Standard Operating Procedures (1.1): Continuous Water Quality Monitoring – Data Sonde

March 2021

Prepared for the United States Environmental Protection Agency

The Bay Foundation
8334 Lincoln Blvd. #310, Los Angeles, CA 90045
(888) 301-2527
www.santamonicabay.org

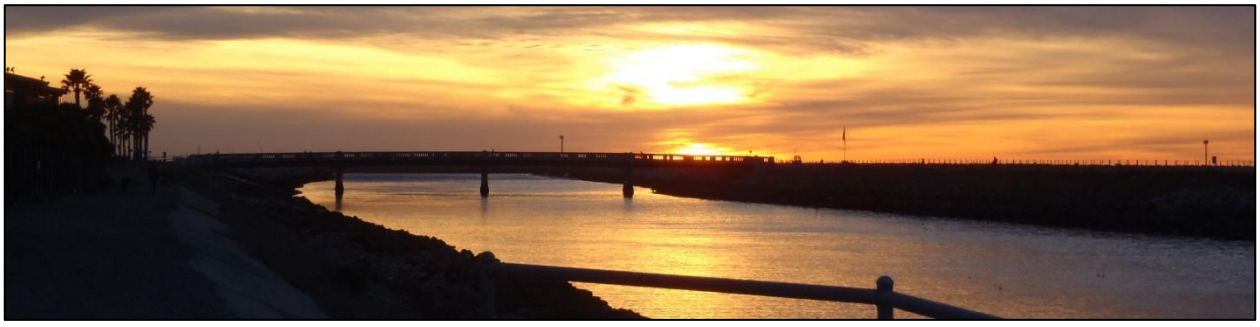
Standard Operating Procedures:
Continuous Water Quality Monitoring – Data Sonde

SOP Identification: SOP 1.1 Continuous Water Quality – Data Sonde
Date of Original Issue: 30 June 2015
Date of Last Revision: 23 March 2021
Developed by: Tijuana River National Estuarine Research Reserve / The Bay Foundation
Protocols reviewed by:

Jeff Crooks, Tijuana River National Estuarine Research Reserve
Kellie Uyeda, Tijuana River National Estuarine Research Reserve
Karina Johnston, The Bay Foundation
Sean Anderson, California State University, Channel Islands
Mark Page, Marine Science Institute, University of California, Santa Barbara
Holly Bellringer, Tijuana River National Estuarine Research Reserve
John Dorsey, Loyola Marymount University
Chris Enyart, The Bay Foundation

Suggested citation: TBF. 2021. Continuous Water Quality Monitoring – Data Sonde Standard Operating Procedures. Unpublished protocols. The Bay Foundation and Tijuana River National Estuarine Research Reserve. Los Angeles, CA.

Disclaimer: Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by contributing agencies.



Protocol Suitability Evaluation

A habitat suitability table containing appropriate estuarine wetland habitat types (of those evaluated) to implement continuous water quality monitoring protocols is displayed in Table 1. A comparative assessment of cost, effort, and data quality are shown in Table 2. A matrix of additional detailed categorical evaluations of continuous water quality monitoring can be found in Appendix 1.1A. For emergent salt marsh habitats, data sonde protocols are only applicable in areas (e.g., tidal channels) that allow for the sonde sensors to be continuously or frequently submerged.

Table 1. Appropriate habitat types for continuous water quality monitoring protocols.

	Habitat Types					
Survey Protocol	**Tidal Channel**	**Mud/sand flat**	**Emergent salt marsh**	**Non-tidal salt marsh**	**Salt pan**	**'Degraded' / fill**
General WQ Parameters	X	X	X			

Table 2. Categorical assessment of cost/effort and data quality for continuous water quality monitoring protocols.

	Evaluation Metric	General WQ Parameters	Notes
Time / Effort	Office Preparation Time	0-10 minutes	May involve printing maps and identifying site locations
	Equipment Construction Time (one time)	> 60 minutes	Involves constructing permanent sonde housing, if applicable, and the first calibration
	Field Time (per deployment)	30-60 minutes	Highly variable, depending on field location and access to site (hiking / boating); housing may require cleaning due to biofouling
	Laboratory Time (per deployment)	> 60 minutes	Monthly calibration and cleaning required (minimum)
	Post-Survey Processing / QAQC Time	> 60 minutes	Requires checking data against calibration standards and equipment specifications
	Minimum Repetition (site-dependent)	Few Repetitions	Usually, 1 permanent sonde in one or multiple locations
	Relative Cost (equipment and supplies)	Very High (> $10,000)	One-time fee plus recurring maintenance, new probes, and calibration standards
Survey / Data Quality	Accuracy (at a survey area level)	High	----
	Precision (at a survey area level)	High	----
	Qualitative-Quantitative Score	Quantitative	----
	Subjectivity-Objectivity Score	Objective	----

Resulting Data Types

The application of continuous water quality data sonde monitoring survey protocols will yield quantitative data for all measured parameters including pH, salinity, temperature, water depth, dissolved oxygen, turbidity, and chlorophyll (optional). These variables are displayed as discreet readings for each monitoring interval (e.g., every 15, 30, or 60 minutes). Resulting data are useful in the identification of trends over varying time scales (e.g., daily, seasonally, annually) and can be helpful in identifying the times, durations, and individual parameter variability during anomalous events such as

freshwater inputs or storm events, nutrient discharges, or algal blooms. If a site is telemetered (i.e., automatic transmission to receiving equipment), results can be viewed in near real-time.

Objective

Water quality measurements may be used as indicators of both human health concerns and the overall chemical, physical, and biological conditions of a site (Johnston et al. 2012). Variations in water quality affect the biota and physical properties of wetlands, including vegetation, ichthyofauna, benthic and pelagic invertebrates, salinity profiles, and anoxic conditions.

Water quality probes are used to measure water parameters in continuous monitoring mode by collecting data at user-defined intervals and storing those data until downloaded at discrete intervals. Water quality multi-probes can be deployed continuously at monitoring stations to characterize parameters over multiple tidal cycles, through freshwater-input events, or over longer periods of time. The number and spatial distribution of monitoring stations depends upon restoration and monitoring objectives and site-specific considerations. The primary objective of this SOP describes a single multi-probe deployed within a primary channel in an estuary or smaller tidal channel to identify the overall general water quality condition of that area and identify gross problematic events (e.g., periods of low dissolved oxygen).

A variety of options are now available for long-term monitoring with dataloggers. Due to the different maintenance requirements of various water quality multi-probe sondes, general guidelines are presented below. General principles should apply reasonably well to most multi-probe sondes, but details will vary with sonde make and model. A focus on the YSI EXO multi-probe is provided (Figure 1), as this model has received extensive consideration as part of the NOAA National Estuarine Research Reserve (NERR) System-Wide Monitoring Program (nerrsdata.org). Other sondes are available (e.g., OTT Hydrolab DS5X). Additionally, multi-probe sondes may be upgraded or replaced over time, especially for long-term monitoring programs. Documentation of dataloggers including model and specifications should be recorded and included in metadata.

Figure 1. YSI EXO sonde (credit: YSI).

Water Quality Parameters

Water quality parameters identified in this SOP include:

- Temperature, salinity, conductivity, dissolved oxygen, depth, pH, turbidity, and chlorophyll (additional optional parameters include oxidation-reduction potential, blue-green algae, ammonium, nitrate, and chloride)

Installation

Methods for sonde deployment will vary by site. Considerations include (modified from USGS 2012, see also nerrsdata.org):

1. Sampling intent (e.g., capturing hypoxic events)
2. Sonde location (e.g., river, tidal channel, or subtidal habitat)
3. Method of access (e.g., boat on high tide vs. wading on low tide)
4. Substrate type (soft substrates may require additional reinforcements)
5. Potential threats to instrument (e.g., biofouling, logs, *Ulva sp.*, boats, vandalism)

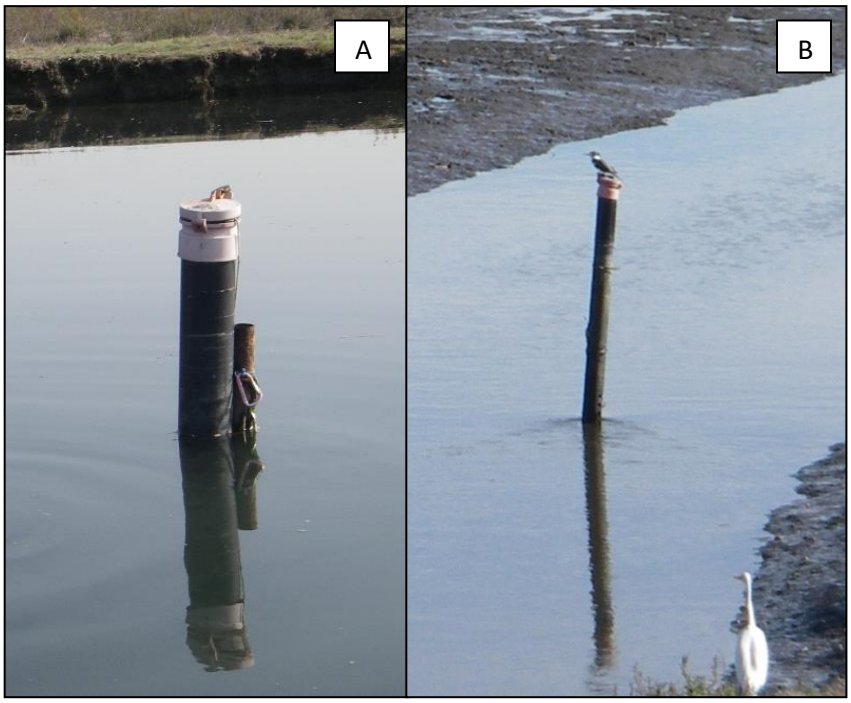


Figure 2. Installed YSI 6600 V2 multi-probe with PVC housing at differing tide heights: (A) high tide, (B) low tide.

For most purposes, installation includes driving a post (stake or PVC) into the substrate to which the sonde housing (PVC tube) is attached. Where available, sondes also can be attached to existing infrastructure such as pier pilings. Sondes should be placed inside a PVC (or ABS) tube, which should have larger holes cut into the sides and bottom of the tube to allow natural water movement on and around the probes. This tube acts as protection for the sonde and as a stilling well.

The elevation of the depth sensor on the sonde body in the field should be measured using surveying equipment or RTK GPS so that water depth data can be converted from relative depth to elevation (relative to a geodetic datum such as NAVD88). It is critical that the probe be returned to the same location after each sonde calibration to help ensure the accuracy of the depth / elevation conversion, and sonde elevation should be re-surveyed periodically (e.g., annually or following a major event).

Helpful hint: Cutting small holes in the bottom of the housing may reduce sedimentation in the housing. Additionally, if subject to tampering, a locking mechanism is recommended for the housing.

Methods

These SOPs are based on those developed by the NERR system and are available at the Centralized Data Management Office website (nerrsdata.org). They will be briefly summarized

below. While the following SOPs are specific to EXO sondes, other model sondes will have similar operating procedures. Always refer to the sonde manufacturer instructions and tutorials when operating sondes and for detailed calibration and download information (e.g., for YSI EXO: https://www.ysi.com/file%20library/documents/manuals/exo-user-manual-web.pdf).

Programming and Calibration

Communication with the EXO sonde is conducted with KORS software, a copy of which is provided with each EXO on a USB thumb drive. This software is used for EXO calibration, post-deployment readings, data file download, sonde/probe firmware updates, and any other necessary interaction with the sonde via a PC. Communication with the sonde and a laptop (running Windows) can occur either through a cabled connection or Bluetooth.

The probe should be calibrated before the initial deployment and post-checked after retrieval, or approximately every two to four weeks (although longer deployments are possible with the EXO sonde, depending on site characteristics such as degree of fouling). Detailed calibration instructions for each parameter are provided at nerrsdata.org, but some general considerations and recommendations include the following:

1. Good laboratory practices should always be followed when handling calibration standards. Please refer to MSDS sheets for any standard when necessary.
2. A **Calibration Log** and **Field Log** should be completed for each instrument's calibration, deployment and retrieval, and post-calibration (see Appendix 1.1B).
3. The sonde should be visually inspected for any abnormalities, such as a broken probe or damaged bulkhead.
4. Remove the wiper brush from the sonde, as the brush can trap residual standard and affect the calibration accuracy.
5. Calibrations are best performed using a guard and calibration cup that are dedicated to calibration only and never taken in the field. This ensures a high level of cleanliness and non-contamination during the calibration process.
6. During the calibration of the probes **NEVER** accept any calibrations that display an error message. Troubleshoot the cause of the problem, correct it, and recalibrate or replace the probe before deploying the instrument.
7. Standards must be active (check expiration date) and fresh for all calibrations. Previously used, clean standards may be used to rinse probes but must not be used to calibrate probes. Discard and replace all expired standards.
8. All diagnostic parameters (pH millivolts, DO gain, and conductivity cell constant) for EXO sondes are presented after calibration of the respective parameter on the KORS generated calibration sheet and should be recorded on the data sheet once calibration of those probes is complete.
9. Recommended probe calibration order: Temperature (not a true calibration, but a check against NIST source), Specific Conductivity, pH, Depth, Turbidity, Dissolved Oxygen.

10. Prior to calibration it is a good idea to record serial number for the sonde and probe on in the Calibration Log's "Datasonde & Probe Identification Numbers" section.
11. Batch calibrations are possible, where multiple versions of the same probe type are installed into an EXO sonde and calibrated one after the other. Once calibrated in this fashion, which can reduce costs associated with calibration solutions, the probes are then installed into their respective EXO sondes.

Deployment

1. For sonde transportation, it is best to use a cooler where the sondes can rest horizontally. A tap-water-soaked white towel must be wrapped around each sonde. This is to be done during both deployment and upon retrieval. The wet towels reduce shock and vibration damage and ensure a saturated environment for the oxygen probe during transport. Alternately, keep the calibration cup with a small amount of water fixed on the sonde during transfer. Towels or other soft materials will keep the sonde from vibration damage. Probes should not be submerged during short- or long-term storage for any substantial length of time.
2. Independent, paired field data readings are suggested at all sonde retrievals / deployments. Ideally, use a hand-held meter, Winkler titration, or other properly calibrated instrument to collect this data alongside the deployed sonde for its last reading and the newly deployed sonde for its first reading. At a minimum, take an independent paired reading with the freshly calibrated sonde against the deployed sonde before replacing. Record the data from the independent instrument in the Field Log with one log following each sonde through its deployment.

Retrieval

1. Retrieve the sonde from the water and visually examine it and the probes for fouling and/or damage. Note any fouling type and amount in the "Fouling Presence" section of the Field Log; however, **DO NOT** remove fouling, so that true post-deployment readings may be obtained.
2. Record field data on the data sheets.
3. Wrap the EXO sonde in a tap-water saturated white towel, and place in a secure container (e.g., a cooler) to prevent severe vibrations to the EXO sonde during transportation. Alternately, replace the sensor guard with a calibration cup with a small amount of DI water. Secure in a similar manner as above with towels or soft materials.

Data Download and Post-Deployment Readings

1. Post Deployment Calibration Checks – These checks note any changes or drift of the probe during deployment combined with effects of biofouling. This process is critical not only for data QAQC, but also for data users to know if the data were affected by biofouling, wear and tear, or other issues. Ideally these checks will take place within 24 hours of sonde retrieval. If not, it is critical to make a visual inspection of the conductivity cells and note, either photographically or via notes, any visible fouling to document related drift. Bubbles and saturated water bath currents may dislodge material and significantly impact drift. Batch calibration is NOT suggested

during post-deployment readings, since it is important to take these readings with the sonde remaining in a condition similar to what it was while deployed in the field.

2. Data Download – Place the sonde into a bucket of clean water that has been aerated for at least 60 minutes to create a 100% air saturated water bath. Allow the sonde ample time to reach temperature equilibration prior to beginning the download and post-deployment readings procedures.

Probe Care and Storage

1. Most of the probes, except Conductivity, have a limited shelf life, so do not purchase replacements too far in advance. The procedure for storage of probes is different for short-term (1 month or less) and long-term (greater than 1 month).
2. For short term storage, it is important to keep the probes moist but not immersed in water. Keep probes attached to the EXO sonde and place the sonde in approximately 0.5 in of tap water (not distilled) in the sealed EXO calibration cup.
3. Long-term Storage – Clean conductivity sensors and store them either dry or wet. If they are in contact with solution, it should not be corrosive. The pH probe should be removed from the EXO sonde if storage will exceed 30 days and stored in the pH storage cup (the one it was shipped in) containing 1 molar KCL or pH 4 buffer. Dissolved Oxygen probes should be stored in a water-saturated air environment (attached to the sonde with a small amount of water in the calibration cup to maintain humidity) to avoid the need for a 12-hour membrane rehydration at a later date (the probe can be stored dry, but if done so it must be re-hydrated in saturated water for a 12 hour period). No special precautions are necessary for the Depth sensor.
4. Remove the brush from the wiper probe and store dry (make sure it is clean and dries in original shape – no gaps or forks in the bristles). The wiper itself can be stored in a humid environment or dry environment.
5. Remover copper tape applied directly to the sensors prior to long-term storage to prevent the glue from hardening and becoming difficult to remove. Copper tape can remain in place if a protective barrier is applied underneath like packing tape or YSI clear anti-fouling sleeve.
6. Remove batteries prior to storage greater than 30 days. The battery compartment and compartment cap should be cleaned thoroughly and re-greased prior to storage.
7. Clean and re-grease the two sonde connectors (located at the top of the sonde) and place connector caps on both.
8. Plug ports of any missing sensors.

QAQC Procedures

Quality Assurance and Quality Control (QAQC) procedures should be conducted on all data. Detailed data management procedures are available at nerrsdata.org. Also, the NERRS Centralized Data Management Office (CDMO) has a free upload service that allows users to upload raw water quality data files (collected using NERR System-Wide Monitoring Program or similar protocols) for automated QC and formatting. The returned files may be used with the NERR QAQC macro for further automated coding and error checking, editing using the CDMO's flagging / coding system, automated graphing, and

summary statistics. This is available at: http://cdmo.baruch.sc.edu/nonswmp/. Some considerations related to QAQC are:

1. Always archive the data. Backup and archive on a regular basis to ensure there will be no data loss. Third party software can be purchased to accomplish this. Archive the raw .DAT and raw .BIN data files from the data sonde as they are retrieved.
2. Record in local Standard Time **NOT** Daylight Savings Time. Set the clocks on your instruments and the computers that interface with them to Standard Time and DO NOT adjust them to Daylight Savings. Try to get in the habit of recording the time off your watch in Standard Time as well.
3. If the temperature sensor fails on a YSI EXO sonde, all data except turbidity will need to be rejected. In the event of such severe failure of the EXO CT probe that the sonde powers it down, DO%, pH, and ChlFluor data may not need to be rejected if they pass other quality control checks.
4. If the conductivity sensor malfunctions or is poorly calibrated then salinity, specific conductivity, DO mg/L (DO concentration) and depth will need to be rejected.
5. Poor calibrations or sensor malfunctions are evident when plotting appended files for multiple deployments, i.e., monthly, seasonal and yearly files.
6. Negative temperature, depth, and turbidity data: The ONLY potentially acceptable negative data are from the temperature, depth or turbidity probes. All other negative data must be rejected.
7. Do not remove data values from the dataset under any circumstances, except for the removal of pre- and post-deployment records.

Data Analyses

After corrections have been made, data may be used in multiple analyses. Examples include graphing the data over time, grouping the data by hour or day to look at broader trends over time, correlating variables, pinpointing events such as the frequency of freshwater inputs, and analyzing percent time against a threshold (e.g., percent time of dissolved oxygen below 1 mg/L).

Health and Safety Precautions

Sharp mollusks are often present within the substrate surrounding the sonde housing and on sondes that have been deployed for an extended period. Appropriate foot protection (e.g., neoprene dive / surf booties with a thick sole, if not collecting by boat) and hand protection (e.g., neoprene gloves) should be worn when wading and handling the sonde. Occasionally, an animal such as a crab or octopus may be inside the housing or sonde.

References and Applicable Literature

Johnston, K.K., E. Del Giudice-Tuttle, I.D. Medel, C. Piechowski, D.S. Cooper, J. Dorsey, and S. Anderson. 2012. "The Ballona Wetlands Ecological Reserve Baseline Assessment Program: 2010-2011 Report." Santa Monica Bay Restoration Commission. Report Prepared for the California State Coastal Conservancy, Los Angeles, California. 215 pp.

US Environmental Protection Agency, Office of Water. 2010. "National Coastal Condition Assessment: Field Operations Manual". Washington, D.C. EPA-841-R-09-003.

US Geological Survey. 2012. Water quality Continuous Standard Operating Procedures. Unpublished protocols. USGS, Western Ecological Research Center, San Francisco Bay Estuary Field Station, Vallejo, CA.

US Geological Survey. 2012. Water level Continuous Standard Operating Procedures. Unpublished protocols. USGS, Western Ecological Research Center, San Francisco Bay Estuary Field Station, Vallejo, CA.

Zedler, J.B., ed. 2001. *Handbook for Restoring Tidal Wetlands.* Baton Rouge*:* CRC Press.

Xylem Instrumentation. 2013. "YSI 6-Series Multi-Parameter Water Quality Monitoring Standard Operating Procedure." *National Estuarine Research Reserve System-Wide Monitoring Program (SWMP)*. Version 4.3.

Contact Information

Karina Johnston, The Bay Foundation
kjohnston@santamonicabay.org

APPENDIX 1.1A

	Evaluation Metric	General WQ Parameters	Notes
	Correlation to L2 CRAM	Attribute 1 & 2	----
Personnel Requirements	Specialty Equipment or Clothing Required	Many Specialty Items	Data sonde plus handheld reading device or laptop; calibration standards
	Ease of Transport (amount or weight of supplies)	Few Items / Easy	Can be heavy
	Ease of Implementation	Moderate	Sonde often needs troubleshooting, depending on the model
	Expertise / Skill Level	Some Technical Knowledge	Familiarity with the manual is needed
	Number of Personnel	1	----
	Training Requirements	Yes	Familiarity with the manual is needed; "How To" YouTube videos available
	Seasonality of Survey Time	Continuous	----
	Suggested Frequency	Continuous	15-30 minute intervals are recommended
Survey / Data Quality	Type of Output	Numerical	----
	Active or Passive Monitoring Style	Passive	----
	Specialty Computer Software Required	Yes	----
	Availability of Online / External Resources	Many	Extensive manuals, videos, and suggested use documents
Potential Limitations	Wetland Type Applicability	All	Must be submerged in water for all or part time
	Images or Multi-Media Required	None required	----
	Degree of Impact / Disturbance	Low Disturbance	Sonde housings must be anchored in ground
	Vegetation Height Limitation	Not Applicable	----
	Appropriate for Tidal / Wet Habitats	Yes	Yes
	Tide Height	All tides	All tides
	Regional or Broad Implementation *	Almost always used	----
	Potential for Hazards / Risk	Low to No Risk	----
	Restrictions	None	----

** based on monitoring literature review*

APPENDIX 1.1B

CALIBRATION WORK SHEET

Date of Calibration: _____ Sonde ID: _____

Technician: _____

RP DO membrane changed? Y N

RP DO membrane o-ring changed? Y N

Note: Wait 3 to 6 hours before calibrating for unattended deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)

Turbidity wiper changed? Y N Chlorophyll wiper changed? Y N

ROX DO wiper changed? Y N BGA-PE wiper changed? Y N

BGA-PC wiper changed? Y N Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant _____ Range 5.0 ± .45

Integrated conductivity cell constant_____ Range 5.0 ± .70

pH mv Buffer 7 _____ Range 0 ± 50 mv

pH mv Buffer 4 _____ Range +180 ± 50 mv*

pH mv Buffer 10 _____ Range -180 ± 50 mv *

***Note:** Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv

Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv

DO charge (RP only) _____ Range 25 to 75

DO gain _____ Range 0.7 to 1.4

ODO gain _____ Range 0.85 to 1.15

Turbidity standard used in calibration _____

Manufacturer and part number _____

Barometric Pressure: _____mmHg

DO % Calculated – (BARO mmHg divided by 7.6) = % saturation

Example: 760 ÷ 7.6 = 100.0%

Record Calibration Values	Standard	Pre Cal / Post Cal
Temperature	_____	____Sonde
Conductivity	_____	____/____
pH 7	_____	____/____
pH 4	_____	____/____
pH 10	_____	____/____
ORP	_____	____/____
Turbidity	_____	____/____
Turbidity	_____	____/____
Turbidity 0.5	_____	____/____
Chlorophyll	_____	____/____
Chlorophyll	_____	____/____
DO RP	_____	____/____
DO ROX	_____	____/____
BGA PE/PC	_____	____/____
BGA PE/PC	_____	____/____
Rhodamine	_____	____/____

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____mmHg

Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg

Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig ± 0.15 _____

Notes:

Modified from Xylem instrumentation, 2013.

Appendix 1.1C

Symptoms	Probable Cause	Action
Data set collected is incomplete (stopped logging prior to pick-up)	Batteries died during unattended sample	1. Check battery voltage of sonde during calibration. The voltage should roughly equate to the voltage of each individual battery x the total number of batteries) 2. Make sure the 650 Handheld is not powering the sonde (System Menu: "Power Sonde" checked-off) during the setup for deployment
	Auto sleep functions were not set to off	1. If the auto sleep functions are set to "Off" they will draw battery power between samples, using the batteries up quicker – Check battery volt output records to detect usage rates
No data recorded during an unattended sample	Batteries were dead before deployment	1. Check battery voltage of sonde during calibration. The voltage should mirror the voltage of each individual battery times the total number of batteries) 2. Make sure the 650 Handheld is not powering the sonde (System Menu: "Power Sonde" checked-off)
	Sonde and handheld were connected during the first reading during the unattended sample	1. It is common practice to wait and observe the first reading before unattended deployment. However the 650 Handheld needs to be disconnected from the sonde prior to the first sample. This will allow the data to be stored in the bulkhead versus the 650 handheld
650 Handheld will not connect with Sonde	There may be water, or other debris, disturbing the connection	1. Use a Q-tip and blot dry the Sonde Connector as well as the connector on the Field Cable. You may also use compressed air to rid the connection of water and other debris
	Data Sonde batteries are dead	1. If this is the case, you want to change your 650 Handheld settings, and check-on the "Power Sonde" option in the System Menu. This will power your sonde in order to upload the data. New batteries will be required for future deployment
New pH probe installed is not reading accurately (calibrating correctly)	"Shipping residue" has clouded the bulb	1. Soak probe in pH 4 standard for 3 - 45 minutes
	Defective probe	1. Return back to YSI (make sure they pay for the 1 day shipping to and from)

For additional troubleshooting tips see here: http://www.ysi.com/media/pdfs/YSI-Calibration-Maintenance-Troubleshooting-Tips-6-Series-Sondes-2-8-10.pdf

Data set is missing parameters (probes not recording)	The specific probe has been disabled	1. Access handheld and enable probe
	The new probe has never been activated/enabled	1. Go in and enable/activate probe (the Sonde will not automatically enable a new probe, it needs to be told to activate said probe and what units to record in)
	The probe has not been set to record	2. Access handheld and set probe to record
Optical DO Probe not calibrating correctly	The DO Membrane has become bio-fouled	1. Replace DO Membrane (roughly $150.00)
Bio-fouling on the bulb of the pH probe	Biologic reasons	1. Soak in 1 mol of Hydrochloric Acid for 30 minutes. Do not attempt to clean bulb with tools (Q-tip, sponge, pipe cleaner, etc.)
Error message "Date/Time" not set when setting probe to "Unattended Sample"	Date/Time needs to be reset	1. Access sonde "System" menu and set correct Date/ Time 2. If Date/ Time is correct, change Time by 1 second

For additional troubleshooting tips see here: http://www.ysi.com/media/pdfs/YSI-Calibration-Maintenance-Troubleshooting-Tips-6-Series-Sondes-2-8-10.pdf

APPENDIX 1.1D

Parameter	Range	Resolution	Accuracy
Optical Dissolved Oxygen	0 to 500%	0.1%	0 to 200%: ±1% of reading or 1% air saturation, whichever is greater; 200 to 500%: ±15% of reading
Conductivity 6560 Sensor*	0 to 100 mS/cm	0.001 to 0.1 mS/cm (range dependent)	±0.5% of reading + 0.001 mS/cm
Salinity	0 to 70 ppt	0.01 ppt	±1% of reading or 0.1 ppt, whichever is greater
pH 6561 Sensor*	to 14 units	0.01 unit	±0.2 unit
Turbidity 6136 Sensor*	0 to 1,000 NTU	0.1 NTU	±2% of reading or 0.3 NTU, whichever is greater**
Depth	Deep: to 656 ft, 200 m Medium: 0 to 200 ft, 61 m Shallow: 0 to 30 ft, 9.1 m Vented Level: 0 to 30 ft, 9.1 m	0.001 ft, 0.001 m 0.001 ft, 0.001 m 0.001 ft, 0.001 m 0.001 ft, 0.001 m	±1 ft, ±0.3 m ±0.4 ft, ±0.12 m ±0.06 ft, ±0.02 m ±0.01 ft, 0.003 m

Specifications for YSI 6600 series sonde probes modified from Xylem instrumentation, 2013.