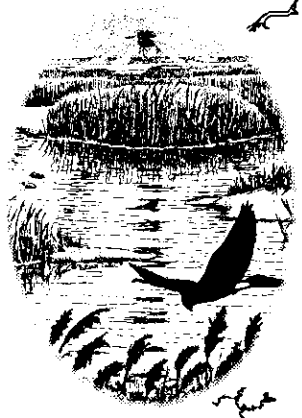
New Jersey WATERS

New Jersey Audubon Society

A WATERSHED APPROACH TO TEACHING THE ECOLOGY OF REGIONAL SYSTEMS



A Guide for Middle School and High School Educators

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NEW JERSEY
AUDUBON
SOCIETY

STATEMENT OF PURPOSE

New Jersey Audubon Society (NJAS) is a privately supported, not-for-profit, statewide membership organization. Founded in 1897, and one of the oldest independent Audubon societies, NJAS has no formal connection with the National Audubon Society.

NJAS fosters environmental awareness and a conservation ethic among New Jersey's citizens, protects New Jersey's birds, mammals, other animals, and plants, especially endangered and threatened species, and promotes preservation of New Jersey's valuable natural habitats.

In order to achieve its purpose, NJAS, through its board of directors, professional staff, members, and volunteers endeavors to:

- Develop, encourage, and support sound conservation practices, programs, and legislation;
- Disseminate information on the natural environment through education programs, information services, and publications;
- Advance knowledge, through field research, of New Jersey's flora and fauna and their relationship to the habitats on which they depend;
- Acquire, establish, and maintain wildlife sanctuaries and educational centers.

The objectives of the society are implemented by its professional staff under the leadership of its President and supervision of an elected, voluntary board of directors.

For membership information and all other inquiries about New Jersey Audubon Society contact:
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NEW JERSEY AUDUBON SOCIETY

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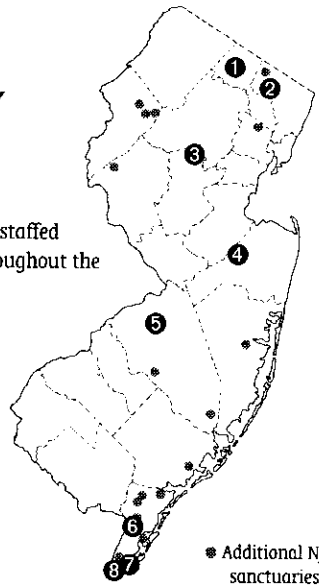

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To Pat Kane

Thank you for your vision and guidance.

Its substance reaches everywhere; it touches the past and prepares the future; it moves under the poles and wanders thinly in heights of air. It can assume forms of exquisite perfection in a snowflake, or strip the living to a single shining bone cast up by the sea.

— Loren Eisely

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Table of Contents

CHAPTER 1

Introduction

The New Jersey Audubon Society (NJAS) has been involved with water-related issues long before terms such as "watersheds" and "impervious surfaces" became the buzzwords that fuel many conservation battles today. New Jersey Audubon Society has urged such legislation as the federal Clean Water Act of 1974, the New Jersey Freshwater Wetlands Act of 1987, and the New Jersey Clean Water Enforcement Act of 1990. In addition, NJAS was a leader in preserving the Great Swamp National Wildlife Refuge, Island Beach State Park, the Highlands, and the Pinelands under which lies thirteen trillion gallons of some of the cleanest, purest water on the East Coast. But still there are hard battles to be fought. The Open Space Referendum of 1998 has bought the conservation movement some more leverage to help continue protecting the water and watersheds of our state and our world. New Jersey Audubon Society supports a stronger New Jersey State Plan that addresses land-use and other environmental and quality of life issues. It is refreshing for an organization to be active during a time when the issues we've been involved in for many years have become ripe enough to allow a publication such as this to come to fruition.

Water, after all, is the root of all life. Before true science emerged, religions and mythologies reflected the importance of water to our existence. The ancient Greeks believed the god of water, Oceanus, was one of the parents of creation, while the Roman god Aquarius was the cupbearer to the gods and the water bearer to the people. The Bible relates that "all rivers run into the sea," while the Koran teaches, "By water, everything lives." Even early scientists recognized the significance of water. Isaac Newton believed that all plant and animal life was made up mostly of water (Hanmer 1985). Today it is known that all organisms on this planet need water in some way, shape, or form to survive. From the kangaroo rats of the driest deserts to the sea creatures immersed in their liquid bath; without water there would be no life.

Water, after all, is the root of all life.... Today it is known that all organisms on this planet need water in some way, shape, or form to survive.

Water may be the root of all life, but where is it all? Over 72 percent of the earth's surface is covered in water. Give or take a glass of water, that is a total of 369 quintillion, 820 quadrillion, 250 trillion gallons (Hanmer 1985). Our continents are literally islands in the sea of life. Most of this water, up to 97 percent of it, is salty. The fertile ocean waters support a myriad of specially adapted life and help fuel the water cycle, while affecting climates throughout the world.

However, most life forms require freshwater to live. That means that less than 3 percent of the earth's water supports all of the world's terrestrial and freshwater aquatic life. Of course, when we are talking about quadrillions of gallons of water, that may seem like a lot, but there is one more thing to consider. Of the available freshwater on earth, 89 percent is frozen. Locked up in the polar ice caps, this water is slowly feeding into our oceans and being moved by glaciers, but is mostly unusable by life in this form. The freshwater supply of the world is a very limited resource for which all life competes.

All of these water supplies move in predictable ways and through predictable systems. These systems of ground water, surface water, and atmospheric water are affected by and also affect the lands directly adjacent to them. Consider a stream corridor. At its center is a channel with water flowing from headwaters to river mouth. Contiguous to the channel are the floodplain habitats. All activity in these habitats plays

a direct role in the quality and quantity of water in the stream. Changes also affect the animals and plants that live there. Telescoping outward, the habitats adjacent to the flood plain contribute to its effectiveness in controlling floodwaters from runoff. Even further removed are the recharge areas, where ground water is replenished from precipitation. Upstream factors affect downstream areas. These connections between the land and the water form one big system of watersheds. In order to ensure both quality of life on land and water, each part of the system needs to be protected and maintained.

When we speak of clean water we need to consider indicators such as "the amount of dissolved oxygen or parts per million (ppm) of chemicals. The ppm can be used to define a level of acceptable risk so that public water supply is not contaminated....When the issue is habitat, the talk turns to indicator species whose presence or absence may define water quality" (Kane 1994). But when we speak of the health of watersheds, there are other factors to consider: "[T]hings like the percent of forest cover in a watershed; the rate of subdivision; the percent of forest loss at buildout according to current zoning in a watershed's communities; the rate of forest loss per year in a watershed; and the percent of impervious surface cover (roof, pavement, etc.) in a watershed. These indicators say a great deal about what the prospects are for future habitat, future wildlife, future water quality, and future clean air; all of which are provided for at no cost by forests" (Kane 1994).

"Watersheds are important to any community because they embody our sense of place in the landscape, and their waters are important in our daily life" (Center for Watershed Protection 1998). In New Jersey, the watersheds are very evident. With the exception of 50 miles between the Delaware River and the Hudson River (our political boundary with New York State), New Jersey is surrounded by water. Geographically New Jersey is actually a peninsula jutting into the Atlantic Ocean. The state has approximately 6,450 miles of rivers and 24,000 acres of lakes, reservoirs, and ponds (NJ SWQIR 1992). Freshwater wetlands total 661,000 acres and the state has approximately 243,000 acres of coastal or tidal wetlands (NJ SWQIR 1992). Needless to say, the citizens of New Jersey are familiar with water.

"Watersheds are important to any community because they embody our sense of place in the landscape, and their waters are important in our daily life"

— Center for Watershed Protection 1998

But what about the land in-between the water? Our communities are home to about eight million people. The forests and fields, vacant lots and backyards, parks and recreation areas support the diversity of plant and animal species found in the state. And it is this diversity which contributes to our quality of life. A quality of life which is in jeopardy.

Take a moment to consider the average New Jersey resident. We use about 90 gallons of water each day individually. This means the average household uses 11,000 gallons of water in one month. With growing populations the strain human use alone puts on this resource is immense. "Even as population growth increases the demand for water, it reduces, with every roof, road, and parking lot, the ability of a watershed to recharge it's underlying groundwater.... The loss of groundwater recharge due to development can exceed 450,000 gallons per square mile per day" (Stapleton 1997). In addition to problems caused by these impervious surfaces, non-point source pollution, saline intrusion, and loss of key headwater habitat and open space are forever changing the face of water quality in the state. For instance, "one gallon of leaked gasoline can contaminate one million gallons of water. Entire aquifers are at risk" (Stapleton 1997). Factor into this equation, all the other life forms which also depend on that water and it becomes apparent that the proverbial well is drying up and something needs to be done about it.

But what to do? "Communities across the nation are finding that their water resources are degrading in response to growth and development. They are also discovering that they can only protect these local water sources by thinking on a watershed level" (Center for Watershed Protection 1998). Like plant and animal communities, water does not recognize political boundaries. The systems as a whole would be much better off if our political boundaries (municipal, county, state) were based on watershed boundaries. Then these areas could be governed as regions, reducing or eliminating many of the issues we face today. No longer would those downstream be forced to contend physically, biologically, and financially with the problems caused by misuse of water systems upstream from them. No longer would decisions be based on the benefit to individuals, but rather on the benefit to the system. This sort of regionalization is

nothing new. "New Jersey has a history of regional regulation which includes CAFRA, the Pinelands Commission, the Hackensack Meadowlands Development Commission, the Delaware and Raritan (D&R) Canal — all of which have been operating with varying levels of success to deal with land use on a regional level" (Kane 1994). Additionally, New Jersey (along with New York, Pennsylvania, and Delaware) has representation on the Delaware River Basin Commission, an interstate agency that regulates the water in the entire Delaware River's watershed. More and more we see that regional issues, like watershed management and development, must be viewed through regional eyes, looking for regional solutions.

It is very true, that something must be done politically to protect watersheds, but the true answer lies in your hands. Ask your friends and neighbors what a watershed is and why is it important. The blank stares you may receive are an indication of the lack of knowledge about this topic. Only through education, and the power knowledge provides, can the protection of our natural resources progress. Only through education will the lament of Samuel T. Coleridge's ancient mariner, "Water, water everywhere nor any a drop to drink," not become our own. ❖

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CHAPTER 2

Environmental Education Overview

Environmental education is the element so sorely needed in our day, when the very fabric of life and living is threatened by the human species which has too much knowledge and not enough wisdom to use it well."

This quote from Liberty Hyde Bailey is more true today than when first spoken in 1903. Advanced technology has gradually insulated and isolated most human beings from the natural world. More and more we depend on experts to decide the best methods for conserving and preserving our natural resources and natural systems. But technological experts are not always expert in understanding the interdependent aspects of our life-support systems. Most people occupy themselves with the by-products of science but have lost touch with the processes of how our natural systems work.

Water touches all aspects of our lives. It has always been there for our use. We assume that fresh water will always be plentiful, and we expect it will always be clean. Clean water is one reason for the great variety of life forms found on the planet.

Water touches all aspects of the natural environment, as well as the political, social, and economic facets of our human environment, and none of these aspects can be separated from the others. As the demand for potable water grows and water issues gain increasing priority, difficult decisions about water rights and watershed management will need to be made while considering all of those interlocking aspects of our environment. For these reasons, studying a regional watershed system should become an important part in a student's educative growth. Watershed education is an open-ended area of study with a process that builds upon experiences and observations, analysis and evaluation, cooperation and implementation.

In our rapidly changing society it is imperative to educate our students to be creative problem solvers, to work in teams and share ideas, and to be able to use technologies that help broaden our knowledge base. Equally important are the experiences that allow the student to connect with the watershed. *Content* is the foundation upon which we build, and *process* is the varied pathway that a person takes to help understand his or her world. Strike a balance between these two educational objectives and a lifelong learner emerges, one who is an active participant in his or her integrated environment and who develops a working knowledge of the systems that power both society and nature.

The mission of New Jersey Audubon Society's department of education is to bring people and nature together. In *New Jersey WATERS: A Watershed Approach to Teaching the Ecology of Regional Systems,* students and teachers are directed to find their location in one of New Jersey's six major watersheds. Through first-hand experience, investigation, and community-based projects they establish an "ecological address" and sense of place within their regional watershed system. The planned projects draw community attention to some aspect of preserving a clean waterway and the habitats connected to that waterway.

Schools that provide lessons drawn from real life experience are places where young people learn how to participate in the plans, decisions, and actions that affect their quality of life. Firsthand experience provides an understanding of the ways that nature's systems share interdependencies. Firsthand observation of how human activity has preserved or degraded these systems provides the opportunity for growing in both wisdom and knowledge. These threads of wisdom, woven through our knowledge, can insure the free flow of clean water that will nourish all of life now and for future generations.

— Patricia F. Kane
Vice President for Education

CHAPTER 3

How To Use This Guide

INTEGRATION INTO THE CURRICULUM

Watershed education touches all aspects of our lives; therefore, it touches all aspects of a school's curriculum. The chemistry teacher may have students analyze the chemical make-up of a local waterway while the biology teacher has the students study the indicator species for environmental quality. A geography teacher may have students map the watershed while the history teacher has students interview local senior citizens about "the way it used to be." All the while the reading teacher has students research various aspects of the watershed and the math teacher has students calculate percentages of impervious surfaces vs. acreage of open space and how this affects water quality.

The suggested activities in *New Jersey WATERS* challenge students to be more active learners. These activities engage the students in critical thinking while involving them in real issues and solving real problems. According to a national study done by the State Education and Environment Roundtable, integrating the environment (built and natural) increases student involvement in their own learning; therefore, student-driven projects which focus on action-oriented challenges are more effective than passive learning (Lieberman and Hoody 1998). Educators can define "the environment" as that which combines the natural systems with the socioeconomic and cultural systems of the community. Student involvement with local issues adds relevance to studies through real life experience.

TEAM TEACHING

Because the study of watersheds touches all aspects of the curriculum it affords the educator an opportunity to cross disciplines. Traditional departmentalization teaching does not reflect the real world and as content areas are synthesized, student learning is enhanced by working with a team of teachers. Teachers who work in teams do not have to be experts in everything, but get to share that challenge with others, as well as having the opportunity to learn with their students.

ALIGNMENT WITH THE NEW JERSEY CORE CURRICULULM CONTENT STANDARDS

The Core Curriculum Content Standards are general guidelines that help educators guarantee that all students receive a "thorough and efficient" education. Each content area has standards that outline the major concepts that students should know at various stages of their education. Progress indicators for each standard further focuses what the students should know at various levels.

Each lesson included in this publication has a listing of the appropriate standards and indicators in the lesson. This information can be found in two places: a) in chart form at the beginning of each chapter, and b) embedded in each lesson. Since this publication is geared toward the middle school and high school levels, we list only the standard/indicators that apply to those levels. We view the standards and indicators from the earlier grades to be the foundation of content and skills to which students should already have been exposed. In most cases the focus is on the content areas of language arts, math, science, and social studies; where they apply, the cross-content workplace readiness skills have been identified.

Copies of the Core Curriculum Content Standards can be accessed at www. state.nj.us/education/index.htm or

ordered from the New Jersey State Department of Education, Office of Publications, 2225 W. State Street, PO Box 500, Trenton, NJ 08625.

WATERSHED BASIN DESCRIPTIONS

The natural boundaries between drainage basins and watersheds come from the earth's topography. Elevation, geology, and soils help determine the divide between these drainage basins. In this publication, we have delineated six major drainage basins in New Jersey. These include the Wallkill Basin, the Passaic/ Hackensack Basin, the Upper Delaware Basin, the Lower Delaware Basin, the Raritan Basin, and the Atlantic Coastal Basin.

Each basin warrants its own publication. Their physiographic characteristics are different, producing the complex drainage patterns that New Jersey exhibits. Their land uses are different based on the state's demographics. Their human history is different. But, each of these chapters briefly gives an overview of these things to introduce the reader to some of each basin's unique information.

The leadoff map for this section shows the state's topography with the watersheds delineated. The population density map gives the reader a visual perspective on the distribution of the state's population. Additionally, each basin section includes two maps generated by the New Jersey Department of Environmental Protection, Division of Watershed Management using Geographic Information System (GIS) technology. These maps show:

- significant natural features
- built structures including towns, roads, and county lines

WATERSHED LESSONS and ACTIVITIES

Each chapter focuses on an aspect of watershed education. Additionally, different methods of teaching are used to accommodate student and teacher learning and teaching styles. This guide was designed with the middle school and high school student in mind. Extensions are suggested to make the lessons more basic or complex.

Taken in sequence, the lessons in each chapter create a well-rounded, interdisciplinary unit that takes the learner from awareness (content and knowledge) to action (how is this information relevant to my life and what can I do about it) in each of the focus areas. Although each lesson stands on its own as a complete lesson (or series of lessons), the chapters also build upon each other taking the learner from a relationship with a "place" in the watershed, then broadening out to compare and contrast watersheds. Finally the students are given the challenge to become regional thinkers in determining their quality of life.

A SENSE OF PLACE

Students will understand their place and role in the watershed. What watershed do they live in? What is the relationship between land use and water use in the watershed? How can they learn more about the watershed and its natural and built environments?

A SENSE OF TIME

Students will understand what causes watersheds to change over time. How do the changes affect water quality and the quality of life for people and other species? What impact do I have on the watershed, here, and on a global level?

A SENSE OF QUALITY AND QUANTITY

Students will learn how to determine the quality of their watershed. What types of indicators help us monitor the health of the watershed? What are the interrelationships between terrestrial and aquatic systems, surface-water, and ground-water systems? How do people impact these systems and what effects are produced?

A SENSE OF CONNECTION

Students will learn how to understand the watershed system as a regional system. How do factors in a watershed relate to each other? How do we maintain the balance between economic growth and sustain our quality of life? Where do I stand on watershed issues?

Taken singly, each lesson gives as much information as possible to the educator for implementing the lesson along with their already established curriculum. Each lesson includes:

- information sheet for the teachers / students
- pedagogical information including: the lesson's goal, student objectives, skills, core curriculum content standards and indicators
- preparation information including: time involved, vocabulary, prior knowledge, materials, lesson preparation

- lesson procedure
- methods for assessing student understanding including discussion questions and alternative forms of assessment
- suggestions for "empowering" the students to become involved in their community (these opportunities have not been included in time allotments or in the assessment)
- suggestions for extending the experience
- a list of related watershed lessons from other established environmental education guides
- a list of reference materials used to create the lesson and/or background information
- associated worksheets

ASSESSMENT

There are countless ways to assess student performance. For the purposes of this publication we have selected the following:

- **Imbedded assessment questions** can be found throughout the lessons - they are key questions that enable the teacher to determine if the students are understanding the concepts. Suggested answers to these have been italicized and set off by brackets.
- **Further discussion questions** draw upon the new content the students have learned and upon prior knowledge they bring to the discussion. These questions allow the students to bring classroom concepts and activities into solving problems in the real world.
- **Final assessment** takes what the students have learned and applies that to a new or different situation. The results of this assessment help the teacher understand if the students understand the concepts as well as the processes involved in the lesson.

APPENDICES

Glossary - All words listed in the vocabulary section of the lessons are defined in this section.

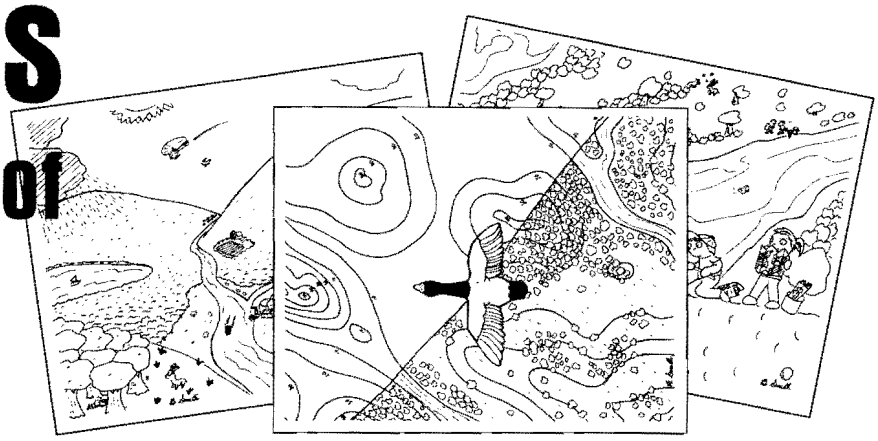
Topographic Map Listing - A matrix of the corresponding topographic maps for each watershed basin is presented here.

Field Trip Sites - Suggests sites throughout the state to take students for watershed study

Resources - This expanded bibliography provides a broader range of education resource materials and web sites than is included in each chapter. ❖

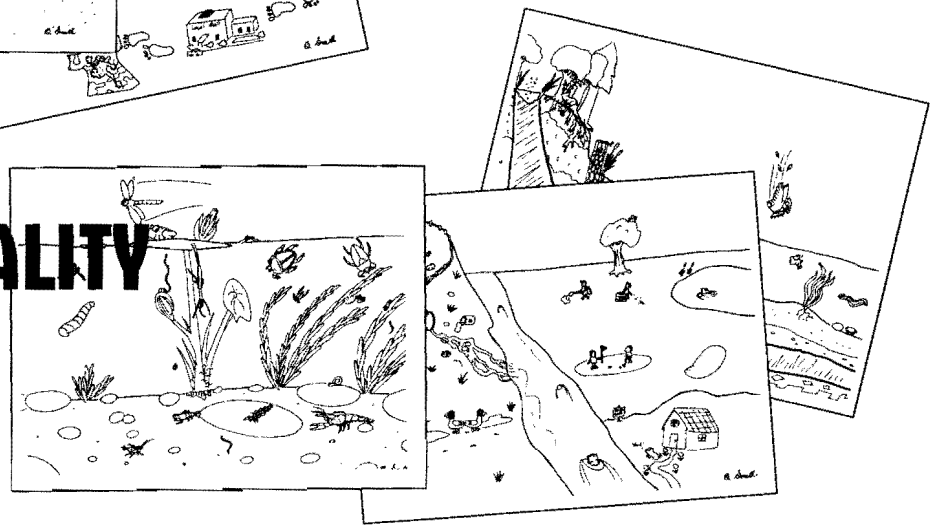
Activities

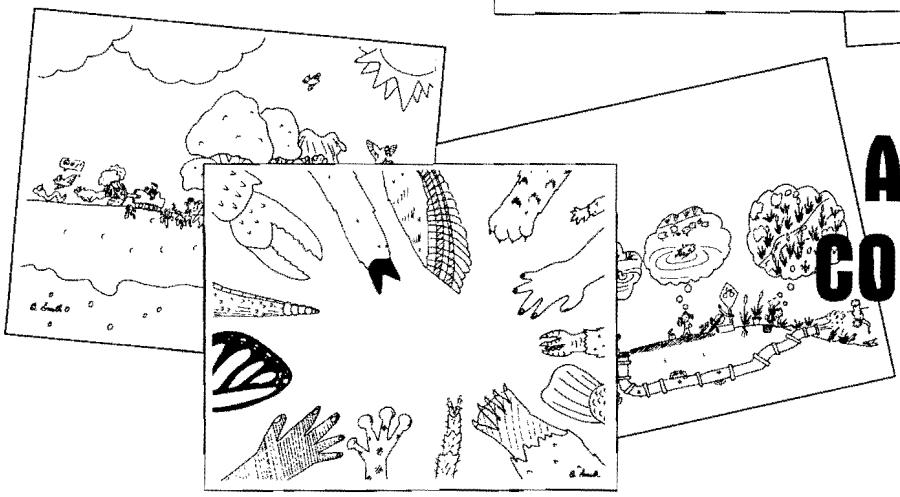
A Sense of PLACE



A Sense of TIME

A Sense of QUALITY AND QUANTITY





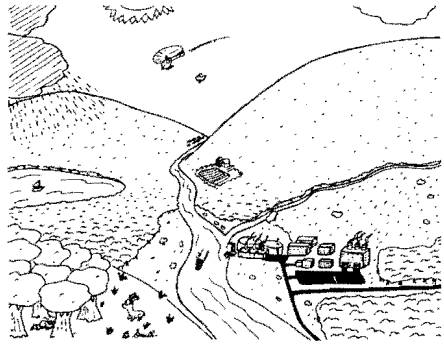
A Sense of CONNECTION

NOTES

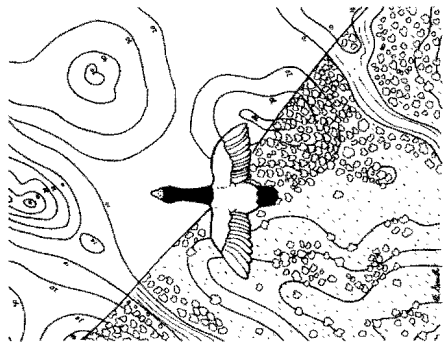
Activities
A SENSE OF PLACE

"I am no scientist. I explore the neighborhood. An infant who has just learned to hold his head up has a frank and forthright way of gazing about him in bewilderment. He hasn't the faintest clue where he is, and he aims to learn.... Some unwonted, taught pride diverts us from our original intent, which is to explore the neighborhood, view the landscape, to discover at least *where* it is that we have been so startlingly set down, if we can't learn why."

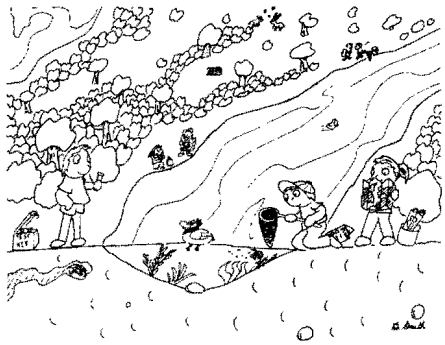
— Annie Dillard
Pilgrim at Tinker Creek



A Dynamic Watershed



Topo Twister



State of the Watershed

A SENSE OF PLACE

NJ Core Curriculum Content Standards

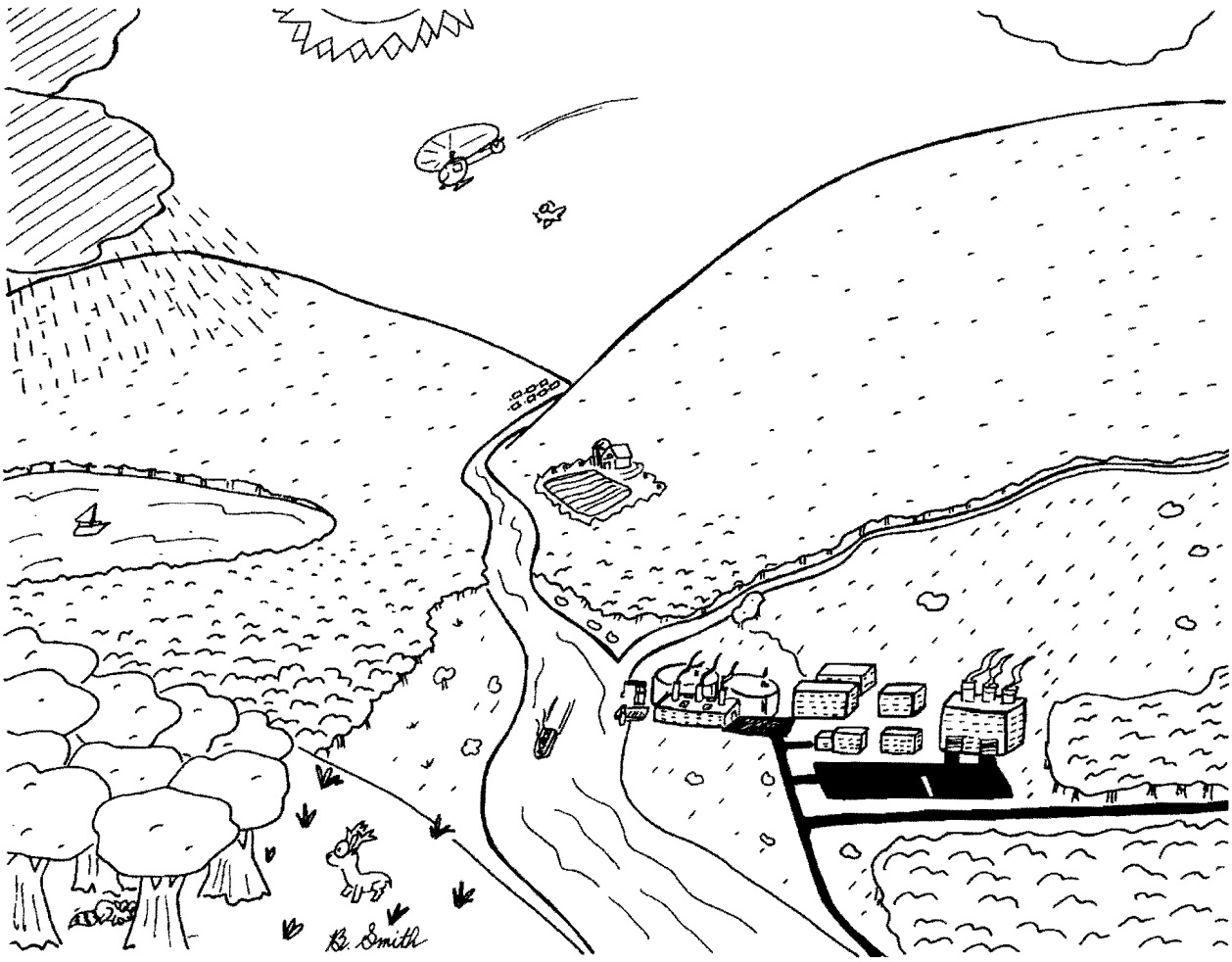
A Dynamic Watershed How does a watershed function?	page **71**
Workplace Readiness	
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15) **3.2** (8,11)
Mathematics	
Science	**5.1** (4,5,7) **5.2** (10,14) **5.10** (10,14) **5.12** (4,5,6,7,9,10)
Social Studies	**6.6** (10,16) **6.9** (5)

Topo Twister Where do I belong in the watershed?	page **75**
Workplace Readiness	
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15) **3.2** (8,11)
Mathematics	
Science	**5.1** (4,6) **5.10** (5,11) **5.12** (4,6,9,10)
Social Studies	**6.6** (10,15,16) **6.7** (6,8,11) **6,8** (8,9,13) **6.9** (5,7)

State of the Watershed How does one assess a watershed?	page **81**
Workplace Readiness	**2** (7,9) **3** (7,12,15) **4** (2) **5** (7)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14-16,18) **3.2** (8,9,11) **3.3** (19) **3.4** (25) **3.5** (12-14, 17)
Mathematics	**4.1** (10-13, 15,16,18) **4.2** (9,10) **4.3** (10,11) **4.4** (7,8,9,10) **4.5** (6-8) **4.6** (14) **4.8** (11) **4.9** (7,8,11-14,19) **4.10** (9) **4.12** (9,11,18,19)
Science	**5.1** (4-6,7) **5.2** (8-11,13) **5.5** (6,10,12,14) **5.10** (5,10,14) **5.12** (5-7,9,10)
Social Studies	**6.7** (9-11,12) **6.9** (5)

Bold Numbers = Standards (Light Numbers in Brackets) = Indicators

A DYNAMIC WATERSHED



Simply defined, a watershed is an area of land where water drains into an individual stream, lake, or other body of water. It includes all of the land, soil, rocks, plants, and animals as well as people and all of those objects that have been built by people. According to the Center for Watershed Protection, "watersheds" can be separated into various categories based on their sizes. Basins are the largest, draining land areas of over 1,000 square miles, subbasins cover 100 to 1,000 square miles, and a watershed drains from 10 to 100 square miles. A subwatershed covers 1 to 10 square miles, and the smallest drainage unit is the catchment which only covers up to 1 square mile. New Jersey has six drainage basins that are made up of numerous subbasins, watersheds, subwatersheds, and catchments.

Any precipitation that falls onto the land which is not used by plants or animals and does not evaporate, travels within the watershed in a specific manner. Higher points of elevation (e.g., ridges, mountains, hills) determine the direction that water flows once it hits the ground. Rivers, streams, storm drains, channels, lakes, ponds, and wetlands all play parts in defining how the water flows through the watershed.

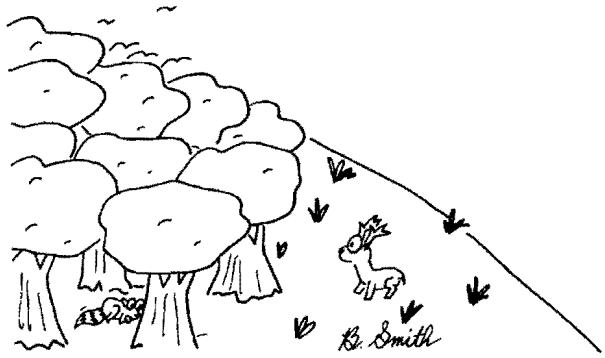
Water that stays on the surface of the earth is termed surface water. It collects in various types of natural wetlands as well as in human-enhanced or human-created bodies of water. Surface water is used in many ways. It provides habitat for countless plant and animal species, including those that live in the water and those that use the water, but live in

A Dynamic Watershed

adjacent habitats. Surface water is used for drinking water and for irrigation of agricultural lands. It is used for recreation as well as for industrial and commercial ventures. Each of these uses requires a different degree of water quality and each of these uses affects water quality in different ways.

Some of the precipitation that reaches the earth seeps into the ground. Ground water moves through the soil and through cracks in bedrock. If the water becomes trapped between layers of clay or other impermeable substrate it becomes a subsurface reservoir called an aquifer. Fifty percent of New Jersey citizens receive their potable (drinking) water from ground-water aquifers. Wells can be owned by individual homeowners or a municipality or a water-purveyor can distribute well water to its residents and/or customers.

Both surface water and ground water are subject to various forms of pollution including point source pollution (that which comes from the "end of a pipe") and non-point source pollution (that which comes from many sources and is difficult to identify). The quality of drinking water supplies can be protected through various measures, including reducing the aforementioned types of pollution and by preserving undeveloped areas surrounding reservoirs, lakes, rivers, aquifer recharge areas, and wellheads. Most of New Jersey's river systems provide drinking water to various populations throughout the state. The quality of these systems can be protected by preserving the headwaters regions of river systems and by creating "greenways" along the river corridors. Besides buffering the river from terrestrial pollution, greenways provides valuable habitat for New Jersey's wildlife as well as recreation opportunities for our state's citizens. Without the protection of buffers and greenways, water designated for drinking purposes may require additional treatment to remove certain pollutants and chlorine and other chemicals may need to be added to make it "drinkable" according to state and federal standards.



TAKE A LOOK AT YOUR WATERSHED:

Where are the waterways and water bodies in your watershed? Which direction do they flow?

What landforms do you see that help determine the topography of the watershed?

How can you tell when you have crossed over into another watershed?

LESSON 1

A Dynamic Watershed

GOAL To understand the definition of a watershed by looking at its physiographic elements and their functions.

TIME
- (1) 45-minute period

OBJECTIVES Students will:
- ✔ construct a landform model as the foundation for learning about a watershed
- ✔ identify the physiographic aspects of a watershed relating to surface water
- ✔ observe and describe drainage patterns in a watershed

SKILLS observe, identify, organize, analyze, predict, evaluate, justify

VOCABULARY

aquifer	open watershed
basin	pervious surface
bedrock	physiographic
catchment	precipitation
closed watershed	ridgeline
drainage area	subbasin
elevation	subwatershed
ground water	surface water
impervious surface	topography
landform	watershed

PRIOR KNOWLEDGE Students should have background in:
- the water cycle

CORE CURRICULUM CONTENT STANDARDS
- Language Arts 3.1 (14,15) 3.2 (8,11)
- Science 5.1 (4,5,7) 5.2 (10,14) 5.10 (10,14) 5.12 (4,5,6,7,9,10)
- Social Studies 6.6 (10,16) 6.9 (5)

MATERIALS

Model A (Paper Watershed):
- ❑ 2 sheets of paper per student or pair of students
- ❑ Masking tape
- ❑ Blue, water soluble markers
- ❑ Permanent markers

Model B (Watershed in a Basin):
- ❑ Newspaper
- ❑ Plastic basin (at least 16" x 24") one per group of six students
- ❑ Clear or white plastic bag big enough to cover the top of the container
- ❑ Blue food coloring

For both models:
- ❑ Spray bottles with water
- ❑ Paper towels
- ❑ Newspaper

PREPARATION

Select one of the following models for the students to construct.

Model A: "Paper Watershed"

(based on "What is a Watershed?" from Global River's Environmental Education Network) Give each student (or pair of students) two sheets of paper. Crumple one sheet, open the paper but do not straighten it out completely. Tape the edges of the crumpled paper to the surface of the other paper. The crumpled sheet should resemble a relief map.

Model B: "Watershed in a Basin"

Instruct the students in each small group to crumple up pieces of newspaper and place them in their plastic container. Explain that the newspaper pieces represent bedrock and create topography (changes in elevation). Lay a sheet of plastic over the entire model (represents the earth's surface) and tuck the edges into the plastic container. (Other materials that can be used to create topography include rocks, Styrofoam pieces, or clay.)

PROCEDURE

1. Have the students create their landform / watershed model.
2. Identify the types of "land" that the topography of their model represents [*hills, mountains, valleys, plateaus, etc.*].
3. Using either model, have the students identify ridgelines. (Model A: have the students trace these with blue, water soluble markers.)
4. Write the words surface water and ground water on the chalkboard. Explain the difference between these two types.
5. Tell the students their models will focus on surface water systems. Discuss why this is the case. [*Neither model allows for water to filter below the surface of the model - the paper on Model A and the plastic layer on Model B are impervious surfaces; to discuss ground water, these layers would have to be pervious like soil.*]
6. Ask the students to predict where the major rivers might be and where, on their model, water would collect after a rainfall. (Model A: have the students mark these sites with permanent markers.)
7. Put each model on newspaper or other water-tolerant surface. Provide each group with several spray bottles. Instruct the students to "mist" spray their models. (Model B: add blue food coloring to the water.) Discuss how the water flowed, where it accumulated, and how topography affected the drainage patterns of their model.
8. Introduce the definition of *watershed* as an area of land where water drains into an individual stream, river, lake, or other body of water. Drainage areas vary in size. Discuss the differences between basins, subbasins, watersheds, subwatersheds, and catchments.
9. Explain the difference between closed watersheds (those that lack a visible outlet) and those that are clearly linked by rivers and streams. Have the students discuss and define which of these are represented on their models.

FURTHER DISCUSSION

- List what the watershed's natural elements might be. [*soil, vegetation, animals, people, rocks, etc.*]
- List what the watershed's human-made elements might be. [*buildings, roads, dams, parking lots, fences, airports, train tracks, etc.*]
- Discuss which of these watershed elements would shed water and which would use and/or absorb water. [*Those that shed water would include the human-made elements, rocks, and some compacted soils; those that use and/or absorb water would be most soils, animals, and vegetation.*]

ASSESSMENT

Pose the following scenarios:

- If this was your watershed, where would you like to live? Why?
- The forest that surrounds the town's reservoir is sold and developed. The town builds a water treatment plant to filter and clean the water. What has been gained? What has been lost?

EXTENSION

Repeat the activity, but add the human aspect to the watershed.

1. Assume that this area (model) includes several towns. Where would be the best place to locate housing, the shopping mall, school and municipal buildings, recreation fields and parks, the water treatment plant, roads, the sewage treatment plant, landfills, etc.
2. Place a drop of food coloring or colored powder (Koolaid) at each of the above sites on Model B. Explain that the colored liquid (or powder) represents pollution. Ask the students to predict what will happen to water supplies the next time it rains. Spray mist the entire model and discuss the outcome and the cumulative effect of pollution.

EMPOWERMENT CHALLENGE

Map the schoolyard to show drainage patterns. Have students locate ridgelines and catchment basins. Have the students predict the direction of surface water flow then do follow-up evaluation of their predictions during (or just after) a rain storm.

LESSONS FROM OTHER SOURCES

Beneath the Shell - The Movement of Water

Project WET - Imagine, The Incredible Journey, Branching Out

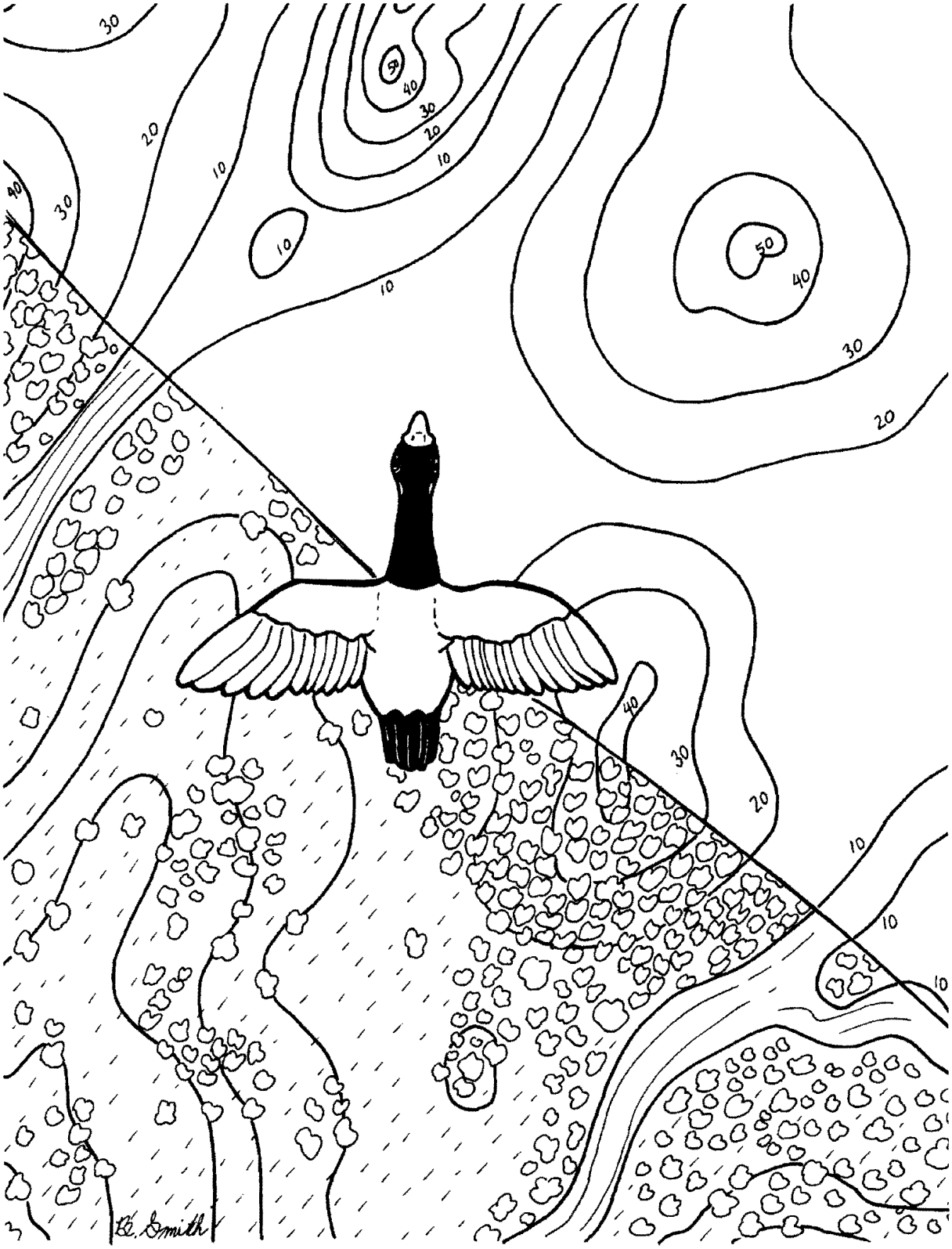
Hands On Save Our Streams - Watershed Workings

WOW! The Wonders of Wetlands - Over Hill & Dale

REFERENCES

Center for Watershed Protection. 1998. *Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds.* Ellicott City, MD.

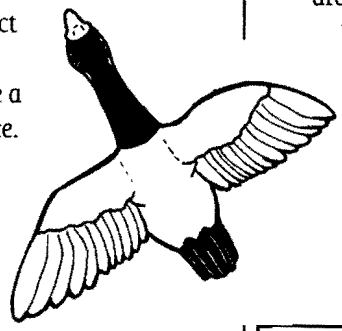
TOPO TWISTER



Topo Twister

Maps represent the way the earth or a portion of the earth looks. A topographic map shows the elevation or "relief" of the earth's surface by using drawn lines to show its contours. These contours stand for all of the earth's landforms including mountains, hills, lakes, rivers, plateaus, and valleys.

On topographic maps, like those produced by the United States Geologic Survey (USGS), contour lines connect points of equal elevation. Closely spaced lines show a steep slope like a mountain ridge, ravine, or precipice. Lines that are spaced far from one another, with no lines in-between, mean that there is little change in elevation. These would indicate areas such as valley floors, flood plains, plateaus, or coastal areas near sea level.



Besides elevation, topographic maps show a number of other types of information including land use, streets, buildings, and habitat types. These maps provide a "birds-eye view" of the entire watershed in which a person lives. Through interpretation of contour lines, symbols, and color one can get an idea of how the land looks without stepping outside. The USGS maps are reviewed and redone periodically, but dates on many of the maps in New Jersey indicate that the newest maps are from the 1980s and some of them are even older. Users of the maps should be aware that ground-truthing is an important process in watershed mapping. Due to changes in the New Jersey from development, maps should always be checked against the actual site.

There are 172 maps (quadrangles) for the state of New Jersey, each of which covers 49 to 71 square miles. The most usable maps for watershed study would be in the 7.5 Minute Series. These maps cover subdivided areas of latitude and longitude and a scale of 1:24,000 indicates that one inch on the map represents 2,000 feet of linear ground.

TAKE A LOOK AT YOUR WATERSHED:

How would some of your watershed's landforms be represented on a topographic map?

What changes do you see in your watershed that need to be added to an updated version of a topographic map?

LESSON 2

Topo Twister

GOAL To develop a broader understanding of the local watershed through the interpretation of United States Geologic Survey (USGS) topographic maps.

TIME
- (3) 45-minute periods

OBJECTIVES Students will:
- ✔ create methods for assembling topographic maps
- ✔ locate their "space" within the watershed (home, school, town, etc.)
- ✔ interpret USGS topographic symbols and colors
- ✔ identify subwatersheds on the map

SKILLS observe, organize, interpret, identify, analyze, synthesize, justify

VOCABULARY

cartographer
channelization
closed watershed system
contour line
drainage basin
elevation
greenway
headwaters
land use
open watershed system
river mouth
slope
stream order
subwatershed
sustainable development
topographic map
tributary
USGS quadrangle
watershed

PRIOR KNOWLEDGE Students should have background in:
- the way a watershed functions
- map reading and interpretation

CORE CURRICULUM CONTENT STANDARDS
- Language Arts 3.1 (14,15) 3.2 (8,11)
- Science 5.1 (4,6) 5.10 (5,11) 5.12 (4,6,9,10)
- Social Studies 6.6 (10,15,16) 6.7 (6,8,11) 6,8 (8,9,13) 6.9 (5,7)

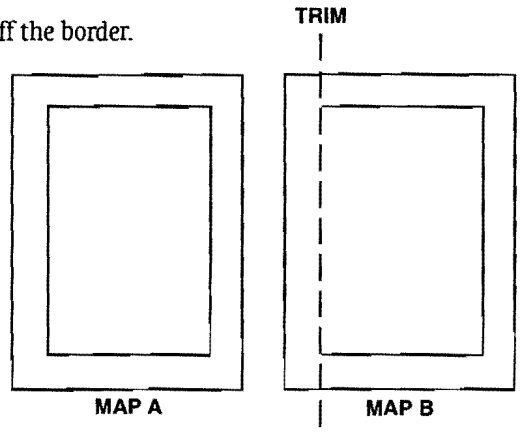
MATERIALS
- ❑ 1 set of USGS topographic maps for your drainage basin (See Appendix B for a complete listing of maps for each of the major drainage basins.)
- ❑ USGS topographic symbols key (See Appendix B)
- ❑ 6 to 8 copies of the USGS topographic map for your local subwatershed
- ❑ Laminating materials
- ❑ Velcro
- ❑ Nonpermanent markers

PREPARATION

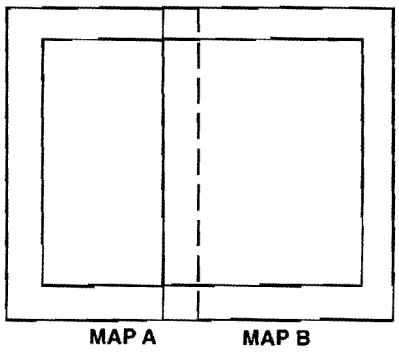
1. Obtain copies of the appropriate USGS topographic maps for your basin. (See Appendix B.)
2. Laminate maps then trim them according to the diagram. (Figure 2A). Be sure to allow at least ½ inch of overlap to apply the Velcro pieces.
3. Affix three or four Velcro pieces to the back (and front) of each map edge. Make sure these line up. It will make it easier for students to attach the individual map edges together.
4. Copy the section(s) of topographic map(s) which include your subwatershed and laminate these for student use.
5. Identify a site in the school where the maps can be manipulated and then assembled on the floor.

Figure 2A
CREATING THE BASIN MAP

Step 1: Trim off the border.



Step 2: Place Map "B" on top of Map "A" to create an overlay system. Do this for all the maps in the system.



Step 3: Affix a velcro strip to the front of the border of "A" and another to the back of "B".

PROCEDURE

Period 1

1. Discuss what a USGS topographic map is and what a cartographer does.
2. This activity is designed so students will be able to visualize a major drainage basin.
   Have the students assemble the USGS maps in one of the following ways:
   Basic version: Divide the students into small groups. Give each group a series of adjoining maps (4 or 5). Have each group assemble its small section of the drainage basin then work with the other groups to assemble the entire basin.
   Challenge version: Scatter all the maps on the floor and challenge the students to work together as a group to create the entire basin.
3. Have the students explain their strategies for assembling the maps. [*Matching roads, rivers, town names, colors, quadrangle names, landforms, lakes, etc.*]
4. Ask each student to look at a section of the basin and take turns describing the symbols, lines, and colors that they see. Ask them to hypothesize what these may indicate. Use the "Topographic Map Symbols" sheet provided by the USGS as a key.

Period 2

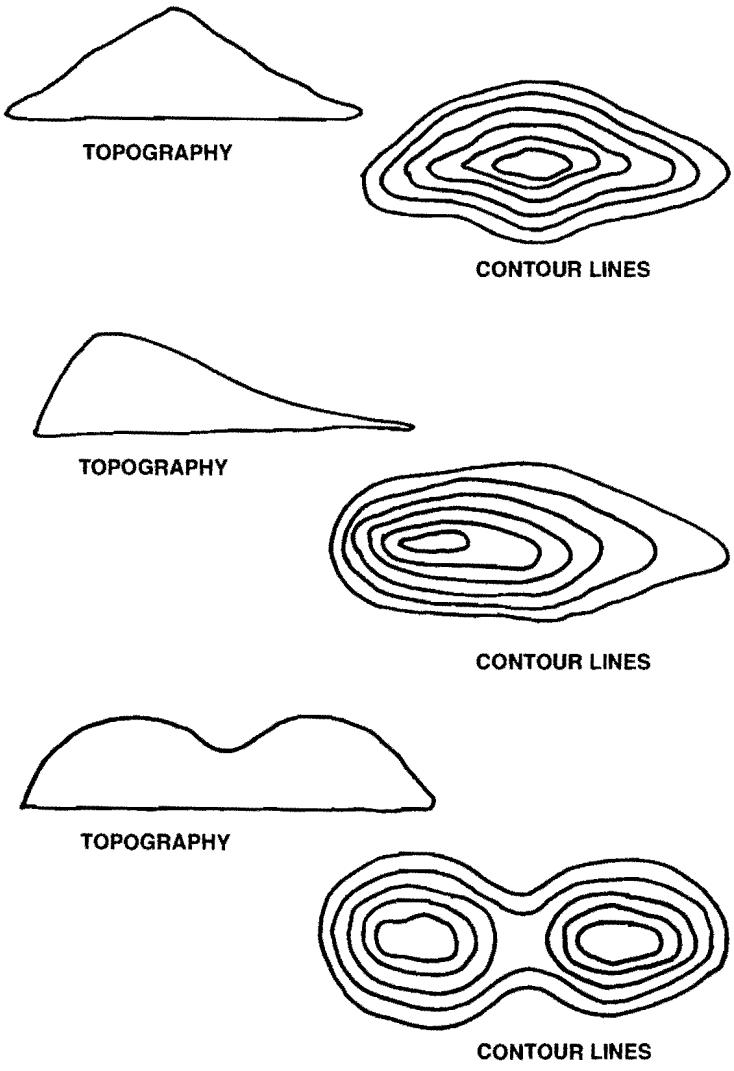
1. On one of the topographic maps, have each student locate a brown contour line.
   a. Discuss the difference between a contour line (thin brown line, usually indicating elevation changes of 10 or 20 feet) and a contour index line (thicker, darker brown line that has an elevation number on it).
   b. Ask the students to locate an elevation number on one of the contour index lines.
   c. Have them determine the elevation of that index contour and then their original contour line.
   d. Discuss how different elevations are represented on the map using the contour lines. [*Contour lines that are drawn close together indicate steep slopes and contour lines that are spaced further apart indicate gentler slopes.*]
2. Use Figure 2B to help the students visualize how contour lines translate into mountains and valleys.
3. Ask the students to locate the upland regions and lowland regions of the basin and justify their findings.
4. Have the students locate examples of the major map colors: green, blue, gray, pink, and purple. Discuss what these colors indicate. [*Green is generally undeveloped open space, forests, and farmland, whereas pink (salmon) or gray indicate built-up areas. Purple indicates information that has been added during an update and blue signifies water*]. Ask the students to describe the basin's land use based on where the different colors are located on the maps.

Period 3

1. Divide the students into small groups and distribute a copy of the topographic map which includes the local subwatershed. These maps may need to be pieced together from several USGS quadrangles, but the final map should be laminated so it can be reused. Have the students locate and identify the

Figure 2B
CONTOUR LINES, ELEVATION, AND TOPOGRAPHY

The landform (left) is represented as contour lines on a map (right).



following with nonpermanent markers:

- the school, their homes
- trace the closest river/stream and its tributaries in blue.

  Using the larger basin map, determine how this river/stream fits into the larger picture by locating its headwaters and mouth and determining its direction of flow. If appropriate have the students create a stream-order map. (Figure 2C)

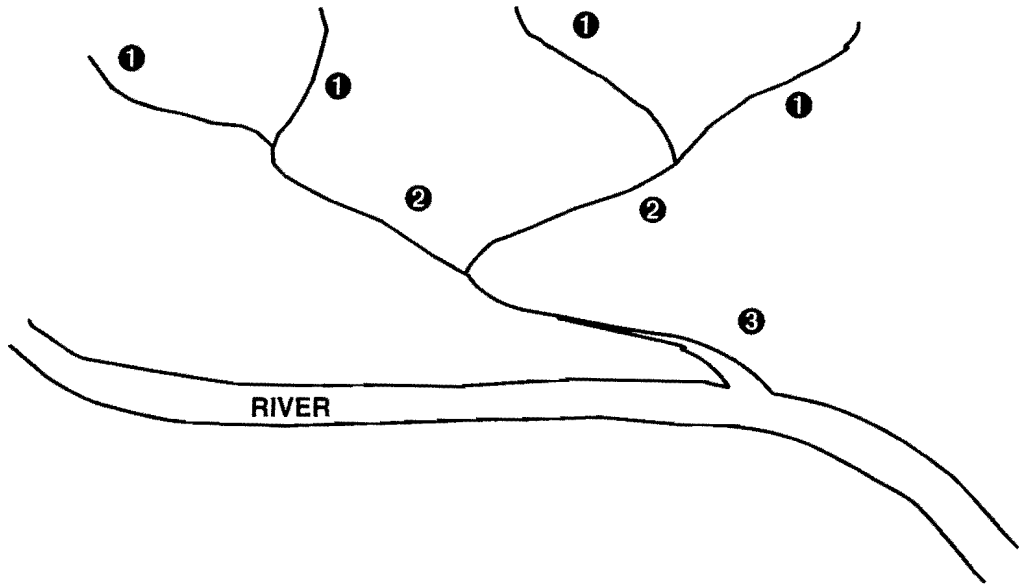
2. On the same map have the students locate, identify, and indicate with another color marker the highest elevation points surrounding the river/stream. Have the students connect these high points by following ridges and crossing slopes at right angles to the contour lines. This will help determine the watershed's boundaries. Determine if the watershed is an open or closed watershed system.

FURTHER DISCUSSION

- How do you think human activity has changed the topography of your watershed?
- Locate bodies of water that were created by dams or changed by the construction of new roads. How is this shown on the map? [*straight lines*] How do you think this has affected the surrounding area?
- Locate rivers or streams where people have channeled the waterway by means of artificial embankments (cement conduits, stream straightening). What might be the pros and cons associated with altering natural steam beds? [*pros - controls floodwaters, moves floodwaters along quicker, allows for more development; cons - alters the natural systems adjacent to the stream bed, destroys the natural systems that function as flood control (i.e., swamps, marshes, and flood plains), alters natural habitat for species*]
- Locate any reservoirs and discuss their purposes. [*store drinking water, control flood waters, provide recreational opportunities*]. Why do you think these are located where they are? Could there have been a better location? Where and why?
- Give reasons why various land uses are located where they are. Do these meet human needs, environmental preservation, or both?
- How might future development of the watershed address 'sustainable development'?

Figure 2C
CREATING A STREAM-ORDER MAP

Stream systems resemble a tree. The trunk becomes the largest river in the system, the biggest branches are the river's major tributaries and the smallest twigs are the streams located at the headwaters. Scientists categorize river systems in the following way: streams without tributaries are first-order streams (1), streams that receive only first-order streams are called second-order streams (2). When two second-order streams meet they become a third-order stream (3). This continues until the largest river in the system is reached.



ASSESSMENT

Pose the following scenarios:

- If you were a cartographer, how would you improve these topographic maps to help you interpret them better?
- If your job was in watershed management, what would you do to your watershed to balance the need for open space and economic growth?
- Discuss how past, present, and future land use might affect water quality and the quality of land in the watershed.

EXTENSION

Challenge the students to develop a "greenway" for their watershed by selecting specific tracts of land that would be the most useful in preserving water quality and reduce filtration costs for potable water.

EMPOWERMENT CHALLENGE

Arrange for the students to visit a portion of their local watershed to try and correlate "real" features with the features that are visible on the corresponding topographic map. This process is called "ground-truthing."

LESSONS FROM OTHER SOURCES

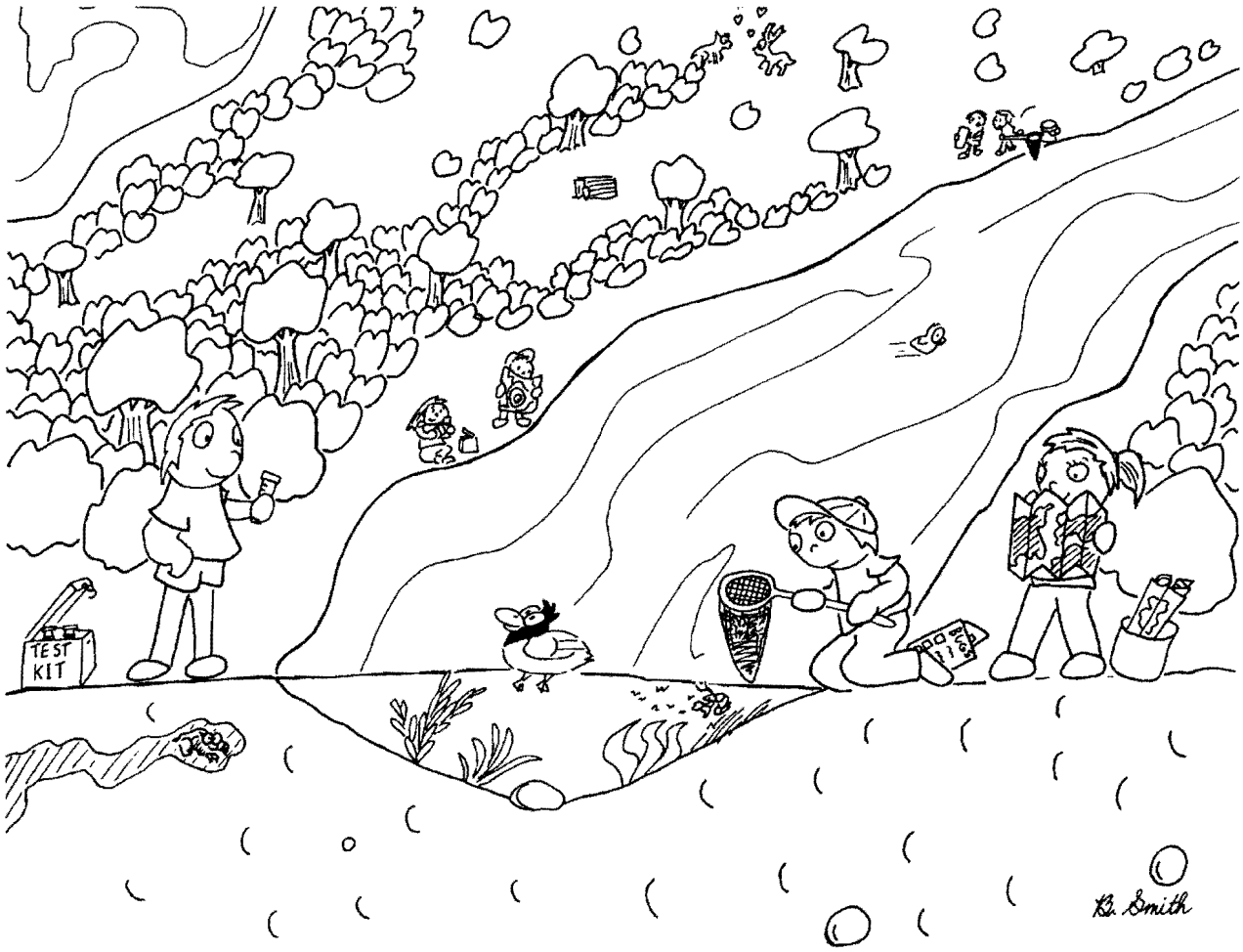
Beneath the Shell - Topo Trouble
Sourcebook for Watershed Education - Watershed Mapping
The Ways of the Watersheds - Line Up!
WOW! The Wonders of Wetlands - Over Hill & Dale

REFERENCES

United States Geologic Survey, Topographic Map Symbols instructional pamphlet.

STATE OF THE WATERSHED

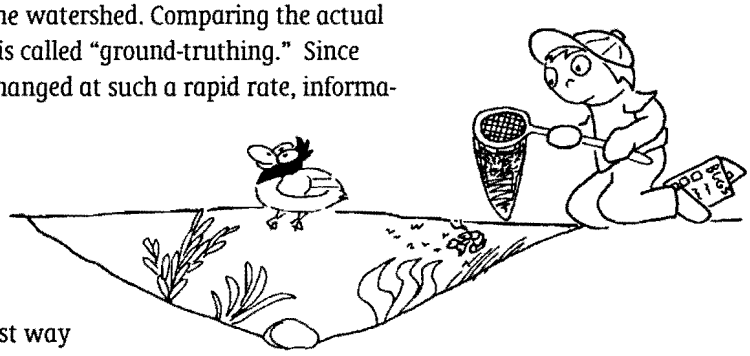
A watershed is an area of land where water drains into an individual stream, lake, or other body of water. Its boundaries are defined by ridgelines and points of higher elevations. A watershed includes all the water systems as well as the land habitats and the human environment within its boundaries. The health of a watershed and its waterways is determined by the way the natural systems within the watershed are handled by humans or altered by natural phenomena.



Every water system can be monitored using a variety of methods. Chemical monitoring helps identify the quality of water by analyzing water samples at specific locations. Monitoring the water quality of a specific site over time enables the results to be compared and documents any changes. Inferences can be made about the cause/s of any changes that are identified. Biological monitoring focuses on looking at plant and animal indicator species (those species that are found in a specific type of habitat). Biologists may conduct biosurveys that collect, process, and analyze aquatic organisms, or they may conduct plant diversity surveys. Both of these help determine the environmental conditions of the waterway. Visual assessment of the habitats and

State of the Watershed

land use are also important factors in understanding more about the watershed. During this phase of monitoring, the watershed boundaries are identified on maps and sections of the watershed are walked. This experience enables the monitor to become familiar with the physical aspects of the watershed. Comparing the actual land and land use to what is shown on a map is called "ground-truthing." Since some maps may be outdated or land use has changed at such a rapid rate, information that was accurate last year may no longer be accurate due to new development or uses. Being out in the field and reporting these inconsistencies to the appropriate officials is a way to help keep maps current.



A combination of these three methods is the best way to obtain a complete picture of the health of a watershed. This can be a difficult task if the watershed is large, but methods have been developed so it can be done in stages and by different people. Standardizing the way people do their research allows them to compare results from site to site, season to season, and year to year. This kind of information enables residents, planners, environmental commission members, and watershed association members to compare land use percentages, identify factors that could be affecting the water quality of bodies of water, and identify pollution problems. Since all of the water systems within a watershed are connected and one affects the other (from headwaters to river mouth), getting a broad picture or "snapshot" of the entire watershed becomes a cooperative project.

Each of these methods can be implemented in separate communities but if conducted in concert with each other it helps to identify the "state of the watershed." It is almost like being the detectives on a case who need to find all the clues, analyze the relationships between them, then pull everything together to understand the "big picture."

TAKE A LOOK AT YOUR WATERSHED:

Note the direction that the water drains from the land.

Identify the types of land uses that you see in your watershed. How do you think these affect water quality and habitat quality in the watershed?

LESSON 3

State of the Watershed

GOAL To observe and record the physical characteristics of a specific body of water and the adjacent land in order to create a more complete picture of the watershed.

TIME
- (3) 45-minute periods
- 1 full-day field trip
- group work time

OBJECTIVES Students will:
- ✔ use maps to ground-truth their watershed
- ✔ collect field data using scientific methods
- ✔ conduct a visual assessment of a watershed using data collection survey forms
- ✔ interpret data to help describe the health of the watershed
- ✔ present data in project form using technology
- ✔ make recommendations about improving their watershed

SKILLS observe, gather and interpret data; analyze, synthesize, formulate hypotheses, communicate, justify

VOCABULARY
ground-truth
visual assessment
volunteer monitoring

PRIOR KNOWLEDGE Students should have background in:
- how to use measuring equipment (Note: If chemical and biological monitoring are going to be done in conjunction with this assessment, students will need to know how to conduct the tests, safety considerations for using the chemicals, and safe methods for sampling macroinvertebrate populations.)
- how to conduct field research using scientific methods and standards
- the understanding that various land uses have impacts on water quality

CORE CURRICULUM CONTENT STANDARDS
- Cross Content Workplace Readiness 2 (7,9) 3 (7,12,15) 4 (2) 5 (7)
- Language Arts 3.1 (14-16,18) 3.2 (8,9,11) 3.3 (19) 3.4 (25) 3.5 (12-14, 17)
- Math 4.1 (10-13, 15,16,18) 4.2 (9,10) 4.3 (10,11) 4.4 (7,8,9,10) 4.5 (6-8) 4.6 (14) 4.8 (11) 4.9 (7,8,11-14,19) 4.10 (9) 4.12 (9,11,18,19)
- Science 5.1 (4-6,7) 5.2 (8-11,13) 5.5 (6,10,12,14) 5.10 (5,10,14) 5.12 (5-7,9,10)
- Social Studies 6.7 (9-11,12) 6.9 (5)

MATERIALS

- ❑ Variety of maps and land use resources including:
  - USGS maps of the watershed
  - Local and county road maps
  - Land use and zoning maps (local planning office)
  - Aerial photographs (Appendix D - Maps)
  - Sewer system maps (local water utility)
  - Maps showing landfill locations, wastewater treatment plants, and stormwater detention ponds (local planning office)
  - NJ stream map (Appendix D - Maps)
  - Shellfishing maps (Appendix D - Maps)
  - Bathymetric maps (Appendix D - Maps)
- ❑ Watershed survey worksheets*
  - Site survey sheet (Student Page #1)
  - Stream/River (Packet 1)
    - Water Characteristics (Student Page #2)
    - Valley Profile, Stream Bank, Channel, and Sediment Characteristics (Student Page #3)
    - Watershed, Habitat, and Human Impact Characteristics (Student Page #4)
    - Term Description sheet
  - Estuary (Packet 2)
    - Water Characteristics (Student Page #5)
    - Basin, Shoreline, Channel, and Sediment Characteristics (Student Page #6)
    - Watershed, Habitat, and Human Impact Characteristics (Student Page #7)
    - Term Description sheet
  - Pond/Lake (Packet 3)
    - Water Characteristics (Student Page #8)
    - Basin, Shoreline, and Sediment Characteristics (Student Page #9)
    - Watershed, Habitat, and Human Impact Characteristics (Student Page #10)
    - Term Description sheet
- ❑ Watershed survey equipment (Each packet lists the specific equipment needed for studying the site.)
  - ❑ Clipboards
  - ❑ Pencils
  - ❑ Thermometer
  - ❑ Hydrometer
  - ❑ Unbreakable white container
  - ❑ Measuring tape
  - ❑ Stop watch
  - ❑ Long-handled net
  - ❑ Seine net
  - ❑ Hip waders or boots
  - ❑ Life Jackets
  - ❑ Collecting containers
  - ❑ Measuring stick
  - ❑ First aid kit
  - ❑ Binoculars (optional)
  - ❑ Camera / film (optional)
  - ❑ Calculator (optional)
  - ❑ Global Positioning System (GPS) instrument (optional)

*Based on survey forms designed by USEPA and Global Rivers Environmental Education Network

PREPARATION

1. Collect as many maps listed under materials as possible.
2. Laminate any that will be taken out into the field.
3. Select a site(s) for a field trip within the watershed. Although one field trip is manageable, consider the following:
   - Visit three sites within the same watershed. Have the students do a comparison study.
   - Visit one site three times during the school year. Space the visits for early fall when water levels are usually low, late fall before onset of freezing weather but after leaves have dropped, and early spring before leaves are out in full and water levels are usually high.
4. Visit the site prior to the field trip to determine the following logistics of the field trip:
   - site size (how much space will be needed for the groups to carry out their research but still stay within given boundaries)
   - where are the group study areas
   - safety considerations and access to the water
5. Duplicate the appropriate Student Pages for the habitat type you will visit: Stream/River (Packet 1), Estuary (Packet 2), and Pond / Lake (Packet 3).

PROCEDURE

Period 1 (pre-field trip)

1. Have the students locate the stream, lake, or estuary that they will visit on a map.
2. Instruct the students to delineate its watershed boundaries and identify the community or communities in which it exists or through which it flows. Use USGS topographic maps, aerial photographs, local and county road maps, land use and zoning maps to identify current types of land use.
3. Discuss the process of ground-truthing.

Field trip

1. Orient the students to the site using the maps with which they are familiar. If at any time during their field research they discover something that is not on the map, ask them to make note of it on their site survey form (ground-truthing).
2. Have each student complete the Site Survey form (Student Page #1). See sample (Figure 3A).

3. Group students into teams of at least six members. Divide each team into three groups for data-gathering purposes. Back in the classroom each team will reassemble to compile their information and present their summary on the "state of the watershed."
4. The three data gathering groups for each team include:
   Group A - Water Characteristics
   Group B - Bank, Channel, and Sediment Characteristics
   Group C - Watershed Habitats and Human Impact Characteristics
5. Distribute the appropriate data forms and equipment. Review the appropriate Term Description sheet.

Period 2 (post-field trip)

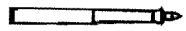
1. Regroup the students so that each presentation group consists of people from all three of the field study areas (Water Characteristics; Bank, Channel, and Sediment Characteristics; Watershed, Habitat, and Human Impact Characteristics).
2. Have each team design a presentation that describes their observations concerning the health of the watershed. This can be done through the visual arts, by graphing and reporting data, or by any means the team members select.
3. Allow time for group work.

Period 3

Have the students present their information to the rest of the class.

FURTHER DISCUSSION

1. What evidence of human activities did you see that might affect the watershed and/or the water quality of the site's water body?
2. What were potential sources of pollution? Are they point source or non-point source pollution?
3. What land use types did you find that could have potential impact on water quality?
4. How would you rate the watershed. (Rate from 1 to 5, 1 as excellent and 5 as poor.) Upon what do you base your opinion?
5. How does rating the physical aspects of the water body help us determine the health of the watershed?
6. What field of study would a person pursue if they wanted to be involved in watershed management?



ASSESSMENT

Have each team make suggestions for improving the quality of the watershed and discuss actions that they might take to improve their watershed.

EMPOWERMENT CHALLENGE

- Participate in and / or organize a community project. Examples: clean-up of a stream, lake, estuary, or beach; storm drain stenciling; streambank stabilization; riparian buffer zone planting; or non-point source pollution education campaign.
- Share data and information with another school in the watershed. Use the Internet to keep a dialogue with a school upstream or downstream.

LESSONS FROM OTHER SOURCES:

Hands on Save Our Streams - Explore A Watershed, Measuring Stream Health
Project WET - Sum of the Parts
The Ways of the Watersheds - Pond and Stream Explorations
WOW! The Wonders of Wetlands - Run for the Border, Water We Have Here?

REFERENCES

Mitchell, Mark K. and William B. Stapp. 1996. *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools.* Ann Arbor, MI: Global Rivers Environmental Education Network.

United States Environmental Protection Agency (USEPA). 1997. *Volunteer Stream Monitoring: A Methods Manual* # 841-B-97-003.

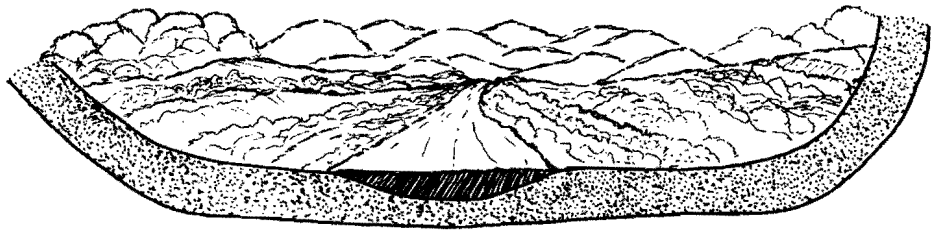
USEPA. 1993. *Volunteer Estuary Monitoring: A Methods Manual* #842-B-93-004.

USEPA. 1991. *Volunteer Lake Monitoring: A Methods Manual* #440/4-91-002.

Each packet contains three student worksheets and a Term Description reference sheet.

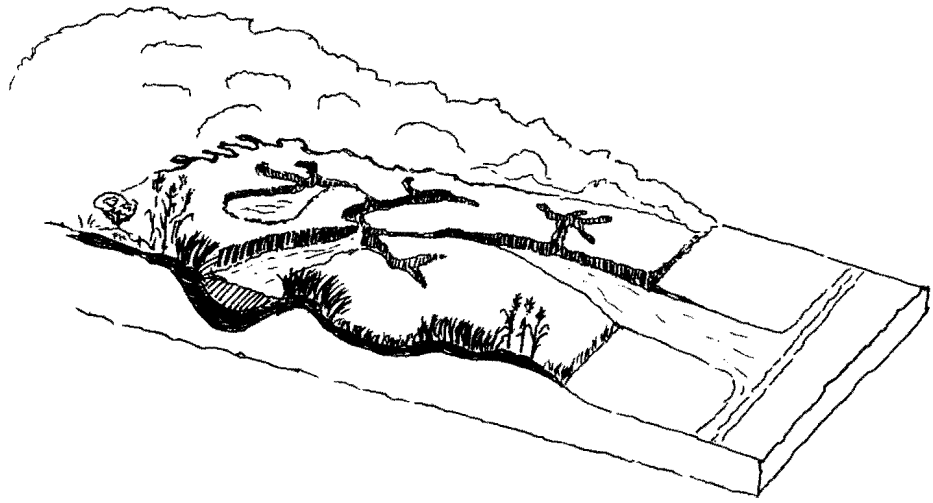
Packet 1 Freshwater Stream/River (pages 89-100)

Student Sheets 2, 3, & 4, and Term Descriptions



Packet 2 Estuary (pages 101-111)

Student Sheets 5, 6, & 7, and Term Descriptions



Packet 3 Pond/Lake (pages 112-122)

Student Sheets 8, 9, & 10, and Term Descriptions

NAME: DATE:

THE STATE OF YOUR WATERSHED
Site Survey

Check the type of water body you are assessing:

_____ **Freshwater stream/river**

_____ **Estuary**

_____ **Lake/pond**

WATER BODY NAME: _____

Watershed: _____

County & State: _____

Latitude: _____ Longitude: _____

Time: _____

	Weather in the past 24 hours:	**Weather now:**
Storm (heavy rain)	❑	❑
Rain (steady rain)	❑	❑
Showers (intermittent rain)	❑	❑
Overcast	❑	❑
Clear / sunny	❑	❑

Ground-truthing: Compare your study site to a USGS topographic map of the area. List any new or changed features, developments, etc. that are not on the USGS map.

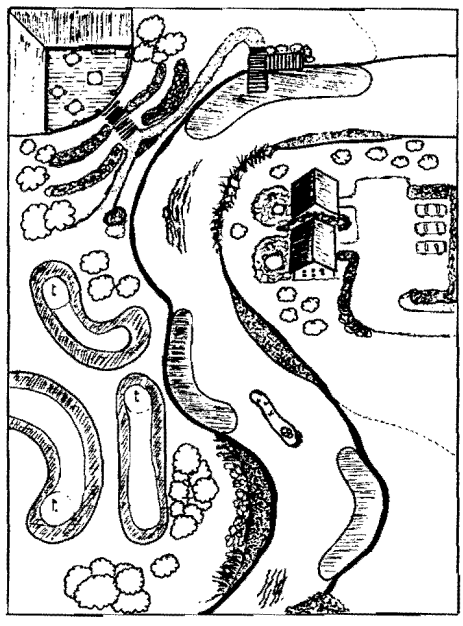


Figure 3A
SAMPLE SITE SKETCH

(Based on survey forms from USEPA and Global Rivers Environmental Education Network)

The State of Your Watershed (continued)

SITE SKETCH (Refer to Figure 3A on front)
Create a "bird's-eye" view sketch of your study site. On your sketch, note features that affect habitat, such as riffles, runs, pools, ditches, wetlands, dams, tributaries, landscape features, logging paths, vegetation, roads, housing, and other types of land use.

NAME: DATE:

Freshwater Stream/River

GROUP A Data Form

Water Characteristics

Research members:

Data recorder:

Equipment needed: white plastic container, thermometer, measuring tape, object that floats, stopwatch, long-handled net, hip waders or boots, Freshwater Stream/River Term Descriptions (pages 98 - 100)

1. Circle which stream habitats are present (you can circle more than one). See Figure 3B.

   Pool (s) Riffle (s) Run (s)

2. **APPEARANCE**: Use the white container to gather a sample of water. Circle the best description.

   Clear Milky Foamy Turbid

   Dark brown Oily sheen Orange Greenish

   Other color, describe _____

3. **ODOR**: Circle the best description.

   Sewage Chlorine (like a pool) Fishy

   Rotten eggs (like sulfur) None Other odor, describe _____

4. **WATER TEMPERATURE**

   Site #1 (at the surface in a sunny area) _____ °C

   Site #2 (at the bottom in a sunny area) _____ °C

   Site #3 (at the surface in a shady area) _____ °C

   Site #4 (at the bottom in a shady area) _____ °C

   Average temperature (Add the four numbers and divide by 4) _____ °C

Freshwater Stream/River (continued)

GROUP A Data Form

Water Characteristics

5. **VOLUME**

a. Measure a length of the stream (stream reach) to calculate volume. _____ ft.
See Figure 3B.

b. Calculate the average width of the stream reach.
Width at the upstream end of the test site _____ ft.
Width at the midpoint of the test site _____ ft.
Width at the downstream end of the test site _____ ft.
Average = _____ ft.

c. Calculate the average depth the stream reach. Take six random measurements.
Depth 1 _____ in.
Depth 2 _____ in.
Depth 3 _____ in.
Depth 4 _____ in.
Depth 5 _____ in.
Depth 6 _____ in.
Average depth _____ in.
Convert average depth in inches to feet. _____ ft.

d. Multiply **length** of the test section x **average width** x **average depth** to determine the volume of water in the test section
Volume = _____ cu. ft.

e. Convert cubic feet to gallons. One cubic foot equals eight gallons of water.
_____ gallons of water in the test section

6. **WATER VELOCITY**

Measure a 20-foot section of the stream (select a site that has a fairly straight run)
Select a small object that will float (could be stick, leaf, etc.).
Measure the time it takes the object to float the selected section.
Repeat this process at least three times and average the times.
_____Time #1
_____Time #2
_____Time #3
_____Average (add all the times together and divide by 3):
Divide the distance (20 ft.) by the average time to determine the velocity (in feet per second).
Stream velocity = _____ ft./sec.

NAME: DATE:

Freshwater Stream/River

GROUP B Data Form

Valley Profile, Stream Bank, Channel, and Sediment Characteristics

Research members:

Data recorder:

Equipment needed: Freshwater Stream/River Term Descriptions (pages 98 - 100), hip waders or boots

1. From the furthest downstream spot in your study area, look upstream, to the left and to the right to determine the stream's valley profile. Pick the best description from the Term Description sheet. See Figure 3C.

2. From this same point pick the description that best fits the shape of the stream bank and the channel. See Figure 3D.

   a. Stream bank:

Left bank		Right bank
❑	Vertical / undercut	❑
❑	Steeply sloping (> 30 degrees)	❑
❑	Gradual / no slope (< 30 degrees)	❑

   b. Estimate how much of your stream / river's bank has been modified by artificial means such as concrete, rip rap (broken debris, i.e., concrete, rocks, or brick), imported rock, walls, etc.

Left bank		Right bank
❑	Bank 0-25% covered	❑
❑	Bank 25-50% covered	❑
❑	Bank 50-75% covered	❑
❑	Bank 75-100% covered	❑

   c. Shape of the channel - circle the best description (width of a channel is from bank to bank, depth of a channel is from the top of the bank to the bottom of the channel)

narrow, deep (width = < 6', depth = > 3')

narrow, shallow (width = < 6', depth = < 3')

wide, deep (width = > 6', depth = > 3')

wide, shallow (width = > 6', depth = < 3')

Freshwater Stream/River (continued)

GROUP B Data Form

Valley Profile, Stream Bank, Channel, and Sediment Characteristics

3. From the same spot, describe the stream side cover. Check "0" if not present, "1" if present, "2" if plentiful.

a. Along the water's edge and stream bank only:

Left bank				Right bank		
0	1	2		0	1	2
❑	❑	❑	Trees	❑	❑	❑
❑	❑	❑	Bushes, shrubs	❑	❑	❑
❑	❑	❑	Tall grasses, ferns, etc.	❑	❑	❑
❑	❑	❑	Lawn	❑	❑	❑
❑	❑	❑	Boulders/rocks	❑	❑	❑
❑	❑	❑	Gravel / sand	❑	❑	❑
❑	❑	❑	Bare soil	❑	❑	❑
❑	❑	❑	Pavement, structures	❑	❑	❑

b. From the top of the stream bank out to 25 yards (measure this distance to get a bearing).

Left bank				Right bank		
0	1	2		0	1	2
❑	❑	❑	Trees	❑	❑	❑
❑	❑	❑	Bushes, shrubs	❑	❑	❑
❑	❑	❑	Tall grasses, ferns, etc.	❑	❑	❑
❑	❑	❑	Lawn	❑	❑	❑
❑	❑	❑	Boulders/rocks	❑	❑	❑
❑	❑	❑	Gravel / sand	❑	❑	❑
❑	❑	❑	Bare soil	❑	❑	❑
❑	❑	❑	Pavement, structures	❑	❑	❑

4. Circle the category that best describes the percentage of shade that the stream receives:

0% 25% 50% 75% 100%

5. From the same point in your study site, look upstream. Check "0" if the condition not present, "1" if there is low to moderate impact and "2" if there is moderate to high impact.

Left bank				Right bank		
0	1	2	**Stream Banks**	0	1	2
❑	❑	❑	Natural stream side plant cover degraded	❑	❑	❑
❑	❑	❑	Banks collapsed / eroded	❑	❑	❑

Freshwater Stream/River (continued)

GROUP B Data Form

Valley Profile, Stream Bank, Channel, and Sediment Characteristics

5. (continued) From the same point in your study site, look upstream. Check "0" if the condition not present, "1" if there is low to moderate impact and "2" if there is moderate to high impact.

Left bank				Right bank		
0	1	2		0	1	2
❑	❑	❑	Garbage / junk present	❑	❑	❑
❑	❑	❑	Foam or sheen on bank	❑	❑	❑
			Stream Channel			
❑	❑	❑	Mud, silt, or sand in or entering the stream	❑	❑	❑
❑	❑	❑	Garbage / junk present	❑	❑	❑
			Other			
❑	❑	❑	Yard waste on bank (grass clippings, leave piles)	❑	❑	❑
❑	❑	❑	Livestock in or with unrestricted access to stream	❑	❑	❑
❑	❑	❑	Actively discharging pipe(s)	❑	❑	❑
❑	❑	❑	Other pipe(s) entering the stream	❑	❑	❑
❑	❑	❑	Ditches entering the stream	❑	❑	❑

6. Investigate the stream bottom along the edges and in the middle (if possible). Check the description that best fits the stream bottom particles that you find:

	none/little	some	most
Silt/Clay/Mud	❑	❑	❑
Sand (up to 0.1" in diameter)	❑	❑	❑
Gravel (0.1" to 2" in diameter)	❑	❑	❑
Cobbles (2" to 10" in diameter)	❑	❑	❑
Boulders (over 10" in diameter)	❑	❑	❑
Bedrock (solid rock)	❑	❑	❑

7. Are there logs or large woody debris in the stream?

None Some Plentiful

8. Is there naturally-occurring organic material (leaves, twigs, etc.) in the stream?

None Some Plentiful

NAME: DATE:

Freshwater Stream/River

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

Research members:

Data recorder:

Equipment needed: long-handled net, collecting container, binoculars, variety of animal and plant identification guides, Freshwater Stream/River Term Descriptions (pages 98 - 100)

1. Determine where the location of your study site is in the watershed by looking at your maps. Circle the best answer.

Upper watershed (nearest to the headwaters) Middle watershed Lower watershed

2. Walk as much of the study site as possible observing not only the stream itself, but also the habitat surrounding the stream to note the following:
Check "1" if present, "2" if clearly having an impact on the stream. If "2" describe what that visible impact is.

1	2	**Residential**	**Impact (describe)**
❑	❑	Single-family housing	
❑	❑	Multifamily housing (condos, apartments)	
❑	❑	Lawns	
❑	❑	Commercial / institutional (schools, hospitals)	
❑	❑	Other	

1	2	**Roads, etc.**	**Impact**
❑	❑	Paved roads or bridges	
❑	❑	Unpaved roads	
❑	❑	Other	

1	2	**Construction underway on:**	**Impact**
❑	❑	Housing development	
❑	❑	Commercial development	
❑	❑	Road bridge construction or repair	
❑	❑	Other	

Freshwater Stream/River (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

2. (continued)

Check "1" if present, "2" if clearly having an impact on the stream. If "2" describe what that visible impact is.

1	2	**Agricultural**	**Impact**
❑	❑	Grazing land	
❑	❑	Feeding lots or animal holding areas	
❑	❑	Cropland	
❑	❑	Inactive agricultural lands / fields	
❑	❑	Other	

1	2	**Recreation**	**Impact**
❑	❑	Power boating	
❑	❑	Golfing	
❑	❑	Camping	
❑	❑	Swimming / fishing / nonmotorized boating	
❑	❑	Hiking / paths	
❑	❑	Other	

1	2	**Other**	**Impact**
❑	❑	Mining or gravel pits	
❑	❑	Logging	
❑	❑	Industry	
❑	❑	Above ground storage tanks	
❑	❑	Trash dump	
❑	❑	Landfill	

3. Rate the following from most (1) to least (5). Approximate the percentage of land use in and around the study site:

_____ Residential	_____ %
_____ Open space (parkland, forest, protected land)	_____ %
_____ Commercial / industrial	_____ %
_____ Roads, parking lots	_____ %
_____ Agricultural / rural	_____ %

Freshwater Stream/River (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

4. Note the types and number of structures that alter the natural stream flow (hydrologic modifications):

_____ None	_____ Dams	_____ Bridges
_____ Waterfalls	_____ Stream fords	_____ Beaver dams

5. Check the categories that best describe the general appearance of the waterway and surrounding habitat:

- ❑ Litter:
  - ❑ No litter visible
  - ❑ Small litter occasionally (e.g., cans, paper, etc.)
  - ❑ Small litter common
  - ❑ Large litter occasionally (e.g., tires, carts, etc.)
  - ❑ Large litter common
- ❑ Erosion:
  - ❑ No stream bank erosion or areas of erosion very rare
  - ❑ Occasional areas of stream bank erosion
  - ❑ Areas of stream bank erosion common
  - ❑ Artificial stream bank stabilization present (concrete walls, rip rap, etc.)
- ❑ Special problems (note in detail in comment section):
  - ❑ Spills of chemicals, oil, etc.
  - ❑ Fish kills
  - ❑ Wildlife, waterfowl kills
  - ❑ Flooding
  - ❑ Periods of no flow

COMMENTS on special problems:

Freshwater Stream/River (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

6. **VISUAL BIOLOGICAL SURVEY**

a. Wildlife in or around the water body - look for actual animals or animal evidence (e.g., footprints, feathers, scat, shells, etc.). Check all that apply and identify species if possible.

- ❑ Amphibians
- ❑ Waterfowl (or other birds)
- ❑ Reptiles
- ❑ Mammals
- ❑ Inveterbrates (mussels, clams, etc.)

Fish in the stream? If possible, use net. (check all that apply):

- ❑ No
- ❑ Yes, but rare
- ❑ Yes, abundant
- ❑ Small (1-2")
- ❑ Medium (3-6")
- ❑ Large (7" and above)

Are there any barriers to fish movement?

- ❑ None
- ❑ Beaver dams
- ❑ Waterfalls > 1 foot
- ❑ Dams
- ❑ Road barriers
- ❑ Other (explain)

b. Aquatic plants (circle the best answer for each line):

None Some Plentiful

Attached Free-floating

Extent of algae (check all that apply):

1. Are the stones, twigs or other material that is underwater coated with algal slime? Circle the best answer for each line.

None Some Plentiful

Light coating Heavy coating (can hardly see the object)

Brownish Greenish Other color, describe _____

2. Are there string-like (filamentous) algae? Circle the best answer for each line.

None Some Plentiful

Brownish Greenish Other color, describe _____

3. Are there any clumps or mats of algae floating on the water's surface? Circle the best answer for each line.

None Some Plentiful

Brownish Greenish Other color, describe _____

Freshwater Stream/River

TERM DESCRIPTIONS

Water Characteristics

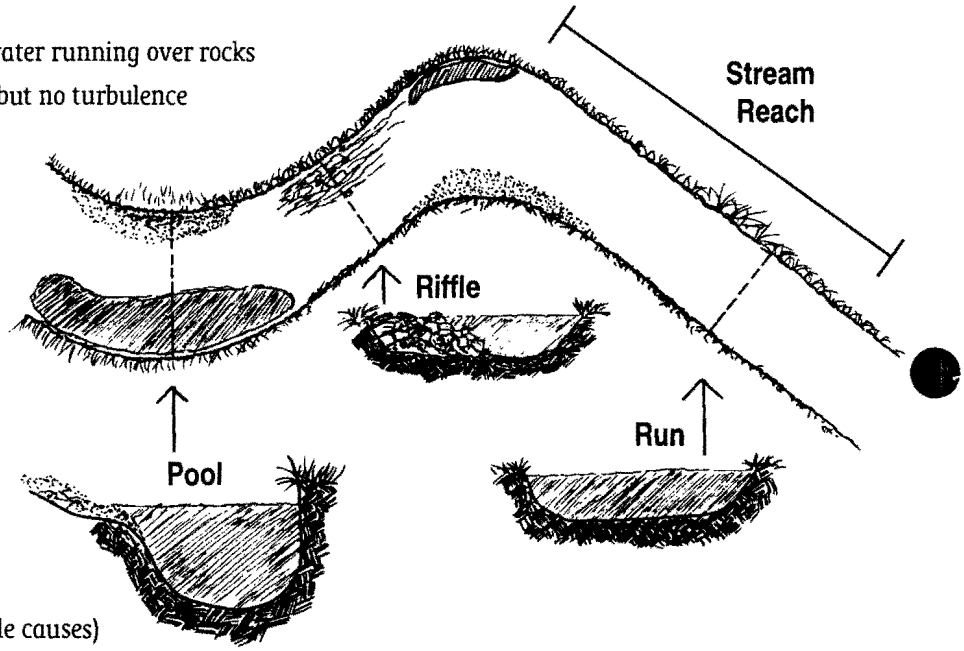
Stream habitats

Pool – deep area with slow water

Riffle – shallow areas with fast water running over rocks

Run – deep area with fast water, but no turbulence

Figure 3B



Water Appearance (possible causes)

Clear – colorless, transparent

Milky – cloudy-white or gray, not transparent; might be natural or due to pollution

Foamy – might be natural or due to pollution, generally detergents or nutrients

Turbid – cloudy brown due to suspended silt or organic materials (could be due to soil erosion)

Dark brown – might be from acids being released into the stream due to decaying plants (tannins)

Oily sheen – multicolored reflection (might be oil or gasoline floating on the surface from fuel line leaks, underground storage tank leaks, runoff from parking lots and roads). Note: Some sheens are naturally occurring.

Orange – might indicate acid drainage or high iron content in the soil

Green – might indicate excess nutrients

Water Odor (possible causes)

Sewage – might indicate human waste material

Chlorine – might indicate over-chlorinated sewage treatment / water treatment plant or swimming pool discharges

Fishy – might indicate excessive algal growth or dead fish

Rotten eggs – might indicate sewage pollution

Freshwater Stream/River (continued)

TERM DESCRIPTIONS

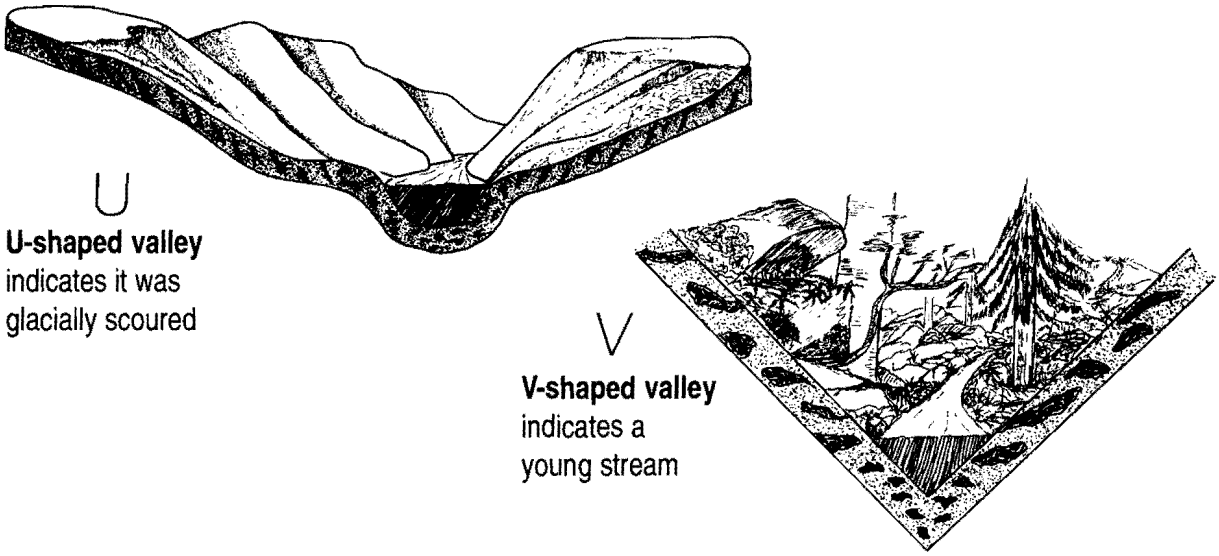
Water temperature has a direct effect on the amount of dissolved oxygen in the water that is available for aquatic organisms. Oxygen dissolves more easily in cooler waters than in warmer waters.

Water velocity changes by season, storm event, and percent of runoff from the land. The amount of water in a stream channel affects bank erosion, how easy or difficult it is for animals to live in the stream, and the percent of woody debris and organic materials present in the stream.

Water volume helps determine whether there will be stream bank erosion. High volume may scour stream banks, expose tree roots, and increase sediments entering the water system. Low volume may increase the concentrations of pollutants and raise water temperature.

Valley Profile, Stream Bank, Channel, and Sediment Characteristics

Figure 3C **Valley Profiles**



U

U-shaped valley indicates it was glacially scoured

V

V-shaped valley indicates a young stream

floodplain valley indicates a mature stream or river

Freshwater Stream/River (continued)

TERM DESCRIPTIONS

Stream bank

Vertical or Undercut

Steeply Sloping

Gradual

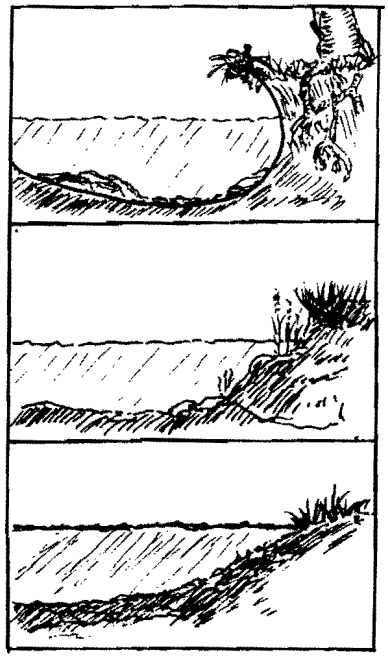


Figure 3D

Stream side cover helps determine the quality and extent of the habitats next to a stream.

The degree of **stream shading** from a forested canopy helps determine the temperature of the water. It also determines how much habitat there is for aquatic animals and those land animals that use the stream. Leaves from overhanging vegetation add organic matter to the stream which provides protection for aquatic animals and insects. Decomposition of this organic matter is the basis of the aquatic food chain.

Watershed, Habitat, and Human Impact Characteristics

Land Use

Different land uses allow for varying amounts of water to filter through the soil. Pervious surfaces include undeveloped land like forests, fields, agricultural areas and parks. Impervious surfaces include anything that does not allow water to get back into the soil such as parking lots, roads, and buildings.

Aquatic Plants

Streams with a high percentage of rooted aquatic vegetation may indicate high amounts of nutrients (organic matter or fertilizer). Streams without plants may indicate high levels of acid or toxic pollutants.

Algae Growth

Algae are simple plants that do not grow true roots, stems, or leaves. They live mainly in water and are important to the aquatic food chain. An abundance of algae may indicate excess nutrients (organic matter or fertilizers).

NAME: DATE:

Estuary

GROUP A Data Form

Water Characteristics

Research members:

Data recorder:

Equipment needed: white plastic container, thermometer, hydrometer/thermometer, hydrometer conversion table, boots or hip waders, life jackets, Estuary Term Descriptions (pages 110 and 111)

1. **WATER APPEARANCE**: Use the white plastic container to gather a sample of water. Circle the best description.

Green	Yellow/brown	Red/yellow
Various colors	Rainbow	Other color, describe _____

2. **ODOR:** Circle the best description.

None	Sewage	Oily	Fishy	Rotten eggs (like sulfur)
Salty	Other odor, describe _____			

3. **WATER SURFACE CONDITIONS**: Circle the best description.

Calm	Ripples	Swells (rolling waves)	Choppy (white caps)

4. **WATER TEMPERATURE**

Site #1 (at the surface) _____°C

(at the bottom) _____°C

Site #2 (at the surface) _____°C

(at the bottom) _____°C

Average temperature _____°C

Estuary (continued)

GROUP A Data Form

Water Characteristics

5. **SALINITY**

Fill a clear container with water from the estuary. Place the hydrometer (measures specific gravity) and a thermometer into the container. Do not let them touch. Wait until the hydrometer stabilizes before taking a reading. (Note: Some hydrometers have built-in thermometers.)

Record the temperature _____ °F

Record the specific gravity on the hydrometer _____

IMPORTANT: Read the hydrometer at the bottom of the curvature of water, not where the curvature of the water touches the glass. Use a hydrometer conversion table to calculate the salinity of the water.

Salinity = _____ 0/00 (ppt)

NAME: DATE:

Estuary

GROUP B Data Form

Basin, Shoreline, Channel, and Sediment Characteristics

Research members:

Data recorder:

Equipment needed: measuring tape, yardstick, hip waders or boots, 2 sticks or poles with a tether attached to each, Estuary Term Descriptions (pages 110 and 111)

1. **TIDAL CHANGE (FLUX)** - Do this immediately upon arriving at your study site. Tie one end of the tether to the pole and secure the other end of the tether to a site on land that will be unaffected by the tide. This ensures that if the tide rises a lot, the pole will be able to be retrieved.
    a. Horizontal change: Insert a stick into the estuary mud at the edge of the water and note the time. When you leave measure the distance from the water's edge to the stick to determine the distance the tide had risen / fallen horizontally.
    b. Vertical change: Insert a stick into the estuary mud (at least 2 feet from the shoreline into the water). Measure from the top of the stick to the water's surface. When you leave, measure the distance that the tide has risen / fallen vertically.

Vertical Change _____ feet

Horizontal Change _____ feet

2. Choose a point in your study area to make your observations. Pick the description that best fits the shoreline and the channel (if applicable) of your study area. See Figure 3E.
    a. Shoreline:
        - ❑ Vertical / undercut
        - ❑ Steeply sloping (> 30 degrees)
        - ❑ Gradual / no slope (< 30 degrees)
    b. Estimate how much of the shoreline has been modified by artificial means such as concrete, rip rap (broken debris, i.e., concrete, rocks, or brick), imported rock, walls, bulkheading, etc.
        - ❑ Bank 0-25% covered
        - ❑ Bank 25-50% covered
        - ❑ Bank 50-75% covered
        - ❑ Bank 75-100% covered

Estuary (continued)

GROUP B Data Form

Basin, Shoreline, Channel, and Sediment Characteristics

3. From the same spot, describe the shoreline cover. Check "0" if not present, "1" if present, "2" if plentiful.

   a. Along the water's edge only:

	0	1	2
Trees	❑	❑	❑
Bushes, shrubs	❑	❑	❑
Tall reeds (i.e., phragmities, etc.)	❑	❑	❑
Salt marsh grasses	❑	❑	❑
Lawn	❑	❑	❑
Boulders/rocks	❑	❑	❑
Gravel / sand	❑	❑	❑
Bare soil	❑	❑	❑
Sand	❑	❑	❑
Pavement, structures	❑	❑	❑

   b. Measure inland from the shoreline 25 yards.

	0	1	2
Trees	❑	❑	❑
Bushes, shrubs	❑	❑	❑
Tall reeds (i.e., phragmities, etc.)	❑	❑	❑
Salt marsh grasses	❑	❑	❑
Lawn	❑	❑	❑
Boulders/rocks	❑	❑	❑
Gravel / sand	❑	❑	❑
Bare soil	❑	❑	❑
Sand	❑	❑	❑
Pavement, structures	❑	❑	❑

Estuary (continued)

GROUP B Data Form

Basin, Shoreline, Channel, and Sediment Characteristics

4. Investigate the estuary bottom along the edges and in the middle (if possible). Check the description that best fits the bottom particles that you find:

	none/little	some	most
Organic matter (leaves, etc.)	❑	❑	❑
Silt/Clay/Mud	❑	❑	❑
Sand (up to 0.1" in diameter)	❑	❑	❑
Gravel (0.1" to 2" in diameter)	❑	❑	❑
Cobbles (2" to 10" in diameter)	❑	❑	❑
Boulders (over 10" in diameter)	❑	❑	❑
Bedrock (solid rock)	❑	❑	❑

5. Are there logs or large woody debris in the estuary?

❑ None ❑ Some ❑ Plentiful

6. Is there naturally-occurring organic material (leaves, twigs, mats of grasses, etc.) in the estuary?

❑ None ❑ Some ❑ Plentiful

7. Check "0" if the condition is not present, "1" if there is low to moderate impact, and "2" if there is moderate to high impact.

	0	1	2
Shoreline			
Natural plant cover degraded	❑	❑	❑
Banks collapsed / eroded	❑	❑	❑
Garbage / junk present	❑	❑	❑
Foam or sheen on bank	❑	❑	❑
Estuary channel			
Mud, silt, or sand in or entering the stream	❑	❑	❑
Garbage / junk present	❑	❑	❑
Other			
Yard waste on bank (grass clippings, leaf piles)	❑	❑	❑
Livestock in or with unrestricted access to water	❑	❑	❑
Actively discharging pipe(s)	❑	❑	❑
Other pipe(s) entering the water	❑	❑	❑

NAME: DATE:

Estuary

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

Research members:

Data recorder:

Equipment needed: boots and hip waders, seine net, collecting container, binoculars, Estuary Term Descriptions (pages 110 and 111), fish identification key, estuarine plant life key

1. Determine where the location of your study site is in the watershed. Circle the best answer.

Upper watershed (nearest to the headwaters) Middle watershed Lower watershed

2. Walk as much of the study site as possible observing not only the estuary itself but also the habitat surrounding the estuary to note the following. Circle which estuarine habitats are present (you can circle more than one). See Figure 3F.

Salt Marsh Open bay Creeks

Submerged Aquatic Vegetation (SAV) beds Salt pannes (shallow ponds)

SAFETY PRECAUTIONS
Estuarine habitats can be difficult to explore due to the unpredictable nature of the salt marsh mud. Be aware of drop-offs near the water's edge. Typically, the taller the grass, the wetter your feet will get. Do not walk into salt pannes - the mud can be deep and difficult to get out of once you are stuck.

3. Check "1" if present, "2" if clearly having an impact on the estuary. If "2" describe what that visible impact is.

1	2	**Residential**	**Impact (describe)**
❑	❑	Single-family housing	_____
❑	❑	Multifamily housing (condos, apartments)	_____
❑	❑	Lawns	_____
❑	❑	Commercial / institutional (schools, hospitals)	_____
❑	❑	Other	_____

Estuary (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

3. (continued)

Check "1" if present, "2" if clearly having an impact on the estuary. If "2" describe what that visible impact is.

1	2	**Roads, etc.**	**Impact**
❑	❑	Paved roads or bridges	
❑	❑	Unpaved roads	
❑	❑	Other	

1	2	**Construction underway on:**	**Impact**
❑	❑	Housing development	
❑	❑	Commercial development	
❑	❑	Road bridge construction or repair	
❑	❑	Other	

1	2	**Agricultural**	**Impact**
❑	❑	Grazing land	
❑	❑	Feeding lots or animal holding areas	
❑	❑	Cropland	
❑	❑	Inactive agricultural lands / fields	
❑	❑	Other	

1	2	**Recreation**	**Impact**
❑	❑	Power boating	
❑	❑	Golfing	
❑	❑	Camping	
❑	❑	Swimming / fishing / nonmotorized boating	
❑	❑	Hiking / paths	
❑	❑	Other	

1	2	**Other**	**Impact**
❑	❑	Mining or gravel pits	
❑	❑	Logging	
❑	❑	Industry	
❑	❑	Above ground storage tanks	
❑	❑	Trash dump	
❑	❑	Landfill	

Estuary (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

4. Rate the following from most (1) to least (5). Approximate the percentage of land use in and around the study site:

_____ Residential	_____ %
_____ Open space (salt marsh, parkland, forest, protected land)	_____ %
_____ Docks / marinas	_____ %
_____ Commercial / industrial	_____ %
_____ Roads, parking lots	_____ %
_____ Agricultural / rural	_____ %
_____ Other	_____ %

5. Check the categories that best describe the general appearance of the waterway and surrounding habitat:

- ❑ Litter:
  - ❑ No litter visible
  - ❑ Small litter occasionally (e.g., cans, paper, etc.)
  - ❑ Small litter common
  - ❑ Large litter occasionally (e.g., tires, carts, etc.)
  - ❑ Large litter common
- ❑ Erosion:
  - ❑ No shoreline erosion or areas of erosion very rare
  - ❑ Occasional areas of shoreline erosion
  - ❑ Areas of shoreline erosion common
  - ❑ Artificial shoreline stabilization present (concrete walls, rip rap, bulkheading, etc.)
- ❑ Special problems (note in detail in comment section):
  - ❑ Spills of chemicals, oil, etc.
  - ❑ Fish kills
  - ❑ Wildlife, waterfowl kills
  - ❑ Flooding

COMMENTS on special problems:

Estuary (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

5. **VISUAL BIOLOGICAL SURVEY**

a. Wildlife in or around the water body - look for actual animals or animal evidence (e.g., footprints, feathers, scat, shells, etc.). Check all that apply and identify species if possible.

- ❑ Amphibians
- ❑ Waterfowl (or other birds)
- ❑ Reptiles
- ❑ Mammals
- ❑ Invertebrates (crabs, etc.)

Fish in the estuary? (if possible, use seine net)
Use the fish identification key to identify the species that are present. Record the species type, approximate number of each species, and average length of the individuals.

b. Vegetation
Use the estuary plant life key to help identify key species, note which are present and what their degree of coverage is

- ❑ Rooted Plants

  Upland species _____ %

  Wetland species _____ %

- ❑ Submerged Aquatic Vegetation beds (check if present)

- ❑ Seaweeds (check if present)
  - ❑ Rockweed - attached to any hard substrate including piers, concrete, shells, etc.
  - ❑ Sea lettuce - originally attached, but often found free-floating
  - ❑ Green hollow weed (intestinalis) - long, stringy algae

Estuary

TERM DESCRIPTIONS

Water Characteristics

Water Appearance (possible causes)

Red/yellow – presence of algae or dinoflagellates

Green – presence of phytoplankton

Tea colored – presence of peat or dissolved organic material

Rainbow – oil slick on the surface or naturally occurring plant breakdown

Water Odor (possible causes of odor)

Sewage – human waste or farm animal waste

Chlorine – overchlorinated waste water treatment discharge

Fishy – excessive algal growth, dead fish

Rotten eggs – sewage pollution or natural breakdown of plant materials

Seaweedy – usually considered healthy

Water Temperature has a direct effect on the amount of dissolved oxygen in the water available for aquatic organisms.

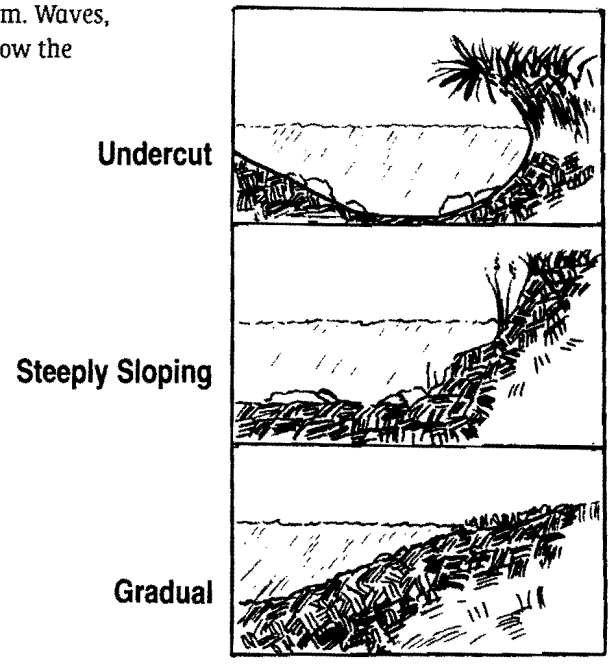
Surface Conditions

How well the surface waters mix has a direct effect on the amount of dissolved oxygen in the water available for aquatic organism. Waves, water flow, current direction, and speed all play a part in how the surface waters mix.

Basin, Shoreline, Channel, and Sediment Characteristics

Channel and Shoreline banks

Figure 3E



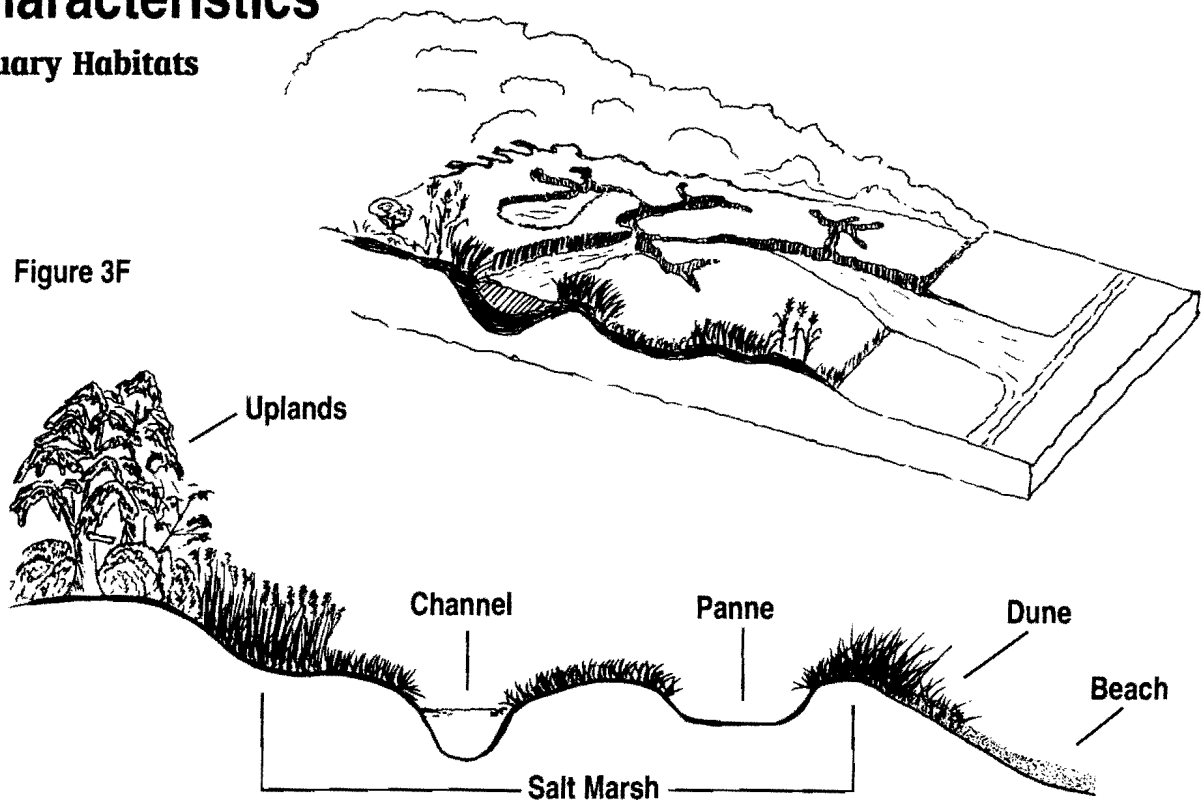
Estuary (continued)

TERM DESCRIPTIONS

Watershed, Habitat, and Human Impact Characteristics

Estuary Habitats

Figure 3F



Land Use

Different land uses allow for varying amounts of water to filter through the soil. Pervious surfaces include undeveloped land such as forests, fields, agricultural areas and parks. Impervious surface include anything that does not allow the water to get back into the soil such as parking lots, roads, and buildings.

Vegetation

1. Rooted Plants
   - Upland species are those plants that require drier, more stable soil. Typically they require freshwater and cannot tolerate salt water.
   - Wetland species are adapted to live in wet areas that are subject to tidal change. In this instance, these plants must be able to survive dry periods (when the tide is out), tidal fluctuations (high tide, severe storm tides), and salt.
2. Submerged Aquatic Vegetation (SAV) are beds of plants that have roots and grow underwater. These beds are extremely important habitat to young fish, crabs, and other aquatic animals.
3. Seaweeds are algae. They have no roots, stems, or leaves. Some are anchored in place, some get knocked loose and float freely. Seaweeds are important habitat for aquatic animals.

NAME: DATE:

Pond/Lake

GROUP A Data Form

Water Characteristics

Research members:

Data recorder:

Equipment needed: white plastic container, thermometer, boots or hip waders, life jackets, rope with one-foot increments, pond/lake map, fishing map showing depth, boat, dock, Pond / Lake Term Descriptions (pages 121 and 122)

1. Circle which type of water body is being studied. Pond Lake

2. Circle which pond / lake habitats are present (you can circle more than one). See Figure 3G.

   Marsh Swamp Open water Feeder stream Springs

3. Determine how water gets into the lake or pond. Circle the best answer/s.

   Feeder stream Rainwater / meltwater Spring Pipes

4. Determine how water leaves the lake or pond. Circle the best answer/s.

   Stream Evaporation Pipes

5. **APPEARANCE**: Use the white plastic container to gather a sample of water. Circle the best description.

   Clear Milky Foamy Turbid

   Dark brown Oily sheen Orange Greenish

   Other color, describe _____

6. **ODOR**: Circle the best description.

   Sewage Chlorine (like a pool) Fishy

   Rotten eggs (like sulfur) None Other odor, describe _____

Pond/Lake (continued)

GROUP A Data Form

Water Characteristics

7. **WATER TEMPERATURE:**

Site #1 (at the edge) _____ °C

(2 feet from the edge) _____ °C

(5 feet from the edge - using waders, from a dock or a boat) _____ °C

Site #2 (at the edge) _____ °C

Site #5 (2 feet from the edge) _____ °C

(5 feet from the edge - using waders, from a dock or a boat) _____ °C

Average temperature _____ °C

(Add the six numbers and divide by 6)

8. Determine the volume of water in the pond / lake: (If actual measurements cannot be taken, estimate distances or determine those from a map.)

a. Radius - take three measurements

R1 _____ft. R2 _____ft. R3 _____ft.

Average radius _____ft. (R1 + R2 + R3 divided by 3)

b. Circumference

$C = r^2 \times \pi$ _____

c. Depth - take six measurements along one radii.

D1 _____ft. D2 _____ft. D3 _____ft.

D4 _____ft. D5 _____ft. D6 _____ft.

Average depth _____ft. (D1 + D2 + D3 + D4 + D5 + D6 divided by 6)

To determine the volume, multiply the average depth by the circumference

Volume of the pond / lake _____cubic feet

NAME: DATE:

Pond/Lake

GROUP B Data Form

Basin, Shoreline, Channel, and Sediment Characteristics

Research members:

Data recorder:

Equipment needed: hip waders or boots, measuring stick, rope with one-foot increments, pond/lake map, fishing map showing depth, boat, dock, Pond / Lake Term Descriptions (pages 121 and 122)

1. Choose a point in your study area to make your observations. Pick the description that best fits the shoreline. See Figure 3H.

   a. Overall shape of the pond / lake. Check the best description.

      ❑ Circular ❑ Irregular with coves and inlets

   b. Shoreline

      ❑ Vertical / undercut

      ❑ Steeply sloping (> 30 degrees)

      ❑ Gradual / no slope (< 30 degrees)

   c. Estimate how much of your pond/lake's bank has been modified by artificial means such as concrete, rip rap (broken debris, i.e., concrete, rocks, or brick), imported rock, walls, bulkheading, dams, etc. (check the best description)

      ❑ Bank 0-25% covered

      ❑ Bank 25-50% covered

      ❑ Bank 50-75% covered

      ❑ Bank 75-100% covered

Pond/Lake (continued)

GROUP B Data Form

Basin, Shoreline, Channel, and Sediment Characteristics

2. From the same spot, describe the natural shoreline cover. Check "0" if not present, "1" if present, "2" if plentiful.

a. Along the water's edge only:

To the left of where you are standing				To the right		
0	1	2		0	1	2
❑	❑	❑	Trees	❑	❑	❑
❑	❑	❑	Bushes, shrubs	❑	❑	❑
❑	❑	❑	Tall grasses, ferns, etc.	❑	❑	❑
❑	❑	❑	Lawn	❑	❑	❑
❑	❑	❑	Boulders/rocks	❑	❑	❑
❑	❑	❑	Gravel / sand	❑	❑	❑
❑	❑	❑	Bare soil	❑	❑	❑
❑	❑	❑	Pavement, structures	❑	❑	❑

b. From the water's edge measure inland to 25 yards.

To the left of where you are standing				To the right		
0	1	2		0	1	2
❑	❑	❑	Trees	❑	❑	❑
❑	❑	❑	Bushes, shrubs	❑	❑	❑
❑	❑	❑	Tall grasses, ferns, etc.	❑	❑	❑
❑	❑	❑	Lawn	❑	❑	❑
❑	❑	❑	Boulders/rocks	❑	❑	❑
❑	❑	❑	Gravel / sand	❑	❑	❑
❑	❑	❑	Bare soil	❑	❑	❑
❑	❑	❑	Pavement, structures	❑	❑	❑

3. Circle the number that best describes the percentage of shade that the overall pond / lake receives:

0% 25% 50% 75% 100%

Pond/Lake (continued)

GROUP B Data Form

Basin, Shoreline, Channel, and Sediment Characteristics

4. From the same point in your study site observe as much of the shoreline as you can. Check "0" if the condition is not present, "1" if there is low to moderate impact, and "2" if there is moderate to high impact.

Left bank 0	1	2		Right bank 0	1	2
			Shoreline			
❑	❑	❑	Natural pond / lake plant cover degraded	❑	❑	❑
❑	❑	❑	Banks collapsed / eroded	❑	❑	❑
❑	❑	❑	Garbage / junk present	❑	❑	❑
❑	❑	❑	Foam or sheen on bank	❑	❑	❑
			Other			
❑	❑	❑	Yard waste on bank (grass clippings, leaf piles)	❑	❑	❑
❑	❑	❑	Livestock in or with unrestricted access to the pond / lake	❑	❑	❑
❑	❑	❑	Actively discharging pipe(s)	❑	❑	❑
❑	❑	❑	Other pipe (s) entering the pond / lake	❑	❑	❑
❑	❑	❑	Ditches entering the pond / lake	❑	❑	❑

5. Investigate the pond/lake bottom along the edges and in the middle (if possible). Check the description that best fits the stream bottom particles that you find:

	none/little	some	most
Silt/Clay/Mud	❑	❑	❑
Sand (up to 0.1" in diameter)	❑	❑	❑
Gravel (0.1" to 2" in diameter)	❑	❑	❑
Cobbles (2" to 10" in diameter)	❑	❑	❑
Boulders (over 10" in diameter)	❑	❑	❑
Bedrock (solid rock)	❑	❑	❑

6. Are there logs or large woody debris in the pond/lake?

None Some Plentiful

7. Is there naturally occurring organic material (leaves, twigs, etc.) in the pond/lake?

None Some Plentiful

NAME: DATE:

Pond/Lake

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

Research members:

Data recorder:

Equipment needed: long-handled net, collecting container, binoculars, a variety of field identification guides, Pond / Lake Term Descriptions (pages 121 and 122)

1. Determine where the location of your study site is in the watershed. Circle the best answer.

   Upper watershed (nearest to the headwaters) Middle watershed Lower watershed

2. Identify the lake or pond's subwatershed on a topographic map. Calculate what percentage of the larger watershed it represents. _____%

3. Walk as much of the study site as possible observing not only the open water, but also the habitat surrounding the pond or lake to note the following land use:
   Check "1" if present, "2" if clearly having an impact on the stream. If "2" describe what that visible impact is.

1	2	**Residential**	**Impact (describe)**
❑	❑	Single-family housing	
❑	❑	Multifamily housing (condos, apartments)	
❑	❑	Lawns	
❑	❑	Commercial / institutional (schools, hospitals)	
❑	❑	Other	

1	2	**Roads, etc.**	**Impact**
❑	❑	Paved roads or bridges	
❑	❑	Unpaved roads	
❑	❑	Other	

1	2	**Construction underway on:**	**Impact**
❑	❑	Housing development	
❑	❑	Commercial development	
❑	❑	Road bridge construction or repair	
❑	❑	Other	

Pond/Lake (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

3. (continued)

Check "1" if present, "2" if clearly having an impact on the stream. If "2" describe what that visible impact is.

1	2	**Agricultural**	**Impact**
❑	❑	Grazing land	
❑	❑	Feeding lots or animal holding areas	
❑	❑	Cropland	
❑	❑	Inactive agricultural lands / fields	
❑	❑	Other	

1	2	**Recreation**	**Impact**
❑	❑	Power boating	
❑	❑	Golfing	
❑	❑	Camping	
❑	❑	Swimming / fishing / nonmotorized boating	
❑	❑	Hiking / paths	
❑	❑	Other	

1	2	**Other**	**Impact**
❑	❑	Mining or gravel pits	
❑	❑	Logging	
❑	❑	Industry	
❑	❑	Above ground storage tanks	
❑	❑	Trash dump	
❑	❑	Landfill	

4. Rate the following from most (1) to least (5). Approximate the percentage of land use in and around the study site:

_____	Residential	_____ %
_____	Open space (parkland, forest, protected land)	_____ %
_____	Bathing Beaches	_____ %
_____	Docks /marinas	_____ %
_____	Commercial / industrial	_____ %
_____	Roads, parking lots	_____ %
_____	Agricultural / rural	_____ %

Pond/Lake (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

5. Note the types and number of structures that alter the pond / lake's natural boundaries (hydrologic modifications):

_____ None	_____ Dams	_____ Bridges
_____ Culverts	_____ Beaver dams	_____ Storm water drains

6. Check the categories that best describe the general appearance of the pond / lake and surrounding habitat:

- ❑ Litter:
  - ❑ No litter visible
  - ❑ Small litter occasionally (e.g., cans, paper, etc.)
  - ❑ Small litter common
  - ❑ Large litter occasionally (e.g., tires, carts, etc.)
  - ❑ Large litter common
- ❑ Erosion:
  - ❑ No bank erosion or areas of erosion very rare
  - ❑ Occasional areas of bank erosion
  - ❑ Areas of bank erosion common
  - ❑ Artificial bank stabilization present (concrete walls, rip rap, etc.)
- ❑ Special problems (note in detail in comment section):
  - ❑ Spills of chemicals, oil, etc.
  - ❑ Fish kills
  - ❑ Wildlife, waterfowl kills
  - ❑ Flooding
  - ❑ Low water

COMMENTS on special problems:

Pond/Lake (continued)

GROUP C Data Form

Watershed, Habitat, and Human Impact Characteristics

7. **VISUAL BIOLOGICAL SURVEY**

a. Wildlife in or around the water body - look for actual animals or animal evidence (e.g., footprints, feathers, scat, shells, etc.). Check all that apply and identify species if possible.

- ❑ Amphibians
- ❑ Waterfowl (or other birds)
- ❑ Reptiles
- ❑ Mammals
- ❑ Invertebrates (mussels, clams, etc.)

Fish in the pond / lake? If possible, use net. (check all that apply):

- ❑ No
- ❑ Yes, but rare
- ❑ Yes, abundant
- ❑ Small (1-2")
- ❑ Medium (3-6")
- ❑ Large (7" and above)

b. Aquatic plants (mark all that apply):

None Some Plentiful

Attached Free-floating

Extent of algae (check all that apply)

1. Are the stones, twigs or other material that is underwater coated with algal slime? Circle the best answer for each line.

None Some Plentiful

Light coating Heavy coating (can hardly see the object)

Brownish Greenish Other Color, describe _____

2. Are there string-like (filamentous) algae? Circle the best answer for each line.

None Some Plentiful

Brownish Greenish Other Color, describe _____

3. Are there any clumps or mats of algae floating on the water's surface? Circle the best answer for each line.

None Some Plentiful

Brownish Greenish Other Color, describe _____

Pond/Lake (continued)

TERM DESCRIPTIONS

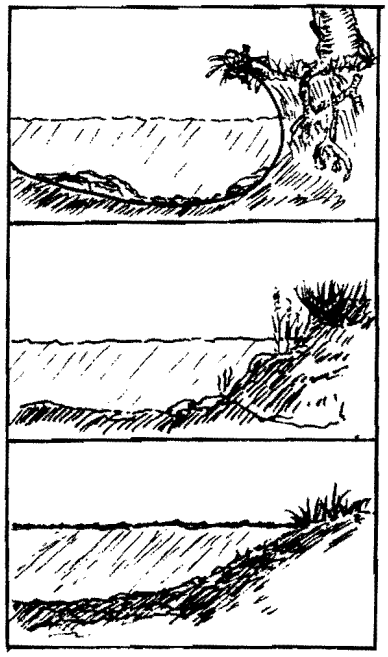
Water Temperature has a direct effect on the amount of dissolved oxygen in the water that is available for animal use. Pond temperatures tend to be fairly constant. Lake temperatures have several layers of water of different temperatures. This is called "stratification."

Basin, Shoreline, Channel, and Sediment Characteristics

Pond / Lake shoreline

Shoreline cover helps determine the quality and extent of the habitats next to a pond or lake. A forested canopy provides important functions by cooling the water; offering habitat, protection, and refuge for aquatic organisms; and providing a direct source of beneficial organic matter and insects to the pond / lake.

Figure 3H



Watershed, Habitat, and Human Impact Characteristics

Land Use

Every type of land use affects the water body in some manner. Different land uses allow for varying amounts of water to filter through the soil. Pervious surfaces include undeveloped land like forests, fields, agricultural areas and parks. Impervious surfaces include anything that does not allow water to get back into the soil such as parking lots, roads, and buildings.

Aquatic Plants

Ponds / lakes with a high concentration of aquatic plants may indicate high amounts of nutrients (organic matter or fertilizer).

Pond / lakes without plants may indicate a high acidity level, toxic pollutants, or the presence of a vegetation control substance.

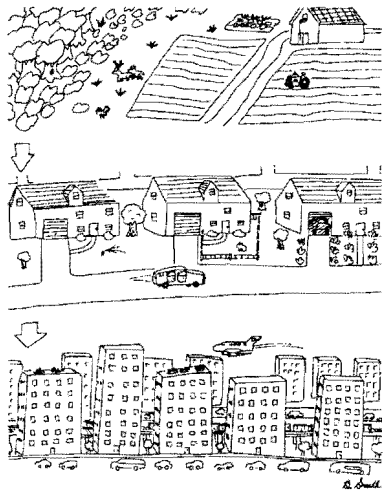
Algae Growth

Algae are simple plants that do not grow true roots, stems, or leaves. They live mainly in water and provide food for the food chain. It naturally occurs in green and brown colors. A lot of algae may indicate excessive nutrients (organic matter or fertilizers) or eutrophication of the pond / lake.

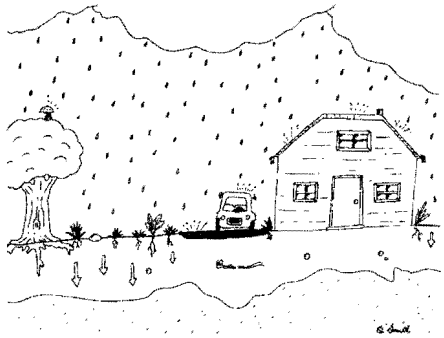
Activities
A SENSE OF TIME

"We teach the past, we see farther backward into time than any race before us, but we stop at the present, or at best, we project far into the future idealized versions of ourselves. All that long way behind us we see, perhaps inevitably, through human eyes alone."

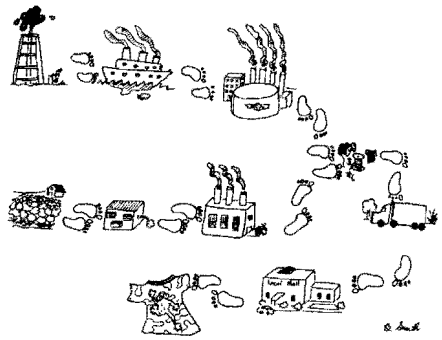
— Loren Eisley
The Immense Journey



A Changed Land



The Nature of Imperviousness



How Lightly Do You Live?

A SENSE OF TIME

NJ Core Curriculum Content Standards

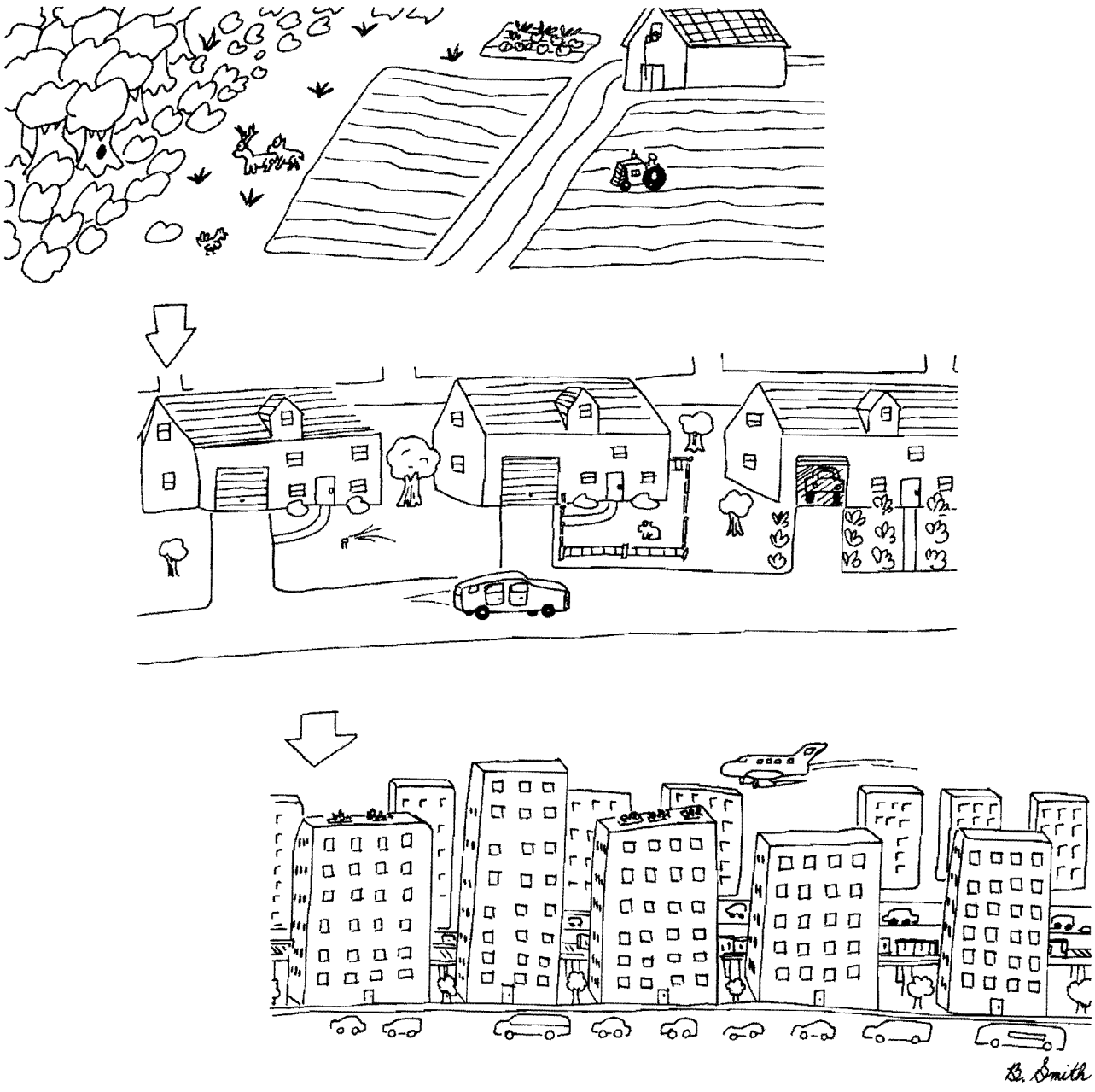
A Changed Land How has population distribution in the watershed changed over time? page **125**	
Workplace Readiness	**2** (5,6) **3** (1-5,8,9,12) **4** (1,2,9)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14-16) **3.2** (8,9,11) **3.3** (15,17,19) **3.5** (14)
Mathematics	**4.1** (10-12,15) **4.3** (11) **4.4** (6-8) **4.5** (6) **4.10** (11) **4.12** (11,17,18)
Science	**5.1** (4,5,7) **5.4** (10) **5.10** (14) **5.12** (4,10)
Social Studies	**6.4** (5) **6.6** (10,16) **6.7** (9,10) **6.8** (6,8,9,10,12,13,16,17) **6.9** (5,8)

The Nature of Imperviousness How has the increase in impervious surfaces affected New Jersey's watersheds? page **131**	
Workplace Readiness	**2** (7,9,10) **3** (1-4,12,13-15) **4** (2)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15) **3.2** (8,9,11) **3.4** (25) **3.5** (13,14)
Mathematics	**4.1** (11,12, 13,15,16) **4.4** (7,8,9,10, 11) **4.7** (16) **4.8** (11) **4.9** (7,8,11-14)
Science	**5.1** (4,5,7) **5.2** (6,8,10,11) **5.4** (11) **5.5** (6) **5.12** (4-6,9,10)
Social Studies	**6.6** (10,16) **6.7** (6,7) **6.8** (8,17) **6.9** (5,6,8)

How Lightly Do You Live? What is your ecological footprint? page **141**	
Workplace Readiness	**2** (1,10) **3** (1,7-12)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15) **3.2** (8,9,11) **3.4** (21)
Mathematics	
Science	**5.1** (4-7) **5.4** (5,10) **5.8** (5) **5.10** (14) **5.12** (4,9,10)
Social Studies	**6.2** (8) **6.4** (5) **6.6** (8-13,15,16) **6.8** (11,16,17) **6.9** (4-8)

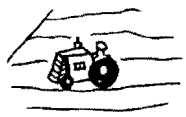
Bold Numbers = Standards (Light Numbers in Brackets) = Indicators

A CHANGED LAND

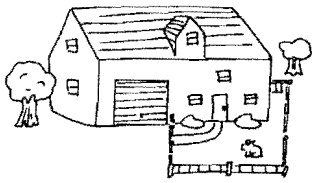


By definition, a population is (a) *a body of persons or individuals having a quality or characteristic in common* and (b) *organisms inhabiting a particular locality* (*Webster's Ninth New Collegiate Dictionary*). Although humans do not represent the largest population of species on our earth, we have had, and continue to have, tremendous effect on the quality of the earth's natural environments. To support the ever-increasing needs of people there have been great demands on the earth's resources. Throughout history this impact has affected social, economic, and environmental components of the global community.

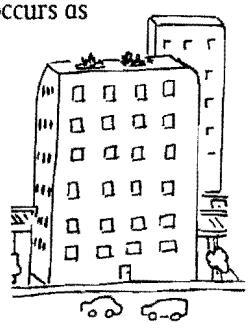
A Changed Land



Ecosystems exhibit a condition termed "carrying capacity." When an animal or plant's population reaches a level whereby there is no longer sufficient food, water, shelter, or space in which the organism can carry out its life functions, carrying capacity has been exceeded. Since natural systems are dynamic, there is an inherent ebb and flow of resources and organisms. Environmental factors (fire, drought, flood) and human impacts (habitat degradation, development, pollution) can alter the carrying capacity of habitats and ecosystems on local levels, regional levels, and global levels. If a population declines or crashes, repercussions filter throughout the ecosystem. As a whole, human populations have thus far side-stepped the global carrying capacity issue by developing new technologies and by trading, buying, and selling resources between communities and countries.



On a local level, human populations of an area are constantly changing. Changes that increase the population are birth and immigration. Those that cause a decline in population are death and emigration from an area. We know the causes of birth and death, but what are some of the historical reasons for immigration and emigration? In a broad historical sense, people have emigrated to escape social or political injustice, to avoid starvation, and to seek out certain freedoms. Immigration occurs as people search for a higher standard of living. Perhaps more or better employment opportunities arise, more efficient modes of transportation make it easier to live away from a job, or family ties bring others into an area. Areas that have good job opportunities and are easily reached tend to be more attractive as suitable places to live. They usually exhibit an increase in population growth. Areas that have few employment opportunities and are remote tend to attract fewer people and will generally show a decline in population.



Population trends are patterns that can be calculated from historical data in order to predict future populations. It is in this way that small towns can assess their current situation and their future needs, in essence calculating the "carrying capacity" of their town by looking at their current infrastructure and services and comparing them to what they will need in the future. New Jersey allows every town to practice "home rule" which gives each town the right to make decisions on land use, development, zoning, and services on a local level. The estimated population growth or decline within a municipality affects the watershed, and watershed boundaries transcend political boundaries.

The U.S. Census Bureau found New Jersey's 1990 population to be 7,747,750 individuals, and they project that the 2000 census will find 8,178,000 people in the state. Further predictions say that by the year 2025 there will be 9,558,000 people in New Jersey. These last two numbers represent a 16.8 percent increase in population in a state that is already the most densely populated state in the country.

TAKE A LOOK AT YOUR WATERSHED:

Where do you see the highest concentrations of human population in your watershed? Where are the lowest concentrations?

What effects do you see that the population or lack of population have on the watershed?

LESSON 4

A Changed Land

GOAL To map the population changes that have occurred in a specific watershed over time.

TIME
- (3) 45-minute periods
- independent research time

OBJECTIVES Students will:
- ✔ list factors that affect population changes
- ✔ use a variety of resources to collect data
- ✔ explain how population changes affect the quality of a watershed
- ✔ use population trends to project the future of the watershed

SKILLS compare, gather and interpret data, estimate, analyze, formulate hypotheses, synthesize, justify

VOCABULARY
immigration
emigration
population trends
carrying capacity
demographics
home rule

PRIOR KNOWLEDGE Students should have background in:
- defining watershed boundaries on a map
- reading a variety of maps
- creating color or symbol keys

CORE CURRICULUM CONTENT STANDARDS
- Cross Content Workplace Readiness 2 (5,6) 3 (1-5,8,9,12) 4 (1,2,9)
- Language Arts 3.1 (14-16) 3.2 (8,9,11) 3.3 (15,17,19) 3.5 (14)
- Math 4.1 (10-12,15) 4.3 (11) 4.4 (6-8) 4.5 (6) 4.10 (11) 4.12 (11,17,18)
- Science 5.1 (4,5,7) 5.4 (10) 5.10 (14) 5.12 (4,10)
- Social Studies 6.4 (5) 6.6 (10,16) 6.7 (9,10) 6.8 (6,8,9,10,12,13,16,17) 6.9 (5,8)

MATERIALS
- ❑ Baseline watershed map (to be created by the teacher)
- ❑ USGS topographic maps for the local watershed
- ❑ Road maps or other local maps
- ❑ Colored pencils
- ❑ Population figures (See References)

PREPARATION
1. Trace the boundaries of the local watershed onto a master map. On this baseline map include a measurement scale, directional symbol, and major waterways or water bodies.
2. Make two copies of this baseline map for each student or pair of students.

PROCEDURE

Period 1

1. Distribute two baseline watershed maps to each student or pair of students (one for historical population figures and the other for current population figures).
2. Have the students use topographic and road maps to identify at least five towns (in addition to their own) in the watershed. These towns should be distributed throughout the watershed and not proximate to each other. All students can use the same towns or have the students select different towns to create a more complex picture of historic and current demographics in the watershed.
3. Instruct the students to transpose the locations of the towns onto their baseline maps.

Independent research time

Have the students find the current and historical (at least 50 years ago) population figures for each town on their map.

Period 2

1. Instruct the students to create a color code or symbol key that clearly shows the population statistics for each town (e.g., red for 10,000-15,000 people, blue for 15,000-20,000 people, etc.)
2. Discuss the results of the mapping exercise - compare the similarities and differences between the populations and give reasons why the demographics of the watershed have changed over time [*immigration, emigration, industry change, transportation change, topography, cost of living, changes in zoning, etc.*]. Which of these changes are a result of technological advances?
3. Divide the students into three groups and have each group analyze one set of the following questions:

   What effects could population changes have on water availability? [*more demand for potable water, less recharge of water supplies, more water used by waste water treatment plants rather than being funneled back into ground-water supplies*] What effects could population changes have on water quality? [*more runoff from development projects, increased pollution, increased need for recreational use*]

   What effects could population changes have on the amount of open space (parks, state forests, wildlife management areas, wetlands, etc.)? [*increases in population often equals a decrease in open space*] What effect could population changes have on the quality of open space? [*smaller parcels of land limit the site's carrying capacity and stability of natural systems*]

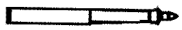
   What effect could population changes have on the local economy? [*more jobs, increase in tax base, more schools, bigger sewage treatment plants, more service- oriented industry*] What effect could population change have on the local environment? [*decrease in open space, change in land use, more pollution, more sedimentation in waterways from construction, more runoff from roads*]

Period 3

Have each group summarize their discussion and present this to the rest of the class.

FURTHER DISCUSSION

- Which of these situations do you see in your watershed?
- What changes have you seen in your watershed within the last few years?
- Fifty years ago, most people did not know what a "watershed" was. How can our increased citizen awareness of the watershed concept contribute to more effective watershed management?
- New Jersey towns maintain "home rule," yet watersheds transcend political boundaries. What are some positive effects of home rule? What are some negative effects of home rule? What are some positive effects of regional decision making? What are some negative effects of regional decision making?
- New Jersey's population is expected to increase by about 16.8 percent from 2000 to 2025. How do you think this increase will be distributed over the entire region? What effects will this increase have on the state's systems including transportation systems, natural systems, social systems, and economic systems.
- What is the carrying capacity of your community? What are some of the limiting factors that will decide this? [*ability of town systems to accommodate higher populations*]



ASSESSMENT

Estimate the future population in the watershed (using population trends and town projections). Have the students use this information to develop a management plan for the future of their watershed by integrating multiple forms of media into a finished product to present to the class. Hold a vote to see which management plan they would prefer to see implemented in the watershed.

EXTENSION

1. Assign population color codes to the towns or municipalities and then have the students use those same colors on their maps to color the path of runoff water downstream from each municipality. This will show the combined influence of possible impacts from several communities in the watershed.
2. Identify open space areas on the baseline maps using current and historic USGS topographic maps (historic topographic maps are available from the USGS - see Appendix B). These would be state parks, forests, wildlife management areas, etc. Have the students estimate the area of the entire watershed, then the area of the open space sites (current and past). Have them compare these numbers and discuss the changes and potential impacts on the watershed.

EMPOWERMENT CHALLENGE

Attend a local planning board meeting or contact the Association for New Jersey Environmental Commissions (ANJEC) for information on how towns actually plan for development and land use within the watershed.

LESSONS FROM OTHER SOURCES

Project WET - Easy Street, Wish Book

REFERENCES

Kreb, Charles J. 1985. *Ecology: The Experimental Analysis of Distribution and Abundance.* New York, NY: Harper Collins.

The New Jersey State Development and Redevelopment Plan. 1992. New Jersey State Planning Commission, Office of State Planning, Trenton, NJ.

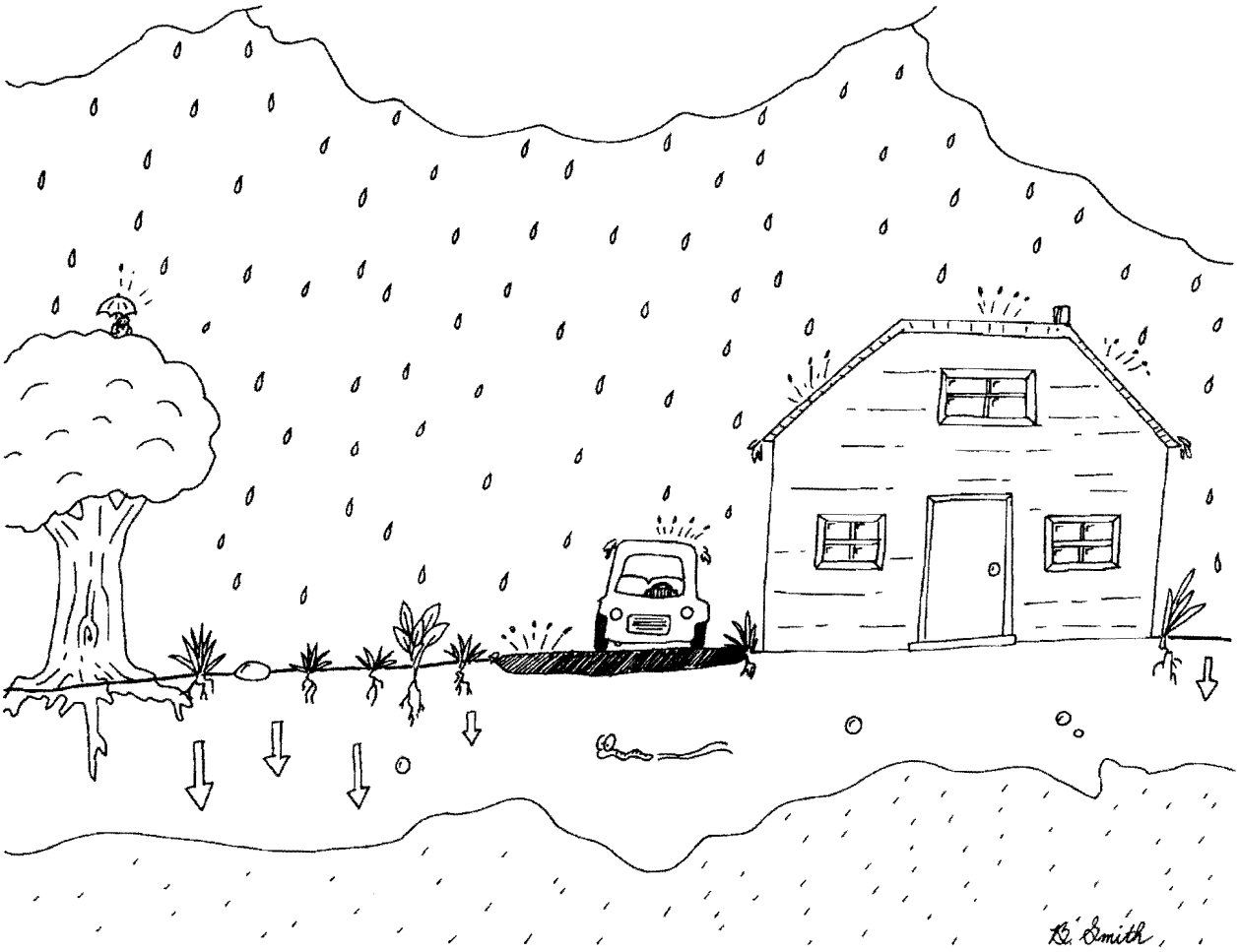
Schueler, Tom. 1998. *Protecting Watersheds in Central and Southern New Jersey.* Workshop

U.S. Census Bureau web site: www.census.gov

NOTES

THE NATURE OF IMPERVIOUSNESS

When precipitation falls on a woodland, field, golf course, park, or lawn it filters through a "pervious surface" into the underlying soil. If the precipitation falls on a road, parking lot, or rooftop it is considered to be an "impervious surface" because the precipitation is unable to penetrate the surface and mostly runs off into the street then into the storm drain system. In some instances pervious surfaces may act like impervious surfaces if the soil has been greatly compacted.



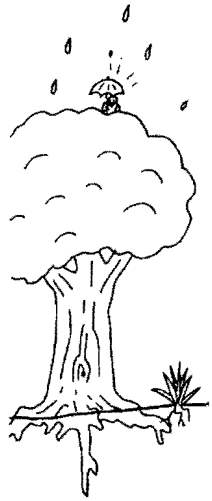
The major pervious surface categories include:

1. **Open space** in the form of natural areas that consist of undeveloped forests, fields, and wetlands. These soak up, retain, and filter precipitation slowly.
2. **Lawns** (whether private or public) which are:
   a. managed with fertilizers, pesticides, or herbicides
   b. mowed, but do not receive added chemical inputs

   These sites also soak up, retain, and filter precipitation slowly, but the degree of management (use of fertilizers, etc.) determines the amount of non-point source pollution that is transported into the water table.
3. **Landscaped areas** at commercial sites. These sites do provide pervious surfaces in areas that are typically built-up. Their degree of effectiveness varies depending on the types of plants used (native, drought-resistant species are best) and the amount of chemical input from fertilizers, etc.

The Nature of Imperviousness

4. **Vacant lots** which receive little if any type of management. The vegetative cover can range from bare earth to wildflowers, grasses, and shrubs with scattered trees. The degree of compacted soil determines how effective these sites are for water infiltration.
5. **Treatment areas** which manage storm water runoff and / or septic system effluent (e.g., storm water ponds, filter strips, grass swales, stone trenches).



In terms of watersheds, "imperviousness" describes the degree to which the watershed's land is developed. It can be defined loosely as all that is not "green." The degree of imperviousness in a watershed can be a useful way to measure the health of aquatic systems. It is estimated that there is a half acre of impervious surface for every person in a watershed (Center for Watershed Protection). Impervious surfaces affect water systems in a variety of ways:

Erosion

Instead of soaking into the soil, precipitation quickly crosses an impervious surface resulting in more volume of water entering a waterway all at once. This can cause stream bank erosion, sedimentation, channel widening, and general habitat degradation.

Pollution

All kinds of pollutants gather on impervious surfaces (oil, gasoline, litter, pet waste). During storms, the pollutants are washed into aquatic systems. This introduces toxic compounds into the system and increases the amount of nutrients in the waterway. It may also increase algae / plant growth and bacterial contamination.

Heat

Impervious surfaces absorb and hold heat which causes surrounding areas to be much warmer than if there was tree cover. Precipitation falling on these surfaces evaporates more quickly, making it unavailable to aquatic systems or ground-water supplies. Also, runoff water from these surfaces will be warmer as it enters waterways.

Stream biodiversity

Biologists use the type and diversity of aquatic insects to determine stream quality. When impervious surfaces in the watershed are above 10 percent to 15 percent sensitive macroinvertebrates (such as stoneflies, caddisflies, and mayflies) are replaced with those that tolerate higher pollution levels, higher turbidity in the water, and warmer water with lower dissolved oxygen levels.

Habitat degradation

Water systems and land habitats are interdependent, each functioning on its own but relying on the other to keep them functioning properly. Removal or alteration of these habitats (freshwater wetlands, riparian or river buffers, and flood plains) impacts negatively on the ecological functions and processes of the stream community.

TAKE A LOOK AT YOUR WATERSHED:

Watch what happens to the water after a rainstorm. Where does the water go and how does it get there?

What does the water take with it in its flow?

Note the differences between how the rainwater is distributed on pervious surfaces and impervious surfaces.

LESSON 5

The Nature of Imperviousness

GOAL To understand how land surfaces affect drainage, water quality, and overall watershed health.

TIME
- (4) 45-minute periods

OBJECTIVES Students will:
- ✔ describe the differences between pervious and impervious surfaces
- ✔ calculate percentages of pervious and impervious surfaces
- ✔ compare historic percentages of impervious surfaces to today's percentages in New Jersey
- ✔ learn how the degree of permeability affects the quality and quantity of surface water and ground-water supplies
- ✔ make recommendations for maintaining / improving their watershed

SKILLS measure, calculate, observe, describe, infer, hypothesize, predict, analyze, synthesize, justify

VOCABULARY

aquifer	impervious surface
buffer zone	infiltration
compacted soil	pervious surface
erosion	recharge area
ground-truthing	runoff
ground water	surface water

PRIOR KNOWLEDGE Students should have background in the following:
- the water cycle
- the differences between ground water and surface water
- an understanding of recharge areas and buffer zones
- how to calculate area and volume
- how to calculate percentages

CORE CURRICULUM CONTENT STANDARDS
- Cross-Content Workplace Readiness 2 (7,9,10) 3 (1-4,12,13-15) 4 (2)
- Language Arts 3.1 (14,15) 3.2 (8,9,11) 3.4 (25) 3.5 (13,14)
- Math 4.1 (11,12, 13,15,16) 4.4 (7,8,9,10, 11) 4.7 (16) 4.8 (11) 4.9 (7,8,11-14)
- Science 5.1 (4,5,7) 5.2 (6,8,10,11) 5.4 (11) 5.5 (6) 5.12 (4-6,9,10)
- Social Studies 6.6 (10,16) 6.7 (6,7) 6.8 (8,17) 6.9 (5,6,8)

MATERIALS

For indoor experiment:
- ❑ Shallow aluminum pan
- ❑ ½ inch tubing (at least four feet long)
- ❑ Fine mesh screening
- ❑ Duct tape
- ❑ Collecting container
- ❑ Sprinkling can
- ❑ Measuring instrument
- ❑ Paper towels / newspaper
- ❑ Water
- ❑ Bare surface (the bottom of the aluminum pan)
- ❑ Soil-covered surface (potting soil)
- ❑ Vegetative surface (sod)

For field work:
- ❑ Clipboards
- ❑ The Nature of Imperviousness (Student Page #11)
- ❑ Calculators
- ❑ Architectural plans of the school
- ❑ Site plan of the school

Other:
- ❑ Imperviousness in New Jersey (Student Page #12)

PREPARATION

1. Set up the demonstration model as outlined in Figure 5A.
2. Obtain a copy of the school's site plan. If this is not available add extra time to have the students create a scale map of the school site.

PROCEDURE

Period 1

1. Describe the pervious/impervious surface demonstration and ask students to predict which of the surfaces will shed the most water and which will absorb the most water.
2. Discuss their reasons and have them hypothesize how real surfaces in the natural and built environment would react in the same manner [*bare surface = impervious surfaces (e.g., roads, sidewalks, roofs, parking lots); soil-covered surfaces = construction sites and agricultural sites; vegetative surfaces = open space, parks, lawns, forests (also known as buffer zones and recharge areas)*].
3. Assign students to pour a measured amount of water from a sprinkling can over each of the three surfaces (one surface at a time).
4. Have the students measure the amount of water that drains into the collecting container for each type of surface. Determine the percentage of runoff by dividing the original amount of water into the collected amount of water and multiplying by 100.
5. Use the findings to rate the surfaces from least amount of infiltration to most amount of infiltration. Discuss how water that infiltrates into the soil recharges the ground-water aquifer.

Period 2

1. Survey the school site to create a list of the school site's land uses (e.g., buildings, parking lots, roads, athletic fields, gardens, forests, playgrounds, etc.).
2. Check these against the school's site plan. Note any changes and alter the site plan accordingly. (This process is called ground-truthing.)
3. As you visit each of these different land-use sites, pour water from a container onto each. Discuss what the students see in regards to infiltration / runoff. Discuss the different ways that water might drain from the school site. [*Rainwater runs off into storm drains; it evaporates; it runs off onto grassy areas and filters down into the soil; it runs off into a local stream or waterway; it collects in a retention basin for slow filtration into the ground.*]

Period 3

Have the students work in teams to interpret their school site plan and collect the data they need to complete the Nature of Imperviousness (Student Page #11).

Period 4

Have the students complete Imperviousness in New Jersey (Student Page #12). Discuss the worksheet and the students' answers to the questions. See Answer key, page 135.

FURTHER DISCUSSION

- If all the water that fell on these surfaces drained to one direction, what might be some results? [*flooding, surface erosion, stream bed widening, stream bank erosion, collection in a natural water body or a human constructed retention basin, siltation*]
- What methods were used on the school grounds to compensate for runoff and water filtration?
- What could be done to increase the amount of pervious surfaces on school property? [*create retention ponds, replace non-porous surfaces with porous surfaces, plant grass buffer zones, plant native vegetation micro-habitats, direct roof runoff to a porous surface*]
- How do you think impervious surfaces and pervious surfaces affect water quantity? (Address both surface water supplies and ground-water supplies.)
- How do impervious surfaces and pervious surfaces affect water quality? (Address both surface water supplies and ground-water supplies.)
- In what ways do the impervious surfaces on the school site seem to parallel those of your community at large?

ASSESSMENT

Have teams of students design "new development" (e.g., new school, shopping mall, condominium complex, senior housing, housing development, etc.) to reflect what they have learned about impervious surfaces, runoff, non-point source pollution and watersheds. Have each team create an architectural drawing, 3D model, or computer generated model to present the information.

EMPOWERMENT CHALLENGE

- Using topographic maps or land use maps from the local town, determine the percentage of impervious surfaces vs. open space in the watershed.
- Attend a local watershed association meeting to find out how their group functions within the watershed.

LESSONS FROM OTHER SOURCES

Aquatic Project WILD - Where Does Water Run Off After School?

Project WET - Get the Groundwater Picture

The Ways of the Watersheds - Pump It Up, Soil Labyrinths, Stopping the Drops, The Lay of the Land

WOW! The Wonders of Wetlands - Runoff Race, Wetland in a Pan

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Horton, Tom and William M. Eichbaum. 1991. *Turning the Tide: Saving the Chesapeake Bay.* Washington, DC: Island Press.

Pennsylvania Department of Environmental Protection, Division of Water Planning and Allocation, Bureau of Water Supply and Community Health. 1996. *Instructor's Guide to Water Education Activities,* "The Great Water Catcher."

Schueler, Tom. "The Importance of Imperviousness," Watershed Protection Techniques. Vol 1, No 3, Fall 1994.

Schueler, Tom. "The Peculiarities of Perviousness", Watershed Protection Techniques. Vol 2, No. 1, Fall 1995.

Southern Rhode Island Conservation District and The University of Rhode Island Department of Natural Resources Science. August 1994. *Active Watershed Education Curriculum Guide.*

U.S. Census Bureau website: www.census.gov For specific historic population numbers: www.census.gov/population/www/censusdata/pop-hc.html

NOTES

ANSWER KEY
Imperviousness in New Jersey

Percent impervious surface:

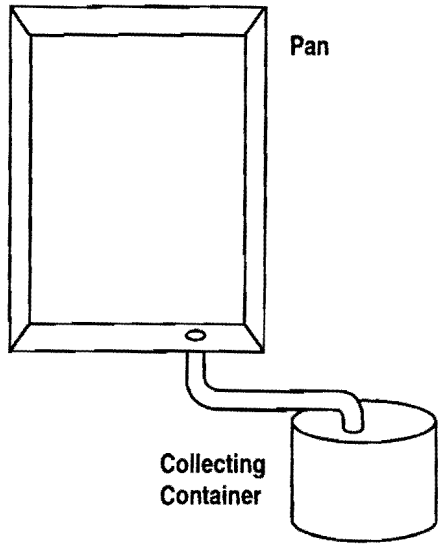
1900	19.6%
1920	32.8%
1940	43.3%
1960	62.5%
1980	76.7%
2000	85.1%
2025	99.5%

Figure 5A
THE NATURE OF IMPERVIOUSNESS DEMONSTRATION

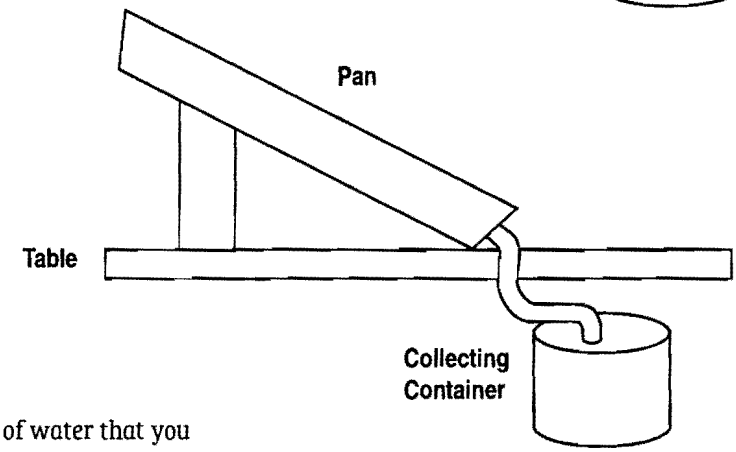
Step 1:

a. Insert the plastic tubing through the aluminum pan side. Tape the tube in place from the outside. Do not cover up the tube opening.

b. Place the other end of the plastic tube in the collecting container.



Step 2: Tilt the pan. Place the collecting container lower than the lowest end of the aluminum pan.



Step 3: Premeasure the amount of water that you will use into a spray mister.

Step 4: Conduct each segment of the experiment separately.

Spray mist the water over the bare surface, collect the water in the collecting container, measure the collected water, and compare this to the amount of water that was initially poured.

Cover the bottom of the pan with top soil. Place a fine mesh screening over the soil to help hold it in place when you tilt the pan. Repeat the same steps from 4a.
Place a piece of grass sod on the bottom of the pan. Repeat the steps from 4a.

NAME: DATE:

THE NATURE OF IMPERVIOUSNESS

A School-Site Exercise

1. What is the total area of the school site? _____ square feet

2. Estimate the surface amounts in square feet:
Impervious surface (parking lots, building, sidewalks, roads)

_____sq. feet

_____% of the whole

Bare soil surface (if applicable)

_____sq. feet

_____% of the whole

Vegetated surfaces (grass and shrubbery, trees, athletic fields)

_____sq. feet

_____% of the whole

3. What is the average amount of rainfall for the site? (Note: Although we are just looking for the average, know that the amount of water that actually soaks into the soil / runs off also depends on the intensity of the rainstorm.)

The Nature of Imperviousness (continued)

4. How many cubic feet of water falls onto the site each year? _____ cubic feet
(rainfall in feet X total surface area)

5. How many gallons of water fall onto the site each year? _____ gallons
(~ 8 gallons of water per cubic foot)

6. If a 20' x 20' x 10' room holds 30,000 gallons of water, how many rooms would be filled with the amount of water that falls onto your school site?

7. Using what you have learned about the different surfaces from the previous experiment, what percentage of the total amount of rainfall actually runs off of:

   the impervious surfaces? _____%

   the bare soil surfaces (if applicable) _____%

8. How much water filters into the soil? _____%

NAME: DATE:

IMPERVIOUSNESS IN NEW JERSEY

DIRECTIONS:
Calculate the percent of impervious surfaces in New Jersey (historic and present day) using the following statistics.

- New Jersey's total land surface = 4.8 million acres
- Each person represents a half acre of impervious surface (Center for Watershed Protection)

New Jersey's population (U.S. Census Bureau)

1900	1,883,669	____% impervious surface
1920	3,155,900	____%
1940	4,160,165	____%
1960	6,004,000	____%
1980	7,364,823	____%
2000	8,178,000 (estimate)	____%
2025	9,558,000 (estimate)	____%

1. What implications does an increase in impervious surfaces have for the amount of open space in the state?

2. What implications does this have for surface water and ground-water supplies?

3. What strategies do you think local, county, state, and regional planners should be developing and applying to water quality and quantity?

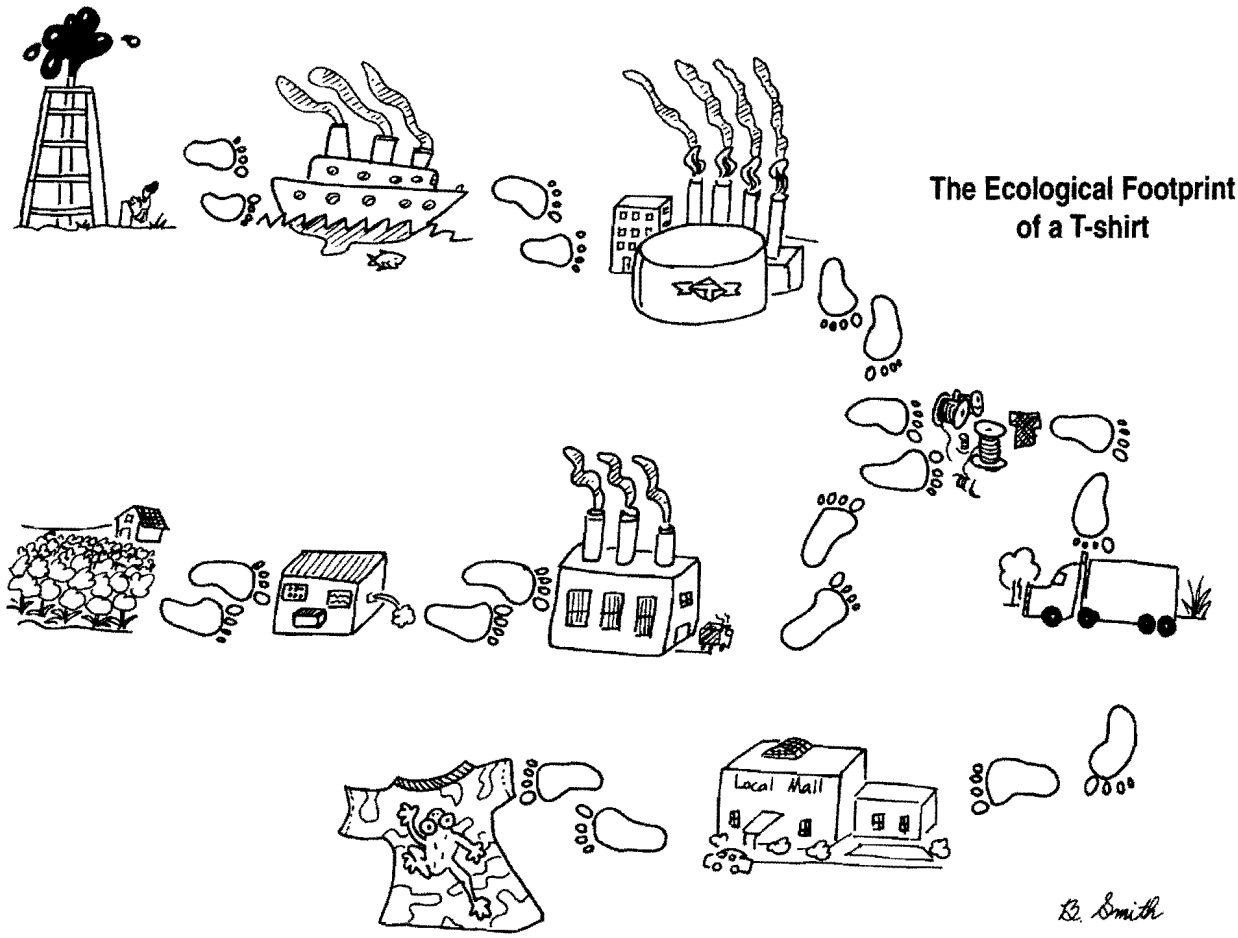
NOTES

HOW LIGHTLY DO YOU LIVE?

"Confronting resource consumption is North America's principal environmental challenge, although few realize this fact because the impacts of consumption are mostly invisible to the consumer. The United States, with less than 5 percent of world population, consumes 24 percent of the world's energy and similar shares of other commodities." * Americans consume an average of 120 pounds of natural resources every day. This includes all that comes from farms, forests, rangelands, and mines. Americans also discard an average of four pounds of garbage each day.

Population, per capita income, and advanced technology all play key roles in determining how much a society consumes. It is generally accepted that as the population increases, the amount of resources and products needed will increase proportionately. Additionally, if that population is fairly wealthy by world standards and supports advanced technology, members of the population may become removed from the natural systems that support it. This combination of factors causes people to be expert consumers of products and resources that have all kinds of "hidden" processes which may or may not damage the natural systems.

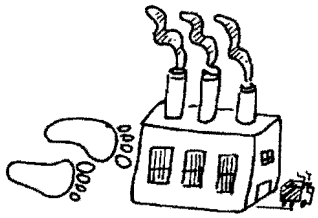
An individual's ecological footprint can be defined as how much impact that individual has on the environment in daily life practices. Every product has a "life cycle" that can be traced from the raw materials to its purchase, to its use, and to its disposal. Each of these steps occur within a watershed and may have an impact on the watershed.



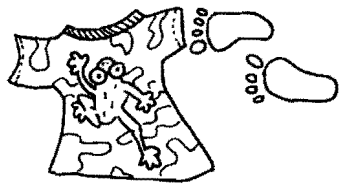
The Ecological Footprint of a T-shirt

How Lightly Do You Live?

The challenge, then, is to balance what the population of the world needs and wants with the earth's limitations on maintaining healthy ecosystems. On a watershed level, we see that regional challenges can only be solved by regional solutions. With the ever-increasing advances in technology the world is becoming a global community with a global economy. From an ecological basis, scientists are finding that even the remotest systems of the world are all exhibiting effects from human actions.



* Ryan, John C. and Alan Thein Durning. 1997. *Stuff: The Secret Lives of Everyday Things.* Northwest Environment Watch, WA.



TAKE A LOOK AT YOUR WATERSHED:

What manufacturing industries do you see that use water or affect a local water body?

What is your water use throughout the day? List the practices for which you use water directly and indirectly. How could you adjust these amounts?

LESSON 6

How Lightly Do You Live?

GOAL To determine people's ecological footprint on the watershed and the world economy by assessing the processes involved in manufacturing clothing today and in the past.

TIME
- (2) 45-minute periods

OBJECTIVES Students will:
- ✔ explain how different manufacturing processes affect water use and the watershed.
- ✔ compare today's clothing manufacturing processes with those in the past.
- ✔ calculate how much and what type of impact these processes have on the global environment and economy.
- ✔ give recommendations to balance human needs and watershed quality.

SKILLS interpret information, identify, sequence, analyze, determine cause and effect, hypothesize, project, justify

VOCABULARY
consumerism
ecological footprint
life cycle analysis
resource
tolerance threshold

PREPARATION
1. Make enough copies of the 1790s and 1990s information sheets so that half the class has one and the other half has the other.
2. Make a copy of the Assessment Table (Student Page #13) for each student.

MATERIALS
- ❑ How Lightly Do You Live - In the 1790s (Figure 6A)
- ❑ How Lightly Do You Live - In the 1990s (Figure 6B)
- ❑ Assessment Table (Student Page #13)
- ❑ Samples of T-shirt, linen shirt, wool shirt (optional)

CORE CURRICULUM CONTENT STANDARDS
- Cross Content Workplace Readiness 2 (1,10) 3 (1,7-12)
- Language Arts 3.1 (14,15) 3.2 (8,9,11) 3.4 (21)
- Science 5.1 (4-7) 5.4 (5,10) 5.8 (5) 5.10 (14) 5.12 (4,9,10)
- Social Studies 6.2 (8) 6.4 (5) 6.6 (8-13,15,16) 6.8 (11,16,17) 6.9 (4-8)

PROCEDURE

Period 1

1. Divide the class into two work groups (one for the 1790s and one for the 1990s).
2. Distribute the appropriate manufacturing process sheet (Figures 6A and 6B) to the members of each group. Have them read the information and complete the first four sections of the Assessment Table (Student Page #13).

Period 2

1. Have the students in each group rate each step in the manufacturing process on how it impacts the watershed using the following scale: (1) no impact, (2) little impact, (3) some impact, (4) great impact
2. Have each group present the steps in the process and their cumulative points to the other group. Discuss how the students arrived at deciding on the degree of impact.
3. Lead a discussion on how the processes in the 1790s mostly had an impact on the local or regional watershed where as the processes of the 1990s have an impact on many local and regional watersheds around the world, or the global watershed.
4. Write the words "ecological footprint" on the chalkboard. Have the students hypothesize what this expression means. Relate this information to their knowledge about manufacturing T-shirts.
5. Define "tolerance threshold" as the degree of environmental impact a person or community is willing to tolerate when one of these processes is happening in their watershed. Discuss the factors that may contribute to low and high tolerance thresholds concerning watershed issues.

FURTHER DISCUSSION

1. What helped you decide the degree of impact a process had on the watershed?
2. In order to continue the T-shirt's "life cycle" from "birth to death" what other processes would we have to include? [*wearing of the shirt, using soap during washing, recycling, using for rags, garbage to landfill*]
3. What strategies could be used to change the ecological footprints that we create as consumers?
4. Why have manufacturing processes changed over time? [*technological advances, discoveries, cost of materials*]

ASSESSMENT

Have the students select an everyday item from their home and complete a life cycle analysis for that item. Ask them to outline a strategy that they could use to minimize their ecological footprint concerning that specific product.

EMPOWERMENT CHALLENGE

- Have the students take an inventory of their T-shirts to determine how many they own. Create a table/graph that shows their composition. Identify where the T-shirts were assembled and plot these countries on a global map. Create a choropleth (color) map to demonstrate distribution.
- Take an inventory of all cleaning materials used in your home. How many say "biodegradable?" How many are oil or chemical based solutions? What can you do to limit their use or change their use?

LESSONS FROM OTHER SOURCES:

Project WET - Water Concentration, Wish Book

REFERENCES

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Palmer, E. Lawrence and H. Seymour Fowler. 1975. *Fieldbook of Natural History.* 2d ed. New York, NY: McGraw-Hill.

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Svinicki, Eunice. 1974. *Step by Step Spinning and Dyeing.* New York, NY: Golden Press.

Wackernagel, Mathis and William E. Rees. 1998. *Our Ecological Footprint: Reducing Human Impact on the Earth.* The Orion Society, MA.

Wool Education Center. 1965. *The Story of Wool,* Denver, CO.

Figure 6A

HOW LIGHTLY DO YOU LIVE IN THE 1790s? (Before the Industrial Revolution)

The typical shirt worn by the person who lived in the late 1700s would have been either linen, wool, or a mixture of the two (called linsey-woolsey). For this scenario, a shirt made from 50 percent linen and 50 percent wool will be made at a farm in western New Jersey.

LINEN PRODUCTION

The children in the family spread last year's flaxseed on a tilled piece of acreage. The older boy of the family led a team of oxen, behind which there was a roller which tamped the seeds down and buried them to a depth of about ½ to 1 inch. The crop took about 85 days to mature because rainfall that season was consistent and flax grows best in an environment where there is about 30 inches of rainfall, evenly distributed throughout the year.

When the flax plants were ready to be harvested, the entire family worked to pull each plant out of the ground by hand. The plants were beaten (threshed) to extract the seeds for next year or to process them into linseed oil. From there plant stalks were soaked in water, usually a shallow pond, for 10 to 20 days, until they could be broken easily (retted). Using a wooden paddle family members would beat the center and outer stalk away from the flax fibers which were about 20 to 30 inches in length. The paddle was hand made from timber that grew along the edge of the family's pastureland.

Individual fibers would be spun into thread using a hand-powered flax wheel then, if desired, dyed using natural materials in a hot bath of water. Spools of thread would be set aside to be woven together with wool thread into cloth. If not dyed when it was thread, the cloth could be soaked in buttermilk and spread out in bright full summer sunlight on the lawn to dry. Subsequent soakings and dryings would gradually bleach the linen cloth.

WOOL PRODUCTION

Sheep are versatile animals that can be at home in a paddock on a farm or grazing over acres of pastureland. Although the amount of wool that a sheep produced would depend on the breed, the health of the animal, and to some extent on the age, an estimate of amount that an average ewe would produce was about 10 pounds of wool per shearing which usually happened only once a year.

When it was time to shear the sheep, highly skilled sheepman were hired to carry out that part of the process. After the fleece was shorn, it was sorted into long or short fibers. Since the wool was very oily and also contained bits of dirt and plant materials, it had to be washed repeatedly with soap and water. About 25-30 percent of the wool's volume would be lost when the fleece was washed - barnyard dirt and lanolin had to be removed before the fleece could be processed further.

The clean wool would be "carded or combed" which untangled the individual wool fibers. At this time the wool would be spun into yarn using a hand-powered wool wheel. The yarn would be dyed in a hot water bath using natural materials. Further spinning would produce the final yarn which would be stored on large spools.

Once enough of both types of yarn/thread were ready, the weaver would take the linen thread on a handmade loom as the warp (running parallel with equal tension) and the wool yarn would be woven through the linen threads to produce the linsey-woolsey cloth. The combination of the two types created a durable material that was then cut to a shirt pattern and sewed by hand or by hand-powered sewing machine.

Figure 6B

HOW LIGHTLY DO YOU LIVE IN THE 1990s?

In order to make your favorite T-shirt a number of processes were needed. This example is for a T-shirt made from 50 percent polyester and 50 percent cotton which weighs about four ounces.
(This information is "typical," which means that although places are named it does not mean that these are the only places that produce and/or manufacture the raw goods.)

PRODUCTION OF POLYESTER

The polyester in a T-shirt started as a few tablespoons of petroleum. On the Caribbean coast of Venezuela, an oil derrick's spinning diamond bit drilled into the ground. The derrick used "drilling muds" containing diesel fuel, heavy metals, and water to flush away bits of rock and to lubricate and cool the diamond bit.

The crude oil was transported to a refinery in Curacao in the Netherlands Antilles where it was washed with water to remove corrosive salts and impurities. It was then heated to 750° F. All but the heaviest tars evaporated and rose through the processing tower. As they rose, they cooled and condensed. The heavier hydrocarbons condensed more quickly and were drawn off to make waxes and lubricants. Lighter compounds rose higher and after several rounds of intensive procedures became various grades of fuel and raw materials for petrochemicals like polyester.

Under high temperature hydrocarbons are processed again into compounds called ethylene and xylene. A chemical plant near Wilmington, DE turns ethylene into ethylene glycol. They turn xylene into DMT (dimethyl terephthalate). DMT and eythlene glycol are combined and chemically linked to form a resin called PET (polyethylene terephthalate) which is one of the most common petrochemicals found in drink containers, clothing, and other plastic products. The PET resin is processed and drawn apart to form hairlike strings, which are the polyester fibers, used to make clothing.

COTTON PRODUCTION

To manufacture the four-ounce 50/50 T-shirt it takes two ounces of cotton. The cotton started out as a fourteen-square foot piece of cropland in Mississippi. Prior to planting, the soil was plowed under and fumigated with a pesticide and the cotton seed was dipped in a fungicide.

During the germination period, the cotton field was sprayed with a soil sterilant to kill off other plants and/or insects that might compete with or eat the young cotton plants. As the plants grew, the field was sprayed several times with pesticides to keep airborne insects from damaging the crops. The field was heavily irrigated.

Just before harvesting, the field was sprayed from the air with a defoliant. This causes the plant to drop its leaves so that the leaves don't stain the white cotton balls. Then a large machine called a cotton stripper harvests the cotton balls. The fibers are separated from the seeds by a cotton gin. Seeds are used to make cooking oil and livestock feed. Fibers are sent to a textile mill in North Carolina, which cards them and blends them with the polyester fibers to make yarn.

At another textile mill, the yarn was knitted into fabric. To reduce friction in the knitting machine, it was lubricated with mineral oil. The fabric was then washed, bleached and dyed. The fabric was finished with industrial chemicals including chlorine, chromium, and formaldehyde. Since cotton resists the dying process, one third of the dye was carried off in the wastewater stream. Textile dyes are regulated by the US Environmental Protection Agency as hazardous substances.

The fabric was shipped to Honduras where workers in a Taiwanese-owned factory cut and sewed it into a T-shirt. They mounted the shirt on a cardboard sheet made of pinewood pulp from Georgia, wrapped it in a polyethylene bag from Mexico, and stacked it in a corrugated box from Maine.

The box from Honduras went by freighter to Baltimore and was then trucked to local malls for purchase.

This description is reprinted with permission from *Stuff: The Secret Lives of Everyday Things* by John C. Ryan and Alan Thein Durning (Northwest Environment Watch, WA. 1997).

NAME: DATE:

HOW LIGHTLY DO YOU LIVE?

Assessment Table

1 = no impact
2 = little impact
3 = some impact
4 = great impact

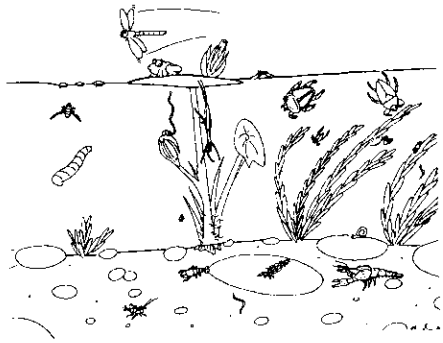
List each step of the manufacturing process.	Does it require water? Y / N	How does this step affect the local economy?	How does this step affect the local watershed?	Rate the impact of each step on a scale of 1 to 4 (use list above)

NOTES

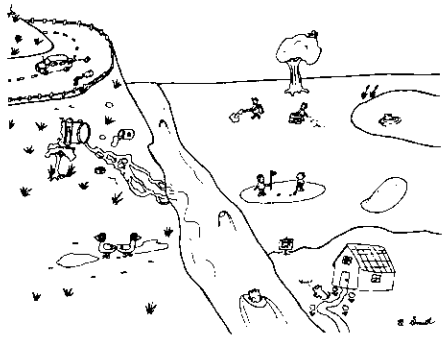
Activities
A SENSE OF QUALITY AND QUANTITY

"We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

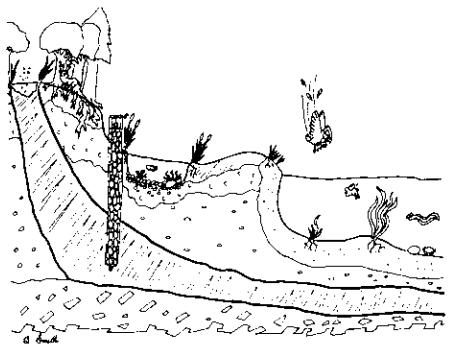
— Aldo Leopold
A Sand County Almanac



A Look at the Bottom Dwellers



Ins, Outs, and In-Betweens



Above and Below

A SENSE OF QUALITY AND QUANTITY

NJ Core Curriculum Content Standards

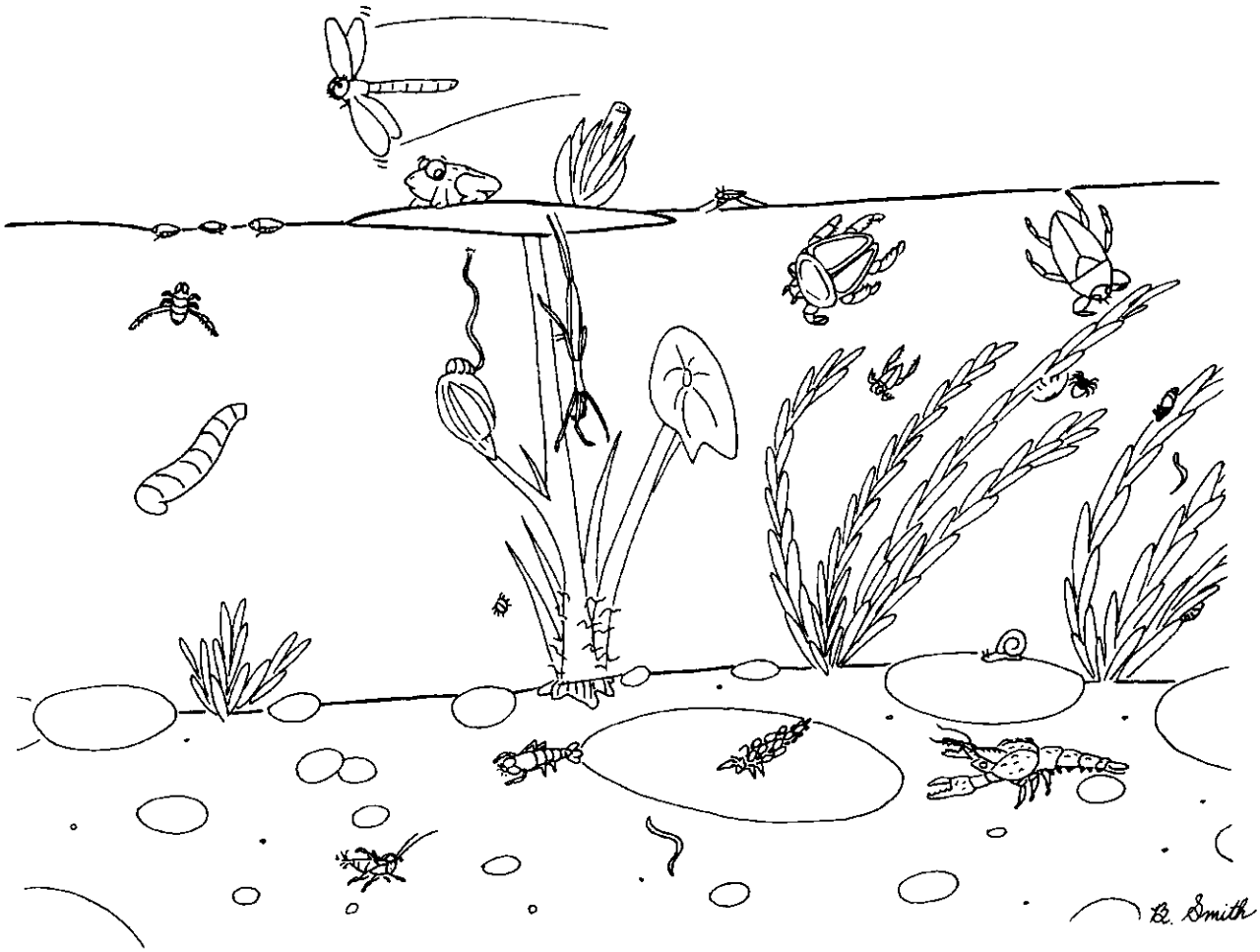
A Look at the Bottom Dwellers	How do indicator species help determine water quality? page **151**
Workplace Readiness	
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15) **3.2** (8,11)
Mathematics	**4.8** (10)
Science	**5.1** (5) **5.5** (11) **5.6** (8,17) **5.7** (7) **5.12** (7,10)
Social Studies	

Ins, Outs, and In-Betweens	How do point source and non-point source pollution affect the watershed? page **165**
Workplace Readiness	
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	**2.1** (8,11,16,18)
Language Arts	**3.1** (14) **3.2** (8,11) **3.5** (12)
Mathematics	
Science	**5.1** (4-7) **5.12** (4,5,6,9,10)
Social Studies	**6.7** (7,8) **6.9** (5,7,8)

Above and Below	How does land use affect surface water and ground-water supplies? page **169**
Workplace Readiness	**3** (2,8,9,11-15) **4** (2)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15) **3.2** (8-11) **3.5** (8)
Mathematics	**4.1** (11,13) **4.2** (9) **4.6** (14) **4.8** (11)
Science	**5.1** (4,5,6) **5.5** (15) **5.10** (10,14) **5.12** (4,5,6,9,10)
Social Studies	**6.6** (10,16) **6.9** (5,7)

Bold Numbers = Standards (Light Numbers in Brackets) = Indicators

A LOOK AT THE BOTTOM DWELLERS

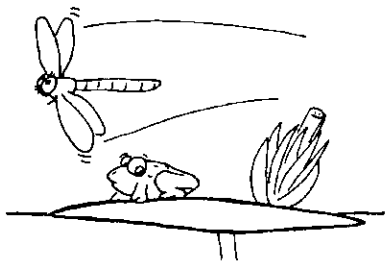


Benthic macroinvertebrates are animals that live on the bottom of a lake, stream, or river. The word "benthic" means bottom dwelling and, in this case, refers to any organism that spends its life or part of its life living, swimming, crawling, or attached to the bottom substrate of a water body. The term "macroinvertebrate" refers to those animals that lack a backbone and are large enough to be seen without the use of magnifying equipment. Macroinvertebrates include, but are not limited to, aquatic insects, some worms, clams, snails, and leeches.

Benthic macroinvertebrates are sensitive to water quality. As the water quality of a specific stream changes from excellent to good to fair to poor, the types of macroinvertebrates that are able to survive under these conditions change. Those species that require high levels of oxygen and low levels of turbidity are replaced by animals that can handle higher water temperature, less available oxygen, and muddier environs. The former require clear, clean water to filter through their external gills. Sediments from erosion or higher water temperature from habitat alteration will affect these species negatively.

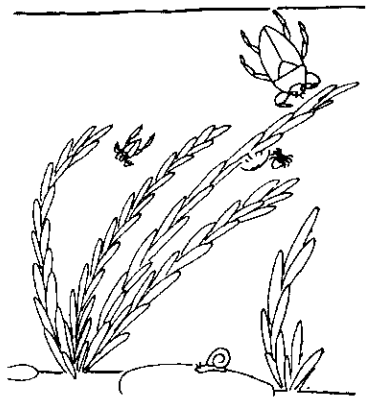
As the bottom substrate of a stream or river changes, the types of species found there also change. Typically, headwaters streams have healthy populations of mayflies, stoneflies, and caddisflies. These animals have specific adaptations that allow them to live with the river's current. They flatten their bodies to crawl under rocks, they have specialized hooks which help

A Look at the Bottom Dwellers



them hold on to submerged vegetation and rocks, and some species actually construct stone cases around their bodies to add weight. As the river widens and deepens it is more likely to have a muddy, silty bottom due to sediment deposition created by the slower current. The aforementioned ability of macroinvertebrates to survive here declines. Instead, they are replaced with aquatic worms, worm-like larvae of midges and black flies, maggots, and leeches. This transition is a natural process, although outside factors, like pollution, can alter each of these stages.

Biologists study benthic macroinvertebrates because the abundance of or lack of these animals gives insight into water quality and habitat health. Since many of these animals are sensitive to both physical and chemical changes in their habitats, they become environmental indicators. They live in the water for over a year in various developmental stages and because of their size and travel limitations they are unable to escape pollution. Being fairly easy to catch makes monitoring their populations relatively easy. These animals occur worldwide and although the species may differ, the orders are generally the same. In essence benthic macroinvertebrates become global biological indicators of water quality and environmental health.



TAKE A LOOK AT YOUR WATERSHED:

What other natural indicators do you see that might describe the health of your watershed?

LESSON 7

A Look at the Bottom Dwellers

GOAL To practice a scientific data collection technique which uses the identification of indicator species to help determine water quality.

TIME
- (1) 45-minute period

OBJECTIVES Students will:
- ✔ identify the types of benthic macroinvertebrates that help determine water quality
- ✔ calculate water quality using the Pollution Tolerance Index
- ✔ explain reasons for using indicator species to assess water quality
- ✔ infer how land use can affect the water quality of any waterway

SKILLS classify, categorize, describe, identify, calculate, analyze, infer, justify

VOCABULARY
benthic macroinvertebrate
bottom substrate
dissolved oxygen
environmental indicator
non-point source pollution
turbidity

PRIOR KNOWLEDGE Students should have background in:
- using an identification key

CORE CURRICULUM CONTENT STANDARDS
- Language Arts 3.1 (14,15) 3.2 (8,11)
- Math 4.8 (10)
- Science 5.1 (5) 5.5 (11) 5.6 (8,17) 5.7 (7) 5.12 (7,10)

MATERIALS
- ❑ Six different color copy paper
- ❑ Six #10 envelopes (one for each student group of four or five)
- ❑ Magic marker
- ❑ Macroinvertebrate illustrations (Figures 7A-F)
- ❑ Macroinvertebrate Key (Figure 7Key pages 158 - 159)
- ❑ Pollution Tolerance Index (Student Page #14)

PREPARATION
1. Copy Figures 7A through 7F, each on a different color. These represent stream samples of different water quality.
2. Laminate each sheet, then cut each sheet into individual macroinvertebrate illustrations.
3. Mark each envelope with a letter for identification and place the corresponding macroinvertebrate illustrations in the envelope. Example: Illustrations from Figure 7A, on blue paper, belong in the envelope marked "A."
4. Make one copy of the two-page Macroinvertebrate Key (Figure 7Key) for each group.
5. Make one copy of the Pollution Tolerance Index (Student Page #14) for each student.

PROCEDURE

1. Divide the class into six groups. Distribute one envelope to each group
2. Explain that in the field, biologists collect a sample of aquatic animals to help them determine the water quality of streams, rivers, ponds, and lakes. The contents of each envelope represent one such sample.
3. Have the students spread their sample of aquatic animals on a table. Tell them to separate the illustrations into categories and list some of the characteristics that the animals from each category portray.
4. Introduce the term "benthic macroinvertebrate" as large (macro) bottom (benthic) dwelling animals without backbones (invertebrate).
5. Instruct the students to use their Macroinvertebrate Identification Key (Figure 7G) to identify the macroinvertebrate illustrations and classify them according to species and order.
6. Have each student calculate the water quality of their stream sample according to the Pollution Tolerance Index (Student Page #14).
7. Have each group present to the class:
   a. the process the group used to assess their sample
   b. which macroinvertebrates were the most common and least common in their sample
   c. the quality of their stream sample
   d. what physical characteristics their macroinvertebrates would need to exist in a stream that exhibits similar water quality to their sample

FURTHER DISCUSSION

1. How does the presence or absence of specific benthic macroinvertebrates indicate water quality? [*Certain species of macroinvertebrates are sensitive to chemical pollution and changes in temperature and turbidity, the presence or absence of these species can help ecologists identify or monitor potential problems.*]
2. Besides monitoring biological factors (like macroinvertebrates) what other indicators or tests might help us determine a specific waterway's water quality? [*chemical monitoring - level of pH, water temperature, percent of dissolved oxygen, phosphates, nitrates; visual assessment - signs of point and non-point source pollution, degree of turbidity which indicates erosion and siltation concerns, bottom substrate materials*]

ASSESSMENT

- What are the pros and cons for using a Pollution Tolerance Index? [*Pros - macroinvertebrates are more sensitive to water quality than fish; therefore the presence or absence of these animals is a far better indicator of the waterway's health than sampling fish populations, consistent monitoring over time can yield long-term data on the water quality of a site in a relatively inexpensive way. Cons - sampling is not an exact science but more like a "snapshot," there are always inconsistencies in sampling and sampling techniques, sampling reveals an effect, but not necessarily a cause.*]
- Have the students identify a section of their local river (or tributary to their river) that might have the same profile as their "stream sample." Ask for justifications. If you were to use this method of biological sampling on a local stream, how would you set up your study? Include: number of sample times, number of sites, location of sites, and how you would present your data.

EXTENSIONS

1. Learn more about the individual macroinvertebrates by researching their life cycle and habitat requirements.
2. Interview fly fishermen and fish and wildlife biologists to create a comprehensive picture of the interrelationships between macroinvertebrates, fish, and other animals and water quality.

EMPOWERMENT CHALLENGE

- Have the students determine the Pollution Tolerance Index of a local stream and make comparisons with the results from another stream or from the same stream further up or downstream.
- Adopt a stream. Monitor the water quality of a nearby waterway on a weekly or monthly basis. Have the students do biological and chemical testing of the study site. Best resource: Field Manual For Water Quality Monitoring by Mark K. Mitchell and William B. Stapp. Compare these data with other schools that are in the same watershed. Submit the data to the local watershed association.

LESSONS FROM OTHER SOURCES

Hands On Save Our Streams - Stream Detectives, Stream Doctors
Project WET - Macroinvertebrate Mayhem
WOW! The Wonders of Wetlands - Wet n' Wild

REFERENCES

Firehock, Karen. 1994. *Hands On Save Our Streams.* Gaithersburg, MD: Izaak Walton League of America.

Mitchell, Mark K. and William B. Stapp. 1996. *Field Manual for Water Quality Monitoring: An Environmental Education Program for School.* Ann Arbor, MI: Global Rivers Environmental Education Network.

USEPA. Office of Wetlands, Oceans and Watersheds. 1997. *Volunteer Stream Monitoring: A Methods Manual* #841-B-97-003.

Figure 7A

STREAM SAMPLE **A**

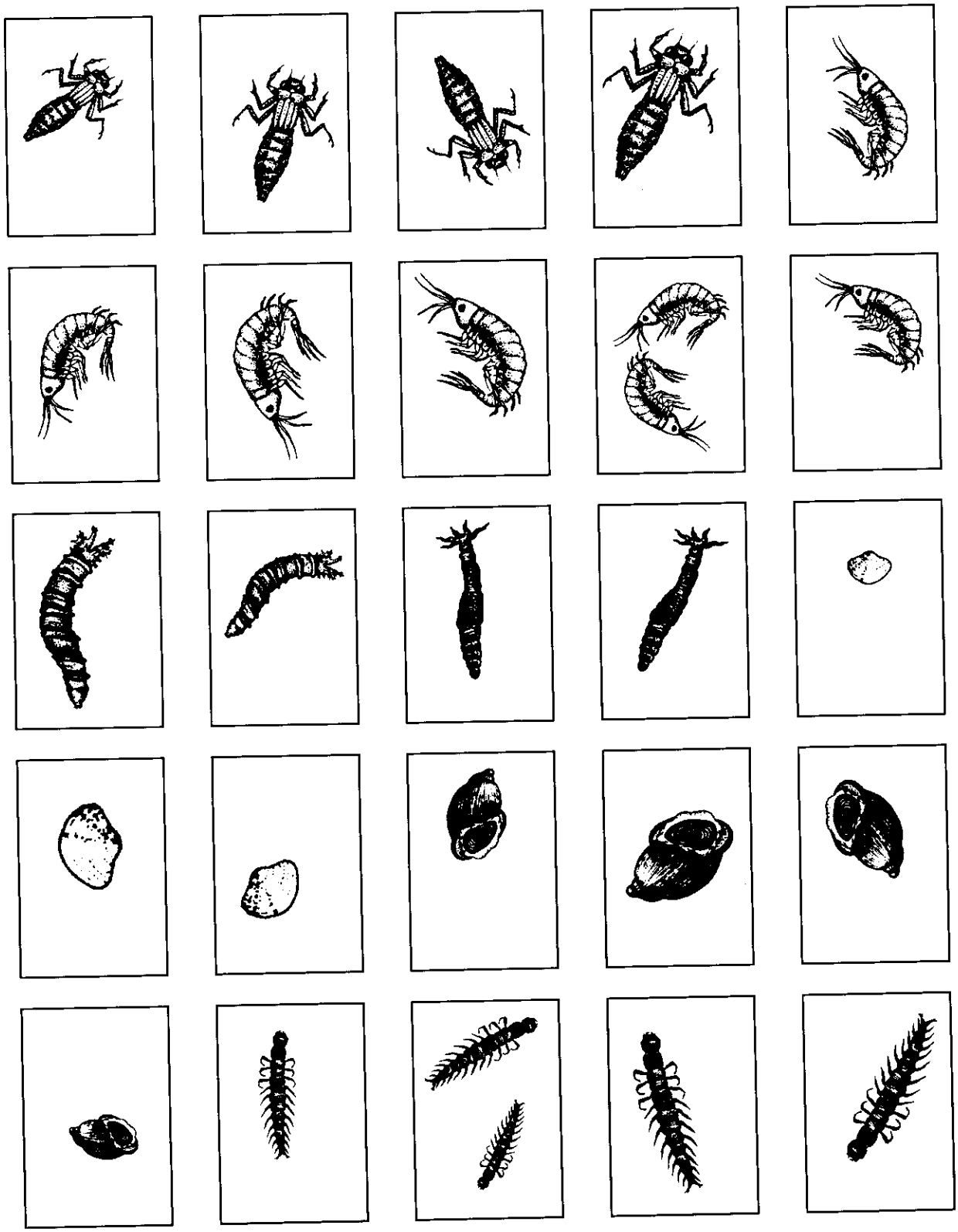


Figure 7B

STREAM SAMPLE **B**

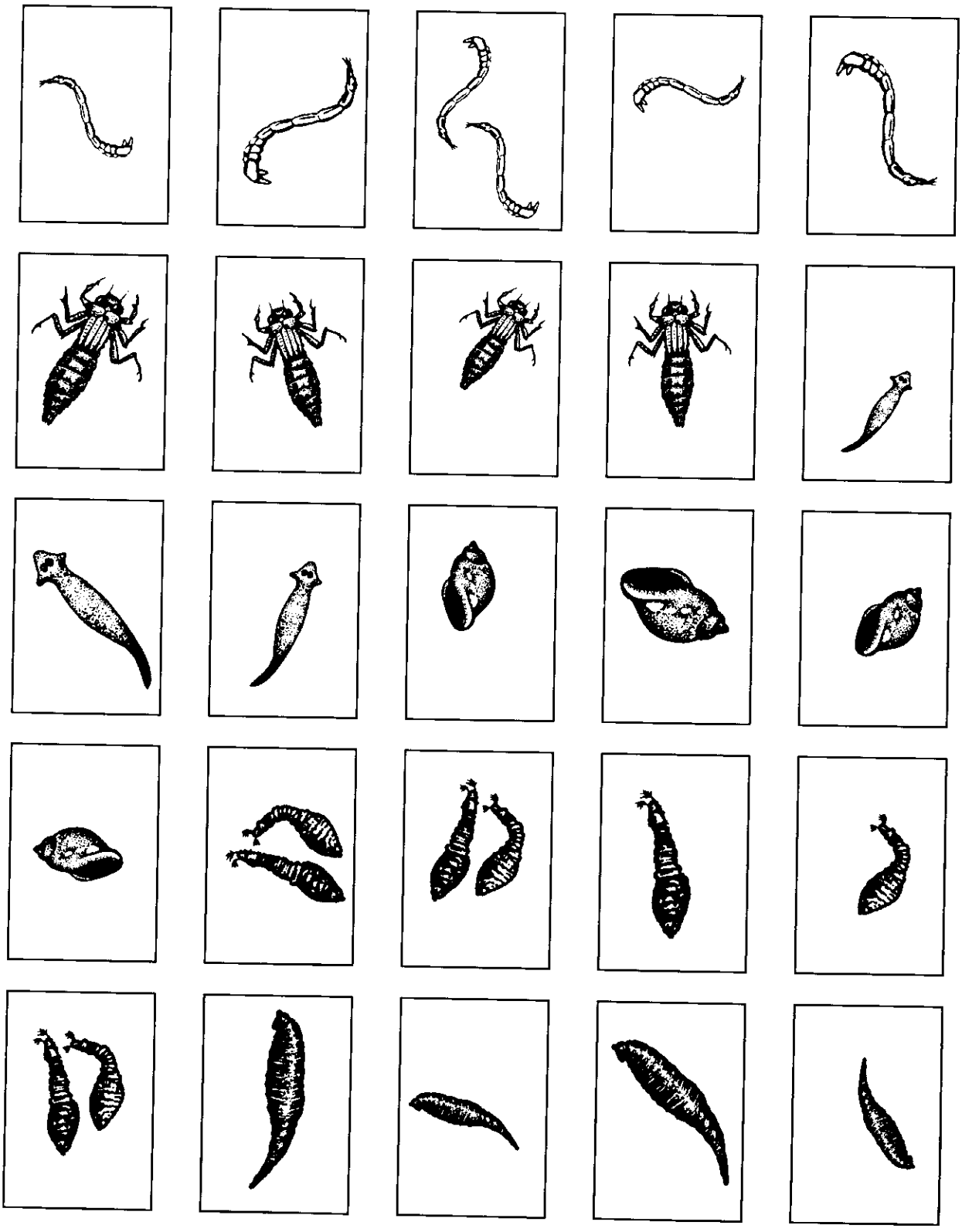


Figure 7C

STREAM SAMPLE **C**

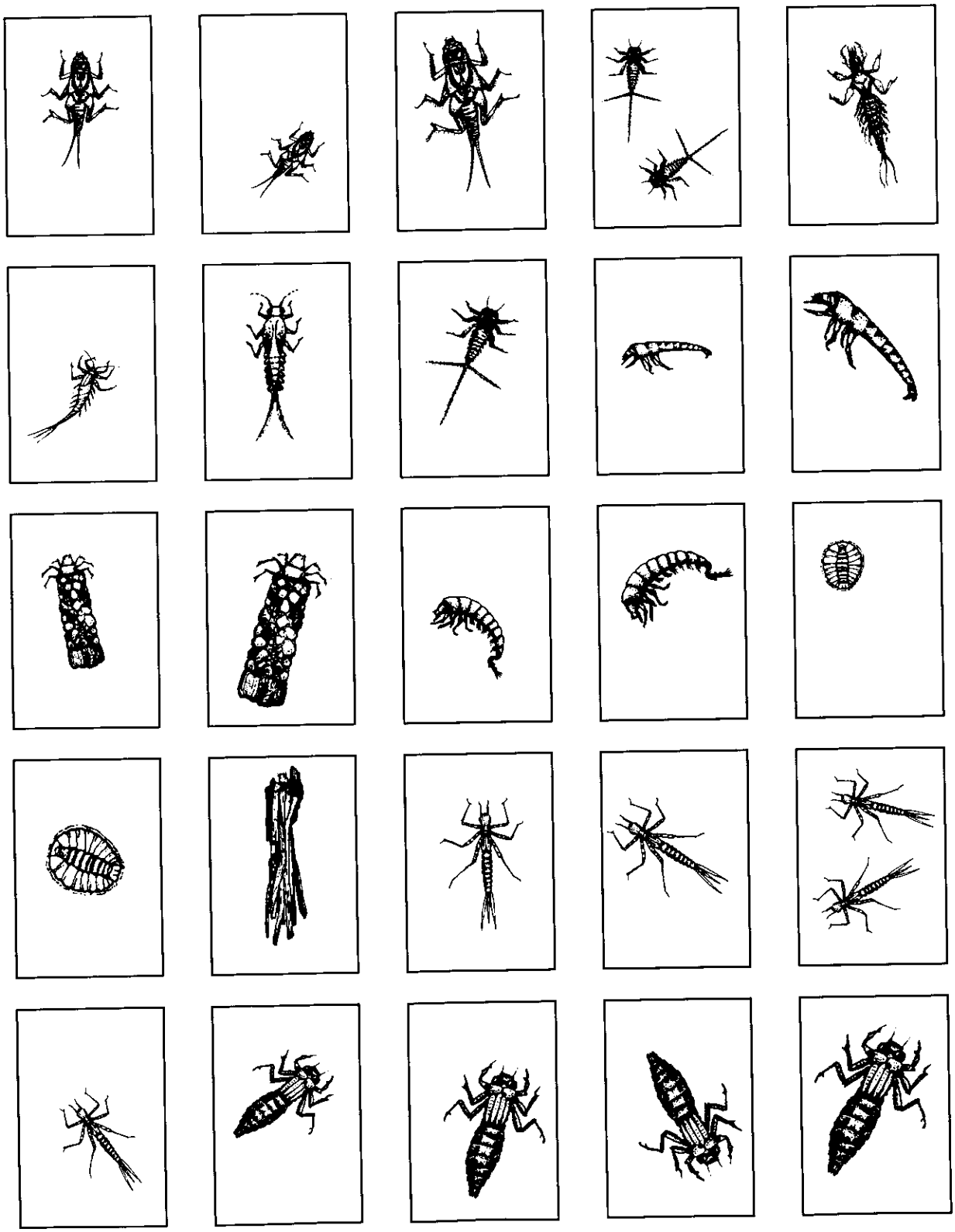


Figure 7Key (left half)
KEY TO MACROINVERTEBRATE
LIFE IN THE RIVER

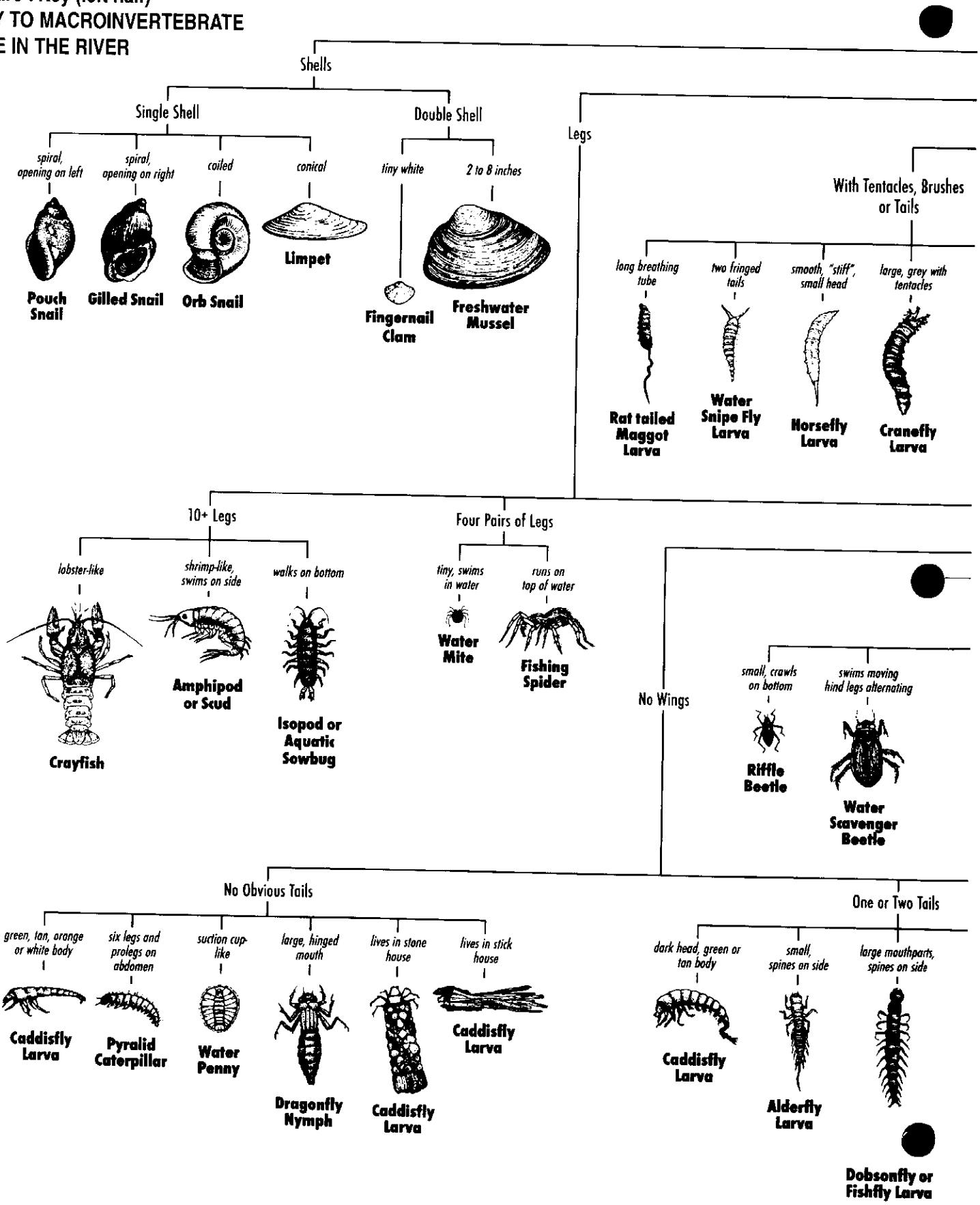


Figure 7Key (right half)
KEY TO MACROINVERTEBRATE LIFE IN THE RIVER

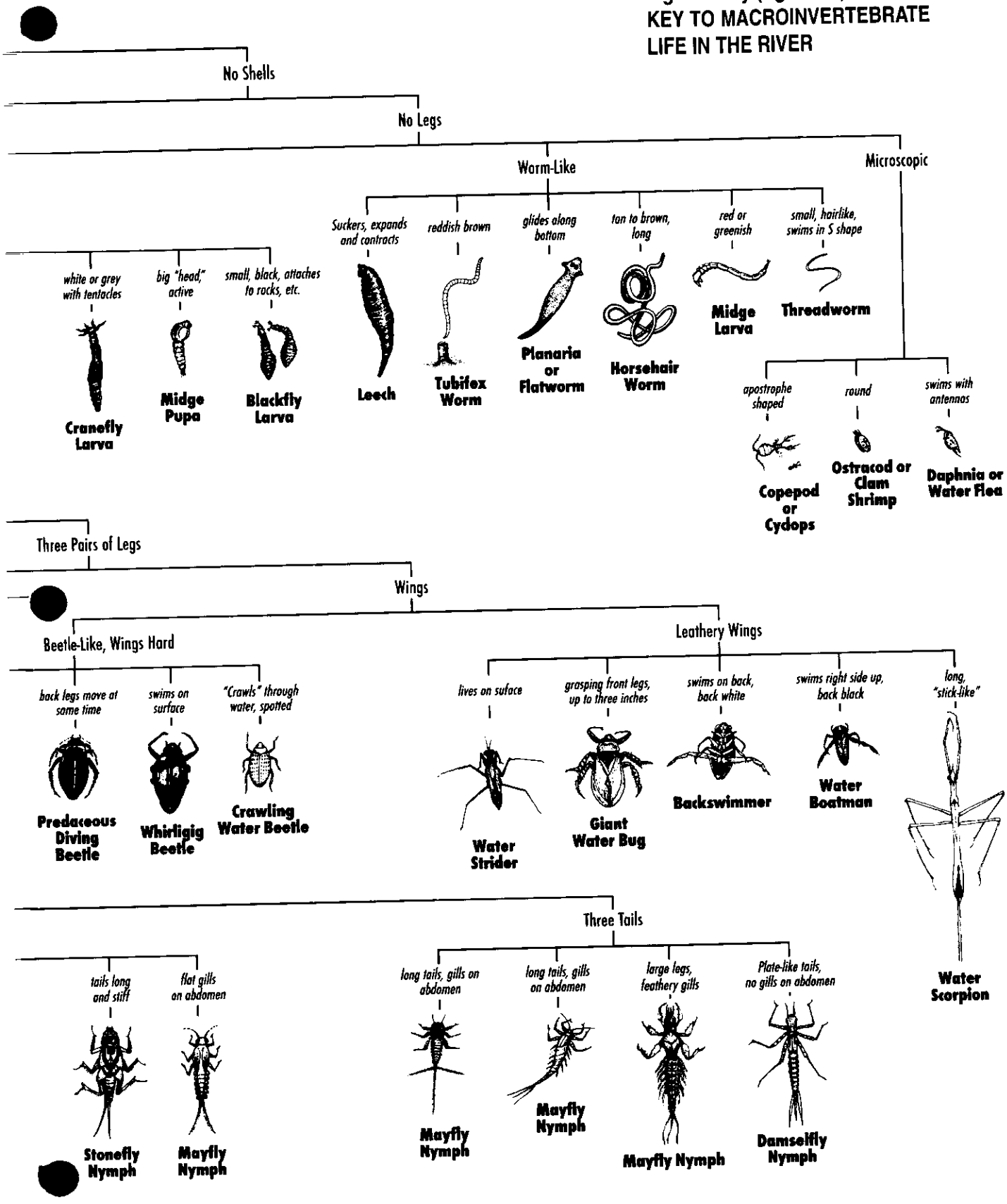


Figure 7D

STREAM SAMPLE **D**

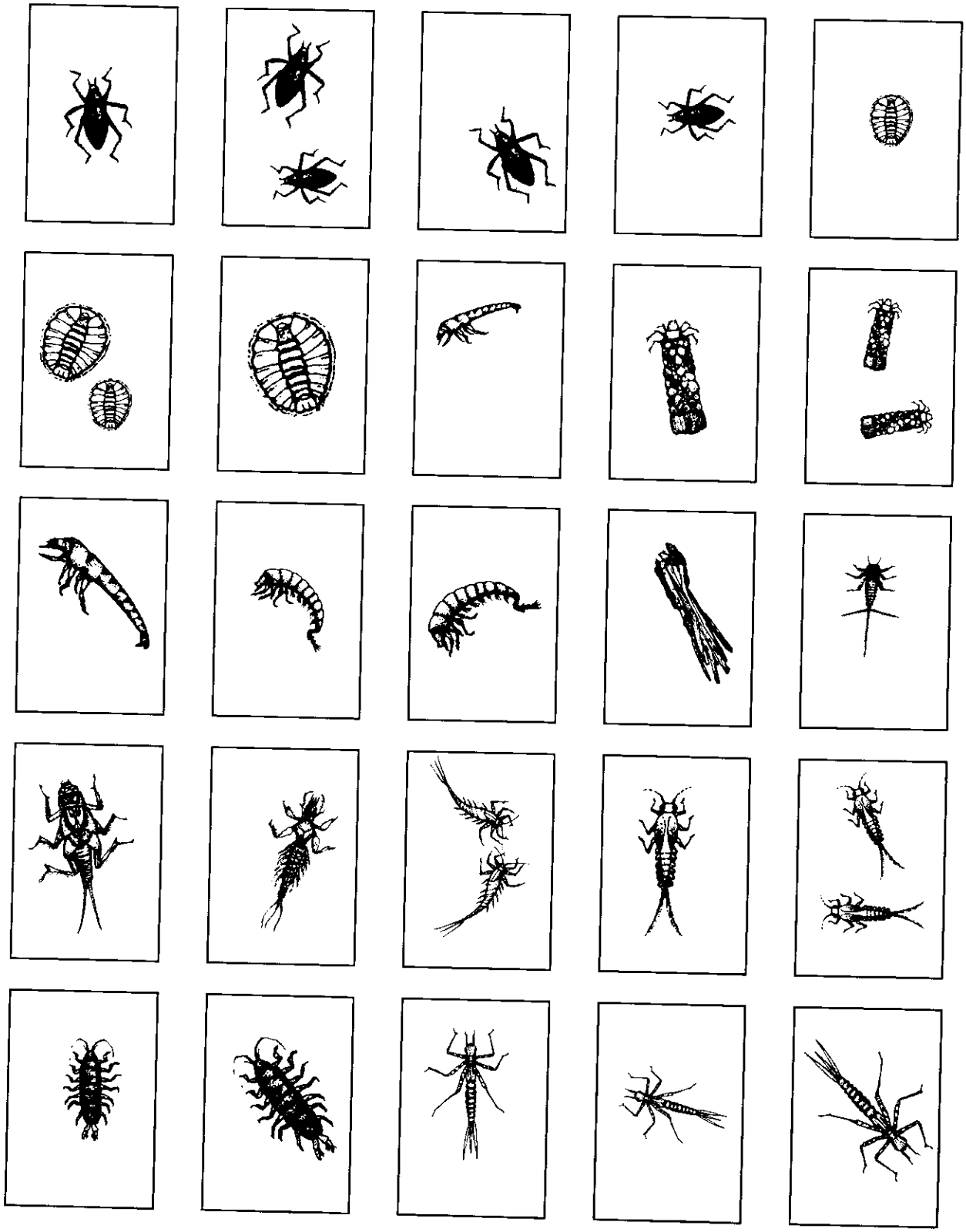


Figure 7E

STREAM SAMPLE **E**

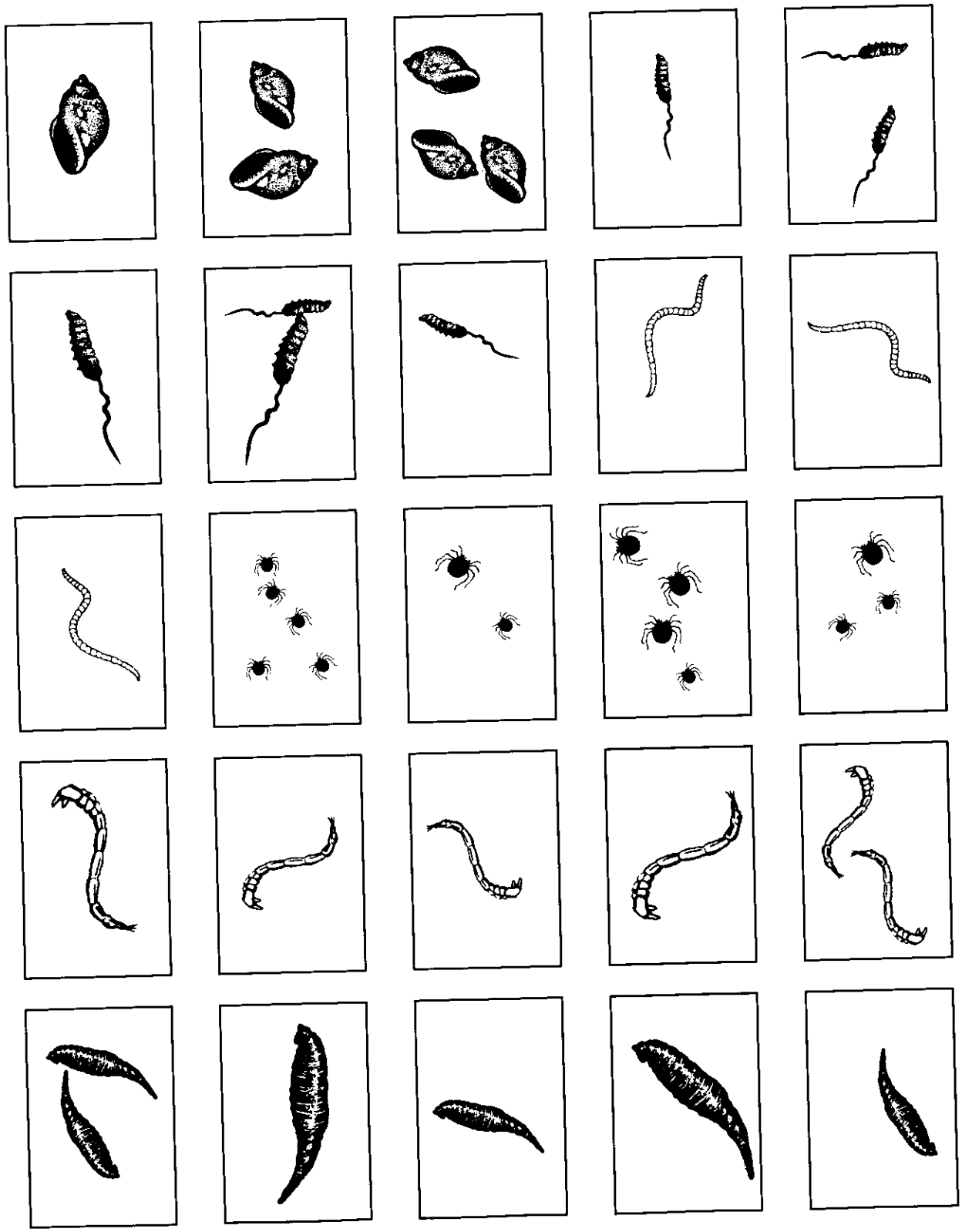
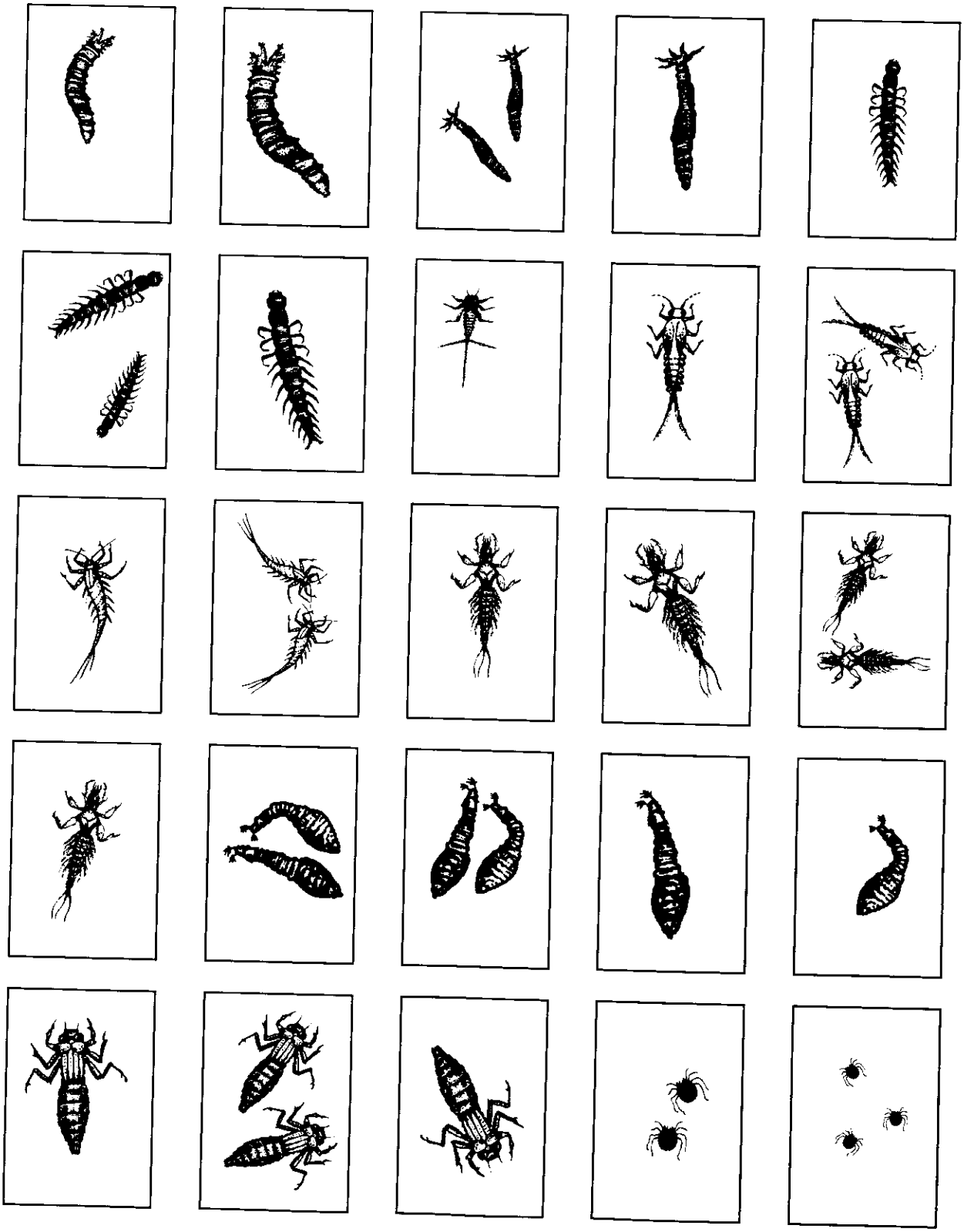


Figure 7F

STREAM SAMPLE **F**



POLLUTION TOLERANCE INDEX

TEAM MEMBER NAMES : _____

STREAM SAMPLE: _____

DIRECTIONS

1. Use the macroinvertebrate key to identify and classify the species in your stream sample.
2. On the Bio-monitoring Data Sheet, mark off each type of **species** that was found in your sample. (If there is one or more species for each order, add them together.)
   Example: If you identify two different types of mayflies, mark off "mayfly" on your sheet.
3. Multiply the number of species in each group by the index value (4, 3, 2, or 1)
   Example: # of species for Group 1 = (2) x Group 1's Index value of 4 = (8)
4. Add the final four numbers (one number for each Group) and divide by the total number of **species** found in your sample.
5. The Pollution Tolerance Index of this stream sample _____

Key: 4 = excellent quality 3 = good quality 2 = fair quality 1 = poor quality

FOR YOUR GROUP PRESENTATION:

1. Describe the process that the group used to assess your sample.

2. Which macroinvertebrates were the most common in your sample?

3. Which macroinvertebrates were the least common in your sample?

4. What physical characteristics do you think the macroinvertebrates would need to have to exist in a stream that exhibits similar water quality to your sample?

Pollution Tolerance Index (continued)

BIO-MONITORING DATA SHEET

Group 1 Check if present

Stonefly Nymph ❑
Mayfly Nymph ❑
Caddisfly Larva ❑
Dobsonfly Larva ❑
Riffle Beetle ❑
Water Penny ❑
Gilled Snail ❑
total number of species _____
multiply by the index value of 4.0 _____

Group 2 Check if present

Damselfly Nymph ❑
Dragonfly Nymph ❑
Aquatic Sowbug ❑
Scud ❑
Cranefly Larva ❑
Clam ❑
total number of species _____
multiply by the index value of 3.0 _____

Group 3 Check if present

Midge (except Blood Midge) ❑
Blackfly Larva ❑
Flatworm ❑
Leech ❑
Water Mite ❑
total number of species _____
multiply by the index value of 2.0 _____

Group 4 Check if present

Pouch Snail ❑
Tubifex Worm ❑
Blood Midge ❑
Rat-tailed Maggot Larva ❑
total number of species _____
multiply by the index value of 1.0 _____

Add the index values of each group together and divide by the total number of species in the sample:_____

POLLUTION TOLERANCE INDEX = _____

This index was developed by the Izaak Walton League of America (Save Our Streams) and the Ohio Department of Natural Resources (Citizen Stream Quality Monitoring Program), adapted by GREEN (Global Rivers Environmental Education Network) and uses illustrations developed by University of Wisconsin-Extension in cooperation with the Wisconsin Department of Natural Resources.

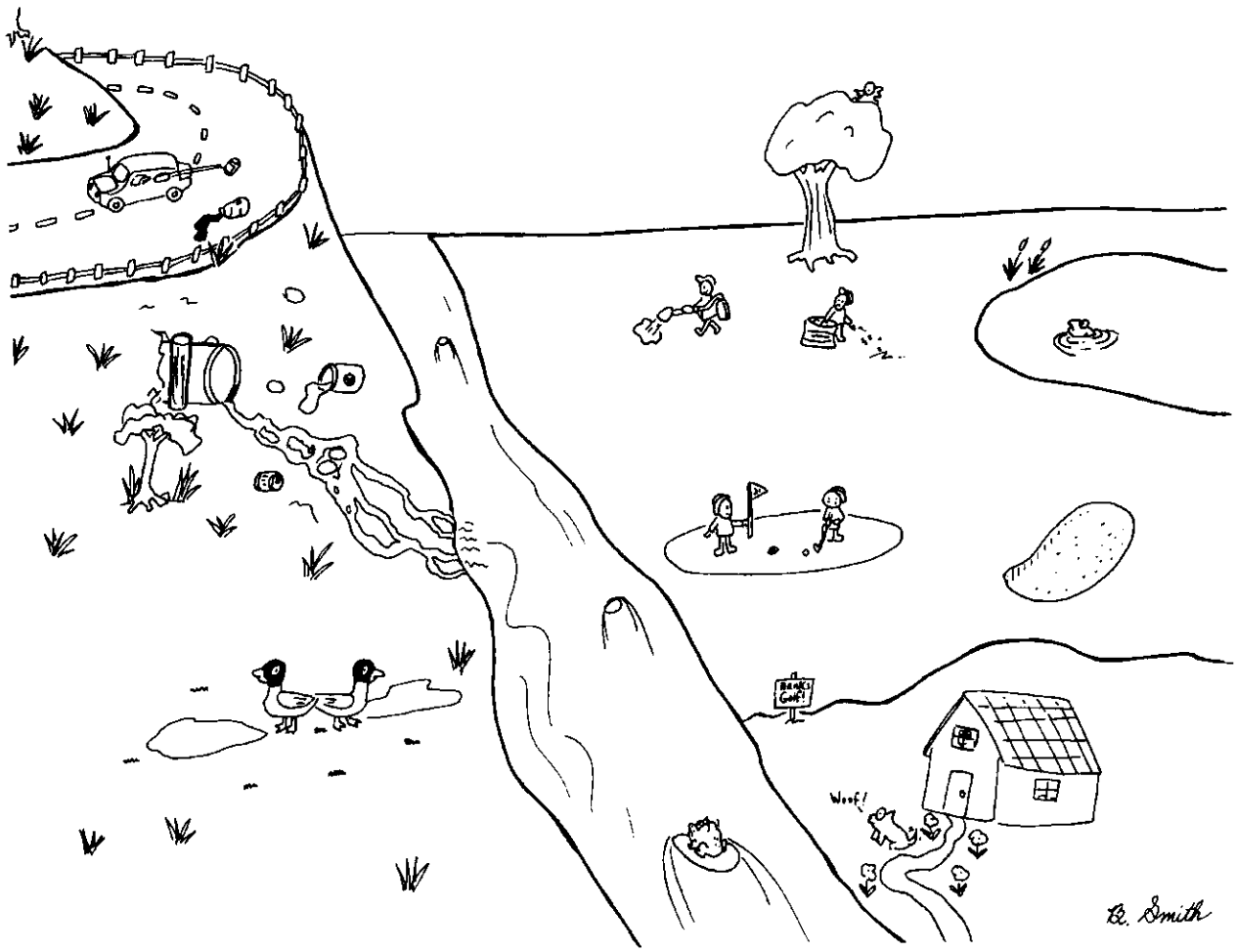
INS, OUTS, AND IN-BETWEENS

According to the New Jersey Department of Environmental Protection, "since Earth Day in 1970, the state's water resource protection efforts have concentrated on sewage treatment plants, industrial discharges and other major 'point' sources of pollution." The origin of point source pollution usually can be identified, controlled, and/or corrected. Many of our major waterways have become cleaner in the last 29 years because of efforts to reduce point source pollution.

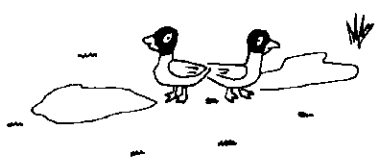
On the other hand, non-point source pollution (NPS) comes from scattered sources — sometimes NPS is called "people pollution" or "pointless pollution." Because NPS directly relates to human behaviors, adjustment of lifestyle can greatly reduce or eliminate these forms of pollution.

Some forms of NPS need to be addressed on a large scale with the cooperation of municipal, state, local, and nongovernmental organizations. For example, in some of our older cities and towns, stormwater and sewer overflow run through the same pipes. During a storm event, both storm water and untreated sewage may travel together into local waterways to create pollution problems. Many individuals, businesses, and industries store a variety of liquids in underground storage tanks. If these are not maintained properly and monitored a tank may leak heating oil or other products into the ground-water supply.

Many forms of NPS can be controlled by our own individual behaviors. People who own agricultural sites may choose to use less fertilizers and apply natural

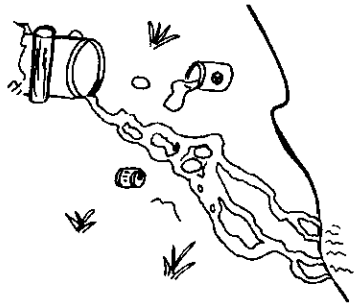


Ins, Outs, and In-Betweens



alternatives over pesticides when possible. Trees and native vegetation can be planted around waterways on farm fields and livestock pastures to reduce nutrient and sediment runoff into waterways. New Jersey is a leader in the nation for its number of horse farms, and many dairy farms and some cattle farms are scattered throughout the state as well. The waste from livestock, as well as from pets in suburban and urban communities, will wash into our waterways if not composted or disposed of as regular garbage or flushed into a water treatment system.

In residential areas lawns can be maintained with organic fertilizers. Grass mowed to a two-inch height requires less watering. The yard can be landscaped with native vegetation that is drought-resistant and requires little, if any, maintenance. Septic systems can be cared for properly and used only for sanitary waste. Many municipalities now have designated disposal areas for household chemicals, cooking grease, paint, and used motor oil. Regular vehicle maintenance greatly reduces the leakage of oil, gas, and antifreeze on driveways and roadways.



Commercial sites can participate in reducing non-point source pollution as well. Runoff from parking lots, sidewalks, and rooftops can be directed to grassy areas or retention ponds rather than to gutters and storm drains. The choice of landscape vegetation can help reduce NPS. Native vegetation that is drought resistant will reduce the amount of water needed to keep the plants alive during the summer months. These areas tend to trap litter, and when checked regularly, can help reduce the volume of litter drawn through storm drains.

TAKE A LOOK AT YOUR WATERSHED:

What forms of point source and non-point source pollution do you see in your watershed?

What behaviors do you see people exhibiting that could be altered and would help reduce the amount of non-point source pollution?

LESSON 8

Ins, Outs, and In-Betweens

GOAL To identify sources of point source and non-point source pollution and possible solutions to their causes.

TIME
- (2) 45-minute periods
- independent project time

OBJECTIVES Students will:
- ✔ explain the difference between point source and non-point sources of pollution
- ✔ relate how land use in their watershed affects water quality
- ✔ create a "pollution" maze
- ✔ offer suggestions for reducing both point source pollution and non-point source pollution

SKILLS organize, categorize, describe, infer, compare, evaluate, analyze, synthesize, justify

VOCABULARY
ground water
land use
non-point source pollution
point source pollution
pollutant
subwatershed
surface water
watershed

PRIOR KNOWLEDGE Students should have background in the following:
- how water flows through a watershed
- the differences between point source and non-point source pollution
- what types of land uses produce what types of pollution
- how to identify a watershed on a topographic map
- how to draw maps and create a symbol key

CORE CURRICULUM CONTENT STANDARDS
- Health & Phys. Ed. 2.1 (8,11,16,18)
- Language Arts 3.1 (14) 3.2 (8,11) 3.5 (12)
- Science 5.1 (4-7) 5.12 (4,5,6,9,10)
- Social Studies 6.7 (7,8) 6.9 (5,7,8)

MATERIALS
- ❑ 11x17 paper
- ❑ USGS map showing your subwatershed
- ❑ Land-use maps (from the town's planning board / zoning board)
- ❑ Markers or crayons

PREPARATION
1. Create a master map of your subwatershed on 11x17 paper to ensure that the distance scales on all the students' maps are the same. Trace its boundaries, major river/s, and major bodies of water from the appropriate USGS topographic map/s. (Appendix B).
2. Make one copy of this outline map for each student or pair of students.
3. Obtain a variety of other land-use maps (from the town's planning board or zoning board, county and town road maps, etc.).
4. If you do not have a USGS topographic map of your subwatershed available for each student or pair of students, duplicate the appropriate section/s for student use.

PROCEDURE

Period 1

1. Have the students generate a list of common pollutants.
2. Describe or illustrate examples of point source and non-point source pollution. Categorize the pollutants on the list into these two subheadings.
3. Distribute copies of the USGS maps and have the students delineate the subwatershed boundaries.
4. Distribute an outline map to each student or pair of students and compare it to the topographic map. Have the students identify and label the rivers and surface bodies of water. If the class is studying a river or estuary, determine the location of the headwaters and the mouth of the river and the direction of water flow. If the class is studying a lake or pond, locate its inflow and outflow.

Period 2

1. Have the students study the USGS maps (or other available maps) to locate and identify at least six potential land-use sites that that might contribute to surface water pollution. Refer back to the point source and non-point source pollution list. [*golf courses, construction sites, landfills, highways, sewage disposal plants, horse farms, orchards, oil refineries, etc.*]. Use the USGS Topographic Symbols pamphlet (listed in Appendix B) to help interpret symbols and colors.
2. Discuss how even though some of these may not be directly connected to a waterway that the pollutants can travel to the waterway during rainstorms and through ground water.
3. Have the students mark these six land-use sites on their maps.

Independent Project Time

1. Challenge the students to design and draw a maze that falls within the boundaries of the subwatershed. The maze must (a) begin at the point closest to the headwaters and end at the point closest to the river's mouth, and (b) connect all of their land use sites.
2. As part of the process, the students should identify the type of pollution that the land use generates by drawing a picture or using a symbol (which will need to be identified in a symbol key).

FURTHER DISCUSSION

1. What types of land use and processes produce point source pollution? What types of land use and behavior contribute to non-point source pollution?
2. Do you think it is easier to control point source or non-point source pollution? [*point source pollution because it originates in one place*]
3. How can the problem of non-point source pollution be addressed? [*altering human behaviors by finding natural alternatives to fertilizers and pesticides, recycling, maintaining septic tanks and other underground storage tanks, controlling construction runoff, landscaping yards to minimize runoff, replanting shorelines and stream banks, cleaning up after your pet, composting, disposing of hazardous household chemicals properly, maintaining cars and boats*]

ASSESSMENT

Make a copy of each maze map. Have each student exchange his/hers with another student in the class. Have the other person follow the maze and when they reach a land-use site, identify the pollution and offer a solution to reduce or eliminate the pollutant.

EXTENSION

For older students - Follow the same procedure but have them make the mazes for younger students. Have the older students teach the younger ones about point source and non-point pollution, then instruct the younger students to complete the mazes.

EMPOWERMENT CHALLENGE

- Choose the maze that offers the clearest and most comprehensive information. Submit it to the local paper for the general public to see.
- Have students implement some of their suggestions for reducing the different types of pollution through actual activities or a community awareness campaign. These can be accomplished through an independent study, extra credit, or through the school's environmental club.

LESSONS FROM OTHER SOURCES

Beneath the Shell - Where Water Meets Humans (background), Getting to the Source, Storm Drain Survey

Bridges to the Natural World - Go with the Flow, Riverside Drive

The Ways of the Watersheds - Nonpoint Source Pollution on Stage, One in a Billion

WOW! The Wonders of Wetlands - Recipe for Trouble

REFERENCES

New Jersey Department of Environmental Protection. 1991. *Beneath the Shell: A Teacher's Guide to Nonpoint Source Pollution and Its Potential Impact on New Jersey Shellfish.* Trenton, NJ: Office of Communications.

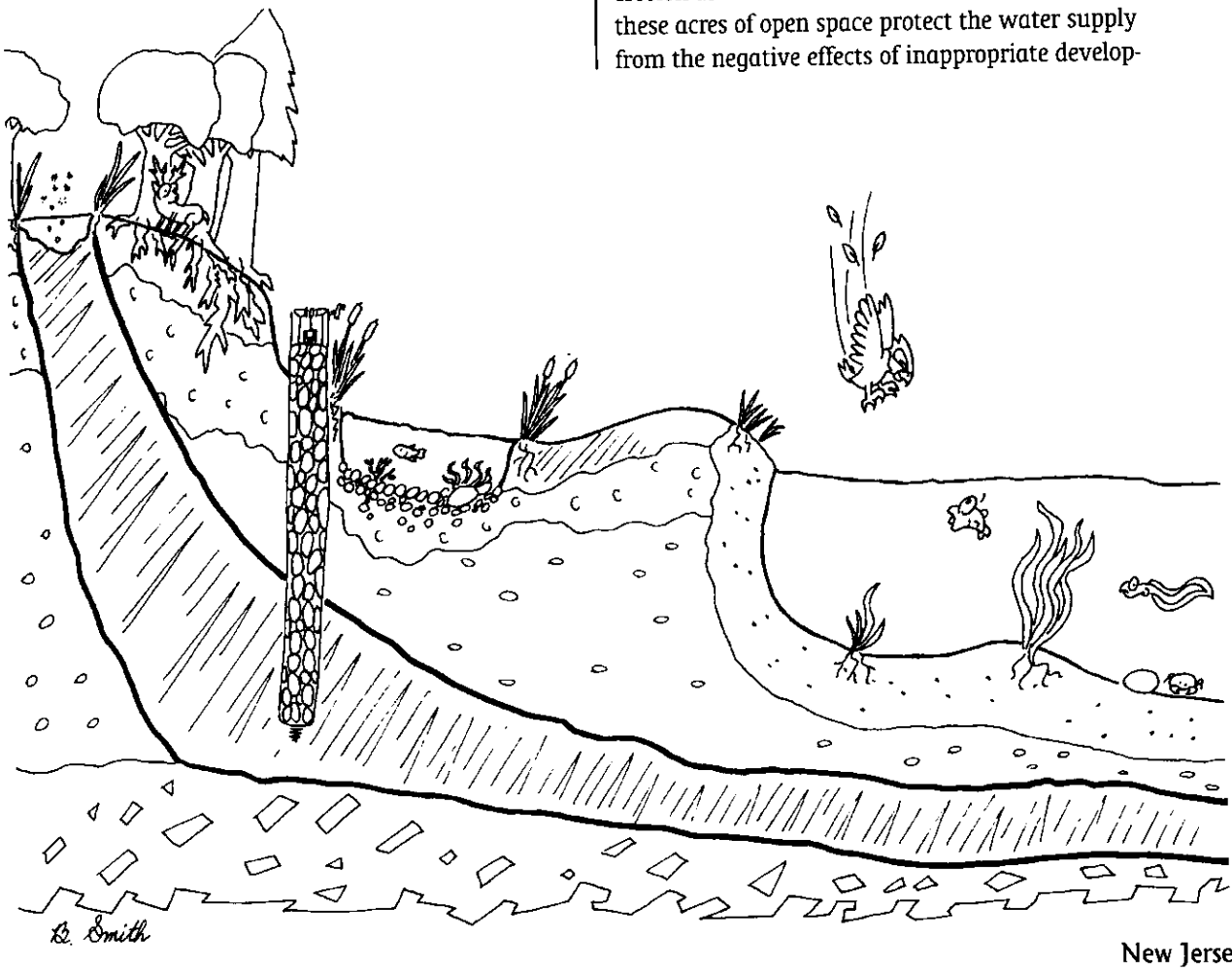
New Jersey Department of Environmental Protection. 1977. *The Clean Water Book: Lifestyle Choices for Water Resource Protection.* Trenton, NJ: Office of Environmental Planning.

New Jersey Department of Environmental Protection and Energy. 1993. U.S. Geologic Survey Water Data Report NJ-93-2 Ground Water Data. Trenton, NJ

ABOVE AND BELOW

There are two types of water supplies that provide drinking water to New Jersey residents: surface water and ground water. Surface waters are those water bodies that lay on the surface of the earth. They include rivers, streams, ponds, lakes, marshes, bogs, swamps, and reservoirs. About half of the people that live in New Jersey get their drinking water from these surface water supplies. Our state has numerous reservoirs and lakes that store water which is then pumped out, purified, and delivered, via pipes, to our homes and businesses. Some people get their water from our larger rivers including the Delaware, Passaic and Raritan Rivers. These waters, too, are treated according to state and federal regulations, then delivered to water supply companies for use. In New Jersey there are 13 major water supply reservoirs with a combined usable storage of approximately 80.3 billion gallons of water [USGS Water Data Report NJ - 93-2, 1993]

Surface water bodies are not isolated habitats; they are intricately intertwined with adjacent habitats like fields, marshes, agricultural lands, developed areas, and woodlands. The wooded borders along stream and river corridors provide shade over the waterway which helps to regulate the water's temperature while also providing habitat for resident and migratory animals including birds, amphibians, reptiles, and insects. Vegetation reduces runoff by allowing water to filter slowly through the soil and into plant roots. During this slow percolation, the soil filters out some pollutants and keeps them from entering the waterways, and plant roots hold soil in place preventing erosion and sedimentation. Termed a "buffer zone" these acres of open space protect the water supply from the negative effects of inappropriate develop-



Above and Below

ment (e.g., erosion, sedimentation, and runoff), pollution, and decreasing availability of the resource. The purpose of a buffer is to ensure that the river system and wetlands function properly, thus maintaining or enhancing water quality and quantity.

Ground water provides drinking water to the remaining 50 percent of the residents in our state and it occurs in either confined or unconfined aquifers. Unconfined aquifers are located directly below the surface of the earth and their water reservoir is replenished from precipitation. The Kirkwood-Cohansey aquifer of southern New Jersey is an example of an unconfined aquifer receiving its water directly from precipitation filtering down through the sandy soil of the Pinelands. Confined aquifers are sandwiched between two underground layers of impermeable rock or soil (such as clay). The water level of these aquifers is maintained as precipitation falls directly on their "recharge" areas. This recharge area is where the aquifer layer is exposed to water percolating down from the surface of the earth. The recharge area doesn't necessarily lie directly above the aquifer and actually can be located many miles away from where the underground aquifer is located. The area's soil type plays a critical role in determining where the recharge areas are located and their ability to sufficiently recharge groundwater supplies.

When a recharge area is covered with impervious surfaces (roads, parking lots, and buildings), it reduces the amount of water entering the ground-water supply. A chemical or oil spill on a recharge area may contaminate a well miles away from the source. It may also take years for the contaminant to show up because water moves slowly through the ground. Identifying recharge areas and preserving them as natural areas helps maintain the quality and quantity of ground-water supplies.

TAKE A LOOK AT YOUR WATERSHED:

Note any buffer zones in your community. Where are they located and what do they buffer?

What sites do you see that could be considered recharge areas?

LESSON 9

Above and Below

GOAL To understand how land use affects the quantity and quality of surface water and ground-water supplies.

TIME
- (2) 45-minute periods

OBJECTIVES Students will:
- ✔ design land use maps based on urban, suburban, and rural land-use percentages
- ✔ describe how different land uses relate to each other
- ✔ explain how buffer zones help maintain good water quality of surface water supplies
- ✔ explain how the undeveloped recharge areas help maintain good water quality in underground aquifers

SKILLS calculate, organize, apply, infer, synthesize, justify

VOCABULARY

buffer zone	impervious surface
confined aquifer	pervious surface
ground water	recharge area
ground-water table	surface water
impermeable layer	unconfined aquifer

PRIOR KNOWLEDGE Students should have background in:
- how to create maps
- the water cycle
- working with percentages
- the difference between surface water and ground-water supplies and how they are replenished
- types of non-point source pollution that are associated with various land-use types

CORE CURRICULUM CONTENT STANDARDS
- Cross Content Workplace Readiness 3 (2,8,9,11-15) 4 (2)
- Language Arts 3.1 (14,15) 3.2 (8-11) 3.5 (8)
- Math 4.1 (11,13) 4.2 (9) 4.6 (14) 4.8 (11)
- Science 5.1 (4,5,6) 5.5 (15) 5.10 (10,14) 5.12 (4,5,6,9,10)
- Social Studies 6.6 (10,16) 6.9 (5,7)

MATERIALS
- ❑ Surface Water worksheet (Student Page #15)
- ❑ Ground Water worksheet (Student Page #16)
- ❑ Land-Use Percentage Cards (Figure 9A)
- ❑ Crayons or colored pencils

PREPARATION
1. Make enough copies of the Surface Water worksheet (Student Page #15) for half of the class and enough copies of the Ground Water worksheet (Student Page #16) for the other half of the class.
2. Prepare two sets of the Land-Use Percentage Cards (Figure 9A).

PROCEDURE

Period 1

1. Divide the class into two sections (one will work on the ground-water scenarios, one will work on the surface water scenarios).
2. Distribute the groundwater worksheets (Student Page #15) to the students in Section 1 and the surface water worksheets (Student Page #16) to the students in Section 2.
3. Review the definition of surface water and ground water by drawing a diagram of each on the chalkboard.
4. Divide each section into three subgroups (A, B, and C).
5. Distribute the appropriate Land-Use Percentage card (A, B, or C) and a set of crayons or colored pencils to each group.
6. Tell each group that they represent the planning boards of different communities. Discuss what a planning board does. On the chalkboard, write the following steps for the students to follow: (a) map the existing land use in the community based on the information on the Land-Use Percentage card; (b) assess how that land use might impact on water quality; (c) make recommendations for improving and / or maintaining current water quality.

Period 2

Have the students in each group discuss and answer the questions on each worksheet then summarize their findings to present to the rest of the class.

FURTHER DISCUSSION

1. How do you think each community in the watershed (urban / suburban / rural) could create and / or maintain buffer zones? [*Urban - reclaim stream side corridors, plant vegetation along stream banks and surface water bodies; suburban - purchase land along river and stream corridors, plant vegetation, encourage homeowners to landscape their properties to decrease surface runoff; rural - protect headwaters of streams and rivers by purchasing land along these waterways, create wooded corridors along agricultural fields*]
2. What actions could be taken to maintain and / or enhance the quantity and quality of groundater in each community of the watershed? [*Urban - direct runoff to retention basins, create a mosaic of open space within the urban setting; suburban - direct runoff from parking lots to retention basins filled with vegetation, direct roof runoff to yards or lawns rather than to gutters and storm drains; diversify types of vegetation in open space area for more water filtration, identify and maintain open space over recharge areas*]

ASSESSMENT

Have each student select and redo one of the maps based on their new knowledge of buffer zones and recharge areas. Have the students evaluate each others' maps to determine which maps represent the best placement of land use while also maintaining the quality and quantity of both ground-water and surface water supplies.

EXTENSION

Have the students determine the soil type of their school or community and assess its ability to recharge ground-water supplies.

EMPOWERMENT CHALLENGE

- Do a visual assessment of the community's surface waters to determine which (if any) could benefit from buffers.
- Participate with local watershed associations in stream side revegetation projects or other projects in which they are involved.

LESSONS FROM OTHER SOURCES

WOW! The Wonders of the Wetlands - Water Under Foot, How Thirsty is the Ground, Over Hill & Dale

Project WET - Get the Groundwater Picture; Capture, Store & Release

REFERENCE

Center for Watershed Protection. 1998. *Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds.* Ellicott City, MD.

Figure 9A
LAND USE PERCENTAGE CARDS

LAND USE PERCENTAGES A

COLOR	LAND-USE	% OF COVER
Black	Transportation corridors (at least 1 block wide)	15
Orange	Business / commercial	30
Gray	Parking lots	10
Red	Residential (high density homes / apartments)	25
Dark Green	Park (recreation fields)	5
Purple	Industrial sites	10
White	Landfill	5

LAND USE PERCENTAGES B

COLOR	LAND-USE	% OF COVER
Black	Transportation corridors (at least 1 block wide)	20
Red	Residential (single family homes)	35
Orange	Business / commercial (office buildings / shopping malls)	20
Dark Green	Park (recreation fields, golf course)	10
Gray	Parking lots	10
Light Green	Open space	5

LAND USE PERCENTAGES C

COLOR	LAND-USE	% OF COVER
Black	Transportation corridors (at least 1 block wide)	10
Red	Residential (scattered single family homes)	20
Orange	Business / commercial	15
Yellow	Agricultural lands	30
Light Green	Open space	25

SUGGESTED ANSWERS FOR WORKSHEETS

(For Teacher Use)

1. Determine which group represented urban (A), suburban (B), and rural (C) communities. [*Compare the percent of built-up spaces (roads, parking lots, commercial/business/industrial sites) vs. open space.*]

2. Some land uses and the types of pollution they might generate. [***roads*** *- oil and gasoline spills, heavy metals left on the road from vehicle brake linings, air pollution that comes back to earth with rain/snow;* ***business/commercial*** *- impervious surfaces cause greater volume and speed of runoff;* ***parking lots*** *- litter, oil/gasoline/anti-freeze spills, impervious surfaces create more runoff;* ***residential*** *- impervious surfaces from roofs, driveways and parking lots, fertilizers and pesticides on lawns, animal waste, improper disposal of household materials;* ***parks*** *- fertilizers (if used);* ***industrial sites*** *- impervious surfaces, parking lots, potential for improper disposal of by-products, possible air pollution;* ***landfills*** *- litter, leachate;* ***agricultural lands*** *- fertilizers, pesticides, sedimentation*]

3. What are the benefits / drawbacks to buffer zones? [*If the zone around the surface water is vegetated, it is referred to as a "buffer zone." It buffers the amount of water entering a waterway; it slows the velocity of water entering a waterway; it tempers the amount and concentration of pollutants entering the waterway. Vegetated buffer zones lessen the amount of pollution entering the waterway; tree, shrub and ground cover roots hold soil in place which prevents erosion and sediments entering the waterway; they allow precipitation to filter through the soil slowly and recharge ground-water supplies as well as prevent flooding to surface water supplies. Treed buffer zones block people's view of the waterway and they limit the amount of acreage upon which people can build.*]

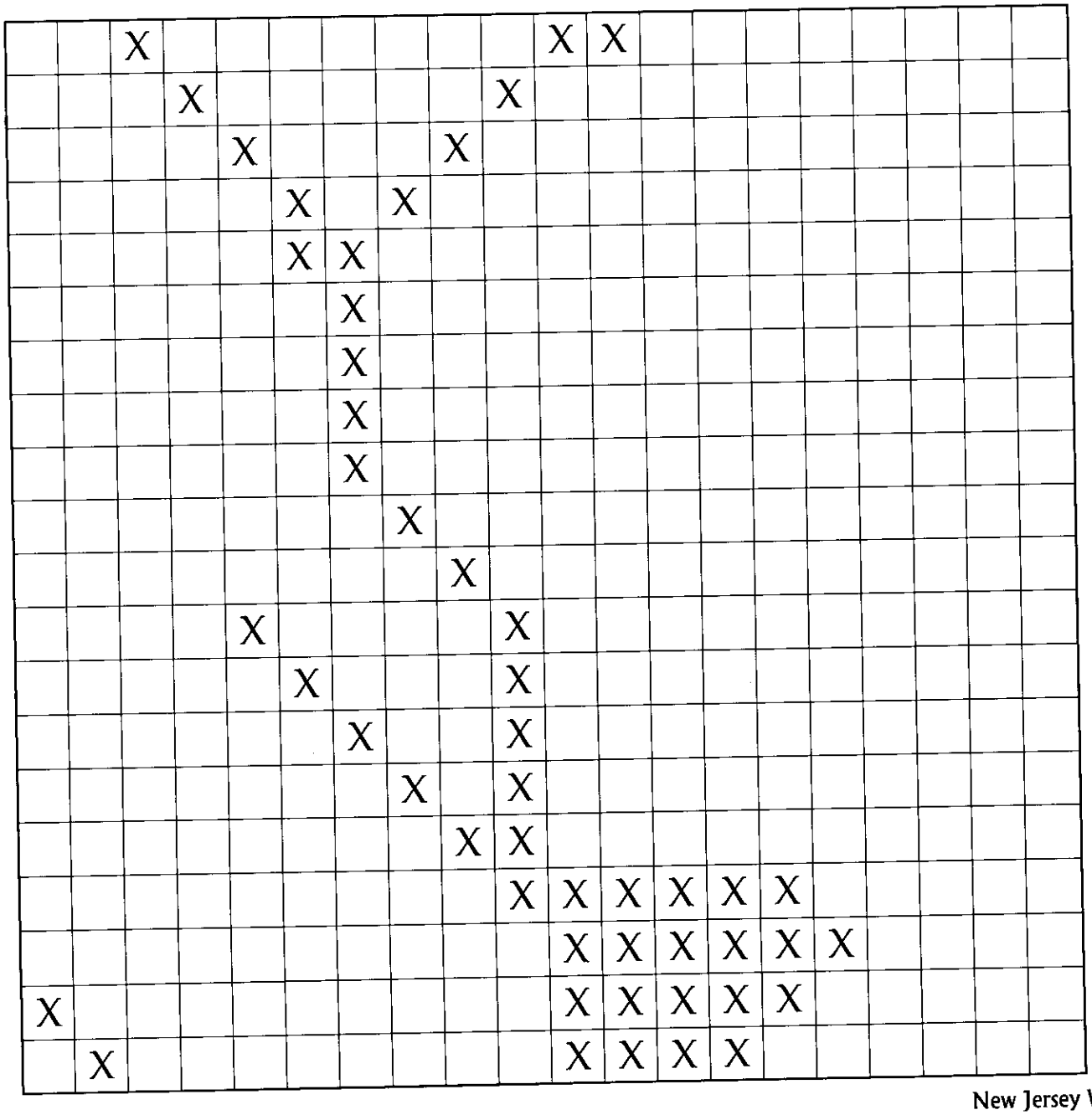
4. What are the benefits / drawbacks to recharge areas? [*Recharge areas that have predominantly open space allow for the slow filtration of water into the ground. This process also cleanses some of the impurities out of the water before it reaches the aquifer. Protecting entire recharge areas ensures the greatest amount of water will be available for human use, but it also allows for the dilution of dissolved solids, ensuring high water quality Since recharge areas are often not directly above the aquifer, it requires that planners from neighboring communities, counties, and states work with each other in designating recharge areas. Example: Since underground water often travels along rock bedding planes, if those planes are tilted, the recharge area for a community's aquifer may very well be tens or hundreds of miles away from the drill site.*]

NAME: DATE:

SURFACE-WATER SUPPLIES

DIRECTIONS:

1. Color all the "x" boxes on the worksheet blue. This represents the amount of surface water in your watershed.
2. Convert the land-use percentages on your card to the number of boxes they equal.
   Note: 12.5% of the total area has been used with the 50 boxes that represent the surface water supply.
3. Decide as a group how to arrange the land-use on the grid.
4. Fill in the grid boxes with the color that represents the specific land-use type. Create a color key for interpretation.



NAME: DATE:

SURFACE-WATER SUPPLIES

1. Each group represents an urban, a suburban, or a rural community. Which of these do you think your group represents? Why?

2. List your land uses and the types of pollution that each of these land-uses might generate.

3. Which of these land-uses represent impervious surfaces (where water runs off quickly) and which represent pervious surfaces (where water slowly filters down into the soil)?

   Impervious surfaces

   Pervious surfaces

4. A "buffer zone" is an area of undeveloped land surrounding a wetland. It helps protect the water from degradation. Describe the areas on your community map that could benefit from buffer zones.

5. Draw a thick line (one box out) around your entire grid's surface water. The land-use in this zone is critical to protecting water quality. Which land-uses (impervious or pervious surfaces) do you think would be the best to have in this zone? Why?

STUDENT PAGE 16

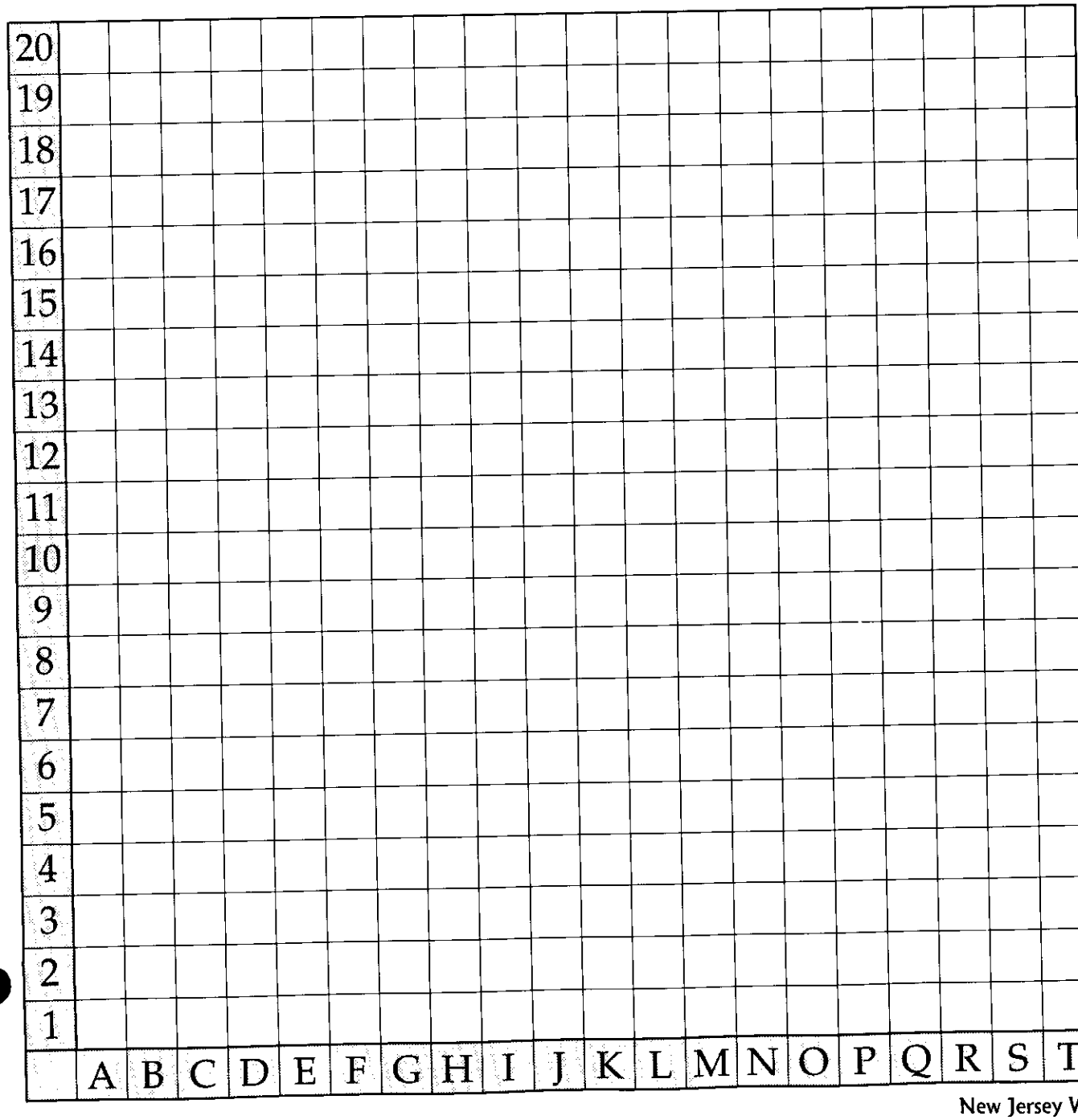
LESSON 9

NAME: DATE:

GROUND-WATER SUPPLIES

DIRECTIONS:

1. Convert the land-use percentages on your card to the number of boxes they equal.
2. Decide as a group how to arrange the land use on the grid.
3. Fill in the grid boxes with the color that represents the specific land use type. Create a color key for interpretation.



NAME: DATE:

GROUND-WATER SUPPLIES

1. Each group represents an urban, a suburban, or a rural community. Which of these do you think your group represents? Why?

2. List your land uses and the types of pollution that each of these land uses might generate.

3. Which of these land uses represent impervious surfaces (where water runs off quickly) and which represent pervious surfaces (where water slowly filters down into the soil)?

   Impervious surfaces

   Pervious surfaces

4. Block out the following coordinates on your grid.

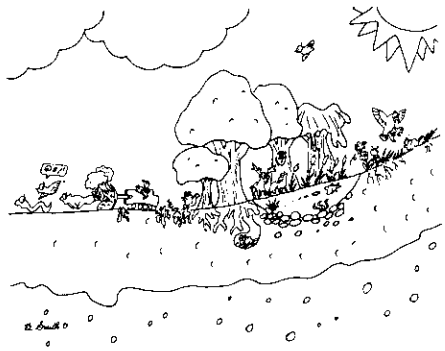
1 L-P	5 J-N	9 H-L	13 F-J	17 D-G
2 K-O	6 I-M	10 G-K	14 E-I	18 D-G
3 K-O	7 I-M	11 G-K	15 E-I	19 D-G
4 J-N	8 H-L	12 F-J	16 D-G	20 D-G

5. This blocked out section is called a "recharge area." It is where the earth's surface is linked to ground-water supplies. Which surface (impervious or pervious) do you think would be the best to have in this area? Why?

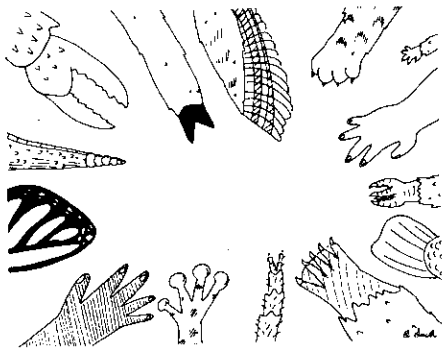
Activities
A SENSE OF CONNECTION

"All things by immortal power
Near and far
Hiddenly
To each other linked are
That thou canst not stir a flower
Without troubling a star"

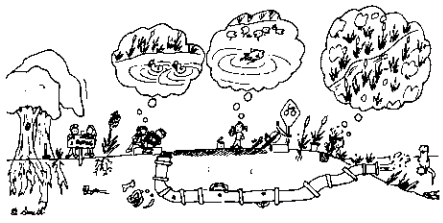
— Francis Thompson



A Perspective on Connections



Come to Consensus



A Community Watershed

A SENSE OF CONNECTION
NJ Core Curriculum Content Standards

A Perspective on Connections	How does the connection between biotic and abiotic factors help us understand more about a watershed? page **181**
Workplace Readiness	**3** (8-10,12) **4** (2,10)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15) **3.2** (8-11) **3.4** (17,19,21,22,24,28,30,31,32)
Mathematics	**4.1** (12)
Science	**5.1** (4-7,9) **5.6** (11,17) **5.12** (7,8)
Social Studies	**6.2** (10,11) **6.9** (6-8)

Come to Consensus	How do stakeholders become involved in resolving a watersehd issue? page **193**
Workplace Readiness	**2** (5-9) **3** (1-5,8,10-15) **4** (1,2,7,9,10)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14,15,16,20) **3.2** (8-11,12) **3.4** (19,25,31) **3.5** (12-14)
Mathematics	
Science	**5**.12 (9,10)
Social Studies	**6.1** (6,7,11-13,14) **6.6** (9,10,16) **6.9** (6)

A Community Watershed	How can one affect change through awareness and education? page **199**
Workplace Readiness	**1**(12) **2** (2,5-9) **3** (1-5, 10-15) **4** (1-5,9,10)
Arts (Visual and Performing)	
Comprehensive Health and Phys. Ed.	
Language Arts	**3.1** (14-16,18) **3.2** (8,9,11,13) **3.3** (14-17) **3.4** (25) **3.5** (13,14)
Mathematics	**4.4** (8,10) **4.10** (8)
Science	**5.1** (4,5) **5.2** (10-15) **5.4** (9,11) **5.12** (6,9,10)
Social Studies	**6.1** (7,9,12,13,14) **6.4** (7,10) **6.5** (8)

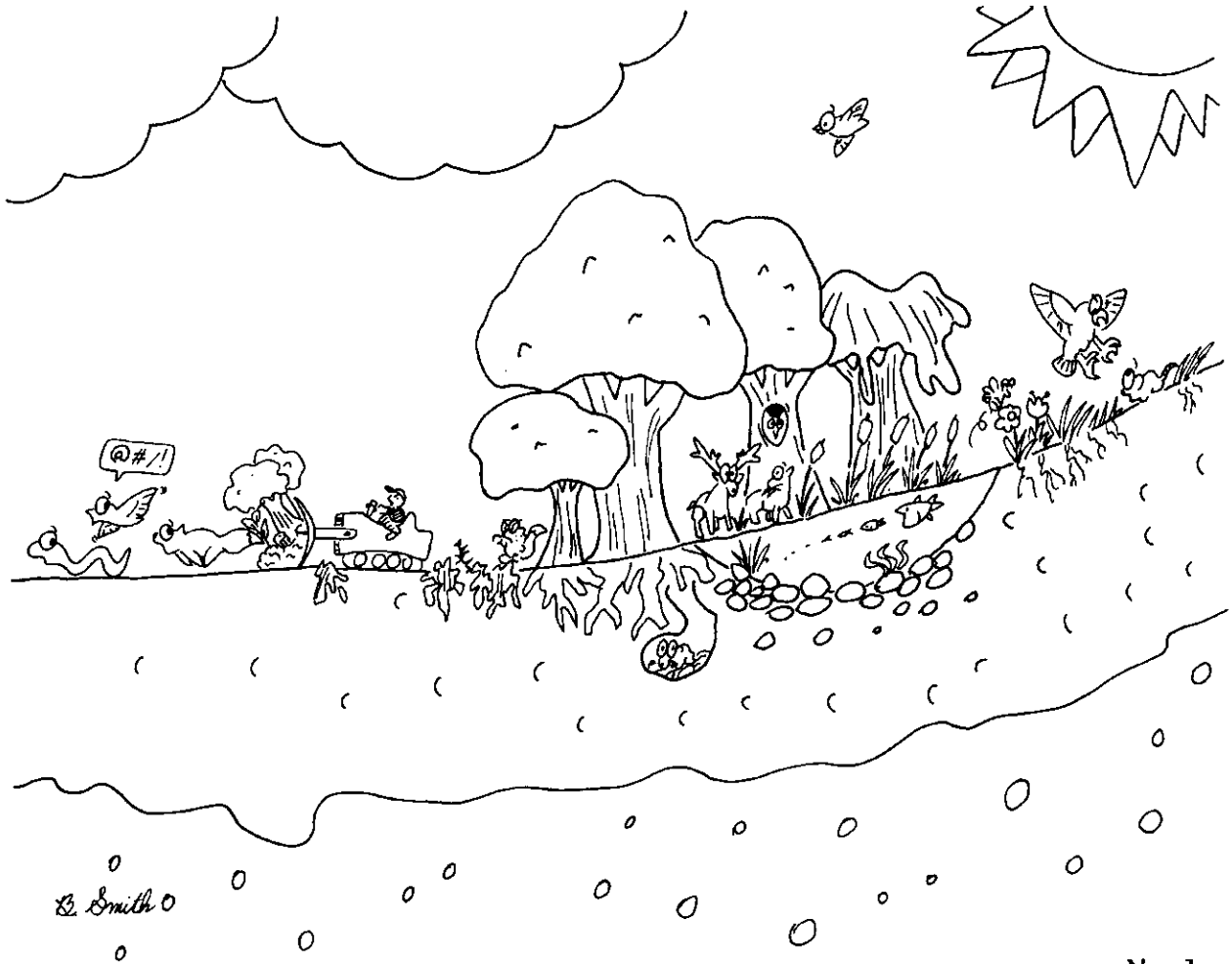
Bold Numbers = Standards (Light Numbers in Brackets) = Indicators

A PERSPECTIVE ON CONNECTIONS

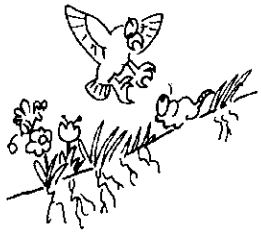
The biotic community and its abiotic environment function as a system and the manner in which they occur sets the stage for a diverse world. Within an ecosystem each biological component fills a certain niche. That is, each species does a specific job unique to that species. For example, beavers fell trees, build dams and lodges, that, in the process, change water flow patterns; turkey vultures scavenge for carrion along roadsides which helps to manage road kills, and the milkweed leaves eaten by monarch caterpillars make those butterflies distasteful to predators. Animals and plants can be defined by their niche much the same way a person is defined by personality or profession.

Food, water, shelter, and space are limited commodities which support a set number of organisms. Therefore, there is a certain amount of competition for these habitat resources. Failure to acquire these life needs may result in a species death or the inability to reproduce which is, in essence, a genetic death.

Biotic organisms exhibit various relationships and connections. The basic way all living things are connected is through food. All living things must eat or produce



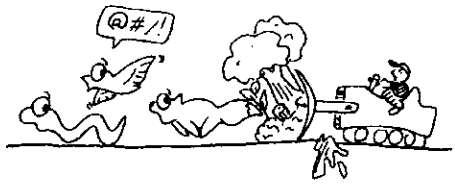
A Perspective on Connections



food. Some organisms are the eaters and others are the eaten. Predator/prey relationships are a study in balance. Besides food connections, two species can be a part of a symbiotic relationship where the organisms exist closely and one or both benefits from the association. Mutualistic relationships exist when benefits are gained by all species involved. Saprophytic relationships occur when one participant benefits with no cost to the other and parasites benefit while harming their host. Other creatures or plants may live on another organism as an epiphyte, while still others rely on organisms for transporting them from one place to another (barnacles on a whale).

Abiotic factors also create and/or affect natural connections. The amount of rainfall, the intensity of wind and sunlight, air and water temperature — all have effects on organisms that inhabit the earth's ecosystems. Many of these natural phenomena affect only local and regional systems although substantial alterations of the system may ripple out to encompass larger areas including watersheds and drainage basin systems.

Humans are intricately woven into these systems and human behaviors can affect the environment on a global scale. Scientists cite deforestation as a reason for increased levels of carbon dioxide in the atmosphere, and forest fragmentation from development is a reason why brown headed cowbirds can penetrate into the forest deeper and lay their eggs in the nests of migrant songbirds, thus decreasing their number of offspring.



All of these interrelationships make up the dynamic systems that support and determine life on the planet. Nothing works in isolation.

LESSON 10

A Perspective on Connections

GOAL To discover how connections between natural and human communities are portrayed in natural history literature and how these connections apply to the study of the watershed.

TIME
- (3) 45-minute periods
- independent reading time

OBJECTIVES Students will:
- ✔ read natural history literature to identify biotic and abiotic interdependencies
- ✔ identify and describe connections within an ecosystem
- ✔ identify which of these connections relate to the human community
- ✔ relate how these connections further the understanding of "watershed"

SKILLS identify, analyze, compare, synthesize, justify

VOCABULARY
abiotic
biotic
interdependency
niche

PRIOR KNOWLEDGE Students should have background in:
- the workings of the water cycle
- the basics of a watershed system
- an understanding of biotic and abiotic relationships

MATERIALS
- ❑ Sample Literary excerpt (Figure 10A)
- ❑ Literary excerpts (Figures 10D - 10G) or a book selected from the Reference section of this lesson.

PREPARATION
1. Make one copy of Figure 10A for each student.
2. Choose an additional literary excerpt from the samples (Figures 10D through 10G and make one copy of that selection for each student).
   Option: Choose a book from the Reference section for this lesson for the students to read.

CORE CURRICULUM CONTENT STANDARDS
- Cross Content Workplace Readiness 3 (8-10,12) 4 (2,10)
- Language Arts 3.1 (14,15) 3.2 (8-11) 3.4 (17,19,21,22,24,28,30,31,32)
- Math 4.1 (12)
- Science 5.1 (4-7,9) 5.6 (11,17) 5.12 (7,8)
- Social Studies 6.2 (10,11) 6.9 (6-8)

PROCEDURE

Period 1

1. Review the definitions of biotic and abiotic.
2. Read Figure 10A (or the first chapter of the selected book) as a class with the intent of identifying biotic and abiotic factors.
3. Discuss with the students what natural history connections are and compile a list of those connections in the selection. (See Figure 10B)
4. Demonstrate how these connections and interdependencies can be illustrated through a flow chart, web map, or Venn diagram. (Figure 10C)
5. Distribute the second selection to each student.
6. Have each student read the excerpt (as homework or independent reading time). Ask them to create a list of the biotic and abiotic connections they identify.

Period 2

1. Divide the class into smaller groups.
2. Have each group come up with their "Top 10" connections based on their individual lists. In addition, have them create a visual form that represents the connections (using a flow chart, web map, etc.)
3. Have each group present their information to the class along with their justification of the connections and how these biotic and abiotic factors relate to the watershed.

Period 3

1. Display each group's visual form on a bulletin board. Using push pins and string expand the connections between charts.
2. Discuss the points where people fit into these connections. Mark each strand that involves humans with colored tape or ribbon.
3. Discuss how these connections fit in with the concept of "watershed" [*everything lives in a watershed, specific actions have direct / indirect consequences on other aspects of the environment*]

FURTHER DISCUSSION

1. How did the author use language to persuade the reader of his / her position?
2. What point was the author trying to make?
3. Why do people write about nature?
4. What impact can people have on individuals and society by writing about nature?

ASSESSMENT

Provide the students with an outdoor experience on the school grounds or during a field trip. Have the students write a literary piece based on their impressions of the habitat. Have them focus on the biotic and abiotic factors and their connections with the watershed.

EXTENSION

Have the students select one part of a connection and write this on a card (e.g., sun, tree, soil, fire, caterpillar, etc.). Designate a student (or the teacher) to pass the ball of string from student to student as they create connections. Have each student read aloud his / her connection, identify another student whose element card connects with theirs and pass the yarn to that student. Continue until all students are connected.

EMPOWERMENT CHALLENGE

Do a schoolyard inventory of the natural and built environment. Have the students identify and list what they find and begin making connections to how these work within the watershed.

LESSONS FROM OTHER SOURCES

Aquatic Project WILD - Blue Ribbon Niche

Bridges to the Natural World - The Eco-Connection

Project Learning Tree - Field Forest, and Stream

Project WET - Dust Bowls and Failed Levees

Project WILD - Carrying Capacity

Sourcebook for Watershed Education - Teaching Flood Literature, Journal Writing: Henry David Thoreau, 1817-1862, Literature and Journal Writing Activity

WOW! The Wonders of Wetlands - Marsh Market

REFERENCES

Control of Nature - John McPhee

Encounters with the Archdruid - John McPhee

Fields of Sun and Grass: An Artist's Journal of the New Jersey Meadowlands - John Quinn

Ishmael - Daniel Quinn

An Island Out of Time - Tom Horton

The Kingbird Highway - Kenn Kaufman

Last of the Curlews - Fred Beston

Life and Death of a Salt Marsh - John and Mildred Teal

The Meadowlands: Wilderness Adventures at the Edge of a City - Robert Sullivan

A Naturalist Along the Jersey Shore - Joanna Burger

Never Cry Wolf - Farley Mowatt

The Night Country - Loren Eiseley

Noah's Garden - Sara Stein

The Outermost House - Henry Beston

The Pine Barrens - John McPhee

A Sand County Almanac - Aldo Leopold

The Sea Around Us - Rachel Carson

Silent Spring - Rachel Carson

Wanderings - Ken Weber

Wild America - Roger Tory Peterson and James Fisher

Wildlife in America - Peter Matthiessen

The Wind Masters - Peter Dunne

NOTES

Figure 10A

The Pine Barrens

"Fire in the pines is never spontaneous, and lightning sets only about one per cent. There is an area in the northeastern part of the woods where most of the lightning fires begin, probably because there is a concentration of iron deposits there. It is supposed that the Chatsworth Fire started when a cigarette was tossed away by one of a group of woodcutters who were clearing the cedar swamp where the fire began. Carelessness is the cause of many fires, but not to the overwhelming extent that one might imagine. A remarkably common cause of fire in the pines is arson. Standing in all that dry sand, the forests glisten with oils and resins that – to some people – seem to beg for flame. Oak leaves in forests that are damp and rich are different from Pine Barrens oak leaves, which have so much protective oil concentrated within them that they appear to be made of shining green leather. The ground soaks up rainfall so efficiently that the litter on its surface is, more often than not, as dry as paper. In the sand soil, there are no earthworms and few bacteria to consume the litter, and it piles up three and four inches deep....

"Of all the natural phenomena of the Pine Barrens, the most startling one is the speed with which the vegetation comes back from fire. There has been so much fire in the pines for so many centuries that, through the resulting processes of natural selection, the species that grow there are not only highly flammable but are able to tolerate fire and come back quickly. There are only three kinds of pines in the United States that respond to fires by putting forth sprouts. Two of these – the pitch pine and the short-leaf pine predominate in the Pine Barrens. (The other, the Chihuahua Pine, grows in New Mexico.) The sprouts develop from dormant buds in the trunks and larger limbs, and soon after the fire dies down, out they come. All over the woods are pine trees with splendid green crowns and trunks that are still black from old fires. Oaks that are burned usually die at the top, but they re-shoot from the roots....

"It is because of fire that pines are predominant in the Pine Barrens. There is thought to be a progression in the development of any forest from pioneer species to climax trees. Most ecologists agree that if fire were kept out of the Pine Barrens altogether, the woods would eventually be dominated by a climax of black oaks, white oaks, chestnut oaks, scarlet oaks, and a lesser portion of hickories and red maples. In some areas, oaks dominate now. Fire, however, has generally stopped the march of natural progression, and the resulting situation is one that might be called biological inertia – apparently endless cycles of fire and sprouting. Fire favors the pine trees because they have thick bark that provides insulation from high temperatures, and also because burned ground is just about perfect for pine seedbeds. Oaks lose vigor when they are repeatedly burned".

Figure 10B (Teacher's Version)

Underlined words and phrases give examples of biotic and abiotic connections.
Words or phrases in italics give examples of human connections through behavior.

The Pine Barrens

"Fire in the pines is never spontaneous, and lightning sets only about one per cent. There is an area in the northeastern part of the woods where most of the lightning fires begin, probably because there is a concentration of iron deposits there. It is supposed that *the Chatsworth Fire started when a cigarette was tossed away by one of a group of woodcutters who were clearing the cedar swamp where the fire began.* Carelessness is the cause of many fires, but not to the overwhelming extent that one might imagine. *A remarkably common cause of fire in the pines is arson.* Standing in all that dry sand, the forests glisten with oils and resins that – to some people – seem to beg for flame. Oak leaves in forests that are damp and rich are different from Pine Barrens oak leaves, which have so much protective oil concentrated within them that they appear to be made of shining green leather. The ground soaks up rainfall so efficiently that the litter on its surface is, more often than not, as dry as paper. In the sand soil, there are no earthworms and few bacteria to consume the litter, and it piles up three and four inches deep....

"Of all the natural phenomena of the Pine Barrens, the most startling one is the speed with which the vegetation comes back from fire. There has been so much fire in the pines for so many centuries that, through the resulting processes of natural selection, the species that grow there are not only highly flammable but are able to tolerate fire and come back quickly. There are only three kinds of pines in the United States that respond to fires by putting forth sprouts. Two of these – the pitch pine and the short-leaf pine predominate in the Pine Barrens. (The other, the Chihuahua Pine, grows in New Mexico.) The sprouts develop from dormant buds in the trunks and larger limbs, and soon after the fire dies down, out they come. All over the woods are pine trees with splendid green crowns and trunks that are still black from old fires. Oaks that are burned usually die at the top, but they re-shoot from the roots....

"It is because of fire that pines are predominant in the Pine Barrens. There is thought to be a progression in the development of any forest from pioneer species to climax trees. Most ecologists agree that if fire were kept out of the Pine Barrens altogether, the woods would eventually be dominated by a climax of black oaks, white oaks, chestnut oaks, scarlet oaks, and a lesser portion of hickories and red maples. In some areas, oaks dominate now. Fire, however, has generally stopped the march of natural progression, and the resulting situation is one that might be called biological inertia – apparently endless cycles of fire and sprouting. Fire favors the pine trees because they have thick bark that provides insulation from high temperatures, and also because burned ground is just about perfect for pine seedbeds. Oaks lose vigor when they are repeatedly burned."

Figure 10C - SAMPLE STORY MAP

The Pine Barrens

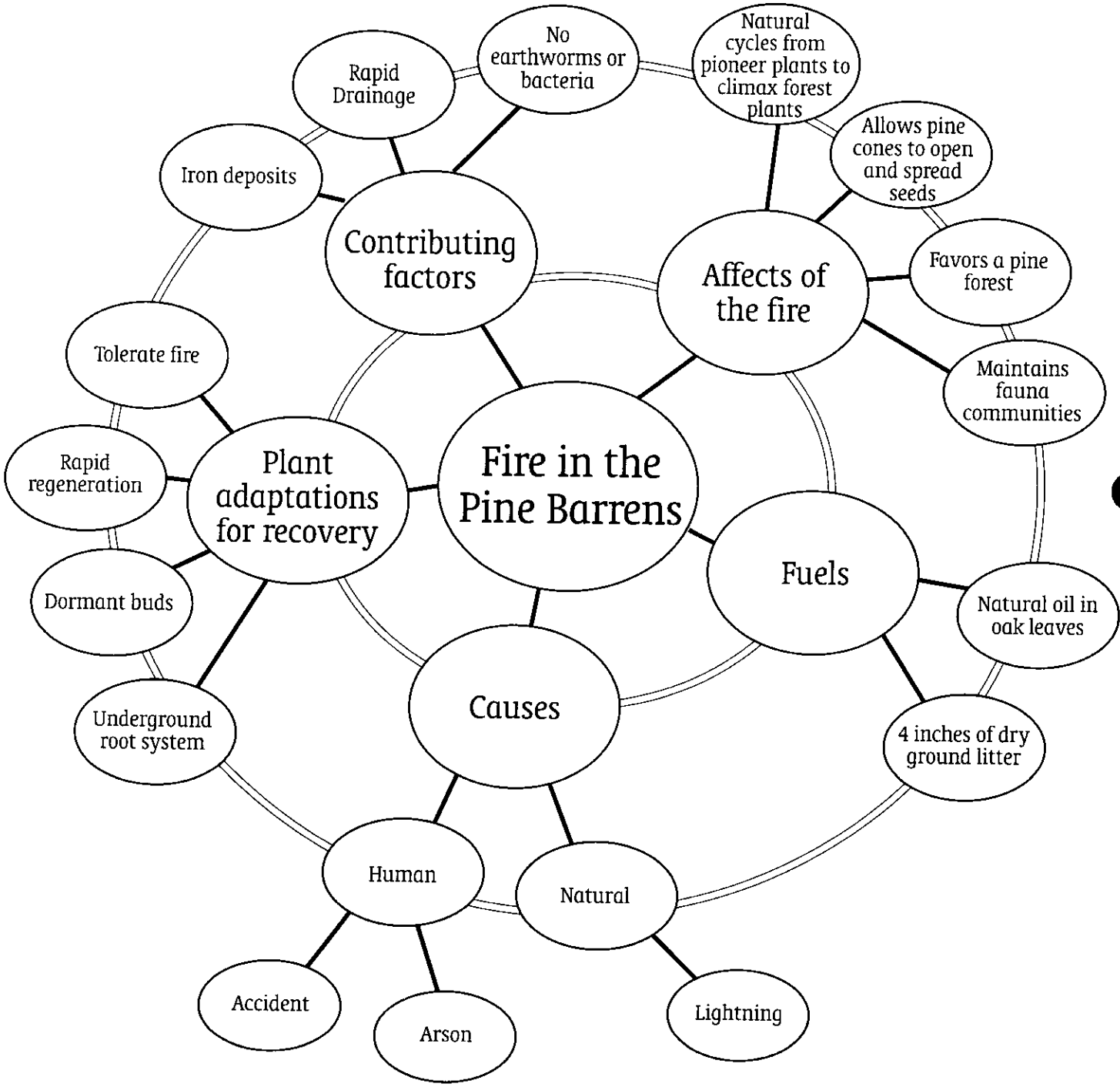


Figure 10D

Swallow Clouds

"That night the tail end of a hurricane that had headed inland through the Carolinas reached Cape May. We watched the seething white tumult of the surf from an upper room in an old inn facing the sea. All that wild and windy night the rain and spray, the flying foam and driven sand whipped and battered the windowpanes....

"By morning the storm had largely spent itself. The surf was high but the clouds were breaking. September, a month that along the Middle Atlantic States has fewer days of rain than June, July or August, was reverting to normal. After a quick breakfast in a restaurant where the waitress asked us if we wanted 'white or tan bread' we wandered down the side roads of a dripping landscape, into a day of swallow clouds.

"By July, each year, the white-breasted tree swallows begin congregating in the coastal marshes of the northeastern states. Their numbers are so great that they sometimes festoon telephone wires, sitting side by side literally for miles on end. Hence the colloquial name: 'Wire Birds'....

"During late August and early September, especially when the prevailing gentle, southerly breezes are supplemented for a day or so by winds from the northwest, tremendous numbers of tree swallows pile up near the tip of Cape May. This is the first spectacular bird event of fall. Roosting by night among the canebrakes of the *phragmites*, with as many as four or five swallows clinging to a single reed, and supplementing their insect fare by day with the frosty-gray berries of the wax myrtle or bayberry, they build up the fat that will provide fuel for the later, longer flights of autumn. Not only are birds at their peak in numbers in the fall but they are at their peak in weight. If you could weigh the southbound migrants of an American autumn, you would have more pounds of birds than at any other time of year.

"We were heading for the western side of the point – where a concrete ship still lies where it ran aground in World War I and where water-smoothed bits of quartz, 'Cape May diamonds,' are scattered through the sand – when we came within sight of the first multitude of swallows. Over a wide expanse of open ground they formed a living cloud, acres in extent, continually in motion, continually changing form, swirling this way and that like windblown smoke. The cloud rose and fell. It elongated and contracted. It condensed and grew vaporous. It scudded low across the ground, zoomed as through caught in a violent updraft. Thousands of separate birds were lost in the group movement, lifting, veering, diving, together.

"There was something hypnotic, something deeply stirring in the sight. Swarm was the word that came instantly to mind. This teeming cloud of birds not only suggested a swarm of bees but there was something about their wild abandon, their holiday mood, that was akin to the spirit of the honeybees when they leave the hive on the great communal adventure of their lives."

Figure 10E

Horseshoe Crabs on Delaware Bay

"A sea of dark brown shapes agitates the shallow water, giving the impression of intense fermentation, a massive pot of coffee coming to a boil. In some places the horseshoe crabs are a layer or two deep, while in others, they are piled high, radiating from a central point....

"The horseshoe crabs gather along the Atlantic shores in the millions. After the breeding season they walk on the bottom muds of Delaware Bay to reach the ocean and swim languidly as far out as the edge of the continental shelf. During the winter, horseshoe crabs lie half buried in the mud in the sediments below the shallow seas. This 'hibernation' allows them to slow down their metabolic processes even further, and to avoid predators....

"With the lengthening days of spring, the crabs begin to stir and to move toward the beaches. First the males arrive, and a week or two later the females appear. The females are some 30 percent larger than males and weigh four to six pounds, while the males weight only two to three pounds. Females can produce up to 20,000 or more eggs at a time, and their larger size is an adaptation to their prolific egg production....

"Although adult horseshoe crabs do not have many natural enemies, they are exploited for a variety of purposes by humanity. The indigenous peoples of North America ate them, used the shell to bail water from their dugout canoes, and fashioned the tips of the tails into fishing spear tips. Indians also used the horseshoe crabs for fertilizer, and this practice was immediately adopted by the early European settlers. Horseshoe crab flesh is high in nitrogen, and a thriving fertilizer industry lasted until the 1950s in south Jersey....Crabs were used for over two centuries to feed chickens and hogs. This practice was discontinued because people did not like their chickens to taste like the sea. Nonetheless, between the 1800s and the 1930s some 1.8 million horseshoe crabs were harvested annually.

"Horseshoe crabs are effective bait for catching eels and conch. They have been used for bait for as long as there have been fishermen in Cape May, and the few that any one local fisherman took did not harm the population. As bait became harder to get along the east coast, truckers from nearby states converged on Delaware Bay. They arrived first with small trucks and then with larger trucks. Eventually they came with large tractor trailers that they filled with thousands of dead, dying, and even vibrant, female horseshoe crabs. The females are preferred because they contain eggs, used to attract eels. Great masses of people began combing the beaches to pick up the hapless crabs and put them in barrels for loading onto the trucks. They cleaned up entire beaches, disturbed the large flocks of migrating shorebirds and removed the entire breeding population of crabs from some areas....

"The wholesale removal of horseshoe crabs was finally reduced by setting catch regulations. It was made illegal to pick up the crabs during the day to reduce disturbance to migrant shorebirds that must feed [on the eggs] before their long northward migration.

"One of the most important medical discoveries, made by Frederick Bang in the early 1950s, was that the copper-based blood of horseshoe crabs contains a clotting agent that attaches to bacterial toxins, the poisons produced by infectious bacteria. To obtain the blood...female horseshoe crabs are collected from Delaware Bay and brought to the laboratory. They are bled with a stainless steel tube that is inserted directly in to the circulatory system. The females are held for a few hours and then returned to Delaware Bay. It appears that the females are not harmed by this process."

Figure 10F

Smiles of Vanished Woods

"The woodpile records an archaeology of clearing: at the bottom, fallen pioneers – poplar, sassafras, birch – long retired from succession and sawed up after death; in the middle, cherry and ailanthus, selected for removal here and there because we didn't like them; on top, green ash and red maple, thinned from the woods behind the pond.

"This woodpile shames me. It doesn't reflect our need for firewood (if it did, it wouldn't have grown high enough to record a decade's cutting). The deadwood on the bottom should not have been removed from the woods. It was the next century's nutrients. It supported more forest life – fungi and minute animals similar to the myriads that digest dead leaves – that is supported by living trees....

"The sawed-down, cut-up black cherries now fill me with regret. A horticultural encyclopedia, which lists *Prunus serotina* under 'Trees to Avoid,' briefly describes this native as having messy fruit and tentworms, to which I'll add that it grows crookedly, branches sparsely, gets heartrot, and soon dies. Yet not just tent caterpillars, but the larvae of coral hairstreaks, red-spotted purple butterflies, and a batch of lovely others eat black cherry leaves; those punctuation butterflies called question marks and commas enjoy the cherry's messy, rotting fruits. Sapsuckers drill holes in the bark to release the sweet sap, a service on which other birds rely for carbohydrates....

"On my way down to the mailbox, in a circle twelve feet in circumference planted by nature, not us, grow an elm, an oak, a hickory, and a birch, all 'large' trees as defined by our town's tree law. The ordinance spells out a formula too cumbersome to repeat for thinning out such clumps. Landscaping books traditionally recommend such thinning; a tree company certainly would say, as mine has often said, that some selection should be made among these crowded trees so that only one would be master. Their first suggestion is that the American elm should go, since it will inevitably succumb to Dutch elm disease. Also, the sweet birch, one of whose three trunks is already dead, its tombstone inscribed by a splotch of white fungus. Also, the shagbark hickory, by reason of its winter littering. That would leave the scarlet oak.

"But why? And at what cost? No one knows which elm will prove resistant to the fungus that for some half century now has fatally been carried tree to tree by imported beetles. Our elms stand so far unafflicted....The sweet birch is senile, I admit it, but I don't know what its fungus means or who might live off it. I'm sure the hickory does its part, whether by raining down ripe nuts to feed the squirrels or dead sticks to feed the soil. I see no reason to reduce it to a woodpile. I'm glad the money it would have cost to thin that group, and the danger of attempting it ourselves, stayed our hand long enough for us to learn from its continuance that forest trees of different species can live harmoniously in crowds."

Figure 10G

Waterlilies

"The people who dammed streams for their mills all those many years ago left us a legacy they probably never considered. Water lilies.

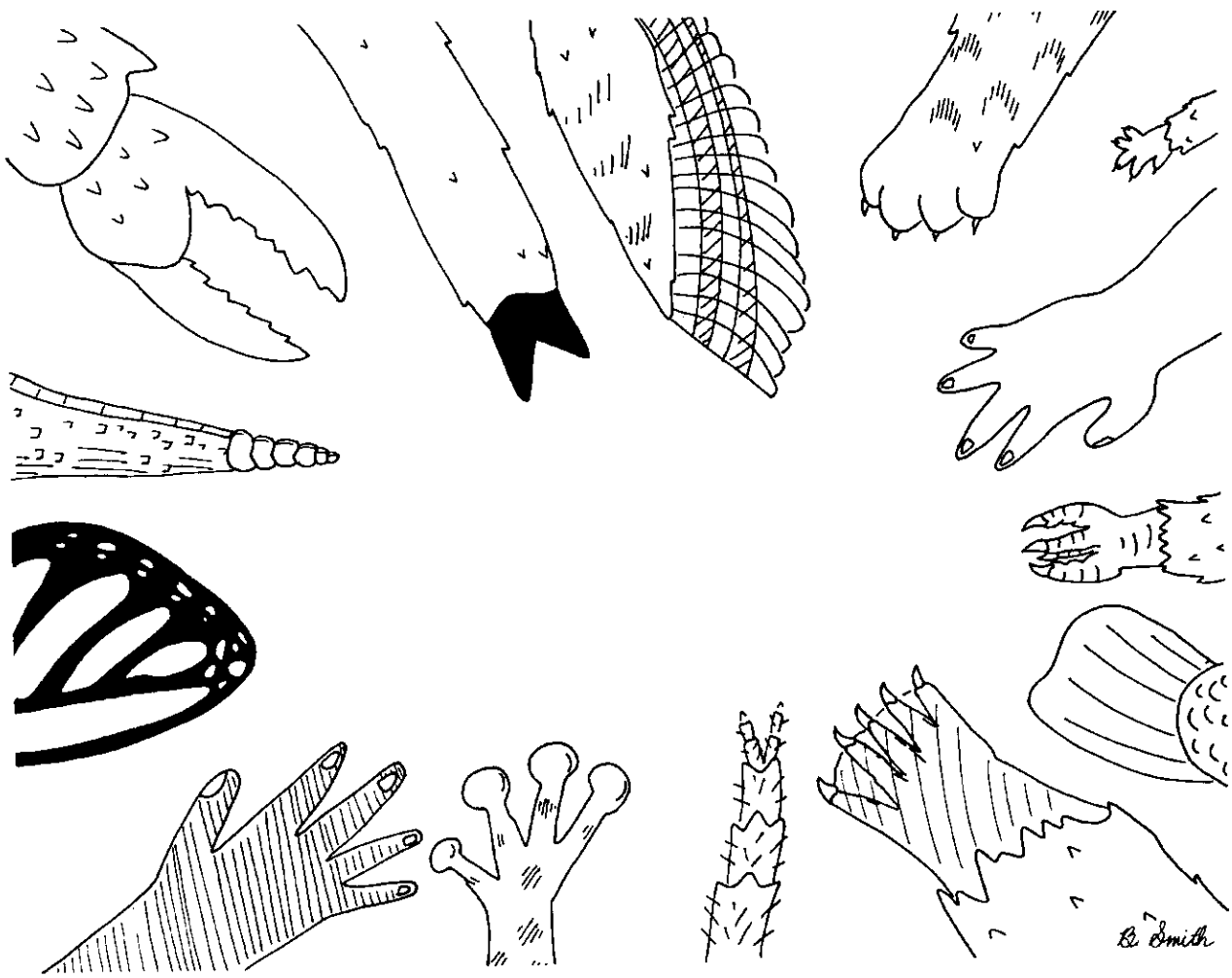
"There are no better places to see the white-and-yellow – and occasionally pink – flowers than the quiet millponds: the shallow, still pools created by the stone-and-concrete dams. Long after the grinding of wheels was silenced, long after the buildings and the millers themselves vanished, the lilies remain....

"The ideal way to see the lilies is by drifting among the pads in a canoe or rowboat. You won't be able to paddle or row very fast, because the stalks beneath the pads get in the way, but a millpond in summer is not the kind of place to hurry through anyway. There may be ducks or muskrats swimming between the pads; both feed on the lily pads. Often you will see dragonflies resting or hovering there, flashing their iridescent blues or reds or greens or bronzes in the sunshine. Sometimes, little frogs are hunched up on the pads, waiting to snap up passing insects. And once in a while there may be a small bird – a rail if you're lucky – probing its way across the pond, deftly stepping from pad to pad.

"To get the most out of any water-lily show, go early. Not only are the attendant wild creatures most active early in the morning, but also the most impressive and fragrant of our native lilies is a mornings-only flower. Called simply the fragrant water lily, it is a gleaming-white blossom that rests directly on the water, next to its shiny foot-long pads. Shortly after sunrise, the flower unfolds gracefully, revealing numerous tapered petals around bright-yellow stamens and emitting a heady aroma. But by noon the flower had closed up shop for the day, with most of its perfume locked up tight as well....

"These days when I paddle around the ponds, I'm usually looking for special lilies, the pink ones. Perhaps it's only because I'm more conscious of them than of others, but it seems there are more pink lilies than there were in the past. They're still not plentiful, by any means, and it's possible to search through a dozen ponds and thousands of flowers without finding one. But now I know of a few places where I can count on finding at least a handful of pink flowers each summer. Plant experts tell me there are two varieties of pink water lilies in our region. One is a mutation of the fragrant lily, mentioned above; the other is a descendant of a European plant introduced years ago as a decorative flower for goldfish ponds and other artificial pools."

COME TO CONSENSUS



A democracy calls for governmental process that allows its citizens to question the decisions of others in an open forum. In the United States, decisions about public policy are often made after there has been an opportunity for individuals and special interest groups to comment on an issue's content and possible implications. Agreeing on a solution that considers various interests is often difficult because individuals tend to focus on only one perspective.

Most people will comment on issues that directly relate to their personal lives. This relevancy is what causes people to speak out, to circulate petitions, to write editorials, to protest, and to contact their elected officials. These people are called stakeholders. In the watershed realm, everyone is a stakeholder. That is, every person is

Come to Consensus

affected in some way by the outcome of decisions made regarding watershed management. To assist in the decision-making process, the following steps can be used:

- identify the issue, concern, or problem
- brainstorm possible solutions by allowing stakeholders time to voice their opinions
- review possible solutions by taking into consideration as many viewpoints as possible
- decide which solution is the best for everyone.

Usually the solution does not satisfy everyone, but as members of a larger watershed community, compromise and best use practices become the most egalitarian methods for addressing issues, problems, special interests, and concerns.

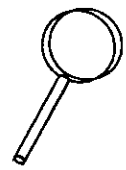
For some laws or rulings, a dictate from a higher level of government is an appropriate method for establishing policy. In other situations it is necessary to have as many segments of the population as possible participate in the decision-making process. Through consensus, the solution becomes effective. Example: non-point source pollution from animal droppings is a major source of high fecal coliform counts in many of our waterways. There is not just one person to blame. Pet owners need to alter their behavior. Park official needs to prohibit feeding of geese, and the animal husbandry people need to address run-off issues if their land is adjacent to a waterway. In order to address this one issue, all of these people need to act responsibly.

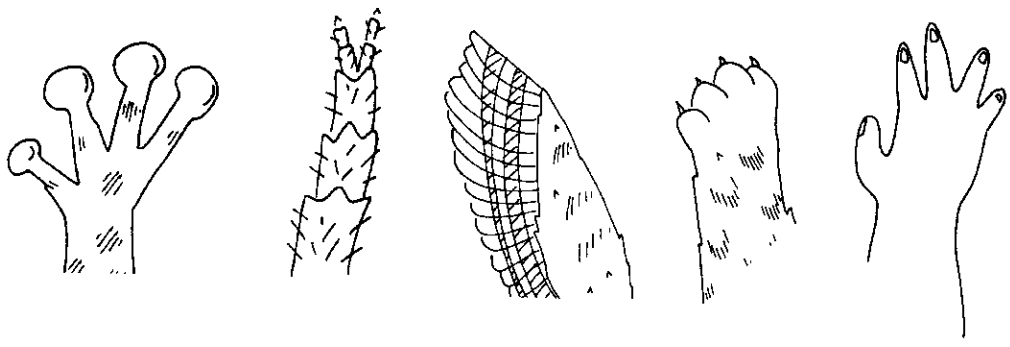
Besides people, the additional stakeholders in a watershed would include its natural systems as well as the plants and animals that live in the watershed's habitats. Their "views" are often represented by environmental organizations, conservation groups, and other wildlife or botanical organizations and agencies.

TAKE A LOOK AT YOUR WATERSHED:

What indicators do you see that show there are several stakeholders working together on a specific issue?

Where do you see an example of a watershed issue that could be addressed from several points of view?





LESSON 11

Come to Consensus

GOAL To learn how consensus building and group dynamics affect issue resolution.

TIME
- (5) 45-minute periods
- 2-3 homework assignments

OBJECTIVES Students will:
- ✔ define diverse stakeholder points of view
- ✔ identify and prioritize local watershed issues
- ✔ gather information from a variety of resources
- ✔ use debate and persuasion techniques to present a specific point of view
- ✔ understand that issue resolution comes from a compromise of different points of view

SKILLS identify, categorize, infer, analyze, synthesize, communicate, justify

VOCABULARY
consensus building
stakeholder

PRIOR KNOWLEDGE Students should have background in the following:
- identifying watershed issues
- doing current events research
- debating techniques

MATERIALS
- ❑ Stakeholder Point of View worksheet (Student Page #17)

PREPARATION
Make four copies of the Stakeholder Point of View worksheet (Student Page #17).

CORE CURRICULUM CONTENT STANDARDS
- Cross Content Workplace Readiness 2 (5-9) 3 (1-5,8,10-15) 4 (1,2,7,9,10)
- Language Arts 3.1 (14,15,16,20) 3.2 (8-11,12) 3.4 (19,25,31) 3.5 (12-14)
- Science 5.12 (9,10)
- Social Studies 6.1 (6,7,11-13,14) 6.6 (9,10,16) 6.9 (6)

PROCEDURE

Period 1

1. Have the students brainstorm what some of the major issues could be that affect the health of a watershed (development, pollution, loss of habitat, changing demographics, road building, etc.).
2. Have the students suggest local issues that could fit into these categories.
3. As a class choose one watershed issue.

Homework

Have each student bring in one piece of information about the watershed issue. Copy these and compile the information into four identical packets. (Resources: newspaper articles, the Internet, radio, television, videos, magazines, or interviews)

Period 2

1. List the following stakeholder names on the board. (Definitions are listed for teacher information.) Lead a discussion on what a stakeholder is and decide on the definitions used to describe each point of view.
   - Property Owner - frequently concerned with own needs regardless of others; may also include the "NIMBY" point of view (Not-In-My-Back-Yard).
   - Local Municipality - strong concern for "home rule"; sensitivity toward state government imposing regulations upon it.
   - Regional Watershed Association - proponent of ecological approach to watershed management, using watershed boundaries (rather than political boundaries) in developing a management plan.
   - State Government Master Plan Commission - concerned about developing a holistic land and water management plan for the overall good of the state population (which may or may not be sensitive to local needs or interests)
2. Divide the class into four groups and identify each group as one of the four stakeholders.

Homework or independent reading assignment

Distribute one packet of information to each group. Have the students share the articles and read the information from the packet, keeping in mind their stakeholder point of view.

Period 3

1. Distribute the Stakeholder Point of View worksheet (Student Page #17) to each group.
2. Students should discuss how their stakeholder would view the watershed issue then write the major points that the stakeholder would bring to a discussion of issue resolution on the worksheet.
3. Have each group develop a plan that addresses the issue from their stakeholder's point of view and write this plan on the worksheet.
4. Select a representative to report on each portion of the plan for a five-minute class presentation. Each presentation should incorporate some type of visual that explains the major points of the issue, their needs as a stakeholder, and their solution to the issue.
5. Select a representative from each group to sit on a "board of reviewers" who will listen to all the presentations and make the final decision on the issue based on the information presented to them.

Period 4

Have the group members present their plan (5 minute presentation, 5 minute question / answer period). Members from other groups and those students on the board of reviewers should take notes on each group's presentation to use as guidance for asking questions.

Period 5

1. Have the board of reviewers weigh each of the points of view and compile a final plan for resolution of the issue.
2. Group members can then question the board of reviewers, if they choose, on how the group made the decision.

FURTHER DISCUSSION

1. Who assumed the leadership role in your group? How was this decided?
2. How did each group's plan evolve (consensus building within the group)?
3. How did the final plan evolve (consensus building among the groups)?
4. With what factors did the board of reviewers have to contend?
5. Which group had the best presentation approach? Explain your answer.
6. Under what circumstances would "compromise" not be a solution to the issue?

ASSESSMENT

Select a different watershed topic. Have each student describe the issue according to the four points of view and create a solution to the issue taking all of these points of view into consideration.

EMPOWERMENT CHALLENGE

Attend a local meeting about a watershed issue. Identify which people or special interest groups fit into the stakeholder points of view. What are some other points of view not covered in the list?

LESSONS FROM OTHER SOURCES

Project WET - Hot Water, Perspectives, Water Court

Sourcebook for Watershed Education - Six Bits, Transactive Discussions, Reaching a Decision, Forcefield Analysis

The Ways of the Watersheds - Welcome to 'Awayville'

WOW! The Wonders of Wetlands - Hear Ye, Hear Ye, Wetland Trade Offs

REFERENCES

Brown, Jeffrey L., editor. 1995. *Sustaining the Future: Activities for Environmental Education in U.S. History.* Union, NJ: Global Learning, Inc.

Cole-Misch, Sally, Larry Price, and David Schmidt. 1996. *Sourcebook for Watershed Education.* Ann Arbor, MI: Global Rivers Environmental Education Network

NOTES

NAME: DATE:

Come to Consensus

STAKEHOLDERS' POINTS OF VIEW

Describe each stakeholder's point of view:

PROPERTY OWNER

LOCAL MUNICIPALITY

REGIONAL WATERSHED ASSOCIATION

STATE GOVERNMENT MASTER PLAN COMMISSION

Describe the issue.

Which stakeholder does your group represent?

List the major points about this issue from your stakeholder's point of view.

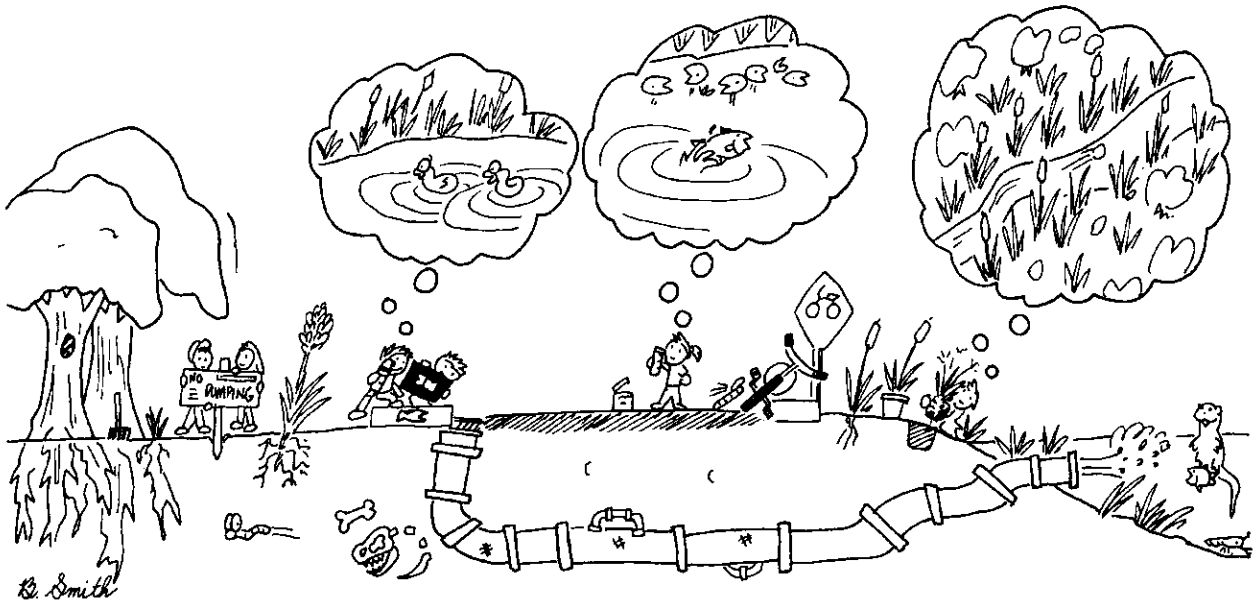
What is your stakeholder's plan for resolving this issue?

Stakeholder needs

List reasons why the use of the watershed according to these needs is important

Stakeholder solution

A COMMUNITY WATERSHED



The basic premise of watershed stewardship is that (a) we all live in a watershed and (b) we must understand how to live within the watershed. According to the Center for Watershed Protection, a non-profit watershed organization, there are four elements to watershed education.*

- watershed awareness - introduces people to their watershed and the concept of "watershed" by bringing attention to it through signage, posters, storm-drain stenciling, etc. Often participation in a stream clean-up or streambank restoration project is an individual's first introduction to the "shed" behind the "water."
- personal stewardship - engages individuals in identifying issues and concerns, looking at possible solutions and implementing changes in their behaviors
- professional training - provides the planner, watershed association member, environmental commission member, or other individual the tools of watershed protection
- watershed engagement - actively engages the public in watershed protection and restoration which usually continues on some level as a lifelong commitment.

These four elements usually occur in sequence. An individual is unlikely to participate in watershed protection and restoration before they understand what a watershed is and how their behaviors and those of their community members are affecting the quality of the watershed.

At each level it is inevitable that projects and plans for projects will develop. To be the most effective, these plans should address the following:

- Is the plan using the most up-to-date information and research?
- Has the plan been developed through consensus building by taking into consideration differing points of view?
- Does the plan involve a variety of community members?
- Is the plan achievable within the prescribed time frame and with the availability of resources?
- Is the plan financially doable?
- Is the plan local enough that the outcome can be seen and measured?
- Has the plan been developed to be adaptable and reproducible which will help others in the long run?

*Center for Watershed Protection. 1998. *Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds*, Ellicott City, MD.

NOTES

LESSON 12

A Community Watershed

GOAL To develop and implement a watershed education or awareness program in the community.

TIME
- (6) 45-minute class periods
- group research time
- plan implementation time

OBJECTIVES Students will:
- ✔ identify a watershed issue that concerns them
- ✔ develop a plan for addressing that issue
- ✔ gather data and other information to support their plan
- ✔ implement their plan in the community
- ✔ evaluate the effectiveness of their plan

SKILLS categorize, gather and interpret data, analyze, evaluate, synthesize, justify

PRIOR KNOWLEDGE Students should have background in:
- identifying watershed issues
- using research skills
- using communication skills

PREPARATION
1. Make one copy of the Peer Assessment sheet (Student Page #18) and the Project Work Plan outline (Student Page #19) for each student.
2. Create a class timeline for periodic progress reports and completion of the project.

MATERIALS
- ❑ Peer Assessment sheet (Student Page #18)
- ❑ Project Work Plan outline (Student Page #19)

CORE CURRICULUM CONTENT STANDARDS
- Cross Content Workplace Readiness 1(12) 2 (2,5-9) 3 (1-5, 10-15) 4 (1-5,9,10)
- Language Arts 3.1 (14-16,18) 3.2 (8,9,11,13) 3.3 (14-17) 3.4 (25) 3.5 (13,14)
- Math 4.4 (8,10) 4.10 (8)
- Science 5.1 (4,5) 5.2 (10-15) 5.4 (9,11) 5.12 (6,9,10)
- Social Studies 6.1 (7,9,12,13,14) 6.4 (7,10) 6.5 (8)

PROCEDURE

Period 1

1. Write the name of a local river or other body of water on the chalkboard. Through discussion have the students relate and list any experiences and/or impressions they have of the water body or its surrounding land. Note: A field trip to a specific water site prior to this experience is recommended or invite a representative from the local watershed association to talk to the class.
2. Categorize the list into major topic areas.
3. Divide the students into small working groups according to the topic that interests them the most. Have the students discuss their topic and identify an issue or concern that relates to them and their watershed.

Period 2

1. Explain that each student group will research their issue and design an awareness and education tool to inform their community about their issue or concern. Sample projects include: teaching younger students about the local watershed, organizing a stream clean-up, posting weekly reports on a waterway's daily flow and water conditions, or producing a video on habitats found within the watershed.
2. Throughout the project students will be responsible for periodic progress reports as well as self and group assessment reports. Explain that after doing their research, each group will explain to the class their issue, the awareness and education tool they plan to use, the audience it targets, and the method of dissemination before actual implementation.
3. Distribute a Project Work Plan (Student Page #19) to each student and discuss the outline points.
4. Have the individuals in each group complete their Project Work Plan according to group consensus.
5. Groups will be responsible for their progress with the following methods:
   - Individual Journal - each student should keep an ongoing record of their impressions and feelings throughout the project. These are personal and are not usually read by anyone but the teacher.
   - Periodic Progress Reports - each group should be responsible for updating the class on their progress.
   - Group Evaluation - an internal periodic assessment of the group's progress - what things are going well, where the group needs improvement, and what actions can be implemented to address changes that need to be made.

Group research time

Research the issue or concern by gathering information from the library, government agencies and non-governmental organizations, by doing interviews, using the Internet, etc.

Period 3

1. Discuss the reasons why assessment and constructive criticism are integral to a well-thought through project [*increases input from other perspectives, people unfamiliar with the plan may see "holes" in the process, identification of resources that may not have been thought of originally*].
2. Distribute the Peer Assessment sheet (Student Page #18) for students to complete after each presentation.
3. Have each group designate a note-taker who will keep track of the comments or concerns that other classmates offer that could strengthen their plan.
4. Have each group present their project plan. Allow time for question and answers.

Period 4

Have each group reassess their plan and design their final product based on class discussion and assessment.

Period 5 (with independent work time, if needed)

Allow time for students to create their final product.

Period 6

Have each group present their finished product to the class.

FURTHER DISCUSSION

1. How does this process apply to everyday life?
2. Which skills did you use that will help you in the future (job, school, family, community, etc.)
3. How do the cultural institutions of your audience (i.e., family background, religion, education) help define the development of your awareness and education tool?

ASSESSMENT

In addition to the student's logs, journals, progress reports, and self and group evaluations, these questions can be added.

1. What was your initial reaction to this type of project?
2. What did you learn about yourself / others during the project?
3. What did you learn about your community in the project?
4. What did you learn about your watershed in the project?
5. How do government processes affect the development of a community project?

EMPOWERMENT CHALLENGE

Take the final product to the target audience in the community using the dissemination strategies. Evaluate the effectiveness of the tool as a method for increasing watershed awareness.

LESSONS FROM OTHER RESOURCES

Aquatic Project WILD - Dragonfly Pond
Project WET - Water Actions
Sourcebook for Watershed Education - Community Sensitivity, Force Field Analysis
WOW! The Wonders of Wetlands - Helping Wetland Habitats

REFERENCES

Center for Watershed Protection. 1998. *Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds.* Ellicott City, MD.

Stapp, William B., Arjen E.J. Wals, and Sheri L. Stankorb. 1996. *Environmental Education for Empowerment.* Dubuque, IA: Kendall/Hunt Publishing Company.

NOTES

NAME: DATE:

A Community Watershed: Getting Involved

PEER ASSESSMENT

NAME OF THE GROUP:

TITLE OF THE PROJECT:

Rate each aspect of the plan on a scale of 1 to 4. Circle the best response.	
1	I don't think so
2	Possibly
3	Likely
4	Definitely

Can the plan realistically be carried out:

within the given time frame?	1	2	3	4
with the resources/materials listed?	1	2	3	4
with the budget outlined?	1	2	3	4
Will the plan stimulate interest among the target audience?	1	2	3	4
Will the plan have a favorable effect on the watershed?	1	2	3	4
Does this plan reflect a "group effort?"	1	2	3	4

Comments:

NAME: DATE:

A Community Watershed

PROJECT WORK PLAN

TOPIC	RESPONSE
Watershed Relationship What is the relationship of this issue to the watershed?	
Issue Question What do you want to learn?	
Rationale Why is this issue important to you and the watershed community?	
Goals What do you expect to achieve in the watershed community?	
Personal Goals What are your expectations for this project?	

Project Work Plan (continued)

TOPIC	RESPONSE
Deliverable Plan What product are you going to deliver to the community about your issue?	Product Target Audience Method of Distribution/Delivery
Project Log Tasks, Timeline, and Responsibilities Use a separate sheet of paper.	Tasks: List the steps you will take to accomplish your plan. Prioritize these, e.g., 1, 2, 3,.... Timeline: Give a date for completing each task. Responsibilities: Note which member/s of your team is/are responsible for each task.
Resources What will you need to complete your project?	Materials Skills Funding (create a budget) Human Resources

APPENDIX A

Glossary

abiotic: Any nonliving element of the natural environment, e.g., water, light, rock, and gases.
aquifer: A subsurface geologic formation of soil or rock that is saturated with water.

biotic: Any living or once-alive component of the natural environment.
bedrock: The solid rock that underlies unconsolidated surface materials such as soil.
benthic macroinvertebrate: An animal that does not have a backbone, is large enough to be seen without the aid of a microscope, and that lives in the bottom mud or under rocks of a water habitat.
bottom substrate: The bottom layer of a pond, lake, river, stream, or tidal habitat.
buffer zone: An area next to a shoreline, wetland, or stream that reduces or moderates the impact or effect of development from an adjacent area. Usually development in this zone is restricted or prohibited.

carrying capacity: The limit of the number of organisms of a particular species that a natural system can support over a long period of time.
cartographer: A person who creates maps.
catchment: The smallest watershed management unit, usually an area that drains a specific site to it's first intersection with a stream or body of water.
closed watershed system: A surface water body that is not part of a larger watershed or basin system, e.g., the pond that forms only from runoff precipitation.
channelization: The artificial containment of a stream or river course.
compacted soil: Soil which is so compressed that it has little permeability.
confined aquifer: A subsurface layer of soil or rock that is saturated with water and trapped between impermeable layers of soil (such as clay) or rock.
consensus building: The process of stakeholders coming to a decision regarding an issue.
consumerism: The theory that increasing the consumption of goods is economically desirable.
contour line: A drawn line on a map that connects all the contiguous land that is the same elevation.

demographics: The statistical characteristics of human populations.
drainage basin: The largest watershed management unit which generally drains into a major water body such as a large river, bay or estuary, or lake. These generally cover several thousand square miles.

ecological footprint: The effect that people have on the environment through their choices in life style.
elevation: The height to which a landform is raised above sea level.
environmental indicator: A factor of a habitat or ecosystem that identifies that system by its very presence, e.g., cattails indicate freshwater wetlands, mayflies indicate healthy water quality.
emigration: The movement of an animal when it leaves an area.
erosion: The wearing away of land due to natural processes (wind and water). Human practices, including deforestation and construction, hasten the rate of these processes.

greenway: A corridor of protected open space adjacent to a stream, river, or other body of water.
ground-truthing: The process of comparing a map against the actual site the map represents.
ground water: Precipitation which has soaked into the ground and exists in the spaces between soil particles or in the cracks of bedrock.

headwaters: The uppermost reaches of a stream or watershed.
home rule: A political term that describes how municipalities may make decisions regarding issues and concerns within their boundaries rather than on a regional basis.

immigration: The movement of an animal into an area.
impermeable layer: A layer of bedrock or soil though which water will not pass.
impervious surface: A covering of the land that will not allow water to soak into the ground, e.g., blacktop, concrete, shingles on a roof, frozen ground, clay, or compacted soil.
infiltration: The movement of water through soil.

landform: A natural feature of a land surface, e.g., mountain, lake, ridge, plateau, etc.
land use: A description of how the surface of the earth is utilized for human endeavors.
life cycle analysis: The complete process of a product from its manufacture to its use to its disposal.

niche: The specific role a organism has in an ecosystem.
non-point source pollution: Contaminants that originate from many sources, such as lawn herbicides, road pollution, animal waste, etc.

open watershed system: A group of connected waterways and waterbodies, e.g., the stream feeds the pond which in turn feeds an outflow stream that flows into the reservoir.

pervious surface: Any surface that absorbs water or allows water to pass through it.
physiographic region: An area that is described largely by its geology and soil type.
point source pollution: Contaminants that originate from a specific place, like the end of a discharge pipe.
pollutant: A by-product of human activity that is detrimental to the ecosystem.
population trends: A statistical curve that reflects changes in population numbers, density, and demographics over time.
precipitation: Any form of water that originates in the atmosphere.

recharge area: The surface area of land which permits water to infiltrate into the ground-water supply (aquifer).
resource: A term applied to anything from which people can profit, or, in nature, the physical properties (including plants and animals of the area) attributed to a natural system.
ridge line: The highest elevations points along a continuous top of a mountain range.
river mouth: The downstream end of a river where it enters an ocean or other larger body of water.
runoff: Any precipitation which does not soak into the soil but moves across the surface of the land until it enters a body of water.

slope: The angle that is created between the top of a hill and the valley floor.

subbasin: Refers to a grouping of watersheds that covers several hundred square miles.
subwatershed: A smaller geographic drainage unit within a watershed that typically covers an area from two to fifteen square miles.
surface water: Precipitation that has collected into a natural or human made depression or body of open water.
stream order: The method for identifying the branching system of a river and its tributaries.
stakeholder: Any individual or organization that has direct or vested interest in decisions being made about an issue.
sustainable development: A term used to describe the balance between economic prosperity and preserving or restoring the integrity of natural systems.

topographic map: A type of map that uses contour lines to represent changes in elevation and landforms.
tolerance threshold: The degree of environmental impact an individual or community is willing to allow concerning an issue.
topography: The description of the relief of the land.
tributary: Any stream or river that flows into a major river.
turbidity: Cloudiness in water caused by natural process such as storm events or by human factors such as soil erosion from construction sites, boat propellers, dredging, etc.

USGS quadrangle: The name for a topographic map which has been identified by latitude and longitude by the United States Geological Survey (USGS).
unconfined aquifer: A subsurface layer of soil or rock that is saturated with water and is replenished directly from above by precipitation.

visual assessment: A survey of the physical aspects of a site.
volunteer monitoring: The process of gathering chemical, biological, or physical data about a watershed without remuneration.

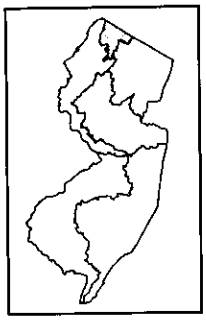
watershed: The land area where water drains into an individual stream, lake, or other body of water.
water table: The top of an unconfined aquifer where the soil or rock is no longer saturated. This level can change depending on fluctuating precipitation rates, drought, freezing, and sometimes by the addition of impervious cover (blacktop, concrete, buildings).

APPENDIX B

Topographic Map Listing

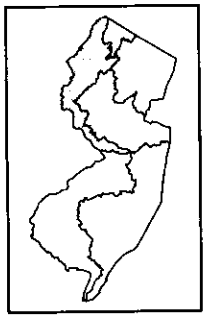
This listing of USGS topographic maps is divided into the six major watershed basins. Maps can be purchased by contacting any of the following:

- *National Cartographic Information Center, USGS/ESIC,* 507 National Center, Reston, VA 22092. Phone: 800-USA-MAPS
- *Maps and Publications Sales Office,* Bureau of Revenue, CN 417, Trenton, NJ 08624-0417 Phone: 609-777-1038
- Local sporting goods or outdoor stores



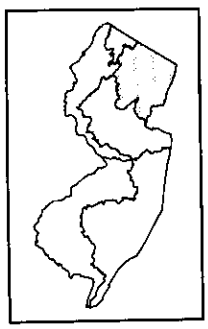
WALLKILL BASIN

Map No.	Map Name
2	Port Jervis South
3	Unionville
4	Pine Island
7	Branchville
8	Hamburg
9	Wawayanda
10	Greenwood Lake
15	Newton East
16	Franklin



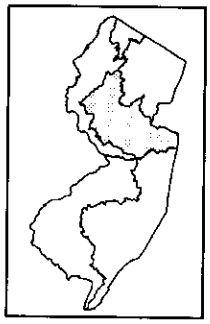
UPPER DELAWARE BASIN

Map No.	Map Name
1	Milford
2	Port Jervis South
5	Lake Maskenozha
6	Culvers Gap
7	Barnchville
12	Bushkill
13	Flatbrookville
14	Newton West
15	Newton East
22	Stroudsburg
23	Portland
24	Blairstown
25	Tranquility
26	Stanhope
27	Dover
33	Bangor
34	Belvidere
35	Washington
36	Hackettstown
44	Easton
45	Bloomsburg
46	High Bridge
55	Riegelsville
56	Frenchtown
57	Pittstown
66	Lumberville
67	Stockton
68	Hopewell
76	Lambertville
77	Pennington
78	Princeton
79	Hightstown
86	Trenton East
87	Trenton West
88	Allentown
89	Roosevelt



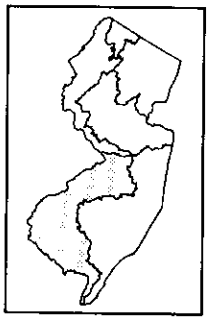
PASSAIC / HACKENSACK BASIN

Map No.	Map Name
10	Greenwood Lake
11	Sloatsburg
16	Franklin
17	Newfoundland
18	Wanaque
19	Ramsey
20	Park Ridge
21	Nyack
27	Dover
28	Boonton
29	Pompton Plains
30	Paterson
31	Hackensack
32	Yonkers
38	Mendham
39	Morristown
40	Caldwell
41	Orange
42	Weehawken
43	Central Park
49	Bernardsville
50	Chatham
51	Roselle
52	Elizabeth
53	Jersey City
62	Perth Amboy
63	Arthur Kill



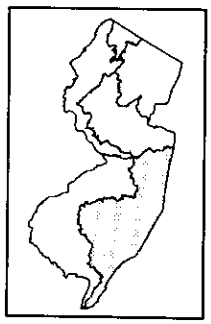
RARITAN BASIN

Map No.	Map Name
26	Stanhope
27	Dover
36	Hackettstown
37	Chester
38	Mendham
46	High Bridge
47	Califon
48	Gladstone
49	Bernardsville
50	Chatham
57	Pittstown
58	Flemington
59	Raritan
60	Bound Brook
61	Plainfield
62	Perth Amboy
67	Stockton
68	Hopewell
69	Rocky Hill
70	Monmouth Junction
71	New Brunswick
72	South Amboy
73	Keyport
74	Sandy Hook (East and West)
77	Pennington
78	Princeton
79	Hightstown
80	Jamesburg
81	Freehold
82	Marlboro
83	Long Branch (East and West)
89	Roosevelt
90	Adelphia



LOWER DELAWARE BASIN

Map No.	Map Name
86	Trenton East
87	Trenton West
88	Allentown
89	Roosevelt
93	Frankford
94	Beverley
95	Bristol
96	Columbus
97	New Egypt
98	Cassville
102	Philadelphia
103	Camden
104	Moorestown
105	Mount Holly
106	Pemberton
107	Browns Mills
108	Whiting
112	Marcus Hook
113	Bridgeport
114	Woodbury
115	Runnemede
116	Clementon
117	Medford Lakes
118	Indian Mills
119	Chatsworth
124	Wilmington South
125	Penns Grove
126	Woodstown
127	Pitman West
128	Pitman East
137	Delaware City
138	Salem
139	Alloway
140	Elmer
141	Newfield
142	Buena
149	Taylors Bridge
150	Canton
151	Shiloh
152	Bridgeton
153	Millville
154	Five Points
160	Bombay Hook Island
161	Ben Davis Point
162	Cedarville
163	Dividing Creek
164	Port Elizabeth
165	Tuckahoe
169	Fortescue
170	Port Norris
171	Heislerville
172	Woodbine
174	Rio Grande
175	Stone Harbor
177	Cape May



ATLANTIC COASTAL BASIN

Map No.	Map Name
81	Freehold
82	Marlboro
83	Long Branch
89	Roosevelt
90	Adelphia
91	Farmingdale
92	Asbury Park
98	Cassville
99	Lakehurst
100	Lakewood
101	Point Pleasant
108	Whiting
109	Keswick Grove
110	Toms River
111	Seaside Park
116	Clementon
117	Medford Lakes
118	Indian Mills
119	Chatsworth
120	Woodmansie
121	Brookville
122	Forked River
123	Barnegat Light
128	Pitman East
129	Williamstown
130	Hammonton
131	Atsion
132	Jenkins
133	Oswego Lake
134	West Creek
135	Ship Bottom
136	Long Beach NE
142	Buena
143	Newtonville
144	Egg Harbor City
145	Green Bank
146	New Gretna
147	Tuckerton
148	Beach Haven
154	Five Points
155	Dorothy
156	Mays Landing
157	Pleasantville
158	Oceanville
159	Brigantine Inlet
164	Port Elizabeth
165	Tuckahoe
166	Marmora
167	Ocean City
168	Atlantic City
172	Woodbine
173	Sea Isle City
174	Rio Grande
175	Stone Harbor
176	Avalon
177	Cape May
178	Wildwood

APPENDIX C

Field Trip Sites for Watershed Study

Watersheds can be studied anywhere in the state – from urban to rural areas and from sites that contain water habitats to those that do not. Every inch of the state exists within a watershed; therefore, one does not have to "go" somewhere to learn more about watersheds.

If a field trip is arranged, consider visiting one of New Jersey's public open space areas which include: wildlife refuges, state parks, wildlife management areas, county parks, or municipal parks (Table 1). Also listed are education facilities that provide water ecology or watershed education programs and/or will allow a teacher to use their facility to conduct their own watershed program (Table 2). The teacher should contact the education specialist at the facility to discuss availability and associated fees.

TABLE 1
PUBLIC OPEN SPACE AREAS FOR WATERSHED STUDY

NATIONAL WILDLIFE REFUGES
United States Fish and Wildlife Service
800-344-WILD
www.fws.gov

In New Jersey
Wallkill River National Wildlife Refuge
1547 County Route 565
Sussex, NJ 07461-4013
973-702-7266
Wallkill Basin

Great Swamp National Wildlife Refuge
152 Pleasant Plains Road
Basking Ridge, NJ 07920-9615
973-425-1222
Passaic / Hackensack Basin

Edwin B. Forsythe National Wildlife Refuge
PO Box 72, Great Creek Road
Oceanville NJ 08231-0072
609-652-1665
Atlantic Coastal Basin

Supawna Meadows National Wildlife Refuge
179 Lighthouse Road
Pennsville, NJ 08070
609-935-1487
Lower Delaware Basin

Cape May National Wildlife Refuge
24 Kimbles Beach Road
Cape May Court House, NJ 08210-2078
609-463-0994
Lower Delaware Basin / Atlantic Coastal Basin

STATE PARKS AND FORESTS
(over 325,000 acres)
New Jersey Department of Environmental Protection
Division of Parks and Forestry
PO Box 404
501 E. State Street
Trenton, NJ 08625
800-843-6420 or 609-984-0370
www.state.nj.us/dep/forestry

STATE WILDLIFE MANAGEMENT AREAS
(over 260,000 acres)
New Jersey Department of Environmental Protection
Division of Fish, Game and Wildlife (Bureau of Land Management)
PO Box 400
501 E. State Street
Trenton, NJ 08625-0400
609-292-2965
www.state.nj.us/dep/fgw

Table 2 - (continued)

EDUCATION FACILITITES THAT OFFER WATERSHED STUDY

SITE	COUNTY	Offers Guided Watershed Study	Allows Self-guided Watershed Study
Scotland Run Park Nature Center **Gloucester County Parks and Recreation** RD4 Box 775, Clayton-Williamstown Road, Franklinville, NJ 08322 Phone: 856-881-0845	Gloucester	Y	Y
ATLANTIC COASTAL BASIN			
Fox Nature Center, Atlantic County Park 109 Boulevard Route 50, Mays Landing, NJ 08330 Phone: 609-645-5960	Atlantic	Y	Y
Coastal Environmental Interpretive Center **Jacques Cousteau National Estuarine Research Reserve** Tuckerton Seaport, Route 9, Tuckerton, NJ 08087 Phone: 609-294-3746	Atlantic	Y	Y
Camden County Environmental Studies Center Park Drive at Broad Avenue, Berlin, NJ 08009 Phone: 856-768-1598	Camden	Y	Y
NJAS Nature Center of Cape May 1600 Delaware Avenue, Cape May, NJ 08204 Phone: 609-898-8848	Cape May	Y	Y
The Wetlands Institute 1075 Stone Harbor Boulevard, Stone Harbor, NJ 08247 Phone: 609-368-1211	Cape May	Y	Y
Cheesequake State Park Interpretive Center Gordon Road, Matawan, NJ 07747 Phone: 732-566-3208	Middlesex	Y	Y
NJAS Owl Haven Nature Center 250 Route 522, PO Box 26, Tennent, NJ 07763 Phone: 732-780-7007	Monmouth	Y	Y
Ocean Institute, Brookdale Community College Box 533, Sandy Hook, NJ 07732 Phone: 732-872-2284	Monmouth	Y	Y
Sandy Hook Education Center, Gateway National Recreation Area **Sandy Hook Unit,** PO Box 530, Fort Hancock, NJ 07732-0530 Phone: 732-872-5970	Monmouth	Y	Y
Cooper Environmental Center 1170 Cattus Island Boulevard, Toms River, NJ 08753 Phone: 732-270-6960	Ocean	Y	Y

APPENDIX D

Resources

This section provides a list of resources that NJAS staff has found helpful in teaching about watersheds. Some of the references used for the basin descriptions are listed here for a second time since they provide excellent New Jersey-specific content information.

ACTIVITY GUIDES

Aquatic Project Wild. 1987. Boulder, CO: Western Regional Environmental Education Council.

Beneath the Shell: A Teacher's Guide to Nonpoint Source Pollution and Its Potential Impact on New Jersey Shellfish. 1991. Trenton, NJ: New Jersey Department of Environmental Protection and Energy.

The Biology of the Hudson-Raritan Estuary: A Teacher's Guide. 1998. Sandy Hook, NJ: New Jersey Marine Sciences Consortium.

Bridges to the Natural World: A Natural History Guide for Teachers of Grades Pre-K to Six. 1992. Kane, Patricia, et. al.. Bernardsville, NJ: New Jersey Audubon Society.

The Comprehensive Water Education Book. Grades K-6. 1994. International Office for Water Education. Logan: UT: Utah State University.

Hands On Save Our Streams. 1994. Firehock, Karen. Gaithersburg, MD: Izaak Walton League of America, Inc.

Project Learning Tree. 1993. Washington, DC: American Forest Foundation.

Project WET Curriculum and Activity Guide. 1995. Bozeman, MT: Western Regional Environmental Education Council and The Watercourse.

Sourcebook for Watershed Education. 1996. Cole-Misch, Sally, et. al. ed. Ann Arbor, MI: Global Rivers Environmental Education Network.

The Ways of Watershed: An Educator's Guide to the Environmental and Cultural Dynamics of NYC's Water Supplies. 1995. Haskin, Kathleen M. Claryville, NY: The Frost Valley YMCA.

WOW! The Wonders of Wetlands: A Educator's Guide. 1995. St. Michaels, MD: Environmental Concern Inc., and Bozeman, MT: The Watercourse.

REFERENCE MATERIALS

Charting a Course for the Delaware Bay Watershed. 1997. Honigfeld, Harriet B. Far Hills, NJ: New Jersey Conservation Foundation.

The Clean Water Book: Lifestyle Choices for Water Resource Protection. 1997. Trenton, NJ: New Jersey Department of Environmental Protection, Office of Environmental Planning.

Communities of Place: The New Jersey State Development and Redevelopment Plan. 1992. New Jersey State Planning Commission. Trenton, NJ: Office of State Planning.

The Estuary Book. 1998. rev. Maine Coastal Program. Augusta, ME: Maine State Planning Office.

Greenways to the Arthur Kill. 1993. New Jersey Conservation Foundation. Far Hills, NJ: New Jersey Conservation Foundation.

Hackensack River Migratory Bird Report. 1997. Kane, Richard and David Githens. Bernardsville, NJ: New Jersey Audubon Society.

Life in the Chesapeake Bay. 1994. Lippson, Alice Jane and Robert L. Baltimore, MD: John Hopkins University Press.

Living Resources of the Delaware Estuary. 1995. Dove, Louise E. and Robert M. Nyman, eds. Delaware Estuary Program.

New Jersey Highlands: Treasures at Risk. 1992. .Mitchell, Alison E. Morristown, NJ: New Jersey Conservation Foundation.

New York-New Jersey Highlands Regional Study. 1991 Michaels, Joseph A., et.al. (The Highlands Study Team) Washington, DC: U.S. Department of Agriculture.

Plant Communities of New Jersey: A Study in Landscape Diversity. 1994. Collins, Beryl Robichaud and Karl H. Anderson. New Brunswick, NJ: Rutgers University Press.

Raritan Bay Wildlife Habitat Report. 1994. Kane, Richard and Paul Kerlinger. Bernardsville, NJ: New Jersey Audubon Society.

The Rockaway River and Its Treasured Resource: Visions and Strategies for their Recovery. 1998. Parsippany, NJ: Friends of the Rockaway River.

The Scientific Characterization of the Delaware Estuary. 1996. Sutton, Clay C., John C. O'Herron, II, and Robert T. Zappalorti. Forked River, NJ: Herpetological Associates, Inc.

Statewide Watershed Management Framework Document for the State of New Jersey. 1997. Trenton, NJ: New Jersey Department of Environmental Protection.

Turning the Tide: Saving the Chesapeake Bay. 1991. Horton, Tom and William M. Eichbaum. Washington, DC: Chesapeake Bay Foundation.

Watersheds: A Practical Handbook for Healthy Water. 1999. Dobson, Clive and Gregor Gilpin Beck. Buffalo, NY: Firefly Books.

VOLUNTEER MONITORING PROGRAMS AND INFORMATION

Clean Water: A Guide to Water Quality Monitoring for Volunteer Monitors of Coastal Waters. 1996. Stancioff, Esperanza. Waldoboro, ME: University of Maine Cooperative Extension.

Citizen Monitoring Manual. 1991. Ellett, Kathleen K. Baltimore, MD: Alliance for the Chesapeake Bay, Inc.

Field Manual for Global Low-Cost Water Quality Monitoring. 1997. Stapp, William B. and Mark K. Mitchell. Ann Arbor, MI: Global Rivers Environmental Education Network.

Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools. 1996. 10th ed. Mitchell, Mark K. and William B. Stapp. Ann Arbor, MI: William B. Stapp.

Great Bay Watch: A Citizens Water Quality Monitoring Program. 1990. Meeker, Bonnie S. and Ann S. Reid. Durham, NH: UNH Cooperative Extension Sea Grant.

Monitor's Guide to Aquatic Macroinvertebrates. 1994. Kellogg, Loren Larkin. Gaithersburg, MD: Izaak Walton League of America, Save Our Streams Program.

The Monitor's Handbook. 1992. Fisher, Nina, ed. Chestertown, MD: LaMotte Company.

Plain Talk About Drinking Water. 1997. Symons, Dr. James M. Denver, CO: American Water Works Association.

Plants in Wetlands. 1994. Redington, Charles B. Dubuque, IO: Kendall/Hunt Publishing Company.

Stream Watch: Comprehensive Water Quality Monitoring Program Volunteer Monitors Handbook. 1995. Pennington, NJ: Stony Brook-Millstone Watershed Association.

Volunteer Estuary Monitoring: A Methods Manual #842-B-93-004. 1993. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

*Volunteer Lake Monitoring: A Methods Manual #*440/4-91-002. 1991. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

The Volunteer Monitor (newsletter). Baltimore, MD: Alliance for the Chesapeake Bay. 410-377-6270.

Volunteer Stream Monitoring: A Methods Manual # 841-B-97-003. 1997. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

Water Quality Monitoring Program: Leader's Handbook #ER-SP-EE-107A/93. 1985. Harrisburg, PA: Commonwealth of Pennsylvania, Department of Environmental Resources.

Water Quality Indicators Guide: Surface Water #SCS-TP-161. 1991. Terrell, Charles R. and Dr. Patricia Bytnar Perfetti. Washington, DC: United States Department of Agriculture, Soil Conservation Service.

SOFTWARE

RiverBank 3.0 1996. Highly Interactive Computer Research Group. Ann Arbor, MI: Global Rivers Environmental Education Network. (water quality monitoring software)

WEBSITES

Green Teacher — www.web.ca/~greentea/

Izaak Walton League (Save Our Streams) -- www.iwla.org/sos

National Watershed Network — www.ctic.purdue.edu

Revitalizing Science Teaching through Remote Sensing Technology (RST ^ 2) Ramapo College of New Jersey – www.rst2.edu/watershed.htm

Surf Your New Jersey's Watershed (New Jersey Department of Environmental Protection, Division of Watershed Management) — www.state.nj.us/dep/dsr/bfbm/watertest/surfnj.html

The Stream Study (Online Macroinvertebrate Key) — www.people.virginia.edu/~sos-iwla

The Volunteer Monitor — www.epa.gov/owow/volunteer/vm_index.html

U.S. Environmental Protection Agency (EPA) Surf Your Watershed — www.epa.gov/surf/

U.S. EPA Water Quality Monitoring Information — www.epa.gov/owow/monitoring

U.S. Geologic Survey (USGS) - New Jersey — wwwnj.er.usgs.gov

U.S. Geologic Survey (USGS) — www.usgs.gov

MAPS

Complete New Jersey Trout Waters: Guide for Anglers
Gogal Publishing, P.O Box 11419, Phildelphia, PA 19111-0419 (215) 722-1410

USGS Earth Science Information Center (aerial photographs, topographic maps, National Wetland Inventory Maps)
506 National Center, 12201 Sunrise Valley Drive, Reston, VA 22092
1-800-USA-MAPS

Shellfish Bureau (shellfishing maps)
609-984-5546 or 609-748-2038

Professor Higbee's Streams of New Jersey (New Jersey streams map)
Vivid Publishing, Inc., Williamsport, PA 17701 800-787-3267

ORGANIZATIONS

Association of New Jersey Environmental Commissions (ANJEC)
PO Box 157, Mendham, NJ 07945, 973-539-7547
members.aol.com/anjec

Center for Watershed Protection
8391 Main Street, Ellicott City, MD 21043, 410-461-8323
www.pipeline.com/~mrrunoff/

Clean Ocean Action
Box 505, Highlands, NJ 07732, 732-872-0111
www.cleanoceanaction.org

Delaware River Basin Commission
25 State Police Drive, West Trenton, NJ 08628, 609-883-9500
www.state.nj.us.drbc

Delaware Riverkeeper
PO Box 326, Washington Crossing, PA 18977, 215-369-1188
www.delawareriverkeeper.org

Global Rivers Environmental Education Network (Earth Force)
1908 Mount Vernon Avenue, 2nd Floor, Alexandria, VA 22301
703-299-9400
www.earthforce.org

Hackensack Riverkeeper
1000 River Road, T090C, Teaneck, NJ 07666, 201-692-8440

Hudson Riverkeeper
25 Wing & Wing, Garrison, NY 10524, 914-424-4149
www.riverkeeper.org

Institute of Marine and Coastal Sciences
c/o Rutgers University
71 Dudley Road, New Brunswick, NJ 08901-8521, 732-932-6555

New Jersey Community Water Watch
119 Somerset Street, 2nd Floor, New Brunswick, NJ 08901
732-247-4606

New Jersey Coalition of Lake Associations (COLA)
21 The Boardwalk, Sparta, NJ 07871, 973-729-6156

New Jersey Department of Environmental Protection, Division of Watershed Management
PO Box 418, Trenton, NJ 08625-0418, 609-292-2113
www.state.nj.us/dep

NY/NJ BayKeeper
American Littoral Society
Sandy Hook, Highland, NJ 07732, 732-291-0176
www.nynjbaykeeper.org

Pinelands Commission
15 Springfield Road, PO Box 7, New Lisbon, NJ 08064
609-894-7300
www.state.nj.us/pinelands

River Network
PO Box 8787, Portland, OR 97207, 503-241-3506
www.rivernetwork.org

Soil Conservation Districts
State Soil Conservation Committee
PO Box 330, Trenton, NJ 08625, 609-292-5540

United States Geological Survey (USGS)
810 Bear Tavern Road, Suite 206, West Trenton, NJ 08628, 609-771-3900
wwwnj.er.usgs.gov

The Watershed Partnership for New Jersey (WPNJ)
c/o The Alliance for New Jersey Environmental Education (ANJEE)
New Jersey Audubon Society
PO Box 693, Bernardsville, NJ 07924, 908-766-5787
http://ceaedep.rutgers.edu