



# WATERSHED ASSESSMENT TEACHER LAB TEMPLATE

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## Objectives

This lab will enable your students to see the links among specific topics of environmental science. They will especially realize how science must inform policy if land use and zoning regulations are to be sustainable.

## Why Use This Lab in the APES Course?

This lab integrates water resources, soil resources, and environmental policy into a very useful product. Students will feel empowered knowing that their study required them to gather both scientific and policy data and then, based on these efforts, make policy recommendations.

## Correlation to Topic Outline in Course Description

- Water Quality
- Soil Quality
- Environment and Society
- Cultural Factors
- Economic Forces
- Laws and Regulations
- Issues and Opinions

## Correlation to National Science Education Standards

- Science As Inquiry
- Life Science
- Science in Personal and Social Perspective

## Introduction

Oftentimes, city and county planners overlook upstream and downstream land use activities when they write land use plans and zoning resolutions. For instance, large parcels of land that abut a stream may be zoned for agriculture. Downstream from this location, one may notice that stream water is warmer and stream health is degraded. Recognition of upstream/downstream issues has generated a greater movement toward regional environmental planning, especially since the 1980s. As you may have taught your students, *environmental pollutants do not obey political boundaries*.

In this investigation, you will study several parameters and investigate water and soil quality, as well as examine land use and zoning. (As the instructor, you may choose to include a wetland delineation in this study.) After having accomplished these tasks, students will make carefully considered land use recommendations.

The investigation you will perform involves the impact of land use on water quality. It will examine how water can become polluted from misuse of land. Such activities as overfarming, paving, deforestation, and urbanization can increase runoff, decrease stream cover, and pollute streams, rivers, and lakes. Thomas V. Cech states, "Water is considered to be polluted if it is unusable for a particular purpose. Natural processes such as chemical reactions between rocks and water, erosion and sedimentation caused by flowing water, and infiltration of surface water into groundwater aquifers can all create pollution" (Cech 2003). He cites a 1998 U.S. Environmental Protection Agency study (*National Water Quality Inventory: 1998 Report to Congress*), which reported, "40 percent of the streams, lakes, and estuaries that were assessed (32 percent of all U.S. waters) were not clean enough for uses such as fishing and swimming." Among the leading pollutants were sediments, bacteria, nutrients, and metals. These derived both from point and nonpoint sources.

Point sources of pollution include factories and wastewater treatment plants, old landfills, abandoned mines, and underground storage tanks. More difficult to control, however, are nonpoint source pollutants. This is because they derive from diffuse sources and flow overland into surface waters. Examples of nonpoint source pollutants include lawns and gardens (pesticides and fertilizers), golf courses (pesticides and fertilizers), farms (pesticides and fertilizers), and roads (exhaust that includes organic pollution from oil and gasoline, rubber from tires, highway salt) (Cech 2003).

## Group Size

Four or five students per group.

## Lab Length

This will be the choice of the instructor. You may wish to spread the lab out over the course of several months or concentrate all of the activities into a week. Activities involve water tests and soil tests, while others have to do with land use issues and planning policy. An important additional study you may wish to perform is a wetland delineation. If you choose to do a wetland delineation, much more time will be spent on the lab. It may be advisable to invite an expert from the state office of the EPA or an environmental consulting firm to class for two or three class periods to teach your class the basics on wetland delineation. Your class will have to learn to identify hydric soils, hydrologic vegetation, and hydrological conditions. It must be left up to the individual instructor to organize this lab in a way that is suitable to your class.

## Preparation and Prep Time

You should have covered water pollution, soil quality, land use planning and zoning, and wetlands (as well as how to execute a wetland delineation should you choose to perform this as an extension) prior to this lab. The purpose of this lab is to synthesize and extend prior knowledge.

## Materials/Equipment

- LaMotte Water Pollution 1 Test Kit (Model AM-22)
- LaMotte Soil Macronutrients Test Kit (Model AM-31)
- County soil survey
- 7.5 minute USGS quadrangle map
- 100-meter tape
- *Munsell Soil Guide*
- Tree, shrub, and herbaceous layer identifying manual (e.g., *Newcomb, Audubon, Peterson*)
- Hydrologic species key for wetland identification (Contact the state office responsible for overseeing wetland protection and delineation if there is no other access to a manual.)
- Access to county, city, township, or borough zoning resolution (depending on area of your study)
- Other materials of students' choosing for presentations (e.g., poster board, camera)

## Suppliers

Ben Meadows Company

[www.benmeadows.com](http://www.benmeadows.com)

800 241-6401

Aquatic Ecosystems Inc.

[www.aquaticeco.com](http://www.aquaticeco.com)

877 FISH-STUFF

Forestry Suppliers, Inc.

[www.forestry-suppliers.com](http://www.forestry-suppliers.com)

800 647-5368

State, county, and local environmental protection agencies

County extension offices

County conservation district offices

## Safety and Disposal

- Follow instructions for water and soil test equipment carefully. "Reagents for LaMotte kits marked with a \* are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using" (LaMotte). For reagents that are not hazardous, empty them into a bucket, dilute with water, and dispose of them down a commode (LaMotte 2003).
- Avoid all contact between chemical reagents and skin/eyes.
- Keep reagents capped when not in use.
- Use lab sinks to clean all lab equipment.
- Do not store equipment where it will be exposed to temperature extremes or direct sunlight (Reen 1970).

## Teaching Tips

### General tips (relating to the procedure or process)

- Prescribe a 100-meter length of stream to study and have students divide this into three equidistant plots to study. Three sampling sites will increase the validity at different points in and along the stream.
- Try to locate a site close to your school for easy accessibility. If this is not possible, reserve transportation for each day your class will have to access the study site(s).
- Carefully watch students' use of water and soil test equipment (safety).
- Be a resource for answering questions about test procedures (to the extent that you feel is proper).
- Direct students to proper human resources, e.g., planners.
- When your students perform the water quality tests, spread them out as much as possible. If you have boots/hip waders available, have some students analyze shallow water while others study deeper water. Let them think about why test results may differ based on water depth alone. Similarly, have them do their core samplings for soil in different locations. Note: each LaMotte kit comes with a handheld core drill. Most high school students will be able to use this to get a good soil sample.
- If you have easy access to your testing site -- e.g., your class can walk to the location -- you may wish to increase the number of tests performed. If it is feasible, you may also have students do the tests at different times of the day. For instance, one group may test the water/soil later in the day, after school, to notice if results vary from earlier in the day. They can then hypothesize on the causes for the changes.
- Spend one or two class periods with students on how to read and interpret soil surveys. County soil surveys are usually available at the county extension office or conservation district in bound form or are accessible online.
- Instruct the students on how to read quadrangle maps.
- Students should understand the concept of zoning and how upstream adjacent land uses affect one another.
- Decide how much information you want to give to your students concerning water quality parameters. Do you want them to do research to learn which parameter will be the most important to study for this investigation? You may use the information contained in this section to inform them so that they can make a more educated decision on the most appropriate tests.
- Make sure students read water and soil test manuals very carefully. Be a resource for them. You may choose to go through the tests with them in a controlled classroom setting using tap water and soil that you bring into class before you set them loose outside.

- Provide students with the information they need on the basic chemical and biochemical processes that impact water quality and that are a part of this laboratory exercise: carbon dioxide, chloride, wide range alkalinity, ammonia, nitrogen, pH, nitrate-N phosphate, dissolved oxygen, hardness, silica, sulfide.

## Information on Water Quality Parameters

- **Carbon Dioxide:** "Carbon dioxide is an odorless, colorless gas produced during the respiration cycle of animals, plants and bacteria." It is produced by all animals and many bacteria and absorbed by green plants in the photosynthetic process. Since green plants photosynthesize more in the presence of sunlight, a larger quantity of oxygen is used, and carbon dioxide enters water during overnight hours. During these times, fish have a harder time respiring; conditions are more difficult when water is warmer. Most fish can tolerate carbon dioxide levels of 20 mg/L (milligrams per liter), because most fish are able to tolerate this carbon dioxide level without harmful effects (Hach 2001).

Ask students to consider what will happen when heavy cloud cover occurs and plants' ability to photosynthesize is reduced. "Carbon dioxide quickly combines in water to form carbonic acid, a weak acid. The presence of carbonic acid in waterways may be good or bad depending on the water's pH and alkalinity. If the water is alkaline (high pH), the carbonic acid will neutralize the liquid. But if the water is already quite acid (low pH), the carbonic acid will only make things worse by making it even more acid" (Hach 2001).

### Effects of CO<sub>2</sub> on fish:

<i>CO<sub>2</sub> (in mg/L)</i>	<i>Effect</i>
1.0-6.0	Fish avoid these waters.
12	Few freshwater fish can survive for long periods of time in water with a carbon dioxide level greater than this.
30	Kills the most sensitive fish immediately.
45	Maximum limit for trout.
Above 50	Trout eggs won't hatch. (Hach 2001)

- **Chloride:** A major anion in water and sewage, it can be an indication of pollution from seawater or industrial or domestic wastes. Alternately, it can derive from the passage of water through natural salt formations in the earth. U.S. Public Health Service Drinking Water Standards recommend a maximum chloride content of 250 ppm (Reen 1970).
- **Wide Range Alkalinity:** Alkalinity is easily confused with pH. While "pH measures the strength of an acid or base, alkalinity indicates a solution's power to react with acid and 'buffer' its pH -- that is, the power to keep its pH from changing" (Hach 2001).

For example, if you take a sample of pure water and buffered water, the pure water would have a pH of 7.0. However, a sample of buffered water with a pH of 6.0 could still have a high alkalinity. If a weak acid were added to the samples, the pure water would change instantly while the buffered water would change little. In a real-life example, if buffered water in a lake were to receive acid rain, life in the lake would fair much better, all other factors being equal, than life in a lake with unbuffered water. A buffering source could be limestone bedrock, for example. Limestone contains carbonate -- an excellent buffer (Hach 2001).

- **pH:** pH is a measure that describes the level of acidity of a solution. It is also an important parameter to measure water quality. The scale refers to the "concentration of hydrogen ions (atoms) in water." Values ranges from 0, very acidic with a great deal of hydrogen ions, to 14, extremely basic with a high concentration of negatively charged hydroxyl ions (Cech 2003). Although 7 on the scale equals that of distilled water, rainwater is typically around 5.6 pH.

According to Hach, most lakes are basic (alkaline) when formed, but become more acidic due to the buildup of organic materials. This happens as organic substances decay, and carbon dioxide forms and combines with water to produce "carbonic" acid, which decreases the water's pH (Hach 2001).

While most fish can tolerate pH values of about 5.0 to 9.0, waters with a pH of at least 6.5 are needed to find healthy fish populations (Hach 2001).

- **Ammonia:** Common in surface water and soil, and a by-product of decaying plant tissue and animal waste. It is made from nitrogen and hydrogen and is also produced from coal gas. In the nitrogen cycle, ammonia is formed by the action of bacteria on proteins and urea. Because it is rich in nitrogen, it provides an excellent fertilizer and is a very effective industrial/household cleaner. Levels at 0.1 mg/L represent polluted waters, while anything above 0.2 mg/L is often toxic to aquatic species (Hach 2001).

Ponds that have large populations of waterfowl usually possess high ammonia levels as well as areas immediately downstream from sewage treatment plants. This presents a problem, as ammonia is toxic to aquatic life in low concentrations. Hach notes that even at 0.06 mg/L, fish can suffer gill damage, and at levels of 0.2 mg/L, sensitive fish like trout and salmon begin to die. At levels of 2.0 mg/L, even the hardiest fish like carp cannot survive the aquatic conditions (Hach 2001; Cech 2003).

- **Nitrate-N Phosphate:** Nitrogen (nitrate) is a crucial nutrient for plant growth. Its presence in sufficient amounts is therefore critical to not only the natural environmental, but also the human economy in terms of agriculture, golf courses, and lawns. Nonetheless, in excess amounts, this important nutrient can become a pollutant. Nitrogen, when in compounds, can enter water as nitrates from fertilizers, sewage, and manures.

Nitrates also get into waterways from leaking septic systems, car exhaust, and cesspools (Hach 2001). Their increase stimulates the growth of plankton, which provides food for

fish, but which also in turn decreases the levels of dissolved oxygen as algae may grow uncontrollably. In response, fish may encounter a massive retaliatory dieback.

"The maximum contaminant load (MCL) established by the U.S. Public Health Service has been set at 45 ppm nitrate or 10 ppm (mg/L) nitrate-nitrogen" (Cech 2003). Cold water species are more sensitive to nitrate-nitrogen levels than are warm water fish.

Phosphorous occurs naturally as a salt in the mineral "apatite." Phosphorous is commonly found in soil and water and is essential to plants for growth. It can be released once it is bound to soil particles. Phosphorous also dissolves from rocks, dead organisms, animal manure, manufacturing processes, and wastewater effluent as well as artificial fertilizers. Phosphates in water stimulate growth of plants and plankton, which are then fed on by fish. Too much phosphate in water can cause too much plant and plankton growth and in turn deplete the oxygen content of the water. In itself, phosphorous has no ill effects on humans. However, at levels above 1.0 mg/L, it can disrupt coagulation processes at water treatment plants and thus hinder the removal of harmful microorganisms. These may then be released into drinking water (Cech 2003).

- **Dissolved Oxygen:** While plentiful in the atmosphere, oxygen comprises just a fraction of 1 percent of water. Dissolved oxygen is microscopic oxygen bubbles in water; it is critical for the survival of plants and aquatic wildlife. It is produced by diffusion of oxygen from the atmosphere into water via passing over rapids and waterfalls and as a by-product of photosynthesis. While trout require rather high levels of dissolved oxygen to survive, other fish, such as carp, can survive in conditions with little dissolved oxygen (Cech 2003). Habitats for warm-water fish should contain a dissolved oxygen concentration of at least 4.0 ppm, while habitats for cold-water fish should maintain levels of at least 5.0 ppm (Reen 1970).

Dissolved oxygen (DO) levels in water are often lowered due to the input of agricultural, lawn, and golf course fertilizers (nitrates and phosphates).

"How much DO an aquatic organism needs depends upon its species, its physical state, water temperature, pollutants present, and more. Consequently, it's impossible to accurately predict minimum DO levels for specific fish and aquatic animals. For example, at 5°C (41°F), trout use about 50-60 milligrams (mg) of oxygen per hour; at 25°C (77°F), they may need five or six times that amount. Fish are cold-blooded animals, so they use more oxygen at higher temperatures when their metabolic rate increases...."

"...studies suggest that 4-5 parts per million (ppm) of DO is the minimum amount that will support a large, diverse fish population. The DO level in good fishing waters generally averages about 9.0 parts per million (ppm). When DO levels drop below about 3.0 parts per million, even the rough fish die" (Hach 2001).

- **Hardness:** Cech defines hardness as "the amount of dissolved calcium, magnesium, and iron present in water" (Cech 2003). When water is hard, one may have a difficult time getting water to make soapsuds. Hard water is especially present in the United States in "Florida, New Mexico, Arizona, Utah, Wyoming, Nebraska, South Dakota, Iowa, Wisconsin,

and Indiana" (U.S. Geological Survey 2001).

Hard water creates a buildup of scale on hot-water heaters, showers, and porcelain surfaces, that is, where water can be found pooling or in residue. The scale is caused by calcium and magnesium, which form a precipitate (Cech 2003).

Hardness is described in milligrams per liter of calcium carbonate ( $\text{CaCO}_3$ ):

0-75 mg/L = soft

75-150 mg/L = moderately hard

150-300 mg/L = hard

300 mg/L and higher = very hard (Cech 2003)

- **Silica:** Silicon dioxide occurs in all natural waters and is a major nutrient for diatoms. Silica enters water through the decomposition of decaying organisms; diatoms depend on the nutrient for their skeletal structure. Values of silica in water can range from 0 to 75 ppm (Reen 1970).
- **Sulfide:** Although more common in well water, sulfide is also formed in surface waters. Sewage and industrial waters are a source of sulfide in water. "Lake muds rich in sulfates produce hydrogen sulfide during periods of very low oxygen levels that result from summer stagnation." At a few hundredths of a ppm concentration, odors develop. Levels range from a "musty" to a "rotten egg" smell. "Hydrogen sulfide is a toxic substance acting as a respiratory depressant in both [hu]man and fish" (Reen 1970).

## Information on Soil Macronutrient Parameters

LaMotte cites nine major soil macronutrients. They are nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), carbon (C), hydrogen (H), and oxygen (O). While not a nutrient, something vital to the health of a fertile soil is its pH. This laboratory exercise requires students to measure for N, P, K, and pH.

- **Nitrogen:** The bacteria on root nodules of legumes allow the plants to fix nitrogen from the air. However, most plants get their nitrogen only from the soil. The majority of plants gain nitrogen following the decomposition of organic matter in the soil as well as the application of commercial nitrogen fertilizers. It is essential to nearly all biochemical processes, which sustain plant and animal life, and is thereby a critical macronutrient to plants. Nitrogen helps the above-ground growth of plants and is a component of the chlorophyll in plants. As stated in the previous section, too much nitrogen can have deleterious environmental impacts. For plants it can also delay crop maturity and weaken stems (LaMotte 2001).

Nitrogen requirements for soil differ greatly depending on the type of crop that is being grown and the climate of the area. While alfalfa can require up to 415 pounds of nitrogen per acre to thrive, soybeans 257 pounds, and corn 240 pounds, most crops require far less than 200: cabbage 100, apples 30, oranges 90, potatoes 125, and tomatoes 100. Further, warmer climates with longer growing seasons require less nitrogen per acre given that crops have a longer time to mature (LaMotte 2001).

- **Phosphorous:** This macronutrient strengthens plant roots and increases overall yield. It also improves the palatability of plants and increases their resistance to disease. Phosphorous is typically found in soil but, as noted above, can be found in parent rock material and decaying animals. Typical topsoil contains only about 0.1 percent phosphorous. This amount can be quickly depleted by overfarming soil (LaMotte 2001).

Farming in the Northern U.S. should contain at least 75 pounds of available phosphorus per acre unless it is sandy soil (then it should contain a minimum of 50 pounds per acre). For garden crops, at least 150 pounds per acre phosphorous is needed, and as much as 200 to 300 pounds is desirable. Since Southern states in the U.S. have a longer growing season, they can get by with about one-half of the phosphorous as Northern states (LaMotte, 2001).

In terms of the amount of phosphorous needed per acre of land, nutrient requirements again vary by type of crop. Most crops need no more than 100 pounds per acre, except cowpeas, which require 250 pounds per acre to grow. While wheat and corn like approximately 100 pounds per acre, potatoes, oats, and sweet clover require no more than 20 pounds (LaMotte, 2001).

- **Potassium:** "A primary plant food of great importance, it imparts increased vigor and disease resistance to plants. It is responsible for producing strong, stiff stalks, increased plumpness in grain and seeds, and is essential in the development of chlorophyll. In mixed fertilizers its concentration is denoted by the third figure given. For example, a formula of 6-10-8 contains 8 percent potassium expressed as  $K_2O$ " (LaMotte 2001).

Soils high in clay usually have high potassium levels, as potassium is either found "fixed" in the interlayers of clay minerals or found in primary minerals. The pounds per acre can vary widely for potassium depending on the crop being grown. While apples require only 35 pounds of potassium per acre, corn and celery may need up to 240 pounds (LaMotte 2001).

- **Soil pH:** (See also the discussion above under "Information on Water Quality Parameters.") The degree of acidity or alkalinity of the soil. Also referred to as soil reaction, this measurement is based on the pH scale (see above). Aluminum is a prime contributor to soil acidity. Lime is used to counteract the aluminum in the soil. At low pH levels, aluminum and manganese become soluble and may become toxic to plants. To maintain good crop health, pH in soil must be kept between 6.0 and 6.5. Above 6.5 manganese usually becomes problematic to plant health (LaMotte, 2001).

**• Potential Problems**

- Failure in water and/or soil testing process
- Mistakes in vegetation identification
- Mistakes in soil identification (Munsell guide and soil survey)
- Mistakes in identifying hydrologic features of a landscape
- Transportation to a suitable site may be difficult for some. If this is the case, the laboratory can be run without water quality sampling, although this will limit its usefulness. Nonetheless, soil tests as well as land use studies can be conducted.

**• Possible Variations**

- Perform a macroinvertebrate analysis (seines available from suppliers listed).
- Write and implement a riparian zone restoration plan. This can be an ongoing process so that each year students build and analyze a database, perform further research, and execute a hands-on restoration project.
- Perform a wetland survey. To do this, the instructor must be familiar with how to perform a delineation. As an alternative, a professional delineator from an environmental consulting firm or the state office of the EPA can be asked to instruct the class on wetland delineation. You should allow at least three class periods to instruct the class on wetland delineation; a minimum for each of the three parameters of hydric soil, hydrologic conditions, and hydrophytic vegetation. Familiarization with a Munsell guide and wetland vegetation study will be crucial to a successful study. The area you survey in your study area should be as follows:

Beginning at least 1 meter from the bank of the creek or river (to avoid the effect of river-deposited soils on your survey), select three equidistant plots that measure 2 meters by 2 meters and perform a vegetation inventory of each canopy layer. Decide whether the area is a wetland. Remember, to be a wetland, it must have hydric soils, proper hydrology, and hydrologic vegetation.
- Soil macronutrients (real) data: pH: 7 and 6.5; nitrogen: 20 and 150; phosphorous: 100 and 200; potassium: 180 and 100.
- Data graphing and analysis.
- Postlab analysis and typical discussion questions.
- Is this an area of high-quality habitat, or can it potentially support a high quality of habitat?
- What is the human carrying capacity of the land? Humans must live somewhere. Would you hold that building in this area is intolerable? Is settlement conditional, or should humans be able to build here without limit due to poor habitat conditions? Support your answer. If humans should be able to conditionally

build here, list those conditions. How should settlement occur and to what extent?

- Discuss your recommendations with the class. If you studied the same stretch of water, are recommendations consistent? Do you agree? Why or why not? Discuss.
- Consider socio-economic as well as environmental factors of the community and respond to the following:
  - Should green space in the community be increased? If so, by how much?
  - Would your stretch of creek be suitable for passive recreation?

## Possible Assessments

Formal lab report creation

- Good class discussion
- Oral presentations

## Grading Base

- Proper page length for lab report
- Oral presentation of lab
- Organization
- Style
- Soundness (science)
- Creativity
- Accurate measurement of study area
- Reasonable parameters selected for water pollution?
- Procedures followed in testing of parameter?
- Use of soil survey (interpretation)
  - Proper identification of soils in study area
- Understanding of soil capabilities and limitations
- Interpretation of 7.5 minute quadrangle map

- Accurate identification of vegetation
- Accurate interpretation of zoning districts and land use
- Recommendations supported by sound reasoning
- Ability to delineate wetland (if applicable)

## References/Resources

### Web Sites

<http://www.ee.enr.state.nc.us/ecoadr.htm> (especially for North Carolina Schools)

<http://water.usgs.gov>

<http://usgs.gov/>

<http://cfpub1.epagov/surf/locate/index.cfm>

<http://www.epa.gov/safewater/dwinfo.htm>

<http://www.waterqualityreports.org>

<http://www.nwi.fws.gov/>

[http://ecos.fws.gov/webpage/webpage\\_usa\\_lists.html?state=all](http://ecos.fws.gov/webpage/webpage_usa_lists.html?state=all)

<http://www.soils.usda.gov/>

<http://nationalatlas.gov/>

<http://nutrientcontrol.com/>

<http://www.sprawlwatch.org/>

<http://www.plannersweb.com/sprawl/home.html>

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## Glossary

**(wide range) alkalinity:** "Indicates a solution's power to react with acid and 'buffer' its pH -- that is, the power to keep its pH from changing" (Hach 2001).

**ammonia:** Common in surface water and soil, and a by-product of decaying plant tissue and animal waste. It is made from nitrogen and hydrogen and is also produced from coal gas. In the nitrogen cycle, ammonia is formed by the action of bacteria on proteins and urea. Because it is rich in nitrogen, it provides an excellent fertilizer and is a very effective industrial/household cleaner (Hach 2001).

**aquifer:** "Porous, water-saturated layers of sand, gravel, or bedrock that can yield an economically significant amount of water" (Miller 2002).

**carbon dioxide:** Although important to maintaining life, carbon dioxide is corrosive to materials. It is a weak acid that hastens chemical weathering. At the same time, it is important in the production of fertile soils. It is an important component in the photosynthetic process. Carbon dioxide is crucial to plant growth, both phytoplankton and rooted plants, as they use the gas in its form as carbon in the water to photosynthesize plant materials such as starches, sugars, oils and proteins (LaMotte, 1970).

**chloride:** A major anion in water and sewage, it can be an indication of pollution from seawater or industrial or domestic wastes. Alternately, it can derive from the passage of water through natural salt formations in the earth (Reen 1970).

**chlorophyll:** "The basic green pigment in plants" (LaMotte 2001).

**dissolved oxygen:** Microscopic oxygen bubbles in water that are critical for the survival of plants and aquatic wildlife. It is produced by diffusion of oxygen from the atmosphere into water via passing over rapids and waterfalls and as a by-product of photosynthesis. While trout require rather high levels of dissolved oxygen to survive, other fish, such as carp, can survive in conditions with little dissolved oxygen (Cech 2003). Habitats for warm-water fish should contain a dissolved oxygen concentration of at least 4.0 ppm, while habitats for cold-water fish should maintain levels of at least 5.0 ppm (Reen 1970).

**hardness:** "The amount of dissolved calcium, magnesium, and iron present in water" (Cech 2003).

**nitrate:** "Created by bacterial action on ammonia, by lightning, or through artificial processes that include extreme heat and pressure. Nitrate is found in soluble form in both surface and groundwater. Nitrates can pollute groundwater aquifers by leaching through soils, or they can move laterally with surface water or subsurface flow to contaminate surface waters. In proper amounts, nitrates are very beneficial. However, excessive concentrations in water can cause health problems if consumed by humans" (Cech 2003).

**nitrogen (soil):** "One of the key elements essential to plant life. It stimulates aboveground growth and produces the rich green color characteristic of a healthy plant. Soils are usually low in nitrate due to the ease with which it is leached out of the soil and because it is consumed in volume by living plants. The nitrogen concentration is represented in the first figure of a fertilizer formula" (LaMotte 2001).

**nonpoint source pollution:** Pollution generated from broad, diffuse sources that can be very difficult to identify and quantify (Cech 2003).

**pH (soil):** "The degree of acidity or alkalinity of the soil. Also referred to as soil reaction, this measurement is based on the pH scale where 7.0 is neutral -- values from 0.0 to 7.0 are acid and values from 7.0 to 14.0 are alkaline. The pH of soil is determined by a simple chemical test where a sensitive indicator solution is added directly to a soil sample in a test plate" (LaMotte 2001).

**pH (water):** "pH is a unit of measure that describes the degree of acidity or alkalinity of a solution and is one of several primary indicators of water quality. The pH scale refers to the power or concentration of hydrogen ions in water. pH values range from 0 (very acidic with a high concentration of positive hydrogen atoms, H+) to 14 (very alkaline, or basic, with a very high concentration of negative hydroxyl ions, OH-). A pH of 7.0 represents exact neutrality of water at 46 degrees Fahrenheit/8 degrees Celsius, where the positive hydrogen atoms and negative hydroxyl ions are in equilibrium" (Cech 2003).

**phosphate (soil):** "A general term for a compound of phosphorous which is one of three most essential plant foods. Bone meal is a source of phosphates. Most phosphate fertilizers are either natural phosphate rock or phosphate rock treated with sulfuric acid -- super phosphates" (LaMotte 2001).

**phosphate/phosphorous (water):** "Phosphorous can originate from dissolved leachate from rocks, from decomposing organisms, animal waste, manufacturing processes, effluent from wastewater treatment plants, and as artificial fertilizers applied to crops, lawns, gardens, and golf courses. Phosphorous by itself does not have any notable health effects on humans; however, at high levels, it may interfere with coagulation processes at water treatment plants. This can hinder the removal of microorganisms bound to sediment and other particles from drinking water" (Cech 2003).

**point source pollution:** Contamination discharged through a pipe or other discrete, identifiable location (Cech 2003).

**potassium:** "A primary plant food of great importance, it imparts increased vigor and disease resistance to plants. It is responsible for producing strong, stiff stalks, increased plumpness in grain and seeds, and is essential in the development of chlorophyll. In mixed fertilizers, its concentration is denoted by the third figure given. For example; a formula of 6-10-8 contains 8% potassium expressed as K<sub>2</sub>O. The presence or absence of available potassium in soil can be determined by a simple soil test using a very small sample of the soil in question" (LaMotte 2001).

**silica:** Silicon dioxide occurs in all natural waters and is a major nutrient for diatoms. Silica enters water through the decomposition of decaying organisms; diatoms depend on the nutrient for their skeletal structure (Reen 1970).

**sulfide:** Although more common in well water, sulfide is also formed in surface waters. Sewage and industrial waters are a source of sulfide in water. "Lake muds rich in sulfates produce hydrogen sulfide during periods of very low oxygen levels that result from summer stagnation. Hydrogen sulfide is a toxic substance acting as a respiratory depressant in both [hu]man and fish" (Reen 1970).

**watershed:** "Land area that delivers the water, sediment, and dissolved substances via small streams to a major stream (river)" (Miller 2002).

**wetland:** "Land that is covered all or part of the time with salt water or fresh water, excluding streams, lakes, and open ocean" (Miller 2002).

**zoning:** "Regulating how various parcels of land can be used" (Miller 2002).