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

Standard Operating Procedure (SOP) for

SONDES

Approval Signatures

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1.0 Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to describe calibration, deployment, and maintenance and storage of sondes used for water quality monitoring. The SOP is also used as a training mechanism and was developed to maintain consistency with data collection activities. This procedure covers the use of the In-Situ Aqua TROLL® 600 sondes. For procedures related to quality assurance of logger data sets and data processing, refer to the most current SWQB SOP 6.4 Long-term Deployment Data Logger QA and SQUID Upload and SOP 15.0 Data Verification and Validation.

2.0 Personnel Responsibilities

The Quality Assurance Officer (QAO) is involved in the development and revision of this SOP to ensure the SOP meets the requirements of the SWQB's Quality Assurance Project Plan. The QAO; the Monitoring, Assessment, and Standards Section (MASS) Program Manager; and SWQB quality subject matter experts (e.g., the MASS Monitoring Team Lead and field staff scientists) will determine if any revisions to this SOP are needed at a minimum of every two (2) years in accordance with the most current SOP 1.1 for the Creation and Maintenance of SOPs (https://www.env.nm.gov/surface-water-quality/sop/). Pending the review and approval of the document, the QAO will ensure the SOP is accessible through the SWQB's website.

The Sonde Equipment Coordinator keeps a record of the disposition of each sonde for MASS within the "Sonde Tracker" spreadsheet. The Sonde Tracker records sonde maintenance by ID and serial number. The spreadsheet must document the status of each sonde (active, field operations (FO), Long-term Deployment (LTD), data offload required (DOR), nonfunctional (NF)), staff responsible for the sonde, date of checkout, probe and sensor maintenance, and any other pertinent sonde information. The Sonde Tracker spreadsheet is located at \\FS01\Data$\WPD\SWQB\MASS\Monitoring Team\Monitoring Equipment.

Responsibilities are detailed below. The Sonde Equipment Coordinator is required to implement field staff responsibilities as applicable (e.g., when deploying sondes and/or collecting instantaneous measurements).

The Sonde Equipment Coordinator is responsible for:

- Ensuring sondes are properly maintained and stored.
- Maintaining and ordering of equipment, sensors, and calibration solution related to Sondes.
- Maintaining the "Sonde Tracker" spreadsheet.
- Providing technical assistance to SWQB personnel, as needed, so they are capable of operating sondes, including calibration, post-deployment calibration verification, and data recording.
- Conducting yearly and mid-season temperature accuracy checks, as detailed in this SOP.

Field Staff are responsible for their specific sample run which includes the following processes:

- Coordinating with the Sonde Equipment Coordinator or Project Manager on the scope of the project and use of the equipment.
- Calibrating sonde and maintaining electronic calibration sheets on NMED's internal server.
- Maintaining electronic and hard copy deployment sheets on the NMED's internal server.
- Maintaining electronic deployment data files on sondes.
- Post-checking sondes, reporting post-deployment values on the calibration sheet and storing on NMED's interval server within 48 hours of calibration post-verification.

- Investigating calibration and calibration verification failures and reporting equipment malfunction to the Sonde Equipment Coordinator, as applicable.
- Filing calibration/calibration verification sheets and deployment sheets in the appropriate survey project folder on NMED's internal server for each of their sample runs.
- Transferring sonde data off instrument for sample run following long-term deployment (LTD) in accordance with the SWQB's LTD Data Logger QA and Upload SOP (SOP 6.4).
- Transferring sonde data off instrument for each sample run and filing it the correct survey folder.
- Ensuring equipment is cleaned and stored in accordance with this SOP.

Staff responsibilities related to verification and validation of data:

- All Monitoring Team staff are responsible for performing data verification and validation including flagging LTD (unattended) data and grab data.

The Monitoring Team Supervisor is responsible for:

- Providing technical expertise, and guidance to Sonde Equipment Coordinator and Field Staff, as needed.

Bureau personnel who operate water quality monitoring sondes are responsible for ensuring that the sondes are properly calibrated, checked and maintained, and that the data are properly recorded in accordance with this SOP and shall acknowledge such by signing the SOP 6.1 Sonde Calibration and Maintenance Acknowledgment Form.

3.0 Background and Precautions

3.1 Background

This Procedure is based on the capabilities of the In-Situ Aqua TROLL® 600, sondes and sensors.

3.2 Procedural Precautions

Individuals using a sonde should have a thorough understanding of its proper use and care and be familiar with the instrument's operational manual in order to ensure data are not invalidated due to calibration or user error.

3.3 Safety Precautions

While the cleaning and calibration solutions used for maintenance of these instruments are generally non-hazardous, operators must have a signature for the Chemical Hygiene Plan (CHP) on file and be familiar with applicable Safety Data Sheets (SDS) stored in the laboratory. Operators must also have a signature for the Sampling Job Hazard Analysis on file and be aware of hazards that might be present, develop, and/or are unique to the position.

Wading across a streambed can be dangerous depending on flow and substrate conditions. Do not attempt to wade into a stream if the depth (in feet) multiplied by the velocity (in feet/second) equals or exceeds ten (10).

4.0 Definitions and Acronyms

For common definitions and acronyms not defined in this SOP, refer to the most up to date SWQB Quality Management Plan for Environmental Data Operations.

Long-term Deployment (LTD) – deployment of a sonde for unattended monitoring at a monitoring location to perform and record measurements of water quality at repeated discrete intervals.

Instantaneous measurement – An instrument reading collected manually at a single point in time. Synonymous with grab measurements.

Sample Run – is used to define the most common collecting period or grouping of sampling activities that are indicative of a SWQB MASS sampling operation. Typically, most monitoring is conducted during multi-day collection events that depart and return to the office in a week (M-F). Typically, sampling run consists of the same staff, using the same equipment, vehicle, and reagents. When multiple, single day sampling runs are conducted within a given week that maintain constant variables as described above, the single day sampling runs are considered collectively as a single sampling run.

Sonde – A water quality monitoring device that is placed in the water to gather water quality data. Sondes usually have multiple sensors and are capable of recording or displaying multiple water quality parameters.

Sonde Equipment Coordinator – A designated individual within each Section (e.g., MASS, WPS) of the SWQB. The Sonde Equipment Coordinator is responsible for keeping a record of the disposition of each Section's sondes.

Sonde Tracking Spreadsheet – An Excel spreadsheet located within the Monitoring Team server folder (\\FS01\Data$\WPD\SWQB\MASS\Monitoring Team\Monitoring Equipment) used for documenting and tracking of sonde and probe deposition. Sonde deposition includes the status of each sonde (active, field operations (FO), Long-term Deployment (LTD), data offload required (OR), nonfunctional (NF)), staff responsible for the sonde, date of checkout, probe and sensor maintenance (e.g., repairs, replacements), and any other pertinent sonde information. The spreadsheet is also used for documenting sonde calibration information specific to Accuracy Temperature verification, pH slope, DO slope, conductivity constant, and barometric pressure calibrations.

Subject Matter Experts (SMEs) – Staff who are familiar with the purpose and procedure for accomplishing a task. All MASS Monitoring Team staff are considered and expected to be subject matter experts with all activities related to sonde calibration, deployment, and maintenance and storage.

5.0 Equipment and Tools

5.1 Sonde Specifications

The sonde used by the SWQB is the In-Situ Aqua TROLL® 600. This instrument can be used with In-Situ's mobile app, VuSitu, for communication with Bluetooth enabled tablets and mobile devices. Sonde and sensors are described in **Table 1**. Instruction manuals for the sonde and sensors are available on the SWQB file server.

In-Situ, Inc.
221 E. Lincoln Ave., Fort Collins, CO 80524
Phone: (800) 446-7488
Email: support@in-situ.com Internet: www.in-situ.com

Table 1. In-Situ Aqua TROLL® 600 Sonde and Sensor Characteristics

Sensor #	Parameter	Units	Range	Accuracy
63460	Temperature	°C	-5 to 50	± 0.10 °C
63460	Conductivity	µS/cm	0 – 350,000	± 0.5% of reading; ± 1 µS/cm for 0-100,000, ± 1% of reading for 100,000 to 200,000, ±2% of reading from 200,000 to 350,000 µS/cm
63450	Dissolved Oxygen	mg/L	0 – 60	± 0.1 mg/L for 0–20 mg/L; ± 0.2 mg/L for greater than 20 mg/L
63470	pH	SU	0 – 14	± 0.1 SU
63480	Turbidity	NTU	0 – 4,000	± 2% of reading; ± 0.5 NTU
AT600	Barometric Pressure	mbar	300 - 1,100	±1.0 mbar
AT600	Pressure (Depth)	m	0-9 0-30 0-76 0-200	±0.01% Full Scale Range

5.2 List of Equipment Required for Sonde Calibration and Maintenance

Sondes:

- In-Situ Aqua TROLL® 600 sonde, complete with probe guard and the following sensors installed: pH, conductivity/temperature, dissolved oxygen, and turbidity, and a wiper or wiper port plug.
- Smartphone or other Bluetooth enabled device with VuSitu software installed.
- RDO Calibration Sponge
- **Sonde Calibration Worksheet or Sonde Deployment/Retrieval Field Sheet**
- Calibration solutions:
    - Deionized (DI) water.
    - pH buffer solutions (e.g., pH 4.0, pH 7.0, pH 10.0) sufficient to bracket samples.
    - Turbidity standards (e.g., 100 NTU, 1000 NTU) sufficient to bracket samples.
    - Specific conductance standard (e.g., 1413 µS/cm) sufficient to bracket samples.
- Standard solution rinsate and disposal containers.
- Sonde maintenance kit (includes silicon grease, O-rings, hex key set for unlocking sonde sensors, pH junctions, junction fluid, desiccant, etc.) and small flathead screwdriver.
- Barometer (integrated on Aqua TROLL® 600 sonde).
- Abrasion-free cleaning cloth (e.g., Kim wipe) and compressed air.

5.3 List of Equipment Required for LTD of a Sonde

• **Nylon Cable Ties**	• **Five-gallon Bucket**	• **Steel T-posts**
• **Hose Clamps**	• **Spare Batteries**	• **T-post driver**

• **Pipe wrench (10” and 12”)**	• **Diagonal pliers**	• **Steel rebar**
• **Modified mattock**	• **Lineman’s pliers**	• **Cable, padlock, and key**

6.0 Step-by-step Procedures for Connecting, Calibration, Deployment, Post-check Calibration Verification, and Maintenance and Storage of a Sonde

Connecting to a Sonde

Prior to collecting any data, calibration of the sonde sensors (probes) is required. Begin by connecting the Aqua TROLL® 600 sonde via Bluetooth to a smartphone or a tablet with the VuSitu application installed. The following steps should be utilized:

A. Open the VuSitu app on the handheld device (e.g., tablet, smart phone).
B. Invert sonde for 3 seconds to turn on sonde. The digital screen on the sonde will illuminate when the sonde is turned on.
C. Establish a Bluetooth connection with the sonde by navigating to the Bluetooth menu on the handheld device and scanning for available devices. To pair the sonde with the handheld device, select the sonde’s serial number (which can be found inscribed on the side of the sonde) from the list of available devices on smart phone or tablet. This usually only needs to be conducted the first time you connect to a new sonde.
D. Select the sonde based on serial number from the list that comes up when you first open the app. If the sonde does not appear as a connected instrument, select Choose or Add a Device from the options and select the sonde out of the list of available connections. Once the sonde is connected to the handheld device it is ready for calibration, calibration verifications, software updates, or live readings. Refer to the quick start guide or the operator’s manual for the manufacturer’s connection instructions and field operation instructions. (In-Situ, 2017 and 2019). For live readings or deployments refer to the SWQB SOP 6.2 Sonde Deployment (NMED/SWQB 2018 or most current version).

General Sonde Calibration Information

Sonde calibration should be conducted in the lab prior to each “sampling run” to ensure sensors and devices are working properly. When preparing a sonde for calibration, rinse all sensors and the inside of the calibration cup (i.e., restrictor - See Aqua TROLL® Manual) once with DI water. This can be done by adding water to the cup while holding the sonde upright and gently swirling so that the water comes in contact with all areas of the sonde sensors and cup (**Figure 1**). Calibration should be conducted in the order of parameters listed in this SOP.

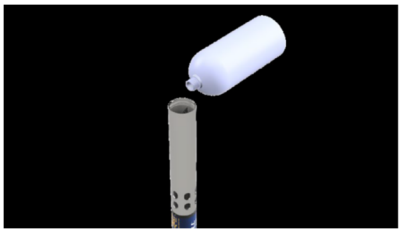


Figure 1. Restrictor cup in calibration mode

Calibration Standard Solutions

Be certain to avoid cross-contamination of standard solutions to avoid calibrations bias. Inscribe the date on the standard solution container when opening a new bottle. Bulk standard solutions in containers with a tap (does not get exposed to air) expire according to the manufacturer's expiration date inscribed on the container. Standard transferred from a bulk container to a smaller container requires the date of transfer on the smaller container and expires after one month (exception: pH standard solutions, see Section 6.1.4). Expired standard can be used as a rinse before calibration and fresh standard used for calibration may be placed in a labeled rinse container and reused as rinse solution for subsequent calibrations.

General Sonde Calibration Documentation

Record calibration data on the **Sonde Calibration Worksheet**, which is available as part of this SOP and is available on the webpage under "related SOP forms." Sonde Deployment**/Retrieval Field Sheet** can also be used for recording calibrations if the sonde is being used for LTD; a copy of the Sonde Calibration Worksheet is on the back side of the **Sonde Deployment/Retrieval Field Sheet, for convenience**. Calibration records must not be discarded. Completed calibration worksheets must be filed in the network server under the appropriate survey. If hard copies were used to record calibration they must be scanned and filed as detailed in this SOP. Post-checks (calibration verification) must be recorded within the file documenting the initial calibration. The calibration worksheet (including calibration verification) should be saved with the data sheets for the stations at which the sonde was used.

Calibration Range

Calibration range limits are shown in **Table 2**. If sensors cannot be calibrated within these limits, the instrument should be returned to the Sonde Equipment Coordinator for maintenance. Refer to Section 8.1 on temperature accuracy check procedures for determining whether thermistors are within in-calibration range.

Table 2. In-Calibration and Interpolation Ranges for Sonde Calibration

Parameter	Standard	Standard Value	In-Calibration Range	Linear Interpolation Range (Max Allowable Limits)
Temperature, °C	NIST Traceable Thermometer	4-10 °C 35-40 °C	± 0.5 °C	± 2 °C
Conductivity, µS/cm	Standard Solution	1413 µS/cm	± 5%	± 30%
Dissolved Oxygen, %	Saturated Air	100 %	± 5%	± 30%
pH, s.u.	Buffer Solution	4.0, 7.0, 10.0	± 0.2	± 1
Turbidity, NTU	DI Water	0 NTU	± 1 NTU	± 10 NTU
	Standard Solution	100 NTU	± 5 NTU	± 30 NTU
		1000 NTU	± 50 NTU	± 300 NTU

Parameter	Corrected Qualifier (LTD only)	Rejected Qualifier
Temperature, °C	**CT**	**RT**
Conductivity, µS/cm	**CSC**	**RSC**
Dissolved Oxygen, %	**C%**	**R%**
Dissolved Oxygen, mg/L	**CDO**	**RDO**
pH, s.u.	**CPH**	**RPH**
Turbidity, NTU	**CY**	**RY**

6.1 Multiparameter Sonde Calibration Procedures (In-Situ Aqua TROLL®)

6.1.1 Temperature Sensors

In-Situ sonde thermistors cannot be calibrated. Annually, when a malfunction is suspected, or when replacing a conductivity probe, the Sonde Equipment Coordinator will check the temperature reading against a NIST traceable thermometer to ensure the instrument temperature readings are within an acceptable in-calibration range (±0.5 °C) (refer to Section 8.1 of this SOP). The manufacturer also recommends a mid-season one-point check (early July) in a cold-water bath and will be the responsibility of the Sonde Equipment Coordinator. The mid-season one-point verification check will be documented on the Sonde Tracker spreadsheet by the Sonde Equipment Coordinator. The sonde calibration spreadsheet must indicate the date the temperature verification was performed, the technician (i.e., Sonde Equipment Coordinator) conducting procedures, if verification passed or failed, and any important notes.

6.1.2 Dissolved Oxygen Calibration

Dissolved Oxygen (DO) probe calibration should be the first calibration completed and must be calibrated in the laboratory and then again upon arriving at a field sampling location to ensure accurate measurements. Laboratory calibration should be recorded on the **Sonde Calibration Workshee**t. When collecting sonde instantaneous measurements, changes in elevation greater than 500 feet (152 meters) from one sampling location to another require a recalibration to local barometric pressure.

Laboratory Calibration

A. Remove the sonde restrictor and blue end cap and thoroughly dry the RDO sensing foil and thermistor. Place the sonde restrictor back on the sonde, ensuring that it is placed in calibration mode (i.e., restrictor openings are located opposite of the sensors, so the restrictor forms a calibration cup for holding liquid).
B. Gently place a dampened RDO calibration sponge into the bottom of the restrictor, leaving ample space between the sponge and the sensors. Attach the end cap by turning it *a quarter to half rotation*. Allow 5 to 10 minutes to reach 100% saturation of the air within the sonde calibration chamber.

   Important: *Do NOT* fully seal the end cap on the restrictor as this may cause a build-up of pressure within the calibration cell and provide inaccurate readings. Also note that the sensing element and thermistor should be dry. Make certain that the sponge is only damp, not dripping water onto the sensors. If there are water droplets on the sensor foil it can cause the calibration to be skewed very high.

C. Follow the process detailed in the Step-by-Step Procedure for Connecting to a Sonde (Section 6.0) for establishing a connection between the Bluetooth handheld device and the sonde.
D. Within the VuSitu app tap the VuSitu menu icon and select **Connected Instrument** from the list. Select **Calibrations**. Select **RDO saturation**. Select **100% Saturation (Figure 2)**.

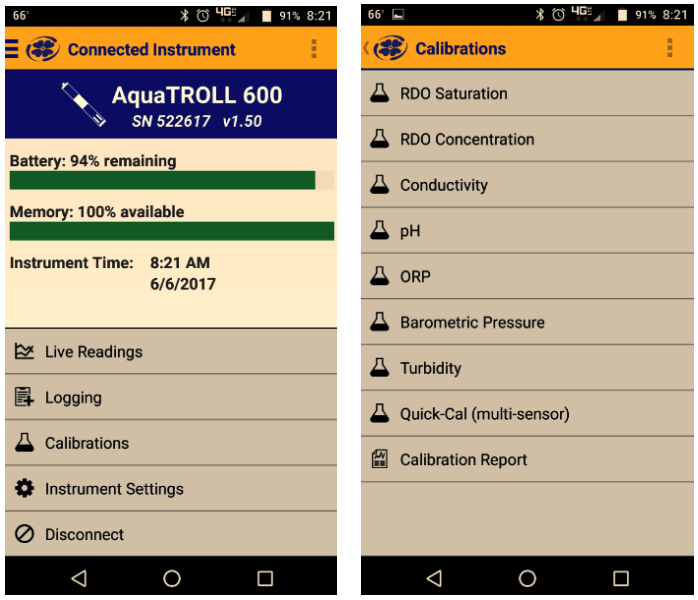


Figure 2. DO Calibration

E. Follow prompts in the app to set the barometric pressure on the sonde by opening the battery cover (twist off plastic battery compartment cover opposite of the restrictor) and exposing the barometer. Barometric pressure will appear on the sonde digital screen. Wait for the pressure to stabilize, indicated by a check mark next to the pressure, before replacing and tightening the battery cover. Record the barometric pressure on the **Sonde Calibration Worksheet (Figure 3).**

Dissolved Oxygen	Barometric Pressure:_____mmHg			**Pass Criteria: ± 5%**
Initial Reading		Calibrated Reading		Temperature (°C)	Pass/ Fail
%	mg/L	%	mg/L		

Figure 3. DO Calibration Documentation

F. In VuSitu, tap **Next**.
Wait ample time to allow the DO and temperature readings to stabilize. Once the concentration, % saturation, and temperature have all stabilized (indicated by a green check mark next to each parameter, **Figure 4**) record the pre-calibration values on the **Sonde Calibration Worksheet** under Initial Reading Section (**Figure 3**). **Note: Pre-calibration values are only recorded when performing the laboratory calibration.**

G. Tap **Accept** to complete calibration (**Figure 4**).

H. Record the dissolved oxygen calibration values from the automatically generated calibration report in VuSitu on the Calibrated Reading Section of the **Sonde Calibration Worksheet** and indicate if the calibration passed (i.e., was in-calibration range according to **Table 2**) or fail on the Pass/Fail portion of the worksheet (**Figure 3**).

I. If the calibrated value is out of range write “fail” and begin troubleshooting the error or retry calibration. As a last resort, a restoration of factory calibration defaults may solve calibration problems. To restore factory calibration defaults, select **Restore Calibration Defaults** under **Instrument Settings** (***IMPORTANT NOTE:* Do not choose Restore Factory Settings**) and follow the instructions. Return the sonde to the Sonde Equipment Coordinator for maintenance and troubleshooting if errors persist.

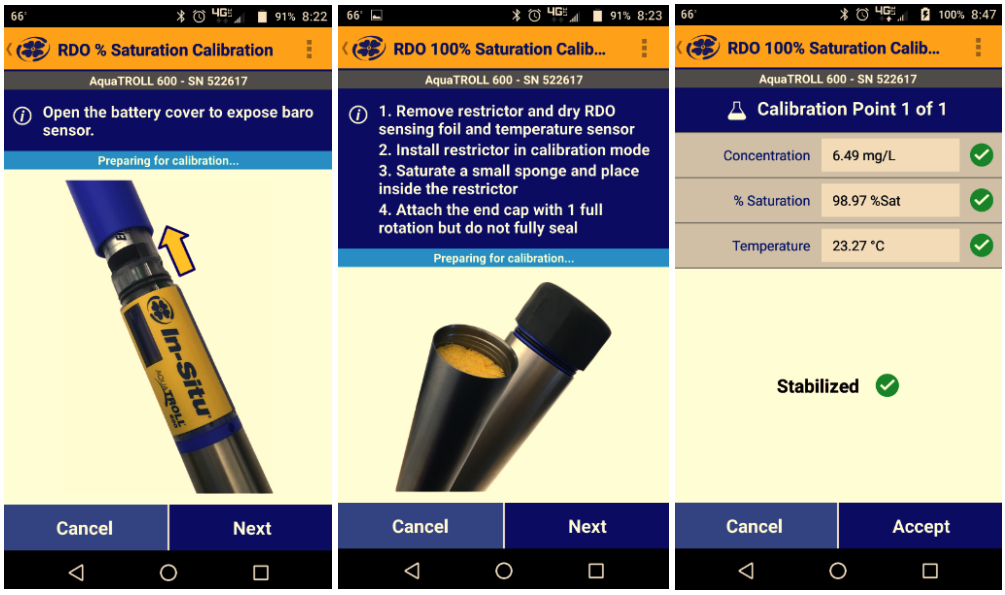


Figure 4. DO Calibration

J. The SWQB Monitoring Supervisor will evaluate MASS Sonde DO probe slope values for probes installed more than 1.5 years through the review of the electronic calibration reports. Values will be tracked in the Sonde Tracker spreadsheet. The slope should be 1 +/- 0.3 and should gradually increase over time.

DO Field Calibration for Instantaneous Measurements

A laboratory calibration must be completed at the SWQB laboratory (or equivalent) prior to a field calibration to ensure that DO sensor can be properly calibrated before beginning a sample run. For instantaneous measurements (grab data) field calibrations are completed at sampling location following Steps A-F (above), **excluding the documentation of calibration on the Sonde Calibration Worksheet**. DO must also be recalibrated when there are changes in elevation greater than 500 feet (152 meters) from one sampling station to another when collecting instantaneous measurements. DO field calibrations are documented on **Steam Field Data Form (Figure 5, red box) when conducting instantaneous measurements.**

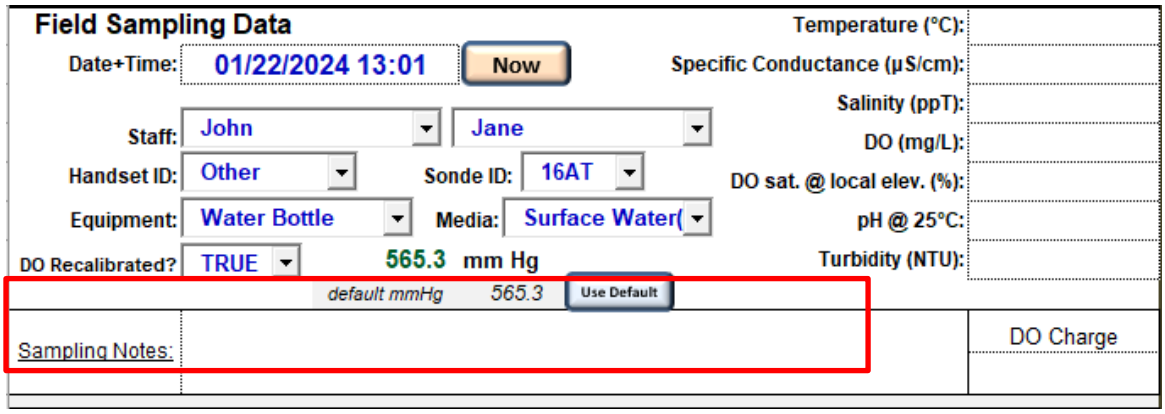


Figure 5. Stream Field Data Form

DO Field Calibration for LTD

LTD DO field calibrations are completed at sampling location following Steps A-F (above), **excluding the documentation of calibration on the Sonde Calibration Worksheet**. LTD DO field calibrations are documented on **Sonde Deployment/Retrieval Field Sheet (Figure 6 red box).**

Location description:					
Lat/Long:				**GPS Accuracy: ±**	
DO Field Cal:		mm Hg	mg/L		°C
Date/time deployed:					
Sonde file name:					

Figure 6. Sonde Deployment Retrieval Field Sheet

Note: Initial pre-calibration values for DO are not documented for any field calibration. However, a laboratory calibration is required prior to performing any field calibration to ensure the probe is in working order.

6.1.3 Specific Conductance Calibration

Conductivity standards are very sensitive to contamination so take particular care to avoid cross-contamination of standards. Calibration of the conductivity probe should be completed following the calibration of DO. ***Important:*** Always perform conductivity calibrations prior to calibrating pH, as pH standard is extremely conductive, and contamination could skew calibration values.

A. Rinse all sensors and the entire inside of the calibration cell once with DI water.
B. With the restrictor in calibration mode and the sonde inverted pour 10-20 mL (1/2" above the sensor face) of conductivity standard on top of the sensors. Holding the sonde vertically, swirl the solution so that it makes contact with all areas of the sensors and the restrictor. It may be necessary to reinstall the end cap while gently swirling to ensure a good rinse. Discard the rinse standard and repeat once.
C. Pour 40-50mL of fresh standard (to the bottom of the threads) into the calibration cell. Make sure that the calibration solution is approximately 1 inch above the surface of the sensor face. Check the sensors for bubbles. Gently swirl the standard to remove any bubbles. Go back to the main Calibrations screen and select conductivity. In VuSitu a screen will appear asking to choose a reference temperature for calibration. Choose 25°C then tap Next and Next again.
D. The VuSitu application will auto-detect the standard that is being used. If it fails to detect the correct standard, the correct value can be manually entered when prompted.
E. Once the conductivity values and temperature have stabilized (indicated by green checkmarks next to each parameter), tap **Accept** to complete the calibration (**Figure 7**).

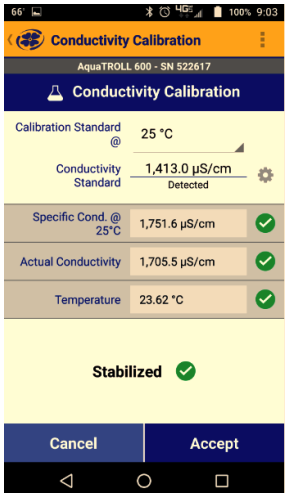


Figure 7. Specific Conductance Calibration

F. Record the pre-calibration values for specific conductivity and temperature on the **Sonde Calibration Worksheet (Figure 8**).

G. Next, record the conductivity calibration value from the automatically generated calibration report in VuSitu under the Calibrated Reading Section of the **Sonde Calibration Worksheet** and indicate that the calibration passed on the pass/fail portion of the worksheet. In addition to calibrated reading and pass/fail information, staff must also document the sensor's cell constant (**Figure 8**).

Specific Conductance Calibration Constant:_____ **Pass Criteria: ± 5%**

Standard Value (µS/cm)	Standard Lot #	Initial Reading (µS/cm)	Calibrated Reading (µS/cm)	Temp. (°C)	Pass/ Fail
1,413					

Figure 8. Specific Conductivity Calibration Documentation

H. If the calibrated value is out of range write "fail" and begin troubleshooting the error or retry calibration. As a last resort, a restoration of factory calibration defaults may solve calibration problems. To restore factory calibration defaults, select **Restore Calibration Defaults** under **Instrument Settings** (*IMPORTANT NOTE:* Do not choose **Restore Factory Settings**) and follow the instructions. Return the sonde to the sonde Equipment Coordinator for maintenance and troubleshooting if errors persist.

I. The SWQB Monitoring Supervisor will evaluate MASS sonde conductivity sensor cell constant values for probes installed more than 1.5 years through the review of the electronic calibration reports. Values will be tracked in the Sonde Tracker spreadsheet. The cell constant should be 1 +/- 0.3. There is typically very little drift. A small amount of drift bouncing back and forth is normal, but normally the cell constant will drift one way if consistently calibrating the sensor. Continual increasing or decreasing values could mean either fouling is present on sensor or there is a drift issue.

6.1.4 pH Calibration

The pH buffers contain high concentrations of phosphate. Take care during calibration to avoid leaving traces of buffer on equipment or workspaces that could contaminate nutrient water samples. Standard transferred from a bulk container to a smaller container expires after six months, with the exception of pH 10.0 buffer which once opened expires within three months.

Calibrate the pH sensor with buffers of pH 7.0, and either pH 4.0 for acidic waters or pH 10.0 for alkaline waters. If the expected pH of the water being sampled is unknown or **the sonde is being used for a LTD**, then a 3-Point calibration should be performed in the following order: pH 7.0, 4.0, then 10.0. For most watersheds within the state a pH 4.0 calibration is not necessary (the most well-known acidic stream in NM is Sulphur Creek in the Jemez River watershed); most waters in the state are alkaline and will only require a two-point calibration with pH 7.0 and pH 10.0 for sonde grab data. All two-point calibrations should begin with pH 7.0.

A. Go back to the main **Calibrations screen**. Select **pH**. Select either **2-point** or **3-point Calibration (Figure 9)**.

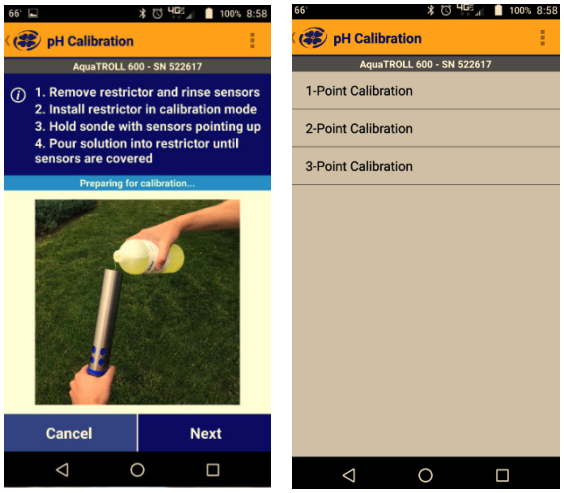


Figure 9. pH Calibration Verification

B. Rinse all sensors and the entire inside of the calibration cell once with tap water.
C. Pour 10-20 mL (1/2” above the sensor face) of pH buffer on top of the sensors. Holding the sonde vertically, swirl the solution so that it makes contact with all areas of the sensors and the restrictor. It may be necessary to reinstall the end cap while gently swirling to ensure a good rinse. Discard the rinse standard and repeat once.
D. Next, pour 40-50mL of fresh standard (to the bottom of the threads) into the calibration cell. The application will auto-detect the pH standard being used. If it does not the value can be entered manually. Wait for the sensor reading to stabilize. Once the sensor has stabilized (indicated by a green check mark next to pH, mV, and temperature, **Figure 10**) continue to step E.

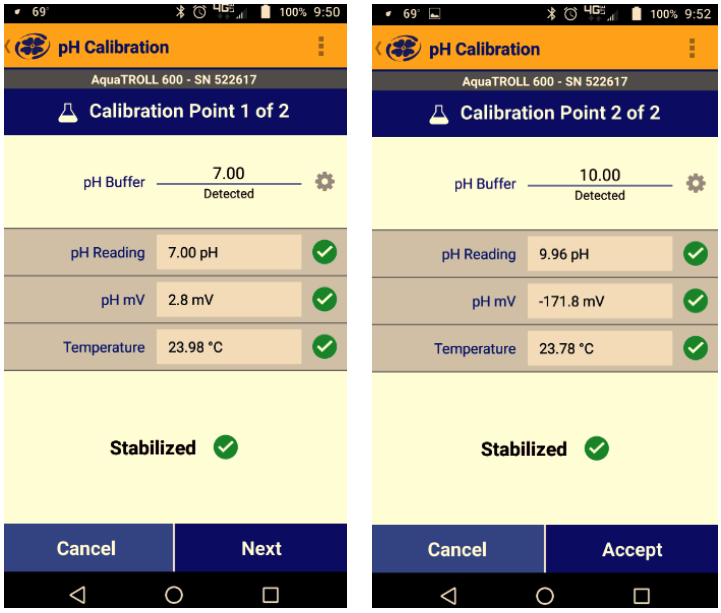


Figure 10. pH Values

E. Repeat steps B–D with the next standard. If performing a 2-point calibration, calibrate in the following order: pH 7.0, then either pH 10.0 or pH 4.0. Then hit **Next** in the app. If performing a 3-point calibration, calibrate in the following order: pH 7.0, pH 4.0, then pH 10.0. See Figure 10. Discard the standard.

F. After the last calibration has been performed, select **Accept (Figure 10).**

G. Record all temperature, pH values and mV from the automatically generated calibration report in VuSitu on the **Sonde Calibration Worksheet** and indicate if the calibration passed on the pass/fail portion of the worksheet (**Figure 11**). **NOTE:** The post calibration value may not exactly equal the buffer value, depending on temperature.

pH						**Pass Criteria: +/- 0.2 s.u.**	
Value (s.u.)	Buffer Lot #	Initial Reading (s.u.)	Calibrated Reading (s.u.)	mV *	Temp. (°C)	Range (mV)	Pass/Fail
7						(0 +/- 50)	
4						(+180+/-50)	
10						(-180+/-50)	

*__Note:__ Difference in mV between pH4 and pH 7, and pH 7 and pH 10 should be approximately 165 to 180 mV (ex. 165 mV - (-10) mV = 175 mv). If not, probe should be reconditioned and recalibrated. mV1(_____) – mV2(_____) = _____ mV

Figure 11. pH Calibration Documentation

H. If the calibrated value is out of range write “fail” and begin troubleshooting the error or retry calibration. As a last resort, a restoration of factory calibration defaults may solve calibration problems. To restore factory calibration defaults, select **Restore Calibration Defaults** under **Instrument Settings** (*IMPORTANT NOTE:* Do not choose **Restore Factory Settings**) and follow the instructions. Return the sonde to the sonde Equipment Coordinator for maintenance and troubleshooting if errors persist.

I. The MASS Monitoring Team Supervisor will maintain and track the sensor’s slope in the Sonde Tracker spreadsheet. Make note of any significant changes in slope.

6.1.5 Turbidity Calibration

Calibration standard expires 6 months from opening or by the manufacturer's expiration date listed on the container, be sure to inscribe opening date on container. Expired standard can be used as a rinse before calibration.

Prior to using any turbidity calibration standard gently tilt the bottle upside down and then gently swirl the standard for approximately 30 seconds to re-suspend the formazin. Failure to do so will bias calibration low and future calibrations high using that standard container. When swirling turbidity standard, avoid vigorous mixing that may create any bubbles in the solution as this may affect the turbidity reading. When calibrating the turbidity sensor, take note if initial turbidity values seem too high for the sensor to be simply out of calibration. If using turbidity standard out of a mostly consumed bottle, try switching to a fresh bottle of solution before investigating the turbidity probe itself.

> ***Important:*** Use only In-Situ brand or Hach StablCal formazin standards for calibrations rather than other polymer-suspension (e.g., AMCO) turbidity standards.

A. Go back to the **Calibration screen.** Select **Turbidity**. Select **2-point Calibration (Figure 12)**.

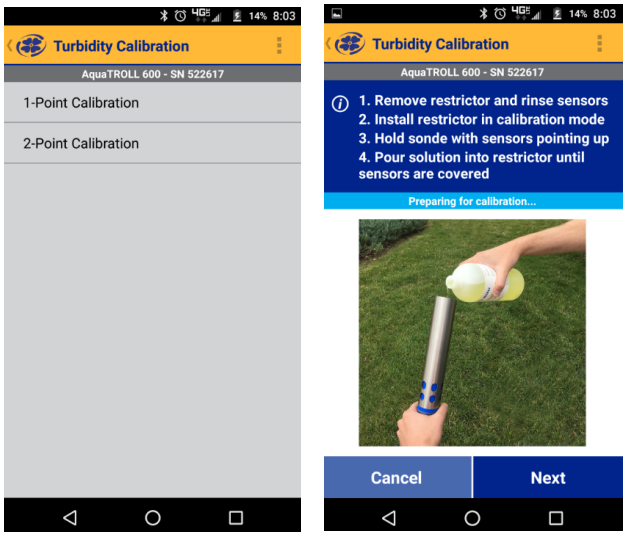


Figure 12. Turbidity Calibration Verification

B. Always start with the calibration of 0 NTU, using DI water. Rinse all sensors and the entire inside of the calibration cell with DI water by adding 10-20 mL of DI water to the restrictor and swirl or invert the sonde so that the water comes in contact with all areas of the sonde sensors and restrictor. It may be necessary to reinstall the blue cap while gently swirling to ensure a good rinse, however it is not necessary to keep the cap on during calibration. Discard the DI and repeat once.
C. Next, pour 40-50mL of DI water (to the bottom of the threads) into the restrictor. Tap **Next**.
D. The VuSitu application will auto-detect the standard being used. If it fails to detect that 0 NTU (DI water) is being used, the correct value can be manually entered when prompted (this is typically the case with DI water).

E. Once the application indicates that the sensor has stabilized (indicated by a green checkmark) record the pre-calibration turbidity value on the **Sonde Calibration Worksheet** (**Figure 13**) and tap **Next** to continue the calibration. Discard the DI water.
F. Pour 10-20 mL of rinse 100 or 1,000 NTU standard (or whichever value is being used for calibration) on top of the sensors. Move the sonde around to allow the standard to make contact with all areas of the sensors and the restrictor. It may be necessary to reinstall the blue cap while gently swirling to ensure a good rinse. Discard the rinse standard. Note: the rinse standard must be the same value as the calibration standard.
G. Next, gently swirl and/or invert the bottle of fresh standard (e.g., 100 or 1000 NTU) for approximately 30 seconds to mix the suspension. ***DO NOT* shake the bottle of standard!** This will suspend air bubbles in the solution and change the turbidity of the standard.
H. Pour 40-50mL of fresh standard (to the bottom of the threads) into the calibration cell.
I. The application will auto-detect the turbidity standard being used (**Figure 14**). If it does not the correct value can be entered manually. Wait for the sensor reading to stabilize.
J. Once the application indicates that the sensor has stabilized, (record the pre-calibration turbidity value on the **Sonde Calibration Worksheet under Initial Reading (Figure 13).**

Turbidity				**Pass Criteria: see chart**
Value (NTU)	Standard Lot #	Initial Reading (NTU)	Calibrated Reading (NTU)	Pass/Fail
0	DI			
100				
1,000				

Figure 13. Turbidity Calibration Documentation

K. After the 2-point calibration is complete, select Accept, VuSitu will generate an updated **calibration report**. Send calibration report to swqmonitoring@env.nm.gov. Record the turbidity post-calibration values from this report on the **Sonde Calibration Worksheet under Calibrated Reading** and indicate that the calibration passed on the pass/fail portion of the worksheet (**Figure 13**).
L. If the calibrated value is out of range write “fail” and begin troubleshooting the error or retry the calibration. As a last resort, a restoration of factory calibration defaults may solve calibration problems. To restore factory calibration defaults, select **Restore Calibration Defaults** under **Instrument Settings** (*IMPORTANT NOTE:* Do not choose **Restore Factory Settings**) and follow the instructions. Return the sonde to the sonde Equipment Coordinator for maintenance and troubleshooting if errors persist.

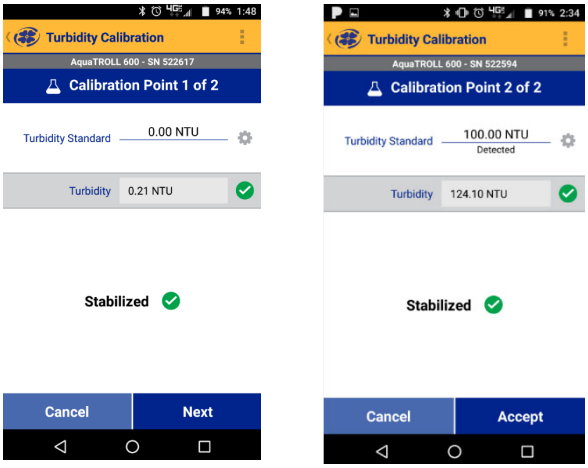


Figure 14. Turbidity Calibration Verification

M. The MASS Monitoring Team Supervisor will maintain and track the sensor's slope in the Sonde Tracker spreadsheet. The slope should gradually change over time and be 1 +/- 0.3.
N. After all probes are calibrated fill the cup with ph4 solution or tap water. Never store the sonde dry this will ruin the pH sensor. Never use DI water.

Note: After the calibration of turbidity, the autogenerated calibration report must be sent to swqmonitoring@env.nm.gov.

6.1.6 Calibration Constants

Please note the calibration constants for the parameters listed. An exceedance is indicative of possible sensor failure.

Conductivity	DO	turbidity	pH 4	pH 7	pH 10	pH
Cell constant 1+/- 0.3	slope 1 +/-0.3	slope 1 +/-0.3	mV 180 +/-50	mV 0 +/-50	mV -180 +/-50	slope -66 to -50

6.1.7 Barometric Pressure Calibration

Barometric pressure should be restored to calibration defaults annually (prior to field season) by the Sonde Equipment Coordinator, and when anomalous values are observed or barometric readings in the lab deviate from expected values. Restoring of barometric pressure defaults is implemented to ensure that dissolved oxygen saturation can be properly calibrated. The annual process of restoring barometric pressure to calibration defaults for each sonde will be documented on the Sonde Tracker spreadsheet, indicating the date the calibration default was performed and the technician (i.e., Sonde Equipment Coordinator) responsible for the process. Calibration defaults can be restored by going to instrument setting in the VuSitu application.

6.1.8 Depth Sensor Calibration

In-Situ sondes with depth sensing capability have an external water pressure (proxy for depth) sensor that should be calibrated to zero depth within ambient air at the barometric pressure at which the sonde is being immediately used for depth sensing capabilities (i.e., if the sonde is being used to measure a lake's depth, then calibrate for zero depth while at that specific lake).

Note: Currently only sondes 22 and 23 (black battery cover) have this capability. Ensure that In-Situ depth readings are within one meter of the marked instrument cable or tagline. If not, use the marked cable or tagline to determine profiling and sample depths.

The Aqua TROLL® 600 sonde uses its pressure reading and specific gravity value to calculate sonde depth. The pressure sensor is located at the center of the instrument, but depth is reported on the smart sensor faces. An embedded gyroscope compensates for the distance between these sensors and allows the sonde to be deployed in any orientation (vertical, horizontal, angled).

A. Follow the procedures outlined in Section 6.0 to establish a connection between the Bluetooth handheld device and the sonde.
B. Within the VuSitu app, tap the VuSitu menu icon and select **Connected Instrument** from the list. Select **Calibrations**. Select **Level**.
C. Follow the on-screen prompt to open the battery cover to expose the sonde's internal barometric pressure sensor to ambient pressure. Allow the pressure on the sonde screen to update and stabilize (indicated by a check mark next to the pressure value).
D. Follow the on-screen prompt to expose the external water/air pressure sensor to the atmosphere (ambient air). Tap **Next.**
E. Allow Zero-in-Air calibration to stabilize. When it is stabilized a green screen with a "stabilized" message and check mark will appear and the barometric pressure displayed will also have a green checkmark next to it. Tap **Accept**.
F. If calibration is not successful or out of range, use a tagline or marked cable for determining depths and not the depth sensor.

Note: If the barometric pressure has recently been updated the sonde will not prompt the user to remove the battery cover to reset barometric pressure. If the sonde is being used to measure level at a different location than where barometric pressure was last reset (>500 feet elevation difference), force a barometric pressure reset on the sonde by exiting out of the calibrations menu and simply opening the battery compartment and allowing the barometric pressure reading on the sonde body's screen to stabilize (indicated by a check mark next to the value) before closing the battery compartment.

6.2 Collection of Instantaneous Measurements and LTD

Prior to collecting data, the sonde must be calibrated. Measure field parameters during each sampling event as specified in the approved project's field sampling plan. Always calibrate and take into the field two sondes, it is a requirement to have a backup sonde for data collection on sampling runs.

6.2.1 Instantaneous Measurement

Sample Location

In streams and rivers, attempt to take measurements where the stream is flowing and well mixed. Avoid stirring up sediment when placing the sonde in the water. If the stream is not well mixed, it may be necessary to move to a location that is mixed (up to 500 meters before a new station must be created). Avoid sampling in backwaters, eddies, and directly below a confluence or discharge. When collecting data replace the calibration cup with the sensor guard and carefully place the sonde in the water with the sensors exposed to oncoming current and above bottom sediments. The sonde should be situated vertically in the water column, three (3) to six (6) inches above the substrate. When water depth is too shallow to allow vertical orientation of the sonde, it may be placed horizontally in the water column, with sensors facing upstream and into the flow.

When instantaneous field parameters (e.g., pH, dissolved oxygen, specific conductance, turbidity, and temperature) cannot be measured due to low flow, they may be measured in the calibration cup/restrictor, or a bucket used for sample collection. A small container can be used to fill the calibration cup/restrictor in very shallow situations. Use a bucket that is large enough to allow full immersion of the sensors and bring the bucket to the same temperature as the water before it is filled. If a bucket is used, make clear notes on the Stream Field Data Form indicating what methods were used to obtain an adequate water sample volume. Also consider building small dams or depressions to create water deep enough to submerge the sonde sensors, if possible. Allow suspended sediment to clear before collecting readings with sonde.

Data Recording

For instantaneous measurements (grab data) record data on the Stream Field Data Form, use a separate form for each monitoring station. Data results can also be logged using the internal storage of mobile device and transferred to the Stream Field Data Form. It is best to do this prior to leaving the monitoring location. Enter additional comments regarding sampling conditions or equipment status as appropriate. Before leaving the site, review the field form for completeness and accuracy. If a reading is clearly unreasonable put a comment on the field form and record the measurement as missing data point (MDP). An example of an unreasonable reading is less than zero for temperature. Use best professional judgement.

After each sampling trip, transfer the information to the SWQB water quality database and store the Stream Field Data Form in the project folder in the shared drive. Note: Dissolved oxygen should be calibrated at elevation when monitoring stations vary in elevation by 500 feet (152 meters).

Field Procedure for Instantaneous Measurements

A. Activate Bluetooth on mobile device.
B. Open the VuSitu App and connect to the sonde.
C. Hold the sonde upside down (sensors pointed up) for three seconds to turn it on.
D. Remove the restrictor and place it in sampling mode.
E. Select live readings.
F. Placed the sonde in stream as described in Sample Location Section for instantaneous measurements and allow to stabilize.
G. Typically, it works best to place the sonde in the stream upon arrival at sample site, to allow for stabilization. Once the readings are stable save them to the sonde data file. Readings are generally considered stable when temperature no longer changes by more than a tenth of a degree. The sonde will create a new data file each day and append new readings in a new row of that file. Transfer measurements to the Stream Field Data Form as soon as possible.
H. After the measurements have been recorded disconnect the Bluetooth connection and remove the restrictor and reinstall it in storage mode. Fill the restrictor with river or tap water to keep the sensors moist. The pH sensor in particular needs to be kept moist as much as possible. Never fill the restrictor with DI water as this will damage the pH sensor.

6.2.2 Sonde Long-term Deployment (LTD)

Sample Location

Sondes are frequently deployed mounted to T-posts or rebar driven into the stream substrate for LTD. Avoid driving T-post or rebar into the stream bottom where underground utilities are suspected. If there is any question of whether underground utilities are present at the monitoring location, call "811" or visit www.nm811.org to schedule a utility location. Rebar and T-posts present trip and impalement hazards. Exercise caution when working around driven rebar and T-posts. Do not install rebar or T-posts in areas used for recreation or adjacent to trails or stream crossings. Avoid mid-channel placements in waters with boat traffic. The Sonde Deployment/Retrieval Form must be utilized when deploying sondes for LTD and completed in its entirety at field site. Sondes deployed for LTD are to be inspected monthly (if practicable) and at the end of deployment. Sonde and sensors should be placed so they do not come in contact with stream substrate, if possible. Secure the sonde with a chain or cable to a tree or other immovable object and lock it with a weather resistant padlock. If the sonde cannot be safely deployed due to a high risk of vandalism, theft, or imminent flooding, it should not be deployed until favorable conditions are met. **Note**: Dissolved Oxygen should be recalibrated at elevation when deploying for LTD.

Field Procedure for LTD

A. Activate Bluetooth on mobile device.
B. Open the VuSitu App and connect to the sonde.
C. Hold the sonde upside down (sensors pointed up) for three seconds to turn it on.
D. Remove the restrictor and place it in sampling mode.
E. Select live logging.
F. Select new log.
G. Name the log. Select Next.
H. Select add new location.
I. Name the location. Enter the GPS location of the site or allow the App. to autofill the location if the device GPS is turned on. Select save.
J. Select the site just created.
K. Choose parameters and units to be collected. Select next.
L. Set the salinity to automatic. Select next.
M. Set the TDS conversion factor. Use the default and select next.
N. Set the TSS conversion factor. Use the default and select next.
O. Select the linear logging method. Select next.
P. Set the sonde to record at least every 15 minutes, but no greater than one hour.
Q. Select manual or scheduled start and stop.
R. If manual start was selected, select start.
S. Install the sonde at the monitoring location, as described in the Sample Location Section for LTD.

LTD Retrieval

Upon retrieving a sonde, perform a post-deployment check of the DO calibration at the monitoring station. The post-deployment check for the other parameters (e.g., conductivity, pH, turbidity) can be done either at the monitoring station or at another location but must be completed within 48 hours after retrieval if practically possible to accurately measure instrument drift. This check is not a recalibration, but an accuracy test to verify that the sensors are still functioning properly and to check for drift in the readings. Note: Typically, the SWQB will collect live readings of sonde parameters with a

second sonde as part of the verification process when retrieving a sonde from LTD. Implement the following steps:

Field Procedure for Retrieval of a Sonde after LTD

A. Collect and document a live reading from a second sonde before retrieval.
B. Remove the sonde from the waterbody.
C. Remove the restrictor, reinstall it in calibration mode and fill it with river or tap water.
D. If a manual stop was selected connect the sonde to a smart phone or tablet via Bluetooth.
E. Select logging.
F. Select the more tab and stop logging.
G. Implement the Sonde Calibration Verification Section of this SOP.
H. Follow In-Situ Sonde Data Upload Instructions from SOP 6.4 *Datalogger (Thermograph and Sonde) Data Management, Quality Assurance and Upload Instructions.*

6.3 Sonde Calibration Verification

Calibration verifications, sometimes referred to as "post checks" will be conducted following grab data collections at the completion of a sampling runs and after LTDs. Calibration verification should be completed within 48 hours of the last grab sample during a sample run and retrieval of a sonde deployed after LTD (NMED/SWQB 2021b or most current). DO calibration verification should be completed at the last monitoring location of the sampling run. The purpose of calibration verification is to check for instrument drift and ensure the accuracy of field readings. Calibration verifications are conducted by viewing the sonde's live readings of a calibration standard or buffer or in 100% saturated air for DO. **Do not clean the sonde prior to conducting the calibration verification**. Fill out the bottom half of the **Sonde Calibration Worksheet** under "Calibration Verification" or the Calibration Verification on the **Sonde Deployment/Retrieval Field Sheet for LTD.** If a sonde was taken into the field and not used, write "Not Used" on the Calibration Verification section of the **Sonde Calibration Worksheet**.

Take care to not remove biofouling from the sonde prior to or during calibration verification. Begin by gently rinsing all sensors and the entire inside of calibration cup once with DI or tap water. Next, rinse twice with the calibration standard by adding standard into the calibration cell and gently swirling the sonde while holding it upright so the standard makes contact with all areas of the sonde sensors before discarding. Be certain to avoid cross-contamination of standard solution with other solutions. Fill the cup with fresh standard and allow it to stabilize. Record the required sensor readings in the Calibration Verification section on the correct form (**Figure 17)**. Calibration verification results that are not within the in-calibration range (or interpolation range for LTD) will be investigated by the operating technician and reported to the Project Manager and/or Sonde Equipment Coordinator. The calibration verification may be troubleshot, and calibration verification reattempted to ensure the issue was not due to staff error. Calibration verification results that fail to meet the in-calibration (or interpolation range for LTD) range must be flagged with correct qualifier code. SWQB SOP 15.0 Data Verification and Validation Procedures contains more information on qualifier codes and the verification and validation process (NMED/SWQB 2020b or most current version). **Table 2** of this SOP also lists valid in-calibration and interpolation values for sondes used by the SWQB.

Calibration Verification	Date/Time:			Technician:	
Dissolved Oxygen		Temperature (°C)	Pressure (mmHg)		P/F or LTD Qual.
%	mg/L				

Specific Conductance (µS/cm)	Standard Lot #	Reading (µS/cm)		Temp. (°C)	P/F or LTD Qual.

pH Value (su)	Buffer Lot #	Reading (s.u.)	mV	Temp. (°C)	P/F or LTD Qual.

Turbidity Value (NTU)	Standard Lot #	Reading (NTU)			P/F or LTD Qual.
0	DI				
100					
1000					

Figure 15. Calibration Verification Documentation

6.3.1 Temperature Sensor Verification

See the quality control and quality assurance section of this SOP.

6.3.2 Dissolved Oxygen (DO) Calibration Verification

For DO, it is recommended that calibration verifications be completed in the field at the last site of a sampling run or upon retrieval or interim download from a LTD site. Ideally, DO saturation calibration verifications should be performed at the same elevation (barometric pressure) at which the sonde was field calibrated. If performing the DO saturation calibration verification off site at a different elevation, use the USGS Dissolved Oxygen Tables (located at: (https://water.usgs.gov/software/DOTABLES/ or available from the sonde Equipment Coordinator) to calculate percent saturation using concentration, temperature, and barometric pressure.

A. When conducting a calibration verification for dissolved oxygen, make sure that the DO sensing foil is dry and install a saturated sponge into the restrictor (see DO calibration Section 6.1.1). Make sure it is damp and not dripping.
B. Install the end cap with *one* full rotation. Do not tighten. Allow 5 to 10 minutes to reach 100% saturation of the air within the chamber.
C. Establish a connection with the sonde in the VuSitu App (see Section 6.0). Select **Live Readings**. After the sonde has stabilized (i.e., values are not fluctuating) record the DO values and temperature in the post-check section of the **calibration worksheet**. If DO values are out-of-range, indicate a "fail" for the calibration verification and add a qualifier code, as applicable.
    a. DO saturation calibration verifications performed in the field at the same elevation where the sonde was field calibrated should be within ± 5% of the calibrated value (**Table 2**).
    b. DO saturation calibration verifications performed off-site or in the lab will require the use of a Dissolved Oxygen Table to determine the correct percent concentration. When performing a DO % saturation calibration verification using this method, follow the above procedures for beginning a DO calibration verification. Once the **live reading** temperature and DO concentration (mg/L) have

stabilized, record these values on the calibration verification section of the worksheet, along with the barometric pressure. Then, use the DO table to find the "expected" DO concentration (mg/L) (based on 100% solubility) at the recorded temperature, and current barometric pressure (**Figure 18**). Divide the live reading DO concentration written on the worksheet by this "expected" DO concentration and multiply by 100 to find the "true" DO percent saturation. Record this number as the DO percent saturation on the worksheet. This percent saturation is then compared to **Table 2** to determine whether a qualifier should be applied, or if the calibration verification passes or fails to fall within in-calibration or interpolation ranges.

c.

Calibration Verification		Date/Time:	6/22/20 12:30		Technician:	MZ	
Dissolved Oxygen at Retrieval		Temperature (°C)	Pressure (mmHg)	DO Gain	QA Criteria		P/F Qua
%	mg/L				Pass: ± 5% Interpolation: ± 30%		
97.58	6.45	22.51	586.1	NA			P

Dissolved Oxygen Table:

Temp. (deg C)	Barometric Pressure (mm Hg) 575	580	585	590
20	6.83	6.89	6.95	7.01
20.5	6.76	6.82	6.88	6.94
21	6.69	6.75	6.81	6.87
21.5	6.62	6.68	6.74	6.8
22	6.56	6.62	6.68	6.74
→ 22.5	6.49	6.55	6.61	6.67
23	6.43	6.49	6.55	6.61

$$\frac{\text{"observed concentration"}}{\text{"expected concentration"}} = \frac{6.45\ mg/L}{6.61\ mg/L} \times 100 = 97.58\%\ \text{saturation}$$

Figure 16. DO Table Example

D. If the DO calibration verification reading is within the in-calibration range, write "pass" or "P" in the pass/fail section of the calibration worksheet. If the DO calibration verification reading is not within the in-calibration range and the sonde was not used for LTD, write "fail" or "F" in the pass/fail section of the **Sonde Calibration Worksheet**. Grab-data cannot be interpolated; thus, the sonde must be within in-calibration range. Grab-data that were collected using a sonde that failed a post-check will be examined during the data validation and verification process and the appropriate data qualifiers applied at that time using the SWQB SOP 15.0. If the sonde was used for LTD and the DO calibration verification reading is between the in-calibration range and the linear interpolation range, record the parameter-specific code for correction (C% and CDO) in the pass/fail section of the **Sonde Deployment/Retrieval Field Sheet**. If the LTD calibration verification is not within the linear interpolation range, record the parameter-specific code for rejection (R% and RDO) in the pass/fail section of the **Sonde Deployment Retrieval Field Sheet**.

6.3.3 Specific Conductance Calibration Verification

Always perform specific conductance calibration verifications prior to pH calibration verification due to the high conductance of pH buffers.

A. Gently rinse all sensors and the entire inside of calibration cup once with DI or tap water.
B. Next, rinse twice with conductivity standard by adding standard into the calibration cell and gently swirling the sonde while holding it upright so the standard makes contact with all areas of the sonde sensors before discarding.
C. Fill the cup with fresh conductivity standard. In VuSitu, select **Live Readings** and allow specific conductivity value and temperature to stabilize.
D. Record the required sensor readings in the Calibration Verification section of the **Sonde Calibration Worksheet** for grab data, LTD verification readings should be recorded on the **Sonde Deployment/Retrieval Field Sheet** (**Figure 19**).

Specific Conductance (µS/cm)	Standard Lot #	Reading (µS/cm)	Temp. (°C)	P/F or LTD Qual.

Figure 17. Specific Conductance Calibration Verification Documentation

E. If the specific conductance calibration verification reading is within the in-calibration range, write “pass” or “P” in the pass/fail section of the proper calibration worksheet. If the calibration verification is not within the in-calibration range and was not used for LTD, write “fail” in the pass/fail section of the **Sonde Calibration Worksheet** (see **Table 2** and the SWQB SOP 15.0). If the sonde was used for LTD and the specific conductance calibration verification reading is between the in-calibration range and the linear interpolation range, record the parameter-specific code for correction (CSC) in the pass/fail section of the **Sonde Deployment/Retrieval Field Sheet**. See Figure 19. If the LTD calibration verification is not within the linear interpolation range, record the parameter-specific code for rejection (RSC) in the pass/fail section of the **Sonde Deployment/Retrieval Field Sheet**.
F. Discard the standard.

6.3.4 pH Calibration Verification

Calibration verification for pH is required for both pH 7.0 and 10.0 for all grab data and deployments. If pH values of less than 7.0 were observed, then a calibration verification of pH 4.0 must also be conducted. Take care to not remove biofouling from the sonde prior to or during the calibration verification.

A. Gently rinse all sensors and the entire inside of calibration cup once with DI or tap water.
B. Next, rinse twice with pH 7.0 standard by adding standard into the calibration cell and gently swirling the sonde while holding it upright so the standard makes contact with all areas of the sonde sensors before discarding.
C. Fill the cup with fresh pH 7.0 standard. In VuSitu, select **Live Readings** and allow pH value to stabilize.
D. Record the required sensor readings in the Calibration Verification section of the **Sonde Calibration Worksheet** for grab data. LTD verification reading should be recorded on the **Sonde Deployment/Retrieval Field Sheet** (**Figure 20**).

pH Value (su)	Buffer Lot #	Reading (s.u.)	mV	Temp. (°C)	P/F or LTD Qual.

Figure 18. pH Calibration Verification Documentation

E. If the pH calibration verification reading is within the in-calibration range, write “pass” or “P” in the pass/fail section of the calibration worksheet. If the calibration verification is not within the in-calibration range and was not used for LTD, write “fail” in the pass/fail section of the **Sonde Calibration Worksheet**. If the sonde was used for LTD and the pH calibration verification reading is between the in-calibration range and the linear interpolation range, record the parameter-specific code for correction (CPH) in the pass/fail section of the **Sonde Deployment/Retrieval Field Form** (**Figure 20**). If the LTD calibration verification is not within the linear interpolation range, record the parameter-specific code for rejection (RPH) in the pass/fail section of the **Sonde Deployment/Retrieval Form.**
F. Discard the pH 7.0.
G. Repeat steps A-E for the second and possibly third pH values. If required, perform a pH 4.0 post-check before performing a pH 10.0 post-check.

6.3.5 Turbidity Calibration Verification

Turbidity calibration verification should be conducted for 0 NTU with DI water and a high range of at least 100 NTU using turbidity standard. It is recommended to perform calibration verifications with the same standard values used during calibration.

A. Gently rinse all sensors and the entire inside of calibration cup twice with DI water.
B. Fill the cup with fresh DI water. In VuSitu, select **Live Readings** and allow turbidity value to stabilize.
C. Record turbidity value in the Calibration Verification section of the **Sonde Calibration Worksheet** for grab data. LTD post check reading should be recorded on the **Sonde Deployment/Retrieval Field Sheet (Figure 21**).

Turbidity Value (NTU)	Standard Lot #	Reading (NTU)			P/F or LTD Qual.
0	DI				
100					
1000					

Figure 19. Turbidity Calibration Verification Documentation

D. If the turbidity calibration verification reading is within the in-calibration range, write “pass” or “P” in the pass/fail section of the calibration worksheet. If the calibration verification reading is out-of-range and the instrument was not used for LTD, write “fail” in the pass/fail section of the **Sonde Calibration Worksheet**. If the sonde was used for LTD and the turbidity calibration verification reading is between the in-calibration range and the linear interpolation range, record the parameter-specific code for correction (CY) in the pass/fail section of the **Sonde Deployment/Retrieval Field Sheet**. If the LTD calibration verification is not within the linear interpolation range, record the parameter-specific code for rejection (RY) in the pass/fail section of the **Sonde Deployment/Retrieval Field Sheet**.
E. Discard the DI water.

F. Next, rinse twice with high range turbidity standard (at least 100 NTU) by adding standard into the calibration cell and gently swirling the sonde while holding it upright so the standard makes contact with all areas of the sonde sensors before discarding.
G. For the high range calibration verification, fill the cup with fresh turbidity standard of at least 100 NTU. The turbidity standard value used to calibrate the sonde should be used for post check verification.
H. Next, repeat steps in letter A-C for high range turbidity calibration verification.

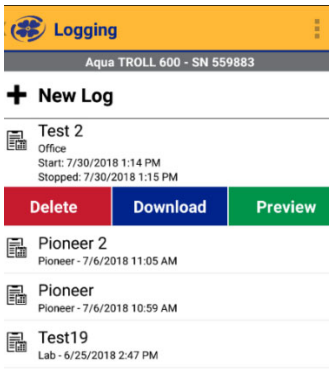
6.4 Sonde Data Upload (transferring of data from sonde)

This section covers the retrieval and upload of logged datasets. **Do not** delete files from a sonde until file copies have been transferred to network storage and backed up. Best practice is to ensure raw files as well as cropped and saved Excel data records have been stored on the network before deleting original raw files from sondes. Instantaneous measurements must be saved on the SWQB's internal storage in the applicable survey folder. LTD files must be saved according to SOP 6.4 Long-term Deployment Data Logger Quality Assurance and SQUID Upload for more information.

6.4.1 Sonde Data Upload Instructions

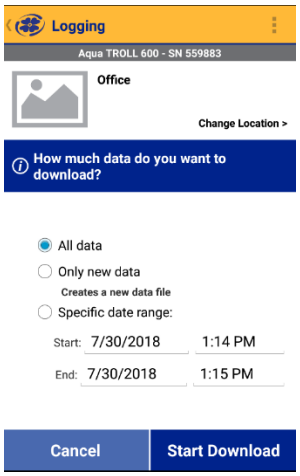
Uploading from the Sonde to Mobile Device

A. Activate the sonde by turning it upside down (sensors pointing up) for five seconds.
B. Turn on the mobile device and open the Vu-Situ app.
C. Connect to the sonde via available Bluetooth connections in the Vu-Situ app. If the sonde is not auto discovered by the app, select Choose or **Add a device** and select the sonde (identified by its serial number) from the previous devices connected list.
D. Once a Bluetooth connection is established, select **Logging** from the main menu.
E. Select **Stop Logging** if the sonde is actively logging.
F. Select the file/site that you wish to download.



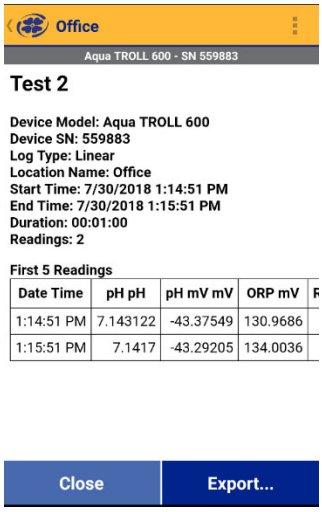
G. Select **Preview** to view the first and last five recorded measurements.

H. Select **Download** to download the file.



I. Select **All data** then select **Start Download**.

J. After download is complete select **Export**.



K. Select the **VuSitu** Folder. The file will then be downloaded to the VuSitu file on the mobile device. If a cable is not available to download the file from the VuSitu file to a PC, the file can be sent as an email attachment.

L. Proceed to Section for Uploading from a Mobile Device to PC.

Uploading from a Mobile Device to PC

A. Connect the mobile device to a PC using the appropriate USB cable.

B. Using the PC file explorer locate the **VuSitu** folder contained in the mobile device file drive. Open the file for the station and copy the HTM/HTML file. Navigate to the raw data subfolder within the project folder and paste the file.

C. Open the HTM/HTML file using the PC internet browser. In the header of the document, select export to CSV and save the file in the processed data subfolder in the project folder. Alternatively, you may either copy and paste into an Excel file or open the HTM/HTML file directly in Excel. File can be saved as either a .csv or .xlsx type.

D. Crop the data to the deployment period (i.e., delete data points occurring before and after the instrument was taking legitimate recordings within the water at the deployment location, as indicated by the "deployed" and "retrieved" time and dates on the instrument's Deployment Form) and save the file.
E. Rename the Excel file using the site name, deployment date and instrument type. For example: "Comanche_abv_Costilla_2017_Apr_26_MP.xlsx". In this example "MP" stands for "multiparameter" to indicate the data is from a multiparameter sonde.

6.5 Sonde Maintenance

After extended storage periods or upon retrieval from deployment (following calibration verification), clean the sonde calibration cell, sonde body and the sensors with cold water from tap. Follow the maintenance schedule listed in the Operator's Manual, replacement kits, and/or sensor instruction sheets. Follow the unit-specific procedures for sensor maintenance and cleaning procedures. Refer to the instrument manual or manufacturer for detailed maintenance requirements specific to In-Situ sondes. Electronic .pdf copies of all manuals are kept on the SWQB file server.

Any staff member who performs maintenance activities (e.g., sensor replacement, junction fluid refills, probe winterization etc.) is responsible for tracking completed maintenance in the sonde tracker spreadsheet. The Sonde Tracker spreadsheet is located on the SWQB file server. However, maintenance of sondes is the primary responsibility of the Sonde Equipment Coordinator. Staff must coordinate with the Sonde Equipment coordinator regarding maintenance of sondes.

6.5.1 Sonde Replacement Parts

See the Sonde Equipment Coordinator for replacement parts. Do not discard any malfunctioning parts, as these may be under warranty.

6.5.2 Sonde O-rings

In-Situ sondes have several O-rings that can be maintained by applying silicone grease to new and old O-rings. Check O-rings for cracks or other damage quarterly and replace as needed If the O-rings and sealing surfaces on the sondes are not maintained properly, water can enter the battery compartment and/or sensor or cable connector ports of the sonde. Water can severely damage the battery terminals or sensor ports causing loss of battery power during a deployment, inaccurate readings and corrosion to the contacts. Therefore, when the battery compartment lid is removed from In-Situ sondes, the O-rings that provide the seal should be carefully inspected for contamination (e.g., hair, grit, etc.) and cleaned if necessary. The same inspection should be made of the O-rings associated with sensors, port plugs and field cable connectors when they are removed. If no dirt or damage to the O-rings is evident, they should be lightly greased (see below) without removal from their groove. If there is any indication at all of damage, the O-ring can be replaced with an identical item from the Maintenance Kit supplied with the sonde. At the time of O-ring replacement, the entire O-ring assembly should be cleaned. See the manufacturer's instrument manual for details regarding O-ring removal and installation.

> ***Important:*** Do not use alcohol on O-rings as this may cause a loss of elasticity and promote cracking. Do not use a sharp object to remove the O-rings. Damage to the O-ring or the groove itself may result. Before re-installing the O-rings, make sure that you are using a clean workspace, clean hands, and are avoiding contact with anything that may leave fibers on the O-ring or grooves, potentially causing a leak. Do not over-grease the O-rings. The excess grease may collect grit particles that can compromise the seal. Excess grease can also cause the

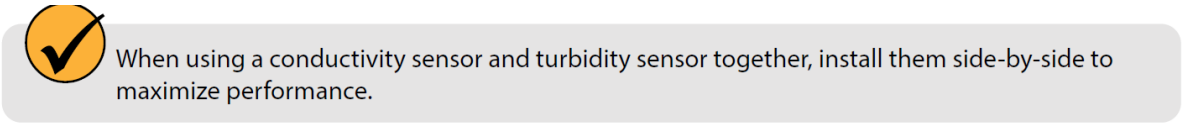
waterproofing capabilities of the O-ring to diminish, potentially causing leaks into the compartment. If excess grease is present, remove it using lens cloth or lint-free cloth.
NOTE: Silicon grease is NOT a sealant. It is a lubricant only and must be used sparingly.

6.5.3 Sonde Cable Connector Port

The cable connector port at the top of the sonde should be covered at all times. When a communications cable is not connected to the cable connector port, the protective cap supplied with the instrument must be securely tightened in place. If moisture has entered the connector port, dry it completely using 95% ethanol and compressed air.

6.5.4 Sonde Probes (i.e., sensors)

Whenever installing, or replacing sensors or port plugs, it is extremely important that the sensor port plugs, and the ports of the Aqua TROLL sonde body be thoroughly dried before any installation to prevent any shortages that may cause damage to the sensor or the sonde. Ensure that the sensor's O-rings are in good condition and are properly greased with lubricant. This will prevent water from entering the ports where the wires connect the sensors to the sonde body. Following removal of sensor or plug, examine the connector inside the sonde sensor port for any moisture. If any moisture is present in both the port where the connector is and the sensor dry thoroughly with KimWipe lint free cloth, compressed air may also be used. If debris is found in the port of the sonde body, then DI water may be used to rinse. Once debris is gone, the port may be dried thoroughly. Sensors may be gently wiped with a clean cloth prior to removal to help prevent moisture from getting in during the removal process. Make sure that the sensors are in the proper configuration from Aqua TROLL Owner's Manual (**Figure 22**).



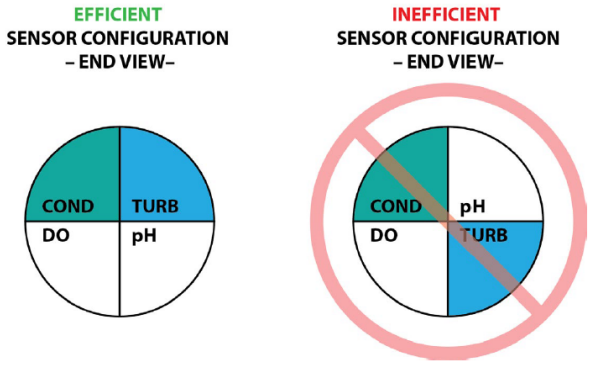


Figure 20. Proper Placement of Probes

Sonde DO Sensor

When turning on the sonde note the time till expiration of the RDO sensor cap. Replace when recommended. Clean with mild soap and water when dirty. Do not clean with anything abrasive this could mess up the film on the cap. Replace if film on cap is overly scratched. If extensive fouling or mineral buildup is present, soak the sensor in vinegar for 15 minutes, then soak in deionized water for 15 minutes.

When changing the sensor cap clean optical window by first removing the sensor cap and then gently wiping the sensing window with lens cloth (e.g., KimWipe).

Sonde pH Sensor

If the ORP platinum electrode is dull or dirty, it can be cleaned with a swab and methanol or isopropyl alcohol. Rub the electrode gently until it is shiny. The pH sensor must be kept moist for the life of the sensor.

The sensor reference junction filling solution has a shelf life of 2 years. Replace the reference junction filling solution every 5 to 6 months or when:

- The sensor fails to calibrate within the acceptable slope and offset range (refer to **Sonde Calibration Worksheet**).
- Sensor readings vary.
- Readings during calibration at pH 7.0 are greater than +30 mV or less than -30 mV.
- Sensor is slow to respond.
- Sensor error notice appears during live readings or calibrations.

If the sensor fails to calibrate after you replace the pH reference junction filling solution, replace the reference junction.

Replacing the pH Reference Junction Filling Solution:

A. Remove the pH sensor from the port. The hex wrench provided with the sonde is necessary to unscrew the sensor before it can be removed.
B. Install the dust cap on the connector end of the sensor or wrap the connector end in a paper towel to prevent solution from entering the connector.
C. Unscrew the reference junction on the head of the sensor using a small flathead screwdriver.
D. Hold the sensor at an angle and shake out the old filling solution into a paper towel and discard.
E. Using the elongated dispenser cap on the filling solution bottle, insert the tube into the bottom of the empty reference junction reservoir. Squeeze a steady stream of filling solution into the reservoir until it overflows, and no bubbles are observed. Continue to add solution while pulling the tube out of the reservoir. This ensures the reservoir is completely full and bubble-free.
F. Screw the reference junction back on to the sensor and hand-tighten until firmly attached. *Do not overtighten.* Some filling solution will overflow. Wipe the excess off the sensor body.
G. Soak the sensor in room-temperature tap water for at least 15 minutes. Make sure the sensor face is immersed but be careful not to immerse or accidentally wet the port end of the sensor.
H. Calibrate the pH sensor (refer to Section 6.1.4).
I. If necessary, thoroughly clean the sensor connector to remove filling solution: Using a disposable pipette, fill the connector with isopropyl alcohol (70% to 100%), and shake to dry. Dry overnight. When thoroughly dry, replace and calibrate the sensor.

Replacing the pH Junction

Replace the pH junction when the pH sensor fails to calibrate with a reasonable slope and offset, even after you have replaced the filling solution.

A. Unscrew the pH reference junction and discard.
B. Replace the filling solution according to the procedures above and screw in a new pH reference junction.
C. Soak the sensor face in room-temperature tap water for 15 minutes, then replace and calibrate the sensor.

Cleaning – Routine Maintenance (pH Sensor)

A. Leave the sensor cap on.
B. Rinse the sensor with clean water.
C. Gently wipe with a soft cloth or brush if biofouling is present.
D. If extensive fouling or mineral buildup is present, soak the sensor in vinegar for 15 minutes, then soak in deionized water for 15 minutes.

Do not use organic solvents—they will damage the sensor cap. Do not remove the sensor cap when rinsing or brushing.

Sonde Conductivity Sensor

Cleaning

Begin with the gentlest cleaning method and continue to the other methods only if necessary. To clean the conductivity sensor face, gently rinse with clean, cold water.

To remove crystalline deposits:

A. Clean the sensor face with warm water and mild soap.
B. Use a soft brush to gently clean the sensor pins and temperature button. Ensure removal of all debris around the base of the pins and button.
C. If crystalline deposits persist, soak in 5% HCl for 10 to 30 minutes followed by warm soapy water and soft brushing.
D. If deposits persist, alternate soaking in 5% HCl and 5% NaOH solutions followed by warm soapy water and soft brushing.

To remove oily or greasy residue:

A. Clean the sensor face with warm water and mild soap.
B. Using a soft brush, gently clean the sensor pins. Ensure removal of all residues around the base of the pins.
C. Isopropyl alcohol may be used for short soaking periods, up to one hour.
D. Do not soak in strong solvents such as chlorinated solvents, ethers or ketones (such as acetone).

To remove protein-like material, or slimy film:

A. Clean the sensor face with warm water and mild soap.

B. Using a soft brush, gently clean the sensor pins and temperature button. Ensure removal of all material/film around the base of the pins and temperature button.
C. Soak the sensor in 0.10% HCl for 10 minutes and then rinse thoroughly with distilled water.

Sonde Turbidity Sensor

Cleaning

The optical windows should be clear of foreign material. To clear material gently rub the sensing windows using clean water and a soft cloth or swab. Do not use solvents on the sensor.

Replacing Wiper Bristles

Wiper bristles need to be replaced based on site conditions. In-Situ recommends replacing bristles at least every 12 months or when visibly bent, damaged, or fouled.

Table 3 Troubleshooting Sonde Probes provides a detailed summary regarding sonde probe issues, the possible cause of the problem, and actions staff can take to address the root cause. If the issues are not captured in Table 3, see In-Situ Aqua TROLL® 600 sonde manual for more information.

Table 3. Troubleshooting Sonde Probes

Symptoms	Possible Cause	Action
DO reading unstable or inaccurate	Sensor not properly calibrated	Follow DO calibration procedures
	End cap on sonde is too tight	Loosen the end cap, ensuring it is turned only one rotation
	Water droplets on the DO sensing foil or thermistor	Gently dry sensing foil or thermistor with a Kimwipe. Ensure sponge is not dripping water – only moistened
	Water in sensor port	Dry port; reinstall sensor
	Algae or other contaminant clinging to DO sensor	Rinse DO sensor with clean water and wipe gently with a Kimwipe
	Calibrated using improper barometric pressure	Repeat DO calibration procedure using proper barometric pressure
	Calibrated at extreme temperature	Recalibrate at (or near) sample temperature
pH readings are unstable or inaccurate. Error messages appear during calibration.	Sensor requires cleaning	Follow sensor cleaning procedure
	Sensor requires calibration	Follow calibration procedures
	pH sensor has dried out from improper storage.	Re-hydrate pH sensor by storing pH 4.0 fluid in the calibration cup overnight. Change the pH reference junction fluid. If necessary, replace reference junction.
	Water in sensor connector	Dry connector; reinstall sensor
	Sensor has been damaged or has expired	Replace sensor
	Calibration solutions out of spec or contaminated with other solution	Use new calibration solutions
	pH value out of range	If all of the above solutions do not fix the problem, replace the pH probe

Symptoms	Possible Cause	Action
Specific conductivity unstable or inaccurate. Error messages appear during calibration.	Conductivity improperly calibrated.	Follow calibration procedure
	Conductivity sensor requires cleaning	Follow cleaning procedure
	Conductivity sensor damaged or has expired	Replace sensor
	Calibration solution out of spec or contaminated	Rinse with DI water and use new calibration solution
	Internal failure	Return sonde for service
	Calibration solution or sample does not cover entire sensor.	Immerse sensor fully
Temperature, unstable or inaccurate	Water in connector	Dry connector; reinstall sensor
	Sensor has been damaged	Replace the sensor
Turbidity sensor: general	Sensor requires cleaning	Follow sensor cleaning procedure
	Sensor requires calibration	Follow calibration procedures
	Sensor has been damaged or has expired	Replace sensor
	Water in sensor connector	Dry connector; reinstall sensor
	Calibration solutions out of spec	Use new calibration solutions
	Wiper is fouled or damaged	Clean or replace wiper
	Internal failure	Return sensor for service
Installed sensor has no reading	Sensor has been disabled	Enable sensor
	Water in sensor port	Dry port; reinstall sensor
	Sensor has been damaged	Replace the sensor
	Report output improperly set up	Set up report output
	Internal failure	Return sonde for service

6.6 General Sonde Storage

Following calibration or calibration verification, clean and rinse the sonde and sensors with tap water or pH 4.0. Do not use distilled or DI water for storage. When in the field use river or tap water.

6.6.1 Sonde Storage

Short-term (<1 Month or during the field season)

The sonde restrictor can be used as a storage cup. Tap water is safe for short periods of storage (i.e., <24 hours), however pH 4.0 solution should be used for longer periods of short-term storage (i.e. >24 hours) to prevent the pH probe from dehydrating while the sonde is not in use.

A. Remove the end cap from the restrictor.
B. Remove the restrictor from the sonde body.
C. Replace the restrictor onto the sonde body in storage mode.
D. Pour 15 mL (0.5 oz.) of clean tap water or pH 4.0 solution (not DI water) into the calibration cup.
E. Screw end cap back on to the restrictor so that the liquid is contained in the calibration cup.

Long-term (>1 Month during the off season)

Note: The pH sensor should not be removed from the sonde during the field season even if it will be in temporary storage for more than one month. It is acceptable to store the sonde with pH 4.0 during periods of storage while the field season is ongoing. This protocol should be used to prepare sondes for off-season storage.

A. Remove the pH/ORP sensor and place a sensor port plug into the empty pH/ORP port.
B. Add a small amount of pH Storage Solution (0065370) or pH 4.0 calibration solution (0083210) to the sponge in the pH/ORP storage cap.
C. Place the storage cap firmly on the sensor. Use electrical tape to seal the cap to the sensor.
D. Place a dust cap on the sensor connector. Store the sensor in its original box in a cool location.
E. Remove the batteries from the sonde.
F. Remove the restrictor from the sonde body. Remove the blue end cap from the restrictor and replace it on the opposite end of the restrictor.
G. Screw the restrictor on to the sonde so that it is in storage mode.
H. Store the sonde and pH/ORP sensor in the box they arrived at temperatures between -5° to 65° C.

Prior to using the pH sensor after long-term storage, rinse the sensor with tap water and then soak it in pH 10.0 buffer for 1 or 2 hours. This will saturate the glass bulb with hydrogen ions and prepare it for use. Do not store the pH sensor in DI water because it will deplete the reference solution and drastically reduce the life of the sensor.

The Aqua TROLL® 600 sonde contains a small, replaceable desiccant capsule in the battery compartment. This capsule prevents moisture from causing damage to the electronic components. It is filled with color-indicating silica that changes from blue to pink as the desiccant's effectiveness decreases. Desiccant is included in the Maintenance kit. Replace the desiccant where it has turned pink. Desiccant can be dried out in incubator, if this does not return desiccant to blue color toss the desiccant and replace.

7.0 Data and Records Management

The following files are generated following the procedures outlined above:

- Sonde Calibration Worksheet
- Sonde Deployment/Retrieval Field Sheet (calibration and calibration verification)
- VuSitu data file and calibration report
- QC check spreadsheet
- Temperature QC check spreadsheet

All calibration files (calibration and calibration verification) and deployment/retrieval sheets must be retained for a minimum of 3 years from the date of project verification and validation on the SWQB's internal server.

For the SWQB MASS the records of the disposition for each Sonde are documented within the "Logger Status Tracker" spreadsheet. Available within a folder \\FS01\Data$\WPD\SWQB\MASS\Monitoring Team\Monitoring Equipment\In-Situ Sondes.

8.0 Quality Control and Quality Assurance

Standardized methods that are documented in this SOP are used to control the quality of sonde data. All personnel who calibrate, deploy, or maintain sondes must be familiar with these protocols and the related documents (e.g., field forms) and sign the acknowledgment form associated with this specific SOP. In addition to standardized methods, proper training of personnel represents a critical aspect of meeting the data quality objectives in order to fulfill the goals of the SWQB's QAPP (NMED/SWQB 2021 or most current). If, at any time, the QAO determines this process is not being adhered to, the QAO has the authority to cease activities specific to this SOP with prior support and approval by the SWQB Bureau Chief and MASS Program Manager, until such a time that the issue can be resolved.

Between each field season, the Sonde Equipment Coordinator verifies that each sonde is reading temperature within ±0.5°C of a NIST-traceable and calibrated thermometer at a minimum of two temperatures (approximately 4-10 °C and 35-40 °C) bracketing the range of water quality standards. The annual temperature verification will be documented in the Sonde Tracker spreadsheet by the Sonde Equipment Coordinator. The sonde calibration spreadsheet must indicate the date the verification was performed, the technician (i.e., Sonde Equipment Coordinator) conducting procedures, if verification passed or failed, and any important notes. New sondes with a Compliance Certificate or equivalent do not require accuracy verification prior to first use. The Temperature Accuracy Procedure is detailed below. The SWQB uses 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. Certified thermometers should be certified annually at two temperatures.

8.1 Temperature Accuracy Check Procedure

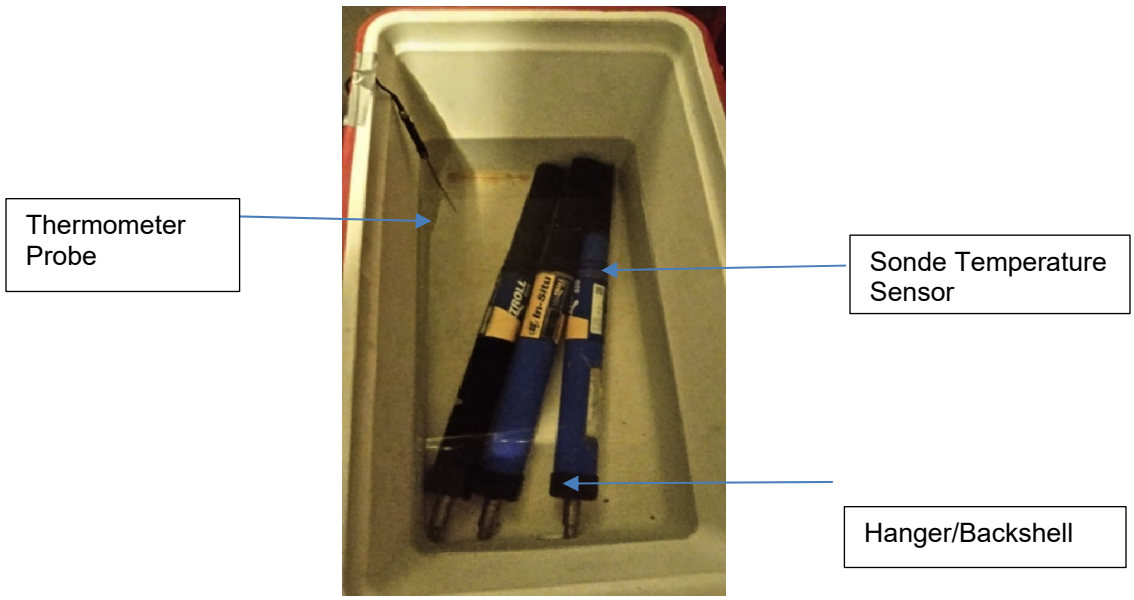
Verify the accuracy of the temperature sensor on sonde(s) between field seasons by completing a temperature validation using a 2-point verification procedure which utilizes a cold bath and then a warm bath. The temperature accuracy verification procedure for sonde(s) is detailed below in a step-by-step process.

A. Begin by preparing a low range cold-water bath between 4-10 °C for the 1st-point of the temperature verification. The cold-water bath can be prepared by using a refrigerator and ice chest. Typically, the SWQB will use a sample cooler and the large walk-in refrigerator located in the laboratory of the Harold Runnels Building.
B. First, fill cooler (e.g., ice chest) with cold water from the tap, shut the lid and place in refrigerator (e.g., walk-in refrigerator).
C. Next, ensure sonde(s) internal clock are set to the correct time and the battery voltage is greater than 50%.
D. After time and voltage are confirmed, ensure the sonde is watertight (i.e., waterproof) to prevent damage to any internal electrical components. This is completed by inspecting sonde(s) O-rings to ensure they are in good condition and the metal back-endcap(s) (hanger/backshell) are securely fastened.
E. Next, program sonde(s) to simultaneously record at least three (3) temperature readings, each 5 minutes apart. When programing the sonde, staff need to account for the stabilization and acclimation period, at least 12 hours (or until equipment has equilibrated with water temperature) to reduce stratification of water. It is recommended the scheduled start and stop time feature be utilized for Aqua TROLL ® 600. See LTD Section of this SOP.

F. Next, place sonde(s) horizontally (or vertically dependent on container) in cold-water bath. Ensure sonde(s) temperature sensor(s) are at equal depths. Note: Avoid overcrowding of sondes in the cold-water bath to reduce stratification for more stable temperature measurements.

G. Next, place NIST certified thermometer temperature sensor in the ice chest and ensure temperature sensor tip is at an equal depth as the sonde temperature sensors. See picture below for an example of sondes and thermometer sensor in cold-water bath. Note: The slightest offset (e.g., an inch or two) may make a difference in temperature readings (sonde(s) and thermometer) due to water stratification. Stratification of water may cause invalidation temperature verification.

H. After sondes(s) and the thermometer sensor are placed in the cold-water bath the lid of the ice chest should be closed and the ice chest should be placed into the walk-in refrigerator (if removed). Allow sensors to equilibrate with water in ice chest for at least 12 hours (or until equipment has equilibrated with water temperature) before moving to the next step. Note: Keeping the cooler lid shut and walk-in refrigerator door closed to help maintain stable temperatures and preserve the mechanical parts of the walk-in refrigerator from rusting.



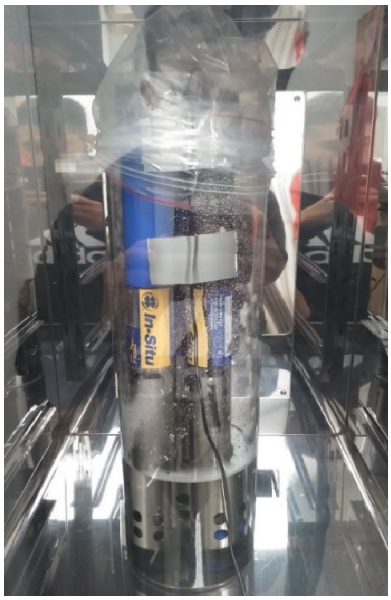
I. Next, record the temperature of the water displayed on the NIST thermometer at the same time interval (set in Step F) set for sondes(s) to collect data points on the Temperature Accuracy Check worksheet. Ensure at least 3 temperature measurements are recorded at least 5 minutes apart between 4-10 °C. The Fisherbrand ™ Traceable ™ Memory-Loc ™ datalogging thermometer can be set to record and store data at 5 minutes increments. For instructions on setting thermometer logging interval and data retrieval see the thermometer manual.

J. When complete with collection of the cold-water bath measurements, the sonde(s) and thermometer may be removed from cold-water bath and the steps below may be initiated.

K. Prepare a warm-water bath 35-40 °C for the 2nd-point of the temperature verification procedure. The warm-water bath temperature range is intended to bracket the highest temperature criterion established in 20.6.4 New Mexico Administrative Code (NMAC), which is currently 34 °C (NMAC 2023).

L. Typically, the SWQB will prepare the warm-water bath using warm-water from the tap and the incubator located in the SWQB laboratory of the Harold Runnels Building.

M. Prepare a warm-water bath by pouring warm-water from the tap into a container large enough to submerge sondes. The container must be placed into the incubator, so plan accordingly. Note: Shelves must be removed from the incubator.
N. The incubator temperature should be set to a temperature so that the water in the container can reach 35-40°C. Typically, the incubator temperature is set to 38-39°C to account for heat absorption.
O. Before the sonde(s) are submerged and deployed in the warm-water bath confirm metal back-end cap is securely fastened to help prevent water damage (See Step D).
P. Next, program sonde(s) to record at least three (3) temperature readings, each 5 minutes apart. When programing the sonde, one needs to account for the stabilization period (at least 12 hours or until equipment has equilibrated with water temperature). It is recommended the scheduled start and stop time feature be utilized for Aqua TROLL ® 600.
Q. After sonde(s) have been programmed, place sondes horizontally or vertically (dependent on container) in warm-water bath and place the thermometer temperature sensor tip at the same depth as sonde temperature probes and attempt to seal container. See picture below.
R. An improvised top/cap with a Ziplock® or trash bag can be used to enclose the sonde(s) in the warm-water bath placed in incubator. Enclosing the bath will reduce temperature fluctuations and stratification as well as prevent rusting the incubator. Below is a picture of the sonde warm-water bath setup. Allow at least 12 hours (or until equipment has equilibrated with water temperature) for water and sondes to stabilize before proceeding to the next step or until equipment has equilibrated with water.



S. Next, record the temperature of the water displayed on the NIST thermometer at the same time interval (set in Step P) set for sondes(s) to record data points on the Temperature Accuracy Check worksheet. Ensure at least 3 temperature measurements are recorded at least 5 minutes apart between 35-40 °C.
T. Next, offload data from sonde(s) and thermometer and store each temperature log in the appropriate Temperature QC folder for the current year located on NMED's internal server (i.e., SWQB\MASS\Monitoring Team\Monitoring Equipment\Temperature QC). See Sonde Data Upload Instructions in this SOP for details on how to transfer data off the sonde. See thermometer manual for instructions on how to offload data.

U. Review offloaded sonde temperature files and verify that the sonde collected at least 3 temperatures at the same time intervals as temperatures were recorded from the NIST traceable certified thermometer.

V. Compare data from the sonde and thermometer. All information is recorded on the Temperature Accuracy Check worksheet located on the NMED internal server.

   a. Record sonde number, temperature sensor serial number, thermometer serial number, temperature reporting error (if applicable), name of staff member conducting the temperature accuracy check, and test date.

   b. Record the low and high reference temperatures from the thermometer and the times they were collected. If the NIST certified thermometer has an associated temperature reporting error from when it was last certified, add or subtract the error to the documented temperature. For example, if the thermometer reads 5.8°C but the lab that checked the thermometer noted an error of -0.2°C, then the reported temperature should be 6.0°C, not 5.8°C. Record the low and high temperatures from the sonde and the times they were collected.

   c. Calculate and record the low/high temperature discrepancy between sonde temperature readings and reference temperatures. Verify that the sonde temperature is within ±0.5°C of the NIST traceable certified thermometer at the time of at least one logging interval following the stabilization period.

Any temperature sensors that fall outside the acceptable accuracy range in Table 4 should be returned to the manufacturer by the Sonde Coordinator. For procedures related to the data processing, refer to SWQB SOP 6.4 LTD Logger QA. For procedures related to the application of SWQB qualifier codes, refer to SWQB SOP 15.0 Data Verification and Validation.

Table 4. Accuracy Verification Criteria and Maximum Allowable Limits for Data Adjustment

Measurement	Standard	Standard Value	In-calibration Range	Linear Interpolation Range (Max Allowable Limits)
Temperature, °C	NIST Certified Thermometer	Ambient Temperature	± 0.5	± 2

9.0 Related Forms

- Sonde Calibration Worksheet
- Sonde Deployment/Retrieval Field Sheet
- Stream/River Field Data Form (see SOP 8.2)
- Long Term Data Management Spreadsheet (see SOP 6.4)
- Temperature Accuracy Worksheet

10.0 Revision History

Original modified from SOP 2007.

Revision 1. February 2012. updated to incorporate Hydrolab sondes.

Revision 2. February 2013. updated to incorporate Onset HOBO DO Loggers, updated Table 2 to current Calibration Range values. Directed "Sonde Data Manager" duties to the survey Project Coordinators
Jodey Kougioulis, QAO; Scott Murray, SME; Jeff Scarano, Program Manager MASS

Revision 3. February 2016. updated to include instructions for YSI V2 sondes, requirements for calibration verification bracketing, and maintenance documentation, formatted to SOP 1.1.
Jodey Kougioulis, QAO; Scott Murray, SME; James Hogan, Acting Program Manager MASS

Revision 4. January 2017. Updated to incorporate In-Situ sondes and HOBO Conductivity Loggers, added post check procedures and in-calibration range table, formatted to SOP 1.1 (2017).
Jennifer Fullam, Acting QAO; Chuck Dentino, SME; Kristopher Barrios, Program Manager MASS

Revision 5. October 2020. Removed references to YSI and Hydrolab sondes. Revised sonde calibration information and organization. Added barometric pressure and depth sensor calibration.
Miguel Montoya, QAO; Meredith Ziegler, SME; Kristopher Barrios, Program Manager MASS

Revision 6. February 2021. Revised content in letter E of the Temperature Accuracy Check Procedure due to a quality control issue in the example provided. The value +.02°C was changed to -0.2°C to make example true. Miguel Montoya, QAO; Meredith Ziegler, SME; Kristopher Barrios, Program Manager MASS

Revision 7. April 10, 2024. Removed Hobo data loggers (DO and specific conductivity) from SOP. Added clarity to the Temperature Accuracy Verification Procedure. Renumbered sections. Combined Sonde Deployment SOP with Sonde Calibration and Maintenance SOP. Also added procedure for removing data from the sonde and uploading into SWQB network server. Removed Subject Matter Expert (SME) requirement to approve SOP. Removed Sonde Manager (and Alternate) and replaced with Sonde Equipment Coordinator.
Miguel Montoya, Acting QAO; Lynette Guevara, Program Manager MASS

11.0 References

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