MULTIMETER: YSI-85

This version of the protocol represents modifications that Streamkeepers incorporated to improve the quality of the YSI-85 Dissolved Oxygen data starting in August 2008. Prior to that time, we followed manufacturer's instructions, which used elevation as a proxy for barometric pressure. After that time, we measured barometric pressure and compensated for it by this method developed in cooperation with YSI technical support manager Tim Grooms:

- Program the meter to think it's at standard atmospheric pressure at zero elevation, then adjust the DO % Saturation reading when entered into the database by multiplying the recorded DO % Saturation reading by the actual number of atmospheres at the measurement site.
- Calculate DO Concentration in mg/L per USGS Office of Water Quality Technical Memorandum 2011.03 (Rounds, 2011; https://water.usgs.gov/admin/memo/QW/qw11.03.pdf), using Rounds' Equation 1 and Equations 7-11 which originate from Benson & Krause.

EQUIPMENT NEEDED

Note: Don't leave this equipment out in freezing temperatures unless you're using it. If the air temperature is below 23°F (-5°C), the YSI meter won't operate properly and your teammates probably won't either!

- YSI-85 multimeter
- Open-cell foam probe calibration sleeve
- Brunton ADC Summit pocket barometer
- watch with second hand or stopwatch
- 6 extra AA alkaline batteries
- data sheet, clipboard, pencil

Where to sample: Pick an area where the stream is flowing and appears to be well mixed. ***Do not sample downstream of where your team has disturbed the bottom.***

INITIAL INSTRUMENT PREPARATION:

1. Turn on the meter. The instrument will activate all segments of the display for a few seconds, then go through a self-test procedure that will last a few more seconds. A number will be displayed, along with the letters "CEL." That number should be between 4.8-5.2. If not, report the number on the data sheet and to the office staff.
2. If the unit displays "Err" at this point, and "Err" does not disappear after a few seconds, try turning the unit off and back on again. If it displays "LO BAT," replace the batteries and discard the old ones. If it displays other error messages, you will not be able to use the instrument—record the problem and let the staff know about it as soon as possible. If it displays number readings, "rcl," or "ErAS," the meter is functioning properly.
3. Remove the probe from the meter's chamber. Turn the chamber upside down. If the sponge inside is dry and falls out, re-insert it and wet it with a few drops of water, noting that it was dry on your data sheet. If it's missing, note that on your data sheet, stuff a lint-free tissue inside, and wet it with a few drops.
4. Check and tighten all connections along the cable, probe, and guard-piece at the end of the probe. Examine the probe. All holes should be clean of debris, and the gold cathode on the end should be shiny. The plastic membrane over the cathode should not be loose, wrinkled, or damaged, and there should be no bubbles under it. Rinse if dirty. Note any unsolvable problems on your data sheet and continue if possible with the procedure.
5. Place the probe in the stream. Set the meter in a safe place on the bank for 15 minutes to let the meter warm up and the probe stabilize to stream temperature.
6. **Record the barometric pressure**, to the nearest 0.01 in Hg (inches of mercury), plus time and sampler's initials. If the screen does not read "BARO" in the upper-left corner, hit the MODE button until it does. If it does not say "inHg" in the upper-right corner, hit the RESET button until it does.

If you have to change the barometer battery in the field, you'll have to reset the meter's "Offset" value before taking readings:

- Press the Mode button until Baro inHG shows at top of screen
- If not in inHG mode, press Reset to cycle through choices until inHG shows.
- Press and hold the Mode button until Storm ·Off shows.
- Release the Mode button and press it again one time.
- Now you should see Offset: and a decimal number.
- Press and hold Reset until the decimal number begins to flash, then release the button.
- The proper Offset value should be written on a sticker on the back of the barometer. Press Reset (increases value) or Set (decreases value) until this proper Offset value shows.
- Press Mode once to exit set mode - value stops flashing.
- Press and hold Mode button until you only see Baro inHG and the barometric pressure.

TAKING MEASUREMENTS FOR DISSOLVED OXYGEN, TEMPERATURE, CONDUCTIVITY, AND SALINITY:

BUTTON BUMMERS: The YSI-85's buttons are slow to respond, so wait a few seconds after pressing any button to give the meter time to react. Otherwise, you may skip over the screen you want. Also, sometimes the buttons don't respond at all and you have to try again. Just be patient.

1. Calibrate the meter for dissolved oxygen:
   a) Take the foam calibration sleeve out of its bag and wet it in the stream, then gently wring it out. (If there's no foam sleeve, a rag will do.) Take the probe out of the stream where it's been soaking, rinse off any dirt, and firmly flick water off the probe as if you were shaking down a fever thermometer. Place the probe into the foam sleeve, pulling the probe back about ½" from the end to keep any foam from touching the DO membrane.
   b) Put the meter and probe in a safe spot, preferably out of the sun. If it's near freezing, set the sponge on the tarp – it will stick to frozen rocks.
   c) Erase prior readings from the meter:
      - Press the MODE button as many times as needed for "ErAS" to appear on the screen.
      - Press the DOWN ARROW and ENTER buttons simultaneously for approximately 5 seconds.
      - When "DONE" flashes on the screen for 1-2 seconds, the data have been erased, and the meter will automatically return to normal operation (DO % Saturation screen).
   d) Wait for stabilization of the probe inside the calibration sleeve, defined as follows:

STABILIZATION CRITERION: During a period of 2 minutes, both DO Sat % and temp (°C) stay within 0.1 of their initial readings.

e) When you believe the probe has stabilized, press both UP and DOWN ARROW buttons at the same time. The screen should then read zero; if needed, use the UP or DOWN ARROW buttons to make it zero. Then press ENTER.*NOTE: If you don't have a barometer and won't be able to get a pressure reading later (e.g., from a nearby weather station), then you should enter the altitude to the nearest number of hundreds of feet. For instance, if you're at 800 feet, you'd enter "8". (Elevations of your sites should be on your forms folder.) On your data sheet, explain what you've done and why.*

f) The meter will now show CAL & 100.0 in the lower part of the display. Confirm stabilization for another 30 seconds.

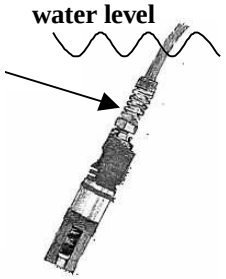
TROUBLESHOOTING THE DO METER: If the meters don't stabilize within 10 minutes of observation, try each of these steps in the following order, trying again to stabilize after each step:

- Take the probe out of the sleeve, squeeze out any excess water, and shake off the probe. Turn the meter off and then on.
- Turn off the meter, take out the batteries, wipe them and the inside of the battery cover-plate with a cloth, and re-insert them in a different order (but according to the diagram on the inside of the tubes).
- Try the above step again. Yep, again!
- Replace the batteries with the fresh batteries in the "Treasure Box" of your kit's Clean Bag.

If problems persist, note on your data sheet the variation in readings within your last stabilization observation period, and proceed.

g) When you have confirmed stabilization, press ENTER. The display should show "SAVE" and then a reading near 100%. The instrument is now calibrated for DO.

2. ***Take the probe out of the calibration sleeve.*** If there are droplets on the membrane big enough to roll off, shake them off and recalibrate (or your readings will not be accurate). If there are no droplets, you can set the foam sleeve aside.
3. ***Re-check the barometric pressure***, to the nearest 0.01 in Hg (inches of mercury). If not the same as the earlier reading, record this second reading as well.
4. ***Insert the probe in the stream:*** Standing downstream or to the side of the probe, hold it in the current, facing the probe upstream, in a place with steady flow, adequate depth, good mixing, and no surface turbulence. If the current is < 1 ft/sec, hold the probe halfway down in the water column and stir back and forth so that water moves over it at the rate of at least 1 ft/sec; but do not create bubbles. Keep the entire probe below water level—see following diagram.



Water level should be at least up to the cable connection—but be careful not to kink the wire at this stress point!

IN LOW OR SLOW WATER CONDITIONS…

- The surface water may be traveling at 1 ft/sec, but just below the surface it may be considerably slower due to the friction of the bottom sediment. Therefore, do not simply take a reading just below the surface in very shallow water. Try to find a little pool in which to stir the probe back and forth without disturbing the bottom.
- You can also look for a little riffle in which the water cascades between a couple of rocks, wedging the probe between the rocks with the water flowing over it. If the Flow team is available and the water is deep enough to immerse the propeller, have them come over and measure the velocity at the spot where the DO membrane will be; or hold the probe down in there and try to feel the force of the water. If it seems satisfactory, wedge the probe into the rocks with the conductivity-sensor holes facing up and the tip of the probe upstream of any place you've touched the rocks.
- The best method would be to test for DO using both methods and record the readings with the higher values.

5. ***Stabilize and save the readings:*** Wait for stabilization according to the following criteria: **Both readings have stopped any steady rise or fall; and during a 30 second observation, they don't vary by more than 0.5% DO and 0.1°C.** Then press ENTER and hold for 2 seconds. The meter will flash SAVE on the display along with a data-point number (which should be 01 if you erased previous readings). You have now saved readings for all parameters.
6. ***If you're taking replicates at this site:*** Remove probe from stream, shake off water, replace in stream, and collect a second reading (same as above). At "Save," the data-point number should show as 02. Also take a ***replicate barometer reading*** and record it with the replicate data.

7. ***Shake off the probe, rinse with purified water if the stream water is dirty, and replace the probe in its sleeve.*** Put the unit in the shade if possible.
8. ***Record the number or name written on the meter (e.g., "1" or "OPI").*** And if you are not submitting the data to Clallam County, record the latest calibration dates for DO ("Winkler"), conductivity, and temperature, which should be written on stickers on the meter.
9. ***Record the sampling time*** on your data sheet, to the nearest minute.
10. ***Record the readings:*** Press MODE repeatedly until "rcl" (recall) is displayed on the screen. The number below "rcl" is the data-point number the meter gave when it saved your data. Use the Up/Down arrows as needed to get to the number you want. (01 should be your sample and 02 your replicate, if you did one.) Then press ENTER successively to record the following readings, in the following order, using our rounding convention as necessary (see Quality Assurance protocol):
    a) ***Temperature***: to nearest 0.1°C.
    b) ***DO % Saturation***: to nearest 0.1%.
    c) ***DO Concentration:*** to nearest 0.1 mg/L.
    d) ***Conductivity:*** You will see a screen with a figure in "µS" or "mS" and the "°C" symbol not flashing. Go to the **next** screen, where the "°C" symbol **is** flashing, indicating that the parameter being measured is temperature-compensated conductivity. Record to the nearest whole number of µS(microSiemens). (If you go too far, work your way around again.) If the reading is in mS (milliSiemens), multiply by 1000 (i.e., move the decimal place 3 places to the right) to convert to µS, and record to the nearest whole number.
    e) **Salinity**: Record the next screen, which shows a "ppt" symbol, to the nearest tenth. This is the salinity in parts per thousand.
11. If you have replicates to transcribe, use the DOWN arrow to get to the proper "rcl" data-point number (probably 02), then continue as above to record readings. Next, check the "Water Chemistry—General" protocol to see if your pairs of readings are within the acceptable precision limits, and resample as needed.

COMMON SENSE AND EXPECTED RANGES:

Please compare your readings with the expected ranges on the datasheet. If you're outside the expected range, consider re-sampling or troubleshooting with your fellow samplers.

Conductivity readings in particular have a nasty habit of being wacky. Stream conductivity is rarely lower than 25 µS. If your readings are lower than this, you'll need to troubleshoot:

-- If the reading is 0.0 or 0.1, you might be reading the salinity ("ppt") screen rather than the proper conductivity screen; if so, scroll through the screens again (by pressing ENTER) until you get to the right one.

-- You might not have held the probe completely underwater. Try taking another set of readings.

-- The readings might be in mS rather than µS (see above).

MEASURED VS. CORRECTED READINGS:

The data for DO saturation and concentration will get adjusted once entered into the database, according to the pressure, temperature, and salinity you recorded. This formula avoids a built-in error in the YSI-85, which assumes "normal" atmospheric pressure for a given altitude, when actually that pressure can vary from normal by 5% or more.

Correction for YSI-85 DO field readings:
DOcorrected = DOfield X Pressure/29.92.

At a high-elevation site on a low-pressure day, the corrected reading could be 10% lower than the field reading; so if the pressure is low and the DO field reading is near the threshold, calculate the corrected reading. (And you can do the same if the field reading is below the threshold but the pressure is high.)

ELECTRONIC PROBLEMS?
If the YSI meters stop showing all the decimals, show wacky readings, or don't respond when you press buttons, try the battery tricks described above. They'll probably work! If not, note what happened on your data sheet and notify program staff.

12. Record the sampler's initials for both sample and replicate.

SAMPLER'S INITIALS:
Be sure to put all the initials of one sampler taking responsibility for the data; this should be someone who has been properly trained (see "Quality Assurance" protocol).

13. ***Perform a DO drift check:*** Hit the MODE button twice to get back to the real-time DO %Sat screen. Re-wet the calibration sponge in the stream, wring it out gently, and re-insert the probe as before. Keep the meter and probe in the shade, if possible, and allow the probe to stabilize as before:

STABILIZATION CRITERION: During a period of 2 minutes, both DO Sat % and temp (°C) stay within 0.1 of their initial readings.

Do NOT hit any buttons on the meter. When stabilization is reached, you'll want the DO % Saturation reading to be between 98-102%; if not, you'll need to re-calibrate the meter and re-take the readings, or your data will be flagged as "estimated" or "rejected".

14. If the stabilized DO % Saturation reading is satisfactory, record it to the nearest 0.1%.
15. Record the time and sampler's initials.
16. ***Turn off the meter***, put the probe into the meter's chamber, and put the calibration sponge back into its bag.

ALTERNATIVE MULTIMETER PROCEDURE FOR POOR CONDITIONS: *If the weather is severe and you wish to minimize your time on the creek, you may collect a sample and conduct testing in your car within 10 minutes (see Water Chem—General chapter & Standard Methods 4500-O):*

- Calibrate the YSI-85 at home, with the soaking sponge as close to stream temperature as possible; note both water temperature and barometric pressure.
- At each site, be sure to warm up the meter for 15' before taking readings (or just keep it on all day); note barometric pressure at each site.
- Explain the deviance from normal procedures on your data sheet. Staff will have to adjust your data because of pressure differences between calibration and sampling sites.