

**CWMN**  
***The Citizen Water Monitoring Network***  
***Restoring a Swimmable Neponset River***

***Dissolved Oxygen***  
***Sampling Manual***  
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# INTRODUCTION

This manual provides a concise summary of the procedures utilized for the testing of Dissolved Oxygen or "DO" under the auspices of the Neponset River Watershed Association's Citizen Water Monitoring Program (CWMN). This manual is intended to supplement the information contained in the CWMN Water Monitoring and Sampling Manual for the subset of CWMN volunteers who are involved in collecting DO. You may wish to refer to that manual for background information about the overall monitoring program.

Government and private sector decision makers rely on the data gathered by the Citizens Water Monitoring Network. The procedures spelled out in this manual are based on accepted standard procedures and have been carefully designed to ensure the quality, consistency and reliability of all CWMN data irrespective of who happens to be gathering the data.

**Sampling according to the procedures described below is critical to the success of the CWMN program.**

*This manual draws heavily on the meter manufacturer's literature, and in fact much of the text of this manual is copied verbatim from the manufacturer's materials.*

## **Dissolved Oxygen in the River**

Dissolved Oxygen or "DO" is a measure of the amount oxygen dissolved in the water. DO is measured both as a concentration (mg/l) and as a function of water temperature in terms of percent saturation.

While the concentration of atmospheric oxygen that humans depend on is relatively constant, levels of oxygen that fish depend on in the water can vary widely. Any pollution that directly or indirectly encourages decomposition such as sewage or nutrients will tend to lower DO levels. Lack of adequate DO, even for a very short time, can cause stress for aquatic organisms, and may even produce fish kills. How would you feel if someone said "we're cutting off your air, but only for 15 minutes!"

The Massachusetts Surface Water Quality Standards require minimum DO levels of 5.0 mg/l and between 60% and 100% saturation in streams designated as warm water fisheries. In streams designated as cold water fisheries, stricter limits of 6 mg/l and 75% saturation apply. While no streams in the Neponset are currently designated as cold water fisheries under the Mass Surface Water Quality Standards, several Neponset streams do support populations of cold water fish and as such the stricter standards should apply.

DO levels fluctuate seasonally and over a daily 24-hour cycle. As aquatic plants photosynthesize during the daylight hours, they give off oxygen. In the night, photosynthesis stops but other processes continue removing oxygen from the water consuming oxygen. Therefore the lowest DO levels over a given 24 hour period will tend to occur just before dawn.

DO levels also vary with water temperature—cold water holds more oxygen than warm water. Furthermore, water holds less oxygen at higher altitudes. Finally,

agitation of the stream water (think bubbling brook or waterfall) can substantially increase DO levels.

As a result, it is important to test for DO in the worst case conditions. With the factors above in mind, it is best to test for DO just before dawn, during hot weather and away from artificial sources of oxygen such as dam waterfalls.

# DO Equipment

## DO Equipment List

All dissolved oxygen monitors are provided with the following equipment:

- Dissolved oxygen meter
- Carrying case
- Size C replacement batteries (4)
- Liter of distilled water
- Dissolved oxygen manufacturer's manual
- Sharpie marker
- Procedure checklist
- DO data sheets
- Disposable latex gloves
- Canvas equipment bag
- Clipboard

All equipment should be picked up at the NepRWA office prior to the sampling event, and dropped off afterwards. NepRWA staff will inspect the meter service it if necessary and calibrate it against a zero DO solution before each use. Please call or email the office to make arrangements.



YSI 550 DO Meter

## Principles of DO Meter Operation

The sensor consists of a silver body as the anode and a circular gold cathode embedded in the end.

In operation, this end of the sensor is filled with a solution of electrolyte containing a small amount of surfactant to improve wetting action. A thin semi-permeable membrane, stretched over the sensor, isolates the electrodes from the environment, while allowing gases to enter. When a polarizing voltage is applied to the sensor electrodes oxygen that has passed through the membrane reacts at the cathode causing a current to flow.

The membrane passes oxygen at a rate proportional to the pressure difference across it. Since oxygen is rapidly consumed at the cathode, it can be assumed that the oxygen pressure inside the membrane is zero. Hence, the force causing the oxygen to diffuse through the membrane is proportional to the partial pressure of oxygen outside the membrane. As the oxygen partial pressure varies, so does the oxygen diffusion through the membrane. This causes the probe current to change proportionally.

It is important to recognize that oxygen dissolved in the sample is consumed during the test. It is therefore essential that the sample be continuously stirred at the sensor tip. If stagnation occurs, your readings will be artificially low. Stirring may be accomplished by mechanically moving the sample around the probe tip, or by rapidly

moving the probe through the sample. The rate of stirring should be at least 1 foot per second.

### **Overview of Basic Functions of the YSI 550 Meter**

Refer to the manufacturer's manual for additional details.

The YSI 550 DO keypad consists of six keys. There are four function keys, and up and down arrow keys. The top left key that has a green circle and line is the ON/OFF key. The top right key is the backlight. The bottom left is the Mode key, and the bottom right is the Enter key.



**Turn the instrument on** by pressing and releasing the ON/OFF button on the front of the instrument. The instrument will activate all segments of the display for a few seconds, which will be followed by a self test procedure that will last for several more seconds. During this power on self test sequence, the instrument's microprocessor is verifying that the instrument is working. If the instrument were to detect a problem, a continuous error message would be displayed. If the instrument does not operate, contact NepRWA for assistance.

The **light key** is at the top right of the keypad. The instrument back-light should illuminate the LCD so that the display can be easily read in the dark. Pushing the LIGHT key again will turn the back light off. The light will power off automatically after two minutes of non-use.

The YSI 550 DO Instrument can display the **temperature units** in either Fahrenheit or Celsius. The CWMN program records all data using the Celsius scale. To change the temperature units, turn the instrument on and simultaneously press the DOWN ARROW key and the MODE key.

# SAFETY PROCEDURES

NepRWA volunteer and staff safety is the CWMN program's top priority. The following safety procedures have been developed to ensure the safety of everyone who participates in the CWMN program. However, common sense is the most important safety tool: under no circumstances should anyone put themselves in harm's way, to complete the sampling.

## Reporting an Emergency

In case of an emergency while monitoring, volunteers should call 911 from any location. All towns in the watershed have "enhanced 911" service. Only after calling 911 should they call the NepRWA office at 781-575-0354.

## Non-Emergency Problems

Non-emergency problems should be reported to NepRWA at 781-575-0354. A volunteer staffs the NepRWA office from 6 AM on sampling days. That person will contact others to answer questions or possibly cover a site at the last minute.

## Automobiles and Roadways

Many sites are located on busy roadways, which are not commonly used by pedestrians. Your presence may be a surprise to motorists. Please observe the following precautions:

- Wear high-visibility clothing.
- Warn approaching traffic of your presence by parking your car nearby on the same side of the street.
- Use extreme caution when crossing the street.

## Bridges

Most CWMN sites are located at bridges. Always use extreme caution at the edge of a bridge.

- Test railings before leaning against them.
- Never climb or sit on railings.

## Wading

Wading is necessary at a few CWMN sites. If a site calls for wading, consult with a NepRWA staff member to see if it might be possible to sample using a pole instead and use the following precautions:

- Do not wade alone!
- Only wade when the water is less than knee-deep and not fast moving.
- Waders and life jackets are required for wading.

## Weather Conditions

The CWMN program requires that volunteers be outside during cold and/or rainy conditions. Monitors should expect to be at their site for up to 45 minutes and should dress appropriately. If there is lightning in the area, stay out of contact with the water, avoid contact with metal on bridges and stay away from all tall trees.

**Pollution Hazards**

While most of the Neponset River and its tributaries are now swimmable during dry weather, some CWMN sampling locations are known to be seriously polluted.

- Volunteers should presume that most CWMN sampling locations are significantly polluted during heavy rain.
- Be aware of the degree of probable pollution associated with your site.
- Wear the disposable latex gloves in your sampling kit (they help protect you and the sample!)
- Avoid putting hands or wet clothing in your mouth.
- Never hold pens, pencils or other sampling equipment in your mouth (even though it would be helpful to have a third hand!)
- Carry disinfectant self-drying hand-washing soap available at pharmacies.
- Avoid eating until after you have washed your hands.

# Sampling Procedures

This section outlines pre-preparation, calibration and sampling procedures in detail. Once you are familiar with the procedures, you may want to refer to the DO Procedure Checklist instead for a quick reminder.

## **When to Sample**

Sampling should be completed between the hours of 6 and 8 am. Please notify the NepRWA office if you are unable to sample during that time.

## **Keeping Records**

It is important to keep meticulous records of observations and sample information. All information is recorded in either ballpoint pen or pencil (which works better on wet paper). Never erase what you think may be a mistake. Instead cross it out, neatly with a single line, and write the correct entry next to or above it. A sample DO Data sheet is provided on the following page.

## **One Week Before Sampling Day**

1. Know your site locations. Make sure that you have a map and/or good directions. Know approximately how long it takes to get to the sampling sites.
2. Contact your sampling partner (if any). Make arrangements to meet and determine who will pick up supplies, who will bring the equipment, who will drop off the equipment, and so forth.
3. If you are unable to sample, contact NepRWA as soon as you know so NepRWA can find someone to cover your route. If you do not find out until the morning of sampling that you cannot sample, please call the NepRWA office (781) 575-0354 immediately and leave a message in the CWMN mail box. NepRWA staff will attempt to sample your site at the last minute.
4. Pick up dissolved oxygen meter and supplies. Confirm that the cable on your meter is long enough to reach the water at each of your sites! Make sure you have driving directions, and information on elevation and salinity for your sites.
5. Inspect your dissolved oxygen meter to make sure it is functioning properly and the batteries are working. If the batteries have died, replace them according to the manufacture's instructions. Do not leave the DO meter in your car overnight, especially during cool or cold weather as the batteries will be quickly depleted!

## **The Night Before Sampling**

1. Review directions and procedures. Know where you will be tomorrow. Review the sampling procedures in the DO Sampling Manual.
2. Assemble all equipment that will be needed the next morning and place it in your equipment bag.
3. Pre-fill the data sheet to the extent possible in order to save time in the morning. Place the data sheet with your other equipment.

4. Finally, notify someone else that you plan to go sampling the next morning.

### **On Sampling Day - Before Leaving Home**

1. Check the cable connection between the probe and meter. Make sure that the probe is filled with electrolyte solution, that the membrane has no wrinkles, and that there are no bubbles trapped on the face of the membrane.
2. Wet the sponge under the rubber cap on one side of the meter's calibration chamber with 3 to 6 drops of water. Drain any excess water from the cap and calibration chamber and pop the cap snugly into the hole. Insert the probe into the other end of the calibration chamber until the o-ring seats, creating an air-tight environment in the chamber.
3. Turn on the dissolved oxygen meter before you leave the house and leave it on. This will save time as you must wait 15-30 minutes after turning on the meter before calibrating (until the readings from inside the calibration chamber have stabilized).
4. Drive to your first site.

### **On Sampling Day – At the Sampling Site: Calibration**

1. Ideally the unit should be at a temperature + or – 10 degrees Celsius from the water temperature when calibrating. If the AC or heat has been running in your car, get out of the car with the meter, unpack it and wait 10 minutes for the meter to adjust to within + or – 10 degrees Celsius the ambient outdoor temperature before proceeding
2. Once the unit is at an appropriate temperature and displays a constant reading inside the calibration chamber (i.e. the chamber has been sealed for 15+ minutes, proceed with the calibration process.
3. Switch display to % saturation mode by pressing the Mode key. Either a "mg/L" or "%" will be displayed on the right side of the screen.
4. Enter the calibration mode by using two fingers to press and release both the UP ARROW and DOWN ARROW simultaneously.
5. The LCD will prompt you to enter the local altitude in hundreds of feet (i.e. 12 = 1,200 feet). Refer to the site altitude table and or driving directions for the average altitude of all your sites. Use the arrow keys to increase or decrease the altitude. When the proper altitude appears on the LCD, press the ENTER key.
6. The meter should now display CAL in the lower left of the display, the calibration target value should be displayed in the lower right of the display and the current DO reading (before calibration) should be the main display. Make sure the DO reading (large display) is stable, then press the ENTER button.
7. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. Use zero for all sites upstream of the Baker Dam in Milton/Dorchester Lower Mills. Use the arrow keys to increase or decrease the salinity setting and press ENTER when done.

8. The meter should now be in normal operation mode. The calibration is done. DO NOT TURN OFF THE METER between sites. When the meter is turned off and on again it will need to be recalibrated.
9. With the probe still in the calibration/storage chamber record the temperature and % dissolved oxygen saturation on your data sheet. This documents the fact that your meter was properly calibrated.

**On Sampling Day – At the Sample Site: Measuring DO**

1. Record the site ID, location, and time on your data sheet
2. Place the probe in the stream below the surface in the center of the stream channel where water is flowing. The probe consumes oxygen as it takes the reading. Therefore, **the water must be continually moving past the probe at a rate of approximately 1 foot per second or more**. If the stream is stagnant, continually move the probe back and forth briskly but smoothly to approximate 1 foot per second. Be careful to keep the end of the probe immersed at all times, to avoid agitating air into the water and to avoid contact with the bottom sediment.
3. Allow the temperature reading (bottom number) to stabilize. This may take a few minutes. Record the temperature (in degrees Celsius) on the field data sheet.
4. Allow the dissolved oxygen reading (top number) to stabilize as the probe is moving through the water at 1 foot per second. Record the lowest average % saturation on the field data sheet.
5. Press the MODE key, and (with probe still moving) record the lowest average dissolved oxygen in mg/L on the field data sheet
6. Record any additional comments or observations, using the back of the sheet if needed
7. Gather equipment and travel to the next stop. REMEMBER – don't turn off the meter in between sampling sites or you will need to recalibrate!
8. After the last sample, press the mode key until you are in % saturation mode. WITHOUT turning the meter off, rinse the probe with DI water, and reinsert it into the calibration chamber, forming an airtight seal. Leave the meter on with the probe in the chamber for 15 minutes as you drive back home or to work. After the temperature and do readings have stabilized, record the % saturation on your data sheet under "post sampling calibration confirmation."
9. Turn the meter off, return the equipment and data sheet to the NepRWA office when time permits and enjoy the rest of your day.

# TROUBLE SHOOTING

## Trouble Shooting Guide

If you should have any problems with the operation of the instrument record the symptom or error message on your data sheet. Refer to the Manufacturer's trouble shooting table below and/ or the instructions for battery replacement, also below.

**Note: If an error message briefly displays at start up, it is not indicative of a problem.**

SYMPTOM	POSSIBLE CAUSE	ACTION (Section)
1. Instrument will not turn on	A. Low battery voltage B. Batteries installed incorrectly C. System requires service	A. Replace batteries (2.3) B. Check battery polarity. (2.3) C. Return system for service (7)
2. Instrument will not calibrate	A. Membrane is fouled or damaged B. Probe anode is fouled or dark C. Probe cathode is tarnished D. System requires service	A. Replace membrane and Electrolyte (3) B. Clean anode (3) C. Clean cathode (3) D. Return system for service (7)
3. Instrument "locks up"	A. Instrument has received a shock B. Batteries are low or damaged C. System requires service	A. Remove batteries, wait 15 seconds for reset, replace batteries. (2.3) B. Replace batteries (2.3) C. Return system for service (7)
4. Instrument readings are inaccurate	A. Cal altitude is incorrect B. Salinity setting is incorrect C. Probe not in 100% water saturated air during Cal procedure D. Membrane fouled or damaged E. Probe anode is fouled or dark F. Probe cathode is tarnished G. System requires service	A. Recalibrate w/correct value (4) B. Moisten sponge and place in Cal chamber w/ probe and Recal (2&4) C. Replace membrane (3.4) D. Clean anode (3) E. Clean cathode (3) F. Return system for service (7)
5. LCD displays "LO BAT" or Main display flashes "OFF"	A. Batteries are low or damaged	A. Replace batteries (2.3)
6. Main display reads "Over"	A. Sample O <sub>2</sub> concentration is more than 60 mg/L or 500%. B. System requires service	A. Recalibrate using correct altitude and salinity compensation (4). B. Replace membrane and Electrolyte (3.4) C. Clean anode (3) D. Clean cathode (3) E. Return system for service (7)
7. Main display reads "Undr"	A. Sample O <sub>2</sub> concentration is less than -0.02 mg/L or -0.3%. B. System requires service	A. Recalibrate using correct altitude and salinity compensation (4). B. Replace membrane and Electrolyte (3.4) C. Clean anode (3)

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7. Main display reads "Undr"	A. Sample O <sub>2</sub> concentration is less than -0.02 mg/L or -0.3%. B. System requires service	A. Recalibrate using correct altitude and salinity compensation (4). B. Replace membrane and Electrolyte (3.4) C. Clean anode (3)

**Battery Replacement**

It is very important that the batteries be installed ONLY as illustrated. The instrument will not function if the batteries are installed incorrectly.



