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Office of Water Resources
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TITLE AND APPROVAL PAGE

Standard Operating Procedure for the Measurement of Dissolved Oxygen, Temperature, Specific Conductance, and Salinity Using a Handheld YSI Model Pro2030 Instrument

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1.0 APPLICABILITY

This SOP provides instruction in routine calibration and operation of a Handheld YSI Model Pro2030 Instrument (YSI 2030) to collect environmental monitoring data on behalf of the Office of Water Resource (OWR) at the Rhode Island Department of Environmental Management (RIDEM). Exemptions from the use of this SOP for project work shall be allowed for reasons determined by management discretion.

2.0 PURPOSE

This SOP establishes a standardized method for performing water quality measurements in the field using a YSI 2030. The YSI 2030 instrument is used to analyze water in situ for dissolved oxygen, conductivity, specific conductance, temperature, and salinity. It sets a consistent protocol to ensure the quality of RIDEM's data collection, which results in improved uniformity, reproducibility, verifiability, and defensibility of the data, as well as increased program credibility. This document describes the RIDEM OWR procedure for calibrating and maintaining the YSI 2030 instrument, details how measurements should be taken, and how data should be recorded.

3.0 DEFINITIONS

Accuracy	The degree of agreement between a measured value and the accepted standard or reference value.
Calibration	A procedure used to establish a relationship between the value measured by the YSI 2030 meter (number the device reads) and the actual value of a traceable standard. This process ensures that the YSI 2030 takes an accurate measurement within the specified limits.
Conductivity	The measurement of the ability of a liquid to conduct electricity without regard to temperature. This value is generally due to the presence of dissolved ions (higher concentrations will conduct more electricity). Units for this value are typically micro-siemens per centimeter (µS/cm).
OWR	RIDEM Office of Water Resources
Precision	The degree of agreement between repeated measurements (duplicates).

QA (Quality Assurance) Systematic processes used to ensure RIDEM OWR produces valuable, accurate, reliable, reproducible, and defensible environmental data.

QAPP (Quality Assurance Project Plan) The document that describes the processes and procedures that are used to ensure RIDEM OWR produces valuable, accurate, reliable, reproducible, and defensible environmental data.

QC (Quality Control) Activities performed to produce valuable, accurate, reliable, reproducible, and defensible environmental data.

QI (Quality Improvement) Any act or process performed to enhance the value, accuracy, reliability, reproducibility, or defensibility of environmental data collected by RIDEM OWR.

Relative Percent Difference (RPD) The absolute value of the difference of two values divided by the average of those two values.

RIDEM Rhode Island Department of Environmental Management

Specific Conductance The measurement of the ability of a liquid to conduct electricity at a certain temperature corrected to 25 degrees Celsius. This allows direct comparison of measurements taken at different temperatures. This value is generally due to the presence of dissolved ions (higher concentrations conduct more electricity). Units for this value are micro-siemens per centimeter (µS/cm) at 25 degrees Celsius.

Sampling Center The room located on the first floor of the RIDEM offices at 235 Promenade St. Providence, Rhode Island. This room is used for OWR storage of field equipment, calibration of field meters, and other field preparation activities (Figure 1).

SOP Standard Operating Procedure

Verification A process used to document and assure the accuracy and consistency of the YSI 2030 instrument by comparing a value measured by the YSI 2030 to a traceable standard measurement. The instrument is considered accurate and consistent if the measured value falls within a specified acceptable range of the traceable standard.

YSI 2030 Handheld	YSI Model 2030 Instrument used to measure dissolved oxygen, temperature, conductivity, specific conductance, and salinity.

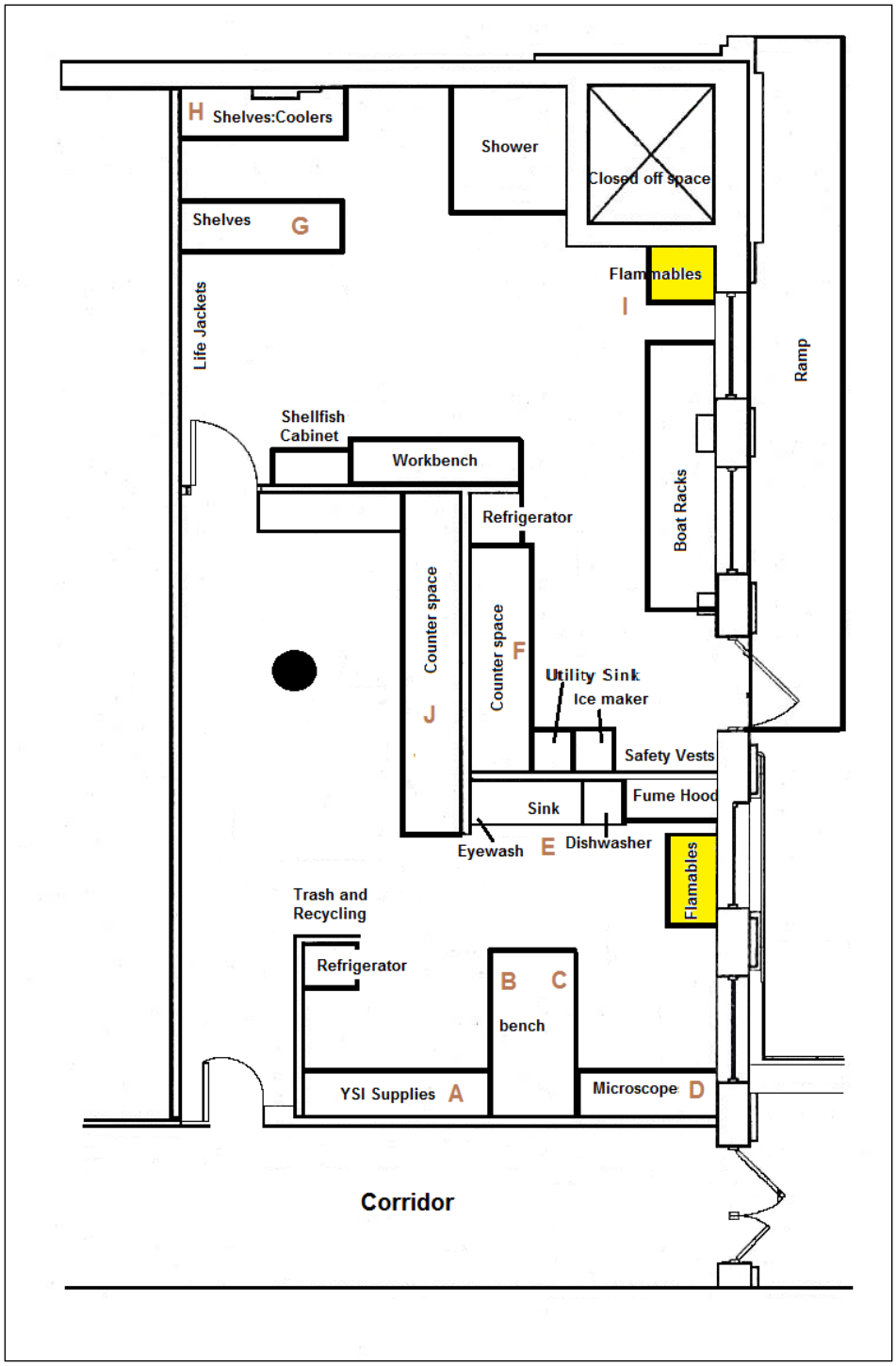


Figure 1 Sampling Center Layout.

4.0 RESPONSIBILITIES

4.1 Training

RIDEM/OWR staff operating the YSI 2030 to collect data for a RIDEM project or program should complete RIDEM's Quality System Awareness Training Program with appropriate documentation from the Quality Assurance Manager. This training ensures that staff recognize the importance of proper data collection and management and comprehends the significance of the environmental decisions that may be made with the data. It is suggested that analysts also complete the USEPA Water Quality Standards Academy Basic Course and Supplemental Topic Modules either online or on location. To properly operate the YSI 2030, the analyst must be familiar and comply with the calibration and measurement techniques stated in this SOP. Any field analyst not familiar with the operation of the YSI 2030 should be assisted by OWR staff who are accustomed to using the instrument.

4.2 Responsibilities of Analyst

The analyst is responsible for verifying that the YSI 2030 is in proper operating condition prior to use and for maintaining it in proper working order. The analyst is responsible for calibrating the instrument in the sampling center at the beginning of the sampling event before taking measurements in the field and for conducting post-sampling verification or quality checks at the end of the day, after the last measurement, in accordance with Section 6.2.5. The analyst is accountable for employing proper measurement procedures and data recording in accordance with Section 6.5. When indicated on the calibration log sheet in the YSI 2030 Meters Maintenance Records and Logbook, the analyst must comply with QA/QC requirements (Section 5.0) and verify the system calibration. When necessary, the analyst should change the batteries and membrane cap (Section 6.1.5 and Section 6.1.6).

4.3 Responsibilities of the Project or Program Manager

The project or program manager is responsible for providing the materials, resources, and/or guidance necessary to perform the calibration and measurements in accordance with this SOP. The project or program manager is responsible for ensuring that the analyst operates the YSI 2030 correctly. The project or program manager is responsible for ensuring that the YSI 2030 is maintained in proper operating condition. This includes ensuring that the membrane cap and batteries are changed at appropriate times, the system calibration is verified, the instrument is sent out for service when necessary, and that any additional project-specific requirements are communicated to the project team. Further, the project or program manager will ensure annual review and periodic revisions to this SOP to reflect current needs and standards and will renew this document every five years.

5.0 QUALITY CONTROL

5.1 Quality Assurance Planning Considerations

Quality assurance requirements are largely based on the end use of the data. Specific project data quality needs should be addressed in project plans to ensure that data of acceptable quality is being collected. Unless specified otherwise in a site or project-specific workplan or Quality Assurance Project Plan (QAPP), all data collected following the protocols set forth in this document will be done in accordance with the minimum QA/QC requirements detailed in Section 5.0. Further quality assurance requirements will be defined in project specific work plans and/or QAPPs and may include duplicate or replicate measurements or confirmatory analyses.

5.2 Calibration and Verification of Field Parameters

The acceptance criteria for the calibration of the YSI 2030 is stated below.

Table 1 Acceptance Criteria for YSI 2030 Parameters

Parameter	Acceptance Criteria
Dissolved Oxygen	±0.5 mg/L
Specific Conductance	±5 micro-Siemen per centimeter
Temperature	Temperature calibration is not required nor is it available.

5.2.1 Dissolved Oxygen Calibration and Verification

The solubility of oxygen varies under differing environmental conditions (i.e., barometric pressure, temperature, and salinity). Calibrating the YSI 2030 establishes a relationship between the actual value of a traceable standard and value reported by the instrument. Calibrations enable YSI 2030 to take an accurate measurement within the specified limits of the instrument. Calibration of dissolved oxygen will be done according to the procedures detailed in Section 6.2. Dissolved oxygen calibration is required at the beginning of each sampling day. The meter should be left on throughout the day once it has been calibrated with a post-sampling data check (i.e., verification) performed after the last field measurement at the end of the day in the Sampling Center. If the end of the day post-check fails, values of dissolved oxygen collected that day are questionable, and field sheets and database entries should be flagged.

5.2.2 Specific Conductance Verification

The verification process for specific conductance is used to document and assure the accuracy and consistency of the YSI 2030 instrument by comparing the specific conductance readings to a traceable standard. The instrument is considered accurate and consistent if the measured value falls within a specified acceptable range of the traceable standard. Specific conductance will be verified according to the procedures detailed in Section 6.3 at a frequency of once per month during the field season. If

verification measurements for specific conductance fail to meet acceptance criteria, any measurements taken since the last successful verification must be flagged as having a faulty reading in all field sheets and databases. Additionally, the meter should be calibrated as described in Sections 6.3.3.

5.2.3 Temperature Verification

The verification process for temperature is used to document and assure the accuracy and consistency of the YSI 2030 instrument by comparing the temperature readings to a National Institute of Standards and Technology (NIST) traceable thermometer. The instrument is considered accurate and consistent if the measured value falls within a specified acceptable range of the traceable thermometer. One-point temperature verifications will be performed according to the procedures detailed in Section 6.4 at a frequency of once per month during the sampling season. If verification measurements for temperature fail to meet acceptance criteria, any measurements taken since the last successful verification must be flagged as having a faulty reading in all field sheets and databases. Since specific conductance and dissolved oxygen measurements are temperature-compensated, these parameters must also be flagged.

5.3 Duplicate Measurements

Duplicate measurements to quantify measurement precision (reproducibility) will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should have a Relative Percent Difference (RPD) of less than ten percent, unless field conditions are such that the analyst would expect larger differences in the data. Examples of such conditions can include storm or snowmelt events, spills or other accidental releases of contaminants, or presence of wildlife.

Relative Percent Difference (RPD) should be calculated as follows:

$RPD = 100 \times ((|P_{Sample\ A} - P_{Sample\ B}|) / (AVG))$

Where:

P = given parameter (dissolved oxygen, specific conductance, etc.)

AVG = arithmetic mean of parameter values for sample A and B.

5.4 Performance Problems

If there are any performance problems with the YSI 2030 meter that result in an inability to achieve the acceptance criteria presented in Section 6.2 through Section 6.5, consult the appropriate section of the meter instruction manual (YSI 2010) for the self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further information (for repairs, see section 6.3.4).

6.0 GUIDELINES AND PROCEDURES

The following guidelines and procedures should be followed for the proper use of the YSI 2030 handheld water quality meter.

6.1 Proper Maintenance of YSI 2030

Instrument, probe, battery, and dissolved oxygen membrane maintenance should be performed according to the procedures and frequencies required by the manufacturer (at minimum).

6.1.1 Required Materials (Office)

The following materials are necessary to perform routine maintenance required in the office:

- YSI Model Pro2030 meter (Figure 1 at A)
- YSI Model Pro2030 manufacturer's instruction manual (Figure 1 at A)
- Lint-free tissues (Figure 1 at A)
- Specific conductance standards (Figure 1 at A)
- NIST traceable thermometer (Figure 1 at A)
- De-ionized or distilled water
- Conductivity probe cleaning solution (Figure 1 at E)
- 1:1 isopropyl alcohol and 10N HCl (Figure 1 at E)
- Nylon brush (Figure 1 at E)
- YSI 2030 replacement membrane cap kit: part #YSI 5906 (Figure 1 at A)
- YSI 5238 probe reconditioning kit (Figure 1 at A)
- Krytox Grease (Figure 1 at A)

6.1.2 Required Materials (Field)

The following materials are necessary to perform routine maintenance required for use in the field.

- YSI 2030 Field Data Collection sheet (Datasheet 1)
- Two alkaline C-Cell Batteries (Figure 1 at A)
- YSI 2030 maintenance records and log book (Figure 1 at A)

6.1.3 Cleaning and Storage of the Dissolved Oxygen Probe

Cleaning of the probe will typically take place when the membrane cap is replaced. Section 6.1.6 details instructions on replacing the membrane cap. Short term storage of the probe should be in the grey calibration sleeve (storage sleeve) with a small piece of wet sponge to keep the electrolyte from drying out. Sponges should be replaced regularly to avoid fouling. If the electrolytic cell (located inside the membrane cap) begins to tarnish or turn black, lightly buff the surface with wet sandpaper from the YSI

5238 Probe Reconditioning Kit, or 400 grit wet/dry sandpaper. This procedure should remove any oxidation.

6.1.4 Cleaning and Storage of the Specific Conductance Probe

Accurate and reproducible results in conductivity measurement is dependent on the cleanliness of the conductivity cell. The conductivity cell should be rinsed with clean water after each use. If the cell becomes fouled, insert the small cleaning brush that is included with the Maintenance Kit into the conductivity holes 10 to 12 times. If deposits have formed, use a mild detergent (laboratory grade soap or bathroom foaming tile cleaner) with the brush. Rinse thoroughly.

6.1.5 Changing the Batteries of the YSI 2030

Avoid changing the YSI 2030 batteries in the field by changing the batteries when the low battery light comes on or by checking the battery voltage periodically. The instrument should be calibrated after the batteries are changed (see Section 6.2).

Figure 2 YSI 2030 Battery Compartment shown with Batteries.

6.1.6 Changing the Dissolved Oxygen Membrane Cap

Dissolved Oxygen membranes should be changed once a month during the field season or if there is evidence of a problem or damage to the sensor. Problems can include bubbles visible under the membrane, significant deposits of dried electrolyte visible on the membrane, and if the sensor shows unstable readings or other sensor-related symptoms (YSI 2010). This replacement procedure requires YSI 2030 replacement

membrane cap kit (YSI Parts 5913 and 5914 for Galvanic sensors or YSI Parts 5908 and 5909 for Polarographic sensors).

To install a new membrane on the meter:

- If not already mixed, prepare the electrolyte solution according to the directions on the KCl solution bottle included in the kit. Avoid shaking the bottle too vigorously because this will dissolve oxygen into the KCl solution and affect the accuracy of the calibration. Allow solution to sit for one hour to prevent air bubbles from developing under the membrane.
- Unscrew and remove the probe sensor guard (Figure 3).
- Unscrew and remove the old membrane cap (Figure 3). Discard.
- Thoroughly rinse the sensor guard tip with deionized or distilled water.

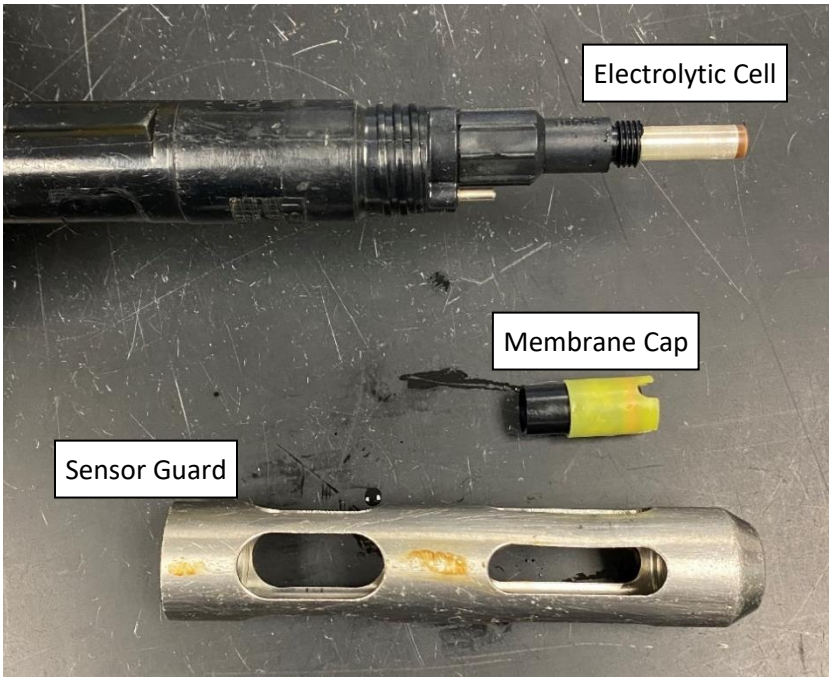


Figure 3 YSI 2030 Probe with Sensor Guard and Membrane Cap Removed.

- Hold the new membrane cap and fill it ¾ full of electrolyte solution (Figure 4). Lightly tap the side of the cap to release any trapped air.

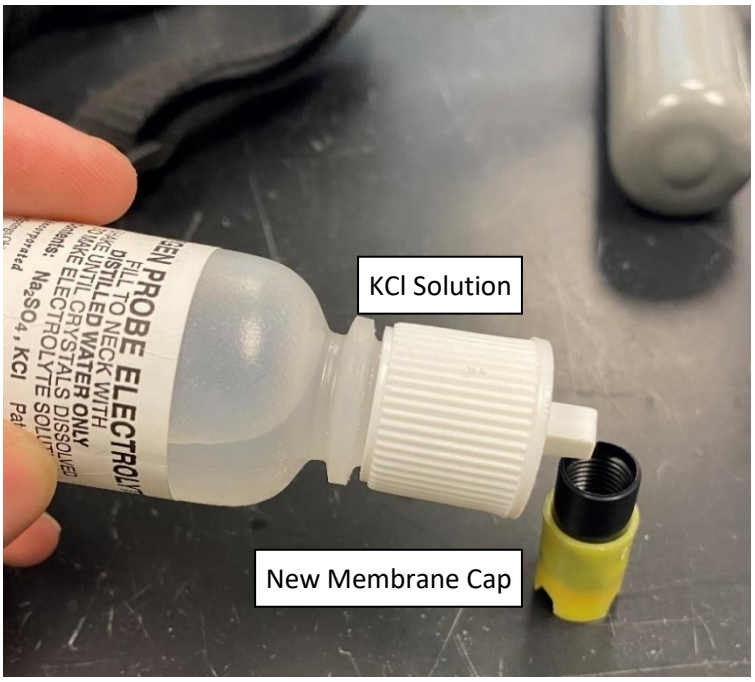


Figure 4 New membrane cap being filled with KCl solution.

- Thread the cap membrane onto the sensor. It should be moderately tight. Take care to ensure no air bubbles are caught under the membrane. A small amount of electrolyte should overflow.
- Screw the probe sensor guard on moderately tightly.
- When possible, allow a new membrane to sit for 6-12 hours before calibration.

6.2 Dissolved Oxygen Calibration and Post-Sampling Verification

The following sections describe the dissolved oxygen calibration procedure.

6.2.1 Required Frequency of Dissolved Oxygen Calibrations

The YSI 2030 must be calibrated for dissolved oxygen measurements each time it is turned on with a post-sampling verification check performed after the last measurement of the day. During long sampling events it must be recalibrated every twelve hours ***with*** a post-check performed after the last measurement of the day. Each time the YSI 2030 is turned off, it is necessary to recalibrate before taking measurements, including after the batteries have been changed. Once the meter is calibrated in the Sampling Center before the sampling day begins, the unit should remain on throughout the day between sampling stations. A post-check on the calibration must occur at the end of the day when the field crew returns to the Sampling Center before the YSI 2030 is turned off. This post-check ensures the instrument was operating correctly while collecting measurements.

If the calibrated value of dissolved oxygen (mg/L) falls within the acceptance criteria as stated in Section 6.2.3, the calibration will be accepted and recorded on the YSI 2030 data sheet. If the calibrated dissolved oxygen value falls outside of the acceptance criteria, the instrument will be recalibrated. If the instrument does not pass post-sampling verification checks at the end of the day, the data collected that day is unreliable. When data do not meet acceptance criteria this should be noted on both the YSI 2030 Field Data Collection Sheets and the logbook. Unacceptable data that do not meet the quality assurance criteria should not be used in analyses or assessments. Those affected samples could be re-sampled on a different day, after the instrument has been properly calibrated.

6.2.2 Dissolved Oxygen Calibration Procedures

Check that the sponge inside the instrument's calibration sleeve is in good repair. The sponge should be damp but not holding water. If water pours out when the probe is removed from the calibration sleeve and the instrument is tipped on its side, then there is too much water in the calibration chamber. Fully insert the probe into the adequately damp calibration sleeve before calibration.

Turn the meter on by pressing the **Power** button. The instrument will activate all segments of the display for a few seconds. Allow the instrument to run for at least fifteen minutes before calibrating. The calibration can begin after fifteen minutes provided that the dissolved oxygen and temperature readings have stabilized.

Record the date, time, whether the membrane was changed, temperature, and barometric pressure on the RIDEM YSI 2030 Calibration Log Sheet (Datasheet 2). Also record the initial dissolved oxygen reading before initiating the dissolved oxygen calibration.

Initiate the dissolved oxygen calibration by pressing and holding the **CAL** key for 3 seconds, highlighting **Dissolved Oxygen,** and pressing **enter**. When calibrating in % DO, highlight "%" and press enter, after pressing **enter** on **Dissolved Oxygen**).

The LCD should now display **CAL** in the lower left portion of the display, the calibration value in the lower right portion of the display, and the current percent reading (before calibration) on the main display. Make sure that the current percent reading (large display) is stable, then press the ENTER button. The display should read SAVE and then return to the normal operation mode.

Record the stabilized, calibrated dissolved oxygen (mg/L) measurement and the temperature on the attached YSI 2030 Calibration Log Sheet (Figure 11) and place in YSI 2030 Meters Maintenance Records and Logbook in the Sampling Center.

6.2.3 Dissolved Oxygen Acceptance Criteria Confirmation

To ensure that the calibrated dissolved oxygen (mg/L) measurement falls within acceptable criteria, consult the 100% Oxygen Solubility Table (Table 2) to determine the ideal dissolved oxygen calibration value at the current temperature. The measured calibration value should be within ±0.5 mg/L of the ideal value to accept the dissolved oxygen calibration. Table 3 includes the minimum and maximum acceptable values at each temperature. When the calibration is accepted, the measurements should be recorded in the YSI 2030 Meters Maintenance and Calibration Log in the Sampling Center. If the calibrated dissolved oxygen measurement exceeds ±0.5 mg/L of the ideal value, recalibrate the YSI 2030. If the problem persists, consult the manufacturer's customer service department immediately for further information.

6.2.4 Dissolved Oxygen Post-Sampling Verification Procedures

After the end of the field day, a post-check of the dissolved oxygen calibration must be completed in the Sampling Center. The post-check must be completed prior before turning off the YSI 2030.

The post-check consists of confirming that the sponge in the calibration sleeve is in good repair and is damp. The sensor should be placed in the calibration sleeve. The temperature, barometric pressure, and dissolved oxygen should be recorded on the datasheet. Consult the 100% Oxygen Solubility Tables to determine the ideal dissolved oxygen value at the current temperature. The measured value should be within ±0.5 mg/L of the ideal value.

6.2.5 Dissolved Oxygen Calibration in the Field

Occasionally it will be necessary to calibrate the YSI 2030 in the field. If the unit turns itself off, if there are questionable readings on the meter, or if there is concern of damage to the probe or membrane, the calibration should be confirmed before making additional measurements.

While it is not ideal, there may be a time when the membrane needs to be changed in the field. In this case, the waiting period after placing the membrane cap on the instrument will not be met and should be documented on the equipment log sheets and the field sheets. The same procedures should be followed (Section 6.2.2 and Section 6.2.3) as for the scheduled daily calibration for dissolved oxygen, and any such calibrations should be documented on field data sheets and log sheets. The membrane should be changed again after the field day with the appropriate waiting time before calibration.

Table 2 Values for 100% Dissolved Oxygen Solubility based on Temperature.

Table 2. 100% Dissolved Oxygen Solubility **Chlorinity: 0** **Salinity: 0**

Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.0	**14.62**	**5.0**	**12.77**	**10.0**	**11.29**	**15.0**	**10.08**	**20.0**	**9.09**	**25.0**	**8.26**	**30.0**	**7.56**	**35.0**	**6.95**
0.1	14.58	5.1	12.74	10.1	11.26	15.1	10.06	20.1	9.07	25.1	8.24	30.1	7.55	35.1	6.94
0.2	14.54	5.2	12.71	10.2	11.24	15.2	10.04	20.2	9.06	25.2	8.23	30.2	7.53	35.2	6.93
0.3	14.50	5.3	12.67	10.3	11.21	15.3	10.02	20.3	9.04	25.3	8.21	30.3	7.52	35.3	6.92
0.4	14.46	5.4	12.64	10.4	11.19	15.4	10.00	20.4	9.02	25.4	8.20	30.4	7.51	35.4	6.91
0.5	14.42	5.5	12.61	10.5	11.16	15.5	9.97	20.5	9.00	25.5	8.18	30.5	7.49	35.5	6.89
0.6	14.38	5.6	12.58	10.6	11.13	15.6	9.95	20.6	8.99	25.6	8.17	30.6	7.48	35.6	6.88
0.7	14.34	5.7	12.55	10.7	11.11	15.7	9.93	20.7	8.97	25.7	8.15	30.7	7.47	35.7	6.87
0.8	14.30	5.8	12.51	10.8	11.08	15.8	9.91	20.8	8.95	25.8	8.14	30.8	7.46	35.8	6.86
0.9	14.26	5.9	12.48	10.9	11.06	15.9	9.89	20.9	8.94	25.9	8.12	30.9	7.44	35.9	6.85
1.0	**14.22**	**6.0**	**12.45**	**11.0**	**11.03**	**16.0**	**9.87**	**21.0**	**8.92**	**26.0**	**8.11**	**31.0**	**7.43**	**36.0**	**6.84**
1.1	14.18	6.1	12.42	11.1	11.01	16.1	9.85	21.1	8.90	26.1	8.10	31.1	7.42	36.1	6.83
1.2	14.14	6.2	12.39	11.2	10.98	16.2	9.83	21.2	8.88	26.2	8.08	31.2	7.41	36.2	6.82
1.3	14.10	6.3	12.36	11.3	10.96	16.3	9.81	21.3	8.87	26.3	8.07	31.3	7.39	36.3	6.81
1.4	14.06	6.4	12.33	11.4	10.93	16.4	9.79	21.4	8.85	26.4	8.05	31.4	7.38	36.4	6.80
1.5	14.03	6.5	12.30	11.5	10.91	16.5	9.77	21.5	8.83	26.5	8.04	31.5	7.37	36.5	6.78
1.6	13.99	6.6	12.26	11.6	10.88	16.6	9.75	21.6	8.81	26.6	8.03	31.6	7.36	36.6	6.77
1.7	13.95	6.7	12.23	11.7	10.86	16.7	9.73	21.7	8.79	26.7	8.01	31.7	7.35	36.7	6.76
1.8	13.91	6.8	12.20	11.8	10.83	16.8	9.71	21.8	8.78	26.8	8.00	31.8	7.33	36.8	6.75
1.9	13.87	6.9	12.17	11.9	10.81	16.9	9.69	21.9	8.76	26.9	7.98	31.9	7.32	36.9	6.74
2.0	**13.83**	**7.0**	**12.14**	**12.0**	**10.78**	**17.0**	**9.67**	**22.0**	**8.74**	**27.0**	**7.97**	**32.0**	**7.31**	**37.0**	**6.73**
2.1	13.79	7.1	12.11	12.1	10.76	17.1	9.65	22.1	8.72	27.1	7.96	32.1	7.30	37.1	6.72
2.2	13.76	7.2	12.08	12.2	10.73	17.2	9.63	22.2	8.71	27.2	7.94	32.2	7.28	37.2	6.71
2.3	13.72	7.3	12.05	12.3	10.71	17.3	9.61	22.3	8.69	27.3	7.93	32.3	7.27	37.3	6.70
2.4	13.68	7.4	12.02	12.4	10.68	17.4	9.59	22.4	8.68	27.4	7.91	32.4	7.26	37.4	6.69
2.5	13.65	7.5	11.99	12.5	10.66	17.5	9.57	22.5	8.66	27.5	7.90	32.5	7.24	37.5	6.67
2.6	13.61	7.6	11.96	12.6	10.64	17.6	9.55	22.6	8.64	27.6	7.89	32.6	7.23	37.6	6.66
2.7	13.57	7.7	11.93	12.7	10.61	17.7	9.53	22.7	8.63	27.7	7.87	32.7	7.22	37.7	6.65
2.8	13.53	7.8	11.90	12.8	10.59	17.8	9.51	22.8	8.61	27.8	7.86	32.8	7.21	37.8	6.64
2.9	13.50	7.9	11.87	12.9	10.56	17.9	9.49	22.9	8.60	27.9	7.84	32.9	7.19	37.9	6.63
3.0	**13.46**	**8.0**	**11.84**	**13.0**	**10.54**	**18.0**	**9.47**	**23.0**	**8.58**	**28.0**	**7.83**	**33.0**	**7.18**	**38.0**	**6.62**
3.1	13.43	8.1	11.81	13.1	10.52	18.1	9.45	23.1	8.56	28.1	7.82	33.1	7.17	38.1	6.61
3.2	13.39	8.2	11.78	13.2	10.49	18.2	9.43	23.2	8.55	28.2	7.80	33.2	7.16	38.2	6.60
3.3	13.36	8.3	11.76	13.3	10.47	18.3	9.41	23.3	8.53	28.3	7.79	33.3	7.15	38.3	6.59
3.4	13.32	8.4	11.73	13.4	10.45	18.4	9.39	23.4	8.52	28.4	7.77	33.4	7.14	38.4	6.58
3.5	13.29	8.5	11.70	13.5	10.43	18.5	9.37	23.5	8.50	28.5	7.76	33.5	7.12	38.5	6.57
3.6	13.25	8.6	11.67	13.6	10.40	18.6	9.36	23.6	8.48	28.6	7.75	33.6	7.11	38.6	6.56
3.7	13.22	8.7	11.64	13.7	10.38	18.7	9.34	23.7	8.47	28.7	7.73	33.7	7.10	38.7	6.55
3.8	13.18	8.8	11.62	13.8	10.36	18.8	9.32	23.8	8.45	28.8	7.72	33.8	7.09	38.8	6.54
3.9	13.15	8.9	11.59	13.9	10.33	18.9	9.30	23.9	8.44	28.9	7.70	33.9	7.08	38.9	6.53
4.0	**13.11**	**9.0**	**11.56**	**14.0**	**10.31**	**19.0**	**9.28**	**24.0**	**8.42**	**29.0**	**7.69**	**34.0**	**7.07**	**39.0**	**6.52**
4.1	13.08	9.1	11.53	14.1	10.29	19.1	9.26	24.1	8.40	29.1	7.68	34.1	7.06	39.1	6.51
4.2	13.04	9.2	11.51	14.2	10.26	19.2	9.24	24.2	8.39	29.2	7.66	34.2	7.05	39.2	6.50
4.3	13.01	9.3	11.48	14.3	10.24	19.3	9.22	24.3	8.37	29.3	7.65	34.3	7.03	39.3	6.49
4.4	12.97	9.4	11.45	14.4	10.22	19.4	9.20	24.4	8.36	29.4	7.64	34.4	7.02	39.4	6.48
4.5	12.94	9.5	11.43	14.5	10.20	19.5	9.18	24.5	8.34	29.5	7.62	34.5	7.01	39.5	6.46
4.6	12.91	9.6	11.40	14.6	10.17	19.6	9.17	24.6	8.32	29.6	7.61	34.6	7.00	39.6	6.45
4.7	12.87	9.7	11.37	14.7	10.15	19.7	9.15	24.7	8.31	29.7	7.60	34.7	6.99	39.7	6.44
4.8	12.84	9.8	11.34	14.8	10.13	19.8	9.13	24.8	8.29	29.8	7.59	34.8	6.97	39.8	6.43
4.9	12.80	9.9	11.32	14.9	10.10	19.9	9.11	24.9	8.28	29.9	7.57	34.9	6.96	39.9	6.42
5.0	**12.77**	**10.0**	**11.29**	**15.0**	**10.08**	**20.0**	**9.09**	**25.0**	**8.26**	**30.0**	**7.56**	**35.0**	**6.95**	**40.0**	**6.41**

Table 3 Acceptance Ranges for 100% Oxygen Solubility Based on Temperature.

Table 1. 100% Oxygen Solubility based on temperature (1 atm, 0 Chlorinity, 0 Salinity)

Temp. (°C)	Ideal D.O. Value (mg/L)	Acceptable Range (± 5% of Ideal D.O.) MIN	MAX	Temp. (°C)	Ideal D.O. Value (mg/L)	Acceptable Range (± 5% of Ideal D.O.) MIN	MAX	Temp. (°C)	Ideal D.O. Value (mg/L)	Acceptable Range (± 5% of Ideal D.O.) MIN	MAX	Temp. (°C)	Ideal D.O. Value (mg/L)	Acceptable Range (± 5% of Ideal D.O.) MIN	MAX
10.0	**11.29**	**10.73**	**11.85**	**14.0**	**10.31**	**9.79**	**10.83**	**18.0**	**9.47**	**9.00**	**9.94**	**22.0**	**8.74**	**8.30**	**9.18**
10.1	11.26	10.70	11.83	**14.1**	10.29	9.77	10.80	**18.1**	9.45	8.98	9.92	**22.1**	8.72	8.29	9.16
10.2	11.24	10.68	11.80	**14.2**	10.26	9.75	10.78	**18.2**	9.43	8.96	9.90	**22.2**	8.71	8.27	9.15
10.3	11.21	10.65	11.77	**14.3**	10.24	9.73	10.75	**18.3**	9.41	8.94	9.88	**22.3**	8.69	8.26	9.12
10.4	11.19	10.63	11.75	**14.4**	10.22	9.71	10.73	**18.4**	9.39	8.92	9.86	**22.4**	8.68	8.25	9.11
10.5	11.16	10.60	11.72	**14.5**	10.20	9.69	10.70	**18.5**	9.37	8.90	9.84	**22.5**	8.66	8.23	9.09
10.6	11.13	10.58	11.69	**14.6**	10.17	9.66	10.68	**18.6**	9.36	8.89	9.83	**22.6**	8.64	8.21	9.07
10.7	11.11	10.55	11.66	**14.7**	10.15	9.64	10.66	**18.7**	9.34	8.87	9.81	**22.7**	8.63	8.20	9.06
10.8	11.08	10.53	11.64	**14.8**	10.13	9.62	10.63	**18.8**	9.32	8.85	9.79	**22.8**	8.61	8.18	9.04
10.9	11.06	10.50	11.61	**14.9**	10.10	9.60	10.61	**18.9**	9.30	8.84	9.77	**22.9**	8.60	8.17	9.03
11.0	**11.03**	**10.48**	**11.58**	**15.0**	**10.08**	**9.58**	**10.58**	**19.0**	**9.28**	**8.82**	**9.74**	**23.0**	**8.58**	**8.15**	**9.01**
11.1	11.01	10.45	11.56	**15.1**	10.06	9.56	10.56	**19.1**	9.26	8.80	9.72	**23.1**	8.56	8.13	8.99
11.2	10.98	10.43	11.53	**15.2**	10.04	9.54	10.54	**19.2**	9.24	8.78	9.70	**23.2**	8.55	8.12	8.98
11.3	10.96	10.41	11.50	**15.3**	10.02	9.52	10.52	**19.3**	9.22	8.76	9.68	**23.3**	8.53	8.10	8.96
11.4	10.93	10.38	11.48	**15.4**	10.00	9.50	10.50	**19.4**	9.20	8.74	9.66	**23.4**	8.52	8.09	8.95
11.5	10.91	10.36	11.45	**15.5**	9.97	9.48	10.47	**19.5**	9.18	8.72	9.64	**23.5**	8.50	8.08	8.93
11.6	10.88	10.34	11.42	**15.6**	9.95	9.46	10.45	**19.6**	9.17	8.71	9.63	**23.6**	8.48	8.06	8.90
11.7	10.86	10.31	11.40	**15.7**	9.93	9.44	10.43	**19.7**	9.15	8.69	9.61	**23.7**	8.47	8.05	8.89
11.8	10.83	10.29	11.37	**15.8**	9.91	9.42	10.41	**19.8**	9.13	8.67	9.59	**23.8**	8.45	8.03	8.87
11.9	10.81	10.26	11.35	**15.9**	9.89	9.40	10.39	**19.9**	9.11	8.65	9.57	**23.9**	8.44	8.02	8.86
12.0	**10.78**	**10.24**	**11.32**	**16.0**	**9.87**	**9.38**	**10.36**	**20.0**	**9.09**	**8.64**	**9.54**	**24.0**	**8.42**	**8.00**	**8.84**
12.1	10.76	10.22	11.29	**16.1**	9.85	9.36	10.34	**20.1**	9.09	8.64	9.54	**24.1**	8.39	7.97	8.81
12.2	10.73	10.20	11.27	**16.2**	9.83	9.34	10.32	**20.2**	9.07	8.62	9.52	**24.2**	8.37	7.95	8.79
12.3	10.71	10.17	11.24	**16.3**	9.81	9.32	10.30	**20.3**	9.06	8.61	9.51	**24.3**	8.36	7.94	8.77
12.4	10.68	10.15	11.22	**16.4**	9.79	9.30	10.28	**20.4**	9.04	8.59	9.49	**24.4**	8.34	7.92	8.76
12.5	10.66	10.13	11.19	**16.5**	9.77	9.28	10.26	**20.5**	9.02	8.57	9.47	**24.5**	8.32	7.91	8.74
12.6	10.64	10.10	11.17	**16.6**	9.75	9.26	10.24	**20.6**	8.99	8.54	9.44	**24.6**	8.31	7.89	8.72
12.7	10.61	10.08	11.14	**16.7**	9.73	9.24	10.22	**20.7**	8.97	8.52	9.42	**24.7**	8.29	7.88	8.70
12.8	10.59	10.06	11.12	**16.8**	9.71	9.22	10.20	**20.8**	8.95	8.51	9.40	**24.8**	8.28	7.87	8.69
12.9	10.56	10.04	11.09	**16.9**	9.69	9.21	10.17	**20.9**	8.94	8.49	9.38	**24.9**	8.26	7.84	8.67
13.0	**10.54**	**10.01**	**11.07**	**17.0**	**9.67**	**9.19**	**10.15**	**21.0**	**8.92**	**8.47**	**9.36**	**25.0**	**8.26**	**7.85**	**8.67**
13.1	10.52	9.99	11.04	**17.1**	9.65	9.17	10.13	**21.1**	8.90	8.45	9.34	**25.1**	8.24	7.83	8.65
13.2	10.49	9.97	11.02	**17.2**	9.63	9.15	10.11	**21.2**	8.88	8.44	9.33	**25.2**	8.23	7.82	8.64
13.3	10.47	9.95	10.99	**17.3**	9.61	9.13	10.09	**21.3**	8.87	8.43	9.31	**25.3**	8.21	7.80	8.62
13.4	10.45	9.93	10.97	**17.4**	9.59	9.11	10.07	**21.4**	8.85	8.40	9.29	**25.4**	8.20	7.79	8.61
13.5	10.43	9.90	10.95	**17.5**	9.57	9.09	10.05	**21.5**	8.83	8.39	9.27	**25.5**	8.18	7.77	8.59
13.6	10.40	9.88	10.92	**17.6**	9.55	9.07	10.03	**21.6**	8.81	8.37	9.25	**25.6**	8.17	7.76	8.58
13.7	10.38	9.86	10.90	**17.7**	9.53	9.05	10.01	**21.7**	8.79	8.35	9.23	**25.7**	8.15	7.74	8.56
13.8	10.36	9.84	10.87	**17.8**	9.51	9.03	9.99	**21.8**	8.78	8.34	9.22	**25.8**	8.14	7.73	8.55
13.9	10.33	9.82	10.85	**17.9**	9.49	9.02	9.96	**21.9**	8.76	8.32	9.20	**25.9**	8.12	7.71	8.53

6.3 Specific Conductance Verification

According to the YSI 2030 manual (YSI 2010), calibration of specific conductance is rarely required because of the factory calibration of the YSI 2030. Specific conductance verifications will be performed at fixed intervals (Section 6.3.1) to ensure that the data collected are of the highest quality. More frequent intervals may be necessary to meet data objectives for certain projects. The conductivity will be calibrated if the specific conductance verification does not meet acceptance criteria.

6.3.1 Required Frequency of Specific Conductance Verification

Specific conductance readings will be verified according to the procedures outlined in Section 6.3.2 at a frequency of once per month during the field season. Verifications and calibrations will be recorded on a RIDEM YSI 2030 Calibration Log Sheet and kept in the logbook located in the sampling center (Datasheet 2).

6.3.2 Specific Conductance Verification Procedures

Use a container that will fully submerge the conductivity sensor. Rinse the container and the sensor twice in 1000 µS/cm standard to ensure that there is no dust or residue that would interfere with accurate measurement of readings.

Fill the container with enough 1000 µS/cm standard to completely cover the oval shaped holes on the probe that are adjacent to the cable (Figure 5). Submerge the probe into the conductivity solution. Gently tap the probe to ensure that there are no air bubbles present in the probe. Wait about one minute for the probe to allow specific conductance to stabilize and adjust to the conductance of the water.

Record the date, time, and name of analyst on a RIDEM YSI 2030 Calibration Log Sheet (Datasheet 2). Each YSI meter has a section in the logbook with the meter number at the top of the sheet.

The YSI 2030 meter is accurate to within ±0.5 percent of the value of specific conductance of a liquid at 25 degrees Celsius. If the reading on the meter is more than ±5 µS/cm than the value of the standard solution, rinse the meter several more times with the standard solution and read again. If the meter continues to read out of range, then it will need to be calibrated (Section 6.3.3).

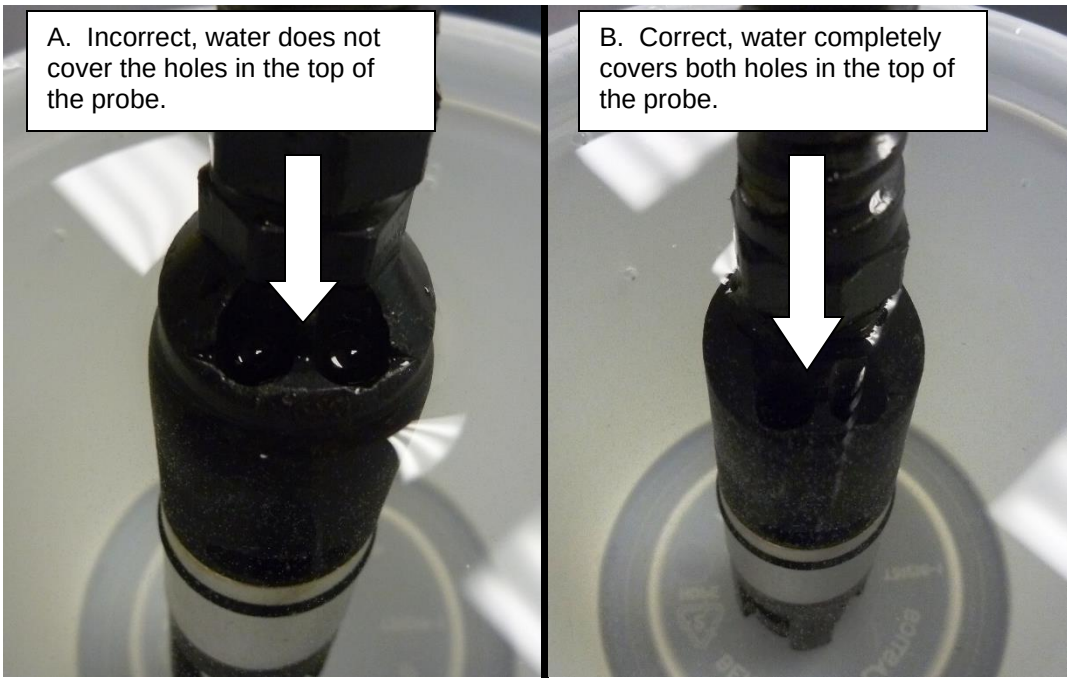


Figure 5 Sensor with Holes (A) Incorrectly and (B) Correctly Submerged for Measurement.

6.3.3 Specific Conductance Calibration Procedures (If Necessary)

If the meter is not reading the correct value of specific conductance within the tolerances of the meter, it is necessary to adjust the meter. Follow the procedures in Section 6.3.2 to submerge the probe in a container with conductivity solution. Press and the **CAL** key, highlight **CONDUCTIVITY**, and press **ENTER**. Highlight **SP CONDUCTIVITY** and press **ENTER**. Highlight the appropriate units and use **UP/DOWN ARROWS** to match the value of the conductivity calibration solution. Press **ENTER** to complete the calibration. **CALIBRATION SUCCESSFUL** will display for a few seconds before returning to the run screen. This calibration will remain stored on the meter even if it is turned off.

If the calibration is unsuccessful, press the **CAL** key to return to the run screen. Refer to the user manual to troubleshoot. Report problems to the Project Manager. This calibration will remain stored on the meter even if it is turned off.

6.3.4 Send YSI 2030 Meter for Service, if Necessary

If the meter does not calibrate properly, consult the manufacturer's customer service department immediately for further information.

6.4 One-Point Temperature Verification

This verification is intended to assure that the meter is accurately measuring temperature. Return the meter to YSI for service if verification fails.

6.4.1 Required Frequency of One-Point Temperature Verification

Temperature readings will be verified using an NIST traceable thermometer according to the procedures outlined in Sections 6.4.2 at a once per month during the field season.

6.4.2 One-Point Temperature Verification Procedures

Immerse Probe and Thermometer in a rinsed container filled with enough water to completely cover the oval shaped holes on the probe that are adjacent to the wire (Figures 5A and 5B). Cold tap water will slowly warm, making it difficult to get a stable temperature reading on either the probe or the thermometer, so it is best to use room temperature water.

Wait about five minutes for the probe and thermometer to stabilize and adjust to the temperature of the water. Do not let the thermometer rest on the bottom or sides of the glass beaker.

Record values, date, time, and name of analyst on an RIDEM YSI-2030 Calibration Log Sheet (Datasheet 2). Each meter has a section in the logbook with the meter number at the top of the sheet.

The YSI 2030 meter is accurate to within $\pm$0.1 degrees Celsius. The NIST traceable thermometer is accurate to within $\pm$1.0 degrees Celsius. If the reading on the meter is different from the reading on the thermometer by more than $\pm$1.0 degrees Celsius, then the meter is not within tolerances. Remove the thermometer and meter from water and inspect to make sure that the thermometer probe and the YSI 2030 probe are clean and not in disrepair. Replace the meter and thermometer back in water. Wait five minutes for the temperatures to stabilize. Monitor that the temperature stays constant. If the meter is still different from the thermometer by more than $\pm$1.0 degrees Celsius, the meter will need to be sent in for service, and the temperature probe will likely be replaced.

Consult the manufacturer's customer service department immediately for further information.

6.5 Field Measurement Procedures

For most purposes the YSI 2030 meter is used specifically for in situ water quality measurements directly taken in the field, in lotic or lentic surface waters at temperatures between -5^{o}C and 65^{o}C. This method does not require sample containers or preservation.

The following section describes the procedures for the in-situ measurement of field parameters from lentic or lotic water bodies in the field using the YSI 2030.

The following sections describe the proper use of the YSI 2030 in the field for in-situ water quality measurements.

6.5.1 Field Parameter Units

The following units should be used when recording measurements taken with the YSI 2030:

Dissolved Oxygen (%)	% Saturation
Dissolved Oxygen	mg/L
Specific Conductance	µS/cm
Temperature	°C
Salinity	ppt

6.5.2 Immerse Probe in Water to be Sampled

Lower the probe to the desired depth (e.g., surface, middle, or bottom) of the water column. When recording the bottom measurement, be sure to keep the electrode at least half a foot above the bottom. Bottom substrates should not be disturbed prior to or during measurement.

The electrolytic cell (for dissolved oxygen) consumes oxygen in the water during measurement. It requires at least 3 to 6 inches per second of moving water. In slower flowing water, it may be necessary to agitate the probe up and down slightly in the water column to ensure that liquid is actively passing across the membrane. It is evident when this occurs because the dissolved oxygen value slowly decreases. Once the probe is agitated, the value of dissolved oxygen should slowly increase to a steady maximum. Once the dissolved oxygen reading stabilizes, record the value on YSI 2030 Field Data Collection Sheet for Monitoring Section Sampling Events (Datasheet 1).

6.5.3 Record Dissolved Oxygen Measurement

Allow the meter at least six seconds to stabilize the measurement. Read dissolved oxygen percent and record measurement on the YSI 2030 Field Data Collection Sheet for Monitoring Section Sampling Events (Datasheet 1). If two analysts are working together to collect samples, one should hold the instrument and read the values, and the other should record. The analyst holding the meter should read the values out loud to the recorder, and the recorder should repeat the measurement to verify the correct number. This is especially important in noisy environments such as sampling stations in high traffic areas.

In some cases, it may be helpful to **SAVE** the oxygen readings and store them in the YSI 2030 to refer to later. For further instructions on saving and storing the data in the YSI 2030, see the procedures outlined in the manual for the YSI 2030 starting on page 258 (YSI 2010). It is not possible to download saved values to a computer, flag the data, or annotate the data. Standard procedures do not require saving data on the instrument.

6.5.4 Read and Record Data from Display

All measured parameters will be displayed on screen at the same time. Record each parameter measurement on the YSI 2030 Field Data Collection Sheet for Monitoring Section Sampling Events (Datasheet 1).

The YSI 2030 has an auto range function that will change units to read in the range of values that are being measured. RIDEM reports values of specific conductance or conductivity in µS/cm, so the large numbers on the display should be followed by µS. If the unit is reading in mS, press **ENTER** to change the units back to µS/cm.

If the instrument is reading conductivity, the display will show a static **°C** temperature unit on the right side of the screen. However, if the meter is reading specific conductance (temperature compensated), the **°C** symbol will flash on and off.

6.5.5 Remove Probe from Water, Clean and Store

Remove probe from water and shake off any excess droplets. Pour distilled or deionized water on the probe to rinse. Blot away excess water with a clean lint-free tissue and replace the probe back in the storage chamber.

6.6 Long-Term and Winter Storage of Meters

The ambient monitoring program measures water quality parameters using the YSI 2030 from April through October. Long-term storage of the YSI 2030 meter during extended periods when it will not be used is essential to proper operation of the unit.

The dissolved oxygen and conductivity sensors should be stored in a dry state. When storing for more than 30 days, unscrew the membrane cap from the dissolved oxygen probe. Rinse the probe and the sensor with deionized or distilled water. Both the probe and the sensor should be dried completely using either compressed air or by air-drying. Use a new clean, dry cap membrane to screw over the sensor. This will protect the anode and cathode during storage while keeping them dry. Ensure that the conductivity sensor is also clean and dry before putting the sensor guard back (Figure 6).

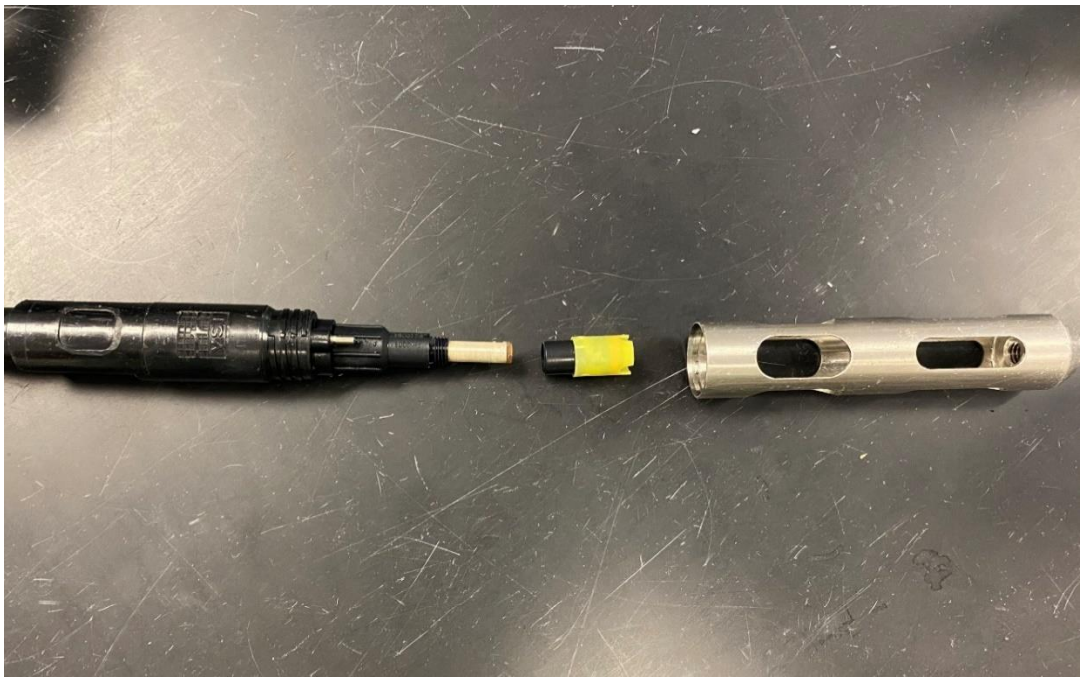


Figure 6 Cleaned and Dried Dissolved Oxygen Sensor Ready for Long-Term Storage.

A small amount of Krytox grease should be applied with finger to coat the O-ring. This will help prevent drying and cracking of the O-ring while not in use (Figure 7).

Figure 7 YSI 2030 Probe O-ring with Krytox Grease.

7.0 DOCUMENTATION

7.1 Field Measurements

All calibration and field measurements will be recorded on YSI 2030 Field Data Collection Sheet for Monitoring Section Sampling Events (Datasheet 1).

7.2 Calibration

Calibration documentation must be maintained in a thorough and consistent manner. A RIDEM YSI 2030 Calibration Log Sheet (Datasheet 2) will be used to document all calibration and maintenance operations and shall be filled out in entirety. These log sheets will be kept in the YSI-2030 Meters Maintenance Records and Logbook in the OWR Sampling Center.

8.0 REFERENCES

YSI Incorporated, 2010. YSI Model Pro2030: User Manual. YSI incorporated. Yellow Springs Ohio, USA.

Radtke, J.D., J.K. Kurklin, and F.D. Wilde. 1998. Temperature. United States Geological Survey Techniques of Water Resources Investigations Book 9, Chapter 6.1. Accessed 08/23/2011 at: https://pubs.usgs.gov/twri/twri9a6/twri9a6_6.1_ver2.pdf

ATTACHMENT A DATA SHEETS

Samping Round _____ ARM 2021 - Coastal Rotation Page ____ of ___

Sampling Day _____

Field Crew:	Weather Conditions:
YSI Instrument (circle one): ProPlus 2030	YSI Serial Number

Site ID												
Location Name												
Date												
Time												
DO (mg/L)												
Saturation (%)												
SPC (µS/cm)												
Temp (°C)												
B. Pres. (mmHg)												
pH												
Nitrate (mg/L)												
Photographs												
O.G.												
Flow												
Sample Method												
Comments												

Rhode Island DEM - Office of Water Resources

Figure 8 Datasheet 1: Field Data Collection Sheet for Monitoring Section Sampling Events

RIDEM Calibration Log **YSI 2030** **Circle: Meter #1(18H108152)** **Meter #2 (18H108153)**

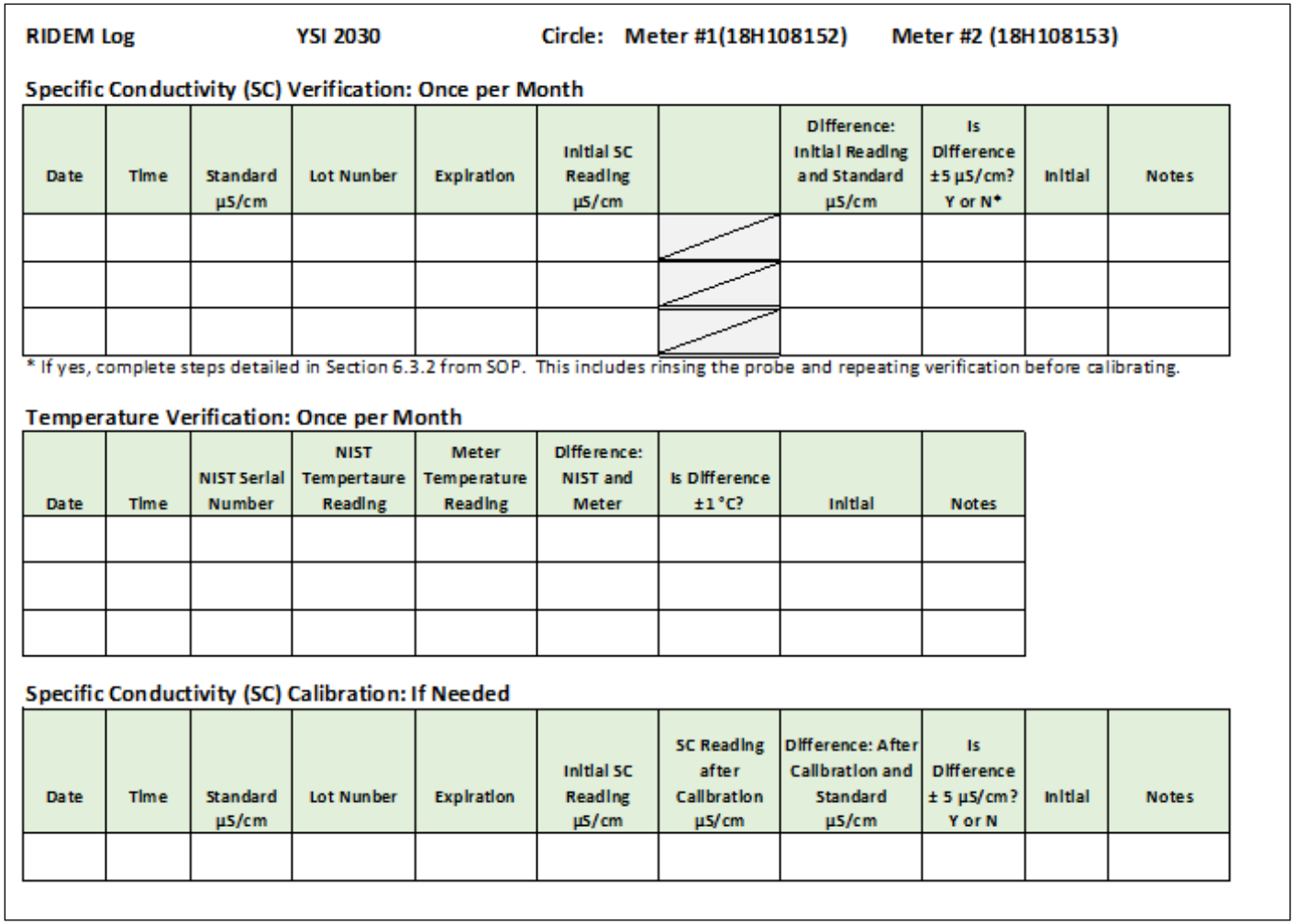
	Date	Time
DO Membrane Change		
Specific Conductivity Verification		
Temperature Verification		

Complete once per month or as needed. See SOP and lab book.

	1 Date	2 Time	3 Date DO Membrane Changed	4 Initial DO Reading mg/L	5 Temp Reading °C	6 Barometric Pressure mm Mg	7 Ideal DO (from Table) mg/L	8 DO Reading after Calibration mg/L	9 Difference: Reading and Ideal Value mg/L	10 Is Col 9 Difference ±0.5 mg/L? Y or N	11 Initial	12 Notes
1 Pre												
2 Post												
3 Pre												
4 Post												
5 Pre												
6 Post												
7 Pre												
8 Post												
9 Pre												
10 Post												

Col 9 Calibration before field work: subtract Col 8 (Post Calibration) and Col 7 (Ideal).
Post field work check: subtract Col 4 (Initial) and Col 7 (Ideal).
Note when batteries have been changed in NOTES column

Figure 9 Datasheet 2: RIDEM YSI 2030 Calibration Log Sheet.



RIDEM Log **YSI 2030** **Circle: Meter #1(18H108152) Meter #2 (18H108153)**

Specific Conductivity (SC) Verification: Once per Month

Date	Time	Standard µS/cm	Lot Number	Expiration	Initial SC Reading µS/cm		Difference: Initial Reading and Standard µS/cm	Is Difference ±5 µS/cm? Y or N*	Initial	Notes

* If yes, complete steps detailed in Section 6.3.2 from SOP. This includes rinsing the probe and repeating verification before calibrating.

Temperature Verification: Once per Month

Date	Time	NIST Serial Number	NIST Tempertaure Reading	Meter Temperature Reading	Difference: NIST and Meter	Is Difference ±1 °C?	Initial	Notes

Specific Conductivity (SC) Calibration: If Needed

Date	Time	Standard µS/cm	Lot Number	Expiration	Initial SC Reading µS/cm	SC Reading after Calibration µS/cm	Difference: After Calibration and Standard µS/cm	Is Difference ± 5 µS/cm? Y or N	Initial	Notes

Figure 10 Datasheet 3: RIDEM YSI 2030 Specific Conductivity and Temperature Verification Log Sheet.