Standard Operating Procedure

Small Water Quality Dataloggers

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Water Quality Planning Bureau

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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
May 2020	1.0	Initial document	All	Elizabeth McWilliams and Alan Nixon

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ACRONYMS

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

1.0 Purpose

This document describes the Montana Department of Environmental Quality (DEQ) Water Quality Planning Bureau (WQPB) Standard Operating Procedure (SOP) for maintaining and deploying small dataloggers. This equipment type collects continuous data for one or two predetermined parameters (i.e. temperature, electrical conductivity, and dissolved oxygen). This SOP covers pre-deployment checks, deployment considerations, field maintenance, data processing, and how certain dataloggers (Onset HOBO and PME miniDOT dataloggers) are launched and off loaded.

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 authors or by DEQ.

2.0 Applicability

Small dataloggers are deployed by the WQPB to collect continuous data for the following parameters: temperature, electrical conductivity, and dissolved oxygen. Dataloggers can be deployed in wadable streams, lakes, reservoirs and some large, non-wadable rivers. This SOP will present some deployment considerations based on waterbody location in **Sections 10.3 – 10.5**.

2.1 Deployment Timeframe

The maximum length of time and period of the year that a small datalogger can be deployed depends on the type of datalogger.

NOTE: Always check the specification table and user guides for any deployment restrictions before deploying a datalogger.

Temperature-only dataloggers can be deployed for whole field seasons without any periodic checking or cleaning needed. Typically, mid-June through late October deployment characterizes when thermal conditions reach annual highs (summertime) and if there are any extended periods of thermal stress that may affect aquatic life populations. Some fish species (i.e., bull trout) require a cold temperature to trigger fall spawning activity, which may require monitoring into November. Deployment planning must consider the timing of the runoff period for the waterbodies, and that the retrieval may be under relatively high stream stage conditions following the end of the irrigation season.

Electrical conductivity (EC) dataloggers can be deployed for whole field seasons as well but do require field personnel to periodically check and clean the sensors. EC dataloggers can be deployed at any time during the year and salinity studies may need to include year-round EC data collection for characterization purposes. EC data during the irrigation season is typically of particular importance for evaluating agricultural water use.

Dissolved oxygen (DO) dataloggers can be deployed for periods ranging from five days to a month or more (Suplee and Sada de Suplee, 2014). The timing of the deployment should typically occur during the aquatic plant growing season and include the period when the highest standing crop occurs.

Lake or Reservoir deployments for all datalogger types should generally begin in late May and continue through October.

3.0 METHOD SUMMARY

All temperature-based dataloggers undergo a temperature accuracy check before and after deployment. This verifies that the datalogger has recorded accurate temperature data in the field.

The methods used to deploy a datalogger will depend on the project objectives, the type of datalogger, and the waterbody conditions. Periodic field cleaning and measurements are needed for EC dataloggers, but are not needed for temperature-only dataloggers. Dissolved oxygen dataloggers may require periodic cleanings in the field.

After dataloggers are retrieved, the data needs to be off-loaded and checked for any errors or drift.

3.1 TEMPERATURE INFORMATION

Daily temperature diurnal cycles occur in all-natural waters. The daily amplitude of intra-day temperature variation (lowest to highest values) can range as high as 15°F or more.

When programing the temperature dataloggers, remember that the duration of the daily maximum is often quite short. It is important that the true, or very near the true, daily value is captured by the datalogger.

Figure 1 shows the plotted temperature data (°F) for a four-day period on the West Fork Madison River, to illustrate the diurnal curves in the data. The daily temperature variation is about 14°F. Judging by the cluster of data points near the daily highs, it appears that the actual maximum temperatures were very close to the recorded maximums using 30-minute logging intervals.

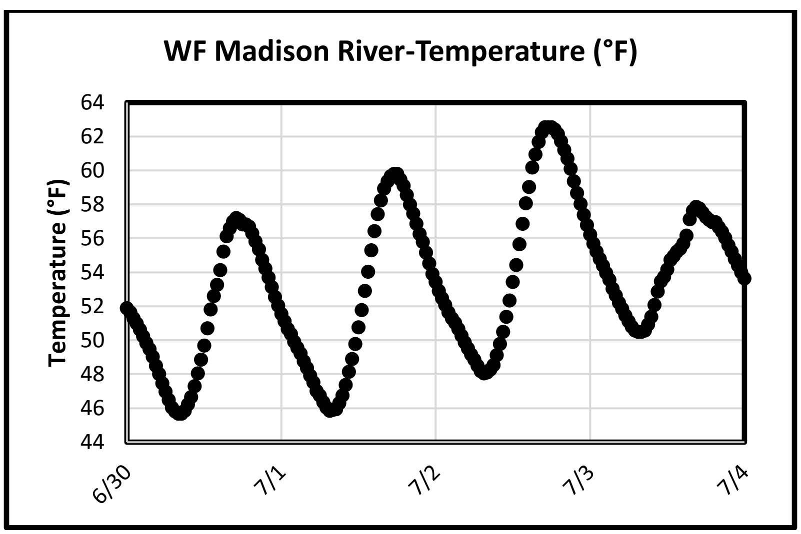

Figure 1. Temperature data recorded at one-half hour intervals.

3.2 Electrical Conductivity Information

The actual electrical conductivity (EC) of a solution is based on the temperature and ion concentrations in the solution. Specific conductivity (SC) is the EC value that has been corrected to a certain temperature (25°C) so that data at different temperatures are comparable. It is normal for a datalogger that measures EC to also be able to report SC.

3.3 Dissolved Oxygen Information

Aquatic plants, including algae, produce oxygen during photosynthesis, thereby boosting daytime dissolved oxygen (DO) levels. The plants continue to use oxygen for respiration during nighttime and other low-light periods. Daily maximum and minimum DO results are used to determine daily DO deltas. When high aquatic plant productivity occurs, daily DO delta values are elevated due to high daytime DO and low DO at night. The low DO period may impact fish and aquatic life.

4.0 Definitions

Accuracy check: A pre- and post-field season deployment verification that the datalogger is operating correctly.

Deploy: Placing the datalogger at the study site.

HOBO U22 Dataloggers: A temperature only datalogger from Onset Corp.

HOBO U24 Dataloggers: An electrical conductivity and temperature datalogger from Onset Corp. Measures actual conductivity, temperature, and calculates specific conductivity at 25°C.

HOBOware: Software used to launch and readout Onset dataloggers. The Pro version is required for all HOBO U24 use.

Launch: Setting the interval, data, and time of data collection on the datalogger.

MiniDOT: A dissolved oxygen datalogger from PME. Measures dissolved oxygen and temperature.

Readout datalogger: The process of transferring the data from the datalogger to another device, a computer primarily, but sometimes a USB drive.

5.0 Health and Safety Warnings

Field personnel should be aware of job hazards associated with collecting datalogger data that could result in personal injury or loss of life. Driving, boating, wading, and tool use 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. Some projects may require using boats to deploy the dataloggers. DEQ field personnel should review the Water Quality Division Job Hazard and Analysis form and the Waterborne Operations Procedure before collecting data (DEQ, 2016).

Additional caution should be used when deploying dataloggers as different types of hand tools may be used during the process (e.g., wrenches, screwdrivers, hammers/mallets) and injury may occur if tools are used incorrectly.

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. Maintain appropriate equipment care and maintenance (e.g., batteries, sensor cleanings, firmware updates, o-ring or other seal replacement).

6.1 BATTERIES AND EQUIPMENT MEMORY

Many types of small dataloggers do not have a user-replaceable battery, whereas some dataloggers do. If the user is not able to replace a failed battery, contact the appropriate company for replacement options.

Retrieve and readout any equipment that may be approaching the end of its suspected battery life. If applicable, batteries must be removed from the datalogger when not in use.

For Onset dataloggers, the HOBOware software shows a good/bad battery icon and an approximate battery life when a datalogger is launched. The approximate battery life indicates the available memory space on the datalogger, not how long the battery will last. HOBO U22-001 temperature loggers have a 6-year battery life with 1-minute or greater logging intervals. All Onset HOBO dataloggers are designed to stop collecting data when the memory is full.

NOTE: Hold the HOBO U22 EC Datalogger by the main body, not by the sensor end. Holding this datalogger by the sensor end and twisting may open the compartment. Opening the datalogger voids all warranties.

The miniDOT memory capacity is very high, however the battery life is the limiting factor on how long a datalogger can be deployed to collect data. The battery life will begin to suffer and decrease faster with multiple files on the datalogger, it is recommended to readout the files to a computer when available and delete them from the datalogger (PME, 2014). The batteries are user replaceable (2-AA batteries). PME recommends Energizer L91 AA size lithium batteries or Duracell AA size alkaline batteries. Alkaline batteries will not last nearly as long, especially at low temperatures, but will likely be adequate for several weeks at a 10-minute logging interval. The batteries should be replaced when the reported battery voltage nears 2.4 Volts. The datalogger will stop recording when the battery voltage reaches 2.4 Volts (PME, 2014).

NOTE: Improper replacement of the batteries will damage the miniDOT datalogger. The warranty will become void if the batteries are installed backwards.

6.2 OPERATING TEMPERATURES

Each small datalogger has an operating temperature range and a given pressure depth range. See the datalogger's specification table for these ranges.

Small dataloggers (e.g., HOBO dataloggers) may continue to operate outside of these temperature ranges. When temperatures are low (~0°C or less) dataloggers may need to be warmed before they are able to transfer information.

NOTE: Data and equipment may be lost or damaged if a datalogger is encased in ice; be cautious of deploying in cases where the water may freeze.

6.3 Software and Firmware Updates

It is best to only update software or firmware on all computers *before* the deployment of any datalogger. This decreases the chance that there will be a miscommunication between the datalogger and computer during the field season.

6.4 Stream Deployment Precautions

Project managers should choose sites carefully when planning a project. Field personnel should choose appropriate locations at the site and methods for deployment. See **Section 10.3 – 10.5** for more information.

- Deploy away from high traffic areas to avoid loss.
- Deploy upstream of bridges. Anglers are thorough in targeting fish habitat.
- Meander pools may have stable undercut outside banks which may help with concealment.
- Avoid fishing access sites. If unavoidable, avoid the put-in spots. These places are heavily used by anglers.
- Avoid using aluminum and plain braided steel cables for deployment in high conductive streams. These may dissolve or rust over time and the datalogger may be lost (**Figure 37**). Stainless steel cables and salt resistant hardware are better options.
- Avoid deploying dataloggers in a location that is being actively eroded. Even if the datalogger is not connected to an eroding stream bank, the bank may slump off into the stream and either bury or wash away the datalogger.
- Avoid stranded pools, slack water, eddies, and backwater areas.
- Avoid deploying a datalogger in direct sunlight. Dark cases (e.g., Onset HOBO dataloggers) will absorb sunlight and could lead to a false positive bias. Shade tubes are used to shade dataloggers from direct sunlight (**Figure 9, Figure** 13**, and Figure** 14).
- If you need to flag the site, place the flag well away from the logger and note that on the Continuous Datalogger Deployment Form (**Section 11.2**). People investigate flags, and livestock and wildlife will often eat paper flagging.

NOTE: Consider deploying a duplicate datalogger at a separate deployment location in the general site area if there are no alternative sites and if high risk of loss is unavoidable.

In cases where public access occurs, concealment of all equipment is important to prevent loss and vandalism of the gear and the loss of the accompanying data. Foreign objects that are even slightly out of sync with the natural background look out of place in streams. Experience has shown that when members of the public see or otherwise find the deployed equipment, they remove it. In almost all cases, the datalogger is lost. Identifying the equipment as belonging to the DEQ may not matter, and those labels are often obliterated by algae growth. Individuals are willing to go to great trouble to remove loggers, including cutting 3/16” steel cable (see **Figure 36**). Additional camouflage may be needed. Shade tubes may be painted to reduce notice, and camo burlap has been found to be an affective camouflage as it alters the geometric shape of the assembly and may mimic the texture and colors of the channel depending on the substrate. Algae may accumulate on the burlap, and this may be a benefit for temperature and EC dataloggers, but will affect DO data. Burlap also works well for temperature loggers deployed in trees to record air temperature. **Figure 13 - Figure** 18**, Figure** 28**, and Figure** 31 show different ways of camouflaging dataloggers.

6.5 Lake and Reservoir Deployments

Temperature dataloggers and miniDOT dissolved oxygen dataloggers should be deployed on separate buoy lines. miniDOT dataloggers may need to be cleaned or replaced during the deployment.

7.0 Interferences

7.1 Sensor Condition

Datalogger deployment assemblies tend to accumulate algal growth and calcium carbonate. Fine sediment can accumulate on sensors, especially if they are deployed near streambeds. Dataloggers should be checked and cleaned whenever practical (**Section 10.6**). If a sensor is damaged, the readings may be skewed or invalid. Sensor condition should be checked before and after deployment for any visual damage (i.e., scratches and missing pieces).

For the HOBO U24 EC dataloggers, the HOBOware Conductivity Assistant helps to correct the data drift contributed by the fouling effects in the field (**Appendix D**).

The coarse copper screen anti-fouling devices on the MiniDOTs have proven to be effective in helping to assure good-quality DO data for deployments of over a month and a half with no interim cleaning events (Suplee and Sada de Suplee, 2014). This is the case even in slack-water deployments, which are often among the most difficult of locations to maintain high-quality DO data in (Suplee and Sada de Suplee, 2014).

Deploy dataloggers with sensors (i.e., EC and DO dataloggers) parallel with the water surface to avoid air bubbles accumulating on the sensors. Air bubbles on a datalogger sensor will interfere with the sensor’s accuracy.

8.0 Personnel Qualifications/Responsibilities

Any personnel who launches, reads out, or conducts any temperature accuracy check or post-deployment processing must understand the applicable programs as well as Microsoft Excel.

Field personnel who deploy, check, and retrieve dataloggers should have prior experience with that type of datalogger. Any field personnel that does not have experience with the equipment should be accompanied by experienced field personnel until the processes are understood.

Quality assurance processing of datalogger data relies on best professional judgment in most cases. Data interpretations must be made by environmental resource professionals with a Bachelor of Science degree or higher and a thorough understanding of state water quality standards.

9.0 Equipment and Supplies

Equipment and supply lists vary for different types of dataloggers and deployment types. Always make sure that all items have been acquired before following procedures in **Section 10**.

Note: Any time ferrules are required, it is extremely important to use stainless steel or alloy instead of aluminum. Aluminum corrodes easily in conductive streams. When aluminum is the only material available, use liquid electrical tape to seal the ferrule from corrosive water as best as possible.

9.1 Temperature Accuracy Check

- ❑ Temperature dataloggers (Include 5-10% extra – some dataloggers may fail the check)
- ❑ Cooler (adequate size to fit all dataloggers)
- ❑ Water to fill the cooler
- ❑ Cube ice (~10-15 lbs.)
- ❑ NIST certified thermometer
- ❑ Computer installed with datalogger software (i.e. HOBOware)
- ❑ Connection device (i.e., base station)
- ❑ Rebar to weigh dataloggers down (if applicable)
- ❑ Wire or cord to string dataloggers onto rebar (if applicable)

9.2 Electrical Conductivity Datalogger Deployment

- ❑ EC dataloggers
- ❑ Field computer (ToughPad) installed with datalogger software (HOBOware PRO
    - Only update software at beginning of field season before deployment
- ❑ Connection device (i.e., base station/shuttle)
- ❑ Q-Tips
- ❑ Toothbrush
- ❑ Dish soap
- ❑ Vinegar
- ❑ Spray bottle with tap water
- ❑ 7/16" wrench and nut driver
- ❑ Extra bolts, nuts, washers, ferrules, thimbles, cable crimpers, nipper, zip ties, straight rebar and wire cutters, hammer, extra dataloggers, shade tubes, bricks.
- ❑ YSI Pro Plus (SC) – be sure to calibrate SC, DO, pH prior to trip
- ❑ Camo burlap for concealment
- ❑ Anchor
- ❑ Cable, cable ferrules, cable cutter, ferrule crimper
- ❑ Leather gloves

9.3 Dissolved Oxygen Datalogger Deployment

- ❑ MiniDOT dissolved oxygen dataloggers
- ❑ MiniDOT anti-fouling kit includes:
    - 1 copper wire mesh disc
    - 1 nylon ring
    - 3 Phillips pan head screws
- ❑ Small phillips head screwdriver (to attach the copper mesh disc)
- ❑ Zip-ties (Heavy Duty)
- ❑ Wire cutters to cut zip-ties
- ❑ Rebar (straight or U-shaped) or fence posts ("T" posts are the most reliable)
- ❑ Post pounder or sledgehammer

- ❑ YSI Pro Plus (DO) – be sure to calibrate SC, DO, pH prior to trip
- ❑ Leather gloves
- ❑ Ear plugs (ear protection)
- ❑ Safety glasses
- ❑ Camo burlap for concealment, if needed. (Do not place burlap near the sensor)
- ❑ Cable, ferrules, cable cutter, ferrule crimper

9.4 Lake or Reservoir Deployment

- ❑ Dataloggers for deployment
- ❑ Cast concrete and rebar anchor, designed to have a large footprint (about 18” by 18”) to prevent the anchor from sinking very far into soft bed sediments
- ❑ Meter measuring tape
- ❑ ¾ inch poly line for each datalogger line - length must be adequate to accommodate maximum depth plus about 20 feet for knots and upper slack line)
- ❑ Medium zip ties to attach loggers to poly line (3 per logger)
- ❑ Large zip ties for line slack line coils as reservoir depth recedes
- ❑ Spray paint or large Sharpie marker to mark poly line at 1-meter intervals
- ❑ Large orange navigational hazard buoy (**Section 10.5.1**)
- ❑ Intermediate buoys (**Section 10.5.3**)
- ❑ 5-gallon buckets

10.0 Procedural Steps

The following procedures are applicable to most small dataloggers deployed by the WQPB:

1. Conduct the pre-deployment temperature accuracy check.
2. Deploy the dataloggers.
    a. Clean and readout EC dataloggers throughout the field season.
3. Retrieve the dataloggers.
4. Readout the dataloggers.
5. Conduct the post-deployment temperature accuracy check.
6. Prepare the data to be uploaded to MT-eWQX.

10.1 Temperature Accuracy Check

The datalogger’s temperature readings are checked before and after deployment. The process is a 2-point check in room temperature (ambient) and cold water. The datalogger readings are compared to NIST certified thermometer readings. EC and DO dataloggers should also undergo these temperature checks.

See **Section 9.1** for the equipment needed for performing a temperature accuracy check.

If a temperature-only datalogger reads a difference of greater than 0.5°C it should not be used be used for data collection (**Section 12.0**). An EC datalogger may see a greater difference between the datalogger reading and the NIST certified reading since the accuracy for an EC datalogger is lower compared to a temperature-only datalogger. If conducting a temperature study, temperature-only dataloggers are recommended for their increased accuracy.

NOTE: There is not a lab calibration or accuracy check for the conductivity component of dataloggers (specifically for Onset models). See **Appendix D** on how to correct EC data for drift.

10.1.1 Prepare the Water Bath

Fill a cooler halfway with water. The size of the cooler depends on the number of dataloggers. The cooler should be large enough that the dataloggers should not be crowded. There should be enough water in the cooler that all dataloggers should be covered by at least 1 inch of water.

Stir occasionally and allow the cooler to sit for a minimum 4 hours to equilibrate to the room temperature. When the NIST thermometer readings are within +/- 0.1°C for ten minutes, the bath has reached equilibrium.

10.1.2 Launch the Dataloggers

Different dataloggers will have different procedures for launching dataloggers. Each file name should include the serial number of the datalogger. Files that are collecting accuracy check data can be named: "Pre-AC_SN" or "Post-AC_SN" depending on if the accuracy is pre- or post-deployment. All dataloggers should be launched at a 2-minute interval at a date/time in the future that allows for all dataloggers to accurately record the water's temperature. See **Appendix C** for tips on how to launch HOBO dataloggers.

NOTE: It is recommended to start the logging on an even time (at 0, 2, 4, or 8 minutes).

The time that it takes for a datalogger to accurately read the water's temperature depends on the mass of the datalogger. 30 minutes is the minimum time that all dataloggers should spend in the water before equilibrium may be reached. One NIST temperature reading of the water is sufficient for all models of dataloggers if the water temperature is stable and well stirred.

10.1.3 Deploy the Dataloggers

Dataloggers should be weighed down if they float. Attach a wire or cord through the hole of the data logger and create a loop. String this loop on a piece of rebar that fits inside the cooler. If dataloggers sink, keep them separated and do not allow them to clump together.

Leave the dataloggers in the water for at least 30 minutes to reach equilibrium before collecting accuracy check readings.

10.1.4 Create the Tracking Spreadsheet

The NIST certified thermometer readings must be entered into a spreadsheet along with the date and time of the reading. Once the accuracy check is complete and the dataloggers are readout, the corresponding date/time and temperature reading must be copied into the spreadsheet. Any difference between the two values that exceed 0.5°C will be flagged. The WQPB has developed an Excel spreadsheet to record the temperature readings and the difference between the datalogger and the NIST certified thermometer readings (**Appendix A**).

10.1.5 Start the Accuracy Check Readings

1. Place the thermometer in a location in the cooler where it will accurately read the temperature.
    a. Stir the water occasionally to prevent stratification.

2. Begin recording thermometer readings after the dataloggers have begun logging and all have been in the water for at least 30 minutes to equilibrate.

NOTE: When not in use, store the NIST certified thermometer securely in its case. Never use the NIST certified thermometer to stir the water bath.

3. Record the date, time, and thermometer reading at the same time as the data loggers are recording (at 0, 2, 4, 6, and 8 minutes).
4. Enter information into the accuracy check spreadsheet. Date format: **3/18/2005 4:16:00 PM**.
5. Repeat the sequence if equilibrium is lost. Equilibrium is lost if the temperature shows a >0.5°C increase or decrease over 10 minutes.
6. Verify that all thermometer readings and times are recorded correctly before continuing.
7. Wait for the dataloggers to record a few buffer readings (about 6 minutes).
8. Add ice to the cooler.
    a. Stir the water to speed up lowering the temperature of the water.
    b. Keep adding ice and stirring until the temperature has stabilized around 0.0°C.

NOTE: It may help to remove some water from the cooler before adding ice. As the ice will melt and replace the removed water. Less ice will be needed if less water at room temperature needs to be cooled.

9. Remove large chunks of ice, as these are temperature sinks, and close the lid of the cooler.
    a. Make sure that the ice is not in contact with any loggers.
10. Leave the dataloggers for at least 30 minutes to reach equilibrium.
    a. Stir the water occasionally to prevent stratification.
11. Repeat Steps 3 – 7.
12. Remove from the cooler, stop and read out the dataloggers.

10.1.6 Review the Accuracy Check Results

Enter the results of the datalogger results into the spreadsheet to calculate differences in readings.

For Pre-Deployment Accuracy Check – Review the results of the pre-deployment accuracy check. Set aside any dataloggers that failed to record within +/- 0.5°C of the corresponding thermometer reading. Failed dataloggers should not be deployed. Repeat the accuracy check for these dataloggers. If a datalogger fails two accuracy checks, contact the manufacture for repair/replacement options.

For Post-Deployment Accuracy check – Review the results of the post-deployment accuracy check. Any datalogger that fails a post-deployment accuracy check will need to go through a second accuracy check. If the datalogger fails the second accuracy check as well: "Failed post-deployment accuracy check" will need to be recorded under the retrieval notes section on the continuous datalogger field form, and in the MT-eWQX Datalogger Template (**Appendix A**). Include details about the failed accuracy check in the notes of the template and flag the data.

10.2 Launch Dataloggers for Deployment

When a datalogger passes all pre-deployment checks it is ready to be launched and deployed into the field. Different types of dataloggers and programs will have different methods for launching a datalogger, but certain things must be known for deployment: file name, date/time of launch, and recording interval.

NOTE: EC dataloggers may need to be "wet launched" if deployed at a dry site. See **Section 10.2.1**. Different types of dataloggers and programs will have different methods for launching a datalogger, but certain things must be known for deployment: file name, date/time of launch, and recording interval.

File Name
If applicable, the file name should include the datalogger's serial number and the Project ID: "Project ID_SN". If the datalogger is being deployed in the field, or if the location is known for the individual datalogger, the location could be included in the file name: "Project ID_Location_SN". Some dataloggers (e.g., miniDOTs) record one file each day with the name: "YYYY-MM-DD-SN" (PME, 2014). Files may be re-named after the files have been readout.

Date and Time
Ensure that all dataloggers are programed with the correct day and time. If applicable to the deployment, consider daylight savings time changes that will occur between launching and retrieval.

Interval
A datalogger's interval will be determined by the project's Sampling Analysis Plan (10, 15, or 30-minute intervals) and the datalogger should be programed accordingly. The allowable temperature change rate for all state water classifications is expressed using "per hour" (one hour) as the temporal component of the standard. To prevent false positive or negative indications the recording interval must be smaller than the base unit expressed in the standard.

10.2.1 EC Datalogger Launching

It is critical that a specific conductivity (SC) reading from a calibrated instantaneous field meter is recorded whenever an EC datalogger is placed in or removed from the water. This includes at the time of deployment, mid-deployment removals and cleanings, and retrieval. If one of these external SC readings are not recorded, the drift corrections cannot be calculated.

NOTE: It is important that the field reading be collected near the datalogger. Collecting a reading a few feet away from the datalogger may give different SC readings. Remember to let the datalogger be deployed for at least 15 minutes to allow for the temperature that the datalogger is collecting to equilibrate with the waterbody.

If the EC datalogger will be deployed at a dry site, it is crucial to have the first few readings taken from a bucket of saltwater before deployment.

1. Calibrate the field meter for SC. It's preferable to use the same meter as will be used for the project.
2. Fill a 5-gallon bucket with water and add an approximate tablespoon or two of salt, stir to dissolve the salt and to evenly distrusted in the water.
3. Launch the EC dataloggers at the interval needed for field data collection and place in bucket
4. Allow the dataloggers to stabilize and collect a few readings.
5. Use the meter to record the SC readings at the logging interval and make a note of the time and reading. This information must be recorded as a note on the Site Visit Form when the datalogger is deployed.
6. Remove the dataloggers from the bucket. Leave the datalogger logging.

10.3 Wadable Stream Deployment Considerations

Appendix E includes figures that show some deployment scenarios for various sized streams and discharge levels. Temperature and EC dataloggers can normally be deployed in the same various ways. Temperature dataloggers normally have an internal monitor so it's not critical to deploy the datalogger in a specific direction (i.e., facing upstream). EC and DO dataloggers have an external sensor to monitor the conductivity of the water. EC sensor faces should be vertical to avoid bubbles collecting on the sensor (Onset, 2013). DO dataloggers require the sensor facing upstream for most accurate data collection. Deploy DO dataloggers parallel with the water surface. If a DO datalogger is deployed with the sensor facing down toward the substrate or up facing the water surface, air bubbles will collect on the sensor and data values will not be accurate.

10.3.1 Location

It's important to conceal dataloggers when deploying in high traffic or public areas to avoid datalogger loss. See **Section 6.4** for more information. Since so many precautions have been taken to camouflage and make the dataloggers not noticeable, it is important to accurately record the datalogger location at the time of deployment so it can be located during retrieval. The WQPB uses a Continuous Datalogger Form (**Appendix A**) at the time of deployment and again when the datalogger is retrieved. The latitude and longitude of the deployed datalogger, and a map of the site is included on the form. See **Section 11.2** for more information.

All dataloggers should be deployed in locations where there is flowing water. When choosing an actual deployment location, field personal should look for adequate stream protection, depth, and mixing. Stream protection keeps the datalogger from becoming dislodged during high flows, depth ensures the datalogger will stay submerged through summer baseflows, and a well-mixed area will be more representative of true stream conditions. Field personal should reposition the datalogger if it is found out of the water on subsequent trips. Depending on the datalogger type, riffles, pools and culverts may provide suitable locations.

When deploying in a pool, keep in mind that

- it is common for pools to be much deeper in the fall after the irrigation season.
- if the pool is created by a beaver structure:
    - be aware that a food cache may be found in the shade tube,
    - expect deeper water upon retrieval, and
    - use good cable attachments to rebar or the low bases of trees (non-willow trees, if possible).

Riffles and runs may be susceptible to becoming dry during summer base flows and should be avoided if possible. If deploying in a riffle or run is unavoidable, deploy dataloggers near the thalweg as the wetted channel width tends to become narrower during low flow periods.

If riprap is present at the location, a tethered cable can be hidden in the crevices and attached to the base of a tree or rebar on the stream bank. Temperature and EC dataloggers may be deployed in culverts. In cases where a location is known to go dry but streamflow is known to occur at a later time, elevate the logger from the bed to assure that any wet conditions that is recorded is due to flowing water.

10.3.2 Tethers and Connections

Different types of tethers and connectors can be used to secure dataloggers to an anchor. **Appendix E** includes figures that show some of the ways that a datalogger may be tethered and connected for deployment.

It is best to conceal all tethers and connections to avoid datalogger detection. This is most important with metal-based materials such as cables, nuts and bolts since metal is an eye-catching silver color until diatoms colonize on the surface. Spray paint may help to conceal but may not adhere well if underwater for long. Use a coarse grit sandpaper to score the surfaces prior to spray painting to help the paint adhere to the metal.

Heavy camo cord and heavy-duty zip ties may also be used as tethers and connectors. Both have a higher risk of breaking than metal materials during deployment due to stress and friction. Beavers have also been known to chew through camo cord if in their way. It is best to double up on zip ties, tie strong knots when using camo cord, and avoid hard sharp edges (such as holes in shade tubes).

10.3.3 Anchoring

Dataloggers must be anchored to a location to prevent loss. **Appendix E** includes figures that show some of the ways that a datalogger may be anchored for deployment. Rebar, native rock ballasts, bricks, and ship anchors are all viable options.

Rebar is often used to tether cables, have dataloggers attached directly for anchoring, or used as a ballast to weigh dataloggers down in the stream. Rebar can be used as straight bars or bent into U-shaped loops, although straight rebar may injure livestock and rebar should be placed carefully to avoid creating a hazard for wading anglers, boating recreating, and livestock. Rebar often rusts to an effective camouflage color and may become difficult to see. It may be difficult to pound rebar into cobble or large gravel substrate.

Native rock ballast bags may be assembled with heavy black nylon netting, local rocks, and black zip ties. These are the most natural looking ballasts but tend to catch flies and lures easily and so should not be placed in known angler wading zones or waterbodies where there is known heavy angler use.

Bricks may be used but are obvious in a streambed due to their rectangular shape (**Figure 18**). Bricks may be painted, but paint may not adhere well if underwater for long. These are best used when the site is not public or recreational.

Depending on the substrate, different types of boating anchors may be used to secure dataloggers. Scoop type anchors designed for soft substrate may be useful large waterbodies with soft substrate.

10.3.4 Air Temperature Datalogger Deployment Considerations

Temperature dataloggers may be used to log ambient air temperature for a project, especially if permanent weather stations are located far from the project area. The data can be used to describe air temperature as a driver or buffer of water temperature, and can also be used to verify when a water temperature logger starts logging a dry channel. Deployment should be in shaded woody riparian vegetation near the middle of the sampling area.

10.4 Non-wadable River Deployment Considerations

Dataloggers deployed in a non-wadable river setting are either deployed from a bridge or from wadable portions of the river. **Appendix E** includes figures that show some deployment scenarios for various sized streams and discharge levels. It is best to deploy dataloggers in or near the thalweg to assure the best flow, often less debris accumulation, and concealment. There are typically three options for deploying at a non-wadable site.

The first option is to attach the datalogger to an anchor ballast (**Figure 27**) and attach the anchor ballast to an upstream anchor with a braided steel cable. The upstream anchor is positioned first so that it is firmly in place. The anchor ballast and datalogger is then placed right-side-up at the downstream extent of the cable. The anchor may be able to be tossed into position, and then the device assembly can be swung into place downstream using a detachable rope, or, the device can be lowered into position from a bridge using the rope loop. Retrieval is accomplished with a grappling hook on a rope.

The second option is to attach the anchor ballast and datalogger to a bridge instead of using an upstream anchor (**Figure 27**). The cable should not create a hazard to boaters. Placement near a mid-stream bridge abutment may be a better option than in the middle of the open span which would be in the path of boat traffic.

The third option is to secure the datalogger (best if used for EC/Temp/Water Level dataloggers) in a closed shade tube and attached at a bridge abutment with a fencepost (**Figure 25 and Figure** 26).

NOTE: Permissions from the appropriate parties (e.g., the county and/or Montana Department of Transportation) are required before attaching anything to any bridge structure.

10.5 Lake or Reservoir Deployment Considerations

Using dataloggers in a lake or reservoir can help determine how the thermal stratification and stability are affected by stage and weather conditions. Lake or reservoir stability can be correlated with turbidity events. Data collected may also help determine if an internal seiche or daily thermal mixing event occurs during prolonged turbidity events in rivers receiving the discharge.

Dataloggers deployed in lakes or reservoirs need to be attached to a line with buoys and anchors. It is best to deploy different dataloggers separately, especially if a datalogger type requires mid-deployment cleanings (e.g., EC and DO dataloggers) to minimize unnecessary disturbance.

Temperature dataloggers are typically deployed at one-meter depth intervals depending on the lake/reservoir depth. DO dataloggers are typically deployed at the midpoint of the euphotic zone, the midpoint of the hypolimnion zone and at regular intervals between the two zones, depending on the lake reservoir depth. About 5 dataloggers are adequate for buoy lines deployed for depths up to 100 feet.

NOTE: Ensure that the maximum depth on the datalogger's specification depth is not exceeded by the lake/reservoir deployment.

The project manager should weigh the benefits and limitations of DO buoy lines that provide continuous logging of data at prescribed time intervals and at set spacing in a reservoir with changing depths, against the value and utility of regularly-taken depth profiles taken with a multi parameter meter lowered at one-meter intervals.

Field personnel need to have knowledge of anticipated changes in the reservoir forebay elevation: increases, drawdowns, maximum anticipated depth – account for wave action from boats and wind, and estimated depth at the time of deployment. To reduce the amount of slack line at the top of the assembly, it is best to conduct the deployment at a time that coincides closely to the highest forebay elevation of the year. As the reservoir depth declines, the upper rope should be coiled and zip tied to take up the slack. The upper dataloggers may be left on the line but will need to be flagged as not collecting data from the intended depth. Depth profiles collected via multi-parameter meters can be used to verify which data should be excluded from the temperature loggers.

Lines should be assembled with:
1. Navigational Hazard Buoy
2. Dataloggers on polyline (or equivalent)
3. Intermediate buoys (if required)
4. Stationary anchor

10.5.1 Navigational Hazard Buoy

A large orange buoy marked with "MT DEQ" should be attached to the top of the line so that it is easily seen by recreationist. In changing elevations systems, the polyline rope needs to be managed so that floating excess does not pose a hazard to recreationists.

10.5.2 Attaching Dataloggers to the Line

All dataloggers are attached to a line in a similar way. It is best to attach the dataloggers before launching the boat. If there are multiple lines, it may save time to set up all the lines at once side by side. Polyline rope is slightly less dense than water, so it floats if not weighted. Shade tubes can be used to limit algae growth on the dataloggers that are placed in the euphotic zone.

Use three to five zip ties per datalogger, depending on the size of the datalogger body and the orientation needed. If using polyline, weave the zip ties through the line strands. Experience in attaching dataloggers to polyline with zip ties has shown that leaving the "tail" on the zip ties reduces the risk of cuts and scratches on the hands and forearms during deployment and retrieval. If using a metal cable for deployment, crimp cable ferrules at each deployment point to prevent the dataloggers from sliding down the cable.

- For larger dataloggers that should be kept horizontal (e.g., miniDOTs), use two zip ties crisscrossed around the datalogger and the line. A third zip tie should be strung through the back hole and the line to provide further security.

NOTE: the crisscrossed zip ties can be doubled up to provide more stability if needed (five zip ties total).

- For small dataloggers that can be kept vertical (e.g., HOBO U22s), use two zip ties to tightly wrap the datalogger to the line and a third zip tie should be strong through the back hole and the line to provide further security.

10.5.3 Assembling and Deploying Intermediate Buoys
The purpose of intermediate buoys is to help maintain a fairly vertical orientation of a datalogger buoy line. Intermediate buoys can be made from two layers of Dow board with a total dimension of: 4”x6”x6”. This provides a buoyancy of about 5 pounds which is suitable for most purposes. Other types of material are often crushed by the pressure from the water depth and is ineffective in operating as an intermediate buoy.

NOTE: Blue Dow board specifications: extruded polystyrene foam, compressive strength: 25 psi. The compressive strength of blue foam Dow board is adequate to a water depth up to 17 meters.

To assemble an intermediate buoy:
1. Tape two layers of foam with two or more layers of heavy-duty duct tape in two directions.
2. Drill a 3/8” hole through the foam and tape.
3. Attach the buoy to the polyline using two zip ties by separating the strands of polyline
4. Place a third zip tie around the polyline above the attachment to prevent the buoy from moving upward.

Two or three intermediate buoys should be enough depending on the lake/reservoir depth.

The top intermediate buoy is attached just above the upper-most temperature logger, below any slack line at the top that is used to allow for increase in water depth after deployment. This buoy can be removed and reattached lower on the line as lake depths decline when the site is revisited.

The bottom intermediate buoy is attached to the line at a distance of about half the total depth, but no deeper than 15 meters from the water surface. It must be at a point below the level of total drawdown that is anticipated.

A third buoy can be added about mid-way between the other two buoys, but it must be below the lowest anticipated reservoir depth.

10.5.4 Stationary Anchor

A freestanding datalogger line needs an anchor attached to the bottom to hold the line in place. The anchor needs to be sturdy and heavy enough to do so but be also be able to be pulled up when it is time to retrieve the dataloggers. The WQPB has used 15- to 20-pound concrete anchors. If a heavier anchor is used, it is best if there are holes in the anchor to reduce suction to the soft sediments.

10.5.5 Retrieval
Retrieving a datalogger line is typically a two-person process. One crewmember retrieves the line by hauling or operating a motorized capstan to pull the line. The other crew member removes loggers as the line is lifted by clipping the zip ties with wire cutters and placing the dataloggers in a bucket. If needed, any algae buildup should be scrubbed off the line with a large brush. The retrieval time recorded for all dataloggers is the time when the retrieval process begins. Any missing dataloggers must be noted on the Continuous Datalogger field form (**Appendix A**).

NOTE: Be cautious when retrieving and handling buoy lines as anglers often lose lures and fishhooks in the lines and cut zip tie tails are sharp.

10.6 Mid-Deployment Checking and Cleaning

10.6.1 EC Dataloggers Checking and Cleaning Procedures

How the datalogger is found will determine the steps taken for cleaning and reading out the datalogger.

At a Wet Site

If the datalogger is found in the water:

1. Record an *in situ* EC reading near the datalogger on the Site Visit Form (SVF). It is best to collect the reading near the time that the datalogger will log.
2. Remove the datalogger from the water, record the removal time and serial number on the SVF.
3. Connect the datalogger to the computer. See **Appendix C** for HOBOware guidance.
4. Select "Readout Device".
5. Select "**NO**" when asked "Do you want to stop logging?"
6. Save the file to a folder for the specific trip.
7. Plot the data:

Data looks alright, and the last record point is close to the meter reading.	**The datalogger was buried and the last recorded point is not close to the meter reading.**
Continue with the next step.	1. Disconnect the datalogger. 2. Lightly remove the sediment from the sensor by swishing it in the stream. <u>Do not clean the sensor face.</u> 3. Place the datalogger in the stream to collect another SC reading. Do not let the logger wash away. 3. Record a meter SC reading at the time of the datalogger logging interval. 4. Repeat the readout process (Steps 3 to 7). 5. If the new data point is closer to the meter reading, continue with the next step.

Table 1. Checking an EC datalogger mid-field steps

8. Relaunch the datalogger so that it will continue recording at the original timing and interval.
    a. Example: A datalogger records a reading at a 30-minute interval starting at the top of the hour. It was removed at 9:35am and will be ready for redeployment at 9:50. The datalogger should be launched for a 30-minute interval to begin logging at 10:00.
9. Disconnect the logger from the computer.
10. Clean the datalogger and shade tube with dish soap, water, and a brush.
11. Clean the sensor face:
    a. Start with dish soap and scrub gently with Q-tips. Rinse with tap water.
    b. If there is a thick layer of calcium carbonate on the sensor face: Soak the sensor face in vinegar for 15-30 min. Replace vinegar about every 5 minutes. Calcium carbonate neutralizes vinegar as it dissolves.
12. Place the logger back in the cleaned shade tube and reassemble.
13. Replace back in the water and record the time on the SVF.
14. Record a second *in situ* SC reading near the datalogger on the SVF.
    a. This is required for drift calculations.
    b. It is best to wait for approximately 10 minutes before recording the result.
    c. Collect the reading near the time that the datalogger will log.

At a Dry Site

If the datalogger was found out of the water and needs to be repositioned:

1. Do not clean datalogger
2. Do not stop datalogger
3. Do not relaunch datalogger
4. Record what was done on SVF

Reading out the datalogger is optional. Collect an instantaneous SC field meter reading after repositioning the datalogger and allowing at least 15 minutes to pass to allow for the temperature of the datalogger to equilibrate with waterbody (**Section 10.2.1**).

NOTE: It is very important for U24 dataloggers that there are no gaps in the data for EC that are not bracketed with *in situ* SC readings. Gaps prevent the HOBOware program from being able to correct for drift.

10.6.2 DO Dataloggers Checking and Cleaning Procedures

DO dataloggers may need to be cleaned during deployment every two weeks or once a month, depending on the conditions that the dataloggers are deployed in. Cleaning frequency should be described in the project's SAP. If cleaning is required for miniDOT dataloggers, the screen can be cleaned with a stout brush or replaced if the copper becomes too corroded. The sensor membrane can be cleaned with a soft toothbrush. See **Section 10.8.1** for more information.

10.7 Retrieving Dataloggers

Always note when a datalogger is removed from the sampling location on the Continuous Datalogger Form or the Site Visit Form (**Appendix A**). It's recommended to make note of the condition that the datalogger was in upon retrieval as well as to take photos. This may help when looking at the collected data.

10.7.1 Temperature Datalogger Retrieval

Temperature-only dataloggers can be retrieved from the field and brought back to the office before the dataloggers are stopped or can be stopped in the field.

10.7.2 EC Datalogger Retrieval

If the EC datalogger is being retrieved from a wet site, follow **Section 10.6.1** steps 1 through 10. If the EC datalogger is being retrieved from a dry site, removed the datalogger, do not clean, and do not stop the datalogger. It is critical to record a few readings in a bucket of saltwater before stopping the datalogger.

10.7.3 DO Datalogger Retrieval

Observe and record the condition of the DO sensor underneath the coarse copper screen upon retrieval of the device. In most cases the coarse copper mesh effectively deters algal growth, but there can be exceptions. Fine-texture sediment can build up and partially cover the sensor. Recorded observations of the sensor condition will help determine the accuracy of the data when it is evaluated (Suplee and Sada de Suplee, 2014).

10.8 Post Deployment

All dataloggers must be stopped, readout, and exported into a spreadsheet before any post-deployment accuracy check. See **Section 11.3** for more information. Any datalogger that went through a pre-deployment temperature accuracy check should go through a post-deployment temperature accuracy check. See **Section 10.1** for more information.

NOTE: Any datalogger that fails the post-deployment accuracy check must be flagged. See **Section 12.0** for more information.

In some programs (e.g., HOBOware), data can be readout into Celsius or Fahrenheit. The project SAP should state which units the data should be readout in.

10.8.1 Cleaning Datalogger Body and Sensor

Most datalogger bodies can be cleaned with dish soap or soaked in a vinegar solution to clear any calcium carbonate deposits. Replace vinegar solution and scrub dataloggers as needed. If the datalogger has sensors, clean the sensors appropriately before storage. EC datalogger sensor cleaning is described in **Section 10.6.1**.

DO dataloggers may be cleanable. Refer to the appropriate user manual when necessary. MiniDOT datalogger's coarse copper mesh disk is cleaned with a toothbrush. If the miniDOT sensing foil underneath the disc becomes fouled it can be cleaned but should be done with caution so that the protective coating is not removed. If calcium carbonate has formed on the sensing foil, a vinegar solution can be used to remove it first by soaking for a few minutes and then by gently wiping the sensing foil with a cotton swab. After cleaning, the sensing foil should be rinsed well with clean tap water before storing or reusing. The sensing foil can also be cleaned using a 3% hydrogen peroxide (H_2O_2) solution or by rinsing it (PME, 2014).

NOTE: Do not use organic solvents such as acetone and toluene on the DO sensing foil since these and other organic solvents will damage the foil (PME, 2014).

11.0 Data and Records Management

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

11.1 Recording on Site Visit Form

Whenever a datalogger is deployed, it is recorded on the Site Visit Form (SVF) (**Appendix A**). There is a section built into all SVFs that addresses dataloggers and the actions taken during the site visit (**Figure 2**).

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

Figure 2. Datalogger section of the SVF

Additionally, if a datalogger is being deployed or retrieved, a Continuous Datalogger Form will be attached to the SVF. This is indicated in the Field Assessments section of the SVF by writing the form name in the "Other:" section (**Figure 3**).

Field Assessments		
Photos ☐	Aquatic Plant Visual Assessment ☐	SAM ☐
Aquatic Plant Tracking ☐	Rosgen ☐	NRCS ☐
EMAP ☐	Total Discharge ☐	Channel X-Section ☐
Wetland ☐	Bacteria ☐	Other:

Figure 3. Field Assessment Section

Any comments about the datalogger condition, retrieval time, or additional field measurements that were collected are recorded in the Site Visit Comments on the back of the Site Visit Form. If the field meter is required to be calibrated in the field for project purposes, there is also a section to record the last date of calibration for specific conductivity and dissolved oxygen (**Figure 4**).

Field Meter Calibration		
pH Meter:	Manufacturer & Model:	Date of Last Calibration:
	Comments:	
Multiparameter Meter:	Manufacturer & Model:	
	Date of SC Calibration:	DO calibrated at site visit ☐
	Comments:	

Figure 4. Field Meter Calibration Record

11.2 Continuous Datalogger Form

Field personnel are required to fill out a Continuous Data Logger Form (**Appendix A**) whenever a datalogger is deployed. The form is connected to the Site Visit Form at the time of deployment with the same Site Visit Code and Project ID. The sampling medium, interval, datalogger make/model, and serial number must be recorded. It is important to record the Launch Date and Time (when the datalogger began logging) and the Deployment Date and Time (when the datalogger is collecting field data). The Latitude and Longitude should be the location where the datalogger was deployed; this location may be different than the site location indicated on the Site Visit Form. Field personnel are to describe any key information about the dataloggers deployed location and draw a map to assist in the retrieval. If flags were used to mark any camouflaged locations, they should be noted on the map.

A photocopy of the deployed Continuous Data Logger Field Form must be made to bring into the field for the retrieval. Additional information at the bottom of the form is to be filled out when the datalogger is retrieved, including the retrieval Site Visit Code, date/time, comment, and file name if given. Field personnel are encouraged to elaborate about the retrieval condition on the Site Visit Form's comment section and take pictures of the datalogger at the time of deployment and retrieval.

11.3 Preparing Data for MT-eWQX Upload

All data collected by or for DEQ must be stored in the Montana EQuIS Water Quality Exchange (MT-eWQX) database. Datalogger data collected by the WQPB is uploaded as a "blob" file to the Montana EQuIS water Quality Exchange (MT-eWQX) after being formatted correctly.

Field dataloggers will be read out and formatted after retrieval. It is best to do this soon after the dataloggers are retrieved and must be done before the start of the next field season. Refer to **Appendix C** for readout procedures for Onset dataloggers and the User Manual for miniDOT dataloggers. If the datalogger underwent a pre-deployment temperature accuracy check, a post-deployment temperature accuracy check must occur (**Section 12.1**). EC dataloggers must be drift-checked (**Section 12.2**). DO datalogger data must be compiled and quality control (QC) checked (**Section 12.3**).

After the data has been QC checked, it is to be saved in the same format as the MT-eWQX Datalogger Template (**Appendix A**). The Excel file has four tabs:

1. Instructions – on how to use the file
2. Final – How the data appears after Quality Control check has occurred. Includes Site and Deployment information, drift corrections, temperature accuracy results, and any flags.
3. Formatted Raw Data – Applicable for Tempture_macro analysis (**Section 11.4**).
4. Original Raw Data – How the data appears when it is read out from the datalogger, no flags.

Once completed, the datalogger spreadsheet is named:
[Waterbody Name]_[Station ID]_[yymmdd]_(Site Visit Code)_[Suffix].xlsx. Suffixes would describe the type of datalogger. TEMP = temperature datalogger, EC = conductivity datalogger, and DO = dissolved oxygen datalogger.

The file is then saved on the DEQ network at the location:
G:\WQP\6_DataMgmt\3_EQuIS\EQuIS_Staging\20xx_FS_MDEQ_WQ\20xx_Dataloggers\Pending\ [Project ID], as well as in the appropriate project folder.

11.4 Temperature Macro Tools

DEQ developed Excel macro files to calculate the individual minimum and maximum result, the average 7-day minimum, maximum, and delta, as well as the number of hours and days with temperatures above certain degrees (**Appendix A**). There are currently three macros:

- Tempture_C_MTbt 10°C, 15°C, 21.1°C for Montana bull trout in Celsius
- Tempture_F_MTbt 50°F, 59°F, 70°F for Montana bull trout in Fahrenheit
- Tempture_F_MTrbt 66°F, 75°F, 78°F for Montana rainbow trout in Fahrenheit

Once all a project's temperature files are formatted into the Datalogger Template Excel book, each "Formatted Raw Data" tab can be copied and combined into a separate Excel book. This file is typically named as "GroupedDataSets_C/F" depending on what temperature units the data is in. Each GroupedDataSet file is run through the appropriate "Tempture_Macro".

NOTE: it is recommended to rename the tab names with the serial number or site location when pasted into the separate Excel book.

It is recommended to read the TEMPTURE_macros_Instructions before using any macros. The Tempture_macro may be modified to accommodate other fish tolerance threshold values.

12.0 Quality Assurance and Quality Control

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 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.

12.1 Temperature Accuracy Check and Quality Assurance

It is important to correctly read the NIST certified thermometer during the temperature accuracy check by reading the value perpendicularly. Prior to the reading, the NIST certified thermometer needs to be placed in well-mixed temperature stable location near the datalogger sensors.

If a datalogger result in a pre-deployment temperature accuracy check exceeds a 0.5°C difference from the NIST certified thermometer, the datalogger should be checked for damage. If no damage is found, the accuracy check should be repeated. If the datalogger fails a second time or is damaged, the manufacturer should be contacted for troubleshooting or replacement.

If a datalogger result in a post-deployment temperature accuracy check exceeds a 0.5°C difference from the NIST certified thermometer reading, the accuracy check needs to be repeated for that datalogger. If the second accuracy check is failed, the data should be flagged. Include "Failed post-deployment accuracy check" in the first "Note" line of the Datalogger Spreadsheet. The manufacturer should be contacted for troubleshooting or replacement.

After the deployed and retrieved dataloggers have been readout, the temperature data should be plotted to inspect if the logger was removed from the water, or if the site had become dry. If the datalogger was exposed to air temperatures, the diurnal cycle will be greater than what will be seen when the datalogger is in the water. Identify and flag any data that is logged during a dry period.

Examine the data files to find when the daily change in temperature appears normal and when it transitions to lower daily amplitudes. Lower amplitudes indicate that the datalogger recordings were affected by being buried. Retrieval or site visit comments may include statements about dataloggers being buried. Flag buried data.

12.2 Conductivity Drift Correction

Data must be checked to identify any time that a datalogger was either removed from the water or if the datalogger was buried by sediment. Lower temperature amplitudes indicate that the datalogger recordings were affected by being buried. Retrieval or site visit comments may include statements about dataloggers being buried. Reject buried data. Specific conductivity data must be corrected for drift before the data is uploaded and analyzed. See **Appendix D** for how to use HOBOware to correct HOBO U24 data for drift.

12.3 Dissolved Oxygen

Data must be checked to identify any time that a datalogger was either removed from the water or if the datalogger was buried by sediment. Reject buried data. Field notes throughout the deployment are critical to being able to check accuracy. DO dataloggers (like miniDOTs) do not have a drift check procedure or correction. It is up to the analyzer to use best professional judgement when determining if the data is useable or not.

13.0 References

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APPENDIX A. FIELD FORMS AND TEMPLATES

- Temperature Accuracy Check Template Spreadsheet
- MT-eWQX Data_Logger_Template
- Tempture_macro Spreadsheet
- Site Visit Form (Front and Back) (**NOTE**: DEQ modifies this form to meet project-specific needs)
- Continuous Datalogger Form (Front)

TEMPERATURE ACCURACY CHECK TEMPLATE SPREADSHEET

An Excel spreadsheet template is available for DEQ staff here: G:\WQP\7_QAProgram\3_SOPs\Small_DataLoggers\WQDWQPBFM-07_SmallDataloggers\Temp_Accuracy_Check_Template.xlsx.

The spreadsheet helps the user conducting the temperature accuracy check track the datalogger results for ambient and cold readings as well as the NIST certified thermometer temperature readings and will calculate the difference between the readings. This determines if a datalogger has passed the temperature accuracy check or not. One spreadsheet is kept for all projects per field season. There is a tab for pre- and post-deployment accuracy checks.

	A	B	C	D	E	F	G	H	I
1	Pre-Deployment Accuracy Check								
2		Field Season:							
3	Project ID, Launch Date/Time:								
4	Project ID, Launch Date/Time:								
5		Interval, Duration:	2 minutes, 10 minutes						
6									
7	Key:	Data to be entered/pasted in							
8		Automatic calculation							
9		Results							
10		Flagged Value							
11									
12		Pre Deployment Accuracy		*Serial Number*		*Project ID*	*Serial Number*		*Project ID*
13		NIST							
14		Date, Time	Temp °C	Date, Time	Temperature	Differences	Date, Time	Temperature	Differences
15									
16						0.00			0.00
17	Ambient Temp					0.00			0.00
18						0.00			0.00
19						0.00			0.00
20						0.00			0.00
21									
22						0.00			0.00
23						0.00			0.00
24	Cold Temp					0.00			0.00
25						0.00			0.00
26						0.00			0.00
27									
28				Ambient Temp Average Diff:		0.00	Ambient Temp Average Diff:		0.00
29				Cold Temp Average Diff:		0.00	Cold Temp Average Diff:		0.00

Figure 5. Temperature Accuracy Check Example

MT-eWQX Data_Logger_Template Spreadsheet

An Excel spreadsheet template is available for DEQ staff on the network here:
G:\WQP\6_DataMgmt\3_EQuIS\EQuIS_Staging\20xx_FS_MDEQ_WQ\20xx_Dataloggers

New field season files are created each year. See the current year for the most recent "Data_Logger_Template" file.

This spreadsheet template ensures that all information is included when DEQ datalogger data is uploaded to MT-eWQX. For more information see **Section 11.3**.

	A	B	C
1	Site Visit Code/Activity ID		
2	Station Name*		
3	Station ID*		
4	Interval*		
5	Logger Make/Model		
6	Serial Number		
7	Deployment Date*		
8	Deployment Time*		
9	Latitude (decimal degrees)*		
10	Longitude (decimal degrees)*		
11	Retrieval Date*		
12	Retrieval Time*		
13	Retrieval Comments		
14			
15	Date	Temp, °F	Notes

Figure 6. Data_Logger_Template Final tab example

TEMPTURE_MACRO SPREADSHEET

The three Excel macros mentioned in **Section 11.4** are available to DEQ staff on the network here: G:\WQP\7_QAProgram\3_SOPs\Small_DataLoggers\WQDWQPBFM-07_SmallDataloggers\TEMPTURE_macro_Tools.

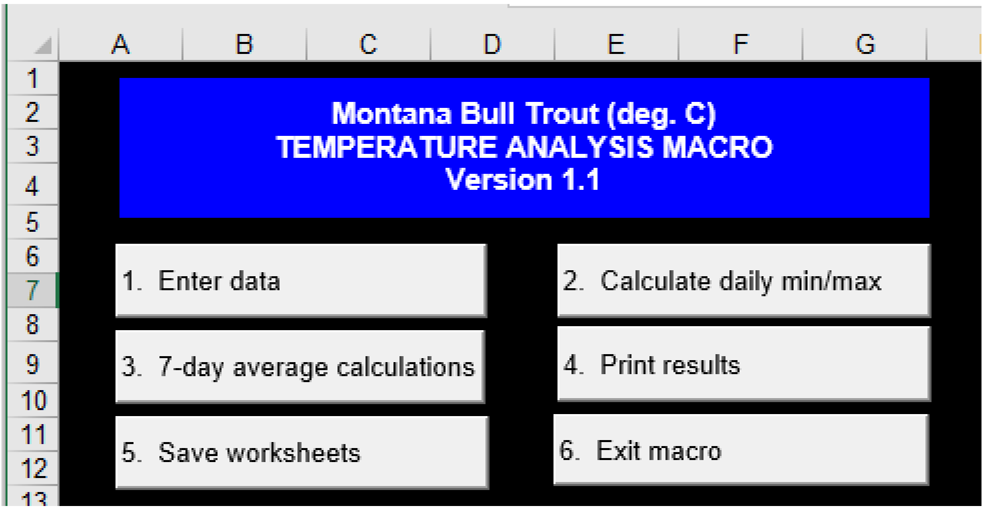


Figure 7. Temperature Macro Main Tab Example

Select "Enter data" and navigate to the correct grouped temperature file. The user has the choice to either to select Automatic Mode (processes all include worksheets) or Manual Mode (processes one worksheet)

The Summary Data tab includes Lat, Long, Start Date, Stop Date, in columns B – E, as well as the columns shown in **Figure 8** below.

Summary Data For Montana Bull Trout (Deg. C)

Return to Main Menu

Site Name	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	Δ T
M01HRSPC01, Horse Prairie Creek (HP1) AIR	07/29/16	34.4	10/11/16	-5.0	07/19/16	29.4	07/28/16	33.0	6.1	26.8
M01HRSPC03, Horse Praire Creek (HP2)	07/29/16	24.1	10/07/16	4.2	08/04/16	9.3	07/27/16	22.7	15.1	7.7
M01HRSPC05, Horse Praire Creek (HP5)	06/29/16	19.6	10/07/16	2.9	07/14/16	7.8	07/22/16	17.7	10.8	6.9
M01HRSPC02, Horse Praire Creek (HP4)	06/29/16	21.6	10/07/16	3.1	08/04/16	10.0	07/30/16	20.4	11.6	8.8
M01HRSPC02, Horse Praire Creek (HP4) AIR	08/02/16	30.0	10/11/16	-4.4	08/20/16	25.6	07/30/16	28.4	6.1	22.3

Site Name	Days > 10.0 C	Days > 15.0 C	Days > 21.1 C	Hours > 10.0 C	Hours > 15.0 C	Hours > 21.1 C	Warmest day of 7-day max			Agency
							Date	Maximum	Minimum	
M01HRSPC01, Horse Prairie Creek (HP1) AIR	99	91	74	1512.0	1120.5	636.0	07/29/16	34.4	7.1	MT DEQ
M01HRSPC03, Horse Praire Creek (HP2)	98	78	26	2058.0	1163.5	128.5	07/29/16	24.1	15.8	MT DEQ
M01HRSPC05, Horse Praire Creek (HP5)	85	42	0	1584.5	342.5	0.0	07/22/16	18.3	12.3	MT DEQ
M01HRSPC02, Horse Praire Creek (HP4)	94	65	4	1790.0	673.0	9.0	07/29/16	21.6	12.5	MT DEQ
M01HRSPC02, Horse Praire Creek (HP4) AIR	96	88	61	1359.5	905.0	441.5	08/02/16	30.0	4.5	MT DEQ

Figure 8. Temperature Macro Summary Tab Example

This is an example Site Visit Form and gives a general idea of the format. 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

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

Place Site Visit Label Here

Site Visit Form Continued

Field Meter Calibration		
pH Meter:	Manufacturer & Model:	Date of Last Calibration:
	Comments:	
Multiparameter Meter:	Manufacturer & Model:	
	Date of SC Calibration:	DO calibrated at site visit ☐
	Comments:	

Site Visit Comments
Data Logger Notes:
Time data logger removed:
Time data logger returned:
☐ Data logger cleaned
☐ Data logger downloaded
☐ Data logger re-launched
Photos:
#
#
#
#
#
#

Place Site Visit Label Here

Continuous Data Logger Field Form

(One Station per page)

Project ID:________________

Date: ________________

Waterbody: ________________

Station ID: ________________

YSI, Surveyor, AquaRod, or Mini DOT Data Logger	
Medium:	Water Air Other:________
Interval *(hh:mm)*:	
Logger Make/Model:	
Serial #:	
Launch Date/Time:	
Deployment Date:	
Deployment Time:	
Latitude *(dd.dddd)*:	
Longitude *(ddd.dddd)*:	
Deployment Location & Additional Information:	
Data Logger Deployment Map:	
Retrieval Site Visit Code:	
Retrieval Date:	
Retrieval Time:	
Retrieval Comment:	
Electronic File Name:	

Temperature or Electrical Conductivity Data Logger	
Medium:	Water Air Other:________
Interval *(hh:mm)*:	
Logger Make/Model:	
Serial #:	
Launch Date/Time:	
Deployment Date:	
Deployment Time:	
Latitude *(dd.dddd)*:	
Longitude *(ddd.dddd)*:	
Deployment Location & Additional Information:	
Data Logger Deployment Map:	
Retrieval Site Visit Code:	
Retrieval Date:	
Retrieval Time:	
Retrieval Comment:	
Electronic File Name:	

Weather Station Data Logger	
Medium:	Water Air Other:________
Interval *(hh:mm)*:	
Logger Make/Model:	
Serial #:	
Launch Date/Time:	
Deployment Date:	
Deployment Time:	
Latitude *(dd.dddd)*:	
Longitude *(ddd.dddd)*:	
Deployment Location & Additional Information:	
Data Logger Deployment Map:	
Retrieval Site Visit Code:	
Retrieval Date:	
Retrieval Time:	
Retrieval Comment:	
Electronic File Name:	

APPENDIX B. FIELD HELP SHEETS

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

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

HOBO U24 EC DATALOGGER FIELD HELP SHEET

Field Check List

- [ ] Extra dataloggers
- [ ] Computer with HOBOware
- [ ] Base Station or Shuttle
- [ ] Extra Base Station or Shuttle
- [ ] Handheld meter with EC calibrated
- [ ] Cleaning Supplies
  - Vinegar
  - Toothbrush
  - Cotton swabs
  - Water in spray bottle

Ensure that the field computer is set up correctly (see **Appendix C**) before leaving the office.

Connecting HOBO U24 dataloggers

The arrow sticker on the datalogger body does not always line up with the correct location. The best way to ensure a good connection is to line up the coupler with the hole at the other end of the datalogger and to check that the coupler is between the two optical lights (see **Appendix C** for photo examples).

When the device is connected its serial number will appear in the bottom left corner of the HOBOware window.

If the datalogger doesn't connect:

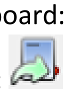
- Check datalogger alignment and that it is firmly seated on the base station.
- Warm the datalogger (cold near freezing dataloggers will not connect).
- Clean the optical windows of the datalogger and the base station.
- Disconnect the base station from the computer and plug it back in (check for a firm connection).
- Try connecting to a different datalogger to ensure it's not a problem with the base station.

HOBOware General Use

If the logger reports a "Read Header Failure" or a low battery warning, try to reconnect the device. Do not deploy a datalogger with a "Read Header Failure."

3s Red Blink = Logging Mode is active

<u>Launch the Device</u>

1. With the menu system: Device → Launch,
2. With the Keyboard: "Ctrl" + "L"
3. With the Icon: 

<u>Readout Device</u>

1. With the menu system: Device → Readout,
2. With the Keyboard: "Ctrl" + "R"
3. With the Icon: 

Mid-field Check at a Wet Site

1. Record an *in situ* EC reading near the datalogger on the Site Visit Form (SVF). It is best to collect the reading near the time that the datalogger will log.
2. Remove the datalogger from the water, record the removal time and serial number on the SVF.
3. Connect datalogger to computer.
4. Select "Readout Device".
5. Select "**NO**" when asked "Do you want to stop logging?"
6. Save file to folder for the specific trip.
7. Plot the data:

Data looks alright, and the last record point is close to the meter reading.	**The datalogger was buried and the last recorded point is not close to the meter reading.**
Continue with the next step.	1. Disconnect the datalogger. 2. Lightly remove the sediment from the sensor by swishing it in the stream. <u>Do not clean the sensor face.</u> 3. Place the datalogger in the stream to collect another SC reading. Do not let the logger wash away. 3. Record a meter SC reading at the time of the datalogger logging interval. 4. Repeat the readout process (Steps 3 to 7). 5. If the new data point is closer to the meter reading, continue with the next step.

8. Relaunch the datalogger so that it will continue recording at the original timing and interval.
    a. Example: A datalogger records a reading at a 30-minute interval starting at the top of the hour. It was removed at 9:35am and will be ready for redeployment at 9:50. The datalogger should be launched for a 30-minute interval to begin logging at 10:00.
9. Disconnect the logger from the computer.
10. Clean the datalogger and shade tube with dish soap, water and a brush.
11. Clean the sensor face:
    a. Start with dish soap and scrub gently with Q-tips. Rinse with tap water.
    b. If there is a thick layer of calcium carbonate on the sensor face, soak the sensor face in vinegar for 15-30 min. Replace vinegar about every 5 minutes as calcium carbonate neutralizes vinegar as it dissolves.
12. Place the logger back in the cleaned shade tube and reassemble.
13. Replace back in the water and record the time on the SVF.
14. Record a second *in situ* SC reading near the datalogger on the SVF.
    a. This is required for drift calculations.
    b. It is best to wait for approximately 10 minutes before recording the result
    c. Collect the reading near the time that the datalogger will log.

Mid-Field Check at a Dry Site

1. Do not clean datalogger
2. Do not stop datalogger
3. Do not relaunch datalogger
4. Record what was done on SVF

Reading out the datalogger is optional.

NOTE: It is very important for U24 dataloggers that there are no gaps in the data for EC that are not bracketed with *in situ* SC readings. Gaps prevent the HOBOware program from being able to correct for drift.

APPENDIX C. HOBOWARE HELP SHEET – USER GUIDE

HOBOware is a software program for Onset dataloggers. The software is downloaded for free and then can be upgraded to HOBOware Pro. The free version only works with temperature only dataloggers (HOBO U22s). The HOBOware Pro version is needed for the EC dataloggers.

HOBOware Pro also includes helpful features when it comes to launching and reading out dataloggers. These will be described in the document as "TIPS."

Downloading HOBOware

1. Go to http://www.onsetcomp.com/products/software/hoboware
2. Click on Download for Free
3. Select Download for the operating system and click Run
4. Go through the Install procedure
5. If required, apply a License Key for HOBOware Pro:
    a. Open HOBOware
    b. Click on Help
    c. Select Manage License Key (DEQ personnel - see WQPB Equipment Specialist for how to obtain a License Key)
    d. Apply License Key

Equipment

Most Onset dataloggers have optical communication. These windows are covered by a cap to prevent the window from becoming scratched and fouled during deployment. There are multiple devices that serve as the connector between a datalogger and a computer.

Optic USB Base Station

Optic USB Base Stations are corded devices that allow for Onset dataloggers to communicate with a computer. Each datalogger type requires a particular coupler for connecting to a Base Station. The U24 and U22 dataloggers use the same coupler. **Please see the Optic USB Base Station User Guide for more information.**

Waterproof Shuttle

Waterproof Shuttles are similar to base stations, but do not always need a computer to readout and relaunch a logger. The main purpose for a shuttle is to stop, readout the data and relaunch the logger in the field. The readout data is stored into "banks" on the shuttle. There are 63 banks. If a USB cord is connected to the Waterproof Shuttle, it operates very similarly as an Optic USB Base Station. **Please see the Waterproof Shuttle User Guide for more information.**

NOTE: Relaunching erases the data file from the datalogger. When connected to the computer the user is asked to stop logging before reading out a running datalogger. The Waterproof Shuttle does not have this option (unless connected to a computer like a base station) and will relaunch the datalogger after the readout process. In this case the data only exists on the Waterproof Shuttle. It is good practice to offload the data from a shuttle to a computer as soon as possible.

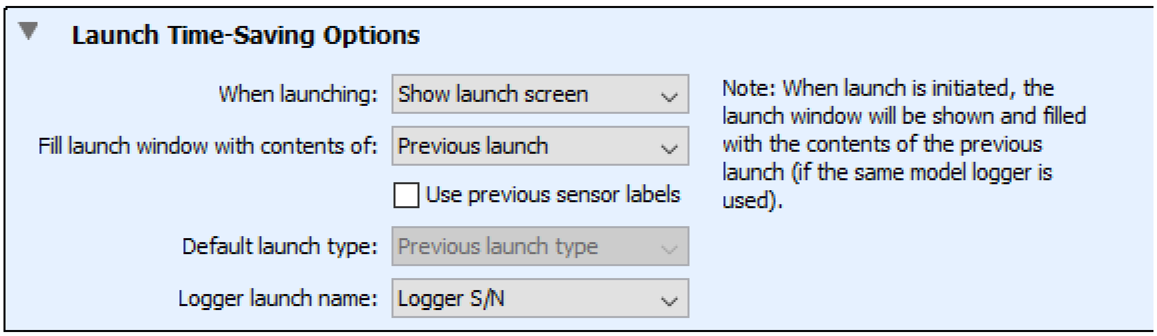
HOBOware Setup

Check HOBOware for updates (Help → Check for Software Updates). If multiple computers are being used, ensure all are using the same updated version.

There are a few set up preferences that are helpful when launching and reading out Onset Dataloggers. File → Preferences "**CTRL + comma**" → General tab

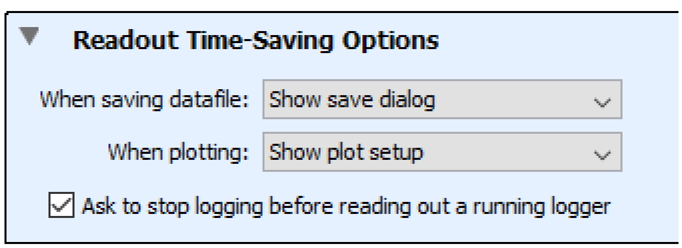
Under "Launch Time Saving Options" select:

- "When launching: Show launch screen" - this will provide a double check for information such as Serial number/naming.
- "Fill launch Window with contents of:" "Previous launch".



Under "Readout Time-Saving Options" select:

- "When saving datafile:" "Show save dialog" - this is to ensure that the file is being saved in the correct location.
- "Ask to stop logging before reading out a running logger" this allows the user the choice ending the logging file or not when reading out the datalogger.



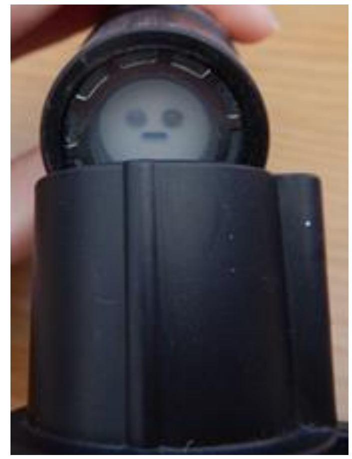
Under Export Settings – Export file type should be Text (.txt or .csv) Including serial numbers in the column headers is a useful feature as well. Especially when dealing with multiple datalogger files.

Base stations and Waterproof Shuttles connect with USB devices only. This can be set in the Communication tab under Device Types.

Connecting – Logger to Computer

1. Plug the base station into a USB port onto a computer that has had HOBOware software installed and open the program.
2. Place the correct coupler onto the Optical Base Station and connect the logger by aligning the arrows on the logger and coupler up for correct optical reading.

a. Ensure that optical screen of the logger is clean and that the logger is firmly seated in the coupler.
b. When a logger is connected with a computer for the first time the device driver software will automatically begin to install.
c. The U24 logger's arrow stickers shift over time. Line the top hole of the logger and the back of the conductivity sensor.



When the logger is connected, information about the logger model and the serial number will be in the lower left-hand corner.

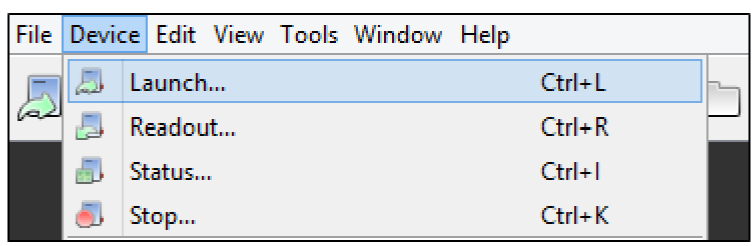
If the datalogger doesn't connect:

- Check datalogger alignment and that it is firmly seated on the base station.
- Warm the datalogger (cold near freezing dataloggers will not connect).
- Clean the optical windows of the datalogger and the base station.
- Disconnect the base station from the computer and plug it back in (Check for a firm connection).
- Try connecting to a different datalogger to ensure it's not a problem with the base station.

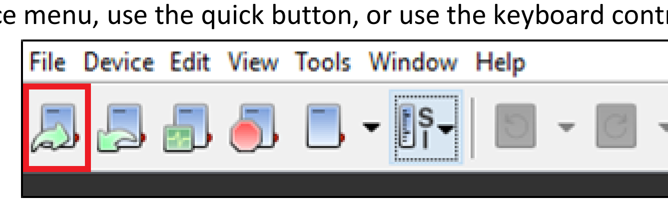
If the logger reports a "Read Header Failure" or a low battery warning, try to reconnect the device. Do not deploy a datalogger with a "Read Header Failure". This error indicates that there is a miscommunication between the datalogger and the base station. Launching with a "Read Header Failure" may result in data loss.

Launching – Set up to start logging.

Launching is the process of setting the datalogger up for deployment. The sampling interval, start time, and other sampling features are selected here.



1. Select the Launch option from the Device menu, use the quick button, or use the keyboard controls of "**Ctrl + L**":



2. The "Launch Logger" window will open.
   a. First Section (Logger Model) are details about the datalogger:

i. File Name should be in one of the following formats:
   1. Pre-AC_SN
   2. Post-AC_SN
   3. Project ID_SN
   4. Project ID_Location_SN (if deployment location is known)

   Where SN = Datalogger Serial Number

b. Second Section (Sensors) are details about what sensors are installed on the datalogger.
   i. Depending on the datalogger, parameters can be selected to be on or off.
   ii. See the datalogger user manual for more information.

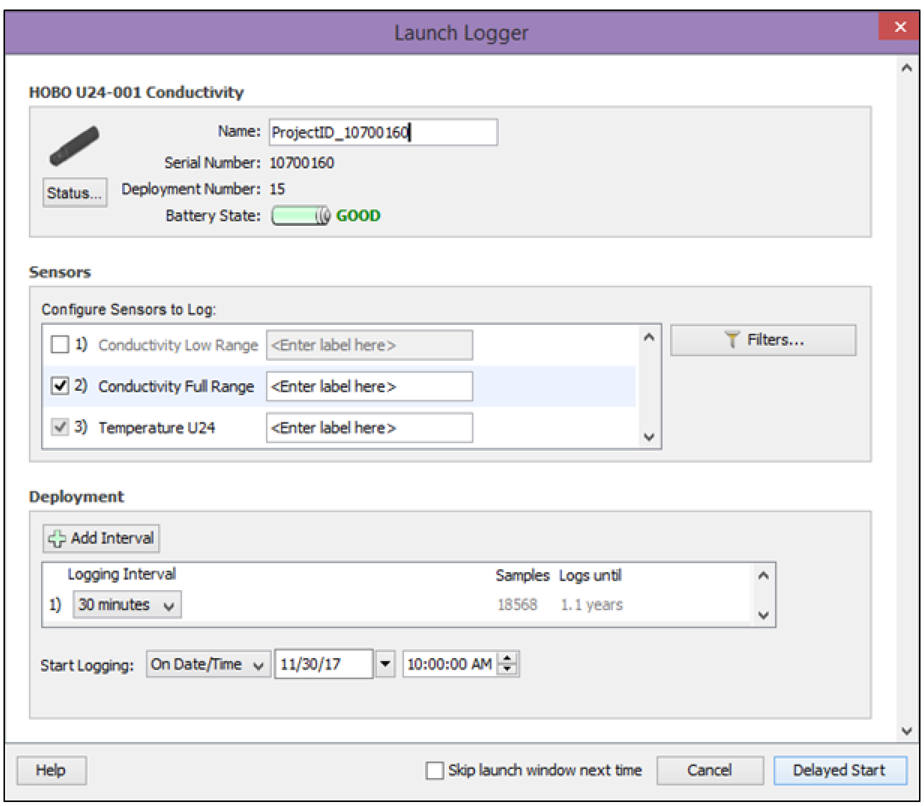
c. Third Section (Deployment) includes deployment information: interval and start date/time.
   i. Logging Interval for Accuracy Check: 2 min
   ii. Logging Interval for Project Deployment: Project determined (15/30 min)
   iii. Set start Logging time

For accuracy checks:

- Change the interval to “Custom” (the last option in the drop-down list) and set for 2 min.
- Change the Start Logging time to an appropriate date and time. (**See Section 10.1.2**)

For field deployment:

- Set the interval that was requested by the project manager in the project’s Sampling Analysis Plan.
- Select an appropriate date and time to begin logging. The datalogger should start logging before the deployment. Pre-deployment data collection can be trimmed when the data is retrieved.



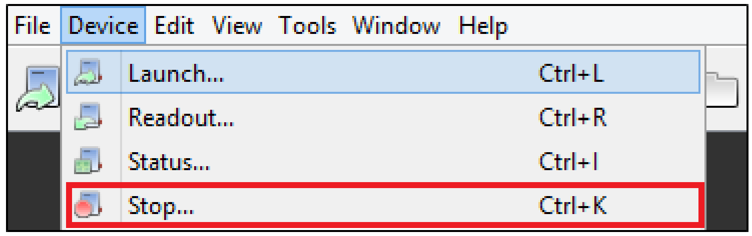
Check the “Launch Logger” window before selecting “Delayed Start” to ensure that the correct name is recorded and that the correct sampling options are checked. It is not recommended to check “Skip launch window next time” as each datalogger has a different serial number and therefore a different name. Once “Delayed Start” is selected, “Launch successful” will be displayed in the bottom left hand corner.

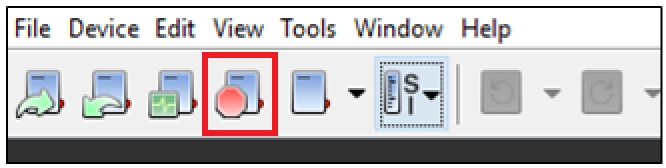
The status of a datalogger can be checked at any time by selecting the Status option from the Device menu, using the quick button, or using the keyboard controls of “**Ctrl + I**”.

Stop – Stopping the datalogger from logging

Stopping a datalogger will end the current logging file. A datalogger can be stopped logging by selecting the Stop option from the Device menu, using the quick button, or using the keyboard controls of “**Ctrl + K**”.

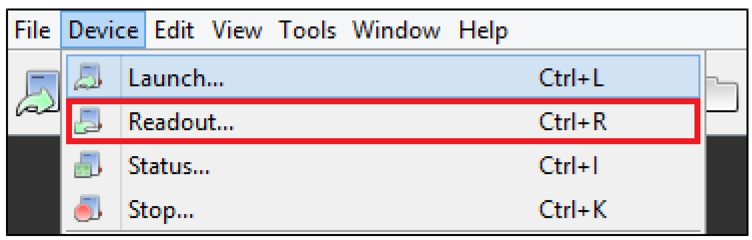
NOTE: Do not stop an EC datalogger if it is found at or being retrieved from a dry site. See **Section 10.6.1**.

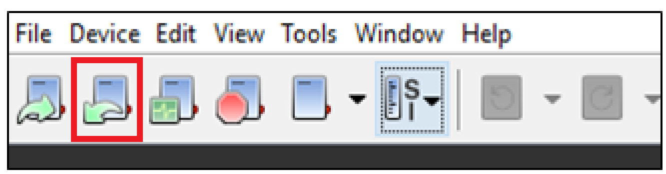




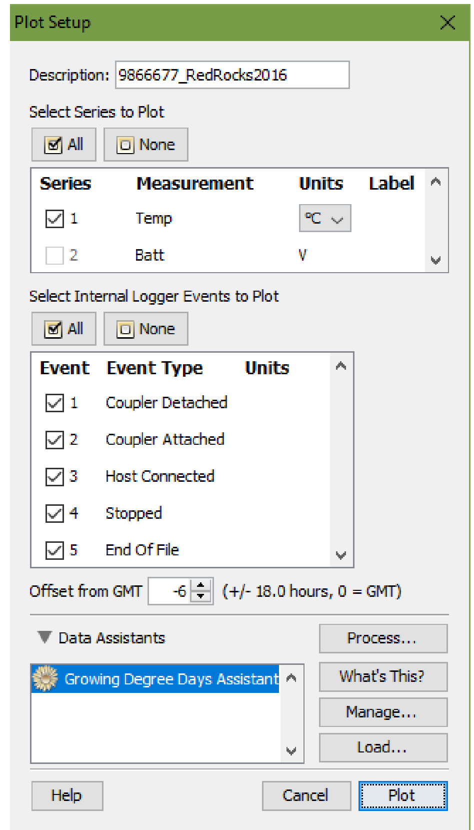
Readout – Removing data from the datalogger

Reading out a datalogger offloads the current datalogger file onto the computer or Waterproof Shuttle. The user will be asked if they want to stop logging when reading out a datalogger in HOBOware. To readout a datalogger, select the Readout option from the Device menu, use the quick button, or use the keyboard controls of “**Ctrl + L**”.



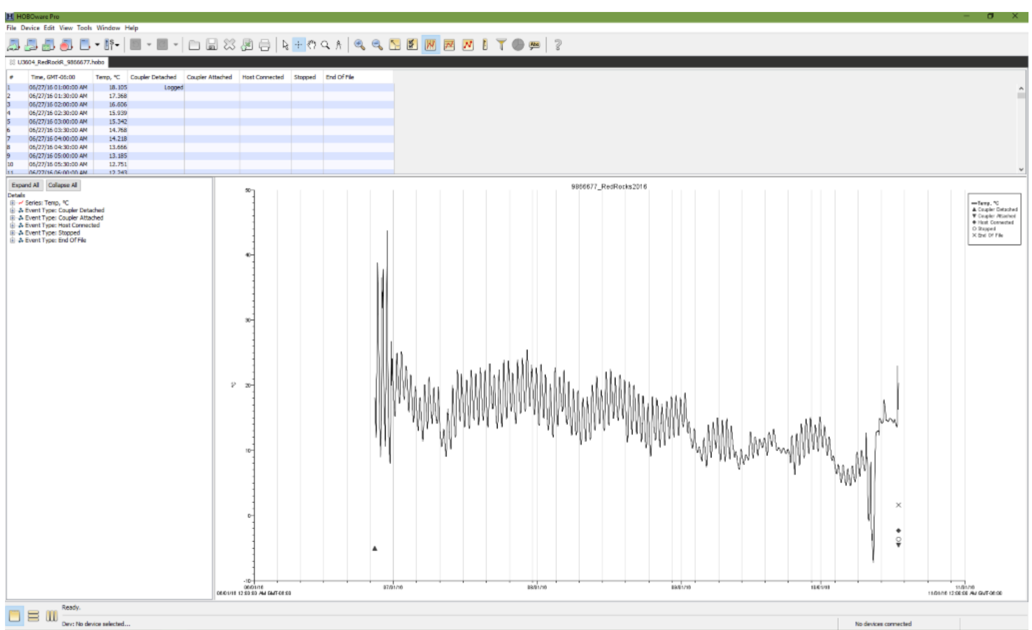


1. Select whether or not to Stop the datalogger from logging
2. Select the appropriate file location to save the (.hobo) file.
3. The datalogger can be removed from the Base Station
4. A "Plot Setup" window will open, choose the appropriate units, and select "Plot". This will open a tab where the tabular and graphical data is presented.
5. Opening a saved HOBOware file also will open the plot setup window.

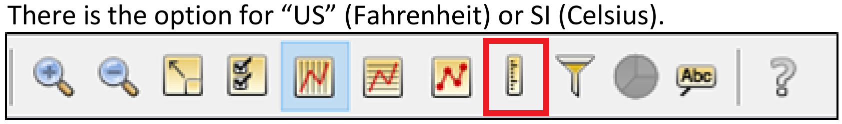


This plot setup window shows options about what will be charted along with any data assistants that could be applied to this data file. The reported units can be selected here or after the data has been plotted.

Select "Plot" to plot the data. A tab will open up and display the numeric data in a table and will show a graph of the data as well.



To change the reported temperature after the data is plotted, select the "Converts units for all series" icon. It looks like a ruler. There is the option for "US" (Fahrenheit) or SI (Celsius).

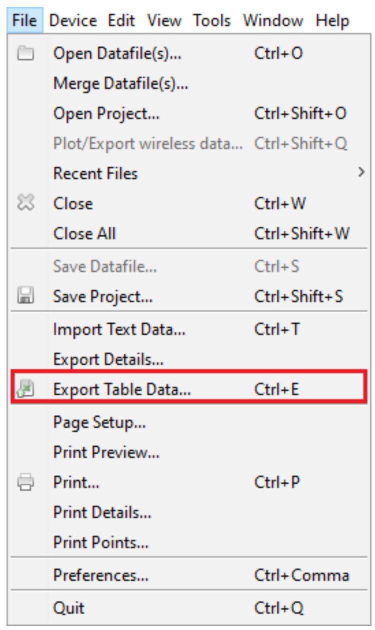


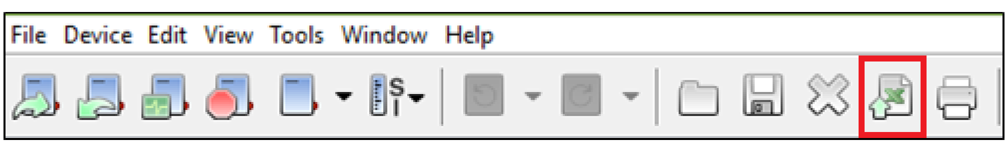
Exporting – Removing the data from the HOBOware

After the data is read out from the datalogger to HOBOware software it will have to be exported to a .csv file. In the past, there have been issues with the recorded days and time when exporting the file directly to a .xlsx file.

Accuracy check data files must be exported in Celsius so that the results can be compared against the thermometer readings. Data files collected for projects should be exported in the units that are listed in the project's Sampling Analysis Plan.

Select the Export Table Data option from the Device menu, use the quick button, or use the keyboard controls of "**Ctrl + E**".





The Export window will open. Verify that the serial number and units are correct. Leave all measurements checked. Select "Export" Choose the file location, Rename the file if necessary.

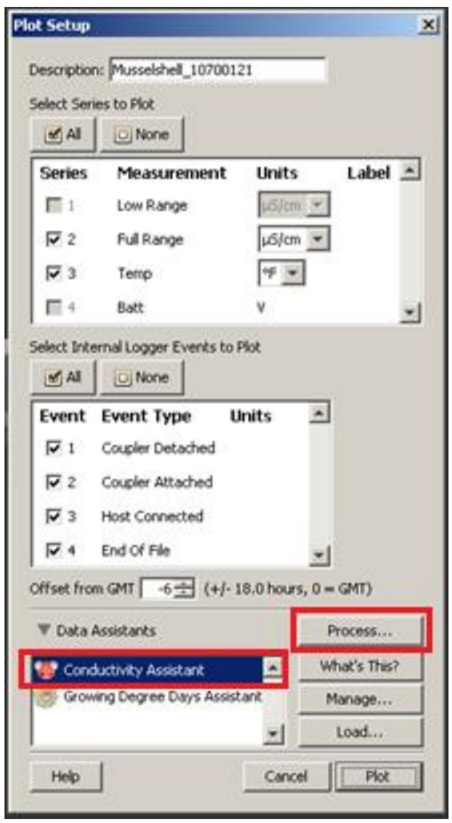
APPENDIX D. HOBOWARE PRO CONDUCTIVITY ASSISTANT – USER GUIDE

The HOBOware Pro Conductivity Assistant is used to correct the datalogger's recorded conductivity data with an actual field conductivity reading. Each file must be bracketed by an actual field conductivity reading and those readings must match up with a logged point on the datalogger.

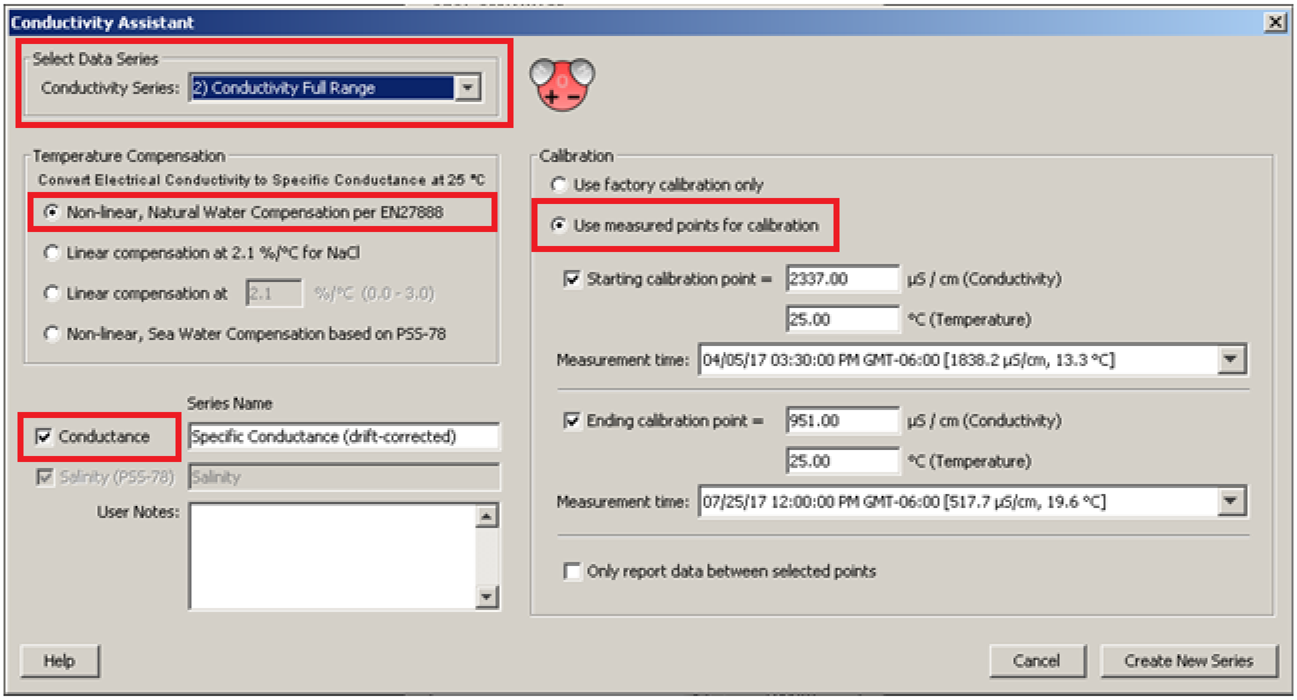
NOTE: Merging data files to create "one file" does not work. Merging data files creates a .prj (project) file. The Conductivity Assistant will only work with .hobo files.

1. To begin the drift-correction process, open the datalogger file (.hobo) that you would like to correct. This will open the Plot Setup Window.

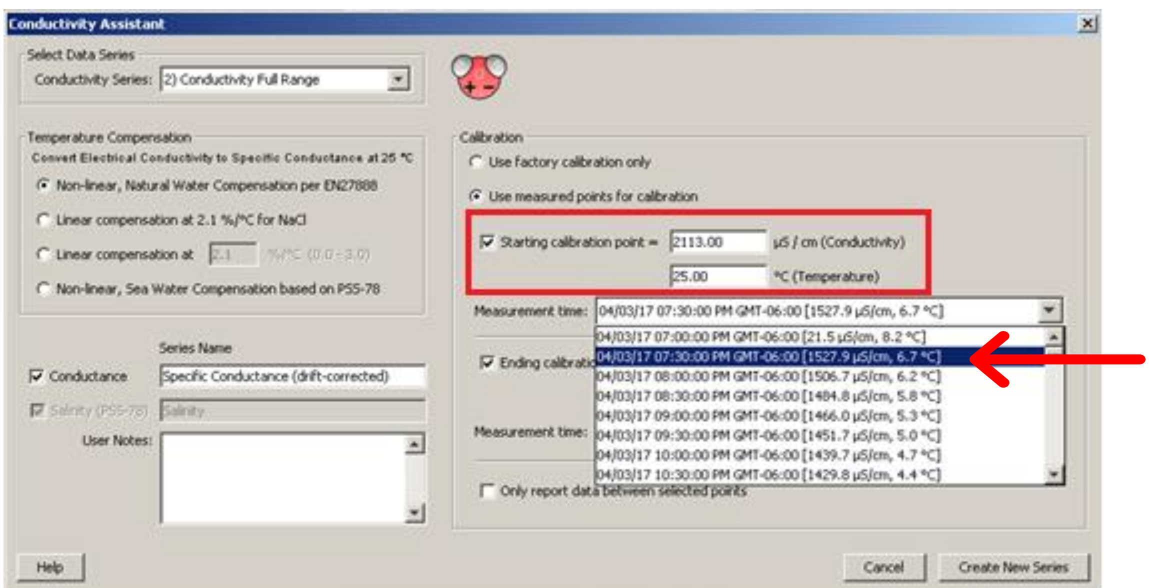
2. Select "Conductivity Assistant" under the Data Assistants section of the Plot Setup window at the bottom and click on the Process… button. This will open the Conductivity Assistant window.



3. In the Conductivity Assistant window:
   a. Select the data series you are correcting (usually this will be Conductivity Full Range unless you are using the high or low range data from a datalogger for a particular reason)
   b. Choose "Non-linear, Natural Water Compensation per EN27888" for the Temperature Compensation
   c. Confirm that the Conductance box is checked, and the Series Name is "Specific Conductance (drift-corrected)"
   d. In the Calibration section, select "Use measured points for calibration"

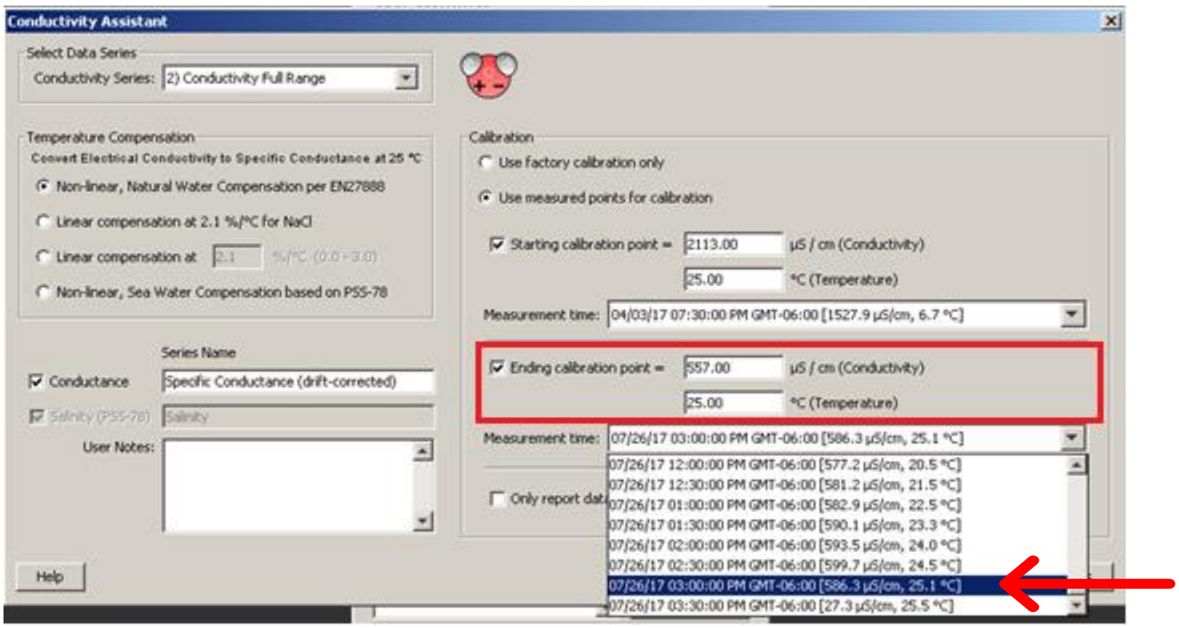


4. For the Starting calibration point, input the specific conductivity or conductivity reading you would like to calibrate to. Set the Calibration point Temperature to **25° Celsius** **<u>if using Specific Conductivity readings</u>** from a YSI or other meter to correct drift. If using Conductivity only, you must enter the corresponding temperature that the conductivity reading was taken at.

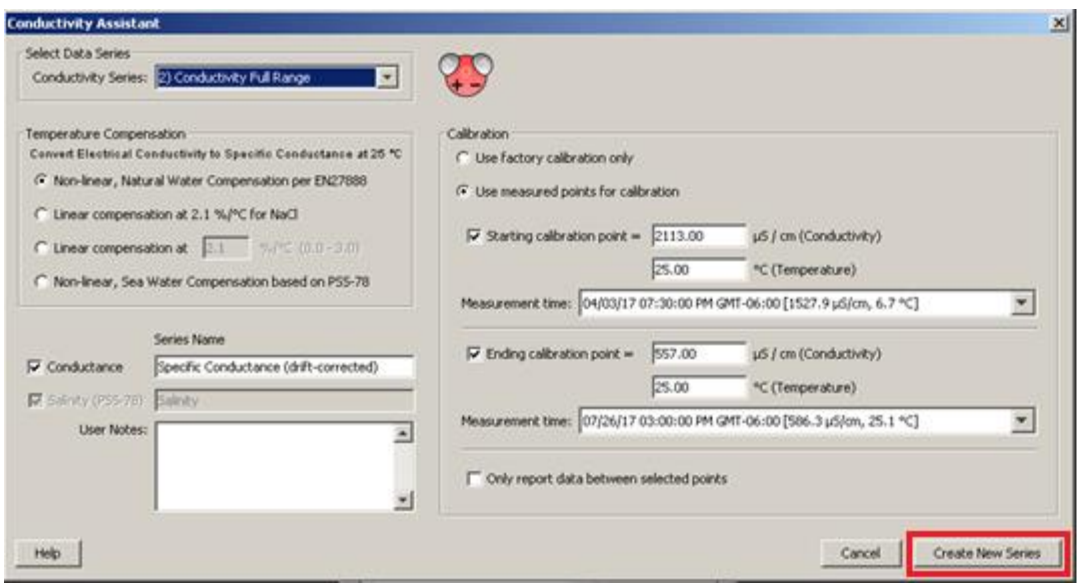


5. From the Measurement time dropdown list, select the logger reading you would like the calibration point to correspond to. Do not just use the first/last data point(s) in the list and be very careful to select a valid conductivity reading, as many times after re-deploying or before downloading the logger there may be a data point logged out of the water.

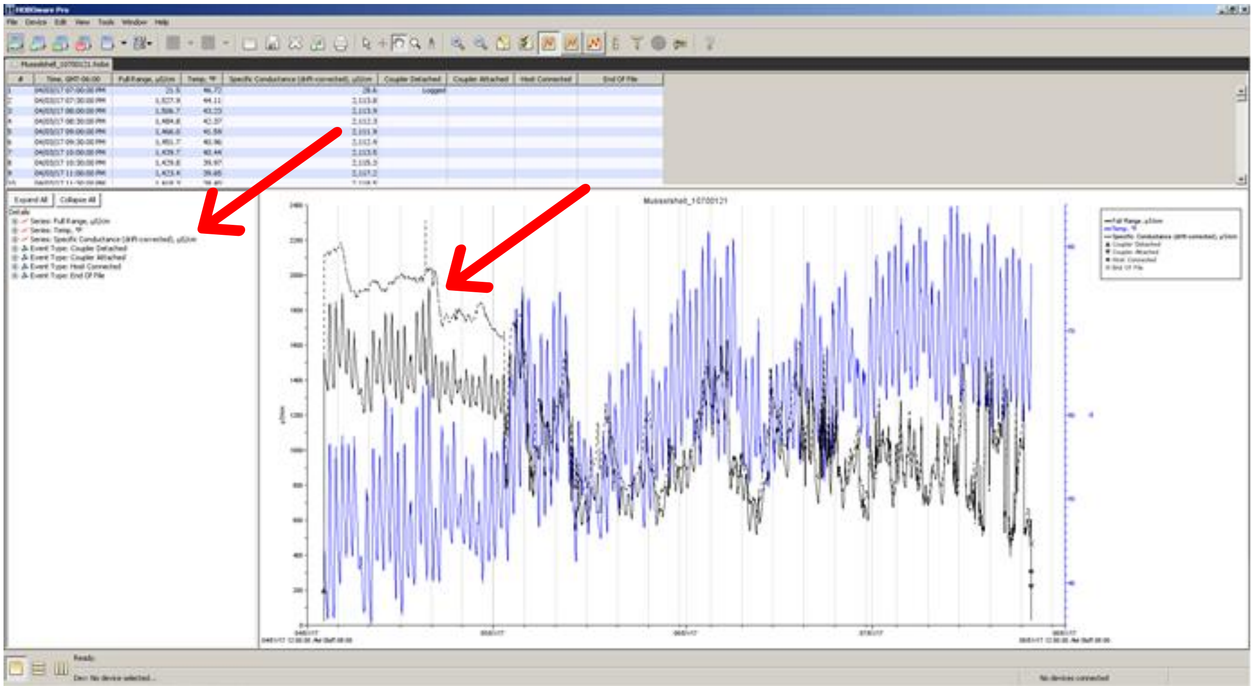
6. Repeat the process in Step 5 for the Ending calibration point.



7. Click **Create New Series** in the bottom right of the Conductivity Assistant window and then click the **Plot** button in the bottom right of the Plot Setup window.



8. Now a graph will appear showing all of the series: unaltered/raw conductivity readings, temperature readings, and a new series, titled **Specific Conductance (drift-corrected), µS/cm**. This series will appear on the graph as a dotted line.



9. Follow Export Procedures

APPENDIX E. SMALL DATALOGGER PHOTOS (FIGURE 9 THROUGH FIGURE 39)

Photos of ways small dataloggers can be deployed.

SHADE TUBE ASSEMBLY

Figure 9. Shade tube assembly

Male/Female Adapter – Pipe with drilled holes

Figure 10. Logger in a shade tube assembly

Bolt – Data Logger – Thimble – Washer – Nut

BEFORE AND AFTER EC CLEANING

Figure 11. Pre-Cleaning

Figure 12. Post-Cleaning

CAMOUFLAGE

Figure 13. Shade tube camouflaged with paint and camo tape

Figure 14. Shade tube and cable with diatom and silt accumulation

Figure 15. Rebar and flagging at a site with no risk of vandalism

Figure 16. Rebar with rust is almost invisible; cable is evident at this low-risk site

Figure 17. A float system setup to assure that the logger is not buried.

Figure 18. Bricks angularness is visible.

HOW TO DEPLOY (LOCATION)

Figure 19. Double rebar loop deployment.

Anchor the cable upstream in the pool tail, and position the logger in the riffle

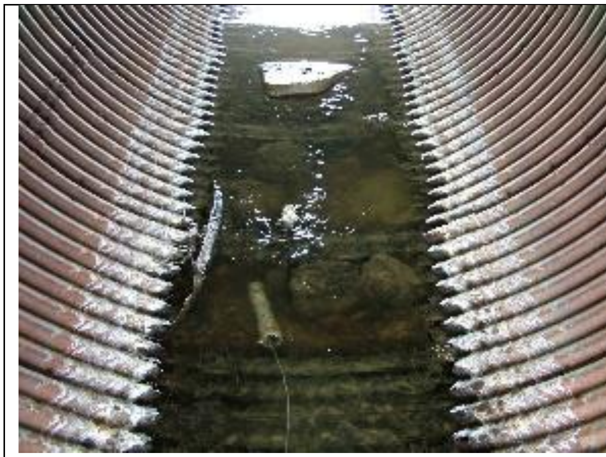


Figure 20. Culvert deployment designed to only capture flowing water data.

The datasets for EC and temperature will reveal when flow is present. Stranded, pooled water is unlikely to occur here.

Figure 21. Deployment site on a very small stream using rebar loop at thalweg location

Figure 22. Site that has gone dry.

EC and temperature data provide the clues as to when flow no longer existed.

HOW TO DEPLOY: LOCATION (CONTINUED)

Figure 23. Culvert At a site known to go dry.

This strategy assures that only flowing water is measured for EC. The logger is shown in the right side of the photo, in a sensor-up position.

Figure 24. Cable attachment to a bridge using stainless steel cable, ferrules, thimble, threaded clevis hardware.

Figure 25. Fencepost deployment at a bridge abutment.

The fencepost is then driven into the soft substrate using a sledgehammer.

Figure 26. Fencepost deployment at bridge abutment closeup

Figure 27. Cast concrete and rebar anchor and shade tube system with stainless steel cable for deployment at a bridge at a large river site.

Large river temperature/EC logger deployment from a bridge, showing cast concrete and rebar anchor and 1/8” stainless steel cable. This may be tethered to the upper span of the bridge or to an anchor in the river. In the latter case, a grappling hook is used to retrieve the apparatus. The assembly is lowered into place in the thalweg of the river using a long, detachable rope loop.

How to Deploy (Setup)

Figure 28. Camo cord temperature logger assembly showing doubled zip ties, camo cord tied through the logger and the zip ties inside the shade tube with a bowline knot, and burlap cloth to be attached around the shade tube.

Figure 29. Grappling hook assembled using commonly available hardware

Figure 30. Shade tube zip tied to brick (note 2 zip ties).

Figure 31. Camo burlap installed on shade tube and brick, tools and flagging

Figure 32. List of tools required

Fasteners (7/16” nuts and 3” bolts)
1/2” washers, stainless steel ferrules, thimbles
1/16” stainless steel cable
two-7/16” crescent and 7/16” ratchet wrenches
Rebar- straight and loop-bent pieces.
High-quality ~10” zip ties and scissors
Cable cutter and Ferrule crimper
2-pound sledgehammer
Camouflage supplies (burlap cloth, spray paint)
50 lb. camo paracord

MINIDOT DEPLOYMENT

Figure 33. MiniDOT is tethered to the bank as well as zip tied

Figure 34. MiniDOT zip tied to rebar (Note 3 zip tie configuration).

Figure 35. MiniDOT deployment in the water column using U-shaped rebar and cable tether. Note horizontal logger orientation

Figure 36. Straight rebar can be used as well.

CORROSION AND LOSS

Figure 37 and 38. High EC stream resulted in corroded aluminum ferrule, which was replaced using a salinity-resistant alloy ferrule.

Figure 39. Vandals will go to great lengths to remove a data logger from a stream by cutting the cable.