

Continuous Water-quality records

Procedure for Analyzing, Approving and Auditing of Continuous Water-Quality Records

The process for analyzing and approving data for water temperature, specific conductance, pH, dissolved oxygen, and turbidity records is specified in [Techniques and Methods 1-D3](#), (TM1-D3--Wagner and others, 2006) *Guidelines and Standard Procedures for continuous water-quality monitors: station operation, record computation, and data reporting*, beginning on p. 39. [Techniques and Methods 1-D5](#) (TM1-D5--Pellerin and others, 2013) *Optical techniques for the determination of nitrate in environmental waters: Guidelines for instrument selection, operation, deployment, maintenance, quality assurance, and data reporting*. WSCs operating chlorophyll, fDOM and other sensors using unapproved methods (those without a Techniques and Methods report) are required to document a standard operating and analysis procedure, as per USGS Fundamental Science Practices (Baker, 2011) and follow [TM1-D3](#) and [TM1-D5](#)) where appropriate. All records are required to conform to the continuous records processing (CRP) procedures of [WRD Policy Memorandum No. 2010.02](#) (Larsen, 2010), [OWQ memo 2017.02](#), (Cunningham and others, 2017a), and USGS Fundamental Science Practices (Aragon, 2017).

The following summarizes the recommended workflow and outlines procedural requirements. A station analysis must be written using the established [Station Analysis Template](#) and stored in the Record Management System (RMS). All record analyses, approvals, and audits must meet the requirements of OWQ memo [2017.07](#) (Cunningham and others, 2017b).

Analysis period

Records are analyzed for discrete periods of time known as analysis periods. The analyst will determine the analysis period. For water-quality records, the analysis period should start and end with calibration checks of the sensor used for the record (an analysis period may include more than 2 calibration checks). The lengths of analysis periods are variable and are only limited by CRP criteria. The procedures below apply to each analysis period. Audits typically would cover more than one analysis period.

Raw data

All field visits should be documented electronically using [SVMAQ](#) (or their eventual replacement) and are required to be stored in AQUARIUS. [SVMAQ](#) files containing readings and observations can be [uploaded to AQUARIUS](#). Field-visit data can be edited, reviewed, and approved in AQUARIUS.

Cross-section surveys of the physical parameters being measured should be made at least twice a year including at least one vertical transect to assess vertical mixing. Cross-section data are to be recorded electronically or on paper to be converted to an electronic format, for example PDF, and uploaded to AQUARIUS.

Data transmitted to the NWIS database must be checked on a daily basis, at a minimum, to determine if gross data errors need to be edited and to apply edits in a timely manner. Such erroneous data include, but are not limited to, data spikes from sensor errors or non-representative sensor readings caused by field visits, sensors out of water, or sensors buried in sediment. In addition, [thresholds](#) must be set for each parameter that automatically censor readings that are obviously in error because they are outside of a reasonable or operational range for the sensor or the site.

Data recorded in various data loggers (EDL data) shall be routinely uploaded to AQUARIUS. The EDL data can be combined with the transmitted data time series to fill data gaps using either the [fill missing data processor](#) or the [copy paste correction](#).

Analyzing data

It is the responsibility of the hydrographer who performed the monitor field visit to record field observations and data pertinent to sensor maintenance and calibration checks. This includes, but is not limited to, sensor-inspection notes, before- and after-calibration readings, and calibration notes as per [TM 1-D3](#), [TM 1-D5](#), and per procedures specified in the Water Science Center's QA plan. The hydrographer analyst (preferably the same hydrographer to perform the field visit) must complete the following steps at a minimum to bring the time-series to an analyzed state.

Initial Data Evaluation

- Ensure that required verification and evaluation of field data have been done and documented, as per [TM1-D3](#), [TM1-D5](#), and WSC procedures, before the analysis begins.
- Cross-section surveys made during the analysis period should be evaluated to determine if the stream is well mixed and if the sensor location should be adjusted or, in rare circumstances, a time-series correction is necessary, as per [TM1-D3](#). A comparison with previously collected cross sections should be summarized.
- Examine raw time-series data for the period for completeness. Data missing from the transmitted record should be added, where possible, using the logged electronic data record. No water-quality data should be estimated.

- Examine the recorded time series and identify periods of erroneous values. Erroneous values should be removed along with masking [qualifiers](#). Document all deletions to the record, including reasoning for the erroneous values. Remaining periods with gaps in the data should be documented.
- Update the Station Analysis with any relevant changes that have occurred at the site during the analysis period, including any relocation of the sensors or monitor or changes in the physical setup of the monitor. These changes should be added to the Station Description also.
- Censor instantaneous values that are outside the calibration or reporting interval and apply the appropriate data [qualifier\(s\)](#).

Application of Data Corrections

- Review time-series plots of raw and corrected data with site visits to determine when a fouling, calibration drift, or other corrections are needed as per [TM1-D3](#), [TM1-D5](#), and WSC procedures.
- Apply fouling and calibration drift corrections [automatically](#) or manually according to [TM1-D3](#) and [TM1-D5](#). All water-quality corrections should be made using the [USGS multi-point correction](#) method.
 - The magnitude and sign of the correction should correspond to improving the agreement of the uncorrected time series and the cleaned and calibrated time series. If this is not true, the analyst should review the readings and look for possible errors.
 - Most water-quality corrections are prorated over some period of time between field visits when cleaning and calibration checks were done. The timing of the correction start and end should typically correlate with the field visit readings, but can be related to other events in the record that may cause fouling, and less common, calibration drift.
 - It may improve the analysis to plot data with other time-series data. For example, it may be useful to view specific conductance with water temperature or pH with dissolved oxygen. Discharge and gage height also are useful comparison datasets.
 - Use the comment field for the correction to record information about the correction. This information is part of the station analysis.
 - Corrections that exceed the maximum allowable limit (MAL) in [TM1-D3](#) and [TM1-D5](#) should be carefully evaluated for accuracy. The reason for the large error/correction should be determined and noted in the correction comment. The analyst must then determine if the correction should be applied or not. If the correction is applied to the time series, then the instantaneous data that are corrected more than the MAL should be deleted from the record or justified and noted in the Station Analysis according to [TM1-D3](#).
- Apply other corrections (set 3; not described above) as needed. An example would be the application of a correction to avoid negative values. A detailed discussion on how

such corrections were developed, their period of applicability, and why they were deemed necessary for the analysis period must be included in the station analysis.

- Review (or revise, if necessary) all applied corrections for the analysis period. This includes comparing all readings to the recorded values and verifying the application period for the corrections. The analyst is responsible for making any adjustments to previously applied corrections to the working period. The reasoning and timing for any corrections that deviate from recommendations in [TM1-D3](#) must be clearly described in the comment for each correction.
- Review the daily values records (max, min, and mean/median) and inspect the days when less than 100 percent of the expected instantaneous values are available (partial graded DVs). The analyst determines if the partial graded DVs are retained or deleted from the record according to procedures in [TM1-D3](#). Partial grade(s) should be reapplied by the analyst for all partial DVs reviewed and correction comments can be recorded for deleted DVs.
- Determine the maximum and minimum for the analysis period. The section of the station analysis must contain the maximum and/or minimum recorded value if it is found to be beyond the maximum or minimum for the period of record (this should also be noted in the station description).
- Provide any pertinent remarks or comments for the analysis period that are not contained in other sections in the Comments section of the station analysis.

An additional experienced hydrographer may be needed for a second analysis when the following conditions occur: (1) at the beginning of a data record when performance at the site is being established, (2) for parameters and/or sites that are more prone to fouling or drift and that are more inherently variable such as turbidity or other optical sensors, and (3) for new, more experimental parameters, that have not yet been covered in a Techniques and Methods report or fully documented in the WSC QA plan.

After completing the above described tasks, the analysis period is set to the analyzed state in NWIS and in the records tracking system (RMS) by the analyst.

Approving data

Each water-quality record is subject to a quality-control process that involves a thorough examination of the methods and procedures used, and to verify the accuracy and interpretations of the analysis period. The examination includes checking for gross errors in the record computation process, as well as verifying that interpretations and justifications for the decisions made during analysis are sound and in accordance with protocols outlined in [TM1-D3](#), [TM1-D5](#), and WSC QA plans. Verification of the analyst's work may require updates to the analysis period. Analysis periods that are determined to have errors are documented and returned to the record analyst for corrections. Contentious changes are negotiated among the parties, with the Office or Project Chief or Water-Quality Specialist resolving any disputes. After all issues are

resolved, the analysis period is set to the approved state in NWIS and the records tracking system.

An approver must be designated by the Science Center Director (or delegate) and must have the necessary skill, experience, and knowledge to evaluate a record analysis for approval. For example, this could include at least 2 years of experience analyzing and reviewing records of the same type and the completion of QW2298, *Guidelines for Operation and Record Computation of Water-Quality Monitors*, or equivalent training. The approver executes the following steps to bring the time-series analysis period to an approved state:

- Verify that field notes were reviewed and the reviews were documented in accordance with [TM1-D3](#) and WSC procedures.
- Ensure the Station Description is current and relevant and has been properly updated to reflect any changes made or observed during the analysis period.
- Verify that any edits to the record were done properly, and that they were documented in NWIS and the station analysis. The approver should verify the analysis period(s) of missing data.
- Evaluate the accuracy and documentation of fouling and calibration drift corrections. This includes verifying that any corrections that exceeded [TM1-D3](#) or WSC criteria and exceptions were documented, verifying the magnitude of the correction, verifying the correction start and end times, and ensuring any adjustments to corrections were properly documented.
- Evaluate the accuracy and documentation of all defined and other types of corrections (set 3). This includes verifying the reasoning for the correction, the correction values, and that the application of the correction is valid.
- Ensure partial graded daily values were verified or removed from the record and the partial grade was reapplied by the analyst.
- Determine if corrections that exceed the MAL were noted, and that data affected were evaluated in accordance with [TM1-D3](#) and WSC procedures.
- Provide a brief written final assessment of the analysis period in an AQUARIUS note.
- The WY Summary will be available when the DVs for the water year are approved. The SIMS manuscript should be completed before the WY summary is publically available. For guidance, refer to [Office of Water Information Memorandum 2015.01](#)

After completing the above described tasks, the analysis period will be set to the approved state in AQUARIUS and RMS by the approver.

Audited data

Routine Auditing of Water-Quality Records

All water-quality records should be audited at intervals of 15 months or less, and on a typical interval of 12 months. More frequent audits should be conducted when the following conditions

occur: (1) at the beginning of a data record when performance at the site is being established, (2) for parameters and(or) sites that are more prone to fouling or drift and that are more inherently variable such as turbidity, and (3) for new, more experimental parameters, that have not yet been covered in a T&M.

Routine audits are performed by Field Office Chiefs, senior hydrographers, Water-Quality Specialists or Project Chiefs. An auditor must have the necessary skill, experience, or knowledge to evaluate a record analysis for approval. For example, this could include at least 2 years of experience analyzing, reviewing, and approving records of the same type and the completion of QW2298, *Guidelines for Operation and Record Computation of Water-Quality Monitors*, or equivalent training. Contentious changes should be coordinated among the parties, with the Center designee resolving any disputes. Routine audits should cover periods of continuous analysis periods over about 12 months. A routine audit for WQ records includes a 2-step process: (1) a [level 2](#) review and verification of continuity and consistency among all the analysis periods of the audited period, and (2) a [level 1](#) review of one or more analysis periods that makes up a quarter or more of the audited period. Auditors should also be looking for consistency among WQ records within the WSC. The audit includes a review of the following:

- Station analysis;
- Approval documentation;
- Deletions to recorded water-quality data;
- Fouling corrections, calibration corrections, and other types of corrections;
- Station description (completeness and accuracy); and
- The continuous record in Aquarius, with an eye for unusual temporal patterns, erroneous shift corrections, or large periods of missing data.

It is highly encouraged to have a subset of these routine audits done by other offices within the WSC or offices in other WSCs. The purpose of routine audits is to ensure that proper methods were applied throughout the process of collecting water-quality data and computing the record. Errors found during a routine audit are to be revised and properly qualified if they meet revision criteria ([OWQ memo 2017.03](#)--Cunningham and others, 2017b).

Non-routine Auditing of Water-Quality Records

Non-routine audits occur anytime an aspect of an approved record is examined outside of the previously defined routine audit process. For example, an end user may have a question about a turbidity record for May and June two years ago. Errors found during non-routine audits are subject to defined error threshold criteria for revisions ([OWQ memo 2017.03](#)--Cunningham and others, 2017b). Non-routine audits do not have any required tasks aside from documentation of the audit to include; the date of the audit, the auditor, what was examined, why it was examined, and the outcome of the audit to include a discussion of potential revisions, if any. Another example of a non-routine audit would be a record that is examined during a triennial discipline review. In this case, most aspects of a designated analysis period are examined (superficially or

in detail) and the documentation should include the notes or forms that were filled out by the reviewer. Non-routine audits are to be documented by filling out the Audit form in RMS.

References Cited

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