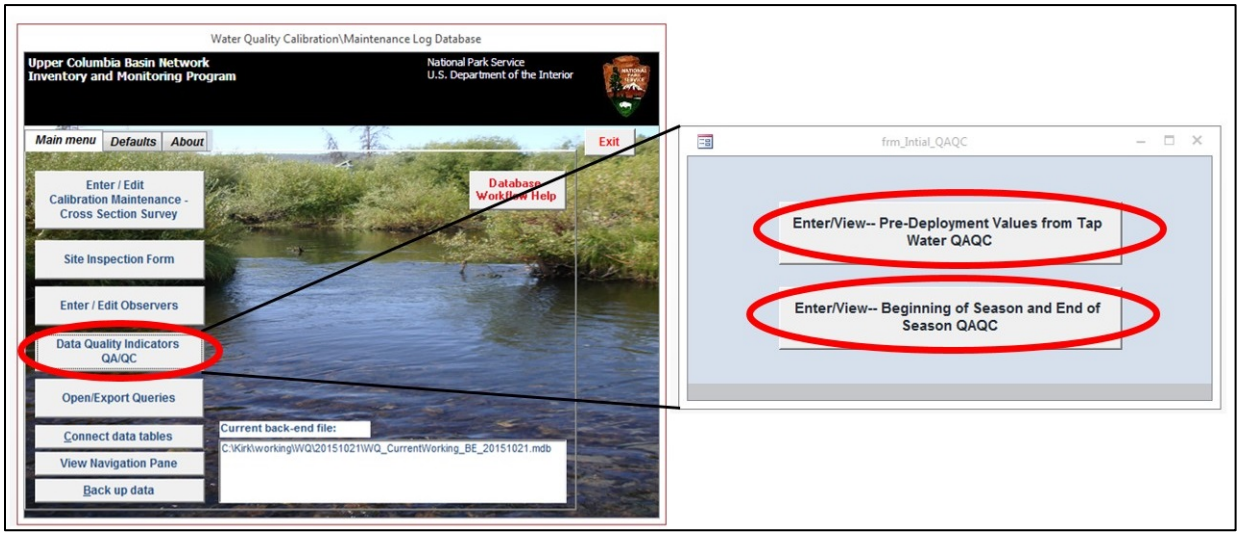


Figure 91. Water Quality Monitoring Station and Instrumentation database queries to be used for quality review.

Metadata Procedures

Detailed metadata for monitoring sites and instrumentation is collected throughout the annual monitoring workflow. This information is entered during initial, revisit and closeout visits to the

Water Quality Monitoring Station and Instrumentation database as described in the site selection and revisit SOPs 4 & 5. Metadata for all UCBN monitoring data will conform to Federal Geographic Data Committee (FGDC) and NPS guidelines and will contain supporting information so data is understood and used appropriately in reporting and analysis.

Metadata information is built within the Water Quality Monitoring Station and Instrumentation database with tables and fields having definition. However, it is still desirable to explicitly create stand-alone accompanying eXtensible markup language (XML) metadata files that will accompany both the Water Quality Monitoring Station and Instrumentation front and back end files. Likewise it is desirable to have XML files for the raw tabular .csv continuous water quality files. Continuous water quality data that is uploaded to the Aquarius system is uploaded to predefined sample site locations where core metadata such as data, time, parameters, units, site location, etc. are pre-defined thus it is not necessary to formally pass on the XML files for the .csv continuous water quality data to Aquarius.

Metadata Creation and Updating

It is necessary to create/update XML data files for: 1) Water Quality Monitoring Station and Instrumentation front-end and back-end databases (one per front-end and back-end certified dataset) and 2) the raw continuous water quality monitoring .csv files (one per park-stream-year). Initial XML metadata templates have been created for these three data sets and are located on the UCBN server at:

"VitalSign_Protocols\Integr_Water_Quality\3_Implement\Data_Management\MetaData (see Figure 92).

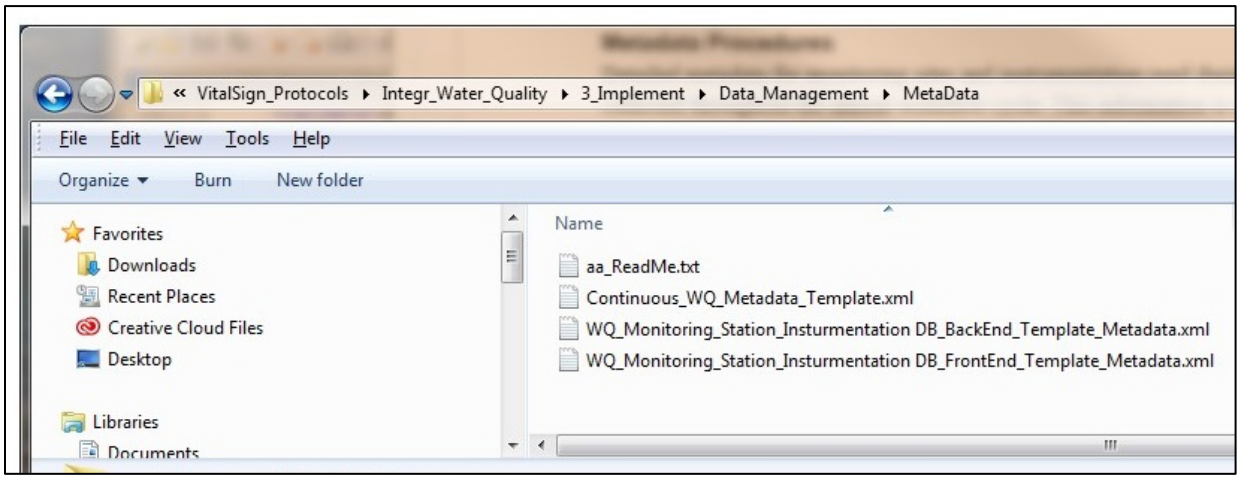


Figure 92. WQ monitoring XML (metadata) template location on the UCBN server, for the WQ Monitoring Station and Instrumentation front-end, back-end and raw continuous WQ monitoring .csv files.

While initial metadata files have been created, the Protocol Lead and Data Manager will need to work collaboratively to update the XML templates to reflect the location, range of data collection, contact information, etc. Updates to XML data can be made in numerous software package including

notepad ++, notepad, wordpad, XML editor etc. A screen shot of the Water Quality Monitoring Station and Instrumentation database front-end XML template is shown in Figure 93.

Updated XML files should be archived in the same server location as respective data files.

Water Quality Access Databases:
VitalSign_Protocols\Integr_Water_Quality\4_Close\Certified_Data_GIS_Metadata\Database)

Raw Continuous .csv files:
VitalSign_Protocols\Integr_Water_Quality\4_Close\Certified_Data_GIS_Metadata\HydroLab-DataLogger_Files\{Park_Site_Year}.

As changes/updates are made to the Water Quality Monitoring Station and Instrumentation database front-end and back-end DBs it may necessary to update the front-end and back-end templates. A tool for automated harvesting of Access database information and creation of XML files is the NPS Database Metadata Extractor MS Access Add-In tool (National Park Service 2012). The metadata tool and a step by step user guide to perform this metadata harvest can be found at: https://irma.nps.gov/DataStore/Reference/Profile/2182070.

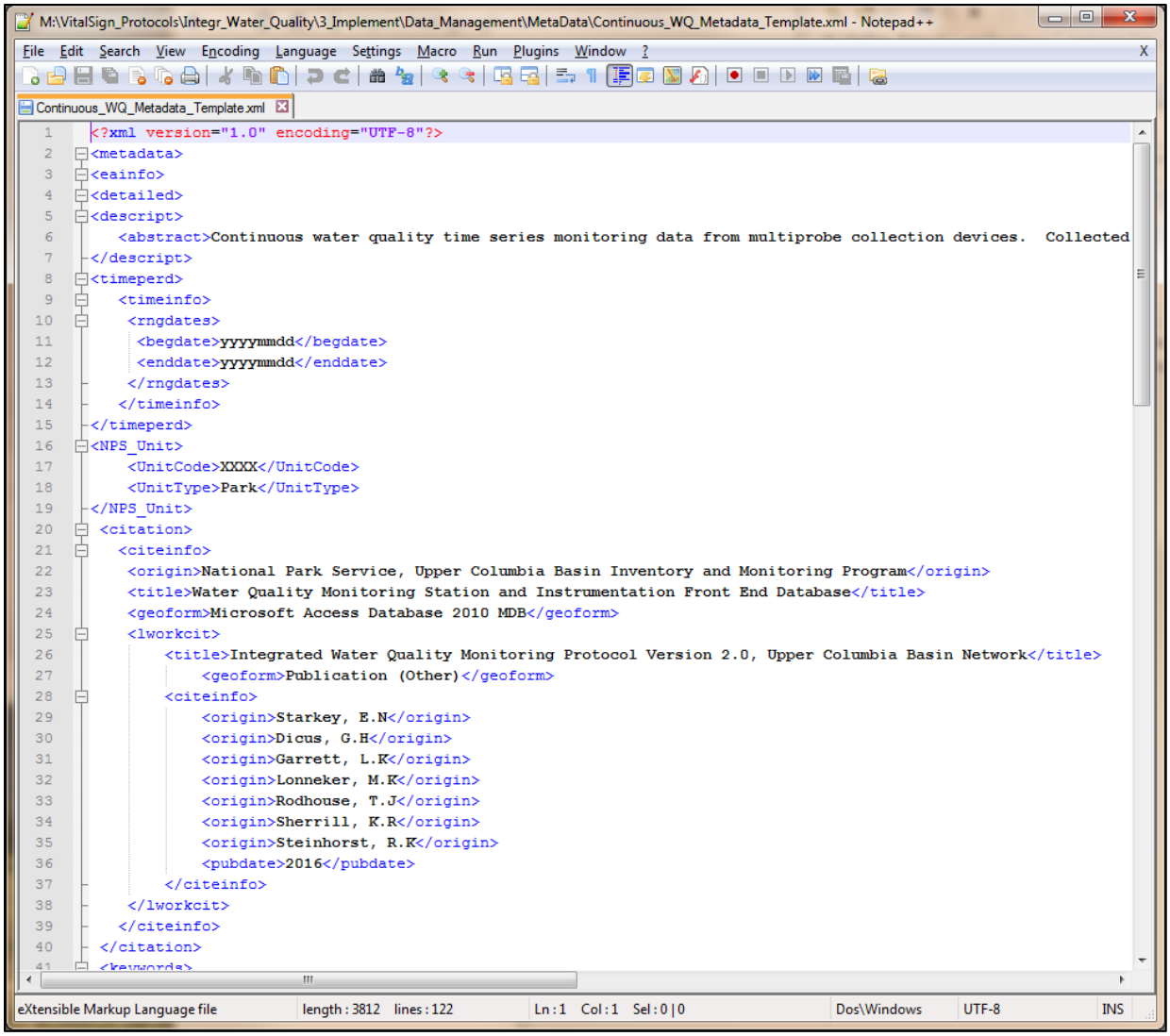


Figure 93. WQ monitoring station and implementation back-end access database XML metadata template screen shot with in the NotePad++ software.

Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which includes specific locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Lead and Park Resource Managers should identify any anticipated sensitive information resulting from monitoring efforts. To date we have not collected sensitive data and don't anticipate the collection of sensitive information from water quality monitoring.

Data Certification and Season Closeout

Data certification is a benchmark in the project information management process that indicates that 1) the data are complete for the period of record; 2) they have undergone and passed the QA/QC checks; and 3) that they are appropriately documented and in a condition for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may not have been detected during QA/QC reviews. To ensure that only data of high quality are included in reports and other project deliverables, the data certification step is an annual requirement for all collected monitoring data. The Project Lead is responsible for completing certification and is assisted by the Data Manager in this process. Completed data certification forms, certified data, and updated metadata should be delivered to the Data Manager according to the timelines defined in Table 12.

I. Water Quality Monitoring Station and Instrumentation Database:

1. After the quality review has been completed, the certified water quality database and associated files will be moved to the local UCBN server for archive. For the Water Quality Monitoring Station and Instrumentation database this will involve moving the working database directory and all associated files to the respective monitoring year folder at:

VitalSign_Protocols\Integr_Water_Quality\4_Close\Certified_Data_GIS_Metadata\Database\{Year}

An example of the water quality database files to be copied (front-end, back-end DB, XML and other associated database files) and the archival location are shown in Figure 94. In this example the files are for the 2015 certified data located at:
VitalSign_Protocols\Integr_Water_Quality\4_Close\Certified_Data_GIS_Metadata\Database\2015

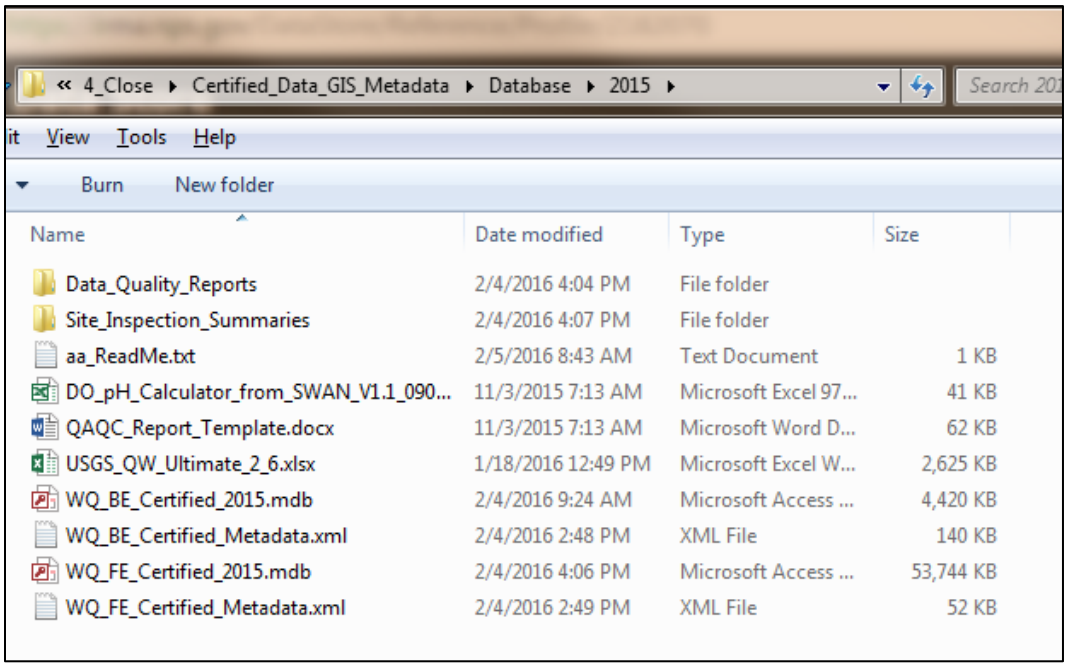


Figure 94. WQ Monitoring Station and Instrumentation DB data files copied to the certified DB directory. (VitalSign_Protocols\Integr_Water_Quality\4_Close\Certified_Data_GIS_Metadata\Database\{Year}).

2) Rename the copied folder to the monitoring year during which the data was collected (e.g. from 20160118 to 2015).

3) Change the WQ front-end, back-end and XML file names to readily identify the data as being certified and for the respective monitoring year. For example front-end and XML filenames to "WQ_BE_Certified_2015.mdb", and "WQ_BE_Certified_Metadata.xml".

II. Data Certification and Season Closeout Forms.

1) Data certification and season closeout template forms should be copied to a respective monitoring year folder (e.g. 2015) on the UCBN server at:

VitalSign_Protocols\Integr_Water_Quality\4_Close\Data_Certification_Forms

Template forms are located at:

VitalSign_Protocols\Integr_Water_Quality\4_Close\Data_Certification_Forms\Templates

2) Complete the data certification (Figure 95 and Appendix F), and season closeout forms (Figure 96 and Appendix F).

Project Data Certification Form

Certification date:	Certified by:
Range of dates for certified data	Title: Integrated Water Quality – {Park}, {Site}
Project code:	Affiliation:
Project title: Integrated Water Quality Monitoring	

Description and scope of data being certified:

- Raw multiprobe log files
- Aquarius corrected data
- Correction History
- Site inspection summary worksheets
- Final Aquarius workstation files
- All QA/QC Information for each parameter
  - MDL
  - AMS
  - AMS+
  - RPD/Precision+

List the applicable parks and provide any park-specific details about this certification.

Park:	Details:
	Water chemistry data has been corrected using standard USGS guidelines, and checked for errors using Aquarius time series software. A history of corrections has been archived on the server. In addition, electronic site inspection summary forms have been archived for each service interval to aid in data quality verification. QA/QC data quality indicators have been provided for all water chemistry data. Macroinvertebrate data was collected as part of stream channel monitoring but has been vetted for errors as part of the water quality season closeout.
	Water chemistry data has been corrected using standard USGS guidelines, and checked for errors using Aquarius time series software. A history of corrections has been archived on the NAS. In addition, electronic site inspection summary forms have been archived for each service interval to aid in data quality verification. QA/QC data quality indicators have been provided for all water chemistry data. Macroinvertebrate data was collected as part of stream channel monitoring but has been vetted for errors as part of the water quality season closeout.

Figure 95. Data Certification Form template screen shot

UCBN Integrated Water Quality Season Close Out Checklist

Page 1 of 3

Project Lead: Monitoring Year:

Parks Involved:

Checklist Submitted to Network Coordinator and Data Manager on: (mm/dd/yyyy)

Deliverable Product	Notes:	Completion Date
Tabular Data		
Data entry completed?		
Data quality verified?	Describe verification procedures (attach pages as needed) See data certification form	
Certified data submitted?	This includes: ☐ Macroinvertebrate Lab Results ☐ Raw multiprobe log files (archived on NAS/Server) ☐ Aquarius corrected data (Aquarius output-Excel file) ☐ Site inspection summary worksheets (electronic format) ☐ Final Aquarius workstation file (Aquarius workflow file used in Aquarius only) ☐ All QA/QC Information for each parameter o MDL o AMS o AMS+ o RPD/Precision+	
Copies of field data forms submitted?	This includes: ☐ Multiprobe Calibration/Maintenance Log forms ☐ Cross Section Survey form ☐ Macroinvertebrate Site Verification/Establishment forms ☐ Macroinvertebrate Sample Collection Form ☐ Macroinvertebrate Sample Shipment/Tracking form	Stored in file cabinet, printer room and scanned data sheets on server
Spatial Data		
Waypoints submitted?	This includes: ☐ Multiprobe stations ☐ All macroinvertebrate sample locations	
New GIS maps submitted?	Describe GIS layers (attach pages as needed)	
GIS metadata submitted?	Notes on metadata (attach pages as needed)	

Figure 96. Season closeout template screen shot

Data Archiving

The final data management step in the annual Water Quality workflow is to insure long-term accessibility and permanence of certified monitoring products via data archival. For water quality monitoring, the certified Water Quality Monitoring Station and Instrumentation database will be uploaded to the NPS IRMA system, while certified continuous water quality monitoring data is

currently being archived in the Aquarius software platform. Pending additional development of the Environmental Protection Agency's STORET water monitoring repository and Aquarius Time-Series functionality, continuous water quality data or derived summary data may be passed from the Aquarius system to STORET (Figure 86). Other WQ annual products such as annual summaries and reports will be archived in the NPS IRMA application.

Directory Structure

The following directory structure will be used to store and archive all information related to the water quality monitoring project on the UCBN server. This is a generic structure that should provide a foundation and a minimum standard of organization and consistency. The goal is to organize all project materials in an efficient hierarchical structure that reflects the life cycle and workflow of the project. Toward this goal, all subfolders are organized into four primary project folders that reflect life cycle stages (initiate, plan, implement, and close). Additional subfolders may be added as needed, but a strong emphasis must be placed on keeping the structure as simple and logical as possible. The four primary project folders and their standard subfolders are presented below.

\Initiate – Store information about the initiation of the project here, including proposals, contract agreements, relevant e-mails, etc.

- **\Agreements_Contracts**
- **\Meetings_Correspondence**
- **\Proposals**

\Plan – Store information about the planning phase of the project here, including monitoring objectives, protocol development summaries, conceptual models, protocol and SOP drafts, study plans, and research permits.

- **\Conceptual_Models**
- **\Data_Mng_Models**
- **\Equipment**
- **\Meetings_Correspondence**
- **\Monitoring_Objectives**
- **\Protocol_Develop_Summary**
- **\Protocol_SOP_Drafts**
- **\Research_Permits**
- **\Study_Plans**

\Implement – Store information about the implementation phase of the project here, including data management documents and draft products, data analysis documents and draft products, project photos, and relevant correspondence.

- **\Data_Analysis**
- **\Data_Management**
  - **\Data_Dictionary**
    - **\PDA_Forms**
  - **\Database_Working**
  - **\Download_Files**
    - **\GPS_Files**
    - **\Datalogger_Files**
  - **\GIS_Data_Working**
    - **\Map_Products**

\Templates
\Features
\Geodatabases

\Meetings_Cooorespondence

\Photos

\Final
\Originals
\Working

\Close – Store finalized documents and products from the close-out phase of the project (on either an annual basis or a final project close-out basis) here, including final reports, certified data and GIS products, and presentations.

\Certified_Data_GIS_Metadata

\Final_Reports

\Annual_Reports
\Investigator_Annual_Reports
\Protocol_SOP_Final

\Other_Final_Deliverables

\Presentations

Schedule for Data Management Tasks

Table 12. Yearly integrated water quality data management task list. This table identifies tasks by project stage, indicates who is responsible for the task, and establishes the timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Preparation	Notify Data manager of needs (field maps, GPS support, training)	Project Leader	ASAP, before Feb 1
	Prepare and print field maps and field forms	Project Leader/Data Manager	by April 1
	Provide database/GPS training as needed	Data Manager	by April 1
	Train field crew in field sampling protocols/Multiprobe calibration techniques	Project Leader/Field Leader/Data Manager	Early April
Data acquisition	Place multiprobe in streams for continuous monthly monitoring (after spring high flow)	Project Leader and/or Field Leader	June
	Collect macroinvertebrate sample (UCBN-Stream Channel Protocol)	Project Leader and/or Field Leader	June - October
	Download multiprobe data monthly and review for completeness and accuracy	Field Leader/Park resource managers	Monthly
Data entry & processing	Import multiprobe data to Aquarius software for processing, and save UCBN WQ database.	Project Leader and/or Technician	Monthly

[1] The UCBN Digital Library is a hierarchical digital filing system stored on the UCBN file server.

[2] NPS IRMA application is a clearinghouse for natural resource reports, data, and metadata (https://irma.nps.gov/Portal).

[3] NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data (https://irma.nps.gov/NPSpecies/).

[4] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://www.nps.gov/policy/DOrders/DOrder19.html).

Table 12 (continued). Yearly integrated water quality data management task list. This table identifies tasks by project stage, indicates who is responsible for the task, and establishes the timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Quality review	Quality review and data validation of multiprobe data using database tools	Project Leader/Data Manager	Monthly
Metadata	Identify any sensitive information contained in the data set	Project Leader	After each season
	Update project metadata records	Project Leader/Data Manager	November
Data certification	Certify the season's data	Project Leader/Data Manager	November
Data delivery	Deliver certified data and updated metadata to data manager	Project Leader	November
	Upload certified data into master project database, store data files in UCBN Digital Library[1]	Project Leader	November
	Notify Project Leader of uploaded data ready for analysis and reporting	Data Manager	November
	Update project GIS data sets, layers and associated metadata records	Data Manager	November
	Finalize and parse metadata records, store in UCBN Digital Library[1]	Data Manager	By Dec 1
Data analysis	Status and trend analyses	Project Leader/Data Analyst	December
Product development	Acquire the proper report template from the NPS website, create annual report	Data Analyst	Dec – Jan
	Screen all reports and data products for sensitive information	Data Manager / Data Analyst	Dec – Jan
	Submit draft report to Network Coordinator for review	Data Manager / Data Analyst	Jan
	Review report for formatting and completeness, notify Project Leader of approval or need for changes	Network Coordinator	Jan
	Upload completed report to UCBN Digital Library[1] submissions folder, notify Data Manager	Project Leader	Feb
	Deliver other products according to the delivery schedule and instructions	Project Leader	Feb

[1] The UCBN Digital Library is a hierarchical digital filing system stored on the UCBN file server.

[2] NPS IRMA application is a clearinghouse for natural resource reports, data, and metadata (https://irma.nps.gov/Portal).

[3] NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data (https://irma.nps.gov/NPSpecies/).

[4] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://www.nps.gov/policy/DOrders/DOrder19.html).

Table 12 (continued). Yearly integrated water quality data management task list. This table identifies tasks by project stage, indicates who is responsible for the task, and establishes the timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Posting & distribution	Submit metadata to NPS IRMA application [2]	Data Manager	Feb
	Create NPS IRMA application record[2], post reports.	Data Manager	Feb
	Update NPSpecies[3] in IRMA [2] according to data observations	Data Manager	Feb
	Submit certified data and GIS data sets to NPS IRMA application[2].	Data Manager	Feb
Archival & records management	Store finished products in UCBN Digital Library [1]	Data Manager	Feb
	Review, clean up and store and/or dispose of project files according to NPS Director's Order #19 4	Project Leader	Feb
Season close-out	Meet to discuss the recent field season, and document any needed changes to field sampling protocols or the working database	Project Leader, Park Resource Managers, and Data Manager	Jan – Feb
	Discuss and document needed changes to analysis and reporting procedures	Project Leader, Park Resource Managers, and Data Manager	Jan - Feb

[1] The UCBN Digital Library is a hierarchical digital filing system stored on the UCBN file server.

[2] NPS IRMA application is a clearinghouse for natural resource reports, data, and metadata (https://irma.nps.gov/Portal).

[3] NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data (https://irma.nps.gov/NPSpecies/).

[4] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://www.nps.gov/policy/DOrders/DOrder19.html).

Literature Cited

National Park Service (NPS). 2012. NPS Database Metadata Extractor MS Access Add-in Version 1.2 documentation. Natural Resource Program Center, Natural Resource GIS Program, Fort Collins, CO.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 9: Data Analysis and Reporting

Version 1.5 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2013	UCBN Aquatic Biologist	Updates to Table- Regulatory thresholds for UCBN streams. Updated resource brief example Figure.	Outdated standards	1.1
1.1	February 2016	UCBN Aquatic Biologist	Updates to Table- Regulatory thresholds for UCBN streams. Slight modification of macroinvertebrate analysis section to reflect that data collection is concurrent with stream channel monitoring. Minor modifications to reflect use of Aquarius Time-Series software.	Macroinvertebrate data collection is concurrent with stream channel monitoring.	1.5

Note: This SOP describes details of the recommended analytical approaches and reporting guidelines for the UCBN Integrated Water Quality monitoring program.

Suggested Reading

Allan, J.D. 1995. Stream ecology: structure and function of running waters. Chapman and Hall. London.

Starkey, E. N., L. K. Garrett, T. J. Rodhouse, G. H. Dicus, and R. K. Steinhorst. 2008. Integrated Water Quality Monitoring Protocol Narrative, Upper Columbia Basin Network. Natural Resource Report NPS/PWR/UCBN/NRR—2008/026. National Park Service, Fort Collins, CO.

Hayslip, G., editor. 2007. Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest. Pacific Northwest Aquatic Monitoring Partnership, Cook, Washington.

Helsel, D.R., and R.M. Hirsch. 2002. Statistical methods in water resources: Techniques of water-resources investigations of the United States. Geological Survey Book 4: Hydrologic Analysis and Interpretation Chapter A3.

van Belle, G. and J.P. Hughes. 1984. Nonparametric Tests for Trend in Water Quality. Water Resources Research 20:127-136.

Analytical Procedures

The statistical methods outlined below, particularly those assessing trend, may be implemented using the statistical freeware R. R is a powerful system for statistical computations and graphics, which runs on Windows, Unix, and Mac computers. R is a combination of a statistics package and a programming language. It can be downloaded for free from http://www.r-project.org/ . The R Wiki provides an online forum http://wiki.rproject.org/rwiki/doku.php and documentation. R is the analytical environment of choice for the Upper Columbia Basin Network however; some of the initial power analyses for this protocol were completed in SAS by a University of Idaho consulting statistician.

Overview

Data analysis and reporting consists of two primary tasks: calculating summary statistics and describing trend, and preparing reports. Annual reports will include summary statistics while 5-year reports will include analyses of trends and recalculation of power analyses after pilot data is available. The procedures for each major monitoring component — core water quality and macroinvertebrates—are described below.

Note that while collection of benthic macroinvertebrate data is done concurrently with stream channel characteristics monitoring (see Starkey et al. 2016); analysis, interpretation and reporting of data will occur in conjunction with continuous water quality data. This co-analysis of vital signs will facilitate better interpretation of results generated from both data sets.

Data Analysis Procedures for Core Water Quality Parameters

Continuous water quality data will be used to examine patterns of status, variability, and trend in core water quality parameters with respect to established water quality criteria (Table 13).

Once multiprobe data have been acquired, quality checked, and submitted to the UCBN Project Lead and Data Manager will collaboratively generate report tables with descriptive statistics using automated scripts that will ensure quality control of the analysis. Analyses may be undertaken in Aquarius Time-Series software or data may be uploaded and analyzed using a script within R or other suitable software package. Regardless, the scripts used to calculate summary statistics will be included in a revision to this SOP following testing and implementation.

Table 13. Regulatory thresholds for UCBN streams. Thresholds are set by state DEQs and consequently differ considerably among parks

Park	Waterbody	Temperature	pH	Dissolved Oxygen	Conductivity/TDS	Turbidity
BIHO[1]	Big Hole River	"A 1ºF (0.56ºC) maximum increase above naturally occurring water temperature is allowed"	6.0-8.5; < 0.5 unit human induced change; Maintain >7.0 if naturally > 7.0	Daily minimum > 8.0 mg/L; 7-d mean > 9.5 mg/L (Early life stage- applicable 16 July to 30 Sept.) 1-day minimum >4.0 mg/L; 7-d mean minimum > 5.0 mg/L; 30 day mean >6.5 mg/L (Other life stages applicable to data collected 20 June to 15 July and 1 Oct. to 17 Oct.)	Not designated	"No increase above natural turbidity is allowed"
CIRO[2]	Circle Creek/Almo Creek	MDMT<22 °C[7] MDAT<19 °C[7]	6.5-9.0	> 6.0 mg/L	Not designated	< 50 NTU (instantaneous); < 25 for 10 consecutive days
CRMO[2]	Little Cottonwood Creek	MDMT<22 °C[7] MDAT<19 °C[7]	6.5-9.0	> 6.0 mg/L	Not designated	< 50 NTU over background (instantaneous) < 25 for 10 consecutive days

[1] *MT DEQ water quality standards for North Fork Big Hole River planning area and Montana numerical water quality standards (MT DEQ 2009 and MT DEQ 2012).*

[2] *ID Criteria for cold water life designation (*ID Admin Code 2015, 58.01.02.101.01a [through 4/5/00].

[3] John Day River basin total maximum daily load (TMDL) and water quality management plan (*OR DEQ 2010) and Admin. Rules of OR 2013, 340-041-001 [through 12/15/2013].*

[4] Criteria established for Salmonid Rearing and Migration (WA Admin. Code 2011, 173-201A-602 [through 8/1/03])

[5] Criteria established for Salmonid Rearing and Migration Only (WA Admin. Code 2011, 173-201A-602 [through 8/1/03])

[6] Special designation for Mill Creek mouth to 13th St. Bridge (WA Admin. Code 2011, 173-201A-602 [through 8/1/03])

[7] MDMT – Maximum Daily Maximum Temperature, MDAT – Maximum Daily Average Temperature, 7-DADMax: 7-Day Average Daily Maximum

Table 13 (continued). Regulatory thresholds for UCBN streams. Thresholds are set by state DEQs and consequently differ considerably among parks

Park	Waterbody	Temperature	pH	Dissolved Oxygen	Conductivity/TDS	Turbidity
JODA[3]	Bridge Creek, John Day River	7 day average of the daily max. < 18 °C (salmon/trout rearing/migration)	6.5-9.0	> 6.5 mg/L instantaneous (cool water, non-spawning)	TDS < 500 mg/L	< 10% cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity
NEPE[2]	Jim Ford Creek, Lapwai Creek	MDMT<22 °C MDAT<19 °C	6.5-9.0	> 6.0 mg/L	Not designated	< 50 NTU over background (instantaneous) < 25 for 10 consecutive days
WHMI	Doan Creek[4]	7-DADMax <17.5 °C	6.5-8.5 with < 0.5 unit human caused variation	>8.0 mg/l Minimum Daily Minimum	Not designated	< 5 NTU increase above background when background NTU < 50, < 10% increase when background NTU > 50
WHMI	Mill Creek[5]	7-DADMax <17.5 °C	6.5-8.5 with < 0.5 unit human caused variation	>5.0 mg/l Minimum Daily Minimum[6]	Not designated	< 10 NTU increase above background when background NTU < 50, < 20% increase when background NTU > 50

[1] *MT DEQ water quality standards for North Fork Big Hole River planning area and Montana numerical water quality standards (MT DEQ 2009 and MT DEQ 2012).*

[2] *ID Criteria for cold water life designation (*ID Admin Code 2015, 58.01.02.101.01a [through 4/5/00].

[3] John Day River basin total maximum daily load (TMDL) and water quality management plan (*OR DEQ 2010) and Admin. Rules of OR 2013, 340-041-001 [through 12/15/2013].*

[4] Criteria established for Salmonid Rearing and Migration (WA Admin. Code 2011, 173-201A-602 [through 8/1/03])

[5] Criteria established for Salmonid Rearing and Migration Only (WA Admin. Code 2011, 173-201A-602 [through 8/1/03])

[6] Special designation for Mill Creek mouth to 13th St. Bridge (WA Admin. Code 2011, 173-201A-602 [through 8/1/03])

[7] MDMT – Maximum Daily Maximum Temperature, MDAT – Maximum Daily Average Temperature, 7-DADMax: 7-Day Average Daily Maximum

Status of Core Water Quality Parameters

Seasonal and annual patterns in the mean and variability of core water quality parameters will be reported in a tabular form similar to the formats in Tables 14 and 15. Estimates of the proportion of observations exceeding state DEQ regulatory thresholds from Table 13 will be routinely performed. These calculations are most easily performed in the "Descriptive Statistics" toolbox in Aquarius. In addition to tabular summaries, plots of time series and exceedance conditions for each parameter will quickly convey status. Figures 97 and 98 provide examples plots for core water quality parameters in Lapwai Creek (NEPE), 2008-2014. To convey data quality, data grades/ratings for each deployment period will be regularly published alongside tabular and summary data plots (Table16). Generation of data grades/ratings is discussed in SOP #7 Continuous Water Quality Record Processing.

Table 14. Summary of descriptive statistics for core water quality parameters for a spring and late summer sampling period at Lapwai Creek, 2007 (NEPE).

Season	Descriptive Statistic	Temp (°C)	pH	Conduct.	Turbidity (NTU)	DO (mg L^{-1})
Spring (4/16-4/24)	N	390	390	390	390	390
	Mean	9.528	7.988	151.056	32.167	10.690
	Standard Dev	1.909	0.179	7.824	143.163	0.552
	Median	9.42	7.9	151	0	10.68
	Minimum	5.64	7.79	136	0	9.41
	Maximum	14.21	8.46	171	1530	11.92
	C.V.	0.200	0.022	0.052	4.451	0.052
	% exceedance	0	0	0	10%	0
Late Summer (9/18-9/30)	N of cases	1138	1138	1138	1138	1138
	Mean	13.756	8.579	255.002	2.976	10.871
	Standard Dev	2.371	0.492	40.415	89.134	1.900
	Median	13.66	8.79	259	0	11.53
	Minimum	8.61	5.98	0	0	7.2
	Maximum	15.51	9.19	276	3000	15.52
	C.V.	0.172	0.057	0.158	29.953	0.175
	% exceedance	0	0	0	0.20%	0

Table 15. Vital sign summary table for water chemistry in Lapwai Creek, June-November, 2014.

Measure	Current Condition (June-November, 2014)	State DEQ Thresholds a	% Exceedance b
Temperature (*MDMT, **MDAT)	* MDMT= 26.59 °C ** MDAT= 22.81 °C	<22 °C [d] **MDAT<19 °C	13% [d,, 2] 32% [3]
Specific conductance (mean)	214.39 µS/cm	N/A	N/A [1]
Dissolved oxygen (mean daily min)	8.13 mg/L	> 6.0 mg/L	0% [1]
pH (mean daily max)	8.6 pH Units	9.0 pH Units, Max	2% [2]
pH (mean daily min)	7.7 pH Units	6.5 pH Units, Min	0% [1]
Turbidity (mean daily max)	22.5 NTU[c]	< 50 NTU over background (instantaneous) < 25 for 10 consecutive days	Insufficient data

[1] Good exceedence (0-5%) (also highlighted in green).

[2] Moderate exceedence (5-55%) (also highlighted in yellow).

[3] Poor exceedence (>25%) (also highlighted in red).

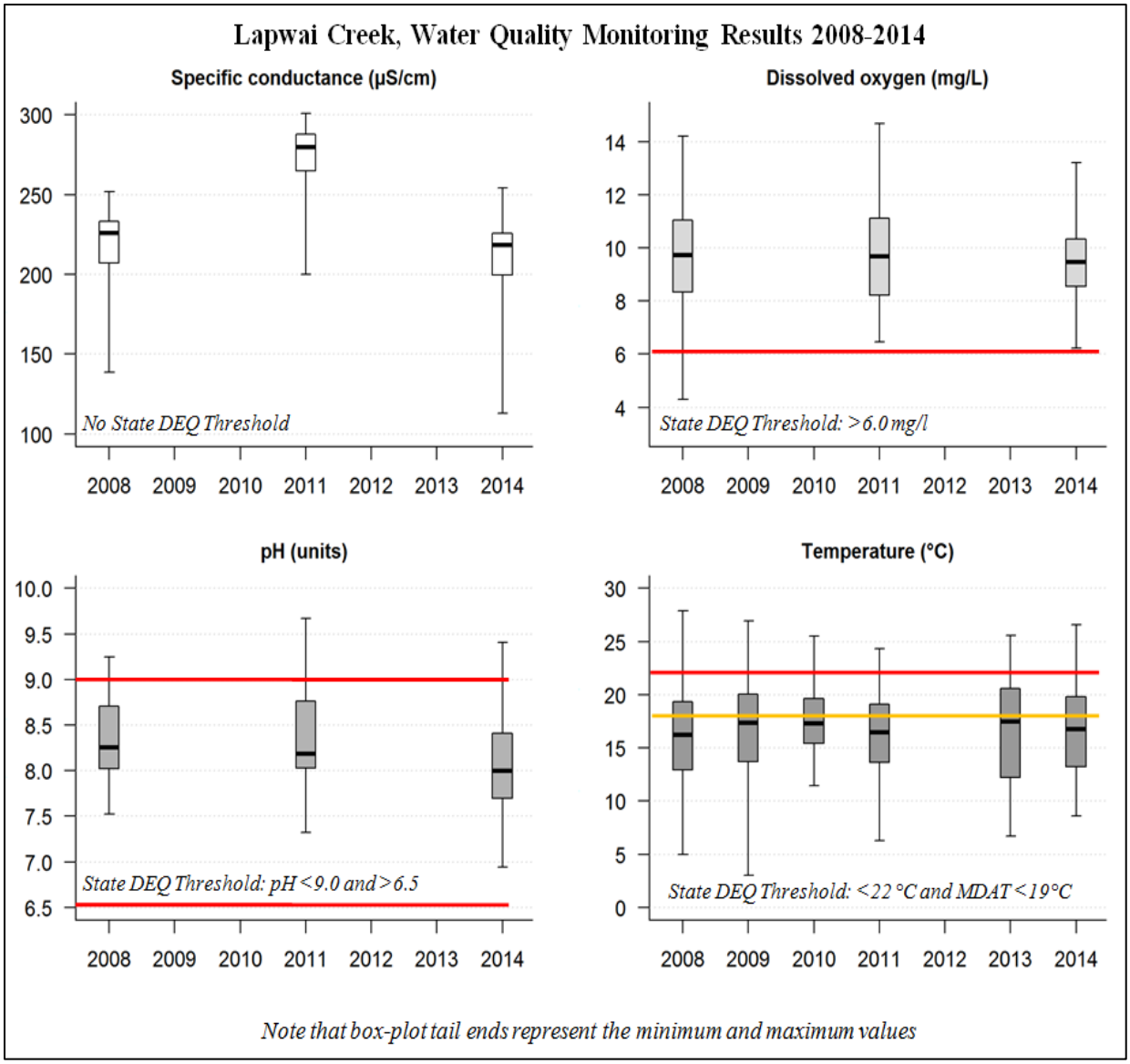


Figure 97. Lapwai Creek, water quality monitoring results box-plot 2008-2014.

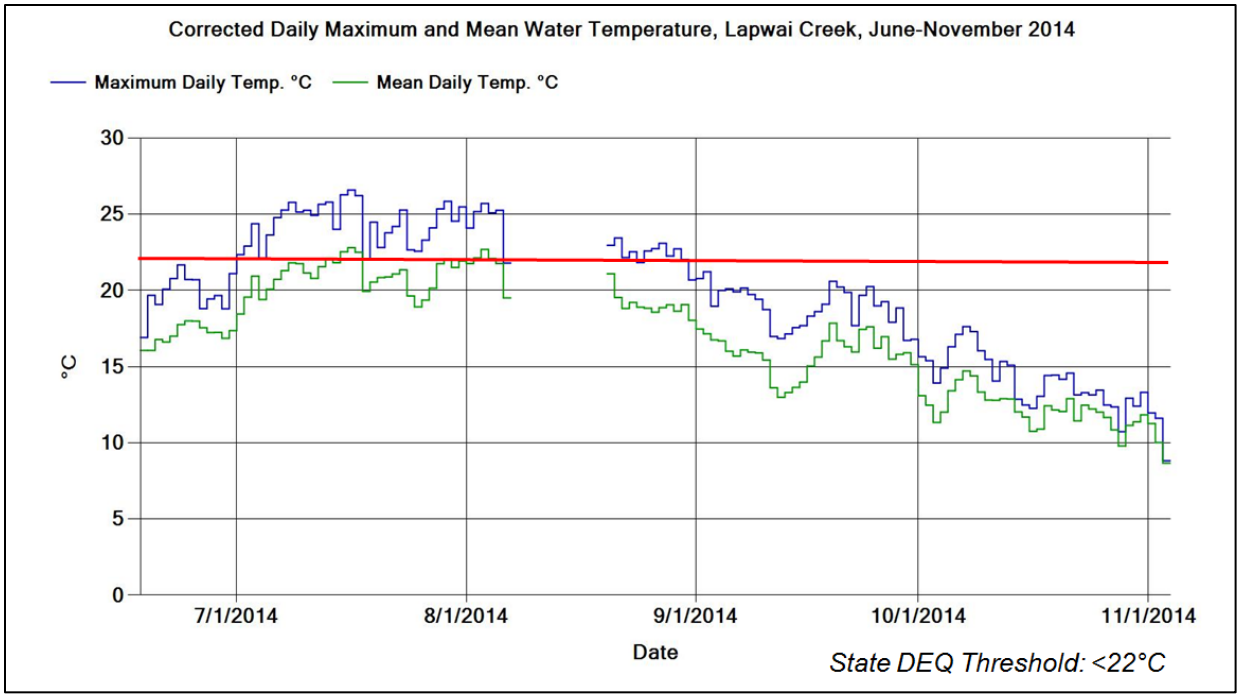


Figure 98. Daily maximum and mean water temperature in Lapwai Creek, NEPE, 2014.

Table 16. Data grade/rating for specific conductance each deployment period June-November 2014 in Lapwai Creek, NEPE.

Specific Conductance Data Grade/Rating	From UTC-07:00	To UTC-07:00
EXCELLENT	06/18/2014 15:00	07/09/2014 09:00
GOOD	07/09/2014 13:00	08/06/2014 08:00
EXCELLENT	08/20/2014 15:00	09/04/2014 08:00
GOOD	09/04/2014 13:00	10/01/2014 08:00
FAIR	10/01/2014 18:00	11/03/2014 09:00

Trend in Core Water Quality Parameters

Long-term trend is measured on a scale of years and may be blocked by months. Trend analysis will use a repeated measures analysis with months as the sampling units (blocks) and years as the repeated measures (treatments). Each year we will obtain one replicate reading for each month (June thru November). For example, at Lapwai Creek we will obtain six observations per year. The long-term monitoring data table consists of readings arranged in years and months. The parametric analysis of simple repeated measures of monthly data over years is equivalent to a randomized complete block ANOVA (van Belle and Hughes 1984). One can also use the seasonal Mann-Kendall test (Helsel and Hirsch 2002). If the UCBN considers only the first and last years of data, it can test for a step trend using the Wilcoxon signed rank test. Tests for linear trend in each core water quality parameter will be conducted once every five years.

The means table will resemble the table below, where μ is the mean and subscripts represent year and month, respectively.

Table 17. Means table, where μ is the mean and subscripts represent year and month, respectively

YR/Month	Month 1	Month 2	…	Month s
Year 1	μ_{11}	μ_{12}	…	μ_{1S}
Year 2	μ_{21}	-	…	μ_{2S}
:	:	:	-	:
Year *t*	μ_{t1}	-	…	μ_{tS}

Power Analysis of Core Water Quality Parameters

We evaluated our ability to detect a ± 20% change in the means of core parameters over 10 years with 80% power and 5% acceptable false-change error (α or Type I error). The null hypothesis is that the monthly means do not change monotonically over time at a rate greater than expected from natural variability. There are two alternative hypotheses, 1) the μ's may change linearly over the 10 years (an 0.02 annual rate of linear change) or 2) there is a step change from year 1 to year 10. In the linear case, the pattern of means in the above table would increase or decrease by 2% each year. Using average monthly temperature for Lapwai Creek as an example, we used sample means from recent years for March (spring), June (summer), September (fall), and December (winter) to give us realistic values for initial conditions ($\mu_{11,}$ $\mu_{12,}$ $\mu_{13,\text{ and}}$ μ_{14}) (see tables below).

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1998	-	-	-	-	-	-	15.1	14.2	16.9	21.8	20.3	17.7
2000	-	-	-	-	-	-	12.0	14.2	17.4	19.4	18.9	15.0
2001	-	7.3	4.7	-	-	-	-	-	-	-	-	-
2002	11.1	-		4.7	4.4	5.0	8.7	13.1	16.6	20.5	17.8	15.0
2003	-	-	-	-	-	-	-	-	17.6	19.8	18.6	15.0

We then increased each μ_{ij} by 2% per year within each month to create a table of μ_{ij}'s consistent with the linear alternative hypothesis. As a result, the means for year 10 are 20% higher than year 1.

Obs	Mar	Jun	Sep	Dec
1	5.00000	17.1200	15.6700	4.74000
2	5.11111	17.5004	16.0182	4.84533
3	5.22222	17.8809	16.3664	4.95067
4	5.33333	18.2613	16.7147	5.05600
5	5.44444	18.6418	17.0629	5.16133
6	5.55556	19.0222	17.4111	5.26667
7	5.66667	19.4027	17.7593	5.37200
8	5.77778	19.7831	18.1076	5.47733
9	5.88889	20.1636	18.4558	5.58267
10	6.00000	20.5440	18.8040	5.68800

We estimated the standard deviation by calculating the square root of the mean square error. Using the SAS function *proc glmpower* with $\alpha = 0.05$, the μ_{ij}'s in the table above, SD=1.1, and an overall sample size of 40, we obtained a power of 0.96. That is, we have a 96% chance of detecting an increase of 20% in temperature by the end of 10 years. If we use the Mann-Kendall test, we would need about 10% more data, i.e., another year (Irwin 2008)

Preliminary power analyses using multiprobe data from Lapwai Creek for two seasons (April and September 2007) are detailed below (Table 18). The results suggest power to detect a 20% linear change in core water quality parameters will be quite good for most parameters (mean temperature = 0.90; minimum temperature = 0.74; specific conductivity = 0.99; dissolved oxygen = 0.99). Higher variability in maximum temperature, and very high variability in turbidity resulted in lower or poor power for these two parameters (maximum temperature = 0.49; turbidity = 0.06). While the power to detect long term trends (defined as 20% change over 10 years) in turbidity was poor, the importance of sedimentation as an impairment in some UCBN streams (e.g., John Day River) justifies estimating this parameter for both status and trend. Graphical tools, such as is illustrated in Figure 97, can be very effective in describing turbidity dynamics over time, as can alternative summaries, such as the number of times turbidity exceeds the threshold criterion over a period of time.

Table 18. Power analyses results for four core parameters for Lapwai Creek at Nez Perce National Historical Park for April and September 2007.

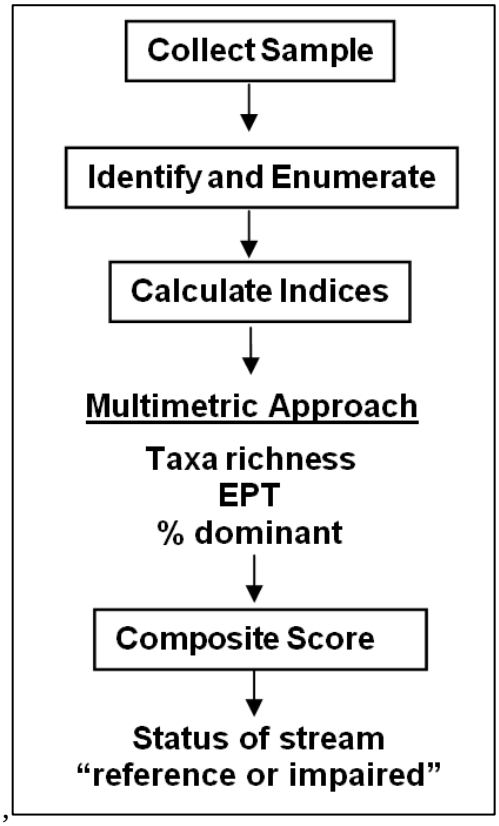
Lapwai Creek	April	September	σ	Power
Avg temp	$\mu_{11} = 9.66$	$\mu_{12} = 12.79$	1.35	0.9
Min temp	$\mu_{11} = 7.85$	$\mu_{12} = 10.4$	1.36	0.74
Max temp	$\mu_{11} = 11.58$	$\mu_{12} = 15.31$	2.69	0.49
SC	$\mu_{11} = 152.8$	$\mu_{12} = 261.7$	8.55	0.99
Turbidity	$\mu_{11} = 34.4$	$\mu_{12} = 1.0$	25	0.06
Dissolved oxygen	$\mu_{11} = 10.63$	$\mu_{12} = 10.33$	0.55	0.99

Data Analysis Procedures for Macroinvertebrate Data

As mentioned above, while collection of benthic macroinvertebrate data is done concurrently with stream channel characteristics monitoring (see Starkey et al. 2016); analysis, interpretation and reporting of data will occur in conjunction with continuous water quality data. This co-analysis of vital signs will facilitate better interpretation of results generated from both data sets.

Macroinvertebrate Status

Each year, a multimetric approach will be used to determine and summarize the status of macroinvertebrate assemblages and water quality relative to reference sites. The UCBN will follow the general procedures for multimetric index development established by Jessup et al. (2006) and Barbour et al. (1999). Figure 99 illustrates the UCBN conceptual model for determining stream status from macroinvertebrate samples.



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Figure 99. Conceptual model for determining stream status used in the analysis of macroinvertebrates data to infer water quality.

Multimetric indices include attributes of the assemblage thought to reflect biodiversity (taxon richness; number of Ephemeroptera, Plecoptera, Trichoptera taxa [EPT taxa, mayfly, stonefly, caddisfly taxa]), sensitivity to organic pollution (Hilsenhoff Biotic Index [HBI]), community evenness (% dominant taxon), trophic structure (% predators, % shredders), or other functional groupings (e.g,. % burrowers) (Barbour et al. 1999; Karr and Chu 1999). The observed multimetric value for each index is compared to threshold or benchmark values for regional streams, when

available. An overall composite index estimates overall water quality. Examination of individual metrics or indices can provide clues to the causes of assemblage shifts. For instance, shifts in HBI values could indicate changes in pollutant sources because this metric includes tolerance values for organic pollutants, while a shift in the percent predators could indicate a shift in the food web resulting from changing land use surrounding a stream. Table 19 lists the metrics that are currently used by state and federal agencies within the UCBN region. Metrics for the integrated water quality protocol will be selected after consultation with the USFS, state DEQ, and macroinvertebrate taxonomists based on utility, robustness and comparability.

As indicated by Barbour et al. (1999) metrics should have a high degree of utility, in that they are ecologically relevant to the community of interest, are sensitive to stressors, and provide a response that can be separated from natural variation. The metrics that are chosen should also be robust and respond in a relatively predictive manner to stressors such that a suite of metrics become a reliable diagnostic tool. Having metrics that are similar to those used by state and federal agencies will allow our data to be easily integrated with other monitoring activities. Furthermore, by selecting similar metrics we will be able to use established reference sites for comparison to UCBN monitoring locations. After calculating individual metrics a composite score is calculated. This composite score is compared to those for streams identified prior to analysis as “reference or impacted” based on watershed condition and impairments to water quality. Reference and impacted sites will be determined based on information provided by state and federal agencies in the UCBN region. As reference sites are developed and become available for UCBN streams, comparisons will be made with reference sites at the end of each collection season.

Figure 100 illustrates a hypothetical example of macroinvertebrate data analysis using a multimetric approach. Sample data (blue circles) are compared to a distribution of values observed for many samples (box plots) taken from reference and impacted streams in the same region (mountainous streams in western Montana). The individual scores for replicate samples are shown adjacent to the mean and a confidence interval to the right. These hypothetical data indicate that the stream was in a reference or unimpacted condition. Each year a similar graph will be constructed for each park, in addition to tables that list individual metric scores.

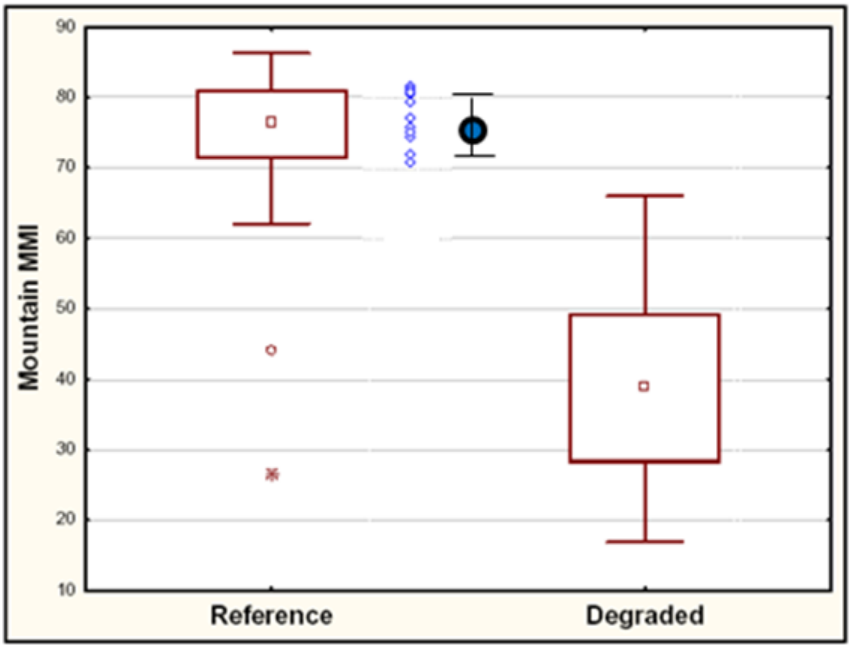


Figure 100. Hypothetical examples of macroinvertebrate data analysis using a multimetric approach. Sample data (blue circles) are compared to a distribution of values observed for many samples (box plots) taken from reference and impacted streams in the same region (mountainous streams in western Montana). Figures modified from Jessup et al. (2006).

Table 19. Candidate metrics for macroinvertebrate multimetric analysis (modified after Barbour et al. 1999; Grafe 2002; Wiseman 2003; OWEB 1999; Montana DEQ 2006). Potential metrics for UCBN water quality monitoring program are highlighted in grey.

Measures	Metric	Definition	Predicted Response to Increasing Perturbation	State / Federal Agencies Using Metric
Richness measures	Total Taxa	Number of distinct taxa in the macroinvertebrate assemblage	-	MT, ID, WA, OR, EPA
	EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	-	MT, WA, EPA
	Ephemeroptera taxa	Number of mayfly taxa	-	MT, ID, WA, OR, EPA
	Plecoptera taxa	Number of stonefly taxa	-	MT, ID, WA, OR, EPA
	Trichoptera taxa	Number of caddisfly taxa	-	ID, WA, OR, EPA
	Sensitive Taxa	This is the number of taxa identified that are known to be very sensitive to stream disturbance. (OR)	-	OR
	Sediment Sensitive Taxa (OR)	Some taxa are known to be very sensitive to inputs of fine sediment. The presence of one or more of these taxa indicates that fine sediments are probably not a major concern. (OR)	-	OR
Composition measures	%EPT	Percent of the sample that is mayfly, stonefly, and caddisfly larvae.	-	MT, WA, OR, EPA
	% Ephemeroptera	Percent of sample that is mayfly nymphs	-	WA, OR, EPA
	% Plecoptera	Percent of sample that is stonefly nymphs	-	ID
	%Chironomidae	Percent of sample of the midge family of flies	+	WA, MT
	% Tanypodinae	Percent of the individuals in the sample that are in the subfamily Tanypodinae (Diptera: Chironomidae)	-	MT
	% Crustacea & Mollusca	Percent of the individuals in the sample that are Crustacea or Mollusca	+/-	MT

Table 19 (continued). Candidate metrics for macroinvertebrate multimetric analysis.

Measures	Metric	Definition	Predicted Response to Increasing Perturbation	State / Federal Agencies Using Metric
Tolerance/Intolerance measures	Number of Tolerant Organisms (0-1)	Taxa richness of those organisms considered to be most sensitive to perturbation (with a tolerance value of 0 or 1)	+	EPA
	Number of Intolerant Organisms (0-3)	Taxa richness of those organisms considered to be sensitive to perturbation (with a tolerance value of 0 to 3)	-	WA
	Hilsenhoff Biotic Index (HBI)	Abundance-weighted average tolerance of organisms to pollution. Originally designed to evaluate organic pollution (Hilsenhoff 1987).	+	MT, ID, WA, OR
	% Tolerant Organisms	Percent of sample considered to be tolerant of various types of perturbation (with tolerance values of 7 to 10)	+	WA, OR, EPA
	% Sediment Tolerant Taxa	This is the percent of the invertebrate community made up of taxa tolerant to fine sediments (OWEB, 2001).	+	OR
Feeding measures	% Filterers / Collectors	Percent of individuals that scavenge or filter organic matter	+/-	MT, WA, EPA
	% Grazers	Percent of individuals that graze upon periphyton	-	EPA
	Scraper taxa	Number of taxa that scrape periphyton from substrates	-	ID
	% Scrapers	Percent of sample that are scrapers	-	MT, WA, EPA
	% Predators	Percent of the sample that are predators but not omnivores	+/-	MT, WA
Habitat measures	Number of Clinger taxa	Number of taxa that have fixed retreats or adaptations for attaching surfaces in flowing water.	-	ID, EPA
	% Clingers	Percent of sample that are clingers	-	WA, EPA
	% Burrower	Percent of the taxa in the sample that burrow in soft sediments	+	MT

Table 19 (continued). Candidate metrics for macroinvertebrate multimetric analysis.

Measures	Metric	Definition	Predicted Response to Increasing Perturbation	State / Federal Agencies Using Metric
Diversity measures	Shannon-Wiener Index	A measure of the heterogeneity of the community or of the diversity of dominant taxa (Shannon and Weaver 1949)	-	None
	Simpson's Index	The probability of randomly and independently selecting the same taxa from the sample twice (Simpson 1949)	+	None
	% Dominant Taxon/Dominant 5 Idaho	Percent of sample in the single most abundant taxon. Also calculated as dominant two, three, five, or 10 taxa.	+	ID, OR,EPA
Voltinism measures	Semi-voltine taxa (long lived richness, WA)	Number of taxa that have aquatic life cycles lasting more than one year.	-	WA

Macroinvertebrate Trend Analysis

Trend in macroinvertebrate assemblage structure will be evaluated after the first 2 sampling rotations and after each rotation thereafter. Two-sample tests (step trend *sensu* Helsel and Hirsch 2002) such as the *t*-test and Wilcoxon rank-sum test may be used to detect statistically significant changes between any two sampling periods. However, given up to 6 replicates per sampling period, power will be restricted to detect only large changes. Once several years of sample data become available, linear trends in measures such as % EPT as a function of time can also be evaluated (Helsel and Hirsch 2002). Simple graphical tools to display biologically important changes in macroinvertebrate indicators over time will also be very powerful.

Macroinvertebrate Power Analysis

Currently, assessing statistical power for macroinvertebrate indices is difficult for UCBN streams because within-site and interannual estimates of variability in macroinvertebrate assemblage structure are not yet available. Available data from regional streams suggests that increasing sample size (e.g., number of replicates/site) decreases variability and improves the probability of detecting uncommon or rare species. For example, in Wyoming streams, increasing the number of samples at each location asymptotically reduces the mean change in taxa richness between samples (Gary Lester, EcoAnalysts, Inc., personal communication). The data from Wyoming suggests that six replicates per stream should provide a reasonable trade-off between cost and power. After the first rotation of sampling, the sampling design for macroinvertebrates will be revisited to estimate power using estimates of variability obtained from the first samples. In particular the evaluation will examine whether it is reasonable to reduce the number of replicates per stream and use these sample resources to increase the spatial extent (add more streams) or temporal frequency of macroinvertebrate sampling (e.g., move to a 2 year rotating panel).

Reporting

A summary report will be produced annually, with a more detailed status and trend report produced every five years. The annual summary will:

- List project personnel and their roles.
- List locations sampled during the current year.
- Provide a summary history of the macroinvertebrate samples taken during each year of monitoring and mean monthly calculations for core water chemistry parameters by location and park.
- Provide descriptive summaries for each core water quality parameter at each sampling location plotted against the DEQ regulatory threshold.
- Provide trend estimates for each core water quality parameter after five years.
- Provide macroinvertebrate metrics at the end of each sampling season.
- Provide macroinvertebrate trend analysis after the first two sampling rotations.
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretability.
- Evaluate and identify suggested or required changes to the protocol.

The annual summary will be developed following the standards for the Natural Resource Technical Report series (http://www.nature.nps.gov/publications/NRPM/index.cfm). This report will be assigned a report series number following peer-review and will be posted to the NRTR series website (http://www.nature.nps.gov/publications/NRPM/nrtr.cfm). A one to two page resource brief will be prepared annually for interpretive staff and the public, and will be provided to park interpretive staff for distribution to interested visitors. Figures 101 and 102 illustrates the resource brief template currently in use by the UCBN for Integrated Water Quality Monitoring. An NPS template for producing maps with ESRI ArcGIS or ArcView software is available at https://imgis.nps.gov/#Cartography. The proportion of observations above or below the DEQ regulatory threshold will be reported annually in the resource brief along with any unusual observations (new taxa, high flow events, invasive species, etc.). Data from annual monitoring efforts will be used to populate and update the Natural Resource Summary Tables maintained by each park in the Network.

A more in-depth analysis and report will be produced approximately every five years, or as the importance of emerging information warrants. This report will provide greater analytical and interpretive detail, and will evaluate the relevance of findings to long-term management and restoration goals. The report should also evaluate operational aspects of the monitoring program, such as whether the sampling period remains appropriate.

The 5-year status and trend report should use the NPS Natural Resource Publications Natural Resource Technical Report (NRTR) template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. This template, guidelines for its use and documentation of the NPS publication standards are available at the following address: http://www.nature.nps.gov/publications/NRPM/index.cfm.

Upper Columbia Basin Network
Inventory and Monitoring

National Park Service
U.S. Department of Interior

Pacific West Region

Water Quality Monitoring in Big Hole National Battlefield (BIHO)

Importance

Freshwater habitats are diverse and productive ecosystems, providing habitat for aquatic plant, invertebrate, and vertebrate species including many fishes and birds. Rivers and streams are intimately connected to riparian zones, providing habitat for many specialist species. Additionally, most upland animals rely on aquatic habitats to one degree or another.

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



North Fork Big Hole River September 2015

Status of North Fork Big Hole River in BIHO

Threats to water resources in BIHO have been listed as: flow impairment, mining, agriculture, and stormwater runoff (Garrett et al. 2007). In 2014, North Fork Big Hole River was listed as a category 4A or impaired water according to the state of MT. Meaning that sufficient data shows that the stream is failing to achieve compliance with applicable water quality standards (i.e., nonsupport or partial support of beneficial uses). Designated state beneficial uses are agricultural, aquatic life, drinking water, and primary contact recreation. Of which, aquatic life and primary contact recreation uses were not supported.

In 2015 the UCBN monitored 5 core water chemistry parameters in the North Fork Big Hole River including: dissolved oxygen, pH, specific conductance, temperature, and turbidity. Each parameter was evaluated hourly between the months of June and October using a continuous water quality monitor. In addition, aquatic macroinvertebrates were collected according to United States Forest Service (USFS) - PACFISH/INFISH Biological Opinion Effectiveness Monitoring (PIBO-EM) Program protocol. For more on macroinvertebrates please see the integrated water quality annual report for BIHO on the UCBN website listed below.

- Water temperature exceeded the threshold to protect against stress or lethal conditions for arctic grayling (18 °C) during 3.6% of observations. These data suggest that reduced streamflow and stream shading may be contributing to high water temperatures.
- During the time period in which there are "early life stage" fishes present in the river, minimum daily dissolved oxygen levels consistently (96% of observations) fell below the criteria of 8.0 mg/l and were likely attibutable to elevated water temperatures and reduced streamflow. The early life stage dissolved oxygen criteria is applicable July 16th to September 30th.

UCBN water quality monitoring is conducted on a 3 year rotating panel. The North Fork Big Hole River will be sampled for water chemistry and macroinvertebrates again in 2018.The following table is a summary of findings from 2015 monitoring along with state regulatory thresholds and other criteria for the North Fork Big Hole River.

North Fork Big Hole River Water Chemistry Summary 2015

Measure	*Current Condition (June-October, 2015)*	*State DEQ Thresholds[a]*	*% Exceedance[c]*
Temperature (*MDMT, **MDAT)	*MDMT=19.59 °C **MDAT=17.57 °C	"A 1 °F [0.56 °C] maximun increase above naturally occurring water temperature is allowed	--
		<18 °C threshold to protect against stress or lethal conditios for arctic grayling	3.6%
Specific Conductance (mean)	58.80 µS/cm	N/A	N/A
Dissolved Oxygen (mean daily min)	6.91 mg/L	Daily minimum >8.0 mg/L;	96%
		7-d mean >9.5 mg/L	100%
		(Early life stage - applicable 16 July to 30 Sept.)	
pH (mean daily max)	7.34 pH Units	6.5-8.5; <0.5 unit human induced change;	0%
pH (mean daily min)	8.19 pH Units	Maintain >7.0 if naturally >7.0	0%
Turbidity (mean daily max)	7.07 NTU	"No increase above natural turbidity is allowed"	--

**MDMT – Maximum Daily Maximum Temperature, **MDAT – Maximum Daily Average Temperature, [a] MT DEQ water quality standards for North Fork Big Hole River planning area, [b] BIHO prefered temperature theshold, [c] Proportion of samples above water quality standard.*

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http://science.nature.nps.gov/im/units/ucbn/monitor/water_quality.cfm

November 2015

Figure 101. Resource brief template (page 1) for annual vital signs reporting to park staff and the public.

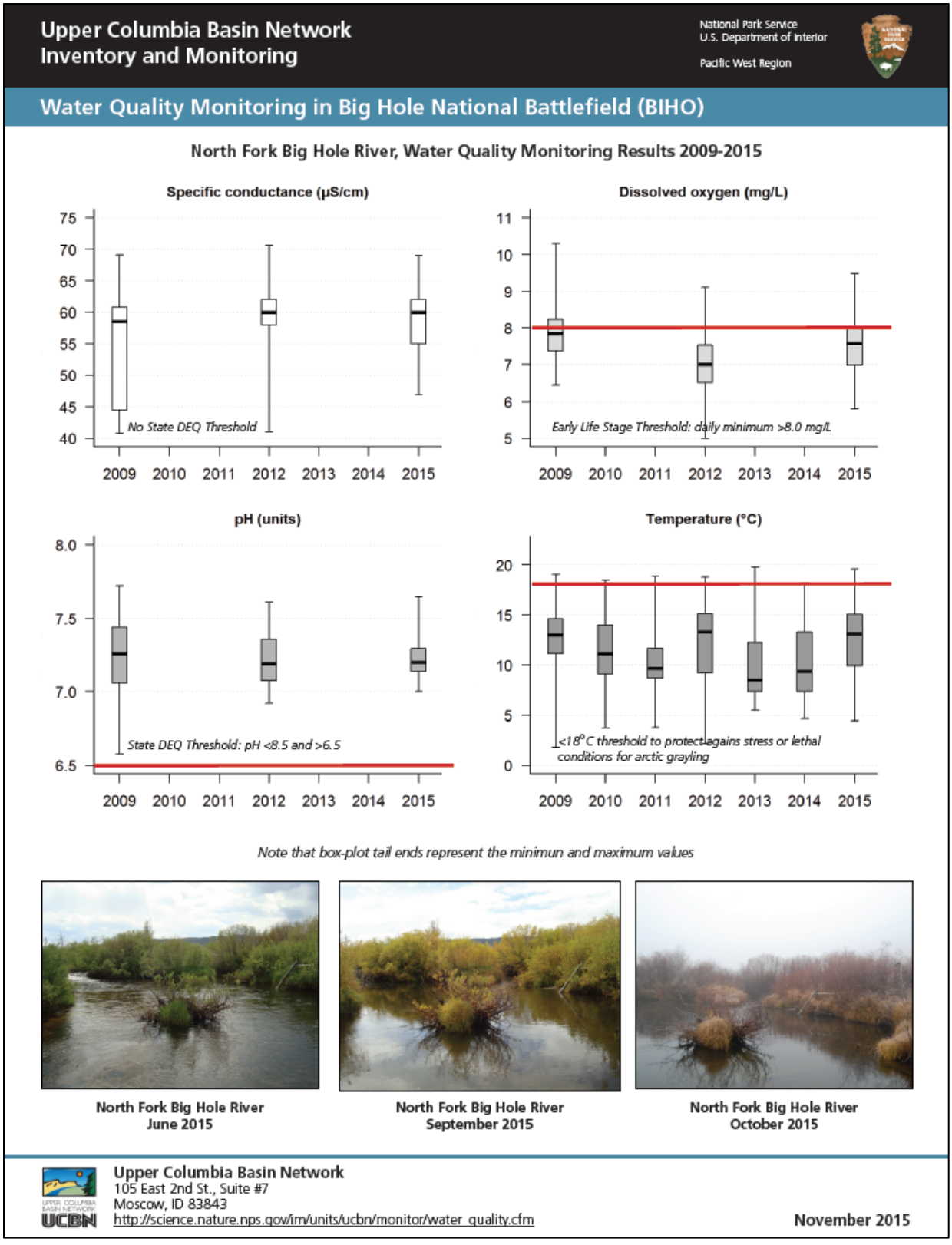


Figure 102. Resource brief template (page 2) for annual vital signs reporting to park staff and the public.

Schedule for Monitoring Project Deliverables

Table 20. Schedule for integrated water quality monitoring project deliverables.

Deliverable Product	Primary Responsibility	Target Date	Destination(s)
Raw data files	Field Leader	November of each year	UCBN Digital Library [1]
Certified working database and geospatial data with draft metadata	Project Leader with Data Manager assistance	December 15	Master project database and GIS data sets, copy to UCBN Digital Library [1], and NPS IRMA application[2]
Full metadata (parsed XML)	Data Manager	January 15	NPS IRMA application[2], UCBN Digital Library [1]
Resource Brief	Project Leader	February 1 of following year	UCBN website
Annual report (for internal purposes)	Project Leader	March 1 of following year	NPS IRMA application[2], UCBN Digital Library [1], printout to local park collections
5-year analysis report	Project Leader	After every 5 years of data collection by March 1 of 6th year	NPS IRMA application[2], UCBN Digital Library [1], printout to local park collections
Other publications	Network Coordinator, Project Leader, Data Manager	As completed	NPS IRMA application[2], UCBN Digital Library [1], printout to local park collections
Other records	Network Coordinator, Project Leader	Review for retention every December	Retain according to NPS Director's Order #19 [3]

[1] The UCBN Digital Library is a hierarchical digital filing system stored on the UCBN file server. Network users have read-only access to these files, except where information sensitivity may preclude general access.

[2] NPS IRMA application is a clearinghouse for natural resource reports, data, and metadata (https://irma.nps.gov/Portal).

[3] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://www.nps.gov/refdesk/DOrders/DOrder19.html

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Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 10: Quality Assurance/Quality Control

Version 1.9 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2016	UCBN Aquatic Biologist	Removal of benthic macroinvertebrate QA/QC information. Macroinvertebrate QA/QC is now covered in the stream channel protocol	Macroinvertebrate sampling is now being completed concurrent with stream channel characteristics monitoring.	1.9

Note: This SOP describes the step-by-step QA/QC procedures for ensuring that data collected by the UCBN integrated water quality monitoring program is of known quality, pertinent to monitoring objectives, and will be useful to future investigations. The general content and format of this SOP is based on the NCPN- Quality Assurance Project Plan (QAPP) SOP#7, Part B lite (Irwin, 2008) and the EPA's National Coastal Assessment Quality Assurance Project Plan 2001-2004.

Suggested Reading

Irwin, R .J. 2008. Draft Part B lite QA/QC Review Checklist for Aquatic Vital Sign Monitoring Protocols and SOPs, National Park Service, Water Resources Division. Fort Collins, CO. http://www.nature.nps.gov/water/vitalsigns/assets/docs/PartBLite.pdf (Accessed February 18, 2016)

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Introduction

Quality Assurance and Quality Control are important aspects of the UCBN integrated water quality monitoring protocol in order to establish and maintain high standards of data collection and maintenance. These QA/QC standards will ensure that data is of known quality, pertinent to UCBN integrated water quality monitoring objectives, and will be useful to future investigations.

The overarching programmatic goal of the UCBN integrated water quality monitoring program is to obtain information that will aid in informed management decisions pertaining to improved water quality within UCBN parks. Park managers have committed to improving the water quality of impaired waters by adopting the NPS Government Performance Results Act (GPRA) goal that 99.3% of streams and rivers managed by NPS will meet State and Federal water quality standards. Many UCBN waters do not meet standards and are listed on 303(d) lists. Park managers would also like to be able to demonstrate and maintain high water quality where it exists. The NPS should be leading the way in high water quality regardless of beneficial uses, i.e. consideration should be given to water resources for their intrinsic value alone.

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

- Are 303(d) listed waterbodies in the UCBN including those with established TMDLs improving over time?
- What is the status and long term trend of core water quality parameters (temperature, pH, conductivity, dissolved oxygen, and turbidity) in or near select UCBN waterbodies?
- What is the status of aquatic macroinvertebrate abundance and assemblage composition in selected UCBN lotic waterbodies?*
- Do aquatic macroinvertebrate assemblages sampled within the UCBN indicate "pristine" or "reference" conditions according to regional criteria established by EPA and the states of Idaho, Montana, Oregon, and Washington?*
- Do aquatic macroinvertebrate assemblages sampled within the UCBN indicate polluted or otherwise impaired water quality? *
- What are the long-term trends in aquatic macroinvertebrate abundance and assemblage composition within selected UCBN lotic waterbodies?*

**Covered in the UCBN Stream Channel Characteristics Monitoring Protocol (Starkey et al. 2016).*

The objectives and sampling design were developed through a process that involved site reconnaissance, pilot data collection and analysis, and thoughtful consideration of budget and Network information requirements. The protocol team consisted of this document's authors, as well as park resource management staff.

We note that, while the aim of the sampling design is to provide optimal statistical robustness and scientific rigor, other considerations including personnel safety, fiscal and logistical constraints, and the ability to integrate data with other vital signs must be considered. In addition, the water bodies of

most UCBN parks are diverse and the most efficient sampling design will differ among parks. Water quality sampling in UCBN parks will be at targeted index sites.

Measurement Quality Objectives (MQOs) for Macroinvertebrates are covered in the UCBN Stream Channel Characteristics Monitoring Protocol (Starkey et al. 2016).

Measurement Quality Objectives (MQOs) for Water Chemistry

From the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

This section is intended to demonstrate how this project generates data of known and documented quality, resulting in complete, accurate and transferable information. Data credibility necessary for the intended uses will be achieved when it is:

1. Consistent over time and consistent between staff members
2. Collected and analyzed using standardized and acceptable techniques
3. Comparable to data collected in other assessments using the same methods
4. Used appropriately to make decisions based on sound statistics

Data Quality Objectives (DQOs)

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

These are the quantitative and qualitative terms that describe how good data need to be in order to meet project objectives. DQOs for water chemistry data are discussed in detail below and are listed by NPS WRD as:

1. Target population
2. Representativeness
3. Completeness
4. Data comparability
5. Measurement sensitivity and detection limits
6. Measurement precision as repeatability
7. Measurement systematic error/bias

Target Population

The initial target population for the integrated water quality monitoring protocol was defined as representative UCBN waterbodies. Due to logistical constraints it is not possible to sample all UCBN waterbodies; as a result the water quality monitoring sample population is defined as representative UCBN wadeable streams with permanent water sampled between the months of June and November.

Representativeness

Spatial: The UCBN seeks to balance the need for a representative location within each stream with factors such as: stream stages, channel morphology, water velocity, potential for debris damage, and logistics. The above mentioned factors will be assessed to help determine the best multiprobe site (SOP #3). In addition, cross-section and stream segment variation will be determined using a survey

of water quality parameters. This survey will consist of measurements taken at the proposed multiprobe site, across a transect at the proposed multiprobe site and at 3 subsequent transects up/down-stream. These values and associated variability among transects will be compared to the proposed multiprobe site. If the proposed multiprobe site values are not significantly different from the other transects it will be inferred that the multiprobe site is reasonably representative of the stream segment within the park. Having stated this, caution should be exercised when making comparisons to other streams within and outside of UCBN parks, due to the longitudinal and spatial variability of streams. For more details about the cross section survey see SOP #3.

Temporal: Annual and daily variations in water chemistry conditions are inherent in any aquatic system; however, in order to assess the status of streams in UCBN parks it is important to account for this variation. To address variation in water chemistry values, the UCBN will be using continuous multiparameter water quality monitors. These multiprobes will record core water quality values every hour, 24 hours a day June through November. It is anticipated that this time period will be adequate to determine overall trends in water chemistry. Logistical constraints such as ice and high flows will prevent deployment of the multiprobes between the months of December and May. Due to this restriction, statements regarding the status of water chemistry between December and May will be avoided. Despite the 6 month gap in water quality data; the fine temporal resolution obtained from these multiprobes is advantageous in that it gives a better "picture" of the stream than the relatively coarse information obtained from grab samples. Monthly calibrations and error checks will ensure quality data throughout the deployment period (SOP #5).

Completeness

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

Given the objectives of the UCBN integrated water quality monitoring protocol it is extremely important that samples be collected during the entire deployment period (June-November). However, erroneous data caused by low battery power will be removed from any analysis and down time due to sensor failures/repair are possible. Given our minimum detectable differences and calculated statistical power, 90% completeness should insure large enough sample sizes to meet objectives outlined in the protocol narrative and at the beginning of this SOP. That being said, every effort will be made to achieve 100% completion of data collection and analysis, but realistically some data may be missed in the monthly deployments. To decrease the number of samples lost due to low battery power, multiprobes should be serviced approximately every 30 days. Exact timing will depend on the power source (internal vs external). In addition, summary statistics should only be calculated when a given time period has at least 80% data coverage. For example, a daily mean should only be calculated if that day has >80% of observations (i.e. >19 hourly readings of 24 possible).

Data Comparability

The UCBN seeks to have water quality data that is easily integrated with data obtained by other agencies and projects. Data that is easily integrated will facilitate a greater understanding of watershed issues, problems and conditions. This will be accomplished by adopting sample designs comparable to that of the United States Geological Survey (USGS). Site selection, sampling frequency, calibration criteria, and correction criteria will all follow guidelines recommended by the USGS (Wagner et al. 2006). By adopting a similar sample design and calibration methods, data should be easily compared with data collected outside NPS boundaries. In addition, the UCBN will be monitoring a set of rather ubiquitous core parameters (Temperature, pH, Specific Conductance, Dissolved Oxygen, and Turbidity). These parameters are widely reported and have broad utility for interpreting water quality.

Measurement Sensitivity and Detection Limits

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007).

The low-level method detection limits (MDL) and minimum level of quantitation (ML) are the terms used to describe the smallest presence that can be observed and the accurate quantity of an analyte of interest. They are important concepts in water quality data reporting and analysis for many reasons especially when considering chronic low level pollution that is near the detection limits of analysis methods (Irwin 2008). These values will be updated / reported at least once per year or when methods change and become part of the permanent data record (Sharrow et al. 2007). Values below the MDL and ML will be reported as “present less than quantification limit” or as “non-detectable.” The only parameter that occurs at levels near the lower detection limit is turbidity. For this reason MDL and ML will not be determined for temperature, pH, specific conductance, or dissolved oxygen. Instead, these measures will have associated “alternative measurement sensitivity +” as described below.

The UCBN will be using the HACH Hydrolab MS5 for continuous water quality monitoring. The range, accuracy and resolution of each sensor as provided by HACH are given in Table 21. This should not be confused with the alternative measurement sensitivity + described below.

Table 21. Range, Accuracy and Resolution of the HACH Hydrolab MS5 multiprobe sensors as defined by the HACH Company.

Sensor	Range	Accuracy	Resolution
Temperature	-5 to 50 °C	± 0.10 °C	0.01 °C
Specific Conductance	0 to 100 mS/cm	± 1% of reading; ± 0.001 mS/cm	0.0001 units
pH	0 to 14 units	± 0.2 units	0.01 units
Hach LDO (dissolved oxygen)	0-20 mg/L	± 0.01 mg/L for 0-8 mg/L; ± 0.02 mg /L for greater than 8mg/L	0.01 or 0.1 mg/L
Self-cleaning Turbidity	0 to 3000 NTU	± 1% up to 100 NTU, ± 3% up to 100-400 NTU, ± 5% from 400-3000 NTU	0.1, up to 400 NTU; 1.0m, 400-3000

Table 22. Comparison table for QC data quality indicators used by the UCBN (Modified from Irwin 2008).

Metric Acronym	Purpose	Metric + Brief STORET Note	Minimum Frequency of Reporting	Description	Sample Size	Equation
MDL: For Control of Very Low Level Sensitivity. This is the standard MDL	EPA, State, and some USGS labs Low Level Sensitivity as Detection Limits (Usually Lab)	Method Detection Level. Put MDL in the detection limit field. If the result is <MDL, STORET Detection Condition is "Not Detected."	1/year or when methods change	Lowest value that can be differentiated from zero, the lower Semi-Quantitative Type of Detection Limit, Based on Short Term Data	Seven	Obtain MDL from laboratory, For field work calculate as 3.134*SD of a blank or very low signal solution
ML: Higher than This, Values are Quantitative	EPA and State Quantitative Sensitivity as Detection Limits (Usually Lab)	Minimum level of quantitation, In STORET, record at LQL	1/year or when methods change	Lowest Quantitative Value Above the ML values are quantitative	Based on Single MDL	3.18 * (MDL)
AMS: Lowest Change Possibly Real	Sensitivity (Usually Field, or Whenever MDL is NA)	Alternative Measurement Sensitivity, For ± STORET "analytical procedure description" field	Beginning and end of field seasons	Determines instrument noise in both directions (up or down). How big of a change is real?	7 measurements from the same field sample	3.708*SD, where SD = Sample Standard Deviation
AMS+: Total Variability of Close Replicates	AMS+ (Usually Field, or Whenever MDL is NA)	Alternative Measurement Sensitivity+, Record In STORET as Stated Above if no other form of AMS is reported	Beginning and end of field seasons	Includes instrument noise and natural heterogeneity	7 measurements of nearby but not identical samples, in-situ for sondes only	SD * 3.708
RPD: QC Precision+ Control	Precision+ (Usually for Field Measurements Only)	Relative Percent Difference. In STORET include both values RPD was based on and optionally include RPD as a comment.	1 for every deployment period, and at the beginning and end of each field season, lab or field. Done Instead of Precision or in Addition to Precision	Variability of repeated measures (precision+) + = potentially some additional true variability (two samples not one)	2 (1 Comparison of two values, measurements of two samples collected in close proximity but not one sample)	RPD = $\left[\frac{S_1 - S_2}{(S_1 + S_2)/2}\right] \times 100$
PD: QC Bias Control	Bias (Lab and Field)	Percent difference: In STORET include both values PD was based on and optionally include PD as a comment, Choose Reference Sample or Field Spike	1 for fouling bias and 1for drift bias, for each parameter, every deployment period. In the field.	Difference Between Measured Result and Expected Result Based on a Reference Sample Standard or a Spike	2 (1 Comparison of two values, one of which is a known correct (or expected) value and the other is the measurement result	PD = [Y - X) / X] * 100, where X is the known (usually "correct" or "expected") or spiked amount, and Y is the measured concentration.

Method Detection Limit (MDL):
The method detection limit (MDL) is the lowest value that can be distinguished from zero. The UCBN will determine MDL for Turbidity each year or more frequently as personnel or methods change. MDL will be based on seven measures of a very low concentration sample (near 0.1 NTU).

> To determine the MDL, at least seven replicate samples with a concentration of the pollutant of interest near the estimated detection capabilities of the method are analyzed. The standard deviation among the replicate measurements is determined and multiplied by the upper (one-sided) critical t-value for n-1 degrees of freedom (in the case of 7 replicates, the multiplier is 3.143, which is the value for 6 degrees of freedom) (Irwin, 2008)

MDLs for each multiprobe will be reported when data included in annual reports and uploaded to NPSTORET. MDL's for the 2015 season are given in Table 25.

Minimum Level of Quantitation (ML):
The minimum level of quantitation (ML) is the lowest value that can be reliably measured (Sharrow et al. 2007). Within NPSTORET, minimum level of quantitation (ML) is synonymous with "lower quantitation limit" (LQL). The UCBN will determine ML by multiplying the MDL by 3.18 (Irwin, 2008). The ML will be calculated annually for turbidity and not other parameters since they do not approach the lower detection limits. MLs will be reported for each multiprobe when data is included in annual reports and uploaded to NPSTORET. MLs for the 2015 season are given in Table 25.

Alternative Measurement Sensitivity Plus (AMS+):
Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

In the range of quantitative values where low level detection limits are not an issue, measurement sensitivity is determined by evaluating the variability of repeated measurements on an environmental sample. Over time, AMS+ can be used to bound measurement uncertainty on each single data point (when 7 measurements are made on the same environmental sample). It includes instrument noise and natural heterogeneity (Sharrow et al. 2007). AMS+ will be based on 7 measurements of nearby but not identical samples, in-situ for sondes (Irwin 2008). In other words, the UCBN will take 1 discreet measure (for each core parameter) every minute for 7 minutes during initial site selection procedures (SOP #3). These 7 measures will then be used to calculate AMS+. Specifically AMS+ is calculated as the standard deviation of the 7 measurements times 3.708, where 3.708 is the 99% confidence middle (two-sided) t-value for sample size 7. AMS+ will be determined at the beginning and end of each sample season and will correspond to pre- and post-season cross section surveys (See SOP #3). AMS+ values will be reported for each parameter when data is included in annual reports and uploaded to NPSTORET. AMS+ values for the 2015 season are given in Table 25.

Measurement Precision/Repeatability

Relative Percent Difference (RPD) – Precision Plus:
Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

Precision Plus (reported as RPD in NPSTORET) is the variability of repeated measures of two samples collected in close proximity. It is a less rigorous measure of sensitivity than AMS (sample

size 2 rather than 7), but is used more frequently to ensure measurements are in 'control' especially in laboratory analyses where 7 duplicates are not always practical (Sharrow et al. 2007). RPD is calculated as:

$$\left[\frac{S_1 - S_2}{(S_1 + S_2)/2}\right] \times 100$$

S_1 = the larger test result value
S_2 = the smaller test result value

The UCBN will calculate RPD based on data obtained during the monthly calibration/error check procedure outlined in SOP#5. Immediately after each parameter is re-calibrated it is placed in a standard solution to verify successful calibration. This measured value is recorded in the Calibration and Maintenance Log in the Water Quality Station and Instrumentation database. After all parameters have been re-calibrated, all sensors are error checked by placing them in corresponding standard solutions (SOP #5). The value obtained immediately following the calibration and during the final readings will be used as S_1 and S_2. As the UCBN transitions to checking calibrations against a calibrated field meter, RPD will be calculated based on data collected in-situ. In addition, RPD will be calculated at the beginning and end of the sample season using data from the cross-section survey (SOP #3), where two separate values (i.e., minute 1 and minute 2) will be used as S_1 and S_2.

Measurement Systematic Error/Bias
Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

Systematic error/bias is the systematic or persistent distortion of a measurement process that causes errors in only one direction (usually high or low). Results for systematic error/bias are usually expressed as a % recovery with the correct or expected answer being considered 100%, with an acceptable range between 90-110% for core parameters (Sharrow et al. 2007, Irwin 2008). During each monthly site revisit/calibration the UCBN will determine the amount of error caused by fouling and calibration drift as described in the Water Quality Site Revisit SOP #5 and the Continuous Water Quality Record Processing SOP #7. The raw values for systematic error/bias will be recorded in the corresponding site inspection summary form as "drift correction" and "fouling correction." Percent difference will be calculated for each parameter based on data obtained during assessment of fouling and drift corrections as: PD = [Y - X) / X] * 100.

PD for Fouling

X = the concentration after fouling has been removed from the sensors
Y = the concentration in stream water before fouling has been removed from the sensors

PD for Drift

X= the known concentration of a standard solution
Y = the measured concentration of the standard solution

The result will be two percent difference values for each parameter for each month (deployment interval), one that accounts for % drift and the other for % fouling.

When data is processed for analysis and when it is uploaded to Aquarius Time-Series Software, it will be corrected to account for fouling and drift error. Data correction will only occur if drift and fouling corrections fall outside of pre-defined criteria (Table 23). The process of data correction is more thoroughly discussed in SOP #7.

Besides percent difference (PD), the degree of data bias will be reflected in the grade or rating that data will receive based on the amount of correction that has been applied. Rating criteria are listed in Table 24. and more thoroughly discussed in the record processing SOP #7. Data grades will be applied on a monthly (deployment period basis).

Table 23. Criteria for water quality data corrections, modified from Wagner et al. 2006.

Parameter	**Calibration / Data Correction Criteria** (Apply correction when the sum of the absolute values for fouling and calibration drift error exceeds the value listed.)
Temperature	± 0.2 °C when checked with another meter ± 0.5 °C when checked with NIST thermometer
Specific Conductance	± 5 µS/cm or ± 3% of the measured value, whichever is greater
Dissolved Oxygen	± 0.3 mg/L
pH	0.2 pH units
Turbidity	± 0.5 turbidity units or ±5% of the measured value, whichever is greater

Table 24. USGS accuracy ratings of continuous water-quality records or “data grade” (modified from Wagner et al. 2006).

Measured field parameter	**Rating of accuracy (data grade)** (Based on combined fouling and calibration drift corrections applied to the record.) **Excellent**	**Good**	**Fair**	**Poor**
Water Temperature	≤ ± 0.2 °C	>± 0.2-0.5 °C	>± 0.5-0.8 °C	>± 0.8 °C
Specific Conductance	≤ ± 3%	>± 3-10%	>± 10-15%	>± 15%
Dissolved Oxygen	≤ ± 0.3 mg/L or ≤ ± 5%, whichever is greater	>±0.3-0.5 mg/L or >±5-10%, whichever is greater	>± 0.5-0.8 mg/L or >± 10-15%, whichever is greater	>± 0.8 mg/L or >± 15%, whichever is greater
pH	≤ ± 0.2 units	>± 0.2-0.5 units	>± 0.5-0.8 units	>± 0.8 units
Turbidity	≤ ± 0.5 NTU or ≤ ± 5%, whichever is greater	>± 0.5-1.0 NTU or >± 5-10%, whichever is greater	>± 1.0-1.5 NTU or >± 10-15%, whichever is greater	>± 1.5 NTU or >± 15%, whichever is greater

Pre/Post Mobilization Check to Minimize Bias:

Pre and post deployment calibration and error checks will be conducted in the UCBN office to ensure all sensors are functional and ready for the field season (See SOP #1 and 5). During pre and post-mobilization calibrations all sensors must calibrate and remain within the calibration criteria during error checks as defined in Table 23 and in SOP #5. The calibration criteria used by the UCBN are the same standards used by the USGS as defined in (Wagner et al. 2006). MDL will be determined for turbidity during the pre-mobilization check. Should any sensors fail to calibrate, or measurements of

standard solutions consistently fall outside of the calibration criteria it will be returned to the HACH Company to be serviced. These calibrations and maintenance service will be documented in the UCBN Water Quality Monitoring Station and Instrumentation database.

Field Calibration to Minimize Bias:
After deployment, the multiprobe will be calibrated monthly, preferably on the stream bank in the morning; the calibration will be documented in the Calibration and Maintenance Log in the UCBN Water Quality Monitoring Station and Instrumentation database. All calibrations follow the HACH MS5 user manual and guidelines established by the USGS. Temperature is a fixed function set by the manufacturer and cannot be adjusted in the field; the instrument reading is verified against a hand-held laboratory thermometer. Calibration of the luminescent dissolved oxygen (LDO) sensor is based on using a water-saturated air environment as the standard; for pH, a three point calibration curve is established with standard buffer solution of pH 4, 7 and 10; the specific conductance probe is calibrated using a two point calibration, in air (zero) and using a standard solution of 1,412 µs/cm; the self-cleaning turbidity sensor is calibrated using a <0.1 and 100 NTU standard solution. Details of field calibrations are more thoroughly discussed in SOP #5. In general, if measures of standard solutions fall outside of the calibration criteria as defined by Wagner et al. (2006) the sensor will need to be re-calibrated; or, if values consistently fall outside of the criteria or exceed the maximum allowable limits (SOP #5) it will need to be returned to the manufacture for repair. Consistent staff training (SOP #2) and strict adherence to the procedures in SOP #5 will help limit bias caused by personnel.

Summary of QA/QC Values Required for Water Chemistry Each Field Season

1. MDLs – Method Detection Limit, for turbidity sensors on each multiprobe. MDL is determined in the lab/office each year with a low signal standard.
2. ML – Minimum Level of Quantitation, for turbidity sensor on each multiprobe. ML is calculated with the MDL.
3. AMS + Alternative Measurement Sensitivity Plus, for all core parameters except turbidity (Temperature, pH, Dissolved Oxygen, Specific Conductance) at the beginning and end of the sample season. AMS+ is based on data from the cross section survey conducted at the start and finish of each sample season.
4. RPD – Relative Percent Difference, also known as precision. RPD is based on data collected during each calibration and during the cross section survey at the start and finish of each sample season.
5. PD – Percent Difference or Bias is based on data collected during each calibration throughout the deployment period (May-October). Two PD values will be reported for each parameter for each month (deployment interval), one that accounts for % drift and the other for % fouling.

Note that these values will be maintained in the UCBN Water Quality Monitoring Station and Instrumentation database in accordance with the guidelines in the data management SOP #8 and also included as an appendix in the annual report for each monitoring season.

Table 25. QC data quality indicators for 2015 season at BIHO, North Fork Big Hole River, Hydrolab #095, Station ID: BIHO #001

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

Literature Cited

Irwin, R .J. 2008. Draft Part B lite QA/QC Review Checklist for Aquatic Vital Sign Monitoring Protocols and SOPs, National Park Service, Water Resources Division. Fort Collins, CO. http://www.nature.nps.gov/water/Vital_Signs_Guidance/Guidance_Documents/PartBLite.pdf

Sharrow, D., D. Thoma, K. Wynn, M. Beer. 2007. Water Quality Vital Signs Monitoring Protocol for Park Units in the Northern Colorado Plateau Network (NCPN). Moab, UT.

Starkey, E. N., T. J. Rodhouse, G. H. Dicus, K. M. Irvine, and E. K. Archer. 2016 (in preparation) Upper Columbia Basin Network stream channel characteristics monitoring protocol: Narrative version 1.2. Natural Resource Report NPS/UCBN/NRR—2016/XXX. National Park Service, Fort Collins, CO.

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan 2001-2004. United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL.EPA/620/R-01/002.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 11: Field Safety for Water Quality Sampling

Adapted from
Water Quality Vital Signs Monitoring Protocol for
Park Units in the Northern Colorado Plateau Network, SOP #1
and
Freshwater Quality Monitoring Protocol for
San Francisco Area Network, SOP #2

Version 1.1 February 2013

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2013	UCBN Aquatic Biologist	Updates to JHA (see appendix E) and addition of regional safety guidelines that require readiness review, field itinerary, and travel forms be completed prior to fieldwork	Updates following UCBN safety plan and regional guidelines	1.1

Note: This Standard Operating Procedure (SOP) describes procedures for conducting field and laboratory aspects of water quality monitoring in a safe manner, recognizing that certain hazards are inherent in the field and laboratory environments. This is done through a process to (1) identify hazards associated with field and laboratory settings and (2) develop approaches to reduce or mitigate those hazards. The primary tool used to promote safe conduct is the Job Hazard Analysis. This approach is consistent with NPS Directors Order 50 and Reference Manual 50B for Occupational Health and Safety.

Suggested Reading

Lane, S.L., and Fay, R.G., October 1997, Safety in field activities: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A9, accessed 15 January 2008 at http://pubs.water.usgs.gov/twri9A9/

Introduction and Objectives

Encountering hazardous situations is inherent in water quality monitoring activities thus staff needs to be aware of these and adjust approaches accordingly so that high quality monitoring can be conducted without injury or property damage.

The objectives for the UCBN water quality monitoring program and the specific objectives for operations under this SOP are:

- To monitor water quality conditions, including accessing monitoring sites, making field measurements, gathering, processing and analyzing water quality samples in a manner where hazardous conditions are recognized and measures are taken to minimize the risk of personnel injury.
- To maintain a high quality monitoring effort, avoiding missed data collection and undue expense due to personnel injury or property damage.

Some hazardous conditions are inherent in all monitoring activities being undertaken by UCBN staff, whereas others are specific to individual sites. Examples include exposure to winter and summer weather, highway driving, use of hazardous chemicals, and specific hazards associated with accessing individual sites. Therefore, two similar procedures will be used. First, a Job Hazard Analysis will be developed for water quality monitoring and will include hazards associated with each park where monitoring will be conducted. Second, hazards associated with specific sampling sites will be identified in the Field Site Description for each site. These are similar in that they both improve operational safety through identifying hazardous conditions to NPS staff and technicians, and develop approaches to avoid or mitigate the hazards.

In addition, prior to the start of each field season, certain safety documents must be reviewed, signed, and returned to the park contact and the network coordinator. These documents include: an official travel checklist, fieldwork itinerary forms that outline when and where field operations will take place, readiness review documents that detail necessary safety topics that have been prepared for the field season, and job hazard analyses (JHAs) that highlight some of the individual risks associated with fieldwork and ways to mitigate those risks. A CRMO specific backcountry travel SOP is required for anyone performing fieldwork in CRMO. These documents are included in the appendices.

Risks Inherent in Water Quality Monitoring

Risks inherent in water quality monitoring in general, and specifically to monitoring the sites selected in UCBN parks, include:

Working alone – Field staff will often work alone when traveling to and from remote sites and when making measurements and collecting samples in the field. As a result, particular attention must be given to safety and communication.

Long road trips – Travel between parks will require long road trips at all times of the year and under varied weather and road conditions.

Backcountry roads and trails – Accessing water quality sample sites may require travel on secondary roads that are graveled or dirt, and some sites require hiking. The unsurfaced roads can become impassible during wet weather, and may remain muddy for several days after snowmelt. Hiking is generally done on established trails that vary in difficulty and condition.

Activities in and on the water - Sample collection will require entering the main current in streams. Extra care is necessary when wading because many streams are swift and stream bottoms can be loose or slippery, and water temperatures can be near freezing in winter. Precautions are needed to (1) recognize and avoid risks, (2) use proper techniques to avoid accidents, and (3) be properly equipped for self-rescue. It is recognized that some sites will not be accessible during periods of bad weather. If there is any doubt, the correct decision is to forgo sampling until another day. The USGS Field Manual (Lane and Fay 1997) chapter 9 gives excellent guidance for safety precautions working on, in and near water. A copy is located in the Field Safety Notebook.

Varied weather conditions – The UCBN region is characterized by weather conditions that vary considerably through the seasons, day-to-day, and even hour-by-hour. Snow, wind and temperatures below 0°F occur in the winter, and summer temperatures may be above 100°F. As a result, field work requires preparation for this range of conditions. Hypothermia and heat-related injury are possible and occasional discomfort is certain.

Use of hazardous materials – Some of the reagents used are hazardous and require proper storage, handling, disposal and personal safety gear including eye and skin protection.

Field Safety Notebook

A notebook containing information related to water quality monitoring safety will be prepared and maintained in the UCBN office and will be carried when sampling activities occur. Copies of information contained in this notebook will be provided to park resource managers during multiprobe data retrieval training. This notebook is intended to facilitate review of safety information, and provide concise information for use during an emergency. The following is a list of items to be included in the Water Quality Field Safety Notebook (Appendix E).

- UCBN - Field Safety for Water Quality Sampling SOP #11
- Field Site Descriptions (Appendix E)
- Job Hazard Analysis (JHA) (Appendix E)
- Material Safety Data Sheets (MSDS) for chemicals
- Emergency Contact Information
- Emergency Evacuation Instructions (Appendix E)
- USGS Field Manual- Chapter 9 –Safety in Field Activities
- Medical Information for Office Personnel (Appendix E)
- Readiness Review Forms (Appendix E)
- Travel Checklist (Appendix E)
- Field Itineraries (Appendix E)

Job Hazard Analysis

The UCBN water quality project lead will, in conjunction with his/her supervisor (and, if appropriate, other knowledgeable persons), develop a Job Hazard Analysis (JHA) of the task to be performed within each park. At the beginning of each sampling season all personnel will review the appropriate JHA and make modifications as necessary. The procedure to be used for writing a JHA is presented in NPS Reference Manual #50B, Occupational Safety and Health Program. (NPS 1999).

- A list of suggested hazards to be included and expanded upon is presented in Table 26.
- A completed JHA for Water Quality Field Work is presented in Appendix E. This JHA was developed based on the San Francisco Area Networks, Freshwater Quality Protocol SOP #2.
- All JHA sheets will be included in the water quality Field Safety Notebook.

Table 26. Suggested topics to be addressed in a Job Hazard Analysis

General Job Activity	Basic Job Step	Potential Hazards
All Field Activities	Environmental Conditions	Temperature and Sun Exposure
		Adverse Weather (rain, snow, lightning and wind)
		Hazardous Animals, Plants, People
Accessing Sites	Highway Driving	Varied Road Conditions Fatigue Behavior of other Drivers Animals and other Obstructions
	Driving on Unimproved Roads	Rough and Rutted Roads
		Muddy Roads
		Narrow Roads with Poor Visibility
	Winter Driving	Slippery Roads and Poor Visibility
	Hiking	Steep/Slippery Terrain, Undergrowth, Rocky Slopes
Sample Collection	Wading	Swift Currents and Deep Water
		Flood Flows
		Cold Water and Ice
		Contaminated Water
	Walking on Stream Banks	Slick Footing
		Adjacent Swift Currents and Deep Water
Sample Processing	Acidifying Samples	Exposure to Acid
	Filtering Samples	Mechanical Pumps

Field Site Description

A record of site locations and specific hazards that might be present will be developed in Field Site Descriptions that are kept as a reference for field staff in the field folder that accompanies resource managers in the field vehicle. An example is given in Appendix E. This will serve as a reference and reminder for existing and new staff. The procedure for completing field site descriptions is outlined in the EMAP field operations manuals (Peck et. al. 2006).

Routine and Emergency Communication

Having established lines of communication and a Check-in/Check-out procedure are essential to ensure timely assistance can be provided in case of a mishap or delay. This will be particularly important since UCBN field staff will often work alone. A routine will be established where UCBN field staff will contact park staff to notify them of the time and location of work in each park using email or other written forms of communication (field itinerary forms and readiness review). In addition, it is required to leave a written/approved travel plan (field itinerary form Appendix E) with UCBN staff or other NPS staff. This plan should include the time and location of work and return times. National Park Service park managers and UCBN staff should be notified if plans have been modified. Emergency and field operations contact information for each park will be included in the Field Safety Notebook and on the field itinerary forms for each park/visit.

UCBN field staff may have a field radio programmed for the applicable radio frequencies used by each district where they will be working. An exception would be parks that have reliable cellular phone coverage. UCBN field staff will also carry back-up means of emergency communication when practical, including a satellite locator beacon (inReach, SPOT, etc.), cellular phone and a signal mirror.

Chemical Storage and Use

Chemicals must be stored according to their Material Safety Data Sheet (MSDS) information. The MSDS sheets for all of the chemicals are kept in a clearly marked folder in the UCBN office and in the Field Safety Notebook.

A list of all the chemicals must be posted on the outside of the cabinet door or wherever they are stored (Table 27). This is done for the following reasons: (1) Emergency personnel are able to identify the contents in case of an emergency and (2) People who are sensitive to certain materials are able to avoid exposure. The list of chemicals should include: the name of the chemical, the number of that chemical in storage, and the number of that chemical that has been used (including anything that has been opened). One list must be in the lab and copies of this list must be given to the Project leader and Network Coordinator.

Table 27. Example chemical list to be posted on chemical cabinet.

Solution*	Size	Number in Cabinet
pH Buffer Solution 4	500ml	1
pH Buffer Solution 7	500ml	1
pH Buffer Solution 10	500ml	1
Deionized Water	4 L	1
Conductivity Standard 100	1 L	1
Conductivity Standard 1412	1 L	1
pH Electrode Solution	500ml	2
Stablcal Formazin Standard <0.1 NTU	500 ml	2 (1 exp)

* Unless otherwise noted all chemicals are in main cabinet for storage.

Table 27 (continued). Example chemical list to be posted on chemical cabinet.

Solution*	Size	Number in Cabinet
Stablcal Formazin Standard 100 NTU	500 ml	2 (1 exp)
Clorox Bleach	1 L	1
70% Ethanol	2 L	1

* Unless otherwise noted all chemicals are in main cabinet for storage.

Procedures for Safety Preparation

The following should be completed before traveling into the field to sample:

1. Completion of a Readiness Review
2. Completion of a Field Itinerary Form (trip plan)
3. Completion of the Official Vehicle Travel Checklist
4. Completion and review of Job Hazard Analysis (JHA)
5. Review and update emergency contact information
6. Update and double check contents of Field Safety Notebook
7. Completion of Medical Information for Office Personnel form
8. Completion of CPR / First Aid Training
9. Review all protective equipment to ensure it is in working order and present
10. Check weather and stream conditions
11. Notify park managers and UCBN Coordinator of changes to itinerary
12. Tailgate safety meeting just prior to field work to address changing conditions/hazards

Required/Recommended Personal Protective Equipment

Required

- Eye Protection (safety glasses or goggles)- while working with water chemistry standards
- Felt sole (or similar) waders (chest, hip, neoprene)- when working in areas with coarse gravel.
- Felt sole (or similar) wading boots-when working in areas with coarse gravel.
- Latex gloves- while working with water chemistry standards.
- Personal Flotation Device (PFD) – Life Jacket
- Leather gloves (for installation and removal of monitoring station)
- First Aid Kit

Recommended

- Bug spray
- Compass / GPS Unit
- Cotton gloves / wool gloves
- First Aid Kit
- Flashlight
- Forceps / vial

- Life Preserver
- Maps
- Neoprene gloves
- Park radio
- Personal water bottles
- Polarized sunglasses
- Rope
- Safety glasses
- Shovel
- Sturdy work boots
- Sun hat
- Sunscreen
- Survival kit
- Technu (poison oak/ ivy cleanser)
- Wading Belt
- Warm clothing / hat

Literature Cited

Cooprider, M.A. 2005. Personnel Training and Safety, Version 1.01, Standard Operating Procedure #2. *In* San Francisco Area Network Freshwater Quality Monitoring Protocol, Version 2.01, Appendix H-SOPs, National Park Service, San Francisco Bay Area Network, CA. 51 pp. Plus appendices

National Park Service (NPS). 1999. Director's Order #50b and Reference Manual #50b Occupational Safety and Health Program.

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 12: Final Site Visit and Post Field Season Activities

Version 1.5 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2016	UCBN Aquatic Biologist	Minor revisions to separate final site visit and post season procedures. Additional detail added. Removed macroinvertebrate procedures.	Add clarity to timing of procedures.	1.5

Note: This SOP describes the step-by-step procedures for equipment removal, maintenance and storage after each field season.

Suggested Reading

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Peck, D. V., A. T. Herlihy, B. H. Hill, R. M. Hughes, P. R. Kaufmann, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.

Final Site Visit Procedures

The following procedures are a guide to the final site visit of the monitoring season (June-November).

Perform Calibration and Maintenance

Follow normal calibration and maintenance activities outline in the Water Quality Site Revisit-Calibration and Maintenance SOP #5.

Conduct Cross Section Survey

After calibration and maintenance has been completed, follow procedures for completion of the second cross section survey of the season (SOP #3).

Remove Multiprobe Housing

Each season the multiprobe housing should be removed from the water quality monitoring station. It is important to remove this housing for several reasons. First, removal will facilitate thorough cleaning and repair. Second, removal will prevent loss of the housing during typical fall and spring high flow events. Third, the absence of the housing will prevent vandalism during the off season when UCBN personnel and park managers will not frequent the site.

Note that leather gloves should be used for removal of potentially sharp and rusty components.

1. Disconnect all electrical connections:
   a. solar panel to battery
   b. battery to calibration cable
   c. calibration cable to multiprobe
   d. coil calibration cable (>6" diameter)
   e. coil power cables
   f. place all electrical and calibration cables and locks inside of battery box
2. Disassemble the solar panel and vertical support
   a. Remove T-post
3. Remove PVC between battery box and multiprobe housing
4. Remove multiprobe housing **(Be careful of sharp rusty components—USE GLOVES!)**
   a. Remove hose clamps
   b. Remove T-posts
   c. If using the housing extension, disconnect the two 5' sections.
5. Clean all PVC and T-Posts
   (Don't skip this step or you will regret it when these are back in the office!)
   a. Use a scrub brush and scrub pad to remove all sediment, algae, and plant material.
   b. Rinse in stream water.
   This step also prevents the spread of invasive species between monitoring locations.
6. Place all equipment back in the vehicle for transport back to the UCBN office.

Post Field Season Activities

Following the water quality field season (June-November), all equipment will be removed from the park monitoring location and stored in the UCBN headquarters. Non-electrical equipment, including wire, tape, bolts, locks, cables, etc. should be stored in well-marked plastic bins. Some of this equipment may be used by other UCBN protocols, so thorough organization and documentation of equipment will be important. Electronic equipment, including; GPS units, multiprobes, tablets, and Archer units, should have the batteries removed during the winter months to prevent corrosion and leaking, and will be stored in plastic bins in the UCBN office. Multiprobes will be cleaned and stored in a hard plastic case, such as a Pelican case, to prevent any damage to the sondes.

Equipment Cleaning

It is important to clean all equipment, to reduce the risk of transferring invasive species and pathogens, and to have equipment ready for the next sampling season.

1. Scrub multiprobe housing PVC with 10% Sparquat solution
2. Remove debris and seeds from the battery box
3. Use a wet rag to clean the calibration cables (coil and store in the battery box)
4. Clean and lubricate all locks (store in the battery box)

Equipment Storage

Multiprobe

1. The water quality multiprobe should be cleaned according to manufacture guidelines given in the HACH Hydrolab MS5 user manual. Generally this means cleaning the external surface of the multiprobe with a clean brush, soap and water. After washing with soap rinse the multiprobe with clean tap water and dry the outside (NOT the sensors). The sensors should be placed in the calibration/storage cup with one ½ inch of clear pH 4 buffer solution. This buffer solution will prevent desiccation, biological growth and damage to the pH sensor. It is important to note that the sensors should never be stored in de-ionized water. **Use the clear pH4 standard to avoid damage to the glass bulb.**
2. All sealing surfaces such as O-rings should be lubricated using silicone grease.
3. Remove batteries
4. The multiprobe should be stored in the Pelican case in the UCBN office to prevent damage and to prevent the standard in the storage cup from freezing.

Deep Cycle Batteries

1. Fully charge each battery with the charger located in the UCBN office.
2. Batteries should be kept in the battery boxes.
3. These batteries should be charged again in late February.

Electronic Equipment

1. All electronic equipment should have pertinent data removed and stored as a hard copy or on a computer.
2. Batteries should be removed.
3. Electronics should be wiped down according to manufacture instructions to remove dust.

Consumable Materials Inventory

At the end of each field season a list should be prepared detailing the amount of consumable materials remaining and how much material should be ordered in the spring. Consumable materials include items such as: calibration standards, paper towels, and batteries. This inventory should be conducted by the project leader and filed in the UCBN office to speed ordering of supplies in the spring.

Seasonal Summary

To adequately prepare for the following sampling season, notes should be taken on where improvements to the sampling protocol or data forms can be made, records kept on the condition of each multiprobe, and notes of any other problems or issues that occurred during the field season. In addition, all items listed on the UCBN Integrated Water Quality Season Closeout Checklist (Appendix F) and Project Data Certification Form must be completed and filed with the data manager.

Prepare Annual Reports

Annual summary reports should be prepared, reviewed, and published as indicated in SOP #9.

Integrated Water Quality Monitoring Protocol
Standard Operating Procedure (SOP)

SOP 13: Administrative Record/Protocol Revision

Version 1.5 February 2016

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review	-	1.0
1.0	February 2013	UCBN Aquatic Biologist	Updated following revisions to other SOPs	Track SOP updates	1.1
1.1	February 2016	UCBN Aquatic Biologist	Updated following revisions to other SOPs	Track SOP updates	1.5

Note: This SOP describes the recommended protocol revision practices and provides a history and documentation of the protocol development and revision process.

Procedures

This monitoring protocol is an actively evaluated and updated document that reflects the latest procedures of the monitoring program. Revisions are expected, and can involve only minor changes with little overall impact or occasional major revisions and course corrections. Evaluation and revision of the protocol is directed by the project leader on an annual basis in association with season close-out. The narrative as well as each SOP has a revision history log whereby changes can be recorded. Older versions of the narrative and SOPs should be archived to ensure proper legacy of past work is maintained. Each revision will require the updating of the version number. Minor changes are recorded as decimal numbers (e.g., 1.0, 1.1, 1.2, etc…). Major changes are recorded as a change in the primary number of the protocol version (e.g., 1.0, 2.0, 3.0, etc…). In some cases, major revisions to the protocol may prompt the need for additional peer-review. The project leader and Network Coordinator will coordinate this with the Regional I&M Program Coordinator.

Administrative Record and Revision History Log

Table 28. Protocol administrative record and revision history log. This table summarizes the major events leading to the development and revision of the UCBN integrated water quality monitoring protocol (version 1.9).

Date	Development Step	Documentation
April 2005	Hired Chris Caudill, University of Idaho Research Scientist, to compile the historic and current status of monitoring in UCBN waterbodies.	UCBN Phase I report
June 2005	Chris Caudill reviewed and certified the NPSpecies fish inventory review for UCBN parks.	NPSpecies fish inventory certification
October 2005	Initial protocol development summaries developed for water chemistry, surface water dynamics, channel/streambank morphology, and macroinvertebrates.	PDS available from UCBN
March 2006-December 2006	Chris Caudill, University of Idaho Research Scientist, worked part-time on development of the monitoring protocol and contributed to the water quality components of the draft monitoring plan.	December 2006 draft monitoring plan submitted
June-September 2007	One HACH multiprobe was purchased and preliminary measurements were taken at Lapwai Creek for use in an initial power analyses.	Water Quality Resource Brief available from UCBN
October 2007	Additional HACH multiprobe purchased for 2008.	-
December 2007	Hired Eric Starkey, aquatic biotechnician, to work with Lisa Garrett, UCBN Coordinator, to finish writing the water quality monitoring protocol.	Draft water quality protocol available from UCBN
January 2008	Internal review of protocol conducted by Kirk Steinhorst (statistician), Tom Rodhouse (ecologist), and Gordon Dicus (data manager).	Comments available from UCBN
February 2008	Draft of integrated water quality monitoring protocol version 1.0 complete, submitted for peer review with the NPS Water Resources Division. **NRR series ID assigned.**	-
February 2008	Eric Starkey attended the Water Resource Professional Meeting to determine how other I&M Networks structure water quality monitoring protocols and manage water quality data. Eric identified ways to improve lab/field calibrations, and QA/QC procedures. These improvements were incorporated into the final protocol.	-

Table 28 (continued). Protocol administrative record and revision history log. This table summarizes the major events leading to the development and revision of the UCBN integrated water quality monitoring protocol (version 1.9).

Date	Development Step	Documentation
April 2008	Eric Starkey attended USGS training entitled "Guidelines and Standard Procedures for Continuous Water Quality Monitors: Station Operation, Record Computation, and Data Reporting" lead by Rick Wagner. This course provided valuable information on multiprobe installation, calibration technique, calibration criteria, data ratings, interpretation of time series data and cross section surveys. Knowledge gained in this course lead to the development of SOPs detailing cross section surveys, multiprobe site revisits, and record processing. These SOP's were not included in the draft submitted for peer review in February 2008. Guidance from Rick Wagner helped standardize parts of the UCBN water quality protocol with USGS procedure. Rick Wagner and Hydrologist Brett Smith suggested that the UCBN investigate the use of Aquarius Time Series Software by the Aquatic Informatics company to manage water quality data.	Meeting notes available from UCBN
May 2008	Eric Starkey provided hands on water quality monitoring training for resource managers at NEPE (Jason Lyon) and WHMI (Roger Trick). This training provided an opportunity for resource managers to learn how to conduct calibrations and routine maintenance on continuous water quality monitoring instruments. In addition, training provided a means of testing the Multiprobe Site Revisit SOP.	-
May-November 2008	Pilot field season. Water chemistry data was collected hourly between the months of May and November at NEPE–Lapwai Creek and WHMI-Mill Creek. Macroinvertebrates were collected at NEPE-Lapwai and Jim Ford Creeks and WHMI-Mill Creek. Experience from the first field season helped guide revisions of the peer reviewed draft protocol.	2008 Water Quality Annual Report and Resource Brief
June-July 2008	Eric Starkey conducted water quality site reconnaissance at BIHO, CIRO, CRMO, and JODA. Assessment of potential monitoring locations helped guide revisions to SOPs on water chemistry site selection and macroinvertebrate sample procedures.	Integrated Water Quality Site Reconnaissance Notebook, available from UCBN
June-August 2008	Eric Starkey and Lisa Garrett worked with Pete Penoyer and Water Resource Division (WRD) to facilitate the purchase of Aquarius Time Series Software by the Aquatic Informatics Company. Aquatic Informatics agreed to reduce the purchase price from $5,000 to $2,500 and WRD agreed to purchase the program with the understanding that the UCBN would pilot test the software. The purchase date for Aquarius Time Series Standard was August 2008	-
June 2008	Integrated Water Quality Monitoring Protocol approved pending minor revisions.	-
August-December 2008	Revision of Integrated Water Quality Monitoring Protocol	-
September 2008	Additional HACH multiprobe purchased by WHMI for network wide use.	-
January 2009	Internal review of protocol conducted by Lisa Garrett (Network Coordinator), Kirk Steinhorst (statistician), Tom Rodhouse (ecologist), and Gordon Dicus (data manager).	-
February 2009	Final draft of integrated water quality monitoring protocol version 1.0 complete, submitted for peer review with the NPS Water Resources Division.	-
August 2009	Protocol version 1.0 approval by NPS Water Resources Division. Minor revisions completed. **Original series ID number and date maintained (February 2008).**	Final water quality protocol available from UCBN v 1.0
May 2009	Hired Eric Starkey as NPS Aquatic Biologist. To serve as project lead for Integrated Water Quality, Stream Channel Characteristics and Riparian Vegetation Monitoring Protocols.	-

Table 28 (continued). Protocol administrative record and revision history log. This table summarizes the major events leading to the development and revision of the UCBN integrated water quality monitoring protocol (version 1.9).

Date	Development Step	Documentation
February 2013	Protocol SOPs # 1, 2, 6, 7, 9, 11, 13, and 15 were updated by Eric Starkey (Aquatic Biologist). Updates were to add clarity to procedures and to reflect lessons learned since the implementation of the approved protocol in 2009. In addition, changes to SOP 7 were due to the integration of benthic macroinvertebrate sample collection with the UCBN stream channel characteristics monitoring protocol. **Protocol SOP document v1.8 was published to IRMA as a draft due to regional staffing changes that prevented review.**	Water quality protocol available from UCBN v 1.8
February 2016	Eric Starkey updated and revised the integrated water quality monitoring protocol narrative and SOPs. No changes were made to the objectives, water quality data collection techniques, analysis or reporting sections. Additional details and revisions were needed following 7 years of implementation. Revisions to the protocol included: Removal of macroinvertebrate sampling techniques. Macroinvertebrate site selection, QA/QC produces, and data management were moved to the UCBN stream channel characteristics monitoring protocol. Reason for the change is because macroinvertebrates are sampled during stream channel monitoring. Because macroinvertebrate analysis remains an important part of the assessment of water quality, macoinvert. analysis remains in the water quality protocol version 1.9. Minor revisions to state water quality thresholds. Revisions to the data management section due to updated water quality database and changes to Aquarius Time-Series Software. In 2008, the timing of water quality sampling was shifted from May-October to June-November. This change was made due to reoccurring high water in May. The sample period is still 6 months. This change is now documented. Better step by step guidance for beginning and end of field season procedures.	Water quality protocol available from UCBN v 1.9

UCBN Protocol Development Summary

Protocol: Integrated Water Quality

Parks Where Protocol Will Be Implemented:

BIHO, CIRO, CRMO, JODA, NEPE, and WHMI

Justification/Issues being addressed:

Monitoring of NPS water resources has been identified as a core objective of the national I&M program, as well as by the UCBN. Several UCBN parks have identified water quality improvement-related land health goals for performance reporting purposes. All Network waters assessed by state DEQ agencies are on 303(d) lists for impairment of at least one parameter, and the riparian and wetland areas supported by Network waterbodies are foci for biological invasions and other management challenges. Several parks have begun concerted riparian and stream channel restoration projects.

Although the UCBN contains more than 34 rivers, streams, ponds, and reservoirs within park boundaries, water resources actually represent a very small percentage of total land cover, except in the case of LARO. Unlike many water resources in the National Park system, most UCBN parks and waterbodies are only small proportions of their watersheds. Consequently, water quality and aquatic resources are strongly affected by activities outside of the park boundaries, and NPS management authority and capability for water quality improvement in waterbodies that pass through the parks is minimal. However, aquatic environments are disproportionately important in terms of biodiversity, biological productivity, and many other ecosystem functions and values. The UCBN has prioritized three water quality vital signs, surface water dynamics, aquatic macroinvertebrates, and water chemistry, and is committed to implementing a modest integrated water quality monitoring program that address those vital signs.

Water quantity and flow regime have overriding influence on stream channel morphology and stream and riparian biota. The strong alteration of flow regimes by human activity in the UCBN has altered biotic communities and ecosystem processes. UCBN parks are small relative to their watershed areas and few contain established flow monitoring sites within their boundaries. Consequently, future revisions to the integrated water quality monitoring protocol will include the monitoring of stream flow and compilation of data available from stations within and outside of UCBN unit boundaries. Aquatic macroinvertebrates are good indicators of ecosystem condition because they occur in all waterbodies, integrate point, nonpoint, pulse, and press disturbances, are trophically diverse, and are less mobile than fishes. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the watershed. The sampling of aquatic macroinvertebrates is relatively effective and efficient compared to other biotic indicators (e.g., algae and fish), and hence, is relatively cost-effective. Water chemistry and temperature have strong effects on aquatic biota. Consequently, direct and indirect human alteration of stream water chemistry and temperature is associated with altered biotic communities and ecosystem processes. Because of the direct relationship between water chemistry and biota, water chemistry is typically a central component of any water quality monitoring program. More recently, monitoring of stream water temperatures has increased because of concerns over cold-water fish habitat (primarily salmonid fishes), the recognized influence of land- and water-use on stream thermal regime, and the need for baseline temperature information to monitor effects of climate change. For example, temperature was selected as one of two key parameters for monitoring in the John Day Basin by the NOAA research, monitoring, and effectiveness program and its partners.

The water monitoring protocol will be a single, integrated protocol because sampling locations and personnel will greatly overlap. Macroinvertebrates will be sampled directly from select UCBN waterbodies, and water chemistry will be monitored by sampling select waterbodies for a set of core water quality parameters using continuous water quality monitoring probes (“multiprobes”; temperature, pH, specific conductance, dissolved oxygen, and turbidity).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- Are the core water quality parameters of streams in the UCBN with established TMDLs selected for sampling improving over time?
- What is the status and long-term trend of core water quality parameters (temperature, pH, conductivity, dissolved oxygen, and turbidity) in UCBN streams selected for sampling?
- What is the status and long term trend in aquatic macroinvertebrate abundance and assemblage composition in selected UCBN streams?
- Do aquatic macroinvertebrate assemblages sampled within UCBN streams indicate polluted or otherwise impaired water quality?
- Do aquatic macroinvertebrate assemblages sampled within UCBN streams indicate "pristine" or "reference" conditions according to regional criteria established by EPA and the states of Idaho, Oregon, Montana, and Washington?

Monitoring objectives addressed by this protocol include:

- Determine status and long term trend in key water quality parameters for selected streams within UCBN park units. ***Justification:*** *Water quality has strong effects on aquatic biota, but both vary through time as a result of natural and human-induced causes. Understanding the patterns of variability among years is critical to detecting long-term trends.*
- Determine status and trend in aquatic macroinvertebrate abundance, assemblage composition, and functional feeding group composition in wadeable streams within the UCBN. ***Justification:*** *Aquatic macroinvertebrates are good indicators of ecosystem condition because they occur in all waterbodies, integrate point, nonpoint, pulse, and press disturbances, are trophically diverse, and are less mobile than fishes. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the watershed. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the watershed.*

Basic Approach:

The monitoring protocol will specify criteria for selecting suitable sites (i.e., maximum distance from UCBN park boundary, etc.). Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs specifying statistical comparisons will include tests of long term changes in and status of macroinvertebrate assemblage structure.

Macroinvertebrate biomonitoring protocols are well developed and SOPs will be adapted from existing protocols developed by the EPA and the states of Idaho, Oregon and Washington, and other NPS monitoring Networks. Therefore, protocol development will not require field research and will primarily consist of writing protocols to meet NPS standards and to make existing national and regional protocols specific to UCBN parks. Site selection will be specified and will include protocols for selecting, permanently marking, photographing, and determining site coordinates using GPS. The type(s) of sampling device, size, and mesh size will be specified following consultation with local experts (EcoAnalysts, Moscow ID, Idaho DEQ, etc). Sample frequency and timing will be conducted using a rotating basin design, where one-third of UCBN waterbodies are sampled each year, resulting in the sampling of each unit every 3 years. Protocols will specify the frequency and sampling within year, and samples will be taken during index periods suggested by Hayslip (2007) and Montana DEQ (2006); June through October. SOPs will also describe field sampling, sample preservation, processing, and archiving, field and laboratory data collection (including sample data sheets), data storage, sharing, and database management, and will include an SOP to ensure QA/QC. Following

the first round of sampling, protocols for data summaries and statistical power analyses will be specified to determine the primary sources of variation in aquatic community structure and whether sampling levels are sufficient to meet monitoring goals. Additional SOPs will recommend potential sampling regime modifications, protocols for data analysis, including methods for testing for long-term trends, and suggested data summary and reporting formats.

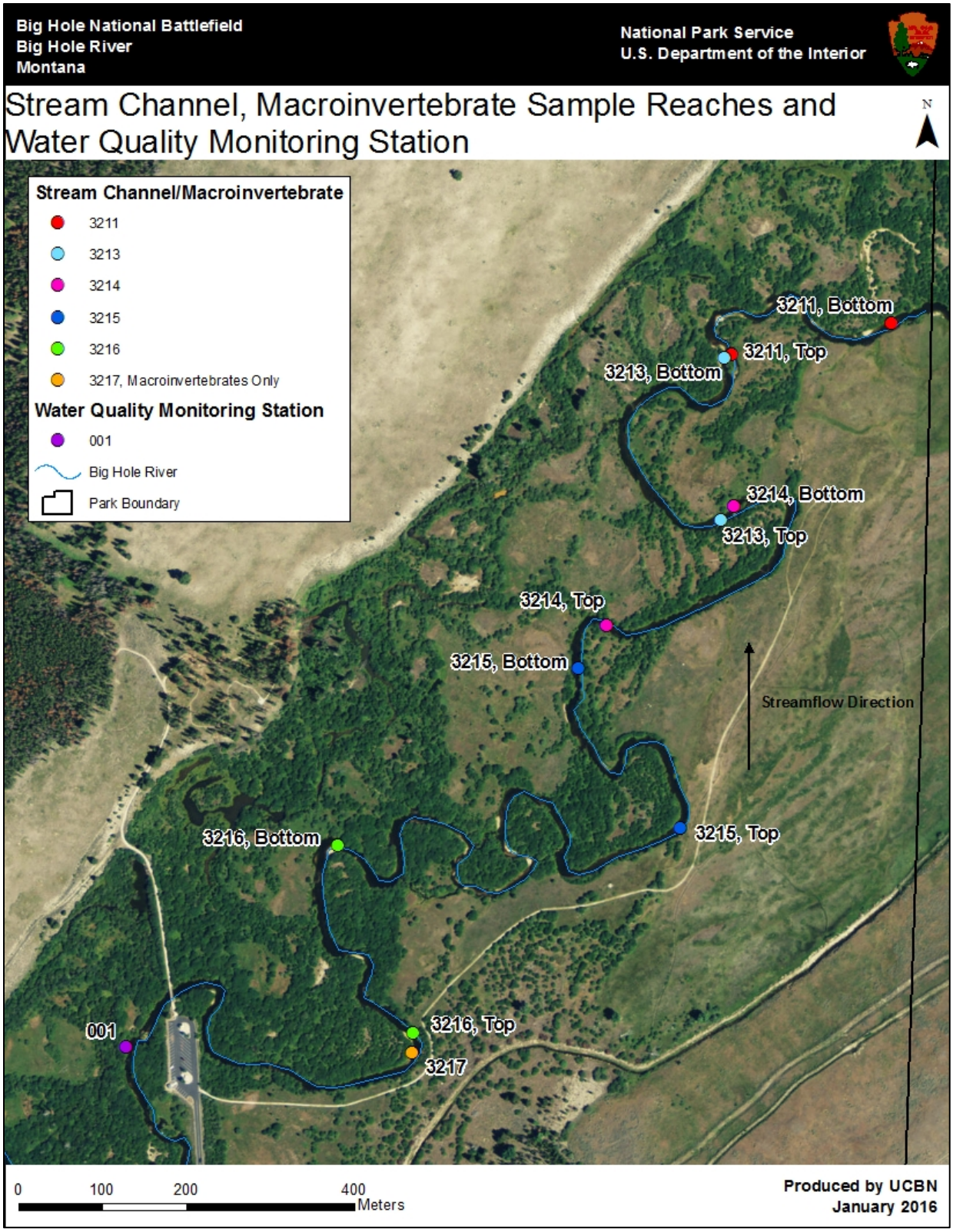
Water chemistry and temperature data will be evaluated to determine the best sites for monitoring. The UCBN seeks to balance the need for a representative location within each stream, with factors such as: stream stages, channel morphology, water velocity, potential for debris damage, and logistics. The reasoning for specific site selection will be fully documented. Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs specifying statistical comparisons will include tests of long term change in the magnitude and variability in parameters, and will emphasize reporting of trends in 303(d) listed streams.

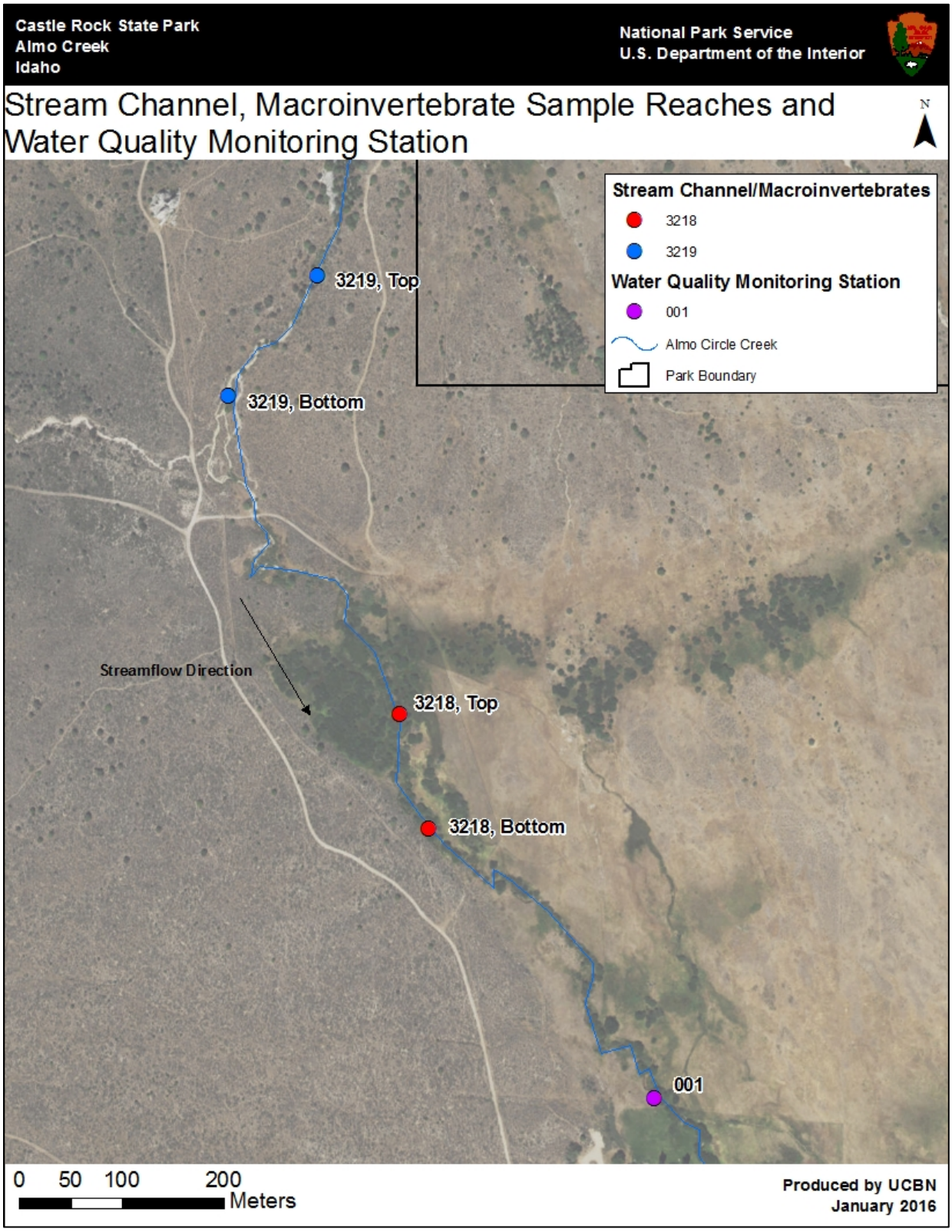
The use of continuous water quality monitors (multiprobes) will allow water quality data for a core set of parameter to be determined at high resolution from selected UCBN waterbodies. The core parameters will be measured every hour by the multiprobe. Probes will be deployed in each stream from May through the end of October to characterize daily, weekly, seasonal, and interannual patterns in mean parameter values and variability. SOPs will describe multiprobe transport, calibration/maintenance, storage, data retrieval, analysis, and archiving. Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs outlining data screening and QA/QC protocols will be included, as well as procedures for revising monitoring protocols and documenting any changes.

NPS Project Leader:
Eric Starkey, 208-885-3010

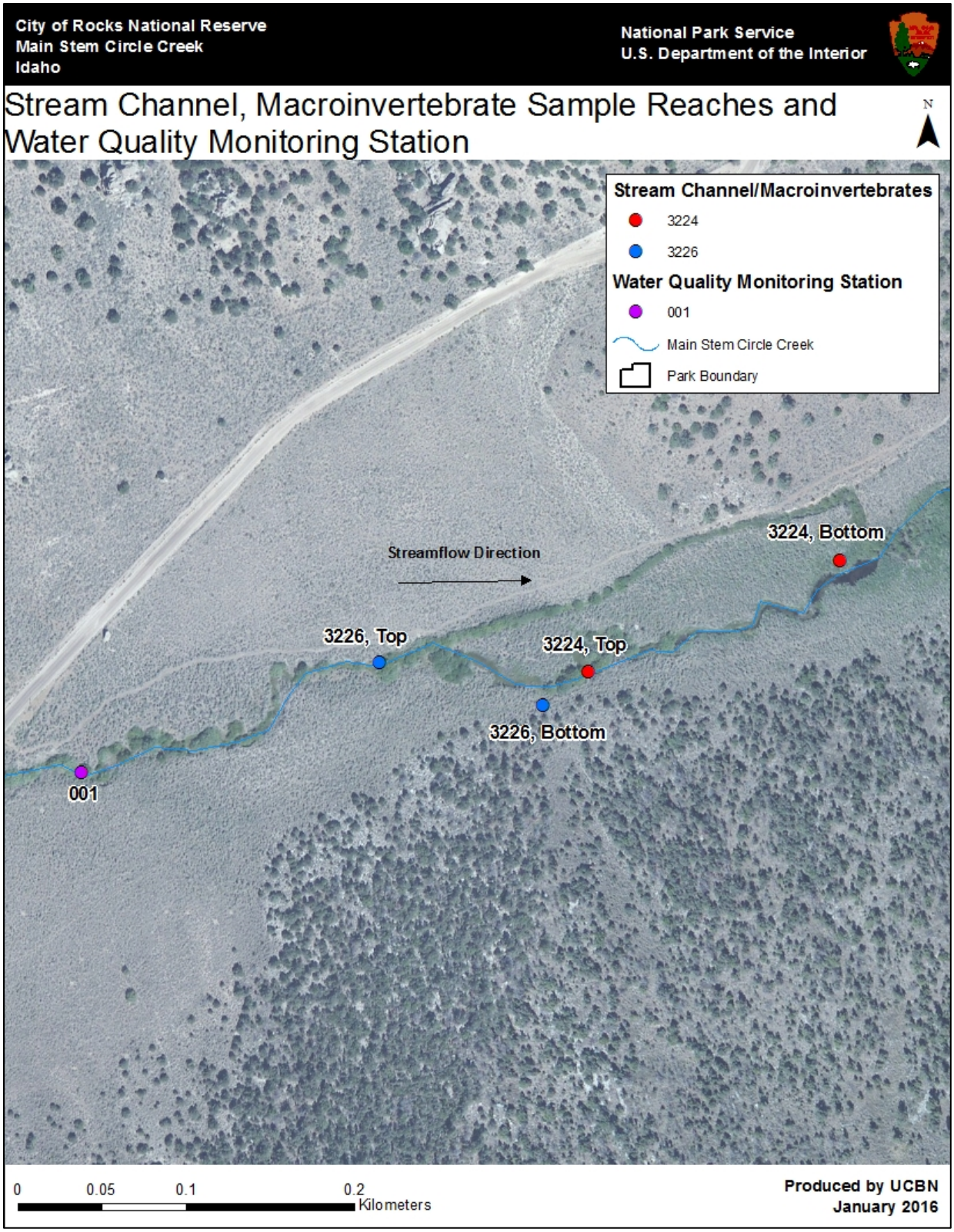
Development Schedule, and Expected Interim Products:
A draft monitoring protocol was submitted to NPS Water Resource Division for review in January 2008. Upon return of the protocol from peer review, comments and revisions were incorporated into the final Integrated Water Quality Monitoring Protocol.

Appendix A. Monitoring Location/Stream Maps

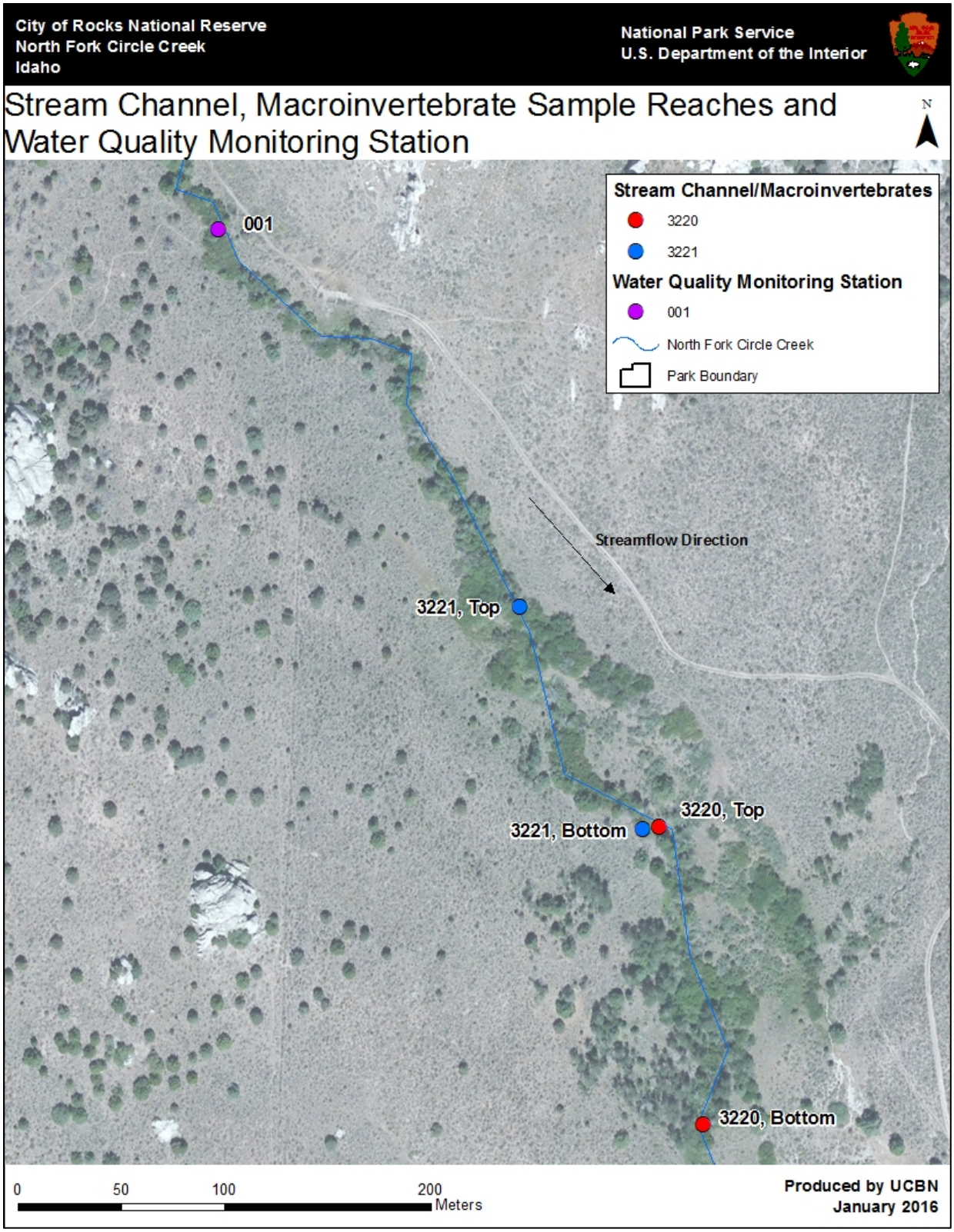




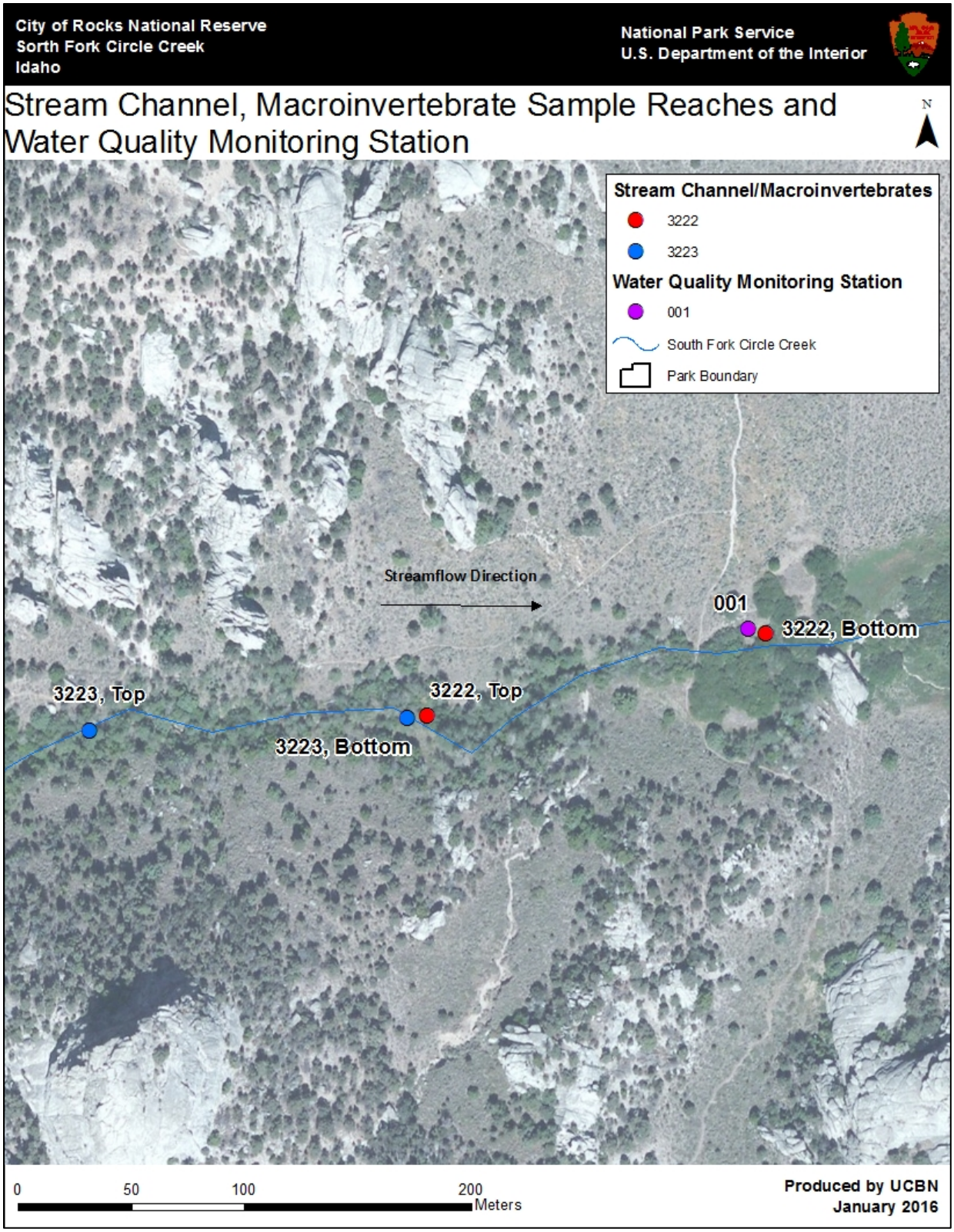
Appendix A. Monitoring Location/Stream Maps (continued)



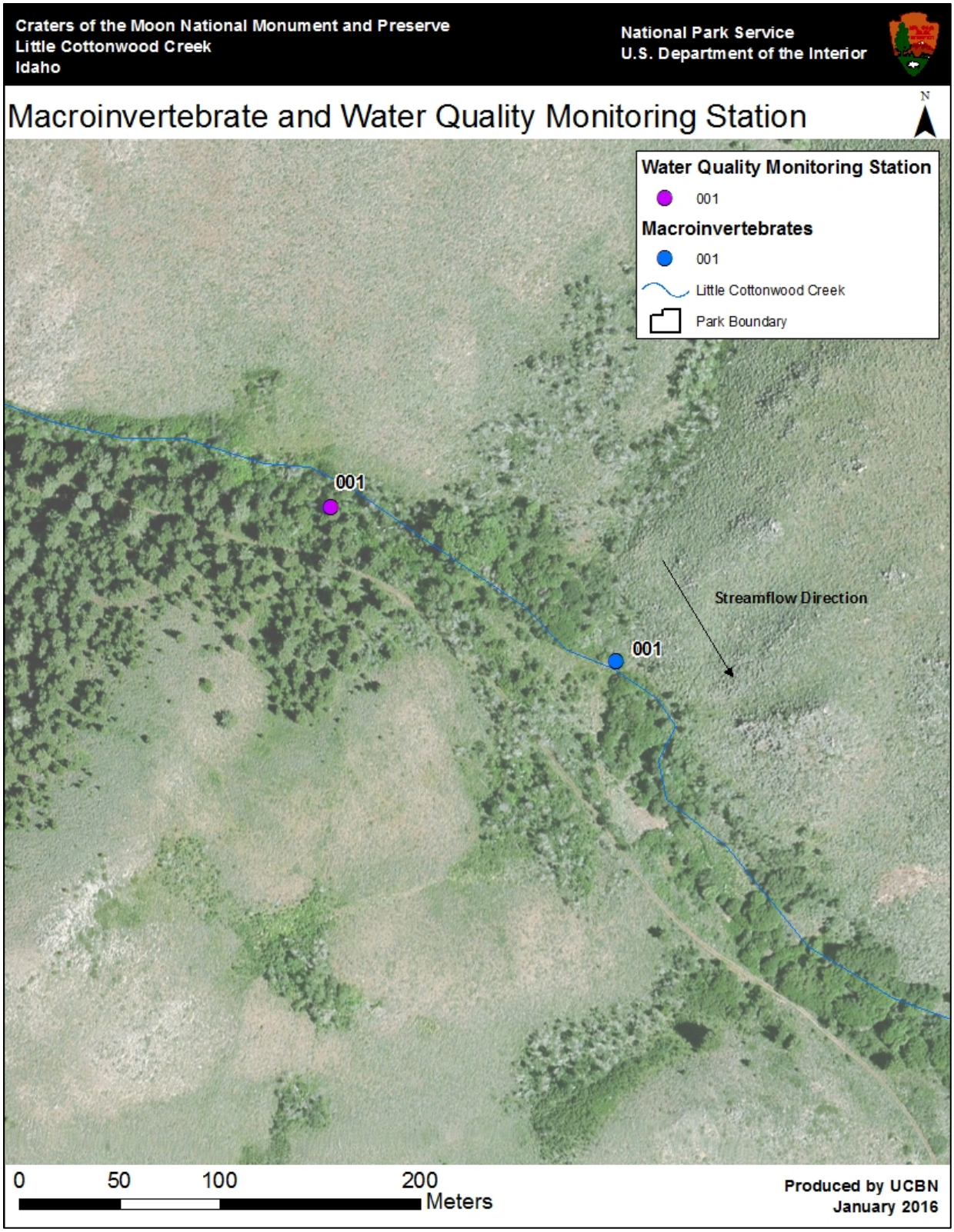
Appendix A. Monitoring Location/Stream Maps (continued)



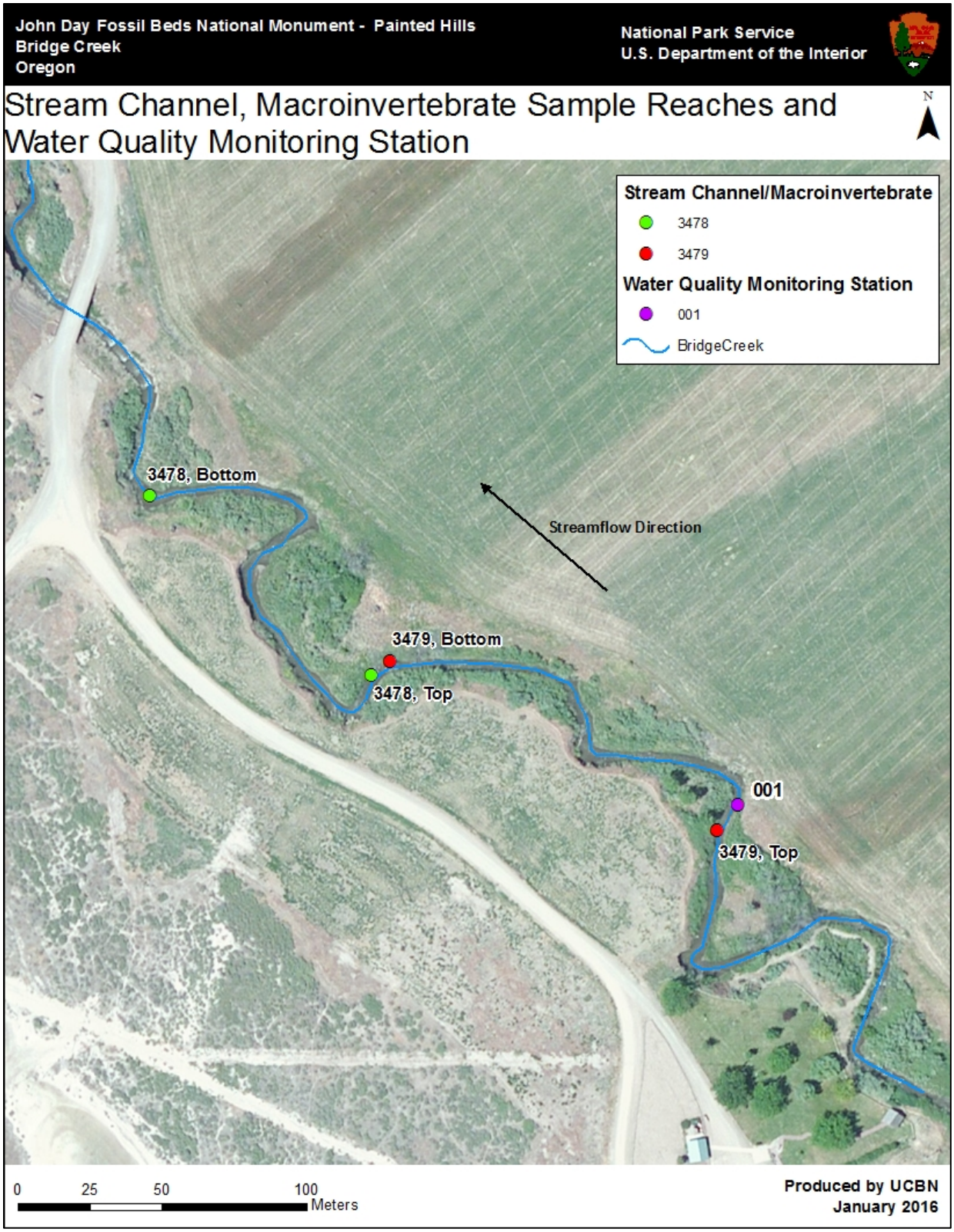
Appendix A. Monitoring Location/Stream Maps (continued)



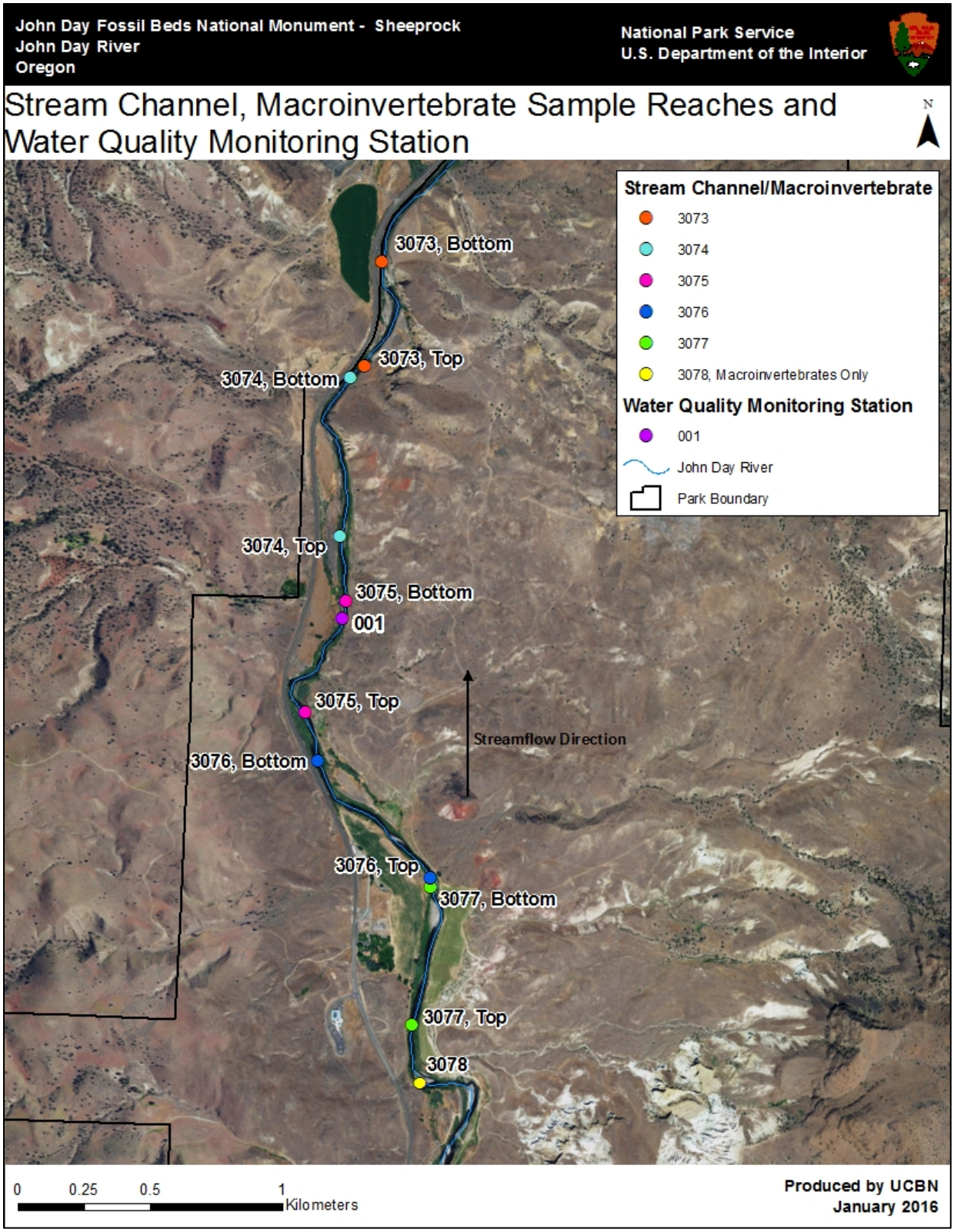
Appendix A. Monitoring Location/Stream Maps (continued)



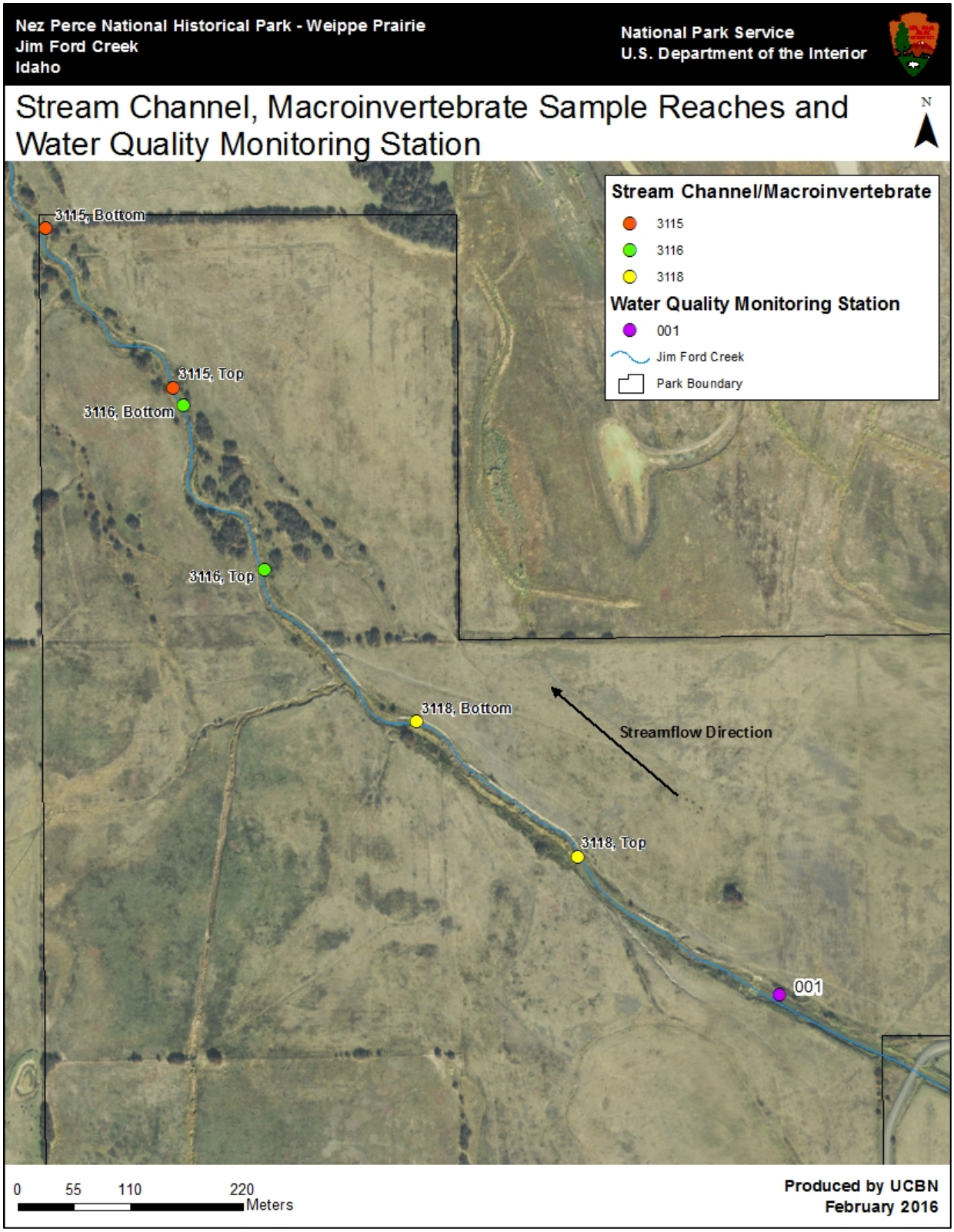
Appendix A. Monitoring Location/Stream Maps (continued)



Appendix A. Monitoring Location/Stream Maps (continued)



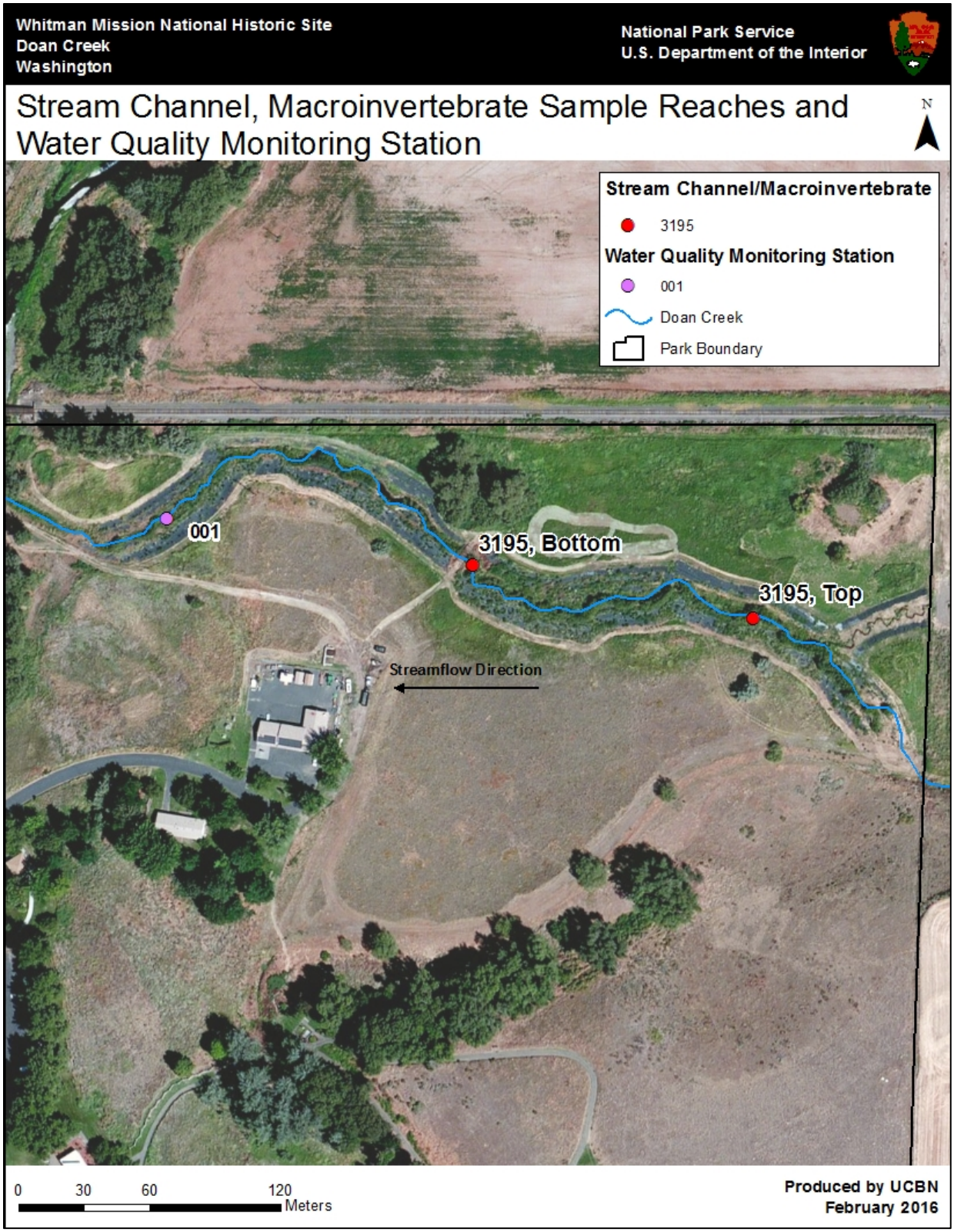
Appendix A. Monitoring Location/Stream Maps (continued)



Appendix A. Monitoring Location/Stream Maps (continued)



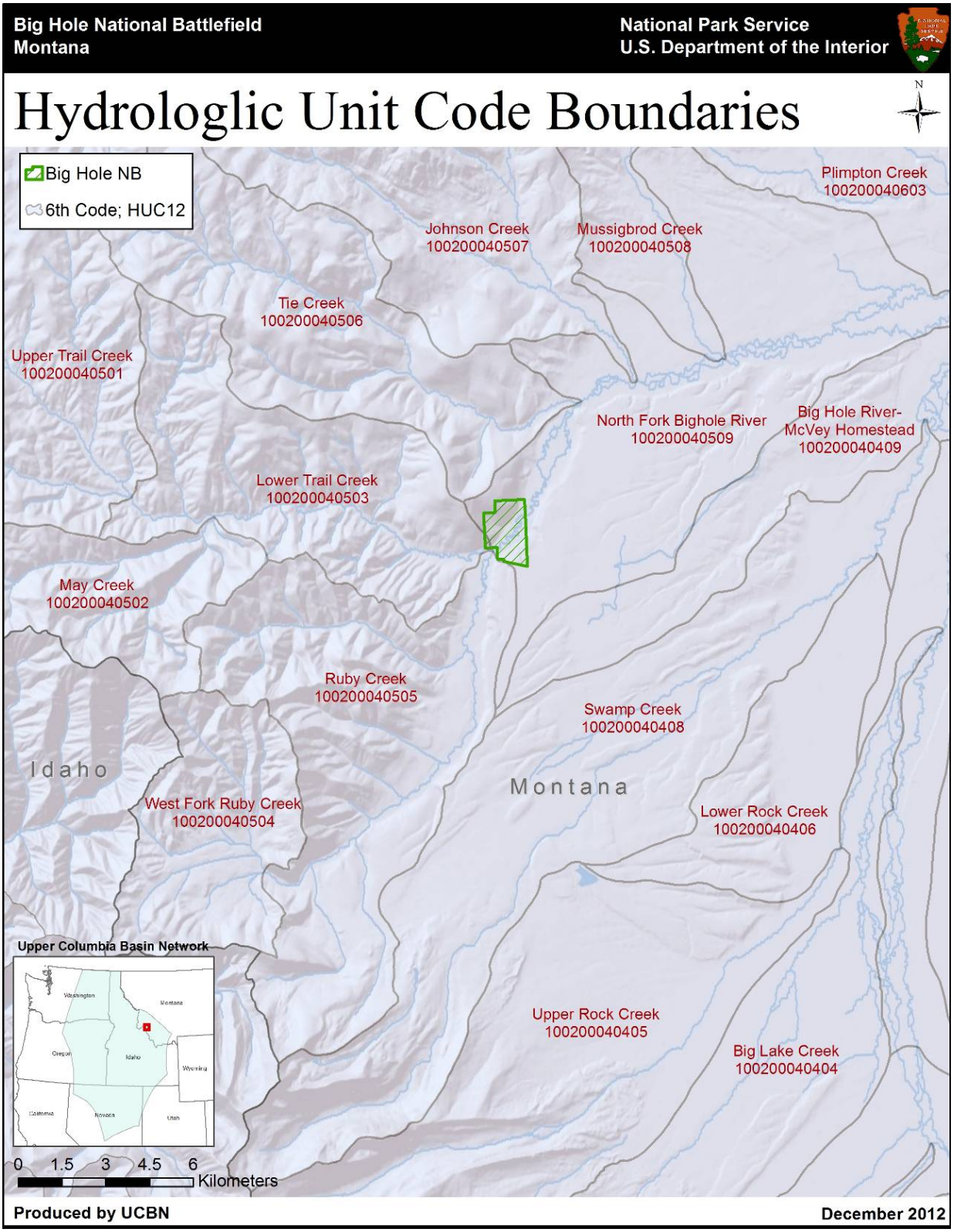
Appendix A. Monitoring Location/Stream Maps (continued)



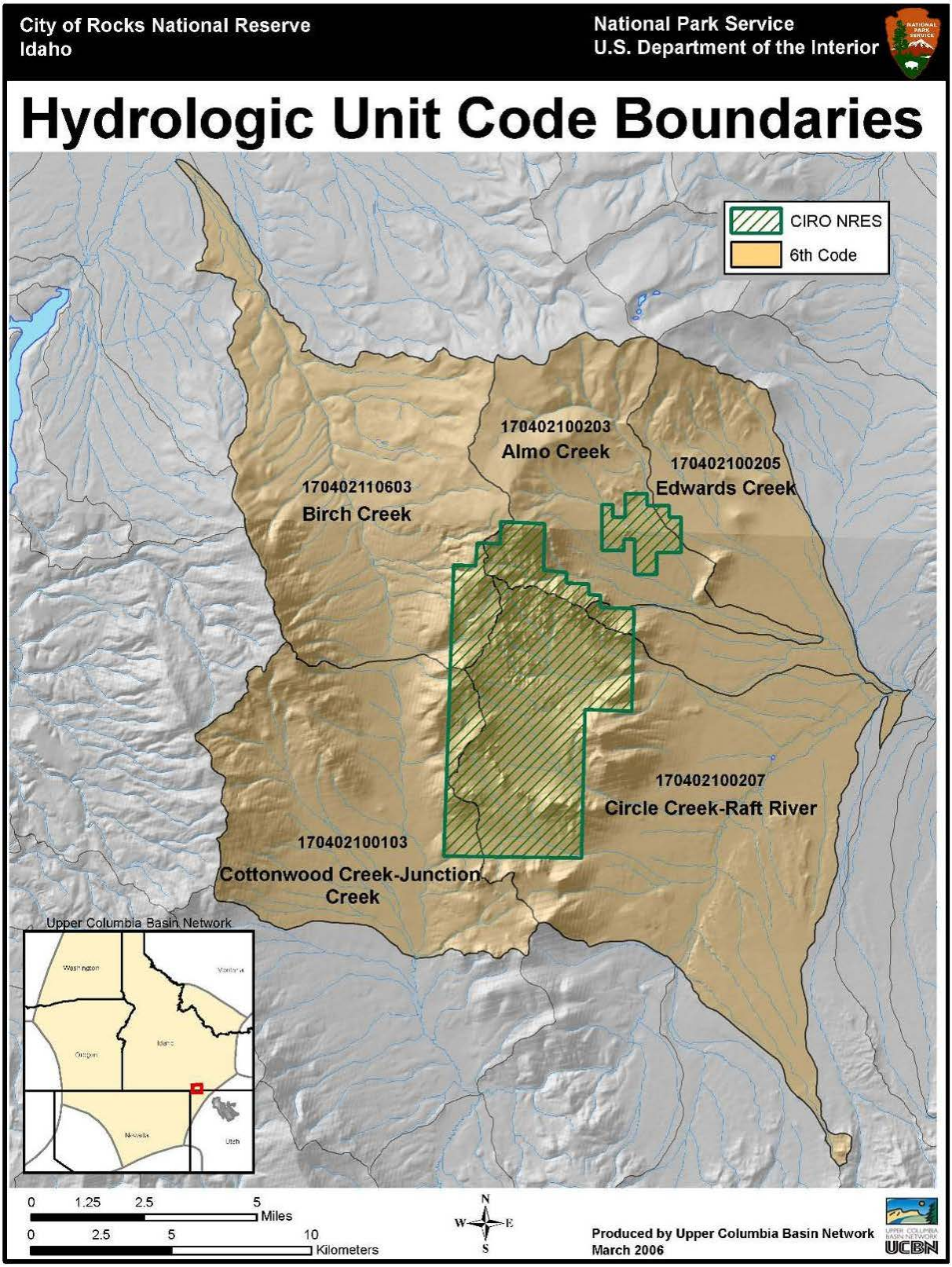
Appendix A. Monitoring Location/Stream Maps (continued)


Whitman Mission National Historic Site
Mill Creek
Washington
National Park Service
U.S. Department of the Interior
Stream Channel, Macroinvertebrate Sample Reaches and Water Quality Monitoring Station
N
Stream Channel/Macroinvertebrate
3194
Water Quality Monitoring Station
001
Mill Creek
Park Boundary
Streamflow Direction
3194, Top
001
3194, Bottom
0 25 50 100
Meters
Produced by UCBN
February 2016

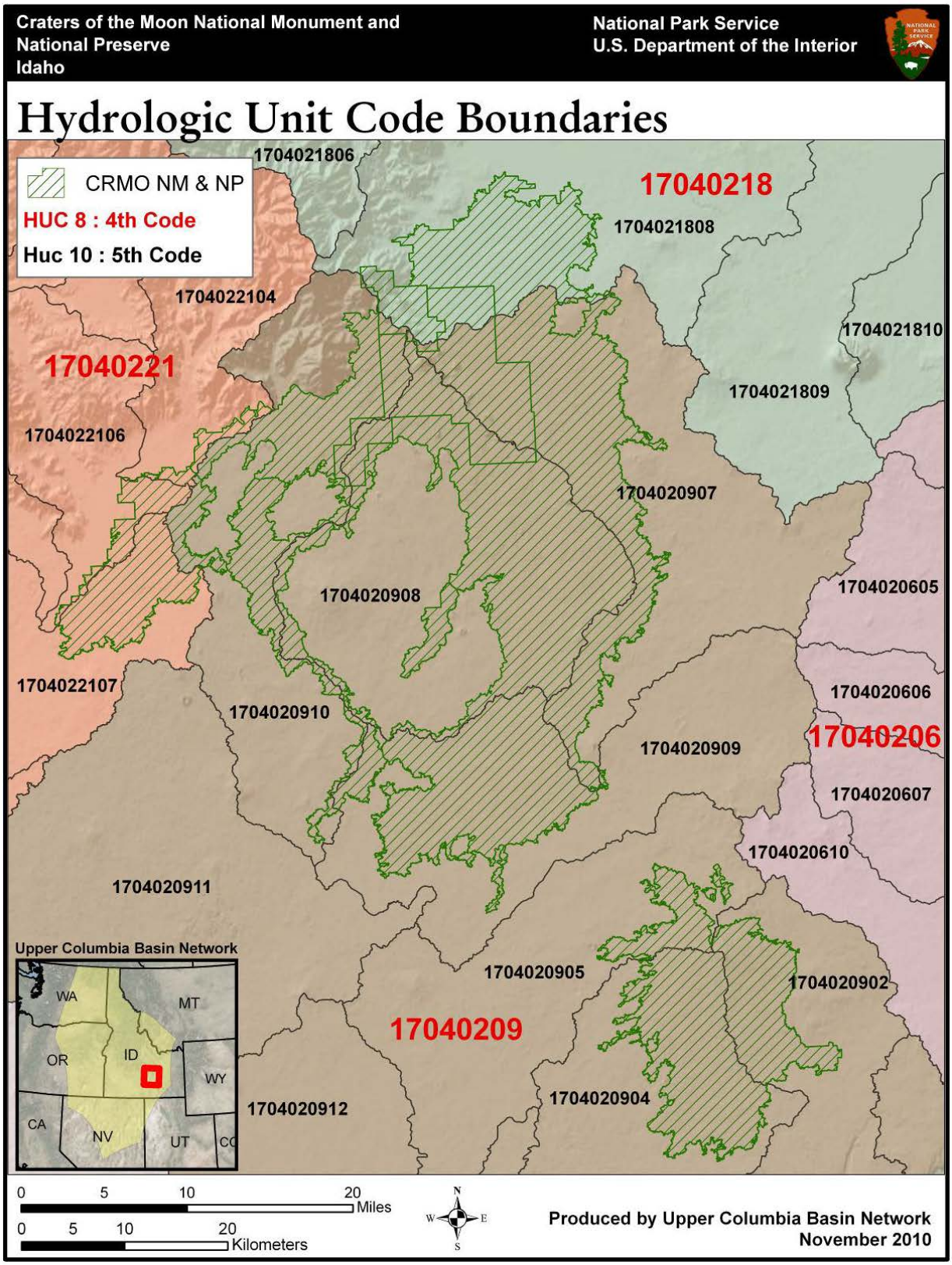
Appendix B. Hydrologic Unit Code (HUC) Boundaries



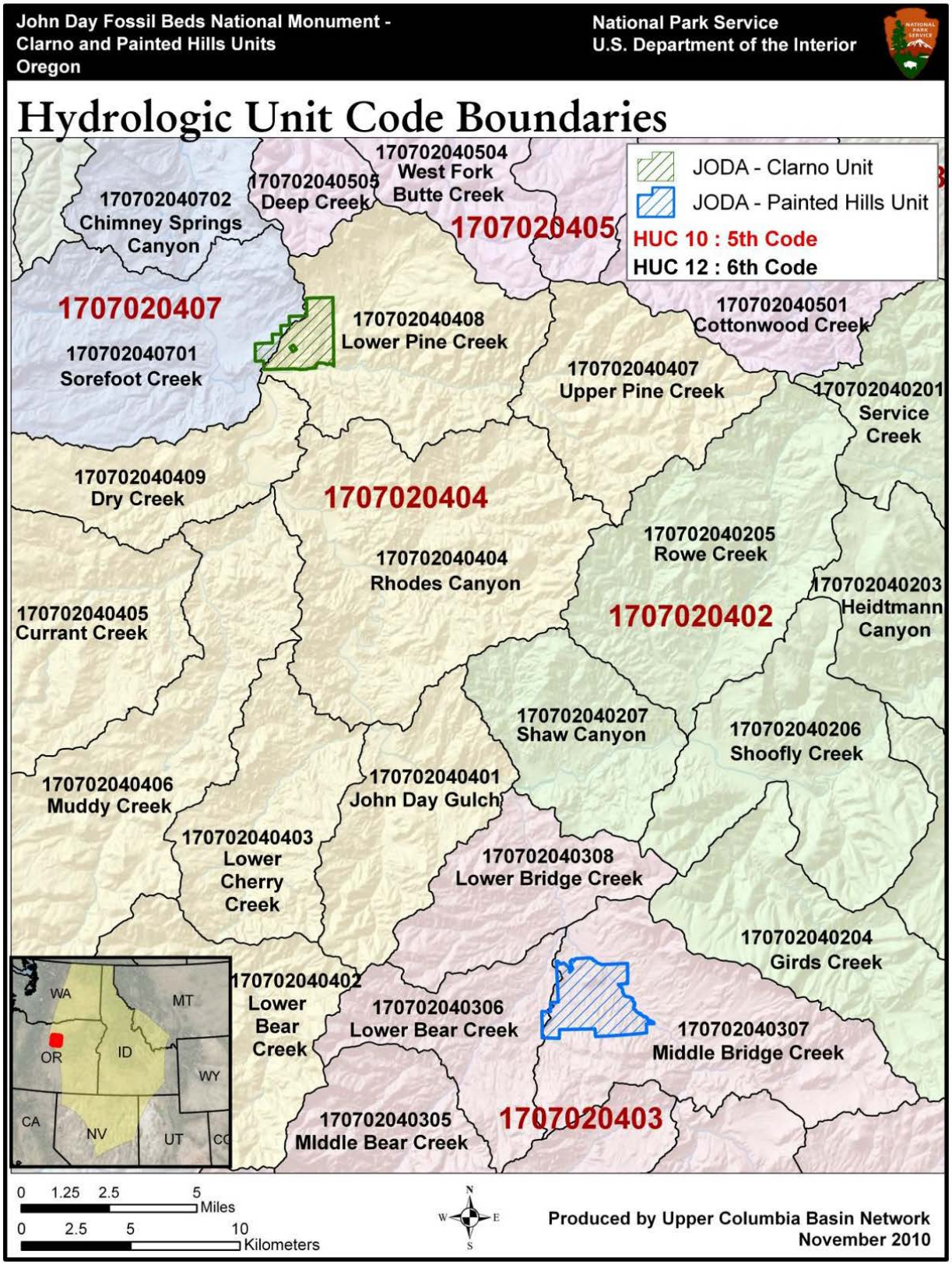
Appendix B. HUC Boundaries (continued)



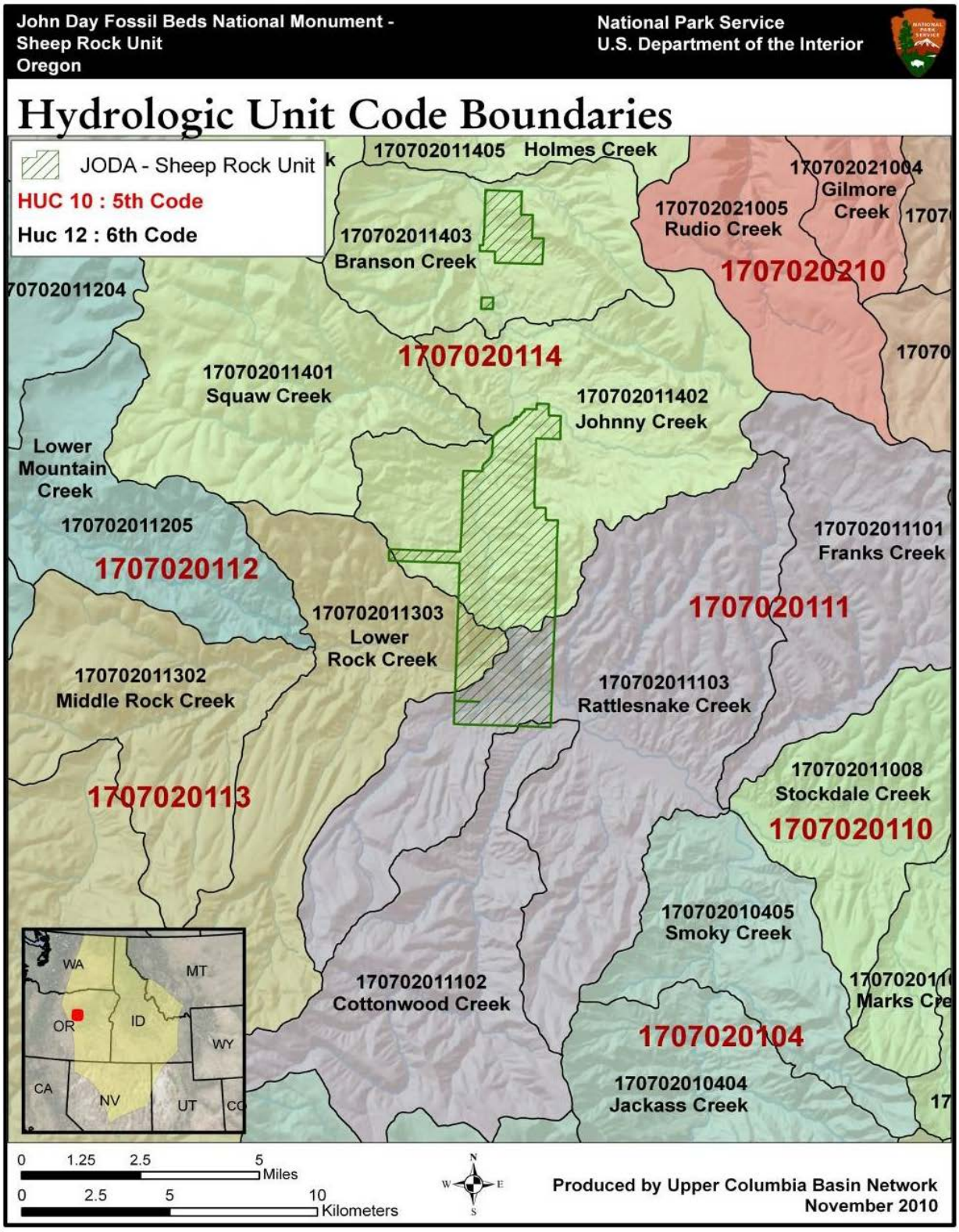
Appendix B. HUC Boundaries (continued)

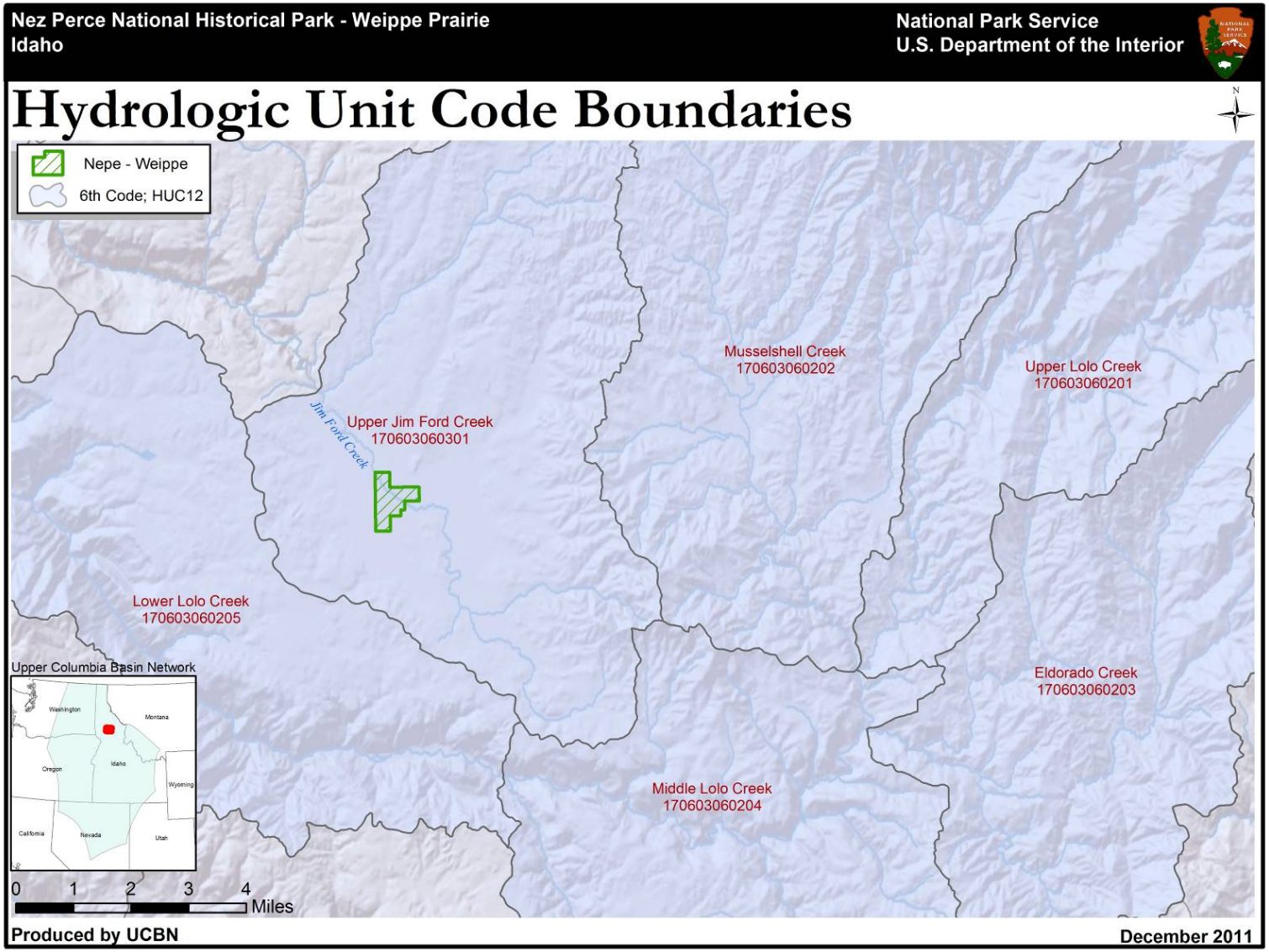


Appendix B. HUC Boundaries (continued)

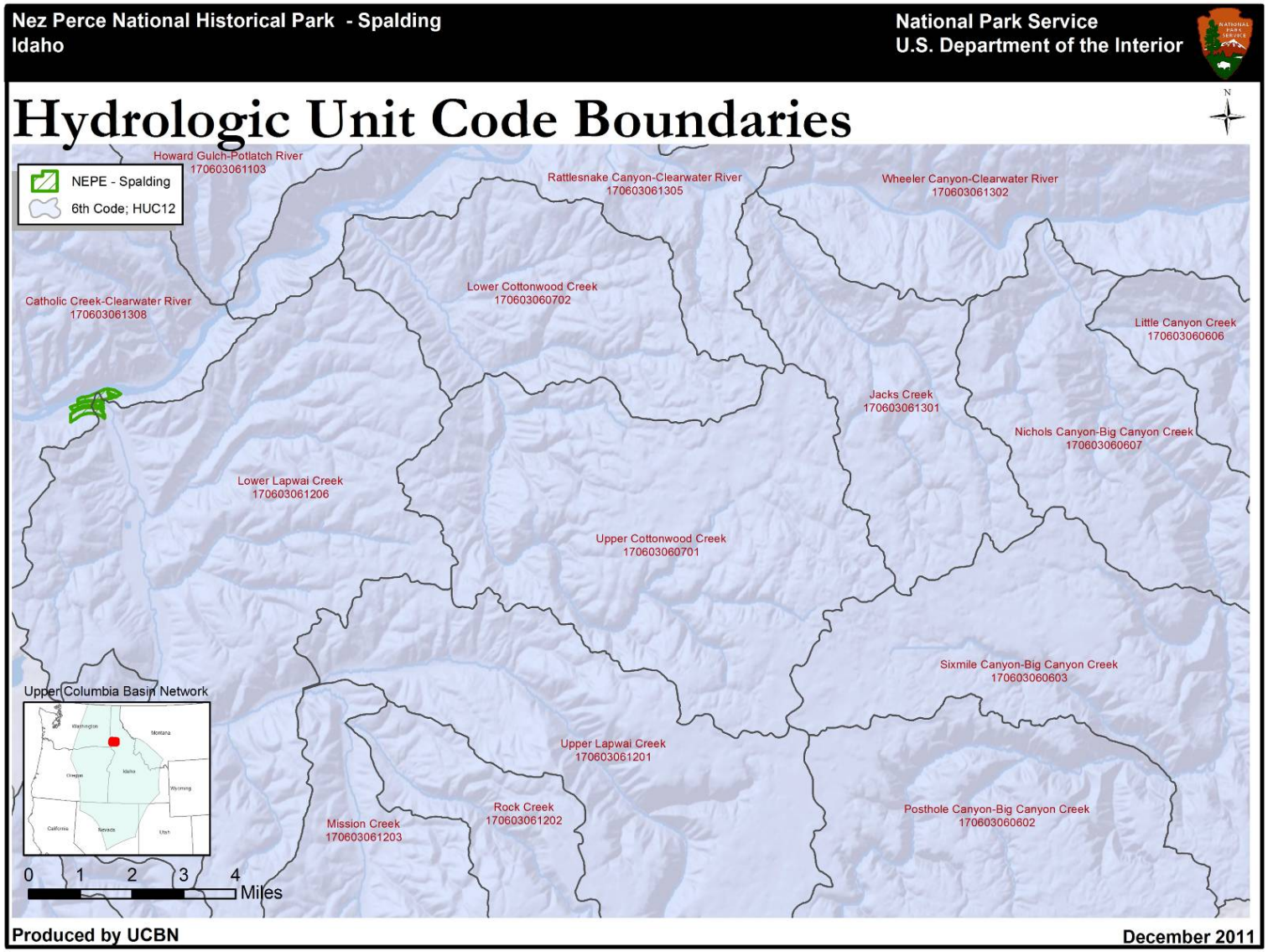


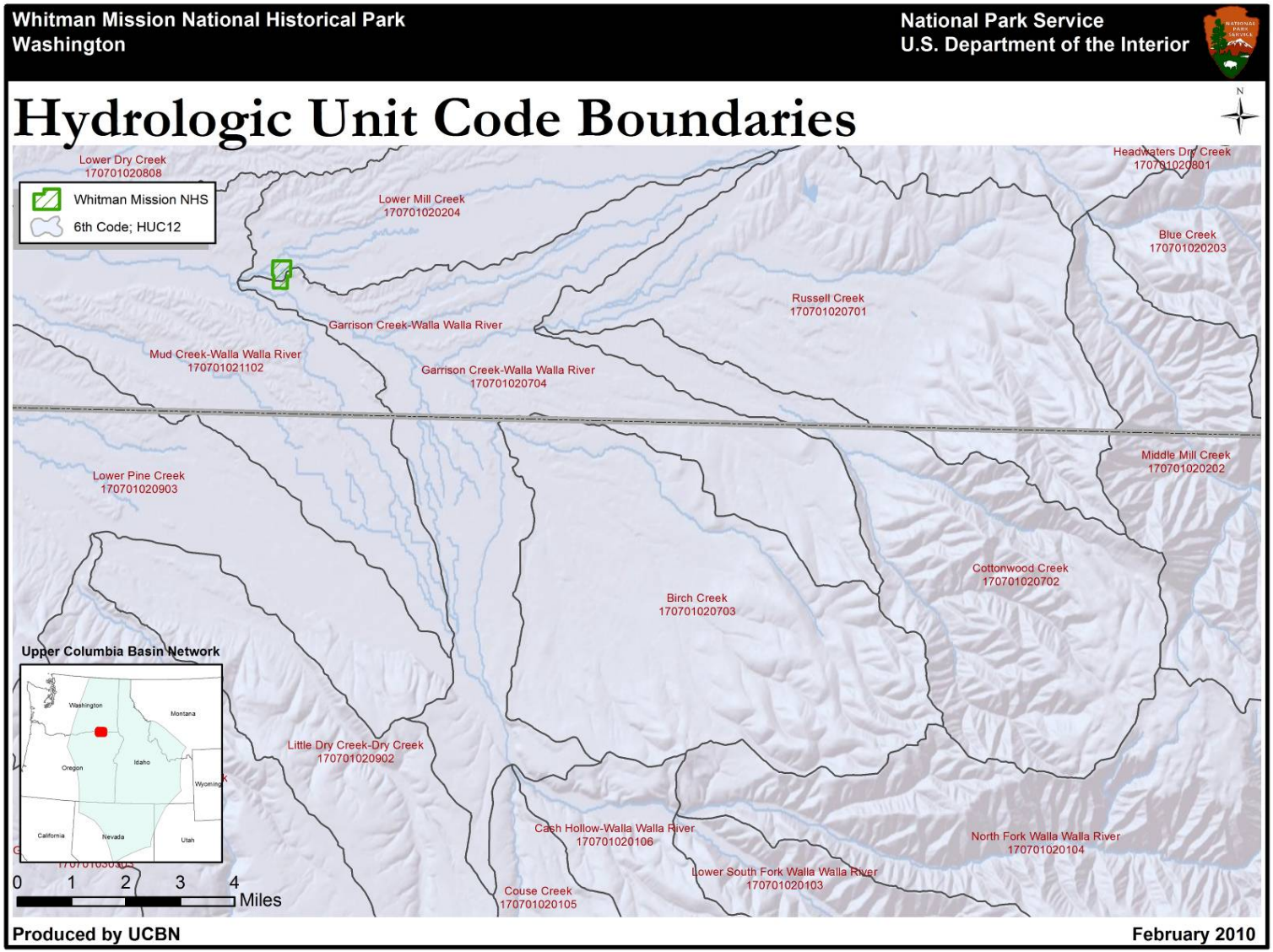
Appendix B. HUC Boundaries (continued)


John Day Fossil Beds National Monument -
Sheep Rock Unit
Oregon
National Park Service
U.S. Department of the Interior
Hydrologic Unit Code Boundaries
JODA - Sheep Rock Unit
HUC 10 : 5th Code
Huc 12 : 6th Code
170702011405 Holmes Creek
170702021004 Gilmore Creek
170702021005 Rudio Creek
170702011403 Branson Creek
1707020210
70702011204
1707020114
170702011401 Squaw Creek
170702011402 Johnny Creek
Lower Mountain Creek
170702011205
1707020112
170702011101 Franks Creek
1707020111
170702011303 Lower Rock Creek
170702011302 Middle Rock Creek
170702011103 Rattlesnake Creek
1707020113
170702011008 Stockdale Creek
1707020110
170702010405 Smoky Creek
170702011102 Cottonwood Creek
1707020104
170702010404 Jackass Creek
WA
MT
OR
ID
WY
CA
NV
UT
0 1.25 2.5 5 Miles
0 2.5 5 10 Kilometers
N
W
E
S
Produced by Upper Columbia Basin Network
November 2010


Nez Perce National Historical Park - Weippe Prairie
Idaho
National Park Service
U.S. Department of the Interior
Hydrologic Unit Code Boundaries
N
Nepe - Weippe
6th Code; HUC12
Musselshell Creek
170603060202
Upper Lolo Creek
170603060201
Jim Ford Creek
Upper Jim Ford Creek
170603060301
Lower Lolo Creek
170603060205
Eldorado Creek
170603060203
Middle Lolo Creek
170603060204
Upper Columbia Basin Network
Washington
Montana
Oregon
Idaho
Wyoming
California
Nevada
Utah
0 1 2 3 4
Miles
Produced by UCBN
December 2011

Appendix B. HUC Boundaries (continued)




Whitman Mission National Historical Park
Washington
National Park Service
U.S. Department of the Interior
Hydrologic Unit Code Boundaries
N
Whitman Mission NHS
6th Code; HUC12
Lower Dry Creek
170701020808
Lower Mill Creek
170701020204
Headwaters Dry Creek
170701020801
Blue Creek
170701020203
Russell Creek
170701020701
Garrison Creek-Walla Walla River
Mud Creek-Walla Walla River
170701021102
Garrison Creek-Walla Walla River
170701020704
Lower Pine Creek
170701020903
Middle Mill Creek
170701020202
Cottonwood Creek
170701020702
Birch Creek
170701020703
Upper Columbia Basin Network
Washington
Montana
Oregon
Idaho
Wyoming
California
Nevada
Utah
Little Dry Creek-Dry Creek
170701020902
Cash Hollow-Walla Walla River
170701020106
North Fork Walla Walla River
170701020104
Lower South Fork Walla Walla River
170701020103
Couse Creek
170701020105
0 1 2 3 4
Miles
Produced by UCBN
February 2010

Appendix C. Sample Locations for Water Quality/Macroinvertebrate Monitoring

Park	Stream	Monitoring Type	Station #, Site ID	Lat.	Long.	Y	X	UTM Zone
BIHO	North Fork Big Hole River	Water Chemistry	001	45.64349069	-113.65407131	5058747.22112554	293967.64787458	12
BIHO	North Fork Big Hole River	Macroinvertebrate	3211	45.6515284028425	-113.642758646643	5058733	294086	12
BIHO	North Fork Big Hole River	Macroinvertebrate	3213	45.6510639458218	-113.645316504799	5058688	293885	12
BIHO	North Fork Big Hole River	Macroinvertebrate	3214	45.6493456648691	-113.644889042235	5058496	293912	12
BIHO	North Fork Big Hole River	Macroinvertebrate	3215	45.6477809496476	-113.647536085331	5058329	293700	12
BIHO	North Fork Big Hole River	Macroinvertebrate	3216	45.6457316184628	-113.65089160712	5058110	293431	12
CIRO	North Fork Circle Creek	Water Chemistry	001	42.090693	-113.707035	4663392.25359	276119.93333	12
CIRO	South Fork Circle Creek	Water Chemistry	001	42.077681	-113.707022	4661946.25176	276076.14854	12
CIRO	Circle Creek	Water Chemistry	001	42.076254	-113.680830	4661720.21418	278238.00566	12
CRSP	Almo Creek	Water Chemistry	001	42.126794	-113.659879	4667279.22126	280145.31404	12
CIRO	North Fork Circle Creek	Macroinvertebrates	3220	42.0868722	-113.703967	4662960	276360	12
CIRO	North Fork Circle Creek	Macroinvertebrates	3221	42.0881861	-113.7044	4663107	276329	12
CIRO	South Fork Circle Creek	Macroinvertebrates	3222	42.0774917	-113.706889	4661926	276085	12
CIRO	South Fork Circle Creek	Macroinvertebrates	3223	42.0772472	-113.708811	4661904	275926	12
CIRO	Circle Creek	Macroinvertebrates	3224	42.0773806	-113.675389	4661832	278691	12
CIRO	Circle Creek	Macroinvertebrates	3226	42.0768028	-113.677481	4661773	278516	12
CRSP	Almo Creek	Macroinvertebrates	3218	42.1292361	-113.662408	4667556	279944	12
CRSP	Almo Creek	Macroinvertebrates	3219	42.1328139	-113.664922	4667960	279749	12
CRMO	Little Cottonwood Creek	Water Chemistry	001	43.48793970	-113.59347828	4818269.5651	290286.3733	12

* Indicates inactive sample locations

Park	Stream	Monitoring Type	Station #, Site ID	Lat.	Long.	Y	X	UTM Zone
CRMO	Little Cottonwood Creek	Macroinvertebrate	001	43.48729061	-113.59169737	4818192.9869	290428.1407	12
JODA	Bridge Creek	Water Chemistry	001	44.65517177	-120.25189075	4948319	717889	10
JODA	John Day River	Water Chemistry	001	44.56650180	-119.64642028	4938202	289853	11
JODA	Bridge Creek	Macroinvertebrate	3478	44.6577	-120.2556	4948590	717585	11
JODA	Bridge Creek	Macroinvertebrate	3479	44.6565	-120.2547	4948459	717661	11
JODA	John Day River	Macroinvertebrate	3073	44.57885	-119.645	4939571	290011	11
JODA	John Day River	Macroinvertebrate	3074	44.5747	-119.646	4939113	289917	11
JODA	John Day River	Macroinvertebrate	3075	44.5672	-119.646	4938279	289889	11
JODA	John Day River	Macroinvertebrate	3076	44.56167	-119.647	4937668	289790	11
JODA	John Day River	Macroinvertebrate	3077	44.5575	-119.642	4937192	290172	11
JODA	John Day River	Macroinvertebrate	3078	44.55081	-119.642	4936449	290148	11
NEPE	Jim Ford Creek	Water Chemistry	001	46.35429603	-115.91867957	5133980.86	583193.94	11
NEPE	Lapwai Creek	Water Chemistry	001*	46.44935628	-116.81816423	5143991.41	513966.60	11
NEPE	Lapwai Creek	Water Chemistry	002	46.45001602	-116.819499204	5144065.16	513862.85	11
NEPE	Jim Ford Creek	Macroinvertebrates	3115	46.36121748	-115.926842	5134742	582554	11
NEPE	Jim Ford Creek	Macroinvertebrates	3116	46.35968941	-115.9251301	5134574	582688	11
NEPE	Jim Ford Creek	Macroinvertebrates	3118	46.35689017	-115.9222344	5134266	582915	11
NEPE	Lapwai Creek	Macroinvertebrates	3114	46.45051829	-116.8179127	5144121	513984	11
WHMI	Doan Creek	Water Chemistry	001	46.044167	-118.463377	5099996	386778	11
WHMI	Mill Creek	Water Chemistry	001	46.04366488	-118.46517032	5099943	386638	11
WHMI	Doan Creek	Macroinvertebrates	3195	46.04414805	-118.4604884	5099989	387001	11
WHMI	Mill Creek	Macroinvertebrates	3194	46.04218851	-118.4687082	5099783	386361	11

* Indicates inactive sample locations

Appendix D. Sources for UCBN Water Quality Data

NPS Water Resources Division (WRD): WRD maintains the NPSTORET database and also maintains a list of 303(d) status for park water bodies nationwide that is updated periodically. The 303(d) list can be accessed through the NPS intranet at: http://www.nature.nps.gov/water/

Pacific Northwest Aquatic Monitoring Program (PNAMP): "The purpose of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is to provide a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. Improved communication, shared resources and data, and compatible monitoring efforts provide increased scientific credibility, cost-effective use of limited funds and greater accountability to stakeholders. PNAMP provides leadership through the development and the advancement of recommendations and agency level agreements that are considered for adoption by the participating agencies." http://www.pnamp.org

State Water Resource Monitoring Programs: State programs include 303(d) assessments, monitoring of surface water quality, and in most of the states, an aquatic macroinvertebrate monitoring program.

Idaho: http://www.deq.idaho.gov/water-quality/
Montana: http://deq.mt.gov/Water
Oregon: http://www.oregon.gov/deq/wq/pages/index.aspx
Washington: http://www.ecy.wa.gov/programs/wq/wqhome.html

StreamNet: "StreamNet is a cooperative venture of the Pacific Northwest's fish and wildlife agencies and tribes and is administered by the Pacific States Marine Fisheries Commission. We provide data and data services in support of the region's Fish and Wildlife Program and other efforts to manage and restore the region's aquatic resources"(www.streamnet.org). StreamNet is primarily a repository for fish surveys, though it is also as contains habitat data.

Tribal Water Resource Monitoring Programs: The Nez Perce Tribe has a water resource monitoring program: http://www.nezperce.org/Programs/water_resources_program.htm

USGS National Ambient Water Quality Assessment (NAWQA):

As described by Fuhrer et al. (2004)
"In 1991, the U.S. Congress began to appropriate funds to the USGS to conduct the National Water-Quality Assessment (NAWQA) Program. Since that time, NAWQA has evaluated the quality of streams, ground water, and aquatic ecosystems in more than 50 major river basins and aquifer systems across the Nation, referred to as "Study Units." As indicated on the map, timing of the assessments varies within the program's rotational design: about one-third of all Study Units are intensively investigated for 3 to 4 years, which is followed by 6 to 7 years of low-level monitoring.

In 2001, the NAWQA Program entered its second decade of investigations and an intensive reassessment of water conditions was begun to determine trends, based on 10 years of comparable monitoring data collected at selected streams and ground-water sites. The next 10 years of study also will fill critical gaps in characterizing water-quality conditions, and increase understanding of processes that control water-quality conditions, which will better establish critical links among sources of contaminants, their transport through the hydrologic system, and the potential effects of contaminants on ecological health and on the quality of drinking water."

Three NAWQA study basins fall within the UCBN boundary. The Upper Snake River Basin study unit (Clark et al. 1998) includes HAFO, CIRO, and CRMO. The Yakima (Fuhrer et al. 2004) and Central Columbia Plateau (Williamson 1998) study basins do not encompass any UCBN Units, but provide good overviews of water resource trends and issues in the region. Resampling of most basins is currently underway and the program should be monitored for the addition of study basins that include UCBN units. More detail on the program, including links to the data storage warehouse can be found at http://water.usgs.gov/nawqa/nawqa_sumr.html .

USGS stream gages near UCBN parks: The following is a list of USGS stream gages near UCBN parks. Most gages are stream discharge and stage only, a few have additional water quality parameters. Note that not all stream gages are on streams flowing through park units, but may provide insight into flow conditions within the park.

BIHO

USGS 06024500 Trail Creek nr Wisdom MT (Historical June 1948 to July 1972)
USGS 06024450 Big Hole River bl Big Lake Cr at Wisdom MT
http://waterdata.usgs.gov/nwis/uv/?site_no=06024450&agency_cd=USGS&
USGS 06024540 Big Hole River bl Mudd Cr nr Wisdom MT
http://waterdata.usgs.gov/nwis/uv/?site_no=06024540&agency_cd=USGS&

CIRO

USGS 13078000 RAFT RIVER AB ONEMILE CREEK NR MALTA ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13078000&agency_cd=USGS&
USGS 13083000 TRAPPER CREEK NR OAKLEY ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13083000&agency_cd=USGS&
USGS 13082500 GOOSE CREEK AB TRAPPER CREEK NR OAKLEY ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13082500&agency_cd=USGS&

CRMO

USGS 13132500 BIG LOST RIVER NR ARCO ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13132500&agency_cd=USGS&

USGS 13148500 LITTLE WOOD RIVER NR CAREY ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13148500&agency_cd=USGS&

Appendix D. Sources for UCBN Water Quality Data (continued).

USGS stream gages near UCBN parks (continued):

HAFO

USGS 13081500 SNAKE R NR MINIDOKA ID (AT HOWELLS FERRY)
http://waterdata.usgs.gov/nwis/uv/?site_no=13081500&agency_cd=USGS&
USGS 13094000 SNAKE RIVER NR BUHL ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13094000&agency_cd=USGS&
USGS 13108150 SALMON FALLS CREEK NR HAGERMAN ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13108150&agency_cd=USGS&
USGS 13095500 BOX CANYON SPRINGS NR WENDELL ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13095500&agency_cd=USGS&
USGS 13090500 SNAKE RIVER NR TWIN FALLS ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13090500&agency_cd=USGS&

JODA

USGS 14044000 MIDDLE FORK JOHN DAY RIVER AT RITTER, OR
http://waterdata.usgs.gov/nwis/uv/?site_no=14044000&agency_cd=USGS&
USGS 14046778 BRIDGE CR ABV COYOTE CANYON NR MITCHELL, OR
http://waterdata.usgs.gov/nwis/uv/?site_no=14046778&agency_cd=USGS&
USGS 14046890 PINE CREEK NEAR CLARNO, OR
http://waterdata.usgs.gov/nwis/uv/?site_no=14046890&agency_cd=USGS&
USGS 14046500 JOHN DAY RIVER AT SERVICE CREEK, OR
http://waterdata.usgs.gov/nwis/uv/?site_no=14046500&agency_cd=USGS&
USGS 14046000 NORTH FORK JOHN DAY RIVER AT MONUMENT, OR
http://waterdata.usgs.gov/nwis/uv/?site_no=14046000&agency_cd=USGS&
USGS 14038530 JOHN DAY RIVER NEAR JOHN DAY, OR
http://waterdata.usgs.gov/nwis/uv/?site_no=14038530&agency_cd=USGS&

LARO

USGS 12409000 COLVILLE RIVER AT KETTLE FALLS, WA
http://waterdata.usgs.gov/nwis/uv/?site_no=12409000&agency_cd=USGS&
USGS 12404500 KETTLE RIVER NEAR LAURIER, WA
http://waterdata.usgs.gov/wa/nwis/uv/?site_no=12404500&agency_cd=USGS&
USGS 12434590 SANPOIL RIVER ABOVE JACK CREEK AT KELLER, WA
http://waterdata.usgs.gov/nwis/uv/?site_no=12434590&agency_cd=USGS&
USGS 12422500 SPOKANE RIVER AT SPOKANE, WA
http://waterdata.usgs.gov/nwis/uv/?site_no=12422500&agency_cd=USGS&

NEPE

USGS 13342450 LAPWAI CREEK NR LAPWAI, ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13342450&agency_cd=USGS&
USGS 13342500 CLEARWATER RIVER AT SPALDING ID
http://waterdata.usgs.gov/nwis/uv/?site_no=13342500&agency_cd=USGS&

Appendix D. Sources for UCBN Water Quality Data (continued).

USGS stream gages near UCBN parks (continued):

WHMI

USGS 14013700 MILL CREEK AT FIVE MILE RD BR NR WALLA WALLA, WA
http://waterdata.usgs.gov/nwis/uv/?site_no=14013700&agency_cd=USGS&

USGS 14015000 MILL CREEK AT WALLA WALLA, WA
http://waterdata.usgs.gov/nwis/uv/?site_no=14015000&agency_cd=USGS&

USGS 14018500 WALLA WALLA RIVER NEAR TOUCHET, WA
http://waterdata.usgs.gov/nwis/uv/?site_no=14018500&agency_cd=USGS&

Appendix E. Field Safety Notebook

Emergency Evacuation Instructions
NEPE – Spalding Area – Lapwai Creek

Be prepared to provide the following information:

1. Nature of the accident or injury.
2. Follow the SAMPLE and SOAP guidelines the back of this sheet.
3. Type of assistance needed, if any (ground, air, or water evacuation).
4. 3. Location of accident or injury, best access route into the worksite (road name/number), i identifiable ground/air landmarks.
5. Radio frequencies.
6. Contact person.
7. Local hazards to ground vehicles or aviation.
8. Weather conditions (wind speed & direction, visibility, temperature).
9. Topography.
10. Number of individuals to be transported.
11. Estimated weight of individuals for air/water evacuation.

Local Emergency Contact	Phone Number
Lapwai Police Department	208-843-2212 Or 911
Latah County Sheriff	208-882-2216 Or 911
NEPE - Park Ranger - Idaho Unit Manager - Scott Eckberg	208 843-7051
NEPE - Integrated Resources Program Manager – Jason Lyon	208 843-7017
UCBN Office	
Gordon Dicus – Program Manager	208-885-3684
UCBN data manager	208-885-3022
Eric Starkey- UCBN Aquatic Biologist	208-885-3010

Nearest Hospital

St Joseph Reg. Medical Center
415 Sixth Street
Lewiston, ID83501-0816
Phone: 208-743-2511

Route to Nearest Hospital:

	Directions	Distance
Total Est. Time: 16 minutes	**Total Est. Distance:** 11.98 miles	
1:	Start out going NORTH on US-95 N toward SPALDING MILL RD.	8.8 miles
2:	US-95 N becomes US-12 W.	2.4 miles
3:	Turn RIGHT onto D ST / US-12 W.	0.1 miles
4:	Turn LEFT onto 9TH ST.	0.3 miles
5:	Turn RIGHT onto 5TH AVE.	0.1 miles
6:	Turn RIGHT onto 6TH ST.	<0.1 miles
7:	End at **415 6th St** Lewiston, ID 83501-2431, US	

DO NOT PANIC

1. **Make sure area is safe for you and victim**
2. **Do not move victim, unless necessary to avoid further injury**
3. **Stabilize victim and treat for shock**
   a. **Stop bleeding (apply pressure) use first aid kit (gloves, gauze, etc.)**
   b. **Make sure victim is lying down**
   c. **Elevate feet**
   d. **Cover with coat / blankets**
4. **Call / Radio for emergency help**
   a. **Provide the information listed at the top of this sheet**
   b. **Do not leave victim unless contact cannot be made**
5. **Remain with victim until help arrives or stabilize victim's condition before you go for help.**
6. **If with other group members consider evacuation of individual using stretcher or other techniques.**

The following is taken from Tilton, Buck. 2007. Backcountry first aid and extended care. National Outdoor Leadership School. 5th ed. Falcon Guides. Helena, MT.

SAMPLE History

The Sample Questions

S for symptoms: pain, nausea, lightheadedness, and other things you cannot see.
A for allergies: any known allergic reactions? What happens
M for medications: Anything legal or illegal? Why? How much?
P for pertinent medical history: Anything like this happen before? Currently under a physician's care for anything?
L for last intake and output: When was food or drink last taken? How much? When were the most recent urination and defecation? Were they normal?
E for events: What led up to the accident or illness? Why did it happen?

SOAP: The Written Report

This information should be given to emergency personnel and retained for records.

S for subjective summary: A summary of who the patient is (including age and sex), what the patient complains of, and what happened to the patient.
O for objective / observations: Observations and results of patient exam, vital signs and **SAMPLE** history.
A for assessment: What you think is wrong.
P for plan: What you are going to do immediately for the patient and the answer to the evacuation question- stay or go, fast or slow? A part of every plan is to monitor the patient for changes and developing needs

Field Site Descriptions/Hazards

The following site descriptions describe the location and hazards for water quality monitoring stations; however, unless otherwise stated, it should be assumed that similar hazards also apply to benthic macroinvertebrate sample sites.

Site ID	Lat.	Long.	General Description	Potential Hazards
BIHO NF Big Hole River WQ Station 001	45.65166414	-113.64428200	The Hydrolab was deployed approximately 100 meters upstream from the bridge over the North Fork Big Hole River and 40m west of the lower parking lot.	Traffic in the parking lot, biting mosquitoes, high water, deep pool just downstream of deployment location, sharp beaver chewed willow stakes, heavy willow cover, and extreme cold during fall samples.
CIRO- NF Circle Creek WQ Station 001	42.090693	-113.707035	The Hydrolab was deployed just upstream of where Stripe Rock Trail crosses North Fork Circle Creek. See the trail map of City of Rocks at http://www.nps.gov/ciro/planyourvisit/upload/CIRO-Trail-Map-11-24-10-4.pdf Stream is moderately incised with steep banks.	Uneven trail/2-track road on the hike in, rattlesnake encounters on trail and in riparian area, steep banks, potential encounters with cattle, and extremes in air temperature.
CIRO- SF Circle Creek WQ Station 001	42.077681	-113.707022	The Hydrolab was deployed just downstream of where Box Top Trail crosses South Fork Circle Creek. See the trail map of City of Rocks at http://www.nps.gov/ciro/planyourvisit/upload/CIRO-Trail-Map-11-24-10-4.pdf	Uneven trail on the hike in, potential rattlesnake encounters on trail and in riparian area, steep banks, and extremes in air temperature.
CIRO- Circle Creek WQ Station 001	42.076254	-113.680830	The Hydrolab was deployed ~150 m downstream of where Circle Creek flows under City of Rocks Road. Follow the equestrian trail to the east towards monitoring station. Stream is very incised with steep banks and sharp drop offs.	Traffic/parking along City of Rocks road, equestrian traffic on trail, uneven trail, very steep and potentially unstable banks, potential encounters with cattle, potential rattlesnake encounters on trail and in riparian area, and extremes in air temperature.
CIRO/CRSP- Almo Creek WQ Station 001	42.126794	-113.659879	The Hydrolab was deployed just to the North of the fence line North of the “ranch house”. Access is from the parking lot ~300m south of site.	Traffic along the road and in parking lot, uneven/rocky banks, and potential rattlesnake encounters on trail and in riparian area.

Field Site Descriptions/Hazards (continued)

Site ID	Lat.	Long.	General Description	Potential Hazards
CRMO- L.Cottonwood Creek WQ Station 001	43.48793970	-113.59347828	The Hydrolab was deployed 580 m upstream from where the 2-track road crosses the creek. The stream lies in a steep valley and is relatively high gradient.	Narrow 2-track road requires high clearance vehicle. If fire danger exists it is best to hike in from field station. Uneven terrain, must traverse steep hillside to access the stream, loose soil/substrate, potential rattlesnake encounters on trail and in riparian area, thick riparian vegetation, and extremes in air temperature.
JODA- Bridge Creek WQ Station 001	44.65517177	-120.25189075	The Hydrolab was deployed approximately 75 m downstream of the picnic area /visitor information kiosk.	Traffic in the parking lot, steep potentially unstable banks, potential rattlesnake encounters, and extreme heat midsummer.
JODA- John Day River WQ Station 001	44.56650180	-119.64642028	The Hydrolab was deployed approximately 1.6 km downstream of the Cant ranch house and approximately 200 m downstream of the first parking area north of the Cant ranch	Traffic in the parking lot and on highway, large cobble-boulder substrate in stream is difficult to traverse, potential rattlesnake encounters, extreme heat midsummer, and deep water/high flow during cross section survey.
NEPE- Jim Ford Creek WQ Station 001	46.35429603	-115.91867957	The Hydrolab was deployed approximately 200 m downstream of the bridge (Larson or Prairie Road) over Jim Ford Creek	Traffic along the county road, several downed fences are a tripping hazard, slick clay/hard pan substrate, biting mosquitoes, and a deep pool near the bridge.
NEPE- Lapwai Creek WQ Station 001	46.44935628	-116.81816423	The Hydrolab was deployed in this location in 2008 and 2011, approximately 100 meters downstream of the railroad bridge. The pool filled with substrate and channel shifted to the west. Station abandon in favor of station 002 below.	-
NEPE- Lapwai Creek WQ Station 002	46.45001602	-116.819499204	The Hydrolab was deployed approximately 175 m downstream of the railroad bridge. The pool is on the left bank. Best access is on the west side of the stream. Park near the “Green House.”	Traffic in the parking lot, very slick cobble substrate, potential rattlesnake encounters, ticks, extreme heat midsummer, and high flow in spring.
WHMI- Doan Creek WQ Station 001	46.044167	-118.463377	The Hydrolab was deployed approximately 100 m upstream from the mouth of Doan Creek.	Traffic in the parking lot, and ticks.
WHMI- Mill Creek WQ Station 001	46.04366488	-118.46517032	The Hydrolab was deployed approximately 150 m downstream from the railroad bridge/northern park boundary.	Traffic in the parking lot, ticks, poison ivy, thick black berry thickets in riparian area, high flow in spring.

Job Hazard Analysis

U.S. Department of Interior National Park Service	WORK PROJECT/ACTIVITY	LOCATION	UNIT
	UCBN Integrated Water Quality Monitoring	Upper Columbia Basin Network Parks	
JOB HAZARD ANALYSIS (JHA)	**DEVELOPED BY**	**JOB TITLE**	**DATE PREPARED**
	Eric Starkey	**Aquatic Biologist**	**9 April 2012**

APPROVED BY: DATE:

Required and/or Recommended Personal Protective Equipment:

RECOMMENDED

Bug spray	Polarized sunglasses
Compass / GPS Unit	Rope
Cotton gloves / wool gloves	Safety glasses
First Aid Kit	Shovel
Flashlight	Sturdy work boots
Forceps / vial	Sun hat
Life Preserver	Sunscreen
Maps	Survival kit
Neoprene gloves	Technu (poison oak/ ivy cleanser)
Park radio	Wading Belt
Personal water bottles	Warm clothing / hat

REQUIRED

Eye Protection (safety glasses or goggles)- while working with water chemistry standards

Felt sole (or similar) waders (chest, hip, neoprene)- when working in areas with coarse gravel.

Felt sole (or similar) wading boots-when working in areas with coarse gravel.

Latex gloves- while working with water chemistry standards.

Personal Flotation Device (PFD) – Life Jacket

First Aid Kit

TASKS/PROCEDURES	HAZARDS	ABATEMENT ACTIONS Engineering Controls* Substitution* Administrative Controls* Personal Protection Equipment
All Tasks and Procedures	**Unfamiliarity**	**All people (permanent, seasonal, VIPs) involved in any project should receive a general orientation and tailgate safety session specific to the task prior to beginning of work.**
1. Driving to and from remote field sites	1a. Narrow roads with bumpy or "washboard" surfaces	WEAR SEATBELTS AT ALL TIMES WHEN VEHICLE IS MOVING 1a. Maintain a safe speed (this may be below the legal speed limit) for the road conditions; stay clear to the right, especially on curves, drive with headlights on at all times; when turning around on mountain roads always "face the danger" (versus backing toward the cliff edge, e.g.); the passenger should get out and spot for driver when backing up.
	1b. Driving with limited visibility	1b. Maintain windshield cleaner fluid level and clean both sides of windows regularly (remember back window); slow down; if blinded by sun or dust, proceed slowly or pullover and wait for hazard to pass; keep to the right hand side of the road and drive with your lights on.
	1c. Sharp rocks on edge or in middle of road	1c. Get out and move sharp rocks out of the way, reduce speed substantially in places with large amounts of rockfall; make sure tires are properly inflated and check tread and walls regularly for damage; make sure tire jack fits the vehicle and all parts are in the vehicle.
	1d. Large animals crossing or standing in roads	1d. Slow down where animals might be present to allow for reaction time; do not swerve abruptly to avoid hitting an animal, if necessary it's better to ride out the impact.
	1e. Fatigue at night and after a long shift in the field	1e. Be aware of signs of fatigue- pull over and rest! Take a short nap, eat a snack or have a partner drive; do not take chances by continuing to drive; communicate with your field partner.
	1f. Storm conditions – wind, lightning, muddy/ slippery roads	1f. Keep informed on the current weather- check www.weather.com or www.wrh.noaa.gov; if winds exceed 15 mph, or the excessive wind category on Beaufort scale (tree tops swaying, twigs and leaves falling, etc.), do not travel into the field; avoid going to the field if lightning is present and avoid using radios; drive slowly when roads are muddy and slippery or snow covered, check with geologists if you are uncertain of back road conditions; avoid wet clay roads as much as possible, these roads can fail after storms, especially in spring, maintain a slow speed when driving on these roads!; if you damage waterbars make sure you repair them immediately.
	1g. Fallen trees on road	1g. For small trees, try and remove tree or cut with a handsaw and

		remove portion of tree; for large trees, notify support crew to remove tree.
	1h. Others driving on the road	1h. Do not assume you are the only one on the road behind locked gates (day or night), people from other agencies use these roads; be alert to the idea that others may be coming in from the field in the early a.m. - drive slow and keep right!; if you encounter an unusual situation, contact your partner to inform and notify the supervisor or park ranger- avoid confrontational situations with visitors- let the proper authorities handle it!
	1i. Dry vegetation on or near road	1i. Dry vegetation especially on 2-track roads has the potential to ignite from hot engines and exhaust. Pay attention to fire conditions and consult with park staff prior to driving on un-paved surfaces in the park. It is advisable to carry a fire extinguisher and in some locations (CRMO) also a backpack sprayer.
2. Check in with Park/Communication	2a. No one available in the park office	2a. Attempt to call park contacts using a phone or radio. If no one responds, check in with the UCBN supervisor/program manager to let them know you have arrived at your destination.
	2b. Unable to reach a radio repeater in a remote location	2b. Make sure radio is charged- try to contact someone on the radio to inform him/her of your predicament; if you are unable to reach a repeater from your location climb upslope toward a ridgetop or knoll and try again; try at regular intervals, meandering around may help in getting a signal; Use cell phone in vehicle (while stopped), as this may be more reliable for communication in remote locations.
3. Hiking	3a. Steep, rugged, and slippery terrain	3a. Assess terrain conditions to find safe route and modify sampling plans to avoid unsafe areas; proper footwear is VERY important- wear boots with slip-resistant soles with tops well above the ankle, broken in before the field season, plus wool socks, NO TENNIS SHOES; if wearing wading boots be cognizant that they are slippery on grass and mud, carry supplies in backpack, make sure pack is comfortable and secure, waist belt recommended; take care when walking on hardwood leaf litter and on wet ground; maintain an erect posture when contouring steep slopes; avoid walking below another person due to the potential for rocks to dislodge from above; Use caution when crossing large and/or wet logs and fences.
	3b. Undergrowth	3b. Wear safety glasses (or other glasses) when hiking in brushy areas to protect eyes from protruding objects.
	3c. Stream crossing	3c. Wear proper slip-resistant footwear and life jacket. Unfasten backpack hip belt before crossing. Cross streams only if you are sure they are safely wadeable. Cross in shallow relatively calm area with limited obstacles (boulders, logs, etc.). Use a walking stick or pole to balance and check for deep pools. Cross at a slight downstream angle to avoid fighting the current.
	3d. Fence crossing	3d. Fences may be crossed during the course of work. When possible use gates (leave them open or closed depending on how you find them) if no gate

		is available cross under or over with caution.
4. Encountering noxious plants, animals, disease, and people	4a. Poison ivy	4a. Make sure you can identify poison ivy in all its growth forms, foliage, bare twigs, and berries (the plant is toxic in winter when foliage is absent!); wear long sleeves; avoid sitting with arms resting on knees; use Technu lotion (or something similar) to prevent exposure; wash with soap immediately after returning from the field; bring an extra set of clothes and shoes to change into after coming out of field; wash field clothes separately from other laundry.
	4b. Bees/Wasps/Hornets	4b. Determine if any field crew are allergic to bee stings. Notify other crew members and the supervisor if you know you are allergic to bee stings; ensure that individual carries prescribed medication to prevent anaphylactic shock; carry a bee sting kit or Benadryl or other antihistamine; be aware of the ground where you step- some hornets build nests in the ground at the base of trees or shrubs, or in rotten logs- watch for bees buzzing in and out of holes or around ground level; if possible, flag a nest so future surveyors won't run into it.
	4c. Ticks	4c. If bitten by a tick, remove it (grasp tick with tweezers at head and pull straight out); fill out an accident report as soon as you remove the tick. In the event that symptoms of Lyme disease appear the accident report will be of assistance.
	4d. Scorpions	4d. Inspect items left lying on the ground, e.g., clothing, for scorpions prior to putting them on
	4e. Mosquitoes	4e. Wear bug repellent and long sleeve shirt to prevent bites; be aware of West Nile Virus symptoms.
	4f. Rattlesnakes	4f. Avoid rattlesnakes by inspecting the ground near logs before stepping over them; avoid placing hands on rock ledges or other natural hoists without visually inspecting them first; in the unlikely event you're bitten by a rattlesnake, stay calm, sit still, and call and wait for help.
	4g. Mountain lions	4g. Avoid mountain lions; if you encounter a lion that doesn't run from you- leave the area; if attacked- fight back!
	4h. Disease (bubonic plague and Hanta Virus)	4h. Stay away from dead rodents and rodent feces, especially in closed buildings.
	4i. Encounters with strangers	4i. Report uncomfortable encounters with strangers in the park to a supervisor as soon as possible; report apparent illegal activity to a park ranger, do not get into a confrontation with visitors in the park.
5. Exposure to environmental variables	5a. Treatment of general injuries	5a. All NPS field staff and contractors should have current first aid and CPR certification.
	5b. Hypothermia	5b. Always anticipate bad weather and dress accordingly, or carry warm clothes with you; always travel in pairs as a minimum; keep clothing as dry as possible; eat high energy nutritional supplements between meals; cover the head and neck to prevent heat loss; keep active to maintain the body's

		metabolism; drink plenty of liquids to prevent dehydration, although an individual does not “feel” thirsty; drink warm liquids not cold; understand the effects of cold and wind; most hypothermia cases develop between 30°F and 50°F. If someone falls in cold water they need to get dry and warm as soon as possible. If possible, leave the field quickly and get inside a heated vehicle or building. Cover the victim with blankets or sleeping bags. Call emergency services if necessary.
	5c. Hyperthermia	5c. Hyperthermia may occur during high temperatures, monitor for dehydration, heat exhaustion, heat cramps, and heat stroke; symptoms include nausea, headache, and flushed, red skin; drink plenty of cold/cool water (even when you are not thirsty); as heat increases, take frequent breaks in cool locations; wear a light shirt.
	5d. Giardia	5d. Giardia is caused by drinking contaminated water- carry plenty of water on outings; also carry water treatment tablets; consider all streams contaminated. Take care not to get stream water on your water bottle. Wash your hands before eating.
	5e. Sunburn	5e. Much of the work takes place in full sunlight (macroinvertebrate sampling, multiprobe installation/calibration, etc.) so to prevent sunburn, use 30+ or greater SFP sunscreen and lip balm; and wear a hat, sunglasses, and shirt.
6. General work in or near streams	6a. Working near unstable, steep, deep channels, swift flows.	6a. Reconnoiter to familiarize yourself with stream and adjacent reach; know the current and projected flow conditions from weather forecasts and stream gauge information; familiarize yourself with work area prior to fieldwork; review maps and aerial photos to determine access points, reference points, and potential evacuation points; develop evacuation plans for remote stream sites and make sure you leave a trip plan with supervisors (written plan is preferred).
	6b. Giardia	6b. Refer to 5d.
	6c. Sunburn	6c. Refer to 5e.
	6d. Undergrowth	6d. Refer to 3b.
7. Aquatic surveys, water quality sampling, macroinvertebrate sampling, habitat monitoring	7a. Wading/walking in and across streams and other aquatic areas	7a. Wear proper waders, felt-soled, chest or hip boots for conditions. When using waders, wear wading belt or similar. Purchase and use waders with felt soles or retrofitted with anti-slip devices. In cold weather, wear neoprene waders or wear warm, preferably polyester garments with standard waders. Use walking stick to improve stability in current. Walk slowly and carefully. Work in teams of two or more and within sight of one another. Cross-stream at shallow riffles, and avoid deep, swift areas. When wading in aquatic sites with deep, fine sediments, test fine sediment depths with wading rod before

		entering. Do not enter when fine sediment depths extend above knee Consult weather forecast each morning or call local observer to determine stream and flow conditions. Avoid wet logs and slippery rocks. **All people should be CPR and First Aid Certified.** Carry a means of communication (e.g., cell phone or radio).
	7b. Crossing debris jams	7b. Avoid crossing debris jams when possible. If there is no other route, determine the safest route along the creek; either climbing around on either side of the banks, or by going under and/or on top of the jam. When crossing you should be in sight of your coworkers in case anything should occur. Free both hands to assist with climbing jams. If crossing under and/or on top of the jam, be cognizant of its structural integrity. Walk or crawl on the larger key pieces/logs in the jam as smaller woody pieces are more prone to shift, break, or completely give way. Usually, the larger pieces are the most stable and structurally sound. The same is true for any handholds you may use when climbing the jam. If unsure, do not put all your weight on a piece at once, be slow and maintain your handholds if possible. Avoid slick wet logs without bark and if cold, be aware of ice that may be on their surfaces. DO NOT JUMP onto log pieces.
	7c. Drowning	7c. Wear proper protective/floatation gear (life vests, water repellent clothing) at all times; work in pairs or teams; consult flow gauge to determine stream safety level; it is advisable for those conducting aquatic work to be able to swim; if swept away, point feet downstream(to avoid rocks and other debris), swim towards the bank.
	7d. Hypothermia	7d. Refer to 5b.
	7e. Giardia	7e. Refer to 5d.
	7f. Sunburn	7f. Refer to 5e.
8. Calibration of water quality multiprobe	8.a Chemical exposure (burns, eye and skin irritation)	8a. Wear protective equipment including; gloves, eye protection, long sleeve shirt, pants, shoes. If exposure occurs, consult the Material Safety Data Sheet, which is located in the field safety notebook and box of water quality standards. Contact emergency personnel if required. It is advisable to wash hands after calibration of water quality multiprobe.
9. Fixing macroinvertebrate samples	9a. Alcohol spill	Pack 95% alcohol in container with appropriate absorptive material; to prevent fire clean spills immediately with appropriate absorptive material; avoid sources of ignition.
	9b. Eye and skin exposure	Rinse affected area with water; consult physician if necessary.

HA Instructions

The JHA shall identify the location of the work project or activity, the name of employee(s) involved in the process, the date(s) of acknowledgment, and the name of the appropriate supervisor approving the JHA. The supervisor acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity.

Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP).

Identify all known or suspect hazards associated with each respective task/procedure listed. For example:

a. Research past accidents/incidents.
b. Research the Health and Safety Code, or other appropriate literature.
c. Discuss the work project/activity with participants.
d. Observe the work project/activity.
e. A combination of the above.

Identify appropriate actions to reduce or eliminate the hazards identified. Abatement measures listed below are in the order of the preferred abatement method:

a. Engineering Controls (the most desirable method of abatement). For example, ergonomically designed tools, equipment, and Furniture.

b. Substitution. For example, switching to high flash point, non-toxic solvents.

c. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices.

d. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills, and portable water pumps).

e. A combination of the above.
Copy of the JHA as justification for purchase orders when procuring PPE.

Emergency Evacuation Instructions

Work supervisors and crewmembers are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a person(s) becomes seriously ill or injured at the worksite.

Be prepared to provide the following information:

a. Nature of the accident or injury (avoid using victim's name).
b. Type of assistance needed, if any (ground, air, or water evacuation).
c. Location of accident or injury, best access route into the worksite (road name/number), Identifiable ground/air landmarks.
d. Radio frequencies.
e. Contact person.
f. Local hazards to ground vehicles or aviation.
g. Weather conditions (wind speed & direction, visibility, temperature).
h. Topography.
i. Number of individuals to be transported.
j. Estimated weight of individuals for air/water evacuation.

The items listed above serve only as guidelines for the development of emergency evacuation procedures.

JHA and Emergency Evacuation Procedures Acknowledgment
We, the undersigned work leader and crewmembers, acknowledge participation in the development of this JHA (as applicable) and accompanying emergency evacuation procedures. We have thoroughly discussed and understand the provisions of each of these documents:

PRINT NAME	SIGNATURE	DATE
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Pacific West Region Inventory and Monitoring Program
Protocol Readiness Review Certification

Monitoring Protocol: Integrated Water Quality

Park and Network: Big Hole National Battlefield (BIHO), Upper Columbia Basin Network (UCBN)

Date: 05/29/2015

We confirm that the above named monitoring protocol has sufficient resources and support to implement with full consideration for safety, field logistics, and supervisory oversight. All relevant Inventory and Monitoring Program and park personnel have been informed of, understand, and concur with safety plans, procedures, and responsibilities, and will effectively communicate, supervise, and execute these measures through the Inventory and Monitoring Program, Inventory and Monitoring Network, and park lines of authority. Park staff and Inventory and Monitoring personnel have jointly identified the key groups and individuals that will contribute and participate to ensure safe implementation of the protocol.

Our Readiness Review assessed the following components of protocol implementation and safety:

- Operations planning and field logistics
- Training requirements
- Risk management
- Awareness of and consistency with park safety protocols and emergency procedures
- Supervisory oversight
- Communications

We certify that each above component has been fully addressed and will be properly implemented and supported prior to initiating and while conducting protocol field work (including pilot data collection or other field work before a protocol is finalized).

Signatures:

Park Superintendent	Name	Park/Network	Date
I&M Network Program Manager	Name	Park/Network	Date
		UCBN	
Protocol Field Supervisor/Manager	Name	Park/Network	Date

Copies of this certification must be provided to the I&M Network Board of Directors Chair and to the Regional I&M Program Manager. The signed original is retained by the I&M Network Program Manager.

Protocol/Field Work Readiness Review-Assessment Components
Supplement to Protocol Readiness Review Certification

Monitoring Protocol: Integrated Water Quality Monitoring

Park and Network: Big Hole National Battlefield (BIHO), Upper Columbia Basin Network (UCBN)

Date: 05/29/2015

Readiness Review Component Details
Describe how the protocol and implementation address the following:

- ***Operations planning and field logistics***

  A detailed field itinerary form will be submitted to the UCBN Program Manager and Park Contact at least one week prior to planned trip. The itinerary will include: a brief description of field work, dates of field work, transportation arrangements, primary and secondary park contact information, list of participants, detailed daily description of field work, location of field work, risk assessment, and items to be completed prior to field work. Signed field itinerary forms are posted on the UCBN server.

  Check in procedures with park staff are outlined in the field itinerary form. Standard UCBN procedure calls for check in with the park upon arrival and daily check in upon completion of field work each day (timing identified in the field itinerary form).

  Job Hazard Analysis forms are completed and sent to the parks prior to field work. These are also posted on the UCBN server.

  Integrated Water Quality Monitoring protocol SOP # 11 “Field Safety for Water Quality” lists the procedures for safety preparation prior to field work. Steps include:

  1. Completion and review of Job Hazard Analysis (JHA)
  2. Review and update emergency contact information
  3. Update and double check contents of Field Safety Notebook
  4. Completion of Medical Information for Office Personnel form
  5. Completion of CPR / First Aid Training
  6. Review all protective equipment to ensure it is in working order
  7. and present
  8. Check weather and stream conditions
  9. File a trip plan
     a) Notify park managers
     b) Leave plan with UCBN Program Manager and NPS staff

Supplement to Protocol Readiness Review Certification (continued)

- ***Training requirements***

  The approved UCBN Integrated Water Quality Monitoring protocol SOPs will serve as the training manual for water quality monitoring. See SOP #2 “Training Field Personnel” and SOP #11 “Field Safety for Water Quality”.

  In addition, daily tailgate safety meetings are held to address changing conditions.

  It is advisable that all UCBN staff in the field have recent CPR and first aid training.

  During initial check in with parks safety concerns and special conditions are discussed with park staff.

- ***Risk management***

  Job Hazard Analysis forms are completed and sent to the parks prior to field work. These are also posted on the UCBN server. Daily tailgate safety meetings are held to address changing conditions. During initial check in with parks safety concerns and special conditions are discussed with park staff.

  All participants are to understand that safety is our first priority.

  The UCBN aquatic biologist completed first aid and CPR training in Lewiston, ID in February 2015. In addition, the UCBN aquatic biologist also completed a GSA endorsed defensive driving course in 2011.

  Risks and risk mitigation are also discussed in SOP#11 field safety for water quality.

  As outlined in the UCBN water quality protocol, the field safety notebook contains the following:

  - UCBN - Field Safety for Water Quality Sampling SOP #11
  - Field Site Descriptions
  - Job Hazard Analysis (JHA) for each park to be sampled
  - Material Safety Data Sheets (MSDS) for chemicals
  - Emergency Contact Information
  - Emergency Evacuation Instructions
  - USGS Field Manual- Chapter 9 –Safety in Field Activities

Medical Information for Office Personnel

- ***Awareness of and consistency with park safety protocols and emergency procedures***

  The park is involved in the review of the UCBN field itinerary forms. Special safety protocols and emergency procedures are discussed at this time and during the initial check in with park staff.

- ***Supervisory oversight***

  Integrated water quality monitoring standard operating procedures have been peer reviewed and accepted for implementation. In addition, the UCBN program manager and park supervisory staff review all proposed field itineraries for activities to be completed in fulfillment of this protocol.

- ***Communications***

  Check in and out procedures are defined on the field itinerary form and are provided to park staff prior to field work. During UCBN integrated water quality monitoring the aquatic biologist will carry the UCBN issued cellular phone. The park will provide a radio and radio training to UCBN staff if deemed necessary by supervisory park staff. Use of a radio will be clearly identified on the itinerary form.

UCBN FIELD ITINERARY FORM

To be submitted to Program Manager and Park Contact at least one week prior to planned trip.

This form may contain confidential information and must be kept secure	
Field Crew Supervisor	Eric Starkey-UCBN Aquatic Biologist
Field Crew Leader	Eric Starkey
Monitoring Project etc	Water Quality Monitoring BIHO
Field work description	The water chemistry monitoring instrument will be serviced (data download and calibration) at BIHO in the North Fork Big Hole River. In addition, a cross section survey will be conducted to address representativeness of monitoring site.
Dates of field work	9/15/2015 to 9/17/2015
Transportation arrangements	Eric Starkey will drive from Moscow ID to BIHO in the UCBN's GSA rig (Black Jeep Grand Cherokee). Access to sample sites will be via foot from the lower parking lot.
What will be the contact arrangement with the Park contact?	**Primary contact person:** Mandi Wick **Phone number:** XXX-XXX-XXXX, after hours: XXX-XXX-XXXX **Frequency of contacts:** Pre-trip, on arrival in the park, when field work has been completed. **Instructions:** Check in should occur with Mandi in the visitor center. If Mandi and alternate contact cannot be reached, check in/out should occur in person with other park staff in the visitor center.
What shall UCBN staff do if no contact is made with primary contact?	**Alternate contact persons:** Jimmer Stevenson **Phone numbers:** XXX-XXXX, after hours: XXX-XXXX cell (limited coverage) XXX-XXXX **Instructions:** If Jimmer and primary contact cannot be reached, check in/out should occur in person with other park staff in the visitor center.
What shall park staff do if no contact is made with UCBN field crew?	If UCBN field crew has not made contact by 7:00 pm, the park contact should try to call field crew using cell phone(XXX-XXXX), respond to previous InReach locator beacon messages and/or radio transmission. If still no contact with field crew is made, park contact should call UCBN Program Manager (Gordon Dicus (cell): XXX-XXXX). Begin initiating search if no contact is made with field crew.

DETAILS OF PARTICIPANTS

NAME	**STATUS** **UCBN staff, UIdaho employee, student, volunteer**	**JOB HAZARD ANALYSIS ATTACHED?** **(Mandatory)**
Eric Starkey	UCBN Staff	Yes
Meghan Lonneker	U. Idaho Employee	Yes

UCBN FIELD ITINERARY FORM (continued)

ITINERARY DETAILS

DATE/TIMES	LOCATION	ACCOMMODATION	CONTACT DETAILS
Tuesday September 15th Departure: 8:30 AM (PST) Arrival: 4:30 PM (MST)	Travel from Moscow ID to BIHO via ID State Highway 12 (depending on fire activity). Alternate route is I-90.	BIHO housing	Eric can be contacted on the UCBN cell phone: XXX-XXXX Eric will check in with the BIHO park contact at the VC. In case of late arrival, check in will occur via text message from satellite locator beacon.
Wednesday September 16th 7:30 AM (MST) 10:30 AM (MST). 12:00 PM (MST) 12:30 PM (MST) 3:30 PM (MST) 5:00 PM (MST)	Safety meeting, calibration of water quality monitor ~150 m to the west of the lower parking lot. Measure for placement of cross section transects, last transect will end approximately 700 meters to the east of the lower parking lot and ~50m from the encampment trail. Lunch at picnic table in parking lot Water chemistry measurements along cross section transects (see above) Deployment of water quality monitor ~150 m to the west of the lower parking lot or movement to new location 100 m east of the lower parking lot. Return to park housing.	BIHO housing	Eric can be contacted on the UCBN cell phone: XXX-XXXX Eric will return to BIHO housing upon completion of work for the day and send a text message from satellite locator beacon.
Thursday September 17th 8:00 AM (MST) Departure: 8:00 AM (MST) Arrival: ~4:00 PM (PST)	Drive back to Moscow via ID State Highway 12 and unload gear at office.		Eric can be contacted on the UCBN cell phone: XXX-XXXX Eric will check out with BIHO park contact (Mandi or Jimmer).

UCBN FIELD ITINERARY FORM (continued)

RISK ASSESSMENT

FIELD WORK ACTIVITY	POTENTIAL HAZARD What might harm you?	RISK RATING (Extreme, High, Medium, Low)	CONTROLS What are you going to do to make this activity as safe as possible?	PERSON WHO WILL ENSURE THIS HAPPENS
Water Quality Monitoring	See WQ JHA	Low	Daily communication with park contact, proper preparation of safety gear and equipment prior to fieldwork. Changes to field itinerary will be communicated with park contact. Park radio/cell contact for serious emergencies.	Eric Starkey
See attached JHA for activities and hazards				

ITEMS THAT WILL BE COMPLETED PRIOR TO THE FIELD WORK

	Tick as appropriate
Participants briefed on details of proposed field work; relevant safety policies, procedures and expected conduct while in the field	X
Job Hazard Analysis signed by all participants	X
All equipment, vehicles and tools will be checked for safety compliance prior to field work commencing	X
I have made the necessary provisions for emergency situations such as the appropriate level of first aid, emergency contact telephone numbers; e.g., helicopter rescue, police, fire, etc	X
I have checked with participants whether they have any medical conditions that should be disclosed	X
I have checked that appropriate licenses, permits and agreements with have been obtained and are up to date for the use of specialized equipment such as boats.	X

UCBN FIELD ITINERARY FORM (continued)

PEOPLE RESPONSIBLE FOR SUBMISSION AND APPROVAL

NAME	SIGNATURE	DATE
Field Work Supervisor		
Field Crew Leader		
Program Manager Based upon the information in the above Field Itinerary Plan: □ Approve XX □ Do not approve □ Grant conditional approval		
Park Superintendent Based upon the information in the above Field Itinerary Plan: □ Approve □ Do not approve □ Grant conditional approval		
Primary Park Contact		
Conditions of approval, if relevant		
NOTE:- • A copy of this Field Itinerary Plan and associated Job Hazard Analysis forms are filed in the UCBN Moscow office. • Copies of all volunteer forms are filed in the UCBN Moscow office.		

Official Vehicle Travel Checklist

No.	CHECKLIST ITEM	YES	NO	N/A
1.	Has the traveler planned the trip to include rest stops and overnight stays?			
2.	Has the traveler checked the weather forecast for the intended route and planned accordingly?			
3.	Has the traveler been briefed to not drive more than 10 hours in a 24-hour period? (note 1 & 2)			
4.	Have you briefed the traveler on the need to get at least 8 hours of rest prior to departure?			
5.	Have you discouraged the traveler from driving during late hours unless mission dictates?			
6	Have you stressed the importance of obeying speed limits and wearing seatbelts?			
7.	Have you briefed the traveler to inspect the vehicle prior to departure? (note 3)			
8.	Have you discussed the results of the risk assessment required prior to multi-day trips? (note 4)			
9.	Does the traveler have a cell phone and in-car charger, and is s/he aware that texting is prohibited while driving while on official Government business? (note 5)			
10.	Does the traveler have the appropriate phone numbers in case of an emergency?			
11.	Does the traveler have maps that cover the planned route?			
12.	Is the vehicle equipped with an emergency kit? (note 6)			

Notes

1. *If traveler has worked any portion of their shift prior to departure, time worked must be added to driving time to equal a maximum of 10 hours.*
2. *Traveler can exceed 10 hour driving time if an emergency situation necessitates and only after s/he receives written approval from a supervisor.*
3. *The following items shall be inspected prior to departure:*
   a) All fluids (fuel, coolant, windshield washer fluid, oil, brake fluid, power steering fluid, and transmission fluid)
   b) All lights
   c) Tires to include spare (tread depth, air pressure, and overall condition)
   d) Jack and necessary equipment to change tire
   e) Windshield wipers
   f) Horn

1. *Risk assessment (e.g. Operational Leadership Green/Amber/Red or Severity/Probability/Exposure analysis).*
2. *Texting is prohibited by Presidential Proclamation 8610. It is recommended that the traveler use a cell phone only when stopped; however, if this is not possible, a hands-free device will be used.*
3. *Emergency kit should contain:*
   a) Water
   b) Food (energy bars, etc.)
   c) Blanket(s)
   d) Road flares
   e) Flashlight
   f) First aid kit
   g) Candle (matches or lighter)
   h) Jumper cables
   i) Any other item the traveler or supervisor deems necessary

_____ _____

Supervisor's Signature Traveler's Signature

Appendix F. Datasheets

*Note that it is best to print datasheets from the files located on the UCBN file server.

UCBN Multiprobe Calibration and Maintenance Log

UCBN Multiprobe Calibration/Maintenance Log

Park abbreviation_____ **Stream**_____ **Site ID**_____ **Multiprobe Number** _____

Monitor Inspected By_____ **Date (mm/dd/yyyy)**_____ **Time**_____**(MST / PST)**

Gage Ht_____ **(Rising, Falling, Steady, Peak)** **Channel Conditions**_____

Monitor Make/Model_____ **Monitor Serial No.**_____

Field Meter Make/Model_____ **Field Meter Serial No.**_____

Weather Cold Cool Warm Hot Rain Mist Sleet Snow Humid Dry Cloudy Pt Cloudy Overcast Clear Windy Gusty Breeze Calm

Comments:

Data Download

Did you download data from the past deployment? Y N

Log file name:_____ including site name, begin and end date (YYYYMMDD)
i.e. WHMI_Mill_20080422_20080520

Ending Battery _____volts _____% Remaining

Multiprobe Fouling Checks

	Before Cleaning Time_____		After Cleaning Time_____	
Parameter	Recorded/Live Monitor Reading	Field Meter Reading	Recorded/Live Monitor Reading	Field Meter Reading
Temp (°C)				
SC (µS/cm)				
DO (mg/L, % Sat)	%Sat / mg/L; D.O. Table mg/l	%Sat / mg/L; D.O. Table mg/l	%Sat / mg/L; D.O. Table mg/l	%Sat / mg/L; D.O. Table mg/l
	Water Temperature °C	Barometric Pressure mmHg	Water Temperature °C	Barometric Pressure mmHg
pH (units)				
Turbidity (NTU FNU)				

Calibration Drift Checks

Temperature Calibration Criteria > ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.	Recorded/Live Monitor Reading Time _____	Field Meter or NIST Reading Time _____	Difference Monitor – Field Meter or Thermometer	Field Meter 2-pt check Date_____

Comments:

Specific Conductance Calibration Criteria ± 5 µS/cm or ± 3%				Calibration Check Time _____			Recalibration Time _____		
Standard Value	Standard Lot No.	Standard Type KCl; NaCl	Expiration Date	Standard Temp.°C	SC Reading µS/cm	%Error	Standard Temp.°C	SC Reading µS/cm	%Error

Reading in air =
(should be zero)

Comments:

Page 1 of 4

Last updated on: 10/14/2010

Dissolved Oxygen Calibration Criteria > ± 0.3 mg/L			Calibration Check Time _____				Recalibration Time _____						
Temp °C	Barometric Pressure mm Hg	DO Table Reading mg/L	Salinity Corr. Factor	DO Reading	Error %	Reading in zero DO solution	Temp °C	Barometric Pressure mm Hg	DO Table Reading mg/L	Salinity Corr. Factor	DO Reading	Error %	Reading in zero DO solution
				%Sat							%Sat		
				mg/L							mg/L		

Altitude:	Salinity:	Salinity correction applied? Y N	DO Charge: (Clark cell sensor)	DO Gain: (Clark cell sensor)	Date Barometer Calibrated:

Comments:	Did you use a handheld barometer or a weather station to determine barometric pressure? (circle one) **Handheld** **Weather Station**_____ (location)

pH Calibration Criteria >0.2 pH units				Calibration Check Time _____			Recalibration Time _____				
pH Buffer	Theoretical pH from Table on Cal. Stand.	Buffer Lot No.	Buffer Expiration Date	Temp °C	pH Reading	Error %	Temp °C	pH Reading	Error %	Slope	Millivolts
pH 7											
pH___											
pH___											

Comments:

Turbidity Calibration Criteria: The greater of 0.5 TU or ± 5%				Calibration Check Time _____			Recalibration Time _____		
Stock Turbidity Standard	Lot no.	Exp. Date	Concentration	Temp °C	Reading (NTU/FNU)	Error %	Temp °C	Reading (NTU/FNU)	Error %
Zero Standard or <0.1 NTU									
Standard 1									
Standard 2									
Standard 3									

Turbidity Sensor Limits:	Comments:

Final Readings In Stream / Standard Solution		**Time**_____
Parameter	Recorded/Live Monitor Reading	Field Meter Reading/Standard Value
Temp (°C)		
SC (µS/cm)		
DO (% Sat. and mg/L)	% Sat. mg/L	D.O. Table mg/l
Barometric Pressure (mmHg)		
pH (units)		
Turbidity (NTU FNU)		

Last updated on: 10/14/2010

Maintenance Record For Multiprobe

Sensors cleaned?	Yes No	**Fouling Presence: Record type of fouling AND amount (e.g. A, E, / H)** Type: A = algae, E = eggs, F = fish, S=sediment, O = other, N = none / Amount: H = heavy, M = moderate, L = light, N = none Sonde / Guard _____ DO Probe_____ External Screen_____ pH Probe_____ Temp / Cond_____ Turbidity_____		
Sensors changed?	Temp	Yes	No	Sensor ID_____
	SC	Yes	No	Sensor ID_____
	DO	Yes	No	Sensor ID_____
	pH	Yes	No	Sensor ID_____
	Turbidity	Yes	No	Sensor ID_____
	Sonde changed?	Yes	No	New Sonde No._____ Old Sonde No._____
pH Teflon junction changed?		Yes	No	Type of fouling_____
pH reference electrolyte changed?		Yes	No	
LDO cap changed?		Yes	No	Type of fouling_____
Lubricate O-rings?		Yes	No	
Changed O-rings?		Yes	No	
Wiper Parks 180 deg from Optics?		Yes	No	
Wiper replaced?		Yes	No	Type of fouling_____
Clock Set		Yes	No	
Battery changed prior to deployment?		Yes	No	_____volts _____% Remaining

Deployment

Name of the new log file:_____(i.e. WHMI_Mill_20080521)

Time of deployment: _____

Housing Locked?	Yes	No
Security Cable Locked?	Yes	No

Field Meter

	Make/Model	Serial No.	Correction Factor Applied?
Multiprobe/Sonde/Meter			None Yes No
Temp			None Yes No
Conductivity			None Yes No
pH			None Yes No
DO			None Yes No
Turbidity			None Yes No
Other			None Yes No

Comments/Observations:

UCBN Office: 208-885-3010 or 208-885-3684
HACH Technical Assistance 1-800-949-3766

Last updated on: 10/14/2010

Useful Equations

$$\%\ \boldsymbol{Error} = \left(\frac{\boldsymbol{Reading - Standard\ Value}}{\boldsymbol{Standard\ Value}}\right) \times \mathbf{100}$$

To determine the current barometric pressure in mmHg record the current absolute (ABS) barometric pressure from the handheld barometer (inHg). Then divide by the constant 0.0393701.

$$\frac{\boldsymbol{ABS}\ \text{inHg}}{\mathbf{0.0393701}} = \boldsymbol{ABS}\ \text{mmHg}$$

If no barometer is available check the nearest weather station (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/) for barometric pressure in mbar. You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

Weather stations report a corrected barometric pressure, barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5\left(\frac{A_{ft}}{100}\right)$$

Where:
BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

Last updated on: 10/14/2010

UCBN Cross Section Survey Form

UCBN Cross-Section Survey Form

Park abbreviation:	Survey Date (mm/dd/yyyy):	UCBN Staff (Initials):
Stream:	Proposed Multiprobe Site: Lat._____ Long._____	
Method: Modified Equal-width increments (EWI) Other_____ No. of Verticals_____		
Mean wetted width _____ m	Survey Site Length (mean wetted width X 40) _____ m	
Distance between transects _____ m (Site length /3)		
Stream Mixing: Excellent Good Fair Poor		
Comments:		

Proposed Multiprobe Site

Allow the sonde to run for 10 min at the proposed site. Record the parameters values each minute.

Record #	Time	m from left bank	Total depth m	Depth of Measurement m (50% total depth)	Temp °C	pH Units	Cond. µS/cm	D.O. mg/L	Turbidity NTU
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Transect 1 *0 m* upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width = m

Station	Time	m from left bank	Total depth m	Depth of Measurement m (50% total depth)	Temp °C	pH Units	Cond. µS/cm	D.O. mg/L	Turbidity NTU
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Page **1** of **4**

UCBN Cross-Section Survey Form

Transect 2_____ m upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width =		m							
Station	**Time**	**m from left bank**	**Total depth m**	**Depth of Measurement m (50% total depth)**	**Temp °C**	**pH Units**	**Cond. µS/cm**	**D.O. mg/L**	**Turbidity NTU**
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Transect 3_____ m upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width =		m							
Station	**Time**	**m from left bank**	**Total depth m**	**Depth of Measurement m (50% total depth)**	**Temp °C**	**pH Units**	**Cond. µS/cm**	**D.O. mg/L**	**Turbidity NTU**
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

UCBN Cross-Section Survey Form

Transect 4_____ m upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width = **m**

Station	Time	m from left bank	Total depth m	Depth of Measurement m (50% total depth)	Temp °C	pH Units	Cond. µS/cm	D.O. mg/L	Turbidity NTU
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Cross-Section Comparison At _____**cfs**

(Use if a USGS gauge is available or if discharge is measured. If no gauge or discharge measure is available use the WRD Flow Severity definitions listed below)

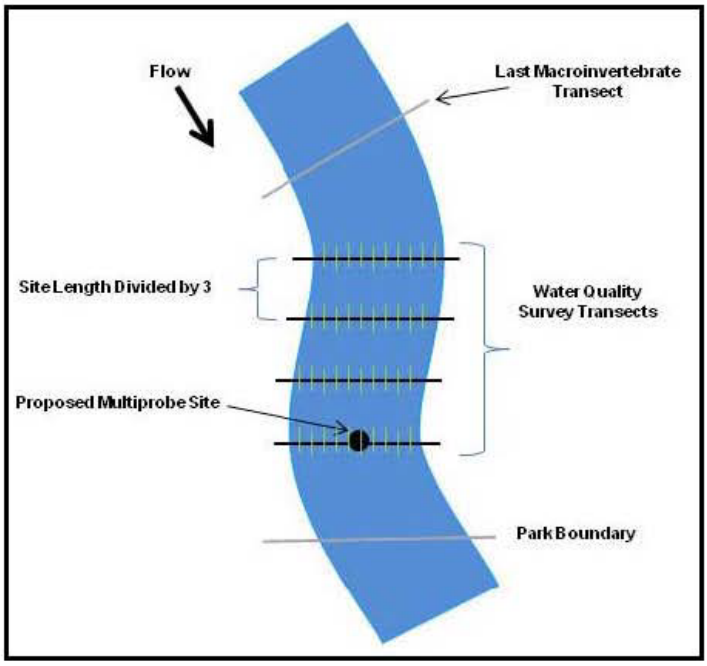
Flow Severity: **Dry** **No Flow** **Low** **Normal** **Above Normal** **Flood**

Based on statistical comparison is the sonde location representative of conditions throughout the cross section?*

Yes / No

UCBN Cross-Section Survey Form

General Survey Design



Notes:_____

Project Data Certification Form. Page 1 of 2

Version 1.0, December 2007

Introduction

Data certification is a benchmark in the project information management process that indicates the data:

- are complete for the period of record;
- have undergone and passed the quality assurance checks;
- are appropriately documented, including identification of sensitive information; and
- are in a condition for archiving, posting and distribution as appropriate.

Certification is not intended to imply that the data are completely free of errors or inconsistencies which may or may not have been detected during quality assurance reviews.

All UCBN products (databases, maps, reports, etc.) are required to be accompanied by an up-to-date product certification form so that the UCBN data manager can ensure that the data has been certified.

Project Data Certification Form Page 2 of 2

Certification date:	Certified by:
Range of dates for certified data:	Title:
Project code:	Affiliation:
Project title:	

Description and scope of data being certified:

List the applicable parks and provide any park-specific details about this certification.

Park:	Details:

This certification refers to data in accompanying files. Check all that apply and indicate the file name(s).

- ❑ Database file(s) _____
- ❑ Spatial data theme(s) _____
- ❑ Geodatabase file(s) _____
- ❑ Excel file(s) _____
- ❑ Other (specify) _____

- ❑ Certified data are already in the master version of a park, UCBN or NPS database. Indicate the database system(s): _____

Is there any **sensitive** information in the certified data which may put resources at greater risk if released to the public (e.g., rare plant or animal locations, cave locations, etc)?

- ❑ Yes Details: _____
- ❑ No _____

Description of data processing and quality assurance measures.
(Note: These can be cut and pasted from appropriate sections of the protocol.)

Results and summary of quality assurance reviews, including details on steps taken to rectify problems encountered during data processing and quality reviews.

UCBN Integrated Water Quality Season Closeout Checklist

Project Lead: _____ Monitoring Year: _____

Parks Involved: _____

Checklist Submitted to Network Coordinator and Data Manager on: _____ (mm/dd/yyyy)

Deliverable Product	Notes:	Completion Date
Tabular Data		
Data entry completed?		
Data quality verified?	Describe verification procedures (attach pages as needed)	
Certified data submitted?	This includes: ☐ Macroinvertebrate Lab Results ☐ Raw multiprobe log files (archived on NAS/Server) ☐ Aquarius corrected data (Aquarius output-Excel file) ☐ Site inspection summary worksheets (electronic format) ☐ Final Aquarius workstation file (Aquarius workflow file used in Aquarius only) ☐ All QA/QC Information for each parameter o MDL o AMS o AMS+ o RPD/Precision+	
Copies of field data forms submitted?	This includes: ☐ Multiprobe Calibration/Maintenance Log forms ☐ Cross Section Survey form ☐ Macroinvertebrate Site Verification/Establishment forms ☐ Macroinvertebrate Sample Collection Form ☐ Macroinvertebrate Sample Shipment/Tracking form	
Spatial Data		
Waypoints submitted?	This includes: ☐ Multiprobe station ☐ All X-site locations	
New GIS maps submitted?	Describe GIS layers (attach pages as needed)	
GIS metadata submitted?	Notes on metadata (attach pages as needed)	
Photos		
All monitoring photos posted on NAS or server and properly named?	This includes: ☐ Photo of Left and Right Bank for each X-Site ☐ Photo of Up and Down Stream for each X-Site ☐ Photo of each multiprobe station ☐ Other photos of each stream	

UCBN Integrated Water Quality Season Closeout Checklist

Reporting		
Revised Protocol/SOPs submitted?	Describe revisions (attach pages as needed)	
Annual report submitted?	Entered review process on: _____(date)	
Resource briefs submitted?	Sent to parks for peer review? Y / N	
Has the above information been posted on the website?		
Data Storage		
Creation of annual folder on NAS or Server?	This folder should include all of the electronic files mentioned above. Location (describe folder name/path on NAS or Server: (should be in the "Close" folder)	
Next-year project preparation files		
GIS files submitted	This includes sample point locations, sampling frames etc. (if applicable)	
Field data forms	Hardcopy or digital field forms for next field season	

Notes on documenting that submitted products have been certified by Project leader:

A Project Data Certification Form (available from appendix F of the UCBN Data Management Plan, or from the UCBN data manager) should be completed and included with any submission of a database file, a spreadsheet file (if project does not have a dedicated database application), a GIS file, and a project report if the report contains sensitive information (i.e., information that may put NPS resources at greater risk if released to the public).

NOTES on data certification; on changes to data collection/entry procedures; on database needs; etc.
Describe issues important to the collection, processing, and certification of project data. This may include descriptions of specific data certification procedures, or needed changes to data collection and/or data entry processes, or needed changes to the project database. (Attach pages as needed)

Appendix G. Data Dictionary

This data dictionary provides a description for every table in the database back-end file, and for each table, lists the field names and their associated field type, size, and description.

Table: *tbl_Sites*

Description: A site is a park unit.

Field Name	Type	Format	Description
Site_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each tbl_Sites record
GIS_Location_ID	Short text	Up to 50 characters	Link to GIS feature, if applicable
Unit_Code	Short text	Up to 12 characters	Park unit code
Site_Name	Short text	Up to 100 characters	Park Name
Site_Description	Short text	Up to 255 characters	Description for a site, if applicable
Site_Notes	Long text	Up to 255 characters	General notes on the site, if applicable

Table: *tbl_Locations*

Description: A location is a water body sampled.

Field Name	Type	Format	Description
Location_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each tbl_Locations record
Site_ID	Short text	Up to 50 characters	Link to tbl_Sites (foreign key)
Loc_Name	Short text	Up to 100 characters	Name of water body sampled
Loc_Type	Short text	Up to 25 characters	Type of water body sampled
Loc_Notes	Short text	Up to 255 characters	General notes on the location, if applicable

Appendix G. Data Dictionary (continued)

Table: ***tbl_stations***

Description: A station is a location to be sampled.

Field Name	Type	Format	Description
Station_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each tbl_Stations record
Location_ID	Short text	Up to 50 characters	Link to tbl_Locations (foreign key)
GIS_Location_ID	Short text	Up to 50 characters	Link to GIS feature, if applicable
Sta_Name	Short text	Up to 100 characters	-
X_Coord	Double	Decimal	X coordinate of Plot
Y_Coord	Double	Decimal	Y coordinate of Plot
UTM_Zone	Short text	Up to 50 characters	UTM Zone (e.g., 11N)
Datum	Short text	Up to 50 characters	Datum of mapping ellipsoid (e.g., NAD83)
Est_H_Error	Integer	Single	Estimated horizontal accuracy in meters
Loc_Notes	Lone text	Up to 255 characters	General notes on the location, if applicable

Appendix G. Data Dictionary (continued)

Table: *tbl_Events*

Description: An Event is a sampling occurrence at a station (site visit).

Field Name	Type	Format	Description
Event_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each tbl_Events record
Station_ID	Short text	Up to 50 characters	Link to tbl_Stations (foreign key)
Protocol_Name	Short text	Up to 100 characters	The Protocol version in use at time of Event
Start_Date	Date/Time	mm/dd/yyyy	Starting date for the event
Start_Time	Date/Time	24 HR time	Starting Time for the event
Time_Zone	Short text	Up to 255 characters	Time Zone (pst, pdt, mst, mdt)
Inspector	Short text	Up to 255 characters	Person who inspected monitor
Download	Yes/No	True/False	Was the data from the past deployment downloaded?
File_Name	Short text	Up to 75 characters	Name of log file downloaded
Battery	Double	Decimal	Battery Level in volts
Remaining	Long Integer	Numeric	Percentage of battery left
Entered_by	Short text	Up to 255 characters	Person entering data
Entered_date	Date/Time	mm/dd/yyyy	Date data was entered
Updated_by	Short text	Up to 50 characters	Person updating data
Updated_date	Date/Time	mm/dd/yyyy	Date date was updated
Verified_by	Short text	Up to 50 characters	Person verifying data
Verified_date	Date	mm/dd/yyyy	Date data was verified
Verified	Yes/No	True/False	To show if data was verified
Certified_by	Short text	Up to 255 characters	Person certifying data
Certified_date	Date	mm/dd/yyyy	Date data was certified
Certified	Yes/No	True/False	To show if data was certified
CS	Yes/No	True/False	Cross Section Survey Event
PD	Yes/No	True/False	Pre-deployment Event
MC	Yes/No	True/False	Calibration Maintenance Event

Appendix G. Data Dictionary (continued)

Table: ***tbl_Event_Details***

Description: Detailed information about sampling events (site visit).

Field Name	Type	Format	Description
Event_ID	Short Text	Up to 50 characters	Primary key, uniquely identifying each tbl_Event record
Probe_Number	Short text	Up to 50 characters	Multi-probe number of instrument being calibrated
Gage_ht	Long Integer	Numeric	Gage ht, Rising, Falling, Steady, Peak
Gage_Level	Short text	Up to 10 characters	Level of the water at the gage location
Channel_Condition	Short text	Up to 100 characters	Channel conditions at the probe location
Monitor_model	Short text	Up to 255 characters	The monitor make/model of the instrument being calibrated
Monitor_serial	Short Text	Up to 255 characters	The serial number of the instrument being calibrated
Field_Meter_Model	Short text	Up to 50 characters	The field meter make/model
Field_Meter_Serial	Short text	Up to 50 characters	The serial number of the field meter
Temp	Short text	Up to 5 characters	Approximate temperature for event
Precip	Short text	Up to 5 characters	Approximate precipitation for event
Moisture	Short text	Up to 5 characters	Approximate moisture cover for event
Cloud_Cover	Short text	Up to 10 characters	Approximate cloud cover for event
Wind	Short text	Up to 10 characters	Approximate wind speed for event
Comments	Short text	Up to 255 characters	Comments about the calibration event
Event_Notes	Long text	Up to 255 characters	General notes on the site, if applicable

Appendix G. Data Dictionary (continued)

Table: *tbl_Maintenance*

Description: Detailed information about maintenance of probe and sensor, recorded during site visit or pre deployment.

Field Name	Type	Format	Description
Maint_ID	Short Text	Up to 50 characters	Primary key, uniquely identifying each Maintenance record
Event_ID	Short text	Up to 50 characters	Link to tbl_Events (foreign key)
Cleaned	Short Text	Up to 3 characters	Were the sensors cleaned?
Sonde	Yes/No	True/False	Was the sonde changed?
pH_Teflon	Yes/No	True/False	pH Teflon junction changed?
pH_Teflon_Fouling	Short text	Up to 50 characters	Type of fouling of the pH Teflon junction
pH_Ref	Yes/No	True/False	pH reference electrolyte changed?
LDO	Yes/No	True/False	LDO cap changed?
LDO_Fouling	Short text	Up to 50 characters	Type of fouling of the LDO
Lubricate_O	Yes/No	True/False	Lubricate O-rings?
Change_O	Yes/No	True/False	Changed O-rings?
Wiper_Parks	Yes/No	True/False	Wiper Parks 180 degrees from optics?
Wiper	Yes/No	True/False	Wiper replaced?
Wiper_Fouling	Short text	Up to 50 characters	Type of fouling of the Wiper
Clock	Yes/No	True/False	Clock set?
Battery	Yes/No	True/False	Battery changed prior to deployment?
Volts	Double	Decimal	Ending battery level in volts
Remaining	Long Integer	Numeric	Percent remaining in battery
File_Name	Short Text	Up to 75 characters	Name of new log file
Time	Short Text	Up to 255 characters	Time of deployment
Housing	Yes/No	True/False	Housing locked?
Security_Cable	Yes/No	True/False	Security cable locked?
TimeZone	Short text	Up to 255 characters	PDT, MDT, PST, MST
Comments	Short text	Up to 75 characters	Comments about the maintenance record

Appendix G. Data Dictionary (continued)

Table: ***tbl_Sensor_record***

Description: Records sensor and probe type and serial numbers from the deployed multiprobe.

Field Name	Type	Format	Description
Sensor_Record_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each tbl_Sensor_record
Maint_ID	Short text	Up to 50 characters	Link to tbl_Maintenance (foreign key)
Sensor_Type	Short text	Up to 255 characters	Sensor type changed out (ph, DO, SC, Turb)
Sensor_Serial	Short text	Up to 255 characters	Monitor/multiprobe SENSORS serial numbers
Probe_Serial	Short text	Up to 255 characters	Serial number for multiprobe/monitor serial number
Field_or_Monitor	Short text	Up to 255 characters	Whether or not this serial number is for the field meter or for the monitor

Table: ***tbl_Field_Meter_Record***

Description: Records sensor and probe type and serial numbers from the field meter.

Field Name	Type	Format	Description
Field_Meter_Record_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each tbl_Sensor_record
Maint_ID	Short text	Up to 50 characters	Link to tbl_Maintenance (foreign key)
Sensor_Type	Short text	Up to 255 characters	Sensor type changed out (ph, DO, SC, Turb)
Sensor_Serial	Short text	Up to 255 characters	Monitor/multiprobe SENSORS serial numbers
Probe_Serial	Short text	Up to 255 characters	Serial number for multiprobe/monitor serial number
Field_or_Monitor	Short text	Up to 255 characters	Whether or not this serial number is for the field meter or for the monitor

Appendix G. Data Dictionary (continued)

Table: *tbl_Fouling_Presence*

Description: Records type and amount of fouling on sensors on the deployed multiprobe.

Field Name	Type	Format	Description
Fouling_Presence_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Fouling_Presence_ID
Maint_ID	Short text	Up to 50 characters	Link to tbl_Maintenance (foreign key)
Sensor	Short text	Up to 50 characters	Sensor type checked for fouling
Type	Short text	Up to 3 characters	Type of fouling
Amount	Short text	Up to 3 characters	Amount of fouling

Table: *tbl_Calibration_SpCond*

Description: Records calibration data for specific conductance.

Field Name	Type	Format	Description
SpCond_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each SpCond_ID
Event_ID	Short text	Up to 50 characters	Link to tbl_Event (foreign key)
Standard_Value	Double	Decimal	Standard value
Standard_Lot	Short text	Up to 25 characters	Standard lot number
Standard_Type	Short text	Up to 255 characters	Standard type, i.e. KCl, NaCl
Expir_Date	Date/Time	mm/dd/yyyy	Expiration date
Air_Reading	Double	Decimal	Reading in the air, should be 0
Comments	Short text	Up to 255 characters	Specific conduction calibration notes

Appendix G. Data Dictionary (continued)

Table: *tbl_Calibration_pH*

Description: Records calibration data for pH.

Field Name	Type	Format	Description
pH_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each pH_ID
Event_ID	Short text	Up to 50 characters	Link to tbl_Event (foreign key)
pH_Buffer	Short text	Up to 10 characters	The pH buffer
Buffer_Lot	Short text	Up to 25 characters	Buffer lot number
Expir_Date	Date/Time	mm/dd/yyyy	Expiration date
Comments	Short text	Up to 255 characters	pH calibration notes

Table: *tbl_Calibration_DO*

Description: Records calibration data for dissolved oxygen.

Field Name	Type	Format	Description
DO_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each DO_ID
Event_ID	Short text	Up to 50 characters	Link to tbl_Event (foreign key)
Altitude	Double	Decimal	Altitude at the location of the probe
Salinity	Double	Decimal	Salinity at the location of the probe
Salinity_Correct	Yes/No	True/False	Was salinity correction applied?
DO_Charge	Double	Decimal	Dissolved oxygen charge (Clark cell sensor)
DO_Gain	Double	Decimal	Dissolved oxygen gain (Clark cell sensor)
Date_Cal	Date/Time	mm/dd/yyyy	Date the barometer calibrated
Type	Short text	Up to 25 characters	Was a handheld barometer or a weather station used to determine barometric pressure?
Weather_Sta	Short text	Up to 255 characters	Weather station location if used to determine barometric pressure
Comments	Short text	Up to 255 characters	Specific conduction calibration notes

Appendix G. Data Dictionary (continued)

Table: *tbl_Calibration_Turbidity*

Description: Records calibration data for turbidity.

Field Name	Type	Format	Description
Turbidity_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Turbidity_ID
Event_ID	Short text	Up to 50 characters	Link to tbl_Event (foreign key)
Standard	Short text	Up to 50 characters	Stock turbidity standard
Lot	Short text	Up to 50 characters	Lot number
Expir_Date	Date/Time	True/False	Stock turbidity standard expiration date
Concentration	Double	Decimal	Concentration of the stock turbidity standard
Sensor_Limits	Short text	Up to 255 characters	Turbidity sensor limits
Comments	Short text	Up to 255 characters	Turbidity calibration notes

Table: *tbl_Calibration_Temp*

Description: Records calibration data for temperature.

Field Name	Type	Format	Description
Temp_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Temp_ID
Event_ID	Short text	Up to 50 characters	Link to tbl_Event (foreign key)
Monitor_Time	Date/Time	hh:mm	Recorded/live monitor reading time.
Monitor_Value	Double	Decimal	Recorded/live monitor reading value.
Meter_Type	Short text	Up to 25 characters	Was another field meter or a NIST thermometer used for calibration?
Meter_Time	Date/Time	hh:mm	Field meter or NIST reading time.
Meter_Value	Double	Decimal	Field meter or NIST reading value.
Difference	Double	Decimal	Difference of live monitor reading minus field meter or thermometer.
Meter_Date	Date/Time	mm/dd/yyyy	Field meter 2-pt check date.

Appendix G. Data Dictionary (continued)

Table: ***tbl_Readings_SpCond.***

Description: Records calibration data for specific conductance.

Field Name	Type	Format	Description
SpCond_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each SpCond_Measure_ID
SpCond_ID	Short text	Up to 50 characters	Link to tbl_Calibration_Sp_Cond (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Standard temperature in degrees Celsius
SpCond_Reading	Double	Decimal	Specific conductance reading in Micro-Siemens (µS/cm)
Difference	Double	Decimal	Percent difference (error)

Table: ***tbl_Readings_DO***

Description: Records calibration data for dissolved oxygen.

Field Name	Type	Format	Description
DO_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each SpCond_Measure_ID
DO_ID	Short text	Up to 50 characters	Link to tbl_Calibration_DO (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Temperature in degrees Celsius
BP_inHg	Double	Decimal	Barometric pressue in inHg, used to calculate BP in mmHg Siemens (µS/cm)
BP	Double	Decimal	Barometric pressure in mmHg
DO_Table	Double	Decimal	Dissolved oxygen table in mg/L calculated from barometric pressure and water temperature values
Salinity_Factor	Double	Decimal	Salinity correction factor
DO_Sat	Double	Decimal	Dissolved oxygen reading, percent saturation
DO	Double	Decimal	Dissolved oxygen reading in mg/L

Field Name	Type	Format	Description
Difference	Double	Decimal	Percent difference (error)
DO_Solution	Double	Decimal	Reading in zero dissolved oxygen solution

Appendix G. Data Dictionary (continued)

Table: *Records calibration data for pH*

Description: Records calibration data for pH.

Field Name	Type	Format	Description
pH_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each pH_Measure_ID
pH_ID	Short text	Up to 50 characters	Link to tbl_Calibration_pH (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Standard temperature in degrees Celsius
pH_Theoretical	Double	Decimal	Theoretical pH from the Table on Calibration Standard
pH_Reading	Double	Decimal	Specific conductance reading in Micro-Siemens (µS/cm)
Difference	Double	Decimal	Percent difference (error)

Table: *tbl_Readings_Turbidity*

Description: Records calibration data for Turbidity.

Field Name	Type	Format	Description
Turbidity_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Turbidity_Measure_ID
Turbidity_ID	Short text	Up to 50 characters	Link to tbl_Calibration_Turbidity (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Standard temperature in degrees Celsius
Turbidity_Reading	Double	Decimal	Turbidity reading in NTU/FNU
Difference	Double	Decimal	Percent difference (error)

Appendix G. Data Dictionary (continued)

Table: ***tbl_Readings_SpCond_Recal***

Description: Records re-calibration data for specific conductance.

Field Name	Type	Format	Description
SpCond_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each SpCond_Measure_ID
SpCond_ID	Short text	Up to 50 characters	Link to tbl_Calibration_Sp_Cond (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Standard temperature in degrees Celsius
SpCond_Reading	Double	Decimal	Specific conductance reading in Micro-Siemens (µS/cm)
Difference	Double	Decimal	Percent difference (error)

Table: ***tbl_Readings_pH_Recal***

Description: Records re-calibration data for pH.

Field Name	Type	Format	Description
pH_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each pH_Measure_ID
pH_ID	Short text	Up to 50 characters	Link to tbl_Calibration_pH (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Standard temperature in degrees Celsius
pH_Theoretical	Double	Decimal	Theoretical pH from the Table on Calibration Standard
pH_Reading	Double	Decimal	Specific conductance reading in Micro-Siemens (µS/cm)
Difference	Double	Decimal	Percent difference (error)

Appendix G. Data Dictionary (continued)

Table: *tbl_Readings_DO_Recal*

Description: Records re-calibration data for dissolved oxygen.

Field Name	Type	Format	Description
DO_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each SpCond_Measure_ID
DO_ID	Short text	Up to 50 characters	Link to tbl_Calibration_DO (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Temperature in degrees Celsius
BP_inHg	Double	Decimal	Barometric pressue in inHg, used to calculate BP in mmHg Siemens (µS/cm)
BP	Double	Decimal	Barometric pressure in mmHg
DO_Table	Double	Decimal	Dissolved oxygen table in mg/L calculated from barometric pressure and water temperature values
Salinity_Factor	Double	Decimal	Salinity correction factor
DO_Sat	Double	Decimal	Dissolved oxygen reading, percent saturation
DO	Double	Decimal	Dissolved oxygen reading in mg/L
Difference	Double	Decimal	Percent difference (error)
DO_Solution	Double	Decimal	Reading in zero dissolved oxygen solution

Table: *tbl_Readings_Turbidity_Recal*

Description: Records re-calibration data for Turbidity.

Field Name	Type	Format	Description
Turbidity_Measure_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Turbidity_Measure_ID
Turbidity_ID	Short text	Up to 50 characters	Link to tbl_Calibration_Turbidity (foreign key)
Type	Short text	Up to 15 characters	Calibration type
Time	Date/Time	hh:mm	Calibration time
Temp	Double	Decimal	Standard temperature in degrees Celsius
Turbidity_Reading	Double	Decimal	Turbidity reading in NTU/FNU

Field Name	Type	Format	Description
Difference	Double	Decimal	Percent difference (error)

Appendix G. Data Dictionary (continued)

Table: ***tbl_Cross_Section_Survey***

Description: Records cross section survey data.

Field Name	Type	Format	Description
CS_Survey_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each CS_Survey_ID
Event_ID	Short text	Up to 50 characters	Link to tbl_Events(foreign key)
CS_Survey_Date	Date/Time	hh:mm	date of CSS
CS_Observer	Short text	Up to 255 characters	Person who measured the CSS
WW_1	Double	Decimal	10 wetted widths
WW_2	Double	Decimal	10 wetted widths
WW_3	Double	Decimal	10 wetted widths
WW_4	Double	Decimal	10 wetted widths
WW_5	Double	Decimal	10 wetted widths
WW_6	Double	Decimal	10 wetted widths
WW_7	Double	Decimal	10 wetted widths
WW_8	Double	Decimal	10 wetted widths
WW_9	Double	Decimal	10 wetted widths
WW_10	Double	Decimal	10 wetted widths
Mean_WW	Double	Decimal	mean wetted width in meters (autopopulated)
Survey_Site_Length	Double	Decimal	Survey Site Length calculated by mean wetted width x 40 (autopopulated)
Distance_transects	Double	Decimal	Distance between transects in meters by Site length / 3 (autopopulated)
Comments	Short text	Up to 255 characters	Cross section survey notes
Season_timimg	Short text	Up to 3 characters	Begining of Season (BOS) or End of Season (EOS)

Appendix G. Data Dictionary (continued)

Table: ***tbl_Cross_Section_Transect_Data***

Description: Records cross section survey data.

Field Name	Type	Format	Description
CS_Transects_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each CS_Transects_ID
CS_Survey_ID	Short text	Up to 50 characters	Link to tbl_Cross_Section_Survey(foreign key)
CS_Distance	Double	Decimal	Distance from proposed site
Transect_WW	Double	Decimal	transect wetted width in meters
Transect	Double	Decimal	Transect number (0-4) at given site ID
Record	Double	Numeric	Recording numbers for each transect (1-10)
Time	Date/Time	hh:mm	Time of recording (hh:mm)
M_from_Left	Double	Decimal	Distance in meters from Left Bank transect wetted width / 10, except for transect 0 which is center of transect (Autopopulate)
Total_Depth_m	Double	Decimal	Total depth of probe for each recording number
Depth_Measurement	Short text	Up to 255 characters	Depth of measurement in meters (50% of total depth)
Temp_C	Short text	Up to 255 characters	Temperature in Celcius- text format so they can add (TS = too shallow)
pH_Units	Short text	Up to 255 characters	pH text format so they can add (TS = too shallow)
Cond	Short text	Up to 255 characters	uS/cm text format so they can add (TS = too shallow)
DO	Short text	Up to 255 characters	mg/L text format so they can add (TS = too shallow)
Turbidity	Short text	Up to 255 characters	NTU's text format so they can add (TS = too shallow)

Appendix G. Data Dictionary (continued)

Table: *tbl_Fouling_Checks*

Description: Records fouling data.

Field Name	Type	Format	Description
Fouling_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Fouling_ID
Event_ID	Short text	Up to 50 characters	Link to tbl_Events(foreign key)
Time	Date/Time	hh:mm	Time at which the multiprobe fouling check occured.
Time_Period	Short text	Up to 255 characters	What time period was the multiprobe fouling check conducted, e.g. before cleaing or after cleaning.
Comments	Long text	Up to 255 characters	Notes on fouling

Table: *tbl_Fouling_Checks_Live*

Description: Records fouling data.

Field Name	Type	Format	Description
Value_Live_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Value_Live_ID
Fouling_ID	Short text	Up to 255 characters	Link to tbl_Fouling_Checks(foreign key)
Reading_Type	Short text	Up to 50 characters	Which reading are the measurements for, e.g. recorded/live monitoring or field meter.
Temp	Double	Decimal	Temperature in degrees Celsius
SpCond	Double	Decimal	Specific conductance reading in Micro-Siemens (µS/cm)
DO_Sat	Double	Decimal	Dissolved oxygen reading, percent saturation
DO	Double	Decimal	Dissolved oxygen reading in mg/L
BP_inHG	Double	Decimal	Barometric pressure in inHg, used to calculate BP in mmHg
BP	Double	Decimal	Barometric pressure in mmHg, used to calculate DO Table
Water_Temp	Double	Decimal	Water temperature in degrees Celsius, used to calculate DO Table
pH	Double	Decimal	pH in units

Field Name	Type	Format	Description
Turbidity	Double	Decimal	Turbidity in NUT FNU
DO_Table	Double	Decimal	Dissolved oxygen table in mg/L calculated from barometric pressure and water temperature values

Appendix G. Data Dictionary (continued)

Table: ***tbl_Fouling_Checks_Values***

Description: Records fouling data.

Field Name	Type	Format	Description
Value_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each Value_ID
Fouling_ID	Short text	Up to 255 characters	Link to tbl_Fouling_Checks(foreign key)
Reading_Type	Short text	Up to 50 characters	Which reading are the measurements for, e.g. recorded/live monitoring or field meter.
Temp	Double	Decimal	Temperature in degrees Celsius
SpCond	Double	Decimal	Specific conductance reading in Micro-Siemens (µS/cm)
DO_Sat	Double	Decimal	Dissolved oxygen reading, percent saturation
DO	Double	Decimal	Dissolved oxygen reading in mg/L
BP_inHG	Double	Decimal	Barometric pressue in inHg, used to calculate BP in mmHg
BP	Double	Decimal	Barometric pressure in mmHg, used to calculate DO Table
Water_Temp	Double	Decimal	Water temperature in degrees Celsius, used to calculate DO Table
pH	Double	Decimal	pH in units
Turbidity	Double	Decimal	Turbidity in NUT FNU
DO_Table	Double	Decimal	Dissolved oxygen table in mg/L calculated from barometric pressure and water temperature values

Appendix G. Data Dictionary (continued)

Table: *tbl_AMS*

Description: Calculation of QA/QC measure.

Field Name	Type	Format	Description
AMS_Tap_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each AMS_Tap_ID
DQI_ID	Short text	Up to 50 characters	Link to DQI_ID in tbl_BOS_NTU (foreign key)
Measure	Double	Decimal	Measurement number
Temp_C	Double	Decimal	Temperature (Celsius) tap water readings
pH_Units	Double	Decimal	pH (units) tap water readings
Sp_Cond	Double	Decimal	Specific Conductance (uS/cm) using tap water readings
DO	Double	Decimal	DO (mg/L) using tap water readings
Turbidity	Double	Decimal	Turbidity (NTU) using tap water readings

Table: *tbl_BOS_NTU*

Description: Calculation of QA/QC measure.

Field Name	Type	Format	Description
NTU_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each NTU_ID
DQI_ID	Short text	Up to 50 characters	Link to DQI_ID in tbl_AMS (foreign key)
NTU_1	Double	Decimal	Measured value 1
NTU_2	Double	Decimal	Measured value 2
NTU_3	Double	Decimal	Measured value 3
NTU_4	Double	Decimal	Measured value 4
NTU_5	Double	Decimal	Measured value 5
NTU_6	Double	Decimal	Measured value 6
NTU_7	Double	Decimal	Measured value 7
StDev	Double	Decimal	Standard Deviation
MDL	Double	Decimal	3.134*Standard Deviation
ML	Double	Deciaml	3.18*MDL

Appendix G. Data Dictionary (continued)

Table: *tbl_AMS_CRMO_CIRO*

Description: Calculation of QA/QC measure. For CRMO and CIRO only.

Field Name	Type	Format	Description
AMS_CRMO_CIRO_ID	Short text	Up to 50 characters	Primary key, uniquely identifying each AMS_CRMO_CIRO_ID
DQI_ID	Short text	Up to 50 characters	Unique DQI_ID
Measure	Double	Decimal	Measurement number
Temp_C	Double	Decimal	Temperature (Celsius) tap water readings
pH_Units	Double	Decimal	pH (units) tap water readings
Sp_Cond	Double	Decimal	Specific Conductance (uS/cm) using tap water readings
DO	Double	Decimal	DO (mg/L) using tap water readings
Turbidity	Double	Decimal	Turbidity (NTU) using tap water readings

Table: *tlu_Contacts*

Description: Lookup table of Contacts associated with protocol data collection and entry. Contacts linked to Events in xref_Event_Contacts table.

Field Name	Type	Format	Description
Contact_ID	Short text	up to 50 characters	Primary key uniquely identifying each tlu Contacts record associated with this protocol
last_Name	Short text	up to 50 characters	Last name of contact person
First_Name	Short text	up to 50 characters	First name of contact person
Middle_Init	Short text	up to 4 characters	Initials of contact person
Organization	Short text	up to 50 characters	Organization with which contact person is affiliated
Position_title	Short text	up to 50 characters	Position with which contact person is affiliated
Email_address	Short text	up to 50 characters	Email
Work_Phone	Short text	up to 50 characters	Work phone
Work_Extension	Short text	up to 50 characters	Extension
Contact_Notes	Long text	up to 255 characters	Notes

Appendix G. Data Dictionary (continued)

Table: *tlu_Probes*

Description:

Field Name	Type	Format	Description
Probe_ID	Short text	up to 50 characters	Primary key uniquely identifying Probe_ID
Property_No	Short text	up to 10 characters	UCBN property number for the probe
Serial_No	Short text	up to 50 characters	Serial number for the probe
Model	Short text	up to 75 characters	The make and model of the probe

Table: *name: tlu_Sensors*

Description:

Field Name	Type	Format	Description
Sensor_ID	Short text	up to 50 characters	Primary key uniquely identifying Sensor_ID
Type	Short text	up to 25 characters	Sensor type, i.e. pH, DO, SpCond, Turbidity
Probe_Serial_No	Short text	up to 255 characters	Probe number
Serial_Number	Short text	up to 50 characters	Serial number for the sensor

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 963/133000, July 2016

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