FLOROSENSE

BRIGHTER GREENER

GUIDANCE NOTE FOR REALTIME WATER QUALITY MONITORING OF NATURAL RESERVOIRS AND WATER BODIES

NOV 2012

Appendices

List of Tables

Table 3-B: Parameters Available for S::can

Table 6-A: QAQC Comparison Chart

Abbreviations and Acronyms

A Ampere
ADRS Automatic Data Retrieval System
Ah Ampere-Hour
ATV All Terrain Vehicle
BOD Biochemical Oxygen Demand
BGA Blue-Green Algae
BTX Benzene, Toluene, Xylene
°C Degree Celsius
CCG Canadian Coast Guard
CCME Canadian Council of Ministers of theEnvironmentcm
Centimeters
COD Chemical Oxygen Demand
CSC Campbell Scientific Canada
DCS Data Communication Systems
EC Environment Canada
GOES Geostationary Operational Environmental Satellite
GSM Global System for Mobile
GPS Global Positioning System
mA Milliamperes
MEMP Mobile Environmental Monitoring Platform
mg/L Milligrams per Liter
NESDIS National Environmental Satellite, Data, and InformationService
NIST National Institute of Standards and Technology
NOAA National Oceanic and Atmospheric Administration
NTU Nephelometric Turbidity Unit
OHS Occupational Health and Safety
ORP Oxidation-Reduction Potential
PAR Photosynthetically Available Radiation
PCB Polychlorinated Biphenyl
PEGNL Professional Engineers and Geoscientists
PFD Personal Flotation Device
PPE Personal Protective Equipment
PTE Performance Evaluation Testing
PVC Polyvinyl Chloride
QA Quality Assurance
QAQC Quality Assurance and Quality ControlQC
Quality Control
RS-232 Recommended Standard 232
RTWQ Real Time Water Quality
SD Secure Digital
SDI Serial Digital Interface
SPOT Système Pour l'Observation de la Terre (System for EarthObservation)TDS
Total Dissolved Solids

TOC	Total Organic Carbon
TSS	Total Suspended Solids
US	United States
USB	Universal Aerial Bus
μS/cm	MicroSiemens perCentimeter
UV254	Ultra Violet 254 nanometer
V.	Volt
W.	Watt
WRMD	Water Resources Management Division
WT	Water Tracing

1. Introduction

Water quality monitoring is imperative in providing the Water Resources Management Division (WRMD) with the physical and chemical properties of water bodies throughout the world. This information is the basis on which the health of these waterways' is determined. Water quality monitoring has been conducted traditionally by collecting grab samples from lakes, rivers and streams across the province for many years. These samples are then sent to an accredited laboratory for analysis. Grab samples taken on a monthly, weekly or even daily schedule, only represent water quality at a particular moment in time. The natural environment is constantly changing and water quality can fluctuatequickly and dramatically with potentially adverse effects to aquatic life, their habitats and the surrounding environment. With the introduction of real time water quality (RTWQ) instrumentation, sensors now can measure water quality data continuously. This information is transmitted through communication systems and made available to the enduser in near real time. This allows the end user to identify, understand, follow and potentially mitigate harmful water quality events should they occur in a water body.

While RTWQ monitoring is gaining in interest and popularity, it cannot and should not be used to replace traditional grab sampling networks. Many grab sampling stations have long term historical databases which provide an essential and valuable source of information for a particular watershed over a long period of time.

RTWQ monitoring can be a useful tool in many aspects of water resource management. Even a short deployment period of RTWQ instrumentation can collect valuable information and help determine key stressors on a water body. NL has found this component of RTWQ extremely useful in urban impacted streams as well as water bodies under pressure from nearby industrial developments. As development expands in NL with respect to construction and natural resource exploration, it is important to find a balance between economic development and environmental protection. RTWQ has contributed significantly to the way in which partnering industries can identify their potential impact on streams and their influence on the health of a watershed. All water quality data gathered through the RTWQ monitoring network is available online for the general public, environmental awareness groups, other government organizations, and the private sector. It is paramount that data being viewed is of the highest quality. When working in the natural environment it is important to standardize protocols and procedures to reduce the likelihood of errors and inconsistencies, hence providing accurate, precise and reliable data.

Since the implementation of the NL RTWQ monitoring program in 2001, the program has expanded across NL. Currently, the RTWQ monitoring program consists of over 30 stations (2013). Most stations operate in partnership with Environment Canada (EC) and industry partners.

1.1. Purpose/Scope

The inception, expansion and improvements of the NL RTWQ monitoring program has been a lengthy process with many partners consistently working to improve and advance the program. Through experience learned, the WRMD has identified many of the necessary components for the development and management of a successful RTWQ network. This manual aims to document the components from the conception and production stages through to data management and reporting. Streamlined processes and procedures to be followed by all WRMD personnel are outlined. It is the responsibility of all WRMD personnel to exercise diligence during tasks to reduce the possibility of errors or inconsistencies during these processes.

This manual will be used as a reference guide in relation to: site and instrument selection, deployment techniques, field procedures, calibration and maintenance of continuous water-quality instruments, quality assurance and quality control measures anddata analysis and reporting.

2. Quality Assurance, Control and Assessment

To ensure the effectiveness and reliability of the RTWQ monitoring program, quality assurance (QA), quality control (QC) and quality assessment procedures have been implemented. Proper procedures outlined in this manual and its attachments should beadhered to consistently. Anything outside the procedure should be documented to explain reasoning. It is essential that all RTWQ personnel ensure that their responsibilities and tasks are completed in reference to this manual. All RTWQ personnel have the responsibility and authority to manage, perform and verify that their work follows QA, QC and quality assessment protocols. Specific components of QA, QC and quality assessment in RTWQ monitoring are summarized below. Specific procedures relating to QA, QC and quality assessment are explained within their respective sections throughout the manual.

2.1. Quality Assurance

QA includes all high-level activities, structures and mechanisms used to ensure and document the accuracy, precision, completeness, effectiveness and representativeness of theRTWQ monitoring program. QA ensures the overall integrity of the program design and consists of two separate but interrelated activities: QC and quality assessment. QA program elements include:

- Annual proficiency testing and evaluations of instrument function
- Personnel qualifications and training
- Technical procedures for sampling and conducting field and analytical work
- Troubleshooting of instruments, recording equipment, installations, transmission of dataand corrective action plans
- Record keeping including field sheet and chain of custody for grab samples, deploymentfield sheet, logbooks and instrument calibration records
- Implementation of QAQC procedures including data verification, validation and varianceforms
- Preparation of analytical reports, data packages and RTWQ web page
- Auditing adherence to program requirements and following internal procedures
- Peer review of RTWQ program design, QAQC procedures and data analysis
- Investigation of emerging RTWQ technology, QAQC procedures, and analysistechniques
- First-hand knowledge of each RTWQ station watershed through observation and fieldvisits

2.2. Quality Control

QC refers to the use of technical activities which ensure that the data collected are adequate for quality assessment purposes. This includes feedback systems to ensure activities are occurring as planned and intended, and to verify that procedures are being carried out satisfactorily. QC program elements include:

- Monthly maintenance and calibration of the probe and its sensors
- Inspection and maintenance of RTWQ station installation
- Field readings taken at the time of removal and redeployment of the probe using a field QAQC instrument

- In situ validation of field and QAQC instrument readings according to comparison tableand troubleshoot to determine cause if significant discrepancies occur
- Collection of a water quality grab sample at the time of redeployment of the probe to besent to an accredited laboratory for analysis
- Updating spreadsheet with grab sample results once laboratory analysis is complete

2.3. Quality Assessment

Quality assessment activities are implemented to quantify the effectiveness of the quality control procedures. Quality assessment program elements include:

- Calculate long-term and monthly period summary statistics
- Produce time series graphs for each parameter and evaluate for gaps, data errors, and guideline exceedances for pH, dissolved oxygen and turbidity
- Publishing near-real time updates of RTWQ data on the WRMD web page for public review
- Produce a report for each station corresponding to deployment periods, including any problems with maintenance, calibration and QAQC procedures; any data issues; time series graphs and summary statistics for each parameter; brief explanations for observed results; and data qualification statements
- Archiving of RTWQ monitoring data records
- Identify any issues with the parameter order, sensor failure or missing data transmissions in a data variance report
- Regular updates to the calibration schedule on the web page

3. Equipment Selection

There are many options when it comes to RTWQ monitoring with respect to available instrumentation and communication. The WRMD has devoted significant time to researching, testing, and comparing results from different instruments available combined with various communication options. Available documents summarizing specific research and data comparisons are on the departmental webpage.

As the field of RTWQ monitoring progresses, it is important to stay informed about advancements in research and technology. The WRMD is committed to continuous investigation of new instrumentation and communication options worldwide.

There are a variety of communication options to facilitate water quality data transfer from a water body to an end user. Existing power and telecommunication infrastructure may be incorporated to create a station. In other cases, a station may be designed to stand alone in a remote location. It is advantageous to understand all the alternatives before a site is chosen and a station is installed. This section summarizes the instrumentation and communication options the WRMD has incorporated or tested in the NL RTWQ network.

3.1. Instrument and Display Selection

This section describes some of the different types of instruments available for incorporation in an RTWQ monitoring station or network. Instrument technology is constantly developing and improving. When selecting an instrument for an RTWQ station or network, it is important to first choose the parameters that are of highest priority and will provide meaningful data. The parameters usually of considerable importance to RTWQ monitoring in NL are temperature, pH, specific conductivity, dissolved oxygen and turbidity. Additional parameters such as chlorophyll, blue-green algae (BGA), and total suspended solids (TSS) are considered on a site-by-site basis.

There are a variety of continuous water quality monitoring instruments available from different manufacturers which offer different designs, options and combinations of sensors. Once the parameters of interest have been determined, it is important to verify the range, accuracy and resolution of the individual sensors. This information is important in determining the type of data the instrument will provide and if the data collected will satisfy the stations objective.

In addition to parameter and sensor selection, there can be many other options and upgrades to the instruments. It is important to weigh each of the options presented and consider their value to the station. One of these factors is the suggested deployment length. Most manufacturers of optical multi-parameter instruments suggest a 30 day deployment period. Spectroscopic instruments can sometimes be deployed for longer periods of time. Some sensors or instruments feature self-cleaning devices which in the experience of the WRMD and the NL RTWQ network have proven useful even in areas not prone to biofouling. Some sensors or instrument casings are available in titanium (vs. stainless steel) and can be used in salt water environments. Due to the errors introduced from biofouling, many manufacturers now offer an anti-bio-fouling kit. Finally, it is important to consider the functioning of the instrument. Instruments may feature battery packs and internal logging capabilities and memory. All of these options will need to be considered when selecting and purchasing an instrument. Background information about the water body will aid in determining what the necessary features are for an instrument to meet monitoring requirements.

1. Multi-Parameter Instruments

Many parameters can be assessed simultaneously using a series of electrochemical and optical sensors connected to the same instrument. Multi-parameter instruments offer multiple ports for sensors and can be designed specifically to measure parameters of interest (Figure 3-1). A multi-parameter instrument can be purchased in a variety of sizes. It is the size of the instruments that determines the number of sensors and/or parameters to be measured (Table 3-A). Depending on the instrument, data can be recorded internally or transmitted through another means of communication.

Multi parameters instruments are most commonly used in RTWQ network. RTWQ sites to measure chemistry parameters including temperature, pH, specific conductivity, dissolved oxygen and turbidity. These measured parameters can be used to further calculate additional parameters such as total dissolved solids (TDS) and percent saturation. Additional sensors that have been incorporated into the RTWQ network include chlorophyll a, BGA, and oxidation-reduction potential (ORP).

Current research by the WRMD examines the potential to extrapolate additional parameters such as TSS, as well as various major ion concentrations such as chloride, sodium, calcium and sulfates. These parameters can be deduced by determining the relationship between measured parameters and laboratory results from grab samples. A report detailing the relationship between specific conductivity and major ions is available on the departmental webpage.

2. Single Parameter Instruments

Single parameter instruments function similarly to the multi-parameter instruments; however, each instrument is specialized for measuring one specific parameter. There are cases where a single parameter is of considerable interest or of high priority. The user may require more detailed data such as higher resolution or improved accuracy or range.

WRMD have tested single parameter instruments designed for measuring turbidityand inferring TSS concentrations (Figure 3-2). WRMD is currently evaluating the difference between the accuracy of the single parameter sondes versus the multi-parameter sondes more commonly used in the network. TSS is an important water quality parameter for many industry partners especially during construction phases as it is a regulatory parameter with defined guidelines. Turbidity is easily measured in the water column by the instrument's opticsand has a significant relationship with TSS. Further research in this area will be carriedout to determine if turbidity readings from the multi-parameter instruments are accurate for TSS prediction and analysis. These single parameter instruments also function as a back-up should a sensor fail mid deployment. WRMD will continue to invest time and research into understanding the differences between the accuracies of the various sondes andthe relationship between turbidity and TSS.

Single parameter temperature sensors have also been incorporated into the RTWQnetwork. This economical sensor can easily be integrated at existing water quantity stations and can provide useful information about water bodies both at the surface and ground water levels.

Figure 3-2: Examples of single parameter turbidity instruments (CSC, 2012; FTS, 2012)

3. Groundwater Monitoring Instruments

RTWQ Groundwater monitoring instruments are very similar to the multi and single parameter instruments. Groundwater multi-parameter instruments tend to be smaller than surface water instruments in order to accommodate the narrow diameter of drilled wells (Figure 3-3). The water quality parameters of interest for groundwater monitoring differ from surface water monitoring. Groundwater multi-parameter instruments are usually equipped with sensors to measure depth, ORP as well as typical water quality parameters like specific conductivity, pH, temperature etc.

Figure 3-3: Examples of groundwater monitoring multi parameter instruments

4. Spectroscopic Instruments

Spectroscopic instruments use wavelength technology to measure water quality parameters. These instruments have capabilities above and beyond measuring the basic water quality parameters offered by multi parameter instruments. These instruments are available in single or multi-parameter models. Spectroscopic instruments have the ability to be calibrated for specific water quality parameters that possess a unique absorbance signature. Table 3-B displays a small selection of the parameters commonly measured by the. Potentially hundreds more can be detected and specific parameter signatures can be purchased from the manufacturer.

5. Display Units

Hand held display units are usually sold in conjunction with the multi or single parameter instruments. There are different models available depending on the instrument and manufacturer chosen.

Hand held display units are useful in the field setting and connect to the instrument via a short (~5-10m) field cable. The field units allowthe user to view the water quality data in situ or via connection in the station shelter. This can be done quickly and easily from the safety of the shore. (Figure 3-4).

Hand held display units allow the user to verify current water quality data from the instrument in the stream which is necessary in order to compare live field instrument readings with QAQC instrument readings, a component of the QC procedure during deployment.

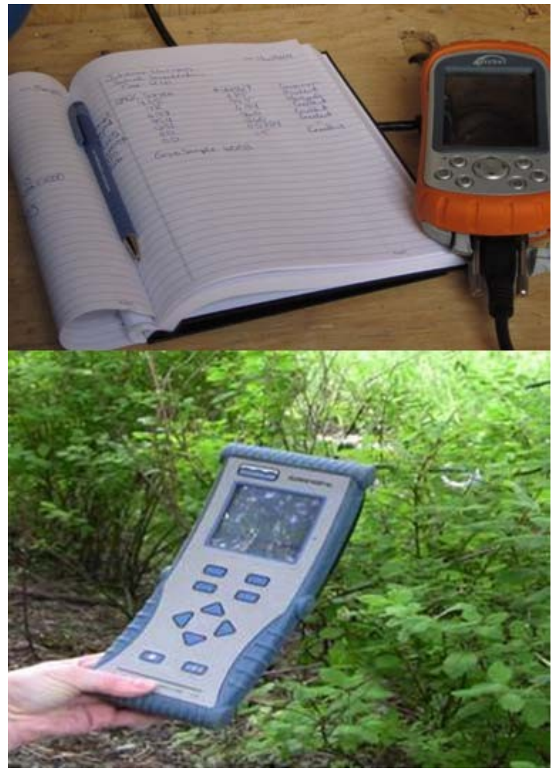

Figure 3-4: Hand held display units for viewing water quality data in-situ

3.2. Data Logger Selection

Data loggers bridge the gap between instruments immersed in a water body and the telemetry system used to relay water quality data back to a database. The data logger will retrieve and store data from the water quality instrument at pre-determined intervals specified in the data logger programming and ensure the data is available to the telemetry unit.

When selecting a data logger, it is important to choose one that is compatible with the instrument and telemetry equipment in use. Water quality instruments can be connected to a data logger using an analogue connection such as a 4 – 20 mA current loop, via an RS-232 (9-pin) connection or through an SDI-12 interfaces. All NL RTWQ stations use the digital interface SDI-12. SDI-12 is considered critical to water quality instrumentation in the network since it provides a power supply and good data signal strength over moderate distances.

Features such as touch screens, USB and SD card access are often optional features that add flexibility to data access, but are not necessary in the monitoring stations establishedin NL.

A variety of data loggers have been used throughout the NL network over the years including but not limited to: Valcom - VEDAS II (Figure 3-5); Sutron - Satlink II and 8210; CSC - CR1000 (Figure 3-6) and FTS data loggers. Data loggers can be found mounted in the station shelters in a protective casing preventing damage from climate, moisture, animals andvandals.

3.3. Communication Options

In RTWQ monitoring applications, a method to connect field equipment to a centralized server is required. There are several options available, each with its own advantages and disadvantages. Commonly used methods of telemetry include telephone, cellular and satellite. The following section will detail the various connectivity options available and the equipment needed namely cost, bandwidth, power requirements and reliability.