Montana Department of Environmental Quality

Standard Operating Procedure

Instantaneous Water Quality Field Meter

WQDWQPBFM-06, Version 1.0
April 2020
Water Quality Planning Bureau

Author: Elizabeth McWilliams, Monitoring and Assessment Section

Approvals:

/s/ Maggie Burnham	3/2/2020
Maggie Burnham, Technical Review	Date
/s/ Katie Makarowski	5/20/2020
Katie Makarowski, Quality Assurance Review	Date
/s/ Galen A. Steffens	6/30//2020
Galen Steffens, Water Quality Planning Bureau Chief, DEQ	Date

Signatures on file

The Montana Department of Environmental Quality (DEQ) Water Quality Planning Bureau (WQPB) Standard Operating Procedures (SOPs) are adapted from published methods or developed by in-house technical and administrative experts. Their primary purpose is for WQPB internal use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. DEQ may provide SOPs to other programs or partners. Distribution of these SOPs does not constitute a requirement to use a particular procedure or method unless stated in other binding communications. This document does not contain regulatory or statutory requirements unless specified.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the DEQ.

Although the WQPB follows this SOP in most cases, there may be situations where an alternative methodology, procedure, or process is used to meet specific project objectives. In such cases, the project manager is responsible for documenting deviations from these procedures in the Quality Assurance Project Plans (QAPPs), Sampling and Analysis Plans (SAPs), and end of project summary reports.

Document Revision and Version History

Revision Date	Version Number	Summary of Change(s)	Revised Sections(s)	Revised By
April 2020	1.0	Initial document	All	Elizabeth McWilliams

Suggested Citation

McWilliams, Elizabeth. 2020. Standard Operating Procedure for Instantaneous Water Quality Field Meters. WQDWQPBFM-06, Version 1.0. Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

DEQ	Montana Department of Environmental Quality
QAPP	Quality Assurance Project Plan
WQPB	Water Quality Planning Bureau
T	Temperature
EC	Electrical Conductivity
DO	Dissolved Oxygen
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SDS	Safety Data Sheet
BP	Barometric Pressure
NIST	National Institute of Standards and Technology
DI	Deionized

1.0 PURPOSE

This document describes the Montana Department of Environmental Quality (DEQ) Water Quality Planning Bureau (WQPB) Standard Operating Procedure (SOP) for using, calibrating, and maintaining instantaneous field meters (meters). There are many types of meters on the market, but there are common procedures to follow when calibrating, maintaining, and using these meters in the field. The meter may be able to report the results in a variety of units. A project's quality assurance plan (QAPP) or sampling and analysis plan (SAP) will describe which field measurements and units are required and which meter will be used.

2.0 APPLICABILITY

The following field parameters are common, useful to collect during water quality investigations and will be discussed in this document:

- Temperature (T)
- Electrical Conductivity (EC)
- pH
- Dissolved Oxygen (DO)
- Turbidity (limited availability for meters)

Many meters are applicable for all waterbody types and seasons, but it is important to understand any limitations that any one meter will have by reviewing the appropriate guides and manuals before use. All relevant information reported by the meter must be recorded on the appropriate form. The WQPB's Site Visit Form includes a section that is used for this purpose for the common parameters (**Section 11.1**).

Specific meters may be used as examples in this document; however, many principles such as calibration procedures and field use may be applicable to other models of meters.

NOTE: Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the DEQ.

3.0 METHOD SUMMARY

There are many different types of meters that may be used to collect one or more of the parameters discussed in this document. Pen meters typically only measure a few parameters (e.g., T, EC, or pH), handheld cabled meters can measure multiple parameters and sensors may be changeable, and other meters may be specifically designed to measure one parameter (e.g., turbidity).

The general calibration process for one type of parameter (pH or EC for example) will be similar (Rinse, Stabilize, and Accept) for all meter models. All calibration and maintenance done to a meter must be recorded in the meter's Calibration/Maintenance log book (**Section 11.2**).

A meter is ready to collect data after it is calibrated. When it is not in use, the meter should be put into the appropriate short or long-term storage.

Appendix B includes more information on how to use a few specific types of meters:

- YSI Professional Plus
- Hach 2100Q Portable Turbidity Meter

NOTE: All users should be familiar with the appropriate user manual or guidance document before using any equipment.

Meter readings are recorded at the time chemical information is collected in the field (Makarowski, 2020). The appropriate readings must be recorded on the Site Visit Form (**Section 11.1**) or another appropriate form before field personnel leave the site.

4.0 DEFINITIONS

Meter: a field meter that collects instantaneous information

Benchtop meter: a field meter that is designed to analyze data on a flat stable surface

Cabled meter: field meters that have sensors attached to a cable and are placed in a waterbody to analyze data

DI water: Deionized water, provided by a lab. Distilled water can be used if Deionized water is unavailable.

Rinse Solution: Calibration solution that can be used only for rinsing the meter. Bottles of this type of solution are marked "Rinse".

Station Pressure: "The absolute air pressure at a given reporting station. The air pressure is directly proportional to the combined weight of all air in the atmosphere located in a column directly above the reporting site" (NOAA, 2019).

5.0 HEALTH AND SAFETY WARNINGS

Field personnel should be aware of job hazards associated with collecting instantaneous water quality data that could result in personal injury or loss of life. Driving, boating, wading, tool use, and chemical safety are especially pertinent to the procedures contained in this SOP. Personnel should be aware of unstable banks, loose substrate, and swift currents when wading and standing in running water. DEQ field personnel should review the Water Quality Division Job Hazard and Acknowledgement form and the Waterborne Operations Procedure before collecting data (DEQ, 2016).

All personnel must adhere to the appropriate use, storage and disposal for any calibration solution. See the appropriate safety data sheet (SDS) for more information.

6.0 CAUTIONS

Field personnel must be cautious when using equipment around water. Water may damage electronics if seals are damaged or left open. Do not allow any equipment to be washed downstream. Do not allow the meter or sensors to become stuck in cobbles or riprap. Maintain appropriate equipment care and maintenance (i.e. batteries, sensor cleanings, firmware updates, O-ring, or other seal replacement) during use.

Installed batteries should be removed from meters when not being used for an extended period of time (3+ months) to avoid damaging the housing or circuity.

Some sensors such as pH or DO may need to be stored in a certain condition to maintain sensor accuracy. DO sensors have a membrane that requires storage in a humid environment when not in use; pH sensors require a humid environment for short term storage and soaking in a storage solution or pH 4 buffer for long term storage (**Section 10.7**). Accuracy typically decreases if these types of sensors dry out; sensors must be replaced or reconditioned if this occurs. See the appropriate manual for any reconditioning instructions.

7.0 INTERFERENCES

Field personnel should choose a location at the sampling site that is well mixed and representative of the waterbody before collecting information. Avoid collecting readings in slack or back water areas.

Some DO sensors (polarographic) require 5 to 15 minutes to warmup (YSI, 2009). Field personnel must turn on the meter for approximately 10 minutes before collecting data or calibrating.

Many EC sensors have a flow chamber that must have water flowing through to produce an accurate reading. An inaccurate reading may be reported if the sensor is not properly submerged or if bubbles have become trapped in the chamber.

8.0 PERSONNEL QUALIFICATIONS/RESPONSIBILITIES

Field personnel must be trained by experienced personnel and must demonstrate proficiency in all applicable field protocols as described in this SOP before collecting data in the field.

Field personnel must be able to troubleshoot any problems with a meter when in the field (e.g. replacing batteries or replacing sensors). Always keep a copy of the manual and appropriate user guides for troubleshooting when in the field.

9.0 EQUIPMENT AND SUPPLIES

Equipment and supply lists vary for each type of meter. Users must make sure that all required items are acquired before following the procedures in **Section 10**. General calibration and field check lists are listed here to cover the basic needs for these activities but may not be inclusive for all meters.

9.1 GENERAL CALIBRATION

- ❑ Meter and installed sensors
- ❑ Calibration/storage cup
- ❑ Necessary calibration buffer and solutions (EC, pH, turbidity)
- ❑ Manual

9.2 GENERAL FIELD

- ❑ Meter
- ❑ Sensor storage
- ❑ Sensor guard (if applicable)
- ❑ Power supply (batteries or charger)
- ❑ Case
- ❑ Calibration/maintenance log book
- ❑ Meter manual
- ❑ Air temperature thermometer
- ❑ Maintenance kit (if applicable)
- ❑ Calibration solutions (if calibrations are needed in the field)
- ❑ Collection vessel (for turbidity meter)

NOTE: If a calibration solution is taken into the field it is recommended to include the corresponding SDS.

Appendix B includes meter specific checklists for the following meters:

- YSI Professional Plus
- HACH 2100Q Portable Turbidity Meter

10.0 PROCEDURAL STEPS

All meters must be calibrated and tested before being used for data collection. Each type of meter make/model may have different methods for how to calibrate; however, general calibration guidelines will be described in this SOP. The YSI Pro Plus meter (Pro Plus) and Hach 2100Q turbidity meter (2100Q) will be used in this SOP as examples.

Many calibration processes require the sensors to be placed in a solution. To prevent contamination and dilution, the sensors should be prepared beforehand by cleaning and rinsing. The WQPB uses “rinse solution” as part of the rinsing cycle. “Rinse solution” is calibration solution that has been previously used for a calibration and is kept in a separate bottle marked “Rinse”. Once the solution has been used to rinse the sensors it should be properly disposed of; do not place rinse solution back into the rinse container after using it to rinse.

Any calibration process that requires sensors to be placed in a solution requires rinsing to remove the previous solution from the sensors and to prepare the sensors for the next calibration solution.

1. Ensure that the calibration/storage cup is clean.
2. Rinse the sensors with deionized water (DI).
3. Rinse cup and sensors twice with the corresponding rinse solution (marked “Rinse” on the bottle).

If doing a two-point calibration repeat steps 2 and 3 for the second calibration solution.

NOTE: Never accept a questionable calibration. If there are warning messages – stop calibrating and determine why there is an error. See the appropriate manual or calibration guide for any troubleshooting.

All calibration and maintenance procedures must be recorded in the appropriate Calibration/Maintenance Log Book (**Section 11.1**)

10.1 TEMPERATURE ACCURACY CHECK

- Accuracy Check Frequency: Annual before field season, and repeated if there is a concern for inaccurate data.
- Units: Degrees Celsius (°C).

Temperature sensors are not user-calibrated but must have the accuracy checked before continuing with other calibrations as it is a foundational field parameter that is necessary for other parameters to be reported accurately. There are two ways to ensure that a temperature sensor is reading accurately. Either in a stable water bath or in stable ambient air. All temperature check readings should be compared to a NIST approved thermometer.

To check the temperature accuracy the user needs to know where the sensor is located on the meter. Depending on the model of meter and the cable set up, the temperature sensor may be integrated into the cable. The WQPB uses a Pro Plus with a Quatro cable that has an installed combined conductivity and temperature sensor.

Using a water bath to check temperature readings is the preferred way to check for accuracy as it provides a stable medium for testing. A container (e.g. bucket, cooler, large beaker) that holds a sufficient amount of water as well as the meter's sensor is filled and left to equilibrate for at least 4 hours with the room's temperature. (Stirring the water occasional can prevent any concern for temperature stratification. Equilibrium is reached after the NIST approved thermometer readings are within +/- 0.1°C for 10 minutes. Multiple sensor readings are compared to a NIST approved thermometer over 10 minutes. The sensor is reading accurately if the readings are within the reported accuracy of the sensor (see the appropriate specification table for the sensor).

An ambient air temperature check can be used if a water check is unavailable (such as if in the field or if checking in the office). Leave the meter and a NIST approved thermometer on a table top for +30 min in a stable temperature environment and compare the readings once equilibrium is reached.

NOTE: The ambient air temperature check cannot be used with sensors that require a hydrated environment for storage (such as polarographic DO and pH sensors) as all sensors on the meter must be left in the same environment.

10.2 ELECTRICAL CONDUCTIVITY SENSORS

- Calibration Frequency: Monthly during field use
- Units: Specific Conductivity microsiemens per centimeter (µS/cm)

Electrical conductivity (EC) is temperature dependent and must be reported in specific conductivity that is temperature corrected to 25°C.

10.2.1 Electrical Conductivity Maintenance

If the EC sensor has flow cells, use a small wire brush to clean the flow cells before calibrating (YSI, 2019):

1. Rinse the maintenance brush in clean DI water.

2. Insert brush into each flow cell 10 to 12 times.
3. Rinse the flow cells with clean DI water.

Figure 1: Electrical Conductivity sensor flow cell

NOTE: If necessary, a mild detergent can be typically used to clean any deposits that have formed on the electrodes (YSI, 2010).

10.2.2 Electrical Conductivity Calibration

The calibration method for an EC sensor is typically a one-point specific conductivity (SC) calibration in a solution of 1,000 µS/cm, or the recommended fresh water value. It is possible in (specifically eastern) Montana to have to calibrate with a higher value solution that is designed for salt water applications if the waterbodies' conductivity is significantly higher than the fresh water calibration solution.

NOTE: Some meters may prompt the user to enter the calibration value as mS/cm and the user will have to convert µS/cm to mS/cm before calibrating (1,000 µS/cm = 1 mS/cm).

For the sensor to accurately measure the SC, the calibration cup must be filled sufficiently to cover the flow cell holes. Make sure that there are no bubbles in the flow cell chamber when calibrating.

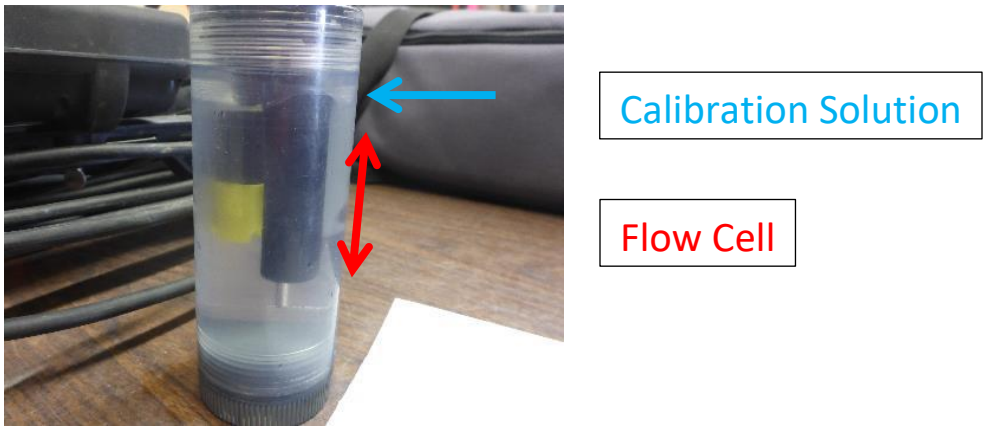

Figure 2: Electrical Conductivity sensor in calibration solution

After the calibration, check what the EC sensor is reporting in the same calibration solution to verify that it was calibrated. If necessary, investigate any problems with the calibration before using in the field.

10.3 pH Sensors

- Calibration Frequency: Monthly during field season with weekly accuracy checks
- Units: pH is a unitless parameter; pH millivolts = mV

pH is temperature dependent and is based on the voltage difference between a known hydrogen ion concentration contained in the sensor and in the sampled solution. The pH mV should always be recorded and interpreted when calibrated. When the mV readings begin to drift away from what they should be, it is an indication that the sensor should either be cleaned (the glass bulb is fouled and there is interference) or replaced (the inner sensor solution has degraded). The typical working life of a pH sensor is 12-24 months (YSI, 2010).

The acceptable pH mV outputs for the Pro Plus pH sensor in calibration solutions (YSI, 2010):

- pH 7 mV value = 0 mV +/- 50 mV
- pH 4 mV value = +165 to +180 from 7 buffer mV value
- pH 10 mV value = -165 to -180 from 7 buffer mV value

The mV span between pH 7 and either pH 4 or pH 10 is ideally 177 mV but can range from 165 to 180 mV (YSI, 2010). If the mV value is outside of that range, it indicates that the sensor either needs to be cleaned or replaced.

10.3.1 pH Maintenance

pH sensors must be kept in a humid environment at all times to preserve the solution in the sensor. See **Sections 10.7** and **10.9**.

Before calibrating:
Visually inspect the bulb for any damage or fouling before calibrating.

- **If damaged: replace the sensor**
    - Damage includes scratches, cracks, and broken bulbs.

- **If fouled: clean the sensor** (YSI, 2010)
    - Never apply pressure to the glass bulb, loosen the cotton from a cotton swab to avoid applying pressure.
    - If cotton swabs are not available, gently use a lint-free lab cloth (i.e., Kimwipe)
    - Remove the sensor from the cable. Soak the sensor 10 to 15 minutes in a clean tap water/dish soap solution.
    - Gently wipe the sensor with a moistened (tap water/dish soap solution) cotton swab to remove any collected material.
    - Rinse the sensor with clean tap water and wipe with a moistened (clean tap water) cotton swab.
    - Re-rinse with clean tap water.

If the sensor remains fouled or inaccurate other cleaning methods may be performed. See the appropriate user manual for more guidance.

Bubbles in the glass bulb are normal and do not interfere with the sensors readings. Bubbles can be removed by securely holding the sensor with the bulb facing up and flinging downwards. The goal is to force the bubble back into the sensor body.

10.3.2 pH Calibration

The calibration method for a pH sensor is a minimum two-point calibration with pH 7 buffer and either pH 4 buffer or pH 10 buffer. The second buffer solution should bracket the natural water's pH (either 7 to 4 or 7 to 10). pH 7 buffer must always be included. A three-point calibration may be used with 7, 4, and 10 pH buffers if the water's pH range is unknown.

NOTE: For the Pro Plus, the order of the calibration does not matter. It is recommended to use pH 7 as the second point. Other meter models may indicate a necessary calibration sequence

After the calibration is completed, check what the sensor is reading in pH 7 buffer to verify that it was calibrated. Investigate any problems with the calibration if necessary before using in the field.

10.4 Barometer Accuracy Check

- Accuracy Check Frequency: Annual before field season, and repeated if there is a concern for inaccurate data.
- Units: Millimeters of Mercury (mmHg).

Some meters have built in barometers and typically report the true barometric pressure. This is needed for accurate DO readings. Barometer readings should be verified against a local barometer (either from a lab or from a weather station) and calibrated as necessary.

One way to verify the true barometric pressure is to use the National Weather Service reports for station pressure at airports:

1. Visit (https://www.wrh.noaa.gov)
2. Search for the nearest city (example: Helena, MT)
3. Select "3 Day History" under "More Information" on the right.

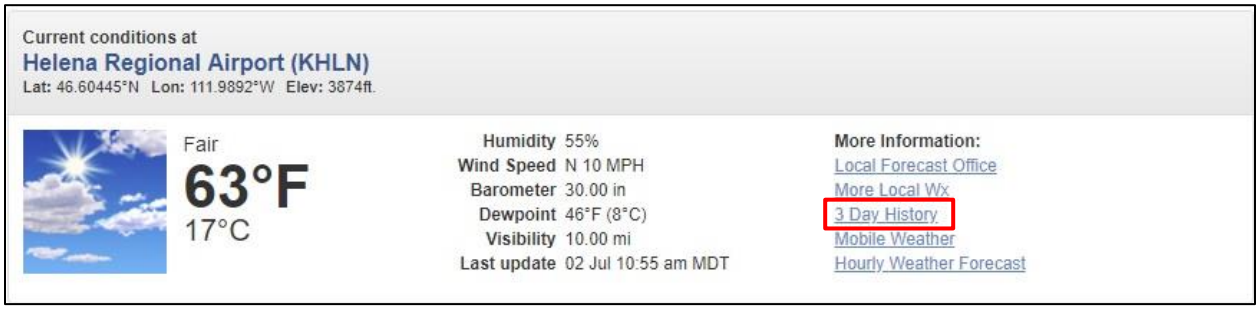

Figure 3: NOAA Helena Regional Airport Front Page (accessed 7/2/19)

That link will open a webpage with a table. One of the columns is titled "Station Pressure (inches)". Use this value when calibrating the meters barometer.

Date (MST)	Temp (F)	Dew Point (F)	Relative Humidity (%)	Wind Chill (F)	Wind Direction	Wind Speed (MPH)	Visibility (miles)	Clouds	Station Pressure (inches)	Sea Level Pressure (mb)	Altimeter Setting (inches)	1 Hour Precip (inches)	6 Hour Precip (inches)	6 Hr Max (F)	6 Hr Min (F)	24 Hr Max (F)	24 Hr Min (F)

Figure 4: NOAA Helena Regional Airport 3 Day History (accessed 7/2/19)

NOTE: The pressure in inches of mercury must be converted into millimeters of mercury before calibrating the meter's barometer

Table 1: How to convert to millimeters of mercury

1 inch of Hg =	25.4 millimeters of Hg
1 millibar of Hg =	0.02953 millimeters of Hg

At other locations, the barometric pressure may only be reported as "Sea Level Pressure." If this is the case, the data will need to be uncorrected before calibrating the meter's barometer. Use this equation to correct for the true barometric pressure (YSI, 2010):

True BP in mmHg = Corrected BP in mmHg – [2.5 * (Local Altitude in ft. above sea level/100)]

Where BP = barometric pressure, and Corrected BP = sea level pressure.

10.5 Dissolved Oxygen Sensors

- Calibration Frequency: daily in the field
- Units: milligrams per liter (mg/L) and percent saturation (%)

Dissolved oxygen (DO) is temperature, salinity, and barometric pressure dependent. Always calibrate a DO sensor with an EC sensor installed. There are multiple types of dissolved oxygen (DO) sensors. This procedure will cover how to use a polarographic sensor with a membrane cap such as the ones used on a Pro Plus.

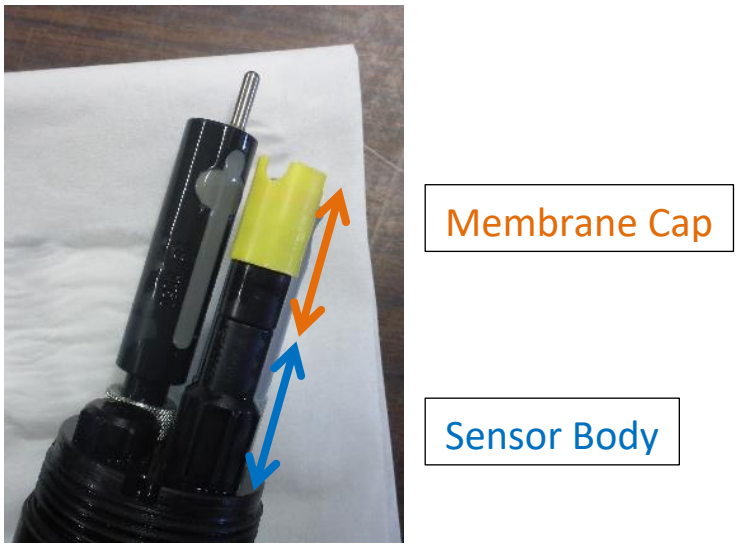

Figure 5: DO sensor and membrane caps

10.5.1 Dissolved Oxygen Maintenance

DO sensors must be kept in a humid environment at all times to preserve the membrane on the sensor. See **Sections 10.7** and **10.9** for storage procedures.

The membrane cap is filled with an electrolyte solution and is installed onto a sensor tip that has a gold cathode and silver anode. The membrane should be replaced once per month or if it meets one of the following situations:

- Bubbles are visible under the membrane,
- Dried electrolyte is visible, or
- Sensor readings are unstable.

How to Replace the sensor cap:

If applicable, make sure to check that sensor and membrane type are correctly entered into the DO sensor set up before replacing the sensor (**Appendix B**).

1. Remove sensor from the meter.
2. Unscrew the old membrane cap.
3. Rinse sensor tip with DI water.
4. Dry with a lint-free lab cloth (i.e., Kimwipe).
5. Inspect the condition of the gold cathode and silver anode.
    a. If the cathode or anode is heavily tarnished follow the mechanical cleaning process described in the manual (YSI, 2009).
6. Fill a new membrane cap with the electrolyte solution.
    a. Do not touch the membrane.
7. Lightly tap the side of the cap to release any trapped bubbles.
8. Thread the cap onto the sensor. It is normal for a small amount of electrolyte solution to overflow.

The WQPB keeps a bottle of premade electrolyte solution with the calibration solutions, and there are small bottles in the DO membrane kits if a replacement is needed in the field. Follow the instructions on the bottle to prepare the electrolyte solution.

10.5.2 Dissolved Oxygen Calibration

Follow the manual or guide's instructions on how to calibrate the DO sensor. YSI recommends calibrating DO % using the Water Saturated Air method (YSI, 2009). Calibrating in % will also calibrate mg/L.

The WQPB uses a polarographic sensor, which means that there is an approximately 15-minute warmup time. The Water Saturated Air method also requires time for the water to saturate the air when calibrating.

To calibrate the DO sensor with the Water Saturated Air method:

1. Ensure the calibration/storage cup is clean. Bacterial growth may consume oxygen and interfere with the calibration (YSI, 2010).
2. Place a small amount of clean tap water in the cup (1/8 inch).
3. Gently dry the DO membrane and temperature sensor with a delicate task wipe (i.e., Kimwipe).
    - Do not damage the membrane when drying.
    - Make sure that there are no droplets of water on the membrane or the temperature sensor.
4. Screw the sensors onto the cup and then disengage 2 threads to ensure atmospheric venting.
    - Make sure that the DO membrane and temperature sensor are not submerged in the water.

5. Turn the meter on and wait approximately 15 minutes for the water to saturate the air and for the sensors to stabilize.
6. Accept calibration.

If the meter or container is disturbed and water is splashed onto the membrane or temperature sensor, start the calibration processes over again, including the 15-minute wait time. If necessary, investigate any problems with the calibration before using in the field.

10.6 FIELD TURBIDITY METERS

Calibration Frequency: every 3 months
Units: Nephelometric turbidity units (NTU) or formazin nephelometric units (FNU)

Turbidity is a measurement of light bouncing off particles in a solution. The type of light source and the collected light refracting angle determines the type of unit that the result has. Tungsten filament lamp light produces results with NTU, whereas LED lamp light produce results with FNU. The conversion rate between the NTU and FNU is 1:1.

Some meters may have optical turbidity sensors that use an LED lamp. Field benchtop meters typically use a tungsten filament lamp source but can use an LED lamp. This procedure will discuss how to collect turbidity data using a benchtop meter, using the HACH 2100Q turbidity meter as an example.

10.6.1 Turbidity Meter Maintenance

Use a slightly damp cloth or dust/lint free cloth to clean the exterior surface of the meter. If necessary, a mild soap solution can be used on the exterior surface (Hach, 2017).

Sample cells and caps need to be kept clean and free from any scratches. A silicone oil is provided to mask any minor scratches in the glass. See the manual on how to properly apply the silicone oil.

NOTE: It is important to use the provided silicone oil with the sample cells as the refractive index has been matched by the manufacturer (Hach, 2017).

Sample cells are to be stored with DI water in them, the insides should not be left to dry. The outsides of the sample cells should be dried with a soft cloth (Hach, 2017).

See the appropriate manual for any additional maintenance that may be needed.

10.6.2 Turbidity Meter Calibration

The calibration process for a portable turbidity meter may differ based on manufacturer and model. The 2100Q recommends using StablCal® prepared calibration cells (shelf life ~ 1 year) or user-prepared formazin standards to calibrate the meter every 3 months. The calibration is a 3-point calibration of 20, 100, and 800 NTU. The calibration process is simple and described in the manual. The meter should be verified with 10 NTU after each calibration.

10.7 METER SHORT-TERM STORAGE

There are typically two types of storage for a meter: short-term and long-term storage. Storage conditions should be described in the meter's manual or guide. See **Appendix B** for storage conditions for the Pro Plus and the 2100Q meters.

Short-term storage should be used during the field season when the meter is being regularly used. Long-term storage should be used if a meter is not being used within the next 3 months (**Section 10.9**).

Some sensors such as pH and DO require a humid environment (~1cm of tap water in the provided sensor storage cup) to maintain accuracy and should not be allowed to dry out. If one of these sensors dries out, then either it will need to be reconditioned or replaced.

NOTE: See the appropriate manual for any reconditioning instructions.

Field benchtop turbidimeters typically have a case that the meter, sample cells, and calibration cells are kept in.

10.8 USING A METER IN THE FIELD

Make sure to do the monthly, weekly, or daily calibration before beginning field sampling.
Turbidity meters are calibrated every 3 months and verified weekly. See **Table 2** for the weekly and monthly requirements for EC, pH, and DO sensors.

Table 2: Pro Plus Weekly and Monthly Calibrations and Checks

Weekly Calibrations and Checks	Monthly Calibrations and Checks
Check pH 7 reading, Calibrate if not reading within the sensors accuracy (For a Pro Plus pH sensor it is +/- 0.2 pH units) Calibrate DO daily in the field	Replace the DO sensor membrane Calibrate EC, pH and DO sensors

Meter readings are collected in the field at the time of chemical sampling activities. It is important that other chemical sampling activities (water sampling or benthic sediment sampling) do not interfere with meter readings (e.g. collecting readings in the path of stirred of sediment from water sampling).

Field personnel are responsible for maintaining the meter during the field season. When collecting measurements in the field, the site locations will be specified in the project SAP. Field personnel are responsible for locating a well-mixed location to record a reading. Avoid collecting readings in slack or back water areas.

10.8.1 Sampling with a pen or cabled meter (T, EC, pH, and DO)

When field personnel arrive at the site:

1. Turn on the meter and leave it in a shaded area for at least 12 minutes for the DO sensor warmup.
    a. If there is a storage cup, unscrew a few threads to vent sensor to atmosphere.
2. Screw the sensor guard onto the sensor (if applicable).

3. Submerge the sensors in the water and shake vigorously to remove any air bubbles that may interfere with sensor readings.
4. Position the sensors perpendicular to flow.
    a. Hold pen meters in the flow so that the screen is visible and results can be read.
5. Make sure that there are no obstructions upstream of the probe (i.e., rocks, macrophytes, debris).

If water is not flowing past the sensors and an alternate location with laminar flow is unavailable, gently move the probe from side to side to circulate the water around the probe.

6. Allow the sensor to stabilize. Readings should not be consistently increasing or decreasing.
7. Record the appropriate readings onto the Site Visit Form (see **Section 11.1**).
8. Inspect sensors and clean off in the stream or with clean tap water before storing.

NOTE: Replace the water in the storage cup with clean tap water when the water becomes fouled.

10.8.2 Sampling with a turbidity meter

When field personnel are ready to collect a turbidity reading:

1. Place the turbidity meter on a stationary level surface, avoiding direct sunlight.
2. Turn on the meter.
3. Collect a representative sample with a clean collection vessel.
4. Fill a clean sample cell with the sample.
5. Wipe the outside of the sample cell with a lint free cloth to remove water spots and fingerprints.
    a. Take care not to add fingerprints to the sample cell by handling the sample by the cap.
6. Apply a thin film of the provided silicone oil as described in the manual.
7. Gently invert the sample to ensure the sample is homogenous.
8. Place sample cell in the compartment so that the orientation marks align with the meter.
9. Push the Read button.

The turbidity result will be displayed after the sample is analyzed and will be stored on the meter.

10. Remove the cell.
11. Empty the cell.
12. Rinse and fill the cell with DI water.
13. Dry the outside of the cell with a lint free cloth.

10.9 METER LONG-TERM STORAGE

After the field season is complete and sampling will not be occurring on a semi-weekly basis, the meter can be put into long-term storage. These processes should be described in the appropriate user manuals, but is typically done by following these steps:

10.9.1 Storing a handheld meter (T, EC, pH, and DO)

1. Inspect and clean the meter and sensor bodies with tap water.
2. Clean the storage case.
3. Remove the Temp/EC sensor.
    a. Store securely.
4. Remove the pH sensor.

   a. Place the pH sensor in the provided small storage cup with storage solution or pH 4 buffer.
5. Remove the DO sensor.
   a. Leave the membrane cap on the DO sensor. The membrane cap will need to be replaced for the next field season but leaving it on for the long-term storage will protect the sensor tip.
6. Remove the batteries from the meter.
7. Store meter and sensors in case.

10.9.2 Storing a turbidity meter

1. Inspect and clean the meter and case
2. Inspect the sample cells, fill with DI water
3. Inspect calibration vials for expiration date
4. Store meter, sample cells, and calibration vials in the case

NOTE: Remember to record all weekly and monthly calibrations and any maintenance in the corresponding Calibration/Maintenance Log book (**Section 11.2**).

11.0 DATA AND RECORDS MANAGEMENT

All hardcopy documentation of the data, such as completed Site Visit Forms, are kept and maintained by the Water Quality Planning Bureau. Data collected will be reviewed, verified, and stored based on the WQPB Quality Control and Quality Assurance procedures (**Section 12.0**) and the Quality Assurance Project Plan (QAPP) for the project.

All calibrations, checks, and maintenance are to be recorded in the Maintenance/Calibration Log Book.

11.1 RECORDING ON SITE VISIT FORM

Field personnel are to record the meter's readings on the Site Visit Form in the Field Measurement section after the readings have stabilized. An example of a Site Visit Form is available in **Appendix A**.

Field Measurements		Time: am pm
Water Temp: °C °F		Air Temp: °C °F
Bar. Pressure: mm/Hg		SC: uS/cm
pH:	DO: mg/L	Turbidity: NTU
Turbidity: Clear ☐ Slight ☐ Turbid ☐ Opaque ☐		
Flow: ft3/sec (Dry Bed ☐ Stranded Pools ☐)		
Meter ☐ Meter-Auto ☐ Float ☐ Gage ☐ Visual Est. ☐		

Figure 6 The Field Measurements section

Field personnel must remember to:

- Record the time of the reading and circle am or pm; the time of readings should not be the same time as the site arrival time recorded at the top of the form,
- Circle the correct units where needed (°C or °F),
- Record all field meter values, and
- Make a visual assessment of the water's turbidity and circle either clear, slight, turbid, or opaque.

The visual assessment of turbidity must always be completed, and if a turbidity NTU measurement was not collected, leave "Turbidity: _____ NTU" blank.

11.2 MAINTENANCE/CALIBRATION LOG BOOK

Field meters should have a water-resistant maintenance/calibration log book dedicated to that meter. Each log book must include the manufacturer, model, and serial number of the meter to distinguish it from other meter's log books. All maintenance (i.e., battery replacement, cleaning, sensor replacement) and weekly/monthly calibrations must be recorded in the equipment's log book.

Each entry in the log book must include:

- Who did it (personnel must initial).
- When it was done (date of calibration).
- What was done (i.e. calibrations, battery replacement, repairs, cleanings, and any corrective actions).
- Any relevant information (e.g. batteries leaked and damaged circuitry).

If a calibration was done, include:

- What calibration was done (the calibration type, number of points).
- What solution was used (manufacture, type, and lot number).
- What temperature the calibration was done at.
- Record the post calibration reading and units.
- Note if the meter passed or failed the calibration.

NOTE: It is important to be efficient with space when using a log book. Someone should not be able to come back and modify a previous entry. When possible, use appropriate pens and markers to prevent erasure.

Site calibrations (such as DO) that are recorded on the back of SVFs are not required to be recorded in the log book. If field personnel conduct any additional calibrations or maintenance in the field, all actions should be recorded in the log book.

12.0 QUALITY CONTROL AND QUALITY ASSURANCE

It is the responsibility of the field personnel to collect good and accurate data at the time of collection, and that forms are properly filled out and that the information is recorded correctly.

All equipment users must be familiar with the equipment and be able to troubleshoot common problems in the field. Routine inspections and repairs (or notification of need for repair) are necessary to ensure quality of collected data. It is up to the user to be thorough with observations and quick with repairs or notifications. Otherwise, loss of data may occur.

All equipment must be checked and verified before field use. Field personnel are to follow the monthly, weekly, and daily calibration schedule. See **Table 2** in **Section 10.8**. All calibrations, checks, and maintenance are to be recorded in the Maintenance/Calibration Log Book.

13.0 REFERENCES

Hach Company. 2017. 2100W and 2100Q*is* User Manual Edition 4. Loveland, CO.

Makarowski, Kathryn. 2020. Standard Operating Procedure for Field Data Collection Activities. WQDWQPBFM-01, Version 1.0. Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau.

Montana Department of Environmental Quality (DEQ). 2016. Waterborne Operations Procedure. Central Services Division. Document number DEQ-OP-SF-10.01. Effective September 6, 2016.

National Oceanic and Atmospheric Administration (NOAA). "National Weather Service Glossary." National Weather Service. Accessed July 2, 2019. https://weather.gov/glossary

YSI Incorporated (YSI). 2009. YSI Professional Plus User Manual. Rev D. Yellow Springs OH.

YSI Incorporated (YSI). 2010. YSI Professional Plus Calibration Tips. Rev A. Yellow Springs OH.

APPENDIX A – FIELD FORM

This example Site Visit Form gives a general idea of the format used by the WQPB. Project-specific Site Visit Forms are created to reflect specific documentation requirements and project IDs.

Place Site Visit Label Here

Site Visit Form

Project ID:____________________

Date: ______________ **Time:** ____________ **Personnel:** ____

Waterbody: ____ Location: ______________________________________

Station ID: ________________ HUC: _____________ County: _________________ AUID: _______________

Latitude: __ __ . __ __ __ __ __ __ Longitude: __ __ __ . __ __ __ __ __ __ Elevation: __________ ft m

Field Duplicate to ☐ Field Blank ☐ Trip Blank ☐ Field Equipment Blank ☐

Samples Collected		**Sample ID**	**Sample Collection Information/Preservation**
Water	☐		GRAB EWI BACT
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Analysis:			0.45µ Filtered | HNO_3 H_2SO_4 H_3PO_4 HCL | Ice Frozen
Sediment	☐		SED-1
Analysis:			Preserved: None Other:
Benthic Chl-a	☐		Sample Method: C=Core H=Hoop T=Template N=None
Composite at Lab ☐ AFDW ☐ Visual Est. <50 mg/m2 ☐			Sample Location: R=Right C=Center L=Left
Transect: A__-__ B__-__ C__-__ D__-__ E__-__			F__-__ G__-__ H__-__ I__-__ J__-__ K__-__
Phytoplankton Chl-a	☐		D1 Filtered:_________mL D2 Filtered:_________mL
Phytoplankton CNP	☐		CN Filtered:_________mL P Filtered:_________mL
Algae	☐		PERI-1-MOD PERI-1 OTHER:
Macroinvertebrates	☐		MAC-R-500 OTHER: # of Jars:

Field Measurements	Time: am pm	**Field Assessments**
Water Temp: °C °F	Air Temp: °C °F	Photos ☐ Aquatic Plant Visual Assessment ☐ SAM ☐
Bar. Pressure: mm/Hg	SC: uS/cm	Aquatic Plant Tracking ☐ Rosgen ☐ NRCS ☐
pH: DO: mg/L	Turbidity: NTU	EMAP ☐ Total Discharge ☐ Channel X-Section ☐
Turbidity: Clear ☐ Slight ☐ Turbid ☐ Opaque ☐		Wetland ☐ Bacteria ☐ Other:
Flow: ft3/sec (Dry Bed ☐ Stranded Pools ☐)		Only Transect F ☐ Total Site Length__________m
Meter ☐ Meter-Auto ☐ Float ☐ Gage ☐ Visual Est. ☐		Transect Length______m Average Wetted Width______m

Data Loggers	
	Temperature ☐ YSI ☐ MiniDOT ☐ EC ☐ TruTrack ☐ AquaRod ☐ Weather Station ☐
	Deployed ☐ Cleaned/Checked ☐ Retrieved ☐

Chemistry Lab Information		
Lab Samples Submitted to:	Account #:	Term Contract Number:
Invoice Contact:		
Contact Name & Phone:		EDD ☒ Format: MT-eWQX Compatible
1) Relinquished By & Date/Time:	1) Shipped By: Hand ☐ FedEx/UPS ☐ USPS ☐	1) Received By & Date/Time:
2) Relinquished By & Date/Time:	2) Shipped By: Hand ☐ FedEx/UPS ☐ USPS ☐	2) Received By & Date/Time:

Lab Use Only - Delivery Temperature: Wet Ice______°C Dry Ice______°C

Rev. 3/6/2019

APPENDIX B – EQUIPMENT HELP SHEETS

These sheets are to help personnel prepare equipment for the field and for use in the field.

- YSI Pro Plus Setup
- YSI Pro Plus Field Help
- Hach Turbidimeter 2100Q Setup and Field Help

If the equipment is calibrated or has maintenance done record this information in Equipment Calibration/Maintenance Log book:

- Date (when it happened)
- User (who did it)
- What was done (i.e. battery change, zero check and adjust, battery removal)

NOTE: Users should reference the appropriate user manual whenever necessary.

YSI PRO PLUS SETUP

- 2 C Batteries (Approx. 80 continuous working hours) – requires Philips head screwdriver.
    - If batteries are changed within <2 min of power loss, date and time will not be erased. If the meter has been without battery power for more than 2 minutes (or dead batteries have been left in the meter) the date and time will have to be re-entered. Press "ESC" after date and time have been entered.

When Installing Sensors onto Quatro Cable:

- Ports must be dry
- O-rings are clean, undamaged, and lightly greased:
    - Too much grease means grit will stick and damage the O-rings
- Finger-tighten all sensors:
    - DO and pH sensor white O-rings must not be visible.
    - Do not force sensors (will cause threads to strip).
    - Use metal tool on the final 2-3 turns of the EC/T sensor.
- Use yellow membrane caps (1.25 mil polyethylene) for DO sensors.

Installing Sensors onto Quatro Cable

Install in this order (1→4), remove in reverse order (4→1)

1. Port 2: Port Plug
2. DO Port: DO sensor only
3. Port 1: pH
4. CT Port: Conductivity and Temperature sensor only

Setting Up the Meter:

"Probe" Button

- Setup: Where user tells handheld what sensors are installed
    - DO: Enabled, and list the correct Sensor and Membrane type
    - EC: Enabled
    - ISE1: Enabled, Select pH [USA]
    - ISE2: OFF (unless an additional sensor is installed)
- Display: Where user tells handheld what units to display on the dashboard
    - Temperature: °C
    - DO: DO% and DO mg/L
    - Conductivity: Sp. Conductance, SPC-uS/cm
    - pH: pH and pH mV
    - Barometer: mmHg

"File" Button

- View Data: If data is logged on the Dashboard it can be viewed later.
    - Find the data by narrowing the selection by selecting the Site, Folder, Begin Date/Time, or the End Date/Time. Not all filters are needed but help when looking for a specific collection.
    - Select "Show Data" when ready
    - Each Date and Time collection will show on one row. Scroll up and down until the correct line is found.
    - Scroll to the right and left to view the data file
    - There is a maximum limit of 100 data records being shown at one time.

- Site List
    - New sites can be added, and existing sites can be edited
    - It is recommended to use a short-hand description of the site or the Station ID as a Site Name
- Folder List
    - New folders can be added, and existing folders can be edited
    - It is recommended to create folders based on project and per trip: "Smith050819"
        - This way all data collected for that trip can be viewed at once by selecting the folder.
- Dashboard – Logging Data
    - "Log One Sample"
    - Select "Site" and "Folder" as necessary
    - Select "Log Now!"

CALIBRATION PROCEDURES

4. Ensure that the calibration/storage cup is clean.
5. Rinse the sensors with deionized water (DI).
6. Rinse cup and sensors twice with the calibrating solution that is marked "Rinse".

    Rinse Solution: Calibration solution that can be only used for rinsing the meter. Bottles of this type of solution are marked "Rinse".

If doing a two-point calibration repeat steps 2 and 3 for the second calibration solution.

Calibration Errors – NEVER accept a calibration that is reporting an error.

Decline the calibration if an error is reported. Check if the cup is clean, the expiration date of the solution, and sensor condition. Recalibrate. If an error persists, check the troubleshooting section of the manual (pg. 68).

Calibration Sequence

Press "Cal" → select the sensor type to calibrate → select type of calibration → follow calibration steps → ensure that calibration value is correct → wait for stabilization → select accept calibration → repeat if necessary → press "Cal" to complete the calibration. "Esc" button cancels the calibration.

Calibration: pH (manual pg. 38)

- Calibrate with a 2-point calibration. (Buffer solutions should bracket the natural water (either 4 to 7 or 10 to 7). pH 7 buffer must always be included.)
- Follow the Calibration Sequence.

The order of the solution does not matter for the Pro Plus. It is recommended to use pH 7 as the second point.

Maintenance: pH (manual pg. 64)

- **If the bulb is damaged: replace the bulb** (Damage includes scratches, cracks, and broken bulbs.)

NOTE: Bubbles in the glass bulb are normal but should be removed before calibrating. Hold the sensor bulb up and fling downwards to the ground to remove the bubble from the glass bulb.

- **If the bulb is fouled: clean the sensor**
    - Never apply pressure to the glass bulb, loosen the cotton from the swab to avoid applying pressure.
    - If cotton swabs are not available, gently use a lint-free lab cloth (i.e., Kimwipe)
    - Remove the sensor from the cable. Soak the sensor 10 – 15 minutes in a clean tap water/dish soap solution.
    - Gently wipe the sensor with a moistened (tap water/dish soap solution) cotton swab to remove any collected material.
    - Rinse the sensor with clean tap water and wipe with a moistened (clean tap water) cotton swab.
    - Re-rinse with clean tap water.

Calibration: Conductivity (manual pg. 36)

- Calibrate specific conductivity with a 1-point calibration (1,000 uS/cm Standard)
- Clean the flow cells of the conductivity sensor before calibration (use lab soap if necessary).
- Dip the maintenance brush into clean water and insert it into each flow cell hole 10 to 12 times.
- Rinse the flow cells with clean water. Use the brush to scrub the temperature sensor (manual pg. 64)
- Follow the Calibration Sequence.

Maintenance: DO (manual pg. 60)

- Replace the membrane if needed:
    - Once a month
    - Dried electrolyte is visible.
    - Bubbles are visible under the membrane
    - Sensor is unstable.
- Remove sensor from cable → Unscrew the old membrane cap → rinse sensor with DI water → inspect the condition of the gold cathode and silver anode. If heavily tarnished, follow the mechanical cleaning process in the manual (pg. 61). A sanding disk should be in the membrane replacement kit.

Do not touch the membrane

- Fill a new membrane with KCl solution. Premade solution is located with calibration solutions.
    - If needed to replace a membrane in the field, there are small bottles in the membrane kits. Fill the bottle with DI water (never tap water).
- Lightly tap the side of the cap to release any trapped bubbles.
- Thread the cap onto the sensor; it is normal for a small amount of electrolyte solution to overflow.

Calibration: DO (manual pg. 21)

- Use DO % in Water Saturated Air method (pg. 27)
- Ensure calibration/storage cup is clean.
- Place a small amount of clean tap water in the cup (1/8 inch)
- Ensure DO membrane and temperature sensor are dry.
- Screw the cable onto the cup and then disengage 2 threads to ensure atmospheric venting. The DO membrane and temperature sensor are not to be immersed in water.
- Turn the Pro Plus on and wait 15 minutes for the container to saturate and for the sensors to stabilize.
- Follow the Calibration Sequence.

YSI PRO PLUS FIELD HELP

Field Check List

- ❑ Pro Plus (handheld, cable, sensors, and case)
- ❑ Maintenance/Calibration Log Book
- ❑ Replacement C Batteries (2 are required)
- ❑ Replacement DO membrane kit (YSI 5908)
- ❑ Screwdriver (Philips, longer shaft)
- ❑ Calibration/Storage cup
- ❑ Sensor guard
- ❑ Air Temperature thermometer
- ❑ Calibration solutions (Project based)
- ❑ Cable organizer (Optional)
- ❑ Manual
- ❑ Kimwipes for DO calibration
- ❑ Maintenance Kit:
  - Grease
  - Sponge
  - Conductivity brush
  - EC/T sensor tool
  - O-rings, White: **For port plugs & sensors**
  - O-rings, Black: **For EC sensor**
  - Port Plug(s)

Weekly Calibrations and Checks	Monthly Calibrations and Checks
Check pH 7 reading, Calibrate if not reading within the sensors accuracy (For a Pro Plus pH sensor it is +/- 0.2 pH units) Calibrate DO daily in the field	Replace the DO sensor membrane Calibrate: Conductivity, pH and DO sensors

FIELD USE

Turn on the meter 10 minutes before recording a DO reading. Unscrew a few threads of the storage cup to vent to atmosphere and leave in a shaded area.

When ready to sample, screw on metal guard and place meter in stream so that the sensors are perpendicular to the flow. Wait for reported results to stabilize before recording a reading.

Collecting data in the field (manual pg. 53)

Sites can be created for each Station ID and folders can be created for each sampling trip.

Creating a Site:

File → Site List → New Site: Enter Name/Choose Site: Edit or Delete
File → Folder List → New Folder

Log Information:

Dashboard: Log Now! → Choose Site and Folder → Select "Log Now!" To save data

View Data:

File → View Data → filter by Site, Folder, Date/Time → Select "Show Data"
Rows are Date and Time of logs. Additional data is seen by scrolling to the right.

Display Screen Contrast (manual pg. 11)

Press backlight key and the left (lighter) or right (darker) arrow at the same time repeatedly.

HACH TURBIDIMETER 2100Q SETUP AND FIELD USE

Hach Turbidity Meter Field Check List

- ❑ Turbidity Meter
- ❑ 4 AA batteries
- ❑ Case
- ❑ Oil and cloth
- ❑ Sample cells
- ❑ Calibration cells
- ❑ Sample collection vessel

Batteries: 4 AAs, meter will power off after 10 minutes of inactivity.
Backlight: The backlight can be adjusted with the buttons located on the left side of the meter.

Sample IDs can be created for each Station ID under the Settings (Wrench Button) Menu. Sample IDs will have to be selected from the same menu before a sample is measured.

General Use:

- All readings must take place on a level stationary surface.
- Handle all cells by the cap
- It is important to match the arrows on the indexed calibration and sample cells to the arrow on the meter. See the manual (Pg. 17) for information on how to index additional sample cells.
- The sample compartment lid will click into place when properly closed.
- Clean and oil all cells before use (Pg. 11).
- Sample Cells are to be stored with DI water, cap on, and the outside dried with a soft cloth. Never let air dry.

Calibrate: Every 3 months and verified weekly.
Calibration is done with premade sealed cells of Hach StablCal® turbidity standards. Cells are to be gently inverted to redistribute the polymer in the solution until there is a homogenous mixture before using for calibration or verification (Pg. 13)

The calibration includes reading the 20, 100, and 800 NTU cells. The calibration is verified with the 10 NTU cell after calibration.

For samples up to 40 NTU the RapidCal setting can be used with the 20 NTU cell. The calibration is verified with the 40 NTU cell after calibration.

Reading Modes:

- Signal Average: 12 measures, good for homogenous samples of low turbidity that have a low settling rate.
- Rapidly Settling Turbidity (RST): Calculates and continuously updates to a confidence of 95%; only use for samples that are initially homogenous when starting to measure but have a rapid settling rate.

Data Management Menu:

Stores all readings, calibrations, and verify calibration Logs. Stores readings, date and time.

See the manual for any reported errors (pg. 22, Troubleshooting).