

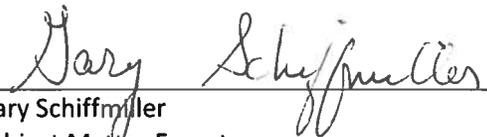
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New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB)

Standard Operating Procedure (SOP) for

TEMPERATURE DATA LOGGERS (THERMOGRAPHS)

Approval Signatures



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6/10/2019
Date



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1.0 Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to describe the Surface Water Quality Bureau's (SWQB) procedure for long-term deployment of temperature loggers to record temperature of air or water in rivers and streams. This SOP also covers temperature logger maintenance and management of data.

2.0 Personnel Responsibilities

Personnel who deploy temperature loggers, offload or manage temperature logger data, or who are responsible for temperature logger accuracy are responsible for implementing this procedure. Field staff are responsible for deploying temperature loggers and for offloading of temperature logger data according to the procedures set forth in this SOP.

One individual within each of the following SWQB sections, Monitoring Assessment and Standards Section (MASS) and Watershed Protection Section (WPS) is designated as the Temperature Logger Manager (manager). A second individual is designated as the Alternate Temperature Logger Manager (alternate) and fulfills the manager's responsibilities when the manager is unavailable. The manager maintains temperature loggers, associated software, instruction manuals, and accessories in working order and available for staff to use.

The manager keeps a record of the disposition of each temperature logger. The record includes the temperature logger serial number, temperature accuracy verification log, current status of each temperature logger (available for use, launched and awaiting deployment, deployed, or retrieved and awaiting offload), deployment location, person responsible for the temperature logger, date of checkout, and any other pertinent information. The manager also keeps a record of the disposition of all temperature logger-related accessories, such as optic shuttles and base stations.

3.0 Background and Precautions

Do not wade a stream to deploy a temperature logger if the depth (ft) of the stream times the stream velocity (cfs) is greater than ten (The "RULE OF 10"). Site conditions or project-specific data collection objectives may necessitate the use of alternative field procedures not included in this SOP. The use of field methods other than those presented in this SOP must be approved by the Program Manager and alternative methods must be accurately documented. This procedure is based on the capabilities of the Onset HOBO temperature loggers described in Section 5.0.

4.0 Definitions

Assessment Units (AUs) – River or stream reaches defined by various factors such as hydrologic or watershed boundaries, geology, topography, incoming tributaries, surrounding land use/land management, water quality standards, etc. AUs are designed to represent waters with assumed homogeneous water quality (WERF 2007). Stream or river AUs in New Mexico are typically no more than 25 miles in length unless there are no tributaries or land use changes to consider along the reach (NMED/SWQB 2017).

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Program Manager – An individual within the SWQB that manages a program such as the Watershed Protection Section (WPS), the Point Source Regulation Section (PSRS) or the Monitoring, Assessment and Standards Section (MASS).

Quality Assurance Officer (QAO) – An individual within the MASS that is responsible for overseeing the development and implementation of all quality assurance procedures and processes within the SWQB including those projects that receive support or funding from the SWQB. The QAO is also responsible for validating and verifying data sets for potential use in assessment of surface waters.

Standard Operating Procedure (SOP) – A document that lists the steps that should be completed when doing a task.

Subject Matter Expert (SME) – A person who is well familiar with the purpose and procedure for accomplishing a task.

Surface Water Quality Bureau (SWQB) – A Bureau under the Water Protection Division of the New Mexico Environment Department. The SWQB’s mission is to preserve, protect, and improve New Mexico’s surface water quality for present and future generations.

Temperature logger - A small portable device that logs temperature data at predetermined intervals.

5.0 Equipment and Tools

The temperature loggers that the Bureau uses are manufactured by:

Onset Computer Corporation
470 MacArthur Blvd.
Bourne, MA 02532
Mailing address: PO Box 3450, Pocasset, MA 02559-3450
Phone: (508) 759-9500 or (800) LOGGERS
Fax: (508) 759-9100
Email: loggerhelp@onsetcomp.com
Internet: <<http://www.onsetcomp.com>>

The specific models currently used by the SWQB are the HOBOb® Water Temp Pro v2, which requires HOBOWare Pro® software, and the HOBOb® MX TidbiT 400, which requires the HOBObmobile® app for mobile devices. The HOBObmobile® app has the ability to transfer the data to the HOBOWare Pro® software.

In addition to temperature loggers and associated software, the following equipment may be useful for temperature logger deployment, retrieval, and offload:

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Table 1. Equipment

Item	Comment
Nylon wire ties	8-inch length to secure temperature logger to rebar or T-post
Surveyor's flagging tape	To mark temperature logger deployment location
rebar stakes	3/8- or 1/2-inch diameter steel (two to four feet long) to anchor temperature logger in stream bed
Steel T-posts	6 and 8 foot; to anchor temperature logger in sediment-dominated stream beds
T-post Driver	To set T-post in the stream bed
Sledgehammer	3 to 4 pounds; to drive rebar stakes
Steel cable kit	Includes 3/32- or 1/8-inch steel cable, cable cutter, ferrules, vise grip, plastic floats, and eye bolts for anchoring to various structures
Steel hose clamps	To secure temperature loggers to rebar or T-post
5/16-inch nut driver	To tighten or loosen hose clamps
Diagonal pliers and lineman's pliers	To cut and twist tie wire or to cut zip ties
Digital camera	To photo-document the location of the temperature logger
GPS unit	To record the coordinates of the temperature logger location
30m measuring tape	To measure the distance from the temperature logger to nearby landmarks to facilitate retrieval
Metal detector	To facilitate temperature logger location upon retrieval
Modified mattock	With a V-notch cut for pulling rebar from the substrate during retrieval
Bumper jack and chain	For retrieval of rebar or T-post, which is sometimes not possible to remove by hand
Pipe wrench	For twisting embedded rebar to facilitate retrieval
Waterproof shuttle	Onset Computer Corp. Part # U-DTW-1; to offload temperature logger without having to remove it from the water
Laptop computer	To launch, download, offload, or otherwise operate temperature loggers in the field
Power inverter	To power the laptop in the vehicle
Tablet or cell phone	With HOBOMobile installed for use with HOBOMobile MX TidbiT 400
Temperature logger Field Forms	For Deployment, Download, and Retrieval

6.0 Step-by-step Process Description

6.1 General Guidance

Temperature loggers may be deployed in the air or in the water. The number and locations of temperature loggers, and whether an air temperature logger is deployed should be described in the Field Sampling Plan. Be sure to always record the status (i.e., available for use, launched and awaiting deployment, deployed, or retrieved and awaiting offload) of temperature loggers in the status spread sheet.

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The maximum interval for SWQB monitoring of standards attainment using a temperature logger is one hour. A fifteen-minute interval is considered optimal. Shorter intervals provide a more precise estimate of the duration of daily maxima, and they may be used without a negative impact to data quality. Intervals of less than five minutes may cause the memory capacity of the temperature logger to be exceeded within one field season.

Monitoring should include the period of maximum expected temperatures. In New Mexico, this is generally from June through August, when incident solar radiation is highest and ambient air temperatures are most likely to be at maxima. Knowledge and documentation of local temperature patterns is necessary if the monitoring period is to vary from this period.

6.2 Deploying the Temperature Logger

6.2.1 Launching Temperature Loggers

When deploying a HOBOb[®] Water Temp Pro v2, the SWQB utilizes HOBOWare Pro[®] software for launching of temperature loggers. The procedure for launching HOBOb[®] Water Temp Pro v2, using HOBOWare Pro[®] is as follows:

- A. Open latest version of HOBOWare Pro[®] software on PC.
- B. Connect HOBOb[®] Optic USB Base Station to HOBOb[®] Water Temp Pro v2. When connecting, ensure the communication end of the temperature logger is clean, insert this end into the HOBOb[®] Optic USB Base Station, aligning arrows on each device.
- C. Use HOBOb[®] Optic USB Base Station to connect HOBOb[®] Water Temp Pro v2, to PC USB port.
- D. In HOBOWare Pro[®] software, click on Device menu item, then Launch option, or Launch icon on toolbar. The Launch window opens. This window is separated into three panes; Logger Information, Sensors, and Deployment.
- E. Confirm serial number in Logger Information pane matches the serial number of the temperature logger. Also, ensure battery life is sufficient (i.e., Good) for deployment.
- F. Sensor pane should indicate type of sensor on unit, temperature. Typically, no adjustments are needed here.
- G. The Deployment pane is used to set logging interval (i.e., 15 minutes, 30 minutes, or 1 hour). Select appropriate logging date and time according to project specifications. General options are start logging now, at interval or on a specific date and time. Once option is selected, click on button in lower right-hand corner of launch window and begin logging ambient temperature. If a date and time or interval was selected the button will read "Delayed Start". If start logging now was selected button will read "Start". For additional information please refer to manual for Getting Started: Using HOBOWare[®] with HOBOb[®] Data Loggers which can be found at Onset[®]HOBOb[®] Data logger official website.
- H. Record status of temperature logger in status spread sheet as launched and awaiting deployment.

When deploying a HOBOb[®] MX TidbiT 400, the SWQB utilizes HOBOMobile[®] app for launching temperature loggers. The procedure for launching HOBOb[®] MX TidbiT 400, using HOBOMobile[®] app is as follows:

- A. Download the HOBOMobile app from the App Store[®] or Google Play[™].
- B. Open the app and enable Bluetooth in the device settings if prompted.

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- C. If this is the first time you are using the logger, firmly press the magnetic start HOBO button near the center of the logger to wake it up. The alarm and status LEDs will blink once when the logger wakes up. This will also bring the logger to the top of the list if you are working with multiple loggers. Tap the logger in the list to connect to it. If the logger does not appear on list, reference logger manual for additional information.
- D. Once connected, tap Configure. Deployment Info, Logging Setup, Sensor & Alarm Setup, Power Saving Mode, and Advance are listed under the Configure tab.
- E. Under Logging Setup, ensure logging interval is set to appropriate interval based on project specifications (i.e., 15 minutes, 30 minutes, or 1 hour). Once completed, tap on start logging, a new window will appear, choose appropriate logging start time based on project specifications. Typically, the SWQB will choose a date and time before a known deployment. No other settings need to be adjusted for Logging Setup.
- F. The SWQB uses default settings for Sensor & Alarm setup.
- G. For Power Saving Mode settings, it is recommended to choose Bluetooth Off Water Detect.
- H. The SWQB uses default setting for Advanced.
- I. Once all settings have been verified, tap Start in the top right corner of Configure page.
- J. Reference the HOBO® MX TidbiT 400 manual for additional information if needed. Manual can be found at Onset®HOBO® Data logger official website.
- K. Record status of temperature logger in status spread sheet as launched and awaiting deployment.

6.2.2 Site Selection

Select temperature logger locations according to the Field Sampling Plan (NMED/SWQB. 2018c). Typically, for water quality ambient/assessment monitoring, which often utilizes targeted monitoring, only one sampling station is located within each Assessment Unit (AU), generally at the downstream end near the bottom of each AU (NMED/SWQB. 2018a). For stream restoration effectiveness monitoring, temperature loggers are deployed pre-treatment and post-treatment, upstream and downstream of the project reach (Grabow, Spooner et al. 1998). Additional locations may be monitored as needed.

When deploying the temperature logger, ensure selected location is representative of ambient conditions. Deploy the temperature logger in water with a consistent flow. Avoid locations in shallow riffles or in deep pools with little current. Locate the temperature logger in a transition between a riffle/run and a pool, and if possible, at the toe of a pool as it becomes shallower, prior to entering a run or riffle. Ensure that under expected flow conditions, the temperature logger will be continually submerged but not buried in sediment. Whenever possible, find an out-of-the-way place where the temperature logger is not easily detectable.

If an air temperature logger is deployed, locate it at a location that will be shaded throughout the day, typically on a tree branch near the trunk. Detail the actual conditions of temperature logger deployment on the deployment field sheet.

6.2.3 Securing Temperature Logger

Unless another stationary object is available, drive a rebar stake or T-post into the stream bed using a small sledgehammer or T-post driver. Secure the temperature logger to the rebar or T-post using at least two nylon wire ties or hose clamps. In very cold water, nylon wire ties may be

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too brittle to tighten without breaking. Storing nylon ties in water keeps them flexible and helps prevent this. For soft sediment or deeper streams, secure the temperature logger to a steel T-post. In areas frequented by the public, take precautions against vandalism, theft, and accidental disturbance by additionally securing, concealing, or camouflaging equipment.

6.2.4 Field Sheet Documentation

Provide a detailed description of the precise deployment location. Complete the temperature logger deployment field sheet as extensively as possible, including logger serial number, the GPS latitude/longitude (in decimal degree format) of the temperature logger location (not the default station latitude/longitude). Draw a sketch map, clearly indicating the direction of flow, left and right bank, and other features that would enable staff not present at the deployment to locate the temperature logger for retrieval. As necessary, take one or more photographs showing the precise deployment location, typically with a person indicating the location of the rebar or T-post and/or flag the locale with surveyor's tape to facilitate location upon return.

Record the status of temperature logger in status spread sheet as deployed and ensure all proper fields are complete associated with deployment in status spread sheet.

6.2.5 Interim Offload of Data

Because temperature loggers are subject to loss for a variety of reasons beyond staff control (e.g. vandalism, theft, high flows), it may be advisable to offload data periodically during the deployment period. Doing so will allow partial data to be retained in the event of instrument loss.

6.2.5.1 HOBO® Water Temp Pro v2 (Using a Shuttle)

A waterproof shuttle for HOBO® Water Temp Pro v2, is the most efficient method for offloading data in the field, but a laptop computer can be used in the field if necessary. It is not necessary to remove the temperature logger from the water to offload data to the shuttle; however, one nylon tie typically must be cut. Make sure the communication end of the temperature logger is clean, insert this end into the shuttle, aligning arrows on each device, and press the coupler lever. An amber LED light will flash during download. Do not remove until LED light turns to flashing green. The shuttle automatically re-launches the temperature logger after interim offload. Assign a file name, consisting of the station name, temperature logger serial number, date of first data point, and type of logger to each data set upon the initial interim offload (this is done when transferring data from the shuttle to the computer, or at the time of offload if using the laptop in the field). Record the interim offload date and time on the deployment field sheet.

Upon return from the field, copy the data to the appropriate folder in the project file on SWQB server. The data may be left in raw form (i.e., *.hobo file) at this time. Ensure data set is assigned a file name. File name should consist of the station name, temperature logger serial number, date of first data point, and type of logger. Provide copies of the interim deployment field sheet to the temperature logger manager.

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6.2.5.2 HOBO® Water Temp Pro v2 (Using a Laptop)

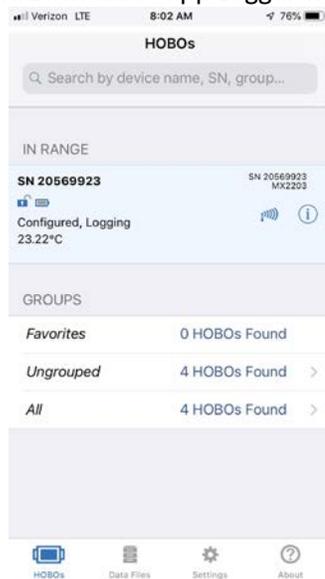
When using a laptop for interim offload of data from the HOBO® Water Temp Pro v2, logger will need to be removed from water. Open latest version of HOBOWare Pro® software on laptop. Connect HOBO® Optic USB Base Station to HOBO® Water Temp Pro v2. Logger can be left in recording mode during the offload when using the laptop. When connecting, ensure the communication end of the temperature logger is clean and dry, insert this end into the HOBO® Optic USB Base Station, aligning arrows on each device. Use HOBO® Optic USB Base Station to connect HOBO® Water Temp Pro v2, to laptop USB port. In HOBOWare Pro® software, begin by clicking on Device menu item, then Readout option, or Readout icon on toolbar. Once data has been read out, save data in raw form (i.e., *.hobo file) in appropriate folder in the project file. Ensure data set is assigned a file name. File name should consist of the station name, temperature logger serial number, date of first data point, and type of logger. Record the interim offload date and time on the deployment field sheet.

Upon return from the field, copy the data to the appropriate folder in the project file on the SWQB sever. The data may be left in raw form (i.e., *.hobo file) at this time if desired. Ensure data set is assigned a file name. File name should consist of the station name, temperature logger serial number, date of first data point, and type of logger. Provide copies of the interim deployment field sheet to the temperature logger manager.

6.2.5.3 HOBO® MX TidbiT 400

For HOBO® MX TidbiT 400 loggers, remove the logger from the water and offload data to a mobile device with the HOBOMobile® app. Begin by opening HOBOMobile® app (app), ensure temperature logger is within range. Serial number of loggers should appear in HOBOMobile® app, tap on serial number, app will then connect to logger. Figure 1 provides an example of a logger within range.

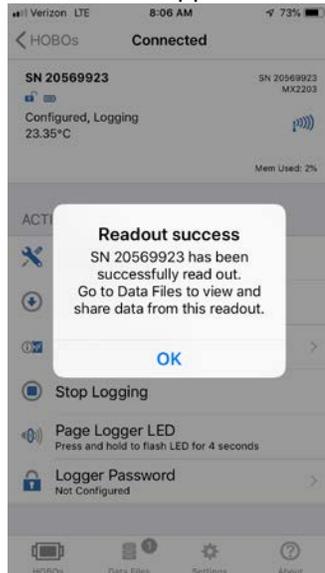
Figure 1. HOBOMobile® app Logger within Range



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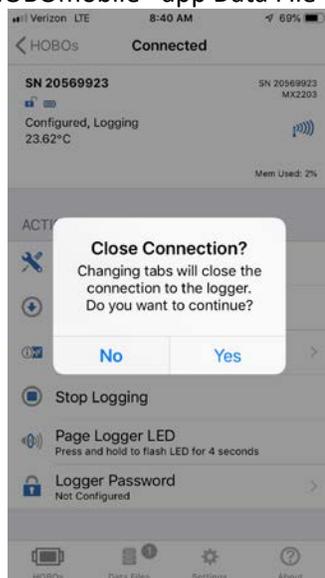
Once connected to logger, the app will read connected and an Action pane will appear. Under Action pane tap on Readout, a notification will appear which states if readout was successful. The notification also gives details on where to locate Data Files. See example of HOBOMobile® app notification in Figure 2.

Figure 2. HOBOMobile® app Readout Notification



The next step will need to be completed in a location which allows the mobile device being used to send email. It can be done in the field or upon return to the office. Once Readout is complete tap on Ok, then tap on Data files on the bottom of screen. The HOBOMobile® app will provide another notification, click on “Yes”. See Data File notification in Figure 3.

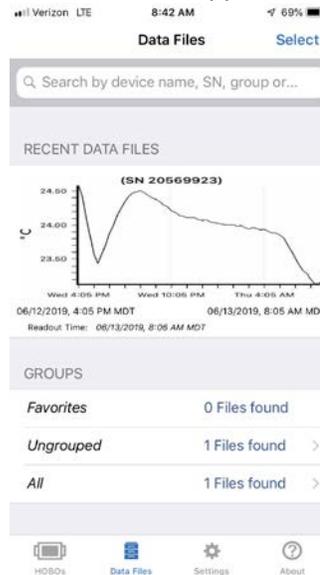
Figure 3. HOBOMobile® app Data File Notification



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The Data File screen will open. Click Select in the top right corner, select the Data file which you would like to transfer (share). See Figure 4 for an example of the Data File screen. Once selected click on Share in the bottom left corner, select file type. Typically, the SWQB transfers files in the HOBOWare file format. Once file type is selected the mobile device will prompt you to Share data using a variety of options. The SWQB typically uses email. Record the interim offload date and time on the deployment field sheet.

Figure 4. HOBOMobile® app Data File screen



Note: Do not delete data from HOBOMobile® app until the data file has been stored in secure location

Upon return from the field, copy the data to the appropriate folder in the project file on the SWQB server. The data may be left in raw form (i.e., *.hobo file) at this time if desired. Ensure data set is assign a file name. File name should consist of the station name, temperature logger serial number, date of first data point, and type of logger. Provide copies of the interim deployment field sheet to the temperature logger manager.

6.2.6 Retrieval of Temperature logger

At the end of the deployment period, retrieve the temperature logger and also remove the rebar or T-post. Removal of rebar or T-post does not need to be completed if another deployment is planned during the survey and it does not pose a safety hazard. If installed properly, the rebar or T-post is difficult to remove. Rebar stakes can be removed using a pipe wrench and/or the modified mattock with the V-notch, much like pulling a nail from wood with the claw of a hammer. A T-post is more difficult to remove and may require the bumper jack connected by a chain or heavy-duty strap. A flat piece of plywood is useful as a base to keep the jack from sinking into the substrate. Extra caution is advised when using the bumper jack as there is a greater risk of injury due to the amount of force applied.

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Record the status of temperature logger in the status spread sheet as retrieved and awaiting offload, ensure all proper fields are complete associated with retrieval in the status spread sheet.

6.3 Post-Deployment of Temperature loggers

Data can be offloaded in the field using the waterproof shuttle, computer (i.e., laptop, tablet with USB port) with HOBOWare Pro® software, or a mobile device (depending on the type of logger) using HOBOMobile® app installed for use with HOBOMobile® MX TidbiT 400. Whether offloaded in the field or in the office, the process for offloading data is stated in the Interim Offload of Data section of this SOP. The process for post-deployment of loggers and logger data is as follows:

- A. Ensure data has been offloaded from each temperature logger, shuttle, laptop or mobile device, used during deployment. HOBOWare Pro® software can be used to save file and store raw data (*.hobo) file to appropriate project folder on the SWQB server. If HOBOMobile® app was used to offload data, data will need to be retrieved from email and stored in appropriate project folder on the SWQB server. The file name will consist of the station name followed by the temperature logger serial number followed by the date of the first data point and type of logger, followed by “air” if the data are for air temperature.
- B. Return the temperature logger and deployment form to the temperature logger manager. (Temperature logger Manager or Alternate).
- C. Record status of temperature logger in status spread sheet (i.e., available for use, launched and awaiting deployment, deployed, or retrieved and awaiting offload).
- D. Ensure the return of temperature logger to storage.

7.0 Data and Records Management

The following forms are generated following the procedures outlined above:

- Temperature Logger Deployment Form
- HOBOWare® data file

These forms must be completed on site with all required field information recorded and reviewed prior to leaving the monitoring location. Upon return to the office, these forms must be stored in the appropriate project file location stored in the project binder located in the SWQB file storage cabinets.

Information recorded by temperature loggers are transferred, stored, and managed as specified in SWQB’s Long Term *Deployment (Temperature loggers and Sondes) Data Quality Assurance and SQUID Offload Instructions SOP 6.4* (NMED/SWQB. 2018b) according to the Data & Records Management section.

8.0 Quality Control and Quality Assurance

Between each field season, the temperature logger Manager verifies that each temperature logger is reading within $\pm 0.5^{\circ}\text{C}$ of a NIST-traceable and calibrated thermometer at a minimum of two temperatures (approximately 4 degrees and 35 degrees Celsius) bracketing the range of water quality standards. See Accuracy Procedure below. New temperature loggers are considered to be within manufacturer’s specifications and not in need of accuracy verification prior to first use. The SWQB uses

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the State Laboratory Division of the New Mexico Department of Health (SLD) and private vendors to inspect and certify thermometers for accuracy traceable to NIST standards. The certified thermometer should be certified annually at two temperatures.

Accuracy Procedure

The manager verifies the accuracy of the temperature loggers according to the following procedure:

- A. Program temperature loggers to record simultaneously at intervals of no longer than fifteen minutes.
- B. Set up a cold-water bath in an insulated cooler that is allowed to equilibrate for low range temperature verification.
- C. Place the temperature loggers in the water bath and allow them to stabilize for at least twenty minutes.
- D. Check and record the temperature of the water with a certified thermometer at the same time that the temperature loggers are set to record, taking care to ensure that the bath is well mixed and has not stratified by the time the temperature loggers are set to record. Allow the temperature loggers to record several data points.
- E. Verify that the temperature loggers record temperatures within $\pm 0.5^{\circ}\text{C}$ of the certified thermometer following stabilization.
- F. Record in the temperature logger log each unit's test date, temperature discrepancy, and the reference thermometer used.
- G. Repeat the steps above in a warm water bath for the high range temperature verification.
- H. Return to the manufacturer any temperature loggers that fall outside the acceptable accuracy range.

Table 2. Accuracy Verification Criteria and Maximum Allowable Limits for Data Adjustment

Measurement	Standard	Standard Value	In-calibration Range	Linear Interpolation Range (Max Allowable Limits)
Temperature, $^{\circ}\text{C}$	Certified Thermometer	Ambient Temperature	± 0.5	± 2

9.0 Related Forms

Temperature logger Deployment/Offload/Retrieval Field Sheets
 HOBO® U22 Water Temp Pro v2 Instruction Manual
 HOBO® Waterproof Shuttle Instruction Manual
 HOBO® Optic USB Base Station Instruction Manual
 HOBO® Tidbit® MX Temp 400 (MX2203) Instruction Manual
 HOBO® mobile-FAQ's

10.0 Revision History

Revision 1 – 3/15/2013 – Minor editorial changes.
 Original modified from SOP 2007.

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Revision 2 – 12/30/2015 – Addition of end of field season check and update to thermometer certification. Modified requirement to remove temperature logger mounting device.
Vacant, QAO; Gary Schiffmiller, SME; Shelly Lemon, Program Manager

Revision 3. June 10, 2019. Formatted and added content to meet the requirements of SOP 1.1 *Creation and Maintenance of SOPs*. Add new equipment used by SWQB, HOBO® MX TidbiT 400, and associated software HOBOMobile® app. Minor editorial changes; grammar and clarity to procedures.
Miguel Montoya, QAO; Gary Schiffmiller, SME; Kristopher Barrios, Program Manager

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New Mexico Environment Department / Surface Water Quality Bureau. (NMED/SWQB). 2018b. Standard Operating Procedure 6.4 Standard Long Term *Deployment (Temperature loggers and Sondes) Data Quality Assurance and SQUID Offload Instructions*. Accessed at: <https://www.env.nm.gov/wp-content/offloads/2017/06/SOP-6-4-Datalogger-and-Offload-20180813-Final.pdf>

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