

WATERSHED TESTING

LAB ENV 5.CALC

From *Biology with Calculators*, Vernier Software & Technology, 2000.

INTRODUCTION

There are many reasons for determining water quality. You may want to compare the water quality upstream and downstream to locate a possible source of pollutants along a river or stream. Another reason may be to track the water quality of a watershed over time by making measurements periodically. When comparing the quality of a watershed at different times, it is important that measurements be taken from the same location and at the same time of day.

In 1970, the National Sanitation Foundation, in cooperation with 142 state and local environmental specialists and educators, devised a standard index for measuring water quality. This index, known as the Water Quality Index, or *WQI*, consists of nine tests to determine water quality. These nine tests are; temperature, pH, turbidity, total solids, dissolved oxygen, biochemical oxygen demand, phosphates, nitrate, and fecal coliform. A graph for each of the nine tests indicates the water quality value (or Q-value) corresponding to the data obtained. Once the Q-value for a test has been determined, it is multiplied by a weighting factor. Each of the tests is weighted based on its relative importance to a stream's overall quality. The resulting values for all nine tests are totaled and used to gauge the stream's health (excellent, good, medium, poor, or very poor).

While the WQI can be a useful tool, it is best used in light of historical data. Not all streams are the same, and without historical data it is difficult to determine if a stream is truly at risk. For example, a stream may earn a very low WQI value and appear to be in poor health. By looking at historical data, however, you may find that samples were collected just after a heavy rain with an overflow from the local city sewer system and do not accurately reflect the stream's health.

PURPOSE

The purpose of this experiment is to perform four of the WQI tests; water temperature, dissolved oxygen, pH, and total dissolved solids, to determine the general quality of the stream or lake sampled.

EQUIPMENT/MATERIALS

LabPro
TI Graphing Calculator
DataMate program
Vernier Dissolved Oxygen Probe
Vernier pH Sensor

Vernier Conductivity Probe
Temperature Probe
4 water sampling bottles
large plastic cup or beaker
DO calibration bottle

PRE-LAB PROCEDURE

Important: Prior to each use, the Dissolved Oxygen Probe must warm up for a period of 30 minutes as described below. If the probe is not warmed up properly, inaccurate readings will result. Perform the following steps to prepare the Dissolved Oxygen Probe.

1. Prepare the Dissolved Oxygen Probe for use (see Figure 1).
 - a. Unscrew the membrane cap from the tip of the probe.
 - b. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling Solution.
 - c. Carefully thread the membrane cap back onto the electrode.
 - d. Place the probe into a 250-mL beaker containing distilled water.

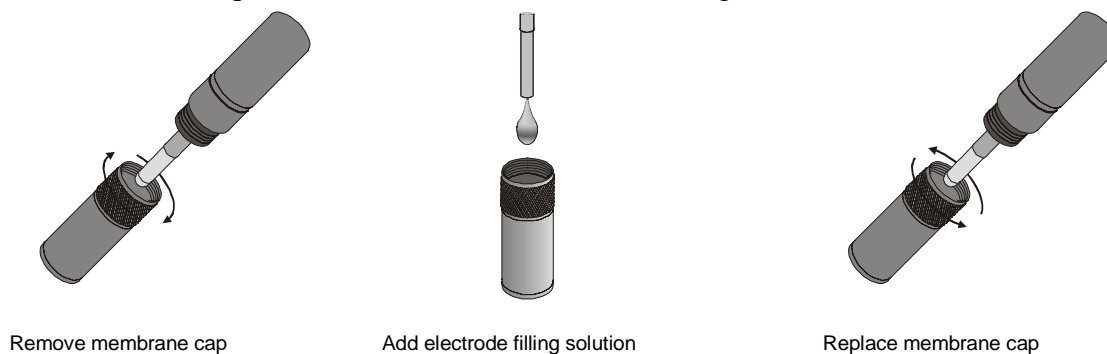


Figure 1

2. Plug the Dissolved Oxygen Probe into Channel 2 of the LabPro. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.
3. Turn on the calculator and start the DATAMATE program. Press to reset the program.
4. The calculator screen should display DO (MG/L) in CH 2. If not, tell your instructor.

5. It is necessary to warm up the Dissolved Oxygen Probe for 10 minutes before taking readings. With the probe still in the distilled water beaker, wait 10 minutes while the probe warms up. The probe must stay connected at all times to keep it warmed up.
6. Prepare the calculator and interface for calibration.
 - a. Select SETUP from the main screen.
 - b. Press once to select CH2.
 - c. Select CALIBRATE from the setup screen.
7. Calibrate the Dissolved Oxygen Probe.
 - If your instructor directs you to manually enter the calibration values, select MANUAL ENTRY from the CALIBRATION screen. Enter the slope and intercept values, select OK, then proceed to Step 1 of the procedure.
 - If your instructor directs you to perform a new calibration, select CALIBRATE NOW from the CALIBRATION screen and follow this procedure.

Zero-Oxygen Calibration Point

- a. Remove the probe from the water bath and place the tip of the probe into the Sodium Sulfite Calibration Solution (see Figure.2)

Important: No air bubbles can be trapped below the tip of the probe or the probe will sense an inaccurate dissolved oxygen level. If the voltage does not rapidly decrease, tap the side of the bottle with the probe to dislodge the bubble. The readings should be in the 0.2- to 0.5-V range.

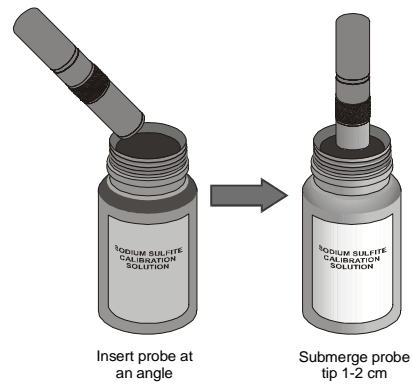


Figure 2

- b. When the voltage stabilizes (~1 min), press .
- c. Enter "0" as the known value in mg/L.

Saturated DO Calibration Point

- a. Rinse the probe with distilled water.
- b. Unscrew the lid of the calibration bottle provided with the probe. Slide the lid and the grommet about 1/2 inch onto the probe body.
- c. Add water to the bottle to a depth of about 1/4 inch and screw the bottle into the cap, as shown. **Important:** Do not touch the membrane or get it wet during this step (see Figure 3).
- d. Keep the probe in this position for about a minute. The readings should be in the 2.0- to 3.3-V range. When the voltage stabilizes, press .

- e. Enter the correct saturated dissolved-oxygen value (in mg/L) from Table 3 (for example, “8.66”) using the current barometric pressure and air temperature values. If you do not have the current air pressure, use Table 4 to estimate the air pressure at your altitude.
 - f. Select OK to return to the setup screen.
 - g. Select OK to return to the main screen.
 - h. Prepare the probe for transport by filling the calibration bottle half full with water. Secure the Dissolved Oxygen Probe far enough down in the bottle that the membrane is completely covered by water. Screw the calibration bottle lid completely onto the bottle so that no water will leak out.
8. Connect the sensors to the interface.
 - a. Plug a pH Sensor into Channel 2 of the LabPro.
 - b. Plug the Temperature Probe into Channel 3 of the LabPro.
 9. If the calculator screen has gone blank, press the key to power up the calculator and select YES from the CONTINUE menu.
 10. Set up the calculator and interface for the pH Sensor and Temperature Probe.
 - a. If the calculator displays a pH Sensor in CH 2 and a Temperature Probe in CH 3, proceed directly to Step 11. If it does not, continue with this step to set up your sensors manually.
 - b. Select SETUP from the main screen.
 - c. Press once, then press to select CH2.
 - d. Select PH from the SELECT SENSOR menu.
 - e. Press once, then press to select CH3.
 - f. Select TEMPERATURE from the SELECT SENSOR menu.
 - g. Select the correct temperature probe from the TEMPERATURE menu.
 - h. Select OK to return to the main screen.

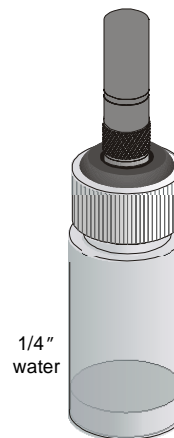


Figure 3

PROCEDURE

You will measure dissolved oxygen concentration, pH, and water temperature at four different sites. You will fill one sample bottle completely full with water from each site so that you can later measure total dissolved solids back in the lab.

PART I: MEASURING DISSOLVED OXYGEN, PH, AND TEMPERATURE

1. Choose a desirable location to perform your measurements. It is best to take your samples as far from the shore edge as is safe. Your site should be representative of the whole watershed.

2. Rinse the sampling bottle a few times with stream water. Place the sample bottle below the surface, allowing water to flow into the opening for two to three minutes. Fill the sampling bottle so it is completely full and then stopper the bottle under water. This should minimize the amount of atmospheric oxygen that gets dissolved in the water prior to making measurements. Label the sample bottle *Site 1a*.
3. Measure dissolved oxygen, pH, and temperature of your water sample. **Important:** Place only one probe in the water at a time.
 - a. Remove the Dissolved Oxygen Probe from its storage bottle. Place the probe into the water and gently swirl to allow water to move past the probe's tip.
 - b. Monitor the readings displayed on the calculator screen. When the reading is stable, record the dissolved oxygen concentration in Table 1. Remove the probe from the water and place it back into the storage bottle.
 - c. Remove the pH Sensor from its storage bottle. Place the sensor into the water.
 - d. Monitor the pH reading displayed on the calculator screen. Record the pH in Table 1 when the reading has stabilized. Remove the sensor from the water and place it back into the storage bottle.
 - e. Place the Temperature Probe into the water sample.
 - f. Monitor the temperature reading displayed on the calculator screen. Record the temperature in Table 1 when the reading has stabilized. Remove the probe from the water.
4. Repeat Procedure steps 2 – 3 at a second location 20 feet from Site 1a. The second location will be designated Site 1b.
5. Repeat Procedure steps 2 – 3 at two locations one mile from Site 1a that are approximately 20 feet apart. These sites will be designated Site 2a and Site 2b.



PART II: MEASURING TOTAL DISSOLVED SOLIDS (TDS)

6. Set the switch on the Conductivity Probe box to 0-2000 μS (2000 μS = 1000 mg/L TDS).
7. Unplug all sensors from the LabPro or CBL 2 interface. Plug the Conductivity Probe into Channel 1 of the interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.



8. Turn on the calculator and start the DATAMATE program. Press to reset the program.
9. Set up the calculator and interface for the Conductivity Probe.
 - a. Select SETUP from the main screen.
 - b. Press to select CH 1.
 - c. Select CONDUCTIVITY from the SELECT SENSOR menu.
 - d. Select CONDUCT 1000 (MG/L) from the CONDUCTIVITY menu.
10. You are now ready to prepare the Conductivity Probe for calibration.
 - If your instructor directs you to use the stored calibration, proceed directly to Step 21.
 - If your instructor directs you to manually enter the calibration values, select CALIBRATE then MANUAL ENTRY. Enter the intercept and slope values for the 0-1000 mg/L conductivity calibration, select OK, then proceed to Step 21.
 - If your instructor directs you to perform a new calibration for the Conductivity Probe, follow this procedure.

First Calibration Point

- a. Select CALIBRATE, then CALIBRATE NOW.
- b. Perform the first calibration point with the probe in the air (e.g., out of any solution).
- c. Wait for the readings stabilize and press .
- d. Enter "0" as the mg/L TDS.

Second Calibration Point

- a. Place the Conductivity Probe into the 500 mg/L TDS standard solution. The hole near the tip of the probe should be covered completely.
 - b. Wait for the readings to stabilize and press .
 - c. Enter "500" as the mg/L TDS.
11. Set up the data-collection mode.
 - a. To select MODE, press once and press .
 - b. Select SINGLE POINT from the SELECT MODE menu.
 - c. Select OK to return to the main screen.

12. Collect TDS concentration data.
 - a. Place the tip of the electrode into the sample water from Site 1a. The hole near the tip of the probe should be covered completely.
 - b. When the reading has stabilized, select **START** to begin sampling. **Important:** Leave the probe tip submerged while data is being collected for the next 10 seconds.
 - c. After 10 seconds, the TDS value will appear on the calculator screen. Record this value in Table 1 (round to the nearest 1 mg/L TDS).
 - d. Press to return to the main screen.
 - e. Rinse the probe with distilled water.
13. Repeat Procedure step 12 for the water samples collected from the other three sites.

DATA SHEET

Name _____

Name _____

Period _____ Class _____

Date _____

WATERSHED TESTING

DATA TABLES

Table 1				
Location	Dissolved Oxygen (mg/L)	pH	Total Dissolved Solids (mg/L)	Temperature (°C)
Site 1a				
Site 1b				
Average				
Site 2a				
Site 2b				
Average				

Temperature Difference: _____

Table 2 DO (% Saturated)			
	Dissolved Oxygen (mg/L)	DO in Saturated Water	% Saturated
Site 1			
Site 2			

PROCESSING THE DATA

1. Calculate the averages for measurements at each location and record the results in Table 1.
2. Determine the % saturation of dissolved oxygen:
 - a. Copy the value of dissolved oxygen measured at each site from Table 1 to Table 2.
 - b. Obtain the barometric pressure, in mm Hg, using either a barometer or a table of barometric pressure values according to elevation (your instructor will provide either the barometer reading or the table of values).
 - c. Note the water temperature at each site.
 - d. Using the pressure and temperature values, look up the level of dissolved oxygen for air-saturated water (in mg/L) from a second table provided by your instructor. Record the results for each site in Table 2.
 - e. To determine the % saturation, use this formula:

$$\% \text{ saturation} = \frac{\text{measured D.O. level}}{\text{saturated D.O. level}} \times 100$$

- f. Record the % saturation of dissolved oxygen in Table 2.
3. Using Tables 3 – 5, determine the water quality value (Q value) for each of the following measurements: dissolved oxygen, pH, and TDS. You may need to extrapolate to obtain the correct Q values. Record your result in Table 7 for Site 1 and in Table 8 for Site 2.
4. Subtract the two average temperatures from the sites that are about a mile apart. Record the result as the temperature difference in the blank below Table 1.
5. Using Table 6 and the value you calculated above, determine the water quality value (Q value) for the temperature difference measurement. You may need to extrapolate to obtain the correct Q values. Record your result in Table 7 for Site 1 and Table 8 for Site 2. The temperature Q-value will be the same in both tables.
6. Multiply each Q-value by the weighting factor in Table 7 for Site 1 and in Table 8 for Site 2. Record the total Q-value in Tables 7–8.

Table 3	
Dissolved Oxygen (DO) Test Results	
DO (% saturation)	Q Value
0	0
10	5
20	12
30	20
40	30
50	45
60	57
70	75
80	85
90	95
100	100
110	95
120	90
130	85
140	80

Table 4	
pH Test Results	
pH	Q Value
2.0	0
2.5	1
3.0	3
3.5	5
4.0	8
4.5	15
5.0	25
5.5	40
6.0	54
6.5	75
7.0	88
7.5	95
8.0	85
8.5	65
9.0	48
9.5	30
10.0	20
10.5	12
11.0	8
11.5	4
12.0	2

- Determine the overall water quality of your stream by adding the four total Q-values in Table 7 for Site 1 and in Table 8 for Site 2. Record the result in the line next to the label “Overall Quality.” The closer this value is to 100, the better the water quality of the stream at this site.

Note: This quality index is not a complete one—this value uses only four measurements. For a more complete water quality determination, you should measure fecal coliform counts, biological oxygen demand, phosphate and nitrate levels, and turbidity. It is also very valuable to do a “critter count”—that is, examine the macroinvertebrates in the stream.

Table 5	
Total Dissolved Solids (TDS) Test Results	
TDS (mg/L)	Q Value
0	80
50	90
100	85
150	78
200	72
250	65
300	60
350	52
400	46
450	40
500	30

Table 6	
Temperature Test Results	
Δ Temp ($^{\circ}$ C)	Q Value
0	95
5	75
10	45
15	30
20	20
25	15
30	10

Table 7 Site 1			
Test	Q-Value	Weight	Total Q-Value
DO		0.38	
pH		0.24	
TDS		0.16	
Temperature		0.22	

Overall Quality: _____

Table 8 Site 2			
Test	Q-Value	Weight	Total Q-Value
DO		0.38	
pH		0.24	
TDS		0.16	
Temperature		0.22	

Overall Quality: _____

QUESTIONS

1. Using your measurements, what is the quality of the watershed? Explain.

2. How do you account for each of the measurements? For example, if the pH of the downstream site is very low, and you took measurements above and below an auto repair station, perhaps battery acid leaked into the stream.

DO:

pH:

TDS:

Temperature:

3. How did measurements between the two sites compare? How might you account for any differences, if any?

4. Compare the measurements you obtained with those from previous months or years. Has the water quality improved, remained about the same, or declined? Explain.

5. Why would you expect the DO in a pond to be less than in a rapidly moving stream? If applicable, did your measurements confirm this assumption? Explain.

6. What could be done to improve the quality of the watershed?

CALIBRATION TABLES

Table 9: 100% Dissolved Oxygen Capacity (mg/L)												
	770 mm	760 mm	750 mm	740 mm	730 mm	720 mm	710 mm	700 mm	690 mm	680 mm	670 mm	660 mm
0°C	14.76	14.57	14.38	14.19	13.99	13.80	13.61	13.42	13.23	13.04	12.84	12.65
1°C	14.38	14.19	14.00	13.82	13.63	13.44	13.26	13.07	12.88	12.70	12.51	12.32
2°C	14.01	13.82	13.64	13.46	13.28	13.10	12.92	12.73	12.55	12.37	12.19	12.01
3°C	13.65	13.47	13.29	13.12	12.94	12.76	12.59	12.41	12.23	12.05	11.88	11.70
4°C	13.31	13.13	12.96	12.79	12.61	12.44	12.27	12.10	11.92	11.75	11.58	11.40
5°C	12.97	12.81	12.64	12.47	12.30	12.13	11.96	11.80	11.63	11.46	11.29	11.12
6°C	12.66	12.49	12.33	12.16	12.00	11.83	11.67	11.51	11.34	11.18	11.01	10.85
7°C	12.35	12.19	12.03	11.87	11.71	11.55	11.39	11.23	11.07	10.91	10.75	10.59
8°C	12.05	11.90	11.74	11.58	11.43	11.27	11.11	10.96	10.80	10.65	10.49	10.33
9°C	11.77	11.62	11.46	11.31	11.16	11.01	10.85	10.70	10.55	10.39	10.24	10.09
10°C	11.50	11.35	11.20	11.05	10.90	10.75	10.60	10.45	10.30	10.15	10.00	9.86
11°C	11.24	11.09	10.94	10.80	10.65	10.51	10.36	10.21	10.07	9.92	9.78	9.63
12°C	10.98	10.84	10.70	10.56	10.41	10.27	10.13	9.99	9.84	9.70	9.56	9.41
13°C	10.74	10.60	10.46	10.32	10.18	10.04	9.90	9.77	9.63	9.49	9.35	9.21
14°C	10.51	10.37	10.24	10.10	9.96	9.83	9.69	9.55	9.42	9.28	9.14	9.01
15°C	10.29	10.15	10.02	9.88	9.75	9.62	9.48	9.35	9.22	9.08	8.95	8.82
16°C	10.07	9.94	9.81	9.68	9.55	9.42	9.29	9.15	9.02	8.89	8.76	8.63
17°C	9.86	9.74	9.61	9.48	9.35	9.22	9.10	8.97	8.84	8.71	8.58	8.45
18°C	9.67	9.54	9.41	9.29	9.16	9.04	8.91	8.79	8.66	8.54	8.41	8.28
19°C	9.47	9.35	9.23	9.11	8.98	8.86	8.74	8.61	8.49	8.37	8.24	8.12
20°C	9.29	9.17	9.05	8.93	8.81	8.69	8.57	8.45	8.33	8.20	8.08	7.96
21°C	9.11	9.00	8.88	8.76	8.64	8.52	8.40	8.28	8.17	8.05	7.93	7.81
22°C	8.94	8.83	8.71	8.59	8.48	8.36	8.25	8.13	8.01	7.90	7.78	7.67
23°C	8.78	8.66	8.55	8.44	8.32	8.21	8.09	7.98	7.87	7.75	7.64	7.52
24°C	8.62	8.51	8.40	8.28	8.17	8.06	7.95	7.84	7.72	7.61	7.50	7.39
25°C	8.47	8.36	8.25	8.14	8.03	7.92	7.81	7.70	7.59	7.48	7.37	7.26
26°C	8.32	8.21	8.10	7.99	7.89	7.78	7.67	7.56	7.45	7.35	7.24	7.13
27°C	8.17	8.07	7.96	7.86	7.75	7.64	7.54	7.43	7.33	7.22	7.11	7.01
28°C	8.04	7.93	7.83	7.72	7.62	7.51	7.41	7.30	7.20	7.10	6.99	6.89
29°C	7.90	7.80	7.69	7.59	7.49	7.39	7.28	7.18	7.08	6.98	6.87	6.77
30°C	7.77	7.67	7.57	7.47	7.36	7.26	7.16	7.06	6.96	6.86	6.76	6.66

Table 10: Approximate Barometric Pressure at Different Elevations					
Elevation (feet)	Pressure (mm Hg)	Elevation (feet)	Pressure (mm Hg)	Elevation (feet)	Pressure (mm Hg)
0	760	2000	708	4000	659
250	753	2250	702	4250	653
500	746	2500	695	4500	647
750	739	2750	689	4750	641
1000	733	3000	683	5000	635
1250	727	3250	677	5250	629
1500	720	3500	671	5500	624
1750	714	3750	665	5750	618