Evaluating a Stream

Virginia SOL

- *Science* 6.7, LS.7, LS.11, LS.12
- *Social studies* CE.1
- *Language arts* 6.6, 7.8, 8.7
- *Math* 6.18, 6.19, 7.17, 7.18, 8.12
- *Technology* C/T8.1

Objectives

- Make plans for local water quality monitoring
- Analyze samples from a local water study site
- Record appropriate physical, chemical, and biological data
- Organize data using tables and graphs
- Interpret water quality data collected
- Make evaluations of water quality
- Relate water quality evaluations to possible pollution sources in the local area
- Present and communicate water quality data and conclusions

Materials

- Test kits and equipment as specified in protocols
- Maps and/or aerial photographs showing the water study site

Safety & Regulations

See Planning a Safe Trip in the Introduction section of this packet and Safety at the Stream at the end of this lesson. Adult chaperones will be needed for visits to the water site.

Follow all safety precautions described for using chemicals in water testing kits.

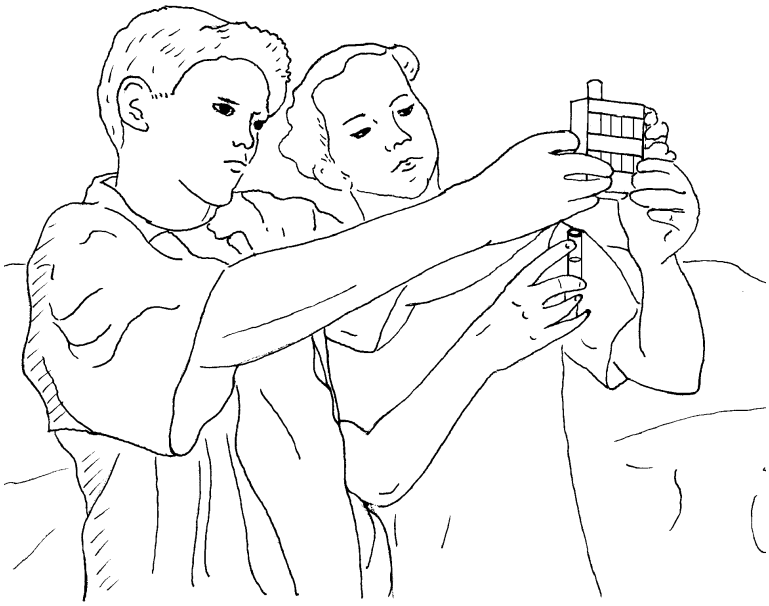
Time Needed

This lesson is written as a long-term project.

How good is the water quality at our local stream site?

Streams or ponds are fascinating for students. There is a natural tendency for both children and adults to be curious about water sites. Typical questions that students might want to answer about a local body of water include, "What lives in the pond?" "What is in the water?" and "Could our stream be polluted?" As teachers, we can take advantage of this natural curiosity and help students carry out investigations that teach the students about water issues, teach them responsible attitudes to water resources for the future, and also teach them skills needed for project-type investigations.

If students identify a local water study site of interest, they can then carry out water quality monitoring of the stream or pond. If the students collect data on a continuing basis, then they can make ongoing assessments of water quality. If goals and objectives for the project are carefully chosen, conclusions about the water quality



can be related to local issues of real significance and importance to the community. This project activity is designed for sixth grade students and so it should be carried out in a relatively simple way. However, it could of course be modified for older students, with testing for additional water quality parameters.

If carried out by sixth grade middle school students, this project will support numerous SOL. Science SOL 6.7, dealing with watersheds, specifically includes “water monitoring and analysis using field equipment including hand-held technology." The sixth grade SOL for science also state that instruction should emphasize data analysis and experimentation. The sixth grade math SOL include collection, analysis, display, and interpretation of data by graphs (6.18) and the use of simple descriptive statistics to summarize data (6.19). If technology resources are available for students to use spreadsheets and databases to organize their data, this will also support computer/technology SOL C/T8.1. For social studies, seventh grade SOL CE.1 includes citizenship skills of reviewing information and assessing problems and alternative solutions. Written descriptions and explanations can be included as part of the project for English SOL 6.6, 7.8, and 8.7.

Many different chemical, physical, and biological factors can be measured. Chemical and physical indicators of water quality can include temperature, pH, dissolved oxygen, turbidity, and various tests for specific chemicals such as nitrate and phosphate. Dissolved oxygen is a particularly important indicator of water quality because most species require oxygen. Sometimes oxygen levels drop dramatically because of sudden increases in algae populations (blooms) caused by excess nutrients. Although the algae produce oxygen by photosynthesis when it is daylight, they also use up oxygen by respiration. Bacteria and other organisms that break down the algae when they die also use up oxygen from the water. Algal blooms are a particular problem during the summer because warmer water promotes algae growth but holds less oxygen than cooler water.

In addition to the chemical and physical parameters, biological indicators are also important in water quality monitoring. Many plants and animals are associated with water of varying levels of quality. Determining the different types and numbers of each type of organisms present at a water site thus provides useful information about the water

quality. Information on all of these water quality indicators is provided in the Water Quality Monitoring chapter immediately ahead of this lesson in this packet.

Typically water quality criteria are established to protect beneficial uses of a waterway. These criteria are usually in the form of numerical standards that are not to be exceeded. For example, a minimum pH level may be established to protect fish and other aquatic wildlife. Different organisms have different tolerances to water pH. For example, carp, catfish, suckers, and many aquatic insects can tolerate a fairly wide pH range from 6–9. On the other hand, trout and mayfly larvae need the pH to be between 6.5 and 7.5. Once water quality criteria are established, this will affect waste discharge into waterways and will also affect land use and other activities. Water quality can be adversely affected by either point source or nonpoint source pollution sources. Point sources are single identifiable sources of pollution, such as sewage outlets. Nonpoint source pollution enters the water over a wide area by runoff in either urban or rural areas. Swings in water quality can also be caused by natural events. For example, periods of heavy rainfall or snowmelt can cause lowering of both pH and dissolved oxygen. Dissolved oxygen will also decline as temperature increases in the spring.

Data from any given site should be compared with other measurements over time to detect trends indicating change in quality. The data should also be compared with data recorded at other nearby sites. Measurements at one site should be recorded for a variety of different depths and locations.

It has to always be remembered that a definition of clean water is dependent on context. For example, water may be clean enough for boating but not clean enough for swimming. Water may be clean enough for swimming, but not for drinking. Conclusions reached from a water quality monitoring program must be presented in the context of the setting of the local water study site. Keeping in mind their own local context, students carrying out a water quality monitoring project can analyze their data and make assessments of the effects of point and nonpoint source pollution in their watershed.

LESSON INTRODUCTION

Making plans for local water quality monitoring...

Begin this project with your students by talking with them about the importance of water quality. Discuss our own dependence on clean, healthy streams and ponds for our local water supply. Discuss our further responsibility for keeping water clean on behalf of other people living "downstream" from us. Also discuss animals and plants that live in ponds and streams and their dependence on clean water.

The planning stages of a water quality monitoring project are very important in determining the ongoing success and usefulness of the project. Selection of suitable test sites and

identification of appropriate goals and objectives for the project are two critical issues. Middle school students should be learning and practicing to design and carry out experimental scientific investigations, and a water quality monitoring project can be a good opportunity to reinforce these skills. See the Designing an Experiment and Analyzing Experimental Data chapters of this curriculum packet for specific suggestions on incorporating skills of experimental design and data analysis into this class project.

Your class can investigate many different questions by carrying out a water quality monitoring project, from simple to complex. The simplest option would be a short-term project testing only one or two parameters. Other projects could be much more extensive, continuing over an extended time period and testing many different water quality parameters. Three possibilities are listed below. You should choose a project that best fits the needs of your teaching situation and the group of students that you are working with.

ACTIVITY PROCEDURES

Carrying out the water quality monitoring project...

Whatever type of water quality monitoring project is carried out, and whatever question is addressed, students will analyze samples from one or more local water study sites. Students will carry out selected water quality tests on the water samples that are collected. The students will need to record the appropriate physical, chemical, or biological data, then organize and summarize their data, and finally reach conclusions based on their data. It will be important for students to be organized and follow good record keeping procedures throughout. Depending on the parameters you choose to monitor, you will want to create a data sheet that can be filled out by the students. Samples of several data sheets can be found on the Internet. See the end of this lesson for web site addresses.

Cautions and Concerns

For all water quality monitoring activities, care must be taken to follow all necessary safety procedures. When making visits to any water site, be sure to follow all school field trip procedures. Adult chaperones will be needed to supervise students. For some more specific suggestions, refer to the Planning a Safe Trip information in the Introduction section of this packet and the Safety at the Stream information at the end of this lesson. When using water test kits, it is also essential to follow all safety instructions for using the different chemicals in the kits. Follow all directions exactly.

How Do Paved Surfaces Affect the Temperature of Rainwater as it Enters Streams?

This question can be addressed very simply. A project based on this question can be accomplished on your school grounds using little more than thermometers.

Students can predict, then measure variations in temperature between rainwater collected directly in a bucket, with rainwater collected from downspouts, or from a paved surface. This question can also be investigated in conjunction with looking at the diversity and abundance of macroinvertebrate communities (discussed below). Students can investigate macroinvertebrates in a stream that receives thermally polluted water, and contrast results from a stream that does not receive warmer water from impervious surfaces.

How Do Temperature, pH, Dissolved Oxygen, Transparency, and Nutrient Levels Compare at Two Different Local Water Sites?

This question leads to a project monitoring six key indicators of water quality – temperature, pH, dissolved oxygen, transparency, and the two nutrients, nitrates and phosphorus. It is important for students to learn the significant ecological role played by streamside plants in water quality. They can learn about this by comparing water quality at two stream sites, one site well shaded by a healthy riparian forest and the other site with little streamside vegetation. Students can compare the temperature, pH, dissolved oxygen, transparency, and nutrient levels of both sites. Students should also observe and record evidence of wildlife near the two stream sites.

For detailed, step-by-step instructions on monitoring these water quality indicators, you should consult the instructions and safety cautions that come with the particular test kits and analyzing instruments. Detailed protocols for these procedures are also quite widely available already. For example, the GLOBE and U.S. EPA web sites both have good information. Search for the "Practicing the Protocols" activity at the GLOBE web site (*www.globe.gov*), or locate the "U.S. EPA Manuals" page (*www.epa.gov/owow/monitoring/vol.html*) at the U.S. EPA site. Some information is also provided in the Water Quality Monitoring chapter preceding this lesson in this packet. Finally, general information on choosing and obtaining testing equipment can be found in the appendix Equipment and Technology, and further information on poss-ible funding sources in the appendix Grants and Other Support.

What Do the Animals Living in a Stream Tell Us About the Water Quality?

Answering this question involves students in looking for animals (macroinvertebrates such

as aquatic insect larvae) living in a stream as indicators of water quality. Students will be able to reach conclusions about the water quality of a stream based on the collection and identification of stream-bottom macroinvertebrates. Many macroinvertebrate species serve as useful indicators of water quality, since they are highly sensitive to swings in the levels of different water quality parameters, such as temperature, pH, or toxic chemicals. For example, some organisms are very sensitive to pollution, including stonefly, caddisfly, mayfly and dobsonfly larvae. Large numbers of these animals indicate good quality water. Conversely, poor water quality is indicated if the only organisms in a stream are pollution tolerant, including aquatic worms, blackfly and midge fly larva.

If students carry out this type of project, they can also participate with Virginia Save Our Streams (SOS), a hands-on stream conservation program of the Izaak Walton League of America. Virginia SOS leads the way in teaching about water quality monitoring by using aquatic invertebrates as indicators. While training volunteers to conduct water quality monitoring is the priority activity of Save Our Streams, the organization will also work with schools and teachers. For more information on this monitoring method, see the Virginia Save Our Streams web site at *www.sosva.com*.

Organizing water quality data...

Students should be encouraged to keep project journals throughout their project to record all their work. The students should organize and summarize their data by preparing summary data tables including simple descriptive statistics. Students should record central tendency (mean, median, or mode) and variation (range or frequency distribution) for their data (Math SOL 6.19). Some information on organizing data in summary data tables is included in the Analyzing Experimental Data chapter in the next section of this curriculum packet. Students should also use a variety of graphs to display the water quality data they have collected (Math SOL 6.18, 7.17). If students can use spreadsheets, databases, and integrated software for organizing and working with their data then Computer/Technology SOL C/T8.1 will also be supported by this activity.

Interpreting water quality data...

Help students to form appropriate inferences from their data and make predictions based on the data (Math SOL 7.18, 8.12). Students will use data to make evaluations of water quality. They will also attempt to relate water quality evaluations to possible pollution sources in the local area. The seventh grade social studies SOL CE.1 requires students to practice reviewing information, assessing problems, and comparing alternative solutions. While helping students to interpret their water quality data, they can be taught to relate their data to existing water quality problems and issues of importance in their local area, and to consider possible solutions to the problems that seem realistic in the light of measured data.

Students should be able to use different types of maps and relate water quality data to patterns of land use. For example, students could calculate what percent of their study area is covered by impervious surfaces such as pavement or rooftop, and then relate this to the measured water quality of adjacent or receiving water bodies. According to the U.S. EPA, highly developed commercial and business districts are estimated to be 85% impervious, while even our least developed urban areas, suburban residential districts with 1-acre lots are about 20% impervious. Water quality problems can be detected at relatively low levels of imperviousness of 10-20%. Topographic maps and aerial photographs can be ordered from the United States Geological Survey (USGS) through their web site (*http://edc.usgs.gov*). Students can also look at topographic maps and aerial photographs on the Internet free of charge. This can be done through the USGS site *http://mapping.usgs.gov.* This site has links to several sources for viewing maps and photographs. Terraserver is one site where both maps and photographs can be viewed and printed (*http://terraserver.homeadvisor.msn.com*). More complete information about accessing maps and aerial photographs can be found in the lesson Mapping a Watershed History later in this curriculum packet.

Ask students to discuss possible point or nonpoint sources of pollution in the local area. Students should be able to relate their water quality evaluations to possible pollution sources. Remember that swings in water quality can also be due to natural events such as periods of heavy rainfall or snowmelt, or seasonal temperature changes.

Presenting and communicating water quality data and conclusions...

Students should prepare written descriptions and explanations of their findings (English SOL 6.6, 7.8, 8.7). First, they will need time while working in small groups for thorough discussion of their data and the meaning of the data. Small groups of students can work together to write conclusion paragraphs using the structured framework suggested in the Analyzing Experimental Data chapter of this curriculum packet. Small groups of students can present their conclusions to the class.

You may then choose to have the class work together to make a group presentation to describe the results of their project to other students in the school and others in their local community. This sharing of results and conclusions could be done using posters, web pages, and/or written summaries. If the project is carried out as a long-term, continuing project, the class could update their display of results and conclusions on a regular basis.

QUESTIONS

- What are the most interesting and informative water quality test results that we have measured and recorded?
- What are the most important findings from your water quality monitoring project?
- How do water quality test results compare from different test sites?
- If past water quality test results are available, how do the present results compare with the previous results?
- What are the most important water quality problems or issues for your local community?
- How can we make use of these water quality test results?
- How could the water quality data that you have collected in this project be used to help solve local water quality problems?
- Do you think the test results would be different if they were measured at a different time of day or year?
- How do you predict water quality problems or issues in your local community will be different after another five years?
- How would you explain the results of the different tests that you carried out?
- How would you explain differences in test results for different sites or for different times?
- How many different point and nonpoint sources of pollution can you identify in your local community?
- What are some alternative solutions for local water quality problems and issues?
- How do you feel about the overall quality of water in the local community now that you have completed this project?

ASSESSMENTS

- Project journals.
- Successful data collection using field equipment, including hand-held technology when available. You might choose to evaluate students on the accuracy of their measurements using test kits.
- Summary data tables and graphical displays of collected data.
- Data organized in databases and spreadsheets.
- Written reports of the project, including background of problems that were addressed, project design, data collection procedures, results, and conclusions.
- Presentations of project results and conclusions using presentation software (for example, PowerPoint).
- If the project is carried out over the long term, regular public displays of data and conclusions, for example in the school hallway.

- If the project is carried out over the long term, regular summary reports of the water quality at the water sites.

EXTENSIONS

- Have students continue water quality monitoring on a long-term basis, collecting data regularly, and producing regular summaries of water quality at the test sites.
- If past water quality data is available, have students compare class results with the past data. What differences are there? How would you explain these differences?
- Another water quality monitoring option would be for students living in some localities to carry out projects monitoring beds of submerged aquatic vegetation (SAV). Contact the Alliance for the Chesapeake Bay for school project ideas: *www.acb-online.org*.
- Students can compare water quality data they have collected with data from other parts of the country and even different parts of the world. They can do this using data available from web-based, collaborative data-sharing programs, such as GLOBE. (See our lesson Comparing Water Quality Data for more information on comparing water quality data and for specific sources of comparative data.)
- You and others at your school might choose to make the commitment to actively participating in one of the web-based data-sharing programs, and contribute the data that your students have collected to a shared database. GLOBE is one well-known program for long-term participation. Another option for schools interested in a one-time effort is The Global Water Sampling Project. More information on both of these programs is provided in the appendix Water SOL and Other Curriculum Materials.
- Using the knowledge they have gained, your students could conduct a concerted public education effort. For example, they could develop and distribute in the community information on proper disposal of such hazardous materials as car batteries, solvents, pesticides, and oil-based paints. Contact your local waste collection facility to find out how they handle such materials. Many facilities have free collection days when you can bring such materials in for proper disposal.

RESOURCES

For the teacher...

- A Pond Investigation. Koschmann, M., & Shepardson, D. (2002). *Science & Children, 39*(8), 20–24.
- *Alliance for the Chesapeake Bay. www.acb-online.org*
- Chesapeake Bay Atlas Animations Temperature Experiments. *Bay Link Lesson Plans.*

  This is a lesson using a graphing calculator and a hand-held calculator based laboratory (CBL) data collector to investigate cooling

rates of shallow and deep water. Information and links are provided to support the use of probe technology for data collection.

- Chesapeake Bay Foundation. *www.cbf.org*
  WAVE (Watershed Action for Virginia's Environment): Contact Barbara Sayre at *bsayre@savethebay.cbf.org* or call 804-780-1392.

  Middle school curriculum unit, linked to Virginia SOL, introducing students to the Chesapeake Bay watershed and water quality issues.

- *GLOBE. www.globe.gov*
- Habitat Hunt. *Bay Link Lesson Plans.*
- Macroinvertebrate Discovery. *GLOBE.*
- Macroinvertebrate Mayhem. *Project WET.*
- Pollution Solutions: Questions of Quality. *Bay Link Lesson Plans.*
- Practicing the Protocols. *GLOBE.*
- *The Global Water Sampling Project:* An Investigation of Water Quality. *www.ciese.org/curriculum/waterproj/index.shtml*
- *U.S. Environmental Protection Agency.*

  Water Quality Standards: *www.epa.gov/waterscience/standards*

  Volunteer Wetland Monitoring: An Introduction and Resource Guide. (2000). Available by e-mailing *wetlands.helpline@epa.gov* or calling 800-832-7828.

- *Virginia Save Our Streams (SOS). www.sosva.com*

For students...

- *Water Quality Report for Kids* ("What's Up with our Nation's Waters?"). *www.epa.gov/owow/monitoring/reporting.html*

  Booklet, designed primarily for middle-school-aged youth, presents key findings of the EPA's National Water Quality Report and includes projects for school or fun, a glossary, and resources for more information.

Vendors of water monitoring field kits...

- Hach Company
  P.O. Box 389
  Loveland, CO 80539
  800-227-4224
  970-669-3050
  www.hach.com

- LaMotte Company
  P.O. Box 329
  802 Washington Avenue
  Chestertown, MD 21620
  800-344-3100
  410-778-3100
  Fax: 410-778-6394
  www.lamotte.com

- Other suppliers of water testing kits and water monitoring equipment are listed in the Equipment & Technology appendix.

Web sites with protocols to test for different water quality indicators...

- GLOBE. *www.globe.gov*
  Search for "Practicing the Protocols"
- U.S. Environmental Protection Agency. *www.epa.gov*

  U.S. EPA Manuals: *www.epa.gov/owow/monitoring/vol.html*

Web sites with water quality monitoring data sheets...

- *GLOBE. www.globe.gov*
  Hydrology Data Sheet: *http://archive.globe.gov/sda-bin/wt/ghp/tg+L(en)+P(hydrology/DataSheet)*

  A data work sheet for all common water quality parameters on a single data sheet.
- *U.S. Environmental Protection Agency. www.epa.gov*

  Volunteer Estuary Monitoring: A Methods Manual: *www.epa.gov/owow/estuaries/monitor/appendix_A.html*

  Many sample data forms for chemical and physical water quality monitoring, as well as monitoring of SAV, shellfish, marine debris, crustaceans, and more.

Safety at the Stream
(Some of these ideas from the "Stream Sense" activity by Project WET.)

For the teacher...

- Make sure the stream site is safe for students. Check the stream depth, velocity, and temperature. Also, check for walking conditions, litter, potentially dangerous wildlife, and poisonous plants.
- Bring a first aid kit on the trip.
- Define the boundaries for your visit. Make sure students understand that staying within these boundaries protects both them and wildlife.
- Locate a place where students can wash hands after the visit.

For the students...

- Stay with group members at all times.
- Wear old shoes or boots because they will likely get wet and muddy. Keep shoes on at all times to protect feet from harm.
- Stay in the designated area, and do not go near or into the water except to collect water samples.
- Do not touch any wildlife that you find or taste any water or plants.
- Learn what poison ivy and poison oak look like, and avoid these plants.
- Do not eat any food without first carefully washing your hands.

NOTES