Environmental Analysis of Watersheds

A Unit for Grades 9-12 Environmental Studies Classes

Environmental Studies Project

SUNY College of Environmental Science and Forestry

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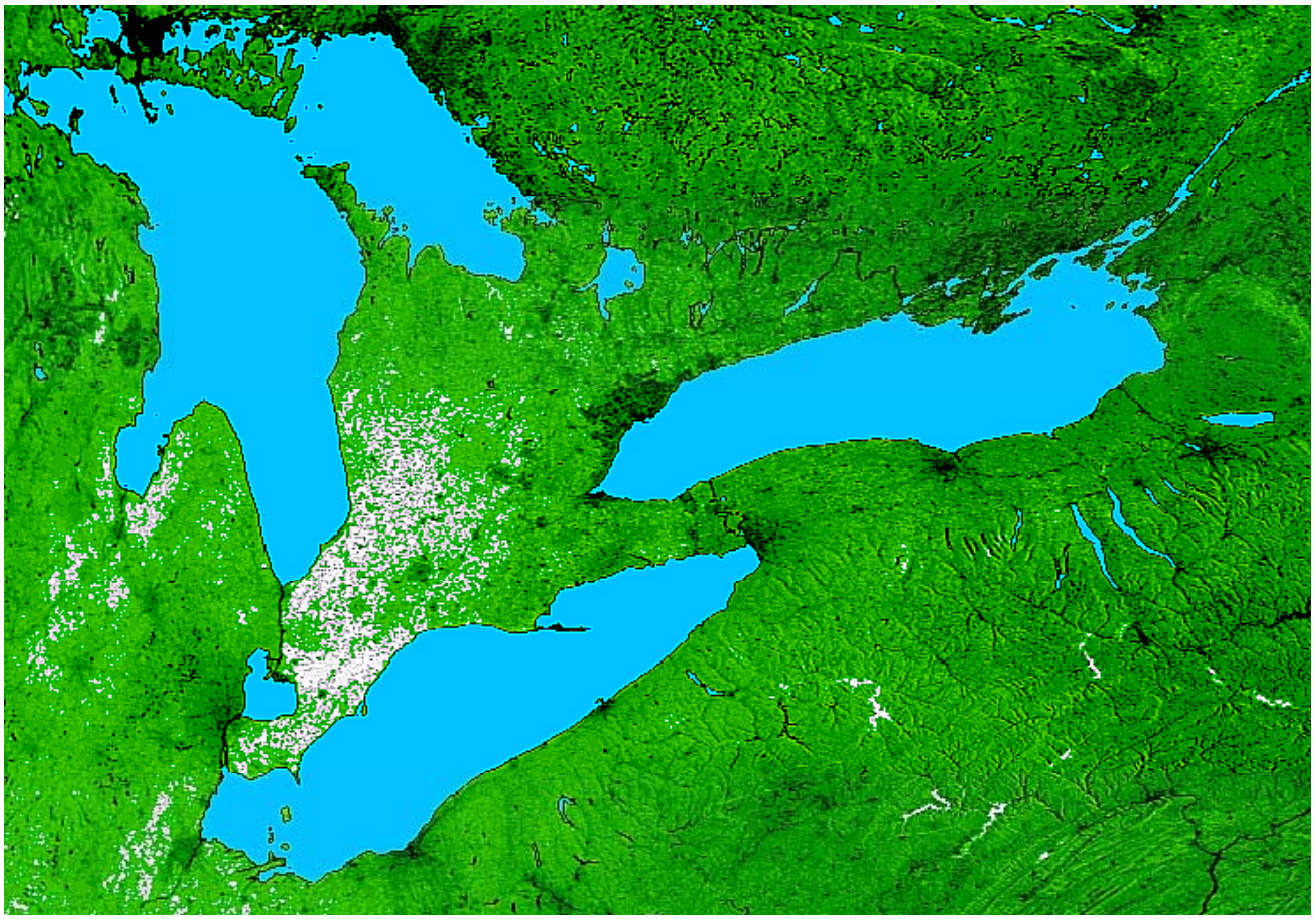

The Environmental Quality of Watersheds: An Analysis

Instructor's Overview

Ask your students in class today, "What is a watershed?" The responses may astound you. Students may not fare much better responding to questions about water quality and sources of pollution. Our students' ignorance of the structure and functions of a watershed should concern us.

There is a struggle going on in this country and throughout the world over drinking water, wetlands, and watersheds. The Watershed Module is a unique opportunity for high school students to learn science and mathematics in a context of real-life environmental issues. Monitoring the health of a stream near their school may help students to see the importance of science and math for their own lives.

The lessons integrate mathematics, biology, chemistry, earth science, engineering, environmental science, computer science, and the social sciences in a series of exercises dealing with the environmental health of a watershed and its associated streams. Students use the watershed as a classroom. The lessons are designed to provide an experience in evaluating impacts of human use on a watershed and its streams. The lessons range from work on the Internet using telemetry data downloaded from a satellite, to field exercises, to an environmental hearing on construction of a new sewage treatment plant. If you choose to do the entire set of lessons, your class will learn to use equipment and techniques typically used in stream analysis to document:

- how land in your watershed is used.
- the extent and severity of pollution in the stream that drains the watershed.
- sources of pollution.

If all lessons are used, the class will be exposed to the social, economic, environmental, and political ramifications involved in a contested proposal for new development in your watershed. The lessons stress inquiry, a team approach, and a "hands on experience" to learning.

The 'Environmental Analysis of Watersheds Module' is intended for high school students in grades 9-12 enrolled in environmental studies, earth science, biology, chemistry, technology, mathematics, computer science, and social studies. Since the module's lessons vary in content and difficulty, the teacher must decide if the students possess the pre-requisite skills cited for each lesson. For the instructor who decides to

teach the entire module, the lessons are sequential. However, each lesson can stand alone as a learning unit for infusion into the existing curriculum.

Each lesson contains a Teachers' Guide that describes equipment needed and provides instructional suggestions, handouts, background materials, Websites, references, and addresses of firms to buy supplies. Some equipment items are required for the lessons. The most noteworthy are a current meter and computers with access to the Internet. The computer is generally not a problem. A current meter can be purchased or borrowed from an academic institution, the local Soil and Water Conservation District, or another such agency.

Series of Lessons

Lesson 1 *Scoping* is intended to introduce students to the concept of a watershed. They visit a watershed and one of its streams to discover what is there. Most students and adults have little idea of how land and water resources within the their watershed are used. What is a watershed? What is a topographic map? Where does the stream originate? Where does it go? Is the surrounding land used for agriculture, industry, etc.? Are there point or nonpoint sources of pollution? Is soil erosion taking place? Are there visible problems?

Lessons 2 and 4 have classroom and field components. In the classroom, students develop the knowledge and skills necessary to use their time in the field effectively. In the field, students determine the velocity, discharge, and nutrient loss of a stream draining a watershed. A simple graphical model is constructed to develop a predictive model of stream discharge as a function of stream depth. Students learn how to use a current meter, calculate discharge, measure nutrients in the water, estimate nutrient loss from the watershed, and compare these data to determine if the watershed is impacted by nutrient pollution.

Lesson 3 enables the student to use the Internet to link into operating stream-monitoring stations, called *gauging stations*, all over the country. Students can download *real-time* discharge data from a nearby stream that is being monitored by the USGS (United States Geological Survey) through satellite technology. This lesson covers the same content as Lessons 2 and 4, but introduces the student to nationwide watershed and stream monitoring system through the Internet.

Lesson 5 introduces students to the concept of the *indicator organism* and the *indicator community*. They learn how the health of the stream can be evaluated, by calculating the Biotic Water Quality Score through sampling the macroinvertebrates in the stream. In New York State and in several other states, this method is used by agencies to evaluate the environmental health of watersheds and their associated streams.

Lesson 6 asks students to be environmental detectives. Through a technique known as *segment analysis*, they make a connection between land use, potential sources of pollution, and the data they collected about the condition of the stream.

Lesson 7 is a hypothetical situation in which the "GRQ Development Corporation" proposes to build 400 new homes along the creek that meanders through your watershed. This new development will require the construction of a sewage treatment plant that will release effluent into your stream. Teams play roles such as The League of Concerned Taxpayers, Tree Huggers of North America, Save the River Coalition, Westside Industrial Development Corporation, Elected Town officials, and hold an environmental hearing. Data collected in previous exercises are used to evaluate the proposal and render a decision. This is an interesting exercise for students and is meant to be the culminating experience of the Watershed Module.

Background: The Concept Of Watershed Analysis

Citizens become aware of problems with their water when aesthetically displeasing conditions exist. Algal blooms, taste and odor problems, decreased water clarity, or increased weed production often prompt calls for action. Homeowners, fishermen, and recreational users become concerned over the "health" of their lake. We know that such water problems are associated with an excess of nutrients, such as phosphorus and nitrates.

Ironically, nutrients found in fertilizer for the land become pollutants as they enter streams and lakes. This is because phosphorus and nitrates found in fertilizers, human sewage, and cow manure encourage over-growth of algae and aquatic weeds. However, even if we know that phosphorus or nitrate is the ultimate cause of the problems encountered, we do not always know where the nutrient originated. It is not necessarily the whole watershed that is polluting the water. It could be a point source, such as a pipe from a sewage treatment plant. It could be a nonpoint source, such as surface runoff, carrying nutrient laden water from a recently fertilized field or lawn. In this unit, students learn how to find these sources, so that effective remediation can begin.

Stream analysis is a comprehensive approach for determining the environmental health of a watershed and its constituent streams. It is a technique that identifies the sources, extent, effects, and severity of pollution in a watershed. It combines the sciences of hydrology, limnology, ecology, and organismal biology to analyze cause and effect relationships in disturbed stream ecosystems. Watershed study provides many hands-on opportunities for high school students to apply scientific and mathematical ideas to understand real-world problems. Thus, it is an effective tool for addressing the New York State Science, Mathematics, and Technology Learning Standards.

Streams are used to monitor the "health" of the watershed, through chemical or biological monitoring. The species composition and abundance of resident stream macroinvertebrates reflects the synergistic effects of chemicals intermittently released into the stream and/or of chemicals present in levels too low for detection. Because nutrients are easily dissolved in waters, they can also be traced to their source by systematic geographic monitoring of the stream. Segment analysis is a technique that divides the sub-watershed into small distinct geographical units. Samples are taken at the beginning and end of each unit of the stream to determine if a nutrient source occurs within that reach. At this point, the cause and extent of pollution may have been

identified. By following the stressed stream analysis approach, researchers and managers are able to determine the most cost effective means to manage a pollution source. As a whole, the stressed stream approach represents a means to clearly define a problem prior to its remediation.

Global Objectives for Module

The Watershed Module is designed to offer students the opportunity to:

- use scientific inquiry and mathematical analysis to investigate the structure and function of a local watershed.
- identify various factors that impact watersheds in a physical or biological manner.
- develop explanations for changes in the flow and quality of the water that runs through a watershed.
- be more aware that human decisions and activities have had a profound impact on the ecology of the watershed.

Correlations with New York State Learning Standards for Mathematics, Science, and Technology

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

> **Key Idea 1:** The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.

Standard 4: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment, and recognize the historical development of ideas in science.

> **Living Environment Key Idea 6**: Plants and animals depend on each other and their physical environment.
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> **Living Environment Key Idea 7:** Human decisions and activities have had a profound impact on the physical and living environment.
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> **Physical Setting Key Idea 2:** Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Standard 7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

> **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision-making, and inquiry into phenomena.

Preparing to Teach the Watershed Module

Start by reading through the whole module. It is designed so that teachers in different contexts can choose to teach the whole module or selected lessons. Which ones you choose will depend on the availability of a nearby stream to study, as well as time and funds for field trips. If field trips are not possible, you can find a great deal of information on watersheds on the World Wide Web, as in Lesson 3.

The Module is designed so that the Teachers' Guide for each lesson precedes the Student Guide. We envision that you will make enough photocopies of the Student Guide so that each student can have one. You may wish to collect these at the end of the Module for re-use with another class. Therefore, worksheets, which are consumable, are put together with the Teachers' Guide. You can photocopy as many as you need each time you teach the lesson.

If you plan to go to a stream, be sure to plan ahead to get permission from the landowner. Further information is in the Teachers' Guides. Also, if you will be collecting live organisms in Lesson 5, you will need to get a collecting permit in advance. Anyone planning to collect or possess aquatic macroinvertebrates in New York State must apply for a New York State Fish and Wildlife License. Since these organisms are food for fish and other aquatic vertebrates, they comprise an essential component of a stream ecosystem's food web. Consequently, these macroinvertebrates must be protected. To apply for a "license to collect and possess", write New York State Department of Environmental Conservation, Division of Fish and Wildlife, Special Licenses Unit, 50 Wolf Road, Albany, New York 12233-4752. The current fee is $10.00.

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Student Introduction

Watersheds, and the streams that drain them, play an important role in our daily lives. In this series of lab and field exercises, you will learn about a local watershed through a process called *scoping*. You will also use techniques used by professionals, such as discharge monitoring, nutrient loading comparisons, and study of the biological and chemical indicators of stream pollution. As you complete the lessons, you will become experts on your watershed. You will be able to ask and answer the question, "Is my watershed and its adjacent stream impacted by pollution?" There will be few people in your town or village who will know as much about your watershed as you. As one final exercise, you will hold an environmental hearing to evaluate the impact of the construction of 400 new homes and a sewage treatment plant on the watershed.

The Watershed Module has seven lessons. Your teacher will choose all or some of them for study, depending on the availability of a stream to study and computers for Web searching. In Lesson 1, you will be introduced to the study of watersheds, and will scope out a watershed near your school. Lesson 2 requires a field trip to a stream. It has two activities, measuring stream velocity and discharge. Lesson 3 can be done in your school. You will be able to study data collected in *real-time* from streams all across the nation, using the facilities of the World Wide Web. Lesson 4 has several activities related to chemical monitoring of streams. In Lesson 5, you will go to a stream to collect macroinvertebrates for the purpose of biological monitoring of the stream. In Lesson 6, you will try to determine the possible sources of any pollutants found through chemical and biological monitoring. In the final lesson, you will hold a mock hearing to discuss the benefits and drawbacks of a housing development to be built on the stream banks. In this hearing, you will use the information you have gained throughout the module.

As you work with these lessons, you will encounter many new terms, which you will find in the glossary.

Careers

Watershed protection is a growing area of research for environmental scientists. Professional people concerned with water quality represent a variety of disciplines. Academic backgrounds in such areas as biology, physics, mathematics, earth science, hydrology, chemistry, social science, engineering, law, and administration are common.

Career opportunities in the general area of water resources and aquatic ecology are almost limitless. Employment opportunities include work in data collection and analysis, water resource planning, flood analysis, stream and lake management, water quality research, ground water studies, teaching, etc.

Employers in this area include:

United State Environmental Protection Agency

United States Geological Service

United States Army Corps of Engineers

United States Fish and Wildlife Service

National Park Service

Bureau of Land Management

Bureau of Reclamation

National Oceanic and Atmosphere Administration

Private Environmental Consulting or Engineering Firms

Federal and County Soil and Water Conservation Service

United States Forest Service

Drinking Water and Wastewater Utilities

Environmental Consulting Firms

Firms specializing in Environmental Analytical Services

International Agencies - The World Bank, UNESCO

Various states, county and town agencies that are concerned with environmental and water related issues.

A good, detailed overview of careers in the broad area of water resources and aquatic ecology may be found at the "Career Opportunities in Water Resources" Website, developed by the Universities Council on Water Resources.
http://www.uwin.siu.edu/ucowr/careers/index.html