

SOP 2.3: Continuous Monitoring Record Computation and Data Quality Evaluation

This document summarizes the process for record computation, data quality evaluation, and finalizing continuous monitoring data. The MIDN follows USGS guidelines for this process; for detailed guidance refer to the full publication (Wagner et al. 2006). All procedures presented in this document are carried out within the Aquarius environment (Aquatic Informatics, Vancouver, BC). This document provides guidance general guidance but not to the specific procedures for working within the Aquarius environment. Refer to WRD and Aquatic Informatics for current guidance working within the Aquarius database and Wagner et al. (2006) for specific procedures regarding record computation and data quality evaluation.

These procedures must be carried out as soon as possible after the log file is retrieved from the field so that: (1) improvements can be made to deployment methods, (2) equipment failures are identified, and (3) field conditions are fresh in the minds of those processing the data records.

Previous SOP Version #	Revision Date	Author	Changes Made	Reason for Change	New SOP Version #

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I. Data-Processing Procedures

Conceptually, the workflow used by MIDN to process continuous water quality monitoring data (outlined in this SOP) is based on USGS methods (Wagner et al. 2006). The Wagner et al. (2006) procedures should be referred to for detailed guidance and clarification. Specific procedures which differ from USGS methods due to differences in equipment and data transfer procedures (e.g., methods for importing log files) are outlined in this SOP.

A. Initial Data Evaluation

- (1) Verify accurate data import into Aquarius
 - a. Ensure expected range and number of records were imported into Aquarius
 - i. Refer to SOP 2.2 Sec. III.B.3 and 4 for expected values

(2) Visually inspect each parameter:

- a. Flag and annotate data that requires further evaluation
 - i. Missing data
 - ii. Anomalies
 1. Intermittent failure of sensors
 2. Inexplicable spikes
 - iii. Truncated signals
 - iv. Out of range values
- b. Inspect battery voltage record
 - i. Flag all observations where battery voltage drops below 6.4v for deletion due to power requirements of sensors

B. Data Corrections

Data corrections are applied to adjust for known biases introduced through calibration drift and sensor fouling during the deployment period. These procedures should be carried out for each site/parameter combination. There are many factors to consider when applying data corrections including knowledge of field sites and their contributing watersheds and using professional judgement (Wagner et al. 2006). Additional information can improve the processing of these data. Relevant information such as stream stage or discharge can provide critical context to understanding the dynamics of various water quality parameters. When data corrections are deemed appropriate from quality control data other relevant information can be used to inform data correction decisions using professional judgement.

Determining if data corrections are appropriate:

Data corrections are applied to continuous water quality records based on the amount of bias documented from sensor fouling and calibration drift. Corrections should be applied to data for which the combined absolute value of the calibration drift and sensor fouling exceeds established criteria (Table1).

Table 1. Maximum allowable deviation of the absolute value of observed error derived from calibration drift and sensor fouling prior to the application of data correction. Adapted from Wagner et al. (2006).

Water Quality Parameter	Data-Correction Criteria
Temperature	$\pm 0.2^{\circ}\text{C}$
Specific Conductance	$\pm 5\mu\text{S}/\text{cm}$ or 3% of measured value*
Dissolved Oxygen	$\pm 0.3 \text{ mg}/\text{l}$ or 5% of measured value*
pH	$\pm 0.2 \text{ pH unit}$
Turbidity	$\pm 0.5 \text{ turbidity units}$ or 5% of measured value*

*whichever is greater

(1) Determine range of observations associated with the evaluation period (Sec. I.A.1.a above)

(2) Identify data that require correction

- a. For each site/parameter combination:
 - i. Compare absolute value of combined fouling correction and calibration drift for the appropriate time period from the QW_Ultimate spreadsheet to the established criteria (Table 1)

1. If combined fouling/calibration drift exceeds threshold for applying a correction determine the appropriate correction procedure:
 - a. See “Application of Data Corrections” section of Wagner et al. (2006)
 - b. Sensor data where fouling/calibration drift exceeds maximum allowable limits for data correction (Table 2)

Table 2. Maximum allowable limits for applying data corrections. If correction value exceeds values in this table then the associated data are censored. This table is adapted from Wagner et al. (2006).

Water Quality Parameter	Data-Correction Criteria
Temperature	$\pm 2.0^{\circ}\text{C}$
Specific Conductance	30%
Dissolved Oxygen	$\pm 2.0 \text{ mg/l}$ or 20%*
pH	$\pm 2 \text{ pH unit}$
Turbidity	$\pm 3 \text{ turbidity units}$ or 30% of measured value*

*whichever is greater

- (3) Apply and annotate corrections within the Aquarius database
 - a. Annotation should provide a description of rationale for applying correction
- (4) If combined fouling/calibration drift does not exceed threshold move on to the next parameter
 - a. All observations for a site should be processed prior to working on another site

C. Data Quality Evaluation

Data quality is evaluated so that end users can gain an understanding of sensor performance during the deployment period. Unlike discrete water quality monitoring, sensors are deployed for extended periods of time where calibration drift and sensor fouling can occur. Quality control data used to apply corrections are also used to rate data quality.

- (1) Determine range of observations associated with the evaluation period (Sec. I.A.1.a above)
- (2) Determine data quality rating:
 - a. For each site/parameter combination:
 - i. Compare absolute value of fouling correction and calibration drift for the appropriate time period from the QW_Ultimate spreadsheet to the rating criteria for data quality (Table 3)
 1. Ensure data quality classification from QW_Ultimate spreadsheet matches rating category from Table 3

Table 3. Data quality rating categories as adopted from Wagner et al. (2006).

Water Quality Parameter	Data Quality Rating			
	Excellent	Good	Fair	Poor
Temperature	$\leq \pm 0.2^{\circ}\text{C}$	$> \pm 0.2 - 0.5^{\circ}\text{C}$	$> \pm 0.5 - 0.8^{\circ}\text{C}$	$> \pm 0.8^{\circ}\text{C}$
Specific Conductance	$\leq \pm 3\%$	$> \pm 3 - 10\%$	$> \pm 10 - 15\%$	$> \pm 15\%$

Dissolved Oxygen	$\leq \pm 0.3$ mg/L or $\leq 5\%^*$	$> \pm 0.3 - 0.5$ mg/L or $> \pm 5 - 10\%^*$	$> \pm 0.5 - 0.8$ mg/L or $> \pm 10 - 15\%^*$	$> \pm 0.8$ mg/L or $> \pm 15\%^*$
pH	$\leq \pm 0.2$ units	$> \pm 0.2 - 0.5$ units	$> \pm 0.5 - 0.8$ units	$> \pm 0.8$ units
Turbidity	$\leq \pm 0.5$ turbidity units or $\leq \pm 5\%^*$	$> \pm 0.5 - 1.0$ turbidity units or $> \pm 5 - 10\%^*$	$> \pm 1.0 - 1.5$ turbidity units or $> \pm 10 - 15\%^*$	$> \pm 1.5$ turbidity units or $> \pm 15\%^*$

- (3) Apply and annotate data quality ratings within the Aquarius database
 - a. Annotation should provide a description of rationale for rating

II. Review Data Processing

All corrections and data quality rating are reviewed for consistency as a final step after data management procedures have been completed in Aquarius. This is meant to serve as a quality control process to ensure that corrections and ratings are applied appropriately.

- (1) Generate “Aquarius_Change_List” report from the Aquarius for all data corrections applied for each site/parameter combination
 - a. Save “Aquarius_Change_List” to MIDN server (see SOP 2.2 section V.A.)
- (2) Generate “Aquarius_Data_Quality_Rating” report from the database for all data quality ratings applied within Aquarius for each site/parameter combination
 - a. Save “Aquarius_Data_Quality_Rating” to MIDN server (see SOP 2.2 section V.A.)
- (3) Compare correction/rating reports from Aquarius with QW_Ultimate spreadsheet
 - a. Check that all corrections were applied correctly
 - i. Correct any discrepancies immediately
- (4) Open and populate “Record Processing Review Log” excel file
 - a. Maintained on MIDN Sever (see SOP 2.2 section V.A.)
 - b. A separate Record Processing Review Log will be created each site/water year combination
 - i. Enter information for each parameters tab to assist in year-end data quality certification
- (5) After the review process is complete the data can be shared outside of the MIDN as provisional and subject to revision
 - a. Data certification occurs annually prior to publishing annual reports (see SOP 2.4)
 - i. Change record status to approved in Aquarius

Literature Cited

Wagner, R. J., R. W. Boulger Jr, C. J. Oblinger, and 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. U.S. Geological Survey, Reston, VA.