

Standard Operating Procedure 3: Continuous Water Quality Monitor Calibration Checks and Calibration

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Change History

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Overview

Sensor calibration and calibration checks are important for quality assurance and quality control when using continuous water-quality monitors (hereafter, monitors). Sensor calibration ensures that sensors are as accurate as possible prior to use (quality assurance) whereas calibration checks provide supporting information for data rating and data correction (quality control) if necessary.

Calibration methods and criteria (Table 1) are the same for field monitors and site monitors except for calibration check frequency. Site monitors are checked for calibration drift prior to deployment and, at a minimum, every three months during deployment. Field monitors are checked for calibration drift prior to every site visits (not to exceed 7 calendar days before the next site visit) and are recalibrated as necessary. Throughout sensor calibration checks and calibrations processes, all data must be recorded in the appropriate spaces on the appropriate data forms. See Standard Operating Procedure 5 (Data Management and Processing) for details regarding data entry.

Much of this Standard Operating Procedure is based on guidance developed by the U.S. Geological Survey (USGS; Bennett et al., 2014) or excerpted directly from the manufacturer (Eureka Water Probes, Austin, TX) user manual (Eureka Water Probes, 2015). Refer to the manual (Eureka Water Probes, 2015) for additional guidance regarding calibration if necessary.

Table 1. Calibration and calibration check methods for water-quality monitors used to continuously measure selected physical and chemical properties in Eastern Rivers and Mountains Network (ERMN) rivers (based on Bennett et al., 2016). Sensors are calibrated if, and only if, calibration criteria (i.e., measurement quality objectives) are exceeded. [°C, degree Celsius; $\mu\text{S}/\text{cm}$, microsiemens per centimeter; FNU, Formazin nephelometric units; mg/L, milligrams per liter; NIST, National Institute of Standards and Technology]

Physical Property	Calibration Method	Check Method	Acceptance Criteria	Check Frequency
Temperature	Cannot be calibrated. Thermistor must be replaced if acceptance criterion is exceeded.	Comparison to NIST-certified thermometer	Within $\pm 0.2^\circ\text{C}$	5-point annual check in the office. 2-point quarterly check in the field.
Specific conductance	1-point calibration with known standard (100 $\mu\text{S}/\text{cm}$) near typically observed values at ERMN sites.	2-point calibration check with known standards (10 $\mu\text{S}/\text{cm}$ and 1000 $\mu\text{S}/\text{cm}$) that bracket typically observed values at ERMN sites.	$\pm 5 \mu\text{S}/\text{cm}$ at 10 $\mu\text{S}/\text{cm}$ $\pm 30 \mu\text{S}/\text{cm}$ at 1000 $\mu\text{S}/\text{cm}$	Every 3 months (minimum) and after replacement of the temperature/conductivity sensor.
pH	2-point calibration with known standards (pH 7 and pH 10) that bracket typically observed values at ERMN sites.	2-point calibration check with known standards (pH 7 and pH 10) that bracket typically observed values at ERMN sites.	Within ± 0.2 pH units of the standards	Every 3 months (minimum) and after replacement of the reference electrolyte, pH sensor, or temperature sensor.
Optical Dissolved Oxygen	1-point air saturated water calibration in conjunction with temperature and NIST-certified barometer.	1-point air-saturated water calibration check in conjunction with temperature and NIST-certified barometer.	Within ± 0.3 mg/L or 5% of the expected dissolved oxygen (mg/L) value	Every 3 months (minimum) and after replacement of the dissolved oxygen sensor or temperature sensor.
Turbidity	2-point calibration with known standards (0.0 FNU turbidity-free deionized water and 100 FNU polymer bead standard) that bracket the typically observed values at ERMN sites.	2-point calibration check with known standards (0.0 FNU turbidity-free deionized water and 100 FNU polymer bead standard) that bracket typically observed values at ERMN sites.	± 0.5 FNU at 0.0 FNU ± 5.0 FNU at 100 FNU	Every 3 months (minimum) and after replacement of the sensor.

Sensor Calibration Checks and Calibration

General Procedure

Specific instructions for checking and calibrating monitor sensors are provided after the following general description:

1. Clean all sensors thoroughly and perform any necessary sensor-specific maintenance.
2. Connect the monitor to a personal computer (PC) or other display that has monitor control software loaded onto it.
3. Select a calibration standard whose value is close to the observed values for the monitoring site. Use fresh calibration solutions and discard them after use.
4. Rinse sensors twice between checks or calibration steps with a small quantity (e.g., 50 ml) of deionized (DI) water. Shake the monitor to remove traces of previously used calibration solutions.
5. Rinse the sensors twice (most sensors) or three times (specific conductance [SC]) with a small quantity (e.g., 50 ml) of the calibration standard. Discard used calibration standard, except for turbidity standard, which is recycled once for sensor rinsing during subsequent checks.
6. Immerse sensors in calibration standard. This is typically accomplished by pouring the standard into the calibration cup after it has been screwed onto the monitor housing. Secure the monitor with sensors pointing up and fill the calibration cup with calibration standard until the sensors and thermistor are covered completely.
7. Open the monitor software then select the parameter to be calibrated by:
 - a. Clicking on the pull-down menu in the 'Main Screen' and scroll down to click on 'Calibrate',
 - b. Select the parameter to be calibrated,
 - c. Enter the calibration standard value and press 'Enter',
 - d. Wait four minutes, and after the measurement has stabilized, press 'Enter' to calibrate.
 - e. The monitor will report the resulting Sensor Response Factor (SRF); press 'Y' to accept the calibration or 'N' to back up one step, or 'Exit' to leave the sensor uncalibrated.
 - i. The SRF is a measure of sensor accuracy relative to expected performance in a given standard. The monitor automatically accepts the calibration if the SRF is between 60% and 140%. If the SRF is beyond those limits, the software will caution you to check your standard value, make sure the sensor is clean, and make sure the measurement has stabilized.
 - ii. If this SRF warning appears, troubleshoot and redo the calibration.
 - iii. If the SRF is repeatedly beyond limits, do not use. Consult manufacturer to replace faulty sensor(s).

Sensor Stabilization

It is critical that sensors equilibrate to the temperature and chemical properties of the calibration standard when checking sensor accuracy or calibrating sensors. A general rule that minimizes uncertainty is to allow the sensors to equilibrate in the standard for at least four minutes before recording measurements or proceeding with calibration steps. An equilibrated sensor might repeatedly 'bounce' up and down between two consecutive values, as opposed to continuously increasing or decreasing. Another safeguard is to avoid conditions (typically in the field) when standards are warming or cooling to ambient conditions.

Thermistor (Temperature Sensor)

The temperature sensor is an electrical resistor (thermistor) for which resistance changes predictably with temperature. The sensor is protected by a stainless steel tube and is very stable through time; this sensor does not require (or allow) calibration. If the temperature sensor does not meet data quality objectives based on calibration checks it must be replaced. The ERMN routinely checks thermistor accuracy at a single point check with a NIST-certified thermometer using the following procedure.

Calibration Check Procedure

1. Double rinse sensors with DI water that has stabilized to ambient temperature.
 - a. Do not use water directly from the tap.
 - b. A 4 L bottle of DI water should be kept full in the laboratory for this purpose.
2. Fill calibration cup with DI water that has stabilized to ambient temperature. Place NIST-certified thermometer next to the monitor's temperature sensor; ensure that the NIST-certified thermometer is not touching the monitor sensors or the calibration cup.
3. Wait at least four minutes for measurements to stabilize and then record temperature measurements from the monitor and NIST-certified thermistors.
4. Calculate and record the error (the difference between NIST-thermistor and the monitor measurement).
 - a. If the error is less than ± 0.2 °C, proceed to the Specific Conductance Calibration Check.
 - b. If the error is more than ± 0.2 °C, the monitor must be replaced. Consult with manufacturer for sensor replacement.

Specific Conductance

Eureka monitors report Specific Conductance (SC; conductivity standardized to 25° C) by calculating the value based on the conductivity sensor and temperature sensor readings. The conductivity sensor uses the four-electrode method to determine water conductivity – two pairs of graphite electrodes are situated in a stable geometry and a constant voltage is applied to one of each electrode pair. The amount of current required to maintain that voltage is measured and used to calculate SC.

Calibration standard solutions (10 $\mu\text{S}/\text{cm}$ and 1,000 $\mu\text{S}/\text{cm}$) that bracket the expected range of anticipated values (typically 70 to 200 $\mu\text{S}/\text{cm}$ at ERMN river sites) are used to check conductivity sensor accuracy.

Calibration Check Procedure

1. Check sensor accuracy in 10 $\mu\text{S}/\text{cm}$ standard solution:
 - a. Triple rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Triple rinse sensors with a small quantity (e.g., 50 ml) of 10 $\mu\text{S}/\text{cm}$ standard solution.
 - c. Fill the calibration cup with enough 10 $\mu\text{S}/\text{cm}$ standard solution to submerge the conductivity and temperature sensors.
 - d. Wait at least four minutes for the measurements to stabilize.
 - e. Record the sensor measurement and calculate the error (the difference between the standard solution and the sensor measurement).
 - i. If the error is less than $\pm 5 \mu\text{S}/\text{cm}$, proceed to check sensor in 1,000 $\mu\text{S}/\text{cm}$ standard solution.
 - ii. If the error is greater than $\pm 5 \mu\text{S}/\text{cm}$, the conductivity sensor needs to be calibrated.
 1. If you are conducting calibration checks for a site monitor during a routine or retrieval visit, you must check the sensor in 1,000 $\mu\text{S}/\text{cm}$ standard solution before calibrating. These data are used for calculating calibration drift for the last deployment period.
 2. If you are conducting calibration checks for a field monitor, you can skip checking the sensor in 1,000 $\mu\text{S}/\text{cm}$ standard solution and proceed to sensor calibration.
2. Check sensor accuracy in 1,000 $\mu\text{S}/\text{cm}$ standard solution:
 - a. Triple rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Triple rinse sensors with a small quantity (e.g., 50 ml) of the 1,000 $\mu\text{S}/\text{cm}$ standard solution.
 - c. Fill the calibration cup with enough 1,000 $\mu\text{S}/\text{cm}$ standard solution to submerge the conductivity and temperature sensors.
 - d. Wait at least four minutes for the measurements to stabilize.
 - e. Record the sensor measurement and calculate the error (the difference between standard solution and the sensor measurement).
 - i. If the error is less than $\pm 30 \mu\text{S}/\text{cm}$, proceed to pH Calibration Check.
 - ii. If the error is greater than $\pm 30 \mu\text{S}/\text{cm}$, troubleshoot and recalibrate.

Calibration Procedure

As recommended by the monitor manufacturer (Eureka Water Probes) the ERMN calibrates the conductivity sensor at a single point (100 $\mu\text{S}/\text{cm}$) that is similar to conductivity of water at ERMN monitoring sites.

1. Calibrate with 100 $\mu\text{S}/\text{cm}$ standard solution.
 - a. Triple rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Triple rinse sensors with a small quantity (e.g., 50 ml) of 100 $\mu\text{S}/\text{cm}$ standard solution.
 - c. Fill the calibration cup with enough 100 $\mu\text{S}/\text{cm}$ standard solution to submerge the conductivity and temperature sensors.
 - d. Wait at least four minutes for the readings to stabilize.
 - e. Follow the software instructions to calibrate the sensor.
 - f. Record the SRF.
2. Conduct post-calibration check with 100 $\mu\text{S}/\text{cm}$ standard solution.
 - a. The calibration cup is already filled and the readings have stabilized; record the post-calibration reading for 100 $\mu\text{S}/\text{cm}$ standard solution.
 - b. Calculate and record the error (the difference between the standard solution and the sensor measurement).
3. Conduct post-calibration check with 10 $\mu\text{S}/\text{cm}$ standard solution.
 - a. Triple rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Triple rinse sensors with a small quantity (e.g., 50 ml) of 10 $\mu\text{S}/\text{cm}$ standard solution.
 - c. Fill the calibration cup with enough 10 $\mu\text{S}/\text{cm}$ standard solution to submerge the conductivity and temperature sensors.
 - d. Wait at least four minutes for readings to stabilize.
 - e. Record the reading for 10 $\mu\text{S}/\text{cm}$.
 - f. Calculate and record the error (the difference between the standard solution and the sensor measurement).
 - i. If the error is less than $\pm 5 \mu\text{S}/\text{cm}$, proceed to pH Calibration Check.
 - ii. If the error is greater than $\pm 5 \mu\text{S}/\text{cm}$, troubleshoot and recalibrate.

pH

pH is measured as the voltage drop across the glass membrane of a pH electrode. A reference electrode is used to complete the voltage-measuring circuit. The pH glass is specially formulated to absorb water so that ions (particularly H^+ and OH^-) in the water are attracted to the glass to offset the ionic constituency of the pH electrode's internal electrolyte; consequently, there is a charge separation across the glass and that is the voltage that is measured. pH measurements are automatically compensated for temperature.

Calibration Check Procedure

1. Calibration Check with pH 7:
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Double rinse sensors with a small quantity (e.g., 50 ml) of pH 7 buffer solution.
 - c. Fill the calibration cup with enough pH 7 buffer solution to submerge the pH sensor, reference electrode, and temperature sensor.
 - d. Wait at least four minutes for the readings to stabilize.
 - e. Record the sensor reading in pH 7 solution.
 - f. Calculate and record the error (the difference between standard solution and the sensor measurement).
2. Calibration Check with pH 10:
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Double rinse sensors with a small quantity (e.g., 50 ml) of pH 10 buffer solution.
 - c. Fill the calibration cup with enough pH 10 buffer solution to submerge the pH sensor, reference electrode, and temperature sensor.
 - d. Wait at least four minutes for readings to stabilize.
 - e. Record the sensor reading in pH 10 solution.
 - f. Calculate and record the error (the difference between the standard solution and the sensor measurement).
3. If both errors (i.e., pH 7 and 10) are less than ± 0.2 pH units, you do not need to calibrate the pH sensor. If either error is greater than ± 0.2 units, the sensor needs calibrated.

Calibration Procedure

As recommended by the monitor manufacturer (Eureka Water Probes) the ERMN calibrates the pH sensor at two points (pH 7 and pH 10) that bracket typical water pH at ERMN monitoring sites.

1. Replace reference electrolyte in the reference electrode.
 - a. Carefully remove the reference electrode cap by unscrewing it from the reference sleeve with an appropriately sized screwdriver. Be sure to hold the base of the sensor to prevent it from turning.
 - b. Discard the used reference electrolyte.
 - c. Fill the reference sleeve with fresh pH reference electrolyte while being careful to not introduce any air bubbles.
 - d. Screw the reference cap back on to the reference sleeve (replace cap if old/heavily fouled). Air will be purged through the junction (i.e., the white dot in the middle of the reference electrode cap) when the cap is screwed back onto the reference sleeve.
2. Calibrate pH sensor with pH 7 and pH 10 buffered standard solution.
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Double rinse sensors with a small quantity (e.g., 50 ml) of pH 7 buffer solution.
 - c. Fill the calibration cup with enough pH 7 buffer solution to submerge the pH sensor, reference electrode, and temperature sensor.
 - d. Wait at least four minutes for readings to stabilize.
 - e. Follow the software instructions to calibrate sensor at pH 7.
 - f. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - g. Double rinse sensors with a small quantity (e.g., 50 ml) of pH 10 buffer solution.
 - h. Fill the calibration cup with enough pH 10 buffer solution to submerge the pH sensor, reference electrode, and temperature sensor.
 - i. Follow the software instructions to calibrate sensor at pH 10.
 - j. Record SRF.
3. Post-calibration check with four pH buffered standard solution.
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Double rinse sensors with a small quantity (e.g., 50 ml) of pH 4 buffer solution.
 - c. Fill the calibration cup with enough pH 4 buffer solution to submerge the pH sensor, reference electrode, and temperature sensor.
 - d. Wait at least four minutes for readings to stabilize.
 - e. Record the sensor reading in pH 4 solution.
 - f. Calculate and record the error (the difference between standard solution and the sensor measurement).
 - g. If the error is less than ± 0.2 pH units, move onto Turbidity Calibration Check.
 - h. If the error is greater than ± 0.2 pH units, troubleshoot and recalibrate.

Turbidity

Turbidity is measured as the fraction of an infrared light beam that is scattered at 90° to that beam. More particles in the water mean more of that light is scattered, leading to greater turbidity values. Any material that accumulates on the optical surfaces of the turbidity sensor is indistinguishable from material in the water; therefore, be sure that the optical lens surface is clean before conducting accuracy checks or calibration.

Turbidity requires a two-point calibration; one point is zero turbidity (DI water) and the other point (i.e., 100 Formazin Nephelometric Units [FNU]) brackets the range of typical turbidity values at ERMN monitoring sites. The ERMN uses polymer-bead calibration solutions based on manufacturer recommendation.

Calibration Check Procedure

1. Clean the turbidity sensor and check the wiper.
 - a. Ensure that the sensor is clean.
 - b. Ensure that the wiper pad is in good working condition and replace it if necessary. If the wiper is replaced, it should be recorded in the monitor maintenance log in the lab (see SOP 1).
2. Calibration Check with 0 FNU.
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Fill the calibration cup with enough DI water to submerge the turbidity sensor, which is almost to the threads for the screw-on cap.
 - c. Loosely place cap on calibration cup.
 - d. Use software to activate the wiper (WIPE) to remove any bubbles on turbidity sensor lens.
 - e. Wait at least four minutes for readings to stabilize.
 - f. Record the reading for 0 FNU.
 - g. Calculate and record the error (the difference between standard solution and the sensor measurement).
 - i. If the error is less than 2.0 FNU in DI water (i.e., 0.0 FNU), proceed to the calibration check with 100 FNU.
 - ii. If the error is greater than 2.0 FNU, repeat these steps and take a second reading once. Record the second reading and calculate and record the second error and then proceed to the calibration check with 100 FNU.
3. Calibration Check with 100 FNU.
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Double rinse sensors with a small quantity (e.g., 50 ml) of recycled 100 FNU buffer solution (it is very expensive). Recycled 100 FNU standard solution is used only once and should be discarded after rinsing.
 - c. Fill the calibration cup with enough new 100 FNU buffer solution to submerge the turbidity sensor – almost to the threads for the screw-on cap.
 - d. Use software to activate the wiper (WIPE) to remove any bubbles on turbidity sensor lens.
 - e. Wait at least four minutes for readings to stabilize.
 - f. Record the reading for 100 FNU.
 - g. Calculate and record the error (the difference between standard solution and the sensor measurement).

- h. Pour the 100 FNU standard solution into a container, labeled 'recycled 100 FNU' for use during future rinsing.
4. If the 0 FNU error is less than ± 2.0 FNU and the 100 FNU error is less than ± 5.0 FNU, you do not need to calibrate the turbidity sensor. If the 0 FNU error is greater than ± 2.0 FNU or the 100 FNU error is greater than ± 5.0 FNU, the turbidity sensor needs to be calibrated.

Calibration Procedure

As recommended by the monitor manufacturer (Eureka Water Probes), the ERMN calibrates the turbidity sensor at two points (100 FNU and 0.0 FNU) that bracket typical water turbidity at ERMN monitoring sites.

1. Calibration with 100 FNU.
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Double rinse sensors with a small quantity (e.g., 50 ml) of recycled 100 FNU buffer solution (it is very expensive). Recycled 100 FNU standard solution is used only once and should be discarded after rinsing.
 - c. Fill the calibration cup with enough new 100 FNU buffer solution to submerge the turbidity sensor – almost to the threads for the screw-on cap. Make sure that the turbidity sensor is fully immersed (i.e., an inch of solution over the sensor) in 100 FNU turbidity standard and has an unobstructed optical path.
 - d. Use software to activate the wiper (WIPE) to remove any bubbles on the turbidity sensor lens.
 - e. Wait at least four minutes for the readings to stabilize.
 - f. Follow the monitor software calibration instructions.
2. Calibration with 0 FNU (DI water).
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of DI water.
 - b. Fill the calibration cup with enough DI water to submerge the turbidity sensor – almost to the threads for the screw-on cap. Make sure that the turbidity sensor is fully immersed (i.e., an inch of solution over the sensor) and has an unobstructed optical path.
 - c. Loosely place cap on calibration cup.
 - d. Use software to activate the wiper (WIPE) to remove any bubbles on turbidity sensor lens.
 - e. Wait at least four minutes for readings to stabilize. Follow the monitor software calibration instructions to complete calibration.
 - f. While DI water is still in the calibration cup, record post-calibration reading (0 FNU).
 - g. Calculate and record the error (the difference between standard solution and the sensor measurement).
 - i. If the error is less than ± 2.0 FNU in DI water (i.e., 0.0 FNU), proceed to the post-calibration check with 100 FNU.
 - ii. If the error is greater than ± 2.0 FNU, troubleshoot and recalibrate.
3. Post-calibration check with 100 FNU.
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of recycled 100 FNU buffer solution. Recycled 100 FNU standard solution is used only once and should be discarded after rinsing.

- b. Fill the calibration cup with enough new 100 FNU buffer solution to submerge the turbidity sensor – almost to the threads for the screw-on cap.
- c. Use software to activate the wiper (WIPE) to remove any bubbles on turbidity sensor lens.
- d. Wait at least four minutes for readings to stabilize.
- e. Record the reading for 100 FNU.
- f. Calculate and record the error (the difference between standard solution and the sensor measurement).
- g. If the error is less than ± 5.0 FNU, move on to Dissolved Oxygen Calibration Check.
- h. If the error is greater than ± 5.0 FNU, troubleshoot and recalibrate.

Dissolved Oxygen Optical Sensor

The optical dissolved oxygen sensor is comprised of a blue light source, a sensing surface, and a red light receiver. The sensing surface is an oxygen-active compound stabilized in an oxygen-permeable polymer, usually silicone. When the sensing surface is exposed to water, oxygen diffuses into the sensing surface according to the amount (partial pressure) of oxygen in the water. The oxygen-active compound fluoresces (i.e., absorbs energy in the form of blue light and then emits energy as red light). In each measurement cycle, the blue light is first turned on and then turned off. The red light receiver measures the time that it takes after the blue light is turned off for the fluorescence to die off. This value is proportional to dissolved oxygen concentration. The sensor output is corrected for the temperature characteristics of 1) the membrane and 2) oxygen saturation in water.

Calibration Check Procedure

1. Turn on NIST-certified barometer so that it has sufficient time (i.e., 10 min) to stabilize to ambient barometric pressure (BP).
2. Prepare 100% air-saturated water.
 - a. Fill a one liter bottle halfway with DI water, recap the jar and shake it vigorously for one minute.
 - b. Take the jar cap off and let the water stand for approximately five minutes to allow air bubbles to escape.
3. Calibration check with air-saturated water.
 - a. Double rinse sensors with a small quantity (e.g., 50 ml) of air-saturated water.
 - b. Fill the calibration cup with the air-saturated water until it submerges the DO sensor by at least 1 cm. Keep the sensors out of direct sunlight.
 - c. Wait at least four minutes for the readings to stabilize.
 - d. Record the water temperature and the DO reading (mg/L).
4. Use the NIST-certified barometer to measure and record BP.
5. Look up (e.g., USGS 2013) or calculate the expected DO concentration (mg/L) in 100% air-saturated water based on the barometric pressure and water temperature. This calculation is done automatically in the ERMN River Water Quality Monitoring database.
6. Calculate and record the error (the difference between the DO Table Reading and the sensor measurement).
 - a. If the error is more than ± 0.3 mg/L, the DO sensor needs to be calibrated.

Calibration Procedure

1. Repeat steps 1 and 2 from DO sensor 'Calibration Check' if necessary.
2. Empty water from calibration cup and make sure that the BP setting in the monitor is accurate.
 - a. Ensure that the monitor sensors are exposed to air (i.e., remove the calibration cup lid).
 - b. Select the 'Calibrate' menu in the monitor software then select 'Barometric Pressure'
 - c. Enter the correct BP value (in mm Hg) from a NIST-certified barometer and follow the software instructions to complete BP setting.
2. Use air-saturated water to rinse sensors and fill calibration cup.
 - a. Double rinse the sensors with a small quantity (e.g., 50 ml) of air-saturated water.
 - b. Fill the calibration cup with the air-saturated water until it submerges the DO sensor by at least 1 cm. Keep the sensors out of direct sunlight.
3. Wait at least four minutes for the readings to stabilize.
4. Record pre-calibration DO sensor reading.
5. Follow software instructions to complete the calibration.
6. Record post-calibration DO sensor reading and record the error (the difference between the DO Table Reading and the sensor measurement).
7. If the error is less than ± 0.3 mg/L, calibration was successful.
8. If the error is greater than ± 0.3 mg/L, troubleshoot and recalibrate.

Literature Cited

- Bennett, T.J., Graham, J.L., Foster, G.M., Stone, M.L., Juracek, K.E., Rasmussen, T.J., and Putnam, J.E., 2014. U.S. Geological Survey quality-assurance plan for continuous water-quality monitoring in Kansas, 2014: U.S. Geological Survey Open-File Report 2014–1151, 34 p. plus appendixes, <http://dx.doi.org/10.3133/ofr20141151>.
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- USGS. United States Geological Survey. 2013. DOTABLES – Dissolved oxygen solubility tables software. Version 3.5. <https://water.usgs.gov/software/DOTABLES/>.

ERMN Continuous Water Quality Monitoring - Calibration Drift Check and Recalibration Sheet

Monitor Serial Number	Date	Military Time	Technician	Calibration Location	Full Check
				LAB SITE	YES NO
Intended Monitor Use and/or Calibration Comments					

Temperature: Double rinse sensors with DI Water at room temperature. If accuracy criterion ($\pm 0.2\text{ }^{\circ}\text{C}$) is exceeded, replace thermistor. For on-site visits, we use the field meter as the NIST Temp.

Calibration Check			Criteria	Does the thermistor need to be replaced? If yes, the monitor should not be used until it is replaced.
NIST/Field Temp	Reading	Error		
			$\pm 0.2\text{ }^{\circ}\text{C}$	YES NO

Specific Conductance: Triple rinse sensors with DI and standards. Conduct cal. check with 10 $\mu\text{S/cm}$ and 1,000 $\mu\text{S/cm}$. If calibration is required, calibrate at 100 $\mu\text{S/cm}$, record post-cal. reading (100 $\mu\text{S/cm}$), recheck at 10 $\mu\text{S/cm}$.

Standard	Std. Maker	Lot #	Exp. Date	Calibration Check		Criteria	Recalibration		
				Reading	Error		SRF	Reading	Error
10 $\mu\text{S/cm}$						$\pm 5\text{ } \mu\text{S/cm}$			
1,000 $\mu\text{S/cm}$						$\pm 30\text{ } \mu\text{S/cm}$			
100 $\mu\text{S/cm}$						$\pm 5\text{ } \mu\text{S/cm}$			

pH: Double rinse sensors with DI water and buffers. Conduct calibration check with 7 and 10. If calibration is required, replace electrolyte, calibrate at 7 and 10 (record post-cal. reading), and recheck at 4.

Was Reference electrolyte replaced? YES NO

Standard	Std. Maker	Lot #	Exp. Date	Calibration Check		Criteria	Recalibration		
				Reading	Error		SRF	Reading	Error
7						$\pm 0.2\text{ units}$			
10									
4									

Hamilton Optical (HDO) Dissolved Oxygen (DO): Double rinse sensors with DI water. Use air-saturated water for measurement.

	Water Temp ($^{\circ}\text{C}$)	NIST Baro. Press. (inHg)	NIST Baro. Press. (mmHg)	DO Table Reading (mg/L)	Reading (mg/L)	Error	Criteria	BP Reset?	SRF
Cal. Check							$\pm 0.3\text{ mg/L}$	YES	
Recal.								NO	

Turbidity: Double rinse sensors with DI water and standard solution.

Standard	Std. Maker	Lot #	Exp. Date	Calibration Check		Criteria	Recalibration	
				Reading	Error		Reading	Error
0 FNU				1 st	1 st	$\pm 2.0\text{ FNU}$		
				2 nd	2 nd			
100 FNU						$\pm 5.0\text{ FNU}$		

ERMN Continuous Water Quality Monitoring - Site Visit Sheet

Site Name	Type of Site Visit	Date	Military Time	Technician
	Deploy Routine Retrieval			
Field Monitor	Field Monitor Calibration Date	Date of Last Visit	Was Data Downloaded?	
			YES NO	
Site Monitor	Were Any Calibration Drift Checks Done?	Was Site Monitor Replaced?	Final Site Monitor	
	YES NO LATER	YES NO		
Site Visit Comments:				

Fouling Checks and Final Readings

	Fouling Checks				After Cleaning Error *	After Cleaning Criteria **	Final Readings
	Before Cleaning		After Cleaning				Mil. Time:
	Mil. Time:		Mil. Time:				Site
	Site	Field	Site	Field			
Temp (°C)						± 0.2 °C	
SC (µS/cm)						± 5 µS/cm	
pH (units)						± 0.25 units	
DO (mg/L)						± 0.4 mg/L	
Turbidity (FNU)						± 5.0 FNU	
*After Cleaning Error = (After Site) – (After Field) – <u>Circle error if it exceeds criteria.</u> ** After Cleaning Criteria – If the error exceeds these criteria, calibration checks must be completed for the parameter. Calibration checks must be completed every 3 months regardless.							Is Parameter order correct?
							YES NO