

## ABSTRACT

Students use laptops and sensors to investigate water quality and human impact on the local water supply. Groups analyze water pressure, pH, conductivity, nitrate ion levels, dissolved oxygen, and flow rate of water at various locations. Final presentations relate the data to the environment studied.

## TIES TO CURRICULUM

In accordance with national science and mathematics standards, *Aquatic Field Data* allows students to conduct hands-on, interactive science inquiry with real-life applications outside school. Students apply technological resources to solve science and math problems.

In an optional part of the activity, students explore technological ways to share their data using the Internet and videoconferencing.

## LEARNING OBJECTIVES

Students will learn to

- ◆ measure water quality data with laptops and sensors;
- ◆ organize results with tables and graphs;
- ◆ analyze data using mathematical skills;
- ◆ determine area and volumetric flow rate of water source from field data; and
- ◆ communicate results for analysis with fellow students by posting information on a Web site, by email, and/or through videoconferencing.

## NUMBER OF LAPTOPS AND GROUP SIZE

Each group of three students needs one laptop. If laptops are limited, form larger groups of 6–8 students. A server networks the computers for sharing and data.

## TIME REQUIREMENT

Time requirements for *Aquatic Field Data* varies with group size.

Task	Time	Location
Introduction	5½ hours	Classroom
Field activity (if each group collects all data)	2 hours	Field
Field activity (if groups share data collection)	1½ hours	Field
Homework assignment	2 hours	Home

## MATERIALS

*Computer and Software*

- ◆ Laptop computer (Pentium II 233, 32 MB RAM, 2GB HD, 13.3 Active Matrixcolor LCD panel)
- ◆ 3COM Megahertz 10/100 LAN & 56K Cellular Modem PCMCIA card with cellular phone support
- ◆ ACCTON 10-Base-T Concentrator 8 RJ-45 Ports
- ◆ Word processing and spreadsheet software

*Sensors and Related Materials*

- ◆ Logger Pro software
- ◆ Serial Box Interface with power supply, SBI-IBM
- ◆ Sensors for pH, dissolved oxygen, flow rate, temperature, conductivity, nitrate ion-selective electrode (ISE), and ISE amplifier
- ◆ Texas Instruments's Calculator Based Lab system
- ◆ Graphing calculator and software
- ◆ Vernier's Graphical Analysis software
- ◆ *Biology with Computers* (Holmquist and Volz, 1997)

*Experimental Design Pool*

- ◆ Plastic swimming pool, about 1.5 m (e.g., Empire Independent's 5' pool with 14" molded plastic laminate, part no. 136457)

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## LESSON DESCRIPTION

**Introduction**

Introduce the concept of water quality, and explain that the class will be testing the water quality of a local body of water using computers and sensors. You may wish to use the following labs from *Biology with Computers* to introduce some key concepts:

- ◆ Lab 5: Conducting Solutions—relates conductivity to dissolved solids
- ◆ Lab 18: Acid Rain—explores pH and the environment
- ◆ Lab 19: Dissolved Oxygen in Water—relates temperature, photosynthesis, and dissolved oxygen

There are other lab activities in the Vernier Sensors manuals that teach students about these concepts using related sensors. To demonstrate the pressure probe, use the Boyle's Law experiment in the Vernier Pressure Probe instruction manual to relate increased pressure with greater water depths. To demonstrate the nitrate ion-selection electrode with ISE Amplifier, calibrate the electrode as described in the Vernier Ion Sensor instruction manual. Take readings of de-ionized water and tap or stream water to determine the nitrate level.

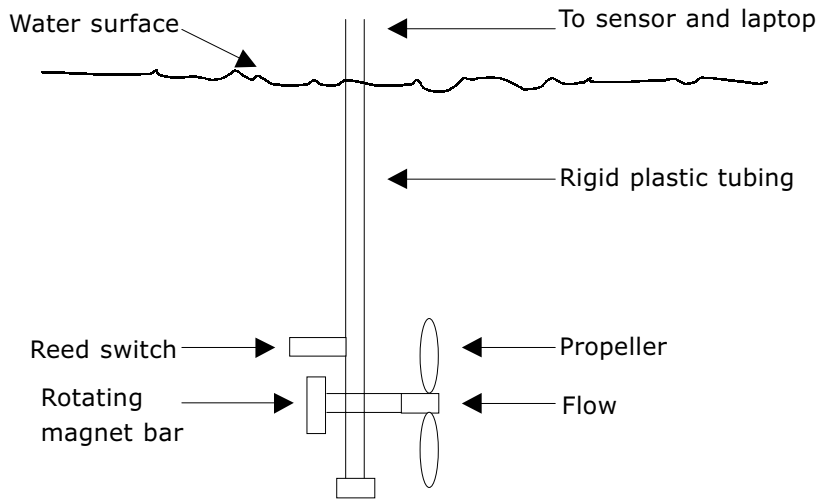
To demonstrate the flow rate sensor, place the flow rate sensor (Figure 1) in a stream or into the Experimental Design Pool (EDP) which is shown in Figure 2. To calculate various flow rates of the EDP, use the valve to regulate the flow of water in the pool, open the flow rate sensor file on Logger Pro, and place the sensor below the water's surface.

Measure depth and width to determine the area (Figures 3–5), then calculate volumetric flow rate (Q):

$$Q = \text{Cross-sectional Area} \times \text{Flow Rate}$$

Use EDP or stream area (in m<sup>2</sup>) and flow rate of water in meters per second.

**Figure 1: Flow rate sensor**



**MATERIALS, cont'd.**

- ◆ Plastic garbage can
- ◆ Circulating pump (e.g., Beckett circulating pump, model PS1600A, 1650 gph at 1 ft., 115 volt plug in connection, submersible with threaded discharge connection, part no. 7060810)
- ◆ Plastic tubing (2.5 cm diameter, 1.8 m long)
- ◆ PVC ball valve (2.5 cm)

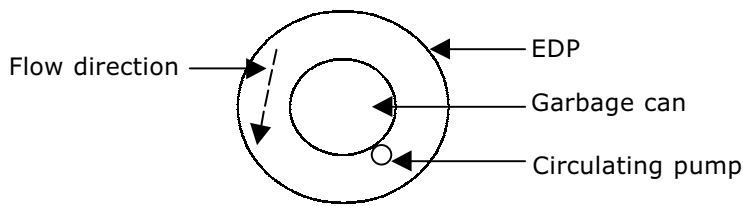
*Miscellaneous*

- ◆ Water sampler bucket
- ◆ Meter stick or tape measure

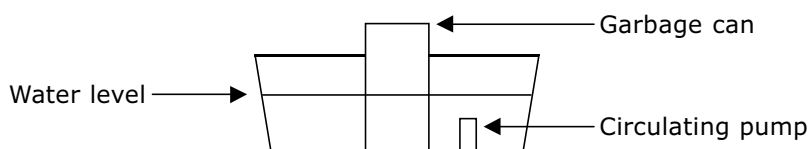
*Relaying Data (optional)*

- ◆ Laptop computer (Pentium II 233, 32 MB RAM, 6GB HD, 13.3 Active Matrix color LCD panel (server computer))
- ◆ NetMeeting, SeeU SeeMe Videoconferencing software, or FullStream Viewing software
- ◆ Connectix QuickCam VC with QuickCam Tripod (A0430-9501-000) or Camcorder with Parallel Video Card (Snappy or Allaris)
- ◆ Digital camera
- ◆ Cellular analog phone
- ◆ RJ11 computer interface
- ◆ Power adapter for cell phone (AC or car)

**Figure 2: Top view of Experimental Design Pool**



**Figure 3: Cross-section of Experimental Design Pool**



## SUGGESTIONS

- ◆ If travel to a field site is impossible, conduct the lesson using only the EDP.
- ◆ Introductory field exercises help develop good work habits.
- ◆ For homework, students can borrow sensors and research waterways in their neighborhoods.
- ◆ To share data, all students should have an email account. Yahoo! (<http://mail.yahoo.com/>) and Hotmail (<http://www.hotmail.com/>) are free email programs accessible from any computer server. Establish a group mailing list so that one message can be sent to the entire class at once.
- ◆ Compatible software is necessary for video-conferencing. Some Internet Service Providers, do not support cellular analog Internet connections. EarthLink (<http://www.earthlink.com/>) provides a connection to the Internet with an analog cellular phone. Other digital data transfer protocols may be available for your area.
- ◆ If your class does not have a Web site, post results on the student bulletin board on "The Biology Place" Web site (<http://www.biologyplace.com/>).

Figure 4: Cross-sectional area through rectangular channel

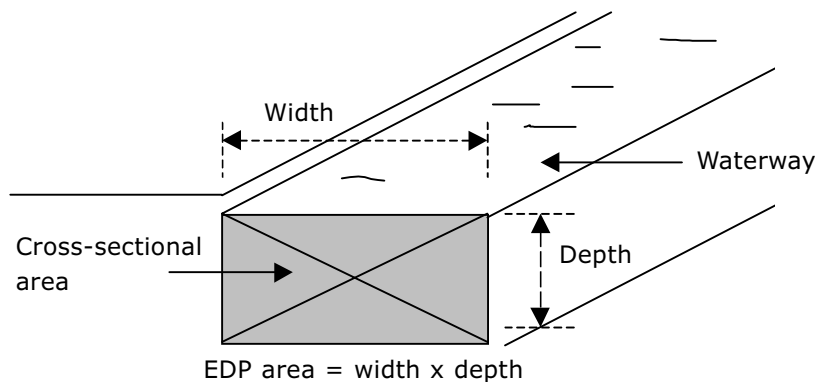
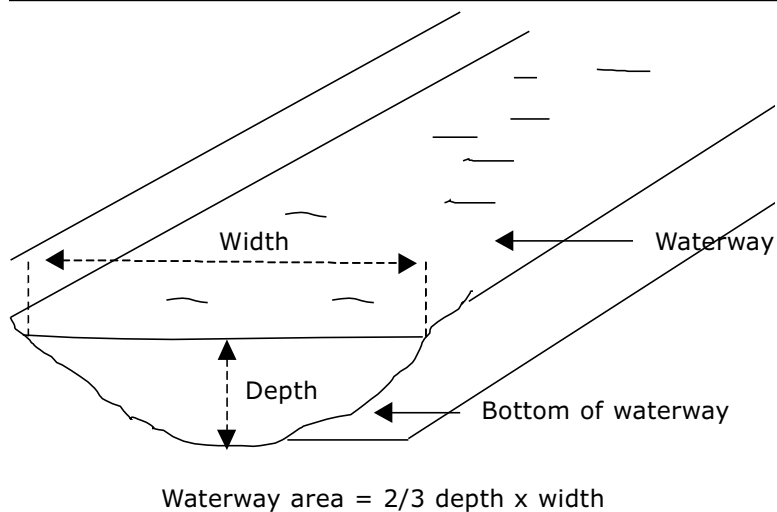


Figure 5 shows a cross-section of more common field conditions.

Figure 5: Cross-section through waterway

**Activity**

Divide students into groups of three (or larger groups if laptops are limited). Conduct preliminary tests with the sensors in the Experimental Design Pool (EDP). Adjust the flow rate in the EDP with the valve. At the first "experimental site" in the EDP, collect dissolved oxygen concentration, pH, total dissolved solids, and temperature. Organize the data into a table similar to the one in the Appendix. Add two cups of salt to the EDP to change water quality. Formulate a hypothesis about the new water quality measurements, and test the hypotheses.

Student groups design labs that test hypotheses related to water quality. Groups first perform tests in the EDP, testing factors such as nitrate ion levels, pressure at various depths, temperature variation and flow rate. At the field site, students should collect data over an extended period of time and at different times of the day. Be sure to record weather conditions.

Groups should allow 15 minutes for calibration of the nitrate ion-selective electrode and 30 minutes for polarization of the dissolved oxygen probe. Temperature, pH, pressure, conductivity, pressure and flow rate sensors are ready once they are connected to the serial box interface. If CBL systems are available, more students may gather data in smaller groups and download the data to the computer with the TI Graph Link and Vernier's Graphical Analysis to the laptop for analysis and storage.

Students should keep a lab journal on the laptop computer and record volumetric flow rate calculations and graphs of water pressure vs. depth. In their journals, students should use digital photos of the waterway, and describe the apparent health of the ecosystem. What are the physical surroundings? What types of pollution can be seen? Is there any wildlife present? Students should explain the connection between their health and the waterway. The journal should also include mathematical analysis of quantitative data.

Back at school, groups compile a final multimedia report on the health of the local waterway. Groups make presentations about local water quality, its effect on the ecosystem, and what can be done to improve water.

### **Relaying Data (optional)**

Relay data to students at school via email, by posting data onto a website, or through video-conferencing. Classmates at school can suggest other experiments.

- ◆ Email: Save the collected data in Logger Pro, copy data into a spreadsheet and email the saved file to class as an attachment.

## REFERENCES

### Books

Masterman, David, and Scott Holman. *Biology with Computers*. Portland, OR: Vernier Software, 1997.  
<http://www.vernier.com/cmat/BWC.html>

Holmquist, Dan, and Donald Volz. *Chemistry with Computers*. Portland, OR: Vernier Software, 1997.  
<http://www.vernier.com/cmat/CWC.html>

National Research Council. *National Science Education Standards*. Washington DC: National Academy Press, 1996.

### Web sites

The Biology Place. Website for students and teachers:  
<http://www.biology.com/>

Jewel Reuter's Web site.  
Pictures of the EDP:  
<http://www.classtech2000.org/Wetlands/trainpool/rain.html>

Hach Company. Water quality monitoring:  
<http://www.hach.com>

Water Quality Parameter. Descriptions of biological and chemical parameters:  
<http://imc.lisd.k12.mi.us/tests.html>

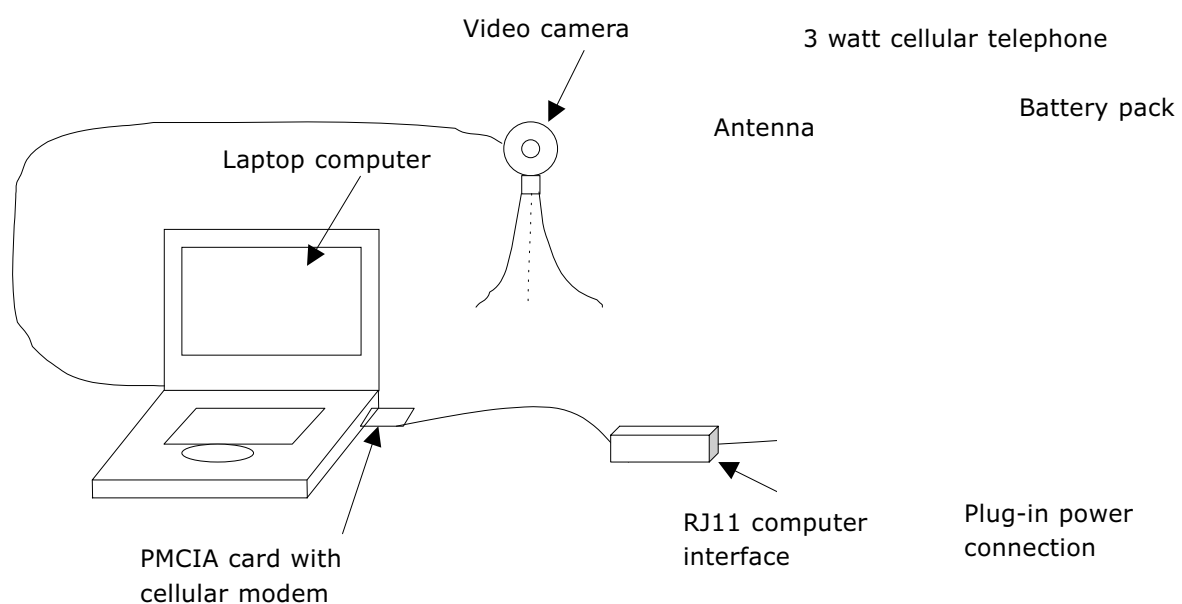
Vernier Software:  
<http://www.vernier.com/>

- ◆ Web site: To relay data to your class Web site or "The Biology Place" student bulletin board, save the image of the graph, and post the image with accompanying data tables onto the Web site. Use the cellular modem-RJ11-cellular phone setup to post the class data and a description of the project activities on your class Web site.
- ◆ Videoconferencing: Use a digital camera to record images of the test location, and save as image files. Record the weather and overall conditions each day of testing. Videoconferencing software (Microsoft NetMeeting, SeeU SeeMe, or FullStream) lets students in the field interact with classmates on campus, by relaying the methods of data collection and field conditions (see Figure 6).

## ASSESSMENT

Base your student assessments on performance in the activity and the final report. Students should come up with practical hypotheses about water quality to test in the EDP and in the field, and assess whether student groups met objectives and effectively tested their hypotheses.

**Figure 6: Remote videoconferencing system**



**APPENDIX: SAMPLE DATA TABLE****Water Quality Data and Description of Site**

Field Site: \_\_\_\_\_

Field conditions/weather: \_\_\_\_\_

<b>Parameter</b>	<b>Measurement</b>
Dissolved Oxygen (mg/L)	
pH	
Total dissolved solids (mg/L)	
Temperature (°C)	
Nitrate concentration (mg/L)	
Flow rate (m/s)	
Volumetric flow rate (m <sup>3</sup> /s)	

Wildlife:

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Appearance of Water:

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Possible Sources of Pollution:

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