Field Measurements for In-Situ Water Quality Monitoring in Fresh and Marine Water

Terms appearing in the tables below are further defined in the Surface Water Ambient Monitoring Program Quality Assurance Program Plan

Table 1 Field measurement instrument requirements for Accuracy, Precision, and Resolution

Analyte	Accuracy (unit)	Precision (unit or RPD) [1]	Resolution[2]
pH	±0.2	±0.2	±0.1
Specific Conductivity	±2	±2 or ±10%	±1
Dissolved oxygen	±0.5	±0.5 or ±10%	±0.1
Temperature (°C)	±0.2	±1 or ±10%	±0.1
Turbidity	±1	±1 or ±10%	±0.1
Velocity	NA	±0.2 or ±10%	±0.1
Flow	NA	±0.2 or ±10%	±0.1
Total Chlorophyll	±1	±1 or ±10%	±1

[1] Relative Percent Difference (RPD) is the difference between two repeated measurements expressed as a percentage of their average. *%RPD = (sample result - duplicate result) * 100*

[2] Resolution refers to the capability of a method or instrument to recognize small differences between values. This term is often used to assess if an instrument or method is useful to a study and is provided by the manufacturer.

Table 2 Required reporting units

Analyte	Required reporting unit
pH	pH
Specific Conductivity	µS/cm; mS/cm
Dissolved oxygen	mg/L; µmol/L
Temperature	°C
Turbidity	NTU; FNU
Velocity	ft/sec;
Flow	m^3/s
Total Chlorophyll	µg/L; RFU

Table 3 Calibration and Accuracy Checks

Parameter	Instrument name or type	Frequency of Calibration & Accuracy checks[1] [2] [3]	Frequency of repeated measurements (Precision)[4]
Dissolved oxygen	DO electrode (Meter) or Probe[5]	Daily, pre-sampling one-point calibration within 24 hours before event.	2 per Trip
Temperature	Bulb Thermometer	Periodic accuracy checks halfway through the duration of project timeline, examine capillary daily (quarterly to annually)	2 per Trip
Temperature	Temperature probe (with multimeter or DO meter)	Periodic accuracy checks halfway through the duration of project timeline	2 per Trip
Specific Conductivity	EC meter	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	2 per Trip
Specific Conductivity	conductivity Probe	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	2 per Trip
pH	pH meter (dry electrode) or Probe	Daily, pre-sampling two-point calibration within 24 hours before event.	2 per Trip
Turbidity	Nephelometer or turbidimeter	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	1 per Trip
Velocity	Electromagnetic	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	1 per Trip
Total Chlorophyll	Optical fluorescence probe	Periodic accuracy check and two-point calibration adjustment halfway through the duration of project timeline[6]	1 per Trip

[1] Unless manufacturer specifies more stringent requirements.
[2] SWAMP requires daily pre and post (within 24 hours after event) sampling accuracy checks when the manufacturer or documented procedure (e.g., standard operating procedure) do not provide instruction.
[3] For ongoing (e.g. trend monitoring) projects, accuracy checks and calibration adjustments should happen no less than every three months. All instruments will be checked for accuracy and calibrated before the first measurement of any project. Pre-project calibration date is reported with dataset.
[4] Repeat a field measurement at least twice by removing the probe from the water, re-submerging the probe and allowing the probe to stabilize. After the instrument stabilizes, record the reading and calculate

the relative percent difference between the readings. If the relative percent difference exceeds the MQO, perform the test again to ensure that the required stabilization period is adhered to. If the instrument continues to provide measurements that exceed the MQO, the instrument must be re-calibrated.
[5]For elevation change of ≥500m, conduct pre transit and post transit accuracy checks between sites with anticipated elevation difference. Depending on results from comparing accuracy checks, field calibration may be necessary.
[6] Refer to manufacturer's instructions to ensure that the meter is not being checked too infrequently.

Table 4 Corrective Action: Field Measurements in Fresh and Marine Water

Field Corrective Action
The field crew is responsible for responding to failures in their sampling and field measurement systems. If monitoring equipment fails, personnel are to record the problem according to their documentation protocols. Failing equipment shall be replaced or repaired prior to subsequent sampling events. It is the combined responsibility of all members of the field organization to determine if the performance requirements of the specific sampling method have been met, and to collect additional samples if necessary. Associated data are entered into the SWAMP Information Management System and flagged accordingly. Calibration adjustments will be required of any sensor failing accuracy checks in accordance with the framework established herein.

Accuracy of Field Measurements

Accuracy is a measure of how close the sensors' readings are to a known measure. Accuracy is assured by calibration adjustments for adjustable instruments before every trip, or as specified herein. Accuracy will be checked by comparing the readings of all instruments and kits (both adjustable and non-adjustable), when introduced to standard solutions, with the known measure of these standards. Field instruments will undergo accuracy checks after each trip, and the difference between the instrument's reading and the standard value will be recorded according to project documentation protocols. This value, the 'instrument drift', will be used to report accuracy (in measurement units, e.g., for pH, or as a percentage of the true value of the standard). If an instrument's drift is significant, that probe should be repaired or replaced. Calibration standards will be selected at values that are as close as possible to, but bracket, expected ambient values.

Precision of Field Measurements

Precision is how close two measurements or analyses of the same thing are to each other. Precision will be reported (according to project documentation protocols) as Relative Percent Difference (RPD) which is the difference between two repeated measurements, expressed as a percentage of their average.

Field Probe/Sensor Calibration

Sensors are calibrated by subjecting them to known conditions, measuring the sensor's responses and adjusting the sensor to provide accurate measurements. In an attempt to accommodate a wide variety of technologies and the proper technique for each, the program defers to manufacturer specifications or SWAMP guidelines for field instrument

calibration, whichever is more stringent. Proper calibration procedures are critical to ensuring the overall accuracy and precision of measurements.

Representativeness of Field Measurements

Field personnel will conduct measurements and collect samples in a manner that will assure the representativeness of the data. The field person should be at a sampling location that has been previously selected and is representative of the physical, chemical, and biological characteristics needed for samples that will address the primary research question being addressed. The samples obtained should be representative in terms of what each data point represents in the environment spatially and temporally for that particular sampling location. Training in measurement techniques as well as consistent and conscientious use of procedures and protocols are to be used to ensure sample integrity and data quality. Refer also to the SWAMP QAPrP and site selection criteria regarding representativeness.

Equipment Handling

In situ field measurement equipment (sondes) are delicate scientific instruments and should be handled, stored and transported with appropriate care.

References

American Public Health Association (APHA). 1995. *Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and Water Pollution Control Federation.* 19th edition, Washington, D.C.

Bartholomay, Roy C. *Field Methods and Quality-Assurance Plan for Water-Quality Activities and Water-Level Measurements, U.S. Geological Survey, Idaho National Laboratory, Idaho*. U.S. Department of the Interior, U.S. Geological Survey, 2014.

Marshack, Jon B. *A Compilation of Water Quality Goals*. 17th ed., State Water Resources Control Board,2016.https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/docs/wq_goals_text.pdf

Marshack, Jon B. "Water Quality-Based Assessment Thresholds." State Water Resources Control Board, 2016. https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/ https://drive.google.com/file/d/1H6FEXvScweq13P9kOlSDXkmxb0u1dzZQ/view?usp=sharing

"Quality Assurance (ACRR) Matrix QA Checklist for Calibration, Quality Checks, and Record Keeping to Ensure That Data Are of Known and Documented Quality." Aquatic Sensor Workgroup, 2010.

Wright, Robert S. Application of Data Quality Objectives and Measurement Quality Objectives to Research Projects. 2003.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 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 p. + 8 attachments; accessed April 10, 2006, at http://pubs.water.usgs.gov/tm1d3