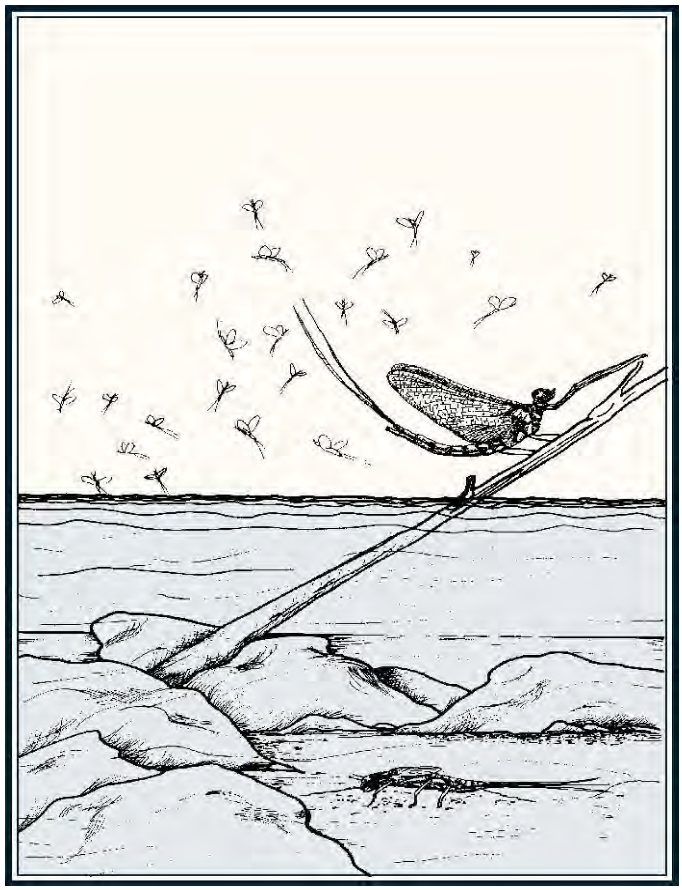
LIVING



WATER

Eno River State Park

An Environmental Education Learning Experience

Designed for the Middle Grades

–Without life, there would still be water.

Without water no life.”

David Quammen, *Natural Acts, A Sidelong View of Science and Nature*

This Environmental Education Learning Experience was developed by Scott Hartley and Martha Woods, former Park Rangers at Eno River State Park.

Revised May 2013 by Brian Bockhahn, Jack Singley and Nathan Swick.

North Carolina Division of Parks and Recreation
Department of Environment and Natural Resources

Other Contributors . . .

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Association for the Preservation of the Eno River Valley, Inc.; Riffle and Pool Naturalists; The N.C. Department of Public Instruction; The N.C. Division of Water Resources; The N.C. Department of Environment and Natural

Resources; and the many individuals and agencies who assisted in the review of this publication.

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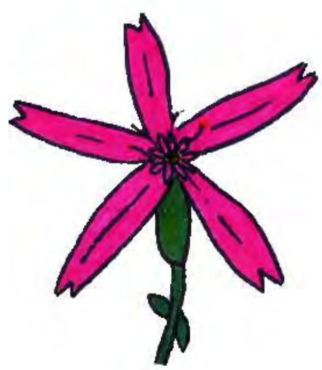
Introduction to the North Carolina State Parks System

Preserving and protecting North Carolina's natural resources is actually a relatively new idea. The seeds of the conservation movement were planted early in the 20th century when citizens were alerted to the devastation of Mount Mitchell. Logging was destroying a well-known landmark the highest peak east of the Mississippi. As the magnificent forests of this mile-high peak fell to the lumbermen's axe, alarmed citizens began to voice their opposition. Governor Locke Craig joined them in their efforts to save Mount Mitchell. Together they convinced the legislature to pass a bill establishing Mount Mitchell as the first state park.

That was in 1915. The North Carolina State Parks System has now been established for nearly a century. What started out as one small plot of public land has grown into 67 properties across the state, including parks, recreation areas, trails, rivers, lakes and natural areas. This vast network of land boasts some of the most beautiful scenery in the world and offers endless recreation opportunities. But our state parks system offers much more than scenery and recreation. Our lands and waters contain unique and valuable archaeological, geological and biological resources that are an important part of our natural heritage.



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Website: **www.ncparks.gov**
parkinfo@ncmail.net

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As one of North Carolina's principal conservation agencies, the Division of Parks and Recreation is responsible for the more than 167,000 acres that make up our state parks system. The Division manages these resources for the safe enjoyment of the public, and protects and preserves them as a part of the heritage we will pass on to generations to come.

An important component of our stewardship of these lands is education. Through our interpretation and environmental education services, the Division of Parks and Recreation strives to offer enlightening programs that lead to an understanding and appreciation of our natural resources. The goal of our environmental education program is to generate an awareness in all individuals which cultivates responsible stewardship of the earth.

Introduction to Eno River State Park

Efforts to establish Eno River State Park began n 1965 when the city of Durham proposed building a reservoir on the Eno. In response, a group of concerned citizens formed the Association for the Preservation of the Eno River Valley. The Association was successful in gaining community support for its proposal that a state park be established along the river. In May of 1972, the state of North Carolina approved the idea, and the city of Durham withdrew its plan to construct the reservoir. By 1975, 1,100 acres of land had been acquired with help of the Association, the Nature Conservancy and the Division of Parks and Recreation.

Today the park protects 14 miles of river and over 4,300 acres of associated lands in Orange and Durham County.

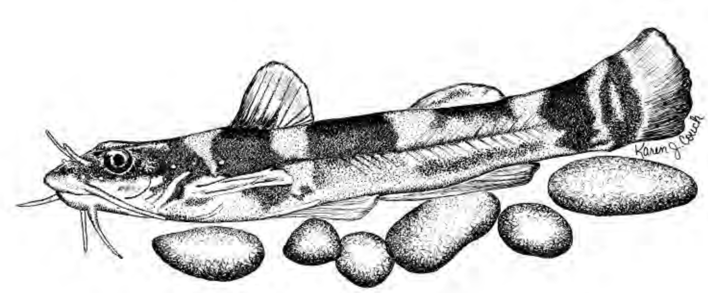
Life in and along the Eno River

Eno River State Park provides important habitat for a host of animals and plants. A mixture of steep rocky ridges and bottomlands creates several distinct plant communities. Many of the wildflowers and shrubs found in the park are normally found in the mountains and foothills of North Carolina. Shrubs, including the Catawba Rhododendron, and wildflowers, such as yellow lady's slipper, showy orchids and wild geranium, find suitable habitat in the river valley.

The River hosts more than 61 species of fish. The Carolina madtom (a catfish) and the Roanoke bass (a game fish) appear in the *Natural Heritage Program List of the Rare Animal Species of North Carolina.*

Numerous macroinvertebrates are also found in the river. The tiny panhandle pebblesnail, listed as "significantly rare", is found only in the Eno River. Freshwater mussels include several endangered or threatened species such as the yellow lampmussel, Atlantic pigtoe and green floater. These and other aquatic macroinvertebrates can be used as indicator species to monitor water quality. The presence or absence of these wonderfully adapted creatures tells us much about the health of our river.

Presently, water quality in the Eno River is good. The river is classified as a public water supply and it also suitable for swimming, fishing and wading. Continuing development and water withdrawals upstream give cause for concern about the river's quality. Only through sustained vigilance and protection efforts can the river's water quality be preserved.



Introduction to the Activity Packet for Eno River State Park

NOTE: Weather and river conditions permitting, on-site activities will be held on the banks of the river and in the river. Students will wade in shallow rocky areas. They should dress appropriately (long pants and tennis shoes) and bring a change of clothing. The students may encounter ticks, poison ivy and snakes, although this is not likely as long as students stay in appropriate areas. Chemical reagents are used in water quality testing. Because misuse of these chemicals can be hazardous, standard chemical protection procedures will be required. Goggles and rubber gloves will be provided for all students handling testing kits. These must be worn at all times during test procedures. The educator will assist in seeing that all safety precautions are followed. It is also the responsibility of the educator to be aware of special considerations, medical needs, etc. of participants and be prepared to take appropriate precautionary measures. Park staff should be informed of any special considerations prior to the group's arrival at the park.

The environmental education learning experience, *Living Water*, was developed to provide hands-on environmental education activities for the classroom and the outdoor setting of Eno River State Park. This educator's activity packet, designed to be implemented in grades 6-8, meets established curriculum objectives of the North Carolina Department of Public Instruction. Three types of activities are included:

1) pre-visit activities
2) on-site activities
3) post-visit activities

On-site activities will be conducted at the park, while pre-visit and post-visit activities are designed for the classroom environment. Pre-visit activities should be introduced prior to the park visit so that students will have the necessary background and vocabulary for the on-site activities. We encourage you to use the post-visit activities to reinforce concepts, skills and vocabulary learned in the pre-visit and on-site activities. These activities may be performed independently or in a series to build upon the students' newly gained knowledge and experiences.

The environmental education learning experience, *Living Water*, will expose the student to the following major concepts:

- **Water Quality**
- **Indicator Species**
- **Water Testing**
- **Watershed**
- **River Basin**
- **Point and Nonpoint Source Pollution**
- **Aquatic Macroinvertebrates**
- **Aquatic Food Webs**
- **Natural Resource Management**
- **Stewardship**

The first occurrence of a vocabulary word used in these activities is indicated in **bold type**. Their definitions are listed in the back of the activity packet. A list of the reference materials used in developing the activities follows the vocabulary list.

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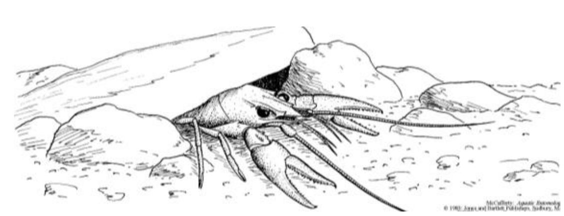


Activity Summary

The following outline provides a brief summary of each activity, the major concepts introduced and the objectives met by completion of the activity.

I. Pre-Visit Activities

1. Map Trivia
Using a transportation map and river basin map, students will learn that the Eno River watershed is part of the Neuse River Basin. They will trace the river from its headwaters to the ocean and identify key geographic locations, as well as potential point and nonpoint sources of pollution.

Major Concepts:
- River basin
- Watersheds
- Point and nonpoint pollution

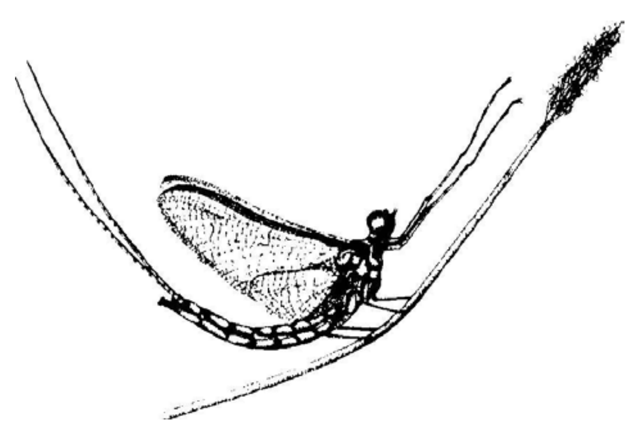
Learning Skills:
- Observing, communicating, inferring
- Reading and interpreting maps
- Estimating distances

Objectives:
- Interpret and use the legends on the North Carolina state transportation map to answer five questions.
- Locate five geographic locations within the Neuse River watershed.
- Identify potential sources of point and nonpoint pollution in the Neuse River Basin.

2. The Key to Water Quality
The students will practice using dichotomous keys to identify unknown tree leaves and macroinvertebrates found in the Eno River. Students will learn that macroinvertebrates are important indicators of water quality.

Major Concepts:
- Dichotomous key
- Indicator species
- Water quality
- Aquatic food webs

Learning Skills:
- Observing, classifying and communicating
- Reading taxonomic keys



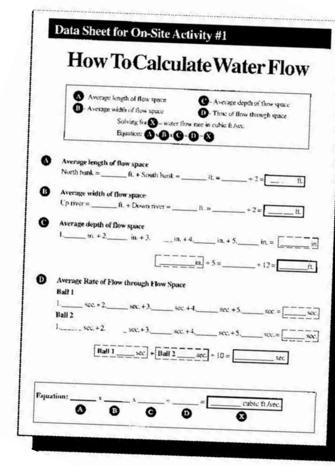
Objectives:

- Use simple dichotomous keys to identify pictures of ten unknown leaves and five unknown macroinvertebrates.
- Name at least two aquatic macroinvertebrates that are tolerant of pollution and two that are intolerant of pollution.
- Give at least two reasons why macroinvertebrates are important to humans.

II. On-Site Activities

1. Go with the Flow

Get wet while taking physical measurements of the river. Students will use their measurements to calculate water flow in the Eno River.



Data Sheet for On-Site Activity #1

How To Calculate Water Flow

A Average length of flow space
B - Average width of flow space
C - Average depth of flow space
D - Time of flow through space
Solving for X -- water flow rate in cubic ft./sec.
Equation: A x B x C ÷ D = X

A Average length of flow space
North bank = _____ ft. + South bank = _____ ft. = _____ ÷ 2 = _____ ft.

B Average width of flow space
Up river = _____ ft. + Down river = _____ ft. = _____ ÷ 2 = _____ ft.

C Average depth of flow space
1._____ in. + 2._____ in. + 3._____ in. + 4._____ in. + 5._____ in. = _____ in.
_____ in. ÷ 5 = _____ ÷ 12 = _____ ft.

D Average Rate of Flow through Flow Space
Ball 1
1._____ sec. + 2._____ sec. + 3._____ sec. + 4._____ sec. + 5._____ sec. = _____ sec.
Ball 2
1._____ sec. + 2._____ sec. + 3._____ sec. + 4._____ sec. + 5._____ sec. = _____ sec.
Ball 1 _____ sec. + Ball 2 _____ sec. ÷ 10 = _____ sec.

Equation: _____ x _____ x _____ ÷ _____ = _____ cubic ft./sec.
A B C D X

Major Concepts:

- Water flow
- Water quality
- Natural and human influences on water flow
- Aquatic habitats

Learning Skills:

- Observing, using numbers, collecting data in the field
- Measuring, averaging numbers, calculating water flow

Objectives:

- Calculate the rate of water flow using measurements and a mathematical formula.
- List three human actions that affect water flow.
- List three natural influences on water flow.
- Describe the important relationship between water quantity and quality.
- Describe three problems that can result from river water quantity extremes.
- Describe three problems that can result from river water quality changes.
- Discuss at least two things people can do to help protect rivers and water quality.

2. Mind Your p's and H's - The Power of Hydrogen (page 4.2.1)

Learn to measure pH by using hands-on methods to determine the pH values of several different liquids including water from the Eno River.

Major Concepts:

- Water quality
- pH range (acid-neutral-base)
- Acid precipitation

Learning Skills:

- Observing, classifying
- Reading informational materials with complex vocabulary
- Expanding on information

Objectives:

- Demonstrate the use of litmus paper and the LaMotte test kit for determining pH.
- Find the pH of at least three common substances.
- List two natural influences that can affect the pH rating of a river.
- List two human influences that can affect the pH rating of a river.
- State the North Carolina Environmental Management Commission pH range for aquatic macroinvertebrates (6.0-9.0).

3. Sediment: The "S" Word

Through a simple experiment, students will learn one method of measuring sediment. Using what they observe, students will discuss where sediment comes from, how it affects water quality, and ways to control sediment.

Major Concepts:

- Water quality
- Sediment
- Sedimentation
- Water pollution

Learning Skills:

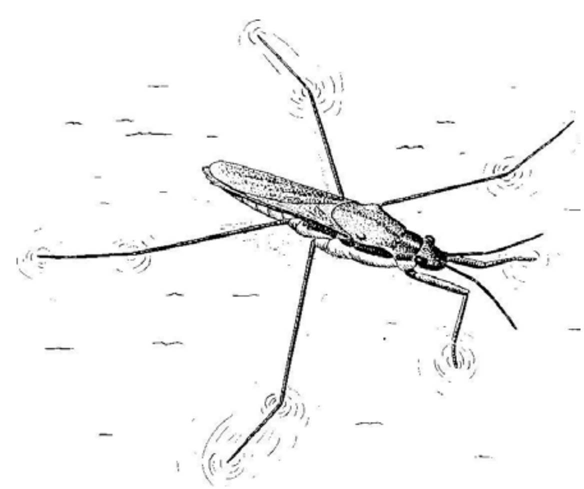
- Observing, inferring and predicting
- Reading technical information and expanding on ideas

Objectives:

- Demonstrate how to measure sediment levels using the Imhoff cones.
- Describe three ways sediment affects aquatic life.
- List three origins of sediment and three possible ways to control the level of sediment in the river.
- List the most important causes of stream degradation in North Carolina today.

4. Water Bugs

Get wet, have fun, and learn while doing it. Students will use different methods to collect and identify aquatic organisms.

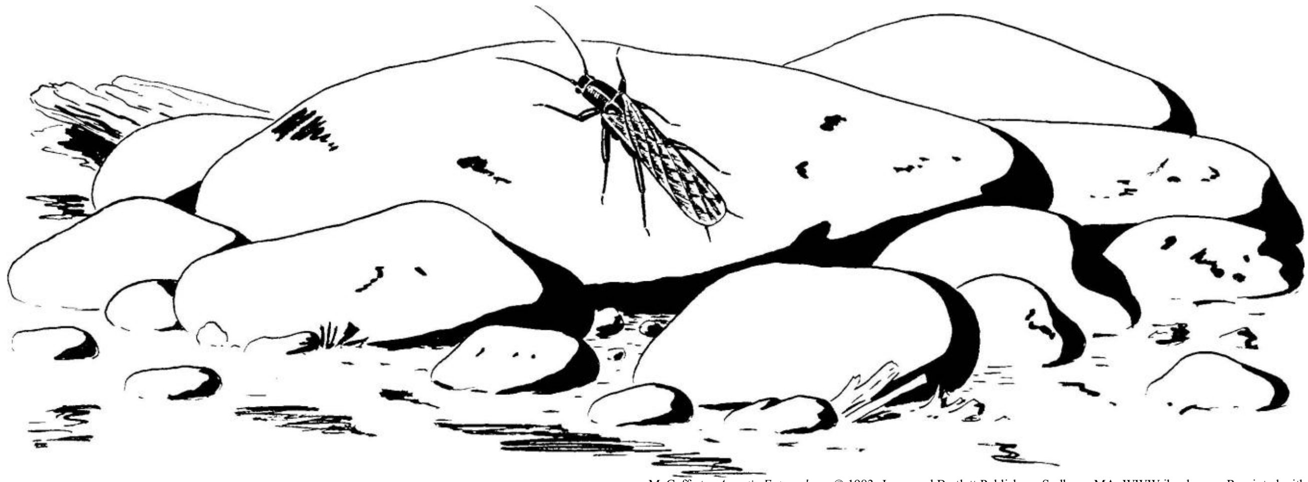


Major Concepts:

- Water quality
- Indicator species
- Adaptations
- Ecosystem
- Energy flow

Learning Skills:

- Observing, using numbers, classifying, inferring and predicting
- Reading informational materials; using keys and identification guides
- Calculating stream index values


McCafferty: *Aquatic Entomology*. © 1983: Jones and Bartlett Publishers, Sudbury, MA. WWW.jbpub.com. Reprinted with permission.

Objectives:
- Describe three characteristics of aquatic macroinvertebrates that help them survive in aquatic habitats.
- Using keys and field guides, identify three macroinvertebrates in the field.
- Name three indicator species and explain how they are used to determine water quality.
- Calculate the stream index rating for a river.
- List and describe five factors necessary for a healthy river ecosystem.

III. Post-Visit Activities

1 Fragile Waters
Using a topographic map and land use cutouts, students will make decisions about the development of a portion of the Eno River's watershed.

Major Concepts:
- River basin
- Water quality
- Land use planning
- Resource management

Learning Skills:
- Observing, communicating and predicting
- Problem solving, respecting differences, working in groups
- Expanding on ideas, recognizing bias and persuasive techniques

Objectives:
- List two animal species endemic to the Neuse and Tar river watersheds.
- Evaluate the effects of different imaginary land uses on the Eno River watershed.
- List and discuss five ways to minimize damaging effects in the Eno River watershed.
- Balance the need to protect water quality with economic and other concerns while working with a group to arrange land use cutouts on a map.
- Give at least two examples of how air and water quality are connected.

2 Growing Water Bugs
Students create a plan for growing water bugs using buckets or other containers. They will monitor the growth of plants and animals, summarize their findings and complete an assessment form highlighting their best practices for growing water bugs.

Major Concepts:

- Water Quality
- Adaptations
- Ecosystems
- Energy flow

Learning Skills:

- Observing, using numbers, classifying, inferring and predicting.
- Using keys and identification guides.
- Creative Writing

Objective:

- Design a water bug habitat plan for your school or backyard.
- Establish habitat for water bugs and aquatic life.
- Monitor and measure growth and colonization of plants, water bugs, algae and other aquatic life.
- Create a summary of your findings including a comparison of habitats, results, productivity and suggested adaptations.

NC Essential Standards Correlation Chart

Note to classroom teachers: The following Correlation Chart shows how each activity in this Environmental Education Learning Experience (EELE) correlates with the Common Core State and North Carolina Essential Standards objectives in science, mathematics, information and Technology, social studies and English language arts. The activities are listed in the order in which they appear in this EELE. The recommended grade levels are listed along the side of the chart. Notice that only the objective numbers are listed. Use the online Essential Standards for each subject area to get a complete description of the objectives in that subject area.

http://www.ncpublicschools.org/acre/standards/new-standards/

Map Trivia	2.RP.1, LITERACY.RI.3.7, 3.RP.1, LITERACY.RI.4, 4.RP.1, OA.6.1, 5.RP.1, 6.RP.1, 7.RP.1, 8.RP.1, 7.G.1, 8.E.1, 8.G.1.
Key to Water Quality	1.G.2, 2.G.2, 2.RP.1, 3.RP.1, OBIO.3.5, 4.L.1, LITERACY.RI.4, 4.RP.1, 5.L.2, OA.6.1, 5.RP.1, 6.RP.1, 7.RP.1, 8.RP.1, 8.E.1, 8.L.3.
Water Flow	1.L.2, 1.MD.A, 2.MD.A, 2.RP.1, 3.L.2, 3.MD.A, 3.RP.1, 3.P.1.1, 3.P.1.2, 4.MD.A, LITERACY.RI.4, 4.RP.1, 5.P.1, 5.MD.A.1, 5.MD.B.2, OA.6.1, 5.RP.1, 6.RP.1, 7.RP.1, 8.RP.1, 8.E.1.
Water Quality/PH	1.L.1, 1.L.2, 1.G.2, 2.RP.1, 3.MD.A, 3.RP.1, CHM.3.2.2, 4.L.1, 4.MD.A, LITERACY.RI.4, 4.RP.1, EEN.2.6, OA.6.1, 5.RP.1, 6.RP.1, 7.RP.1, 8.RP.1, 8.E.1, 8.L.3.
Sediment	2.RP.1, 3.RP.1, 4.L.1, LITERACY.RI.4, 4.RP.1, OA.6.1, 5.RP.1, 6.RP.1, 7.RP.1, 8.RP.1, 8.E.1.
Water Bugs	K.P.1, K.L.1, 1.L.2, 1.G.2,2.L.1, 2.L.2, 2.RP.1, 3.RP.1, BIO.3.5, 4.L.1, 4.MD.A, LITERACY.RI.4, 4.RP.1, BIO.2.1, 5.L.2, 5.MD.B.2, OA.6.1, 6.L.2, 7.E.2, 8.E.1, 8.L.3.
Fragile Waters	2.G.2,2.RP.1, 3.C&G.2.2, 3C&G.2.1, 3.RP.1, LITERACY.RI.4, 4.RP.1, BIO.2.2, EEN.2.4, EEN.2.6, 5.G.1, OA.6.1, 6.E.1, 5.RP.1, 6.RP.1, 7.RP.1, 8.RP.1, 8.E.1.
Growing Water Bugs	1.G.2, 2.L.1, 2.L.2, 2.RP.1, 3.L.2, 3.RP.1, 4.L.1, LITERACY.RI.4, 4.RP.1, BIO.2.1, 5.L.2, OA.6.1, 6.L.1, 5.RP.1, 6.RP.1, 7.RP.1, 8.RP.1, 8.E.1, 8.L.3.

Pre-Visit Activity #1 — Map Trivia

Major Concepts:
- River basin
- Watersheds
- Point and nonpoint source pollution

Learning Skills:
- Observing, communicating, inferring
- Reading and interpreting maps
- Estimating distances

Subject Areas:
- Science
- English Language Arts
- Social Studies
- Mathematics

* See **Activity Summary** for a Correlation with NC Essential Standards.

Location: Classroom

Group Size: 30 students

Estimated Time: 60 minutes

Appropriate Season: Any

Materials:
Provided by educator:
Per student: One copy of Student's Information and Neuse River Basin Map
Per group of 4 students: Map Trivia worksheet and current North Carolina transportation map

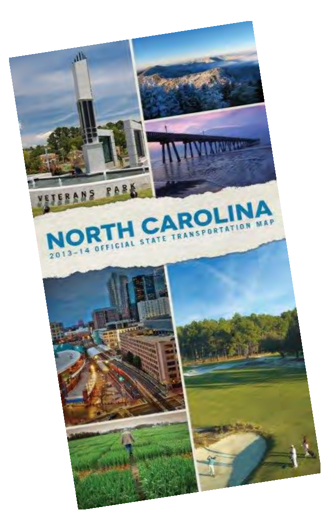
Maps are available through your local tourism office or by calling:

1-800-VISITNC or 1-877-DOT-4YOU

Objectives:
- Interpret and use the legends on the North Carolina transportation map to answer five questions.
- Locate five geographic locations within the Neuse River Basin.
- Identify potential sources of point and nonpoint pollution in the Neuse River Basin.

Educator's Information:

This activity is designed to illustrate the concept that the Eno River **watershed** is part of a larger river system––the Neuse **River Basin**. Students will trace the river from its headwaters to the ocean, using map legends and identifying key geographic locations along the water course. Students will participate in a group activity to obtain the answers for the worksheet.



Instructions: Part 1 – Map Trivia

1. Provide one North Carolina transportation map and one worksheet for every four students.

Note: The 2013 transportation map includes an insert on river basins. This map is preferred for this activity.

2. Have each group of students answer questions on the worksheet, using the map as a reference.

3. After the groups have finished their worksheets, have each group answer one of the questions and explain how they got the answer to the class. Continue with each group reporting their answer until all questions have been answered and discussed.

Part 2– Sources of Water Pollution

1. Have students use the Neuse River Basin map in this activity, along with the DOT map, to determine how many cities with a population over 10,000 exist in the Neuse River Basin. [Answer: eight—Durham, Cary, Raleigh, Garner, Smithfield, Goldsboro, Kinston, and New Bern.]

Ask students to find the population growth statistics located on the Neuse River Basin map. Note also that one-third (33%) of all the monitored streams in the basin are listed as "impaired" (from the 1998 study of the Neuse). Discuss: If population continues to grow as projected, what might happen to the water quality in the river basin? Explain. Sample Answer: The water quality of the basin would likely decrease due to increased amounts of **sediment** and other types of **runoff** from lawns, streets and parking lots. To provide for a growing population, more water will be needed for households, businesses and industries. A reduction in the quantity of water would result in a concentration of pollutants in the remaining water supply.

2. Ask students to read the Student's Information that discusses **point** and **nonpoint source pollution.**

Then, using the Neuse River Basin map and the DOT map, teams of students should list possible sources of point and nonpoint pollution in the Neuse River Basin. (To find out about actual sources of pollution, call the Division of Water Quality at (919) 733-5083 to receive a copy of the Neuse River Basin wide Water Quality Management Plan. Or, see web site given under Extensions.)

Assessment:

As a post-test, design some questions of your own about the Neuse River Basin (or another river basin), based on the DOT map.

In addition, ask students to write their answers to the following questions:

1. Define point and nonpoint source pollution, giving examples of each.

2. Explain the connection between air and water pollution.

3. Describe at least three ways that they, as individuals, may be contributing to water pollution and what can be done about it.

Extensions:

If research on the web is possible, have students find out what river basin they live in. Use the Division of Water Quality web site at: http://h2o.enr.state.nc.us/wqs/ At this site, you can view basin statistics and maps for all the river basins in North Carolina. You can also find recent data on **dissolved oxygen**, salinity, **pH**, etc. for the Neuse River.

Student's Information: Map Trivia

Each of us lives in a watershed. Unfortunately many of our watersheds today are being damaged by pollution. Water pollution is generally defined as human-caused contamination of **water** that reduces its usefulness to humans and other **organisms**.

Scientists divide water pollution into two major categories: point and nonpoint. **Point source pollution** comes from a localized source and is fairly easy to pinpoint. An example would be a specific type of chemical that a factory releases through a pipe into a stream. The factory may be the only source of this particular chemical in the watershed. We could prevent further pollution from the chemical by ordering the factory to stop discharging into the water.

Nonpoint source pollution cannot be easily traced to a specific source. It often occurs as **runoff** from large areas such as farms, logging roads, construction sites, lawns, streets and parking lots. Nonpoint source pollution does not enter the waterway at a single point or originate from a single location. Therefore, it is much harder to manage than point source pollution. Examples of nonpoint source pollution include **sediment**, nutrients and pesticides.

Sedimentation
Sediment is the main source of pollution of North Carolina's surface waters. Sedimentation (or **erosion**) results mainly from construction sites, urban runoff, row-cropping, livestock operations, and logging operations. Sediment often carries other pollutants along with it. It can have a negative impact on recreational, industrial and municipal water uses, as well as on aquatic **habitats**. Sediment can fill lakes, navigation channels and harbors, resulting in costly dredging operations.

Nutrients
Other than sediment, the pollutants of greatest concern from both rural and urban areas are nutrients. Nutrients are compounds containing nitrogen and/or phosphorous. They stimulate plant growth, causing **algal blooms**. When the **algae** die and sink to the bottom, they use up oxygen as they decompose. Fish kills occur when **dissolved oxygen** drops below levels needed by fish to breathe.

Point sources of nutrients may be traced to septic tank failures or discharges from **wastewater treatment plants**. Nonpoint sources include runoff from urban lawns and farm fields, as well as atmospheric sources.

Air Pollution
Atmospheric pollutants can cause problems when they reach water bodies as wet or dry fallout. According to recent scientific studies, 25-50% of the nitrogen entering eastern North Carolina waterways each year comes from atmospheric sources. One important source is the combustion of fossil fuels in vehicles, factories and power plants. Another source is the vaporization of wastes and fertilizers from large farming operations and wastewater treatment plants. Nitrogen oxides contribute to **acid rain**, which increases the acidity of our waters.

It is important to realize that the Eno River watershed is connected to many other small watersheds that make up the Neuse **River Basin**. If one watershed in the basin becomes contaminated, it will eventually affect all the watersheds downstream. Watersheds near the ocean can be severely degraded by the accumulation of pollutants from many sources.

As you explore the Neuse River Basin on the transportation map, consider the various sources of pollution that might enter the basin from Hillsborough to the Atlantic Ocean.

Neuse River Basin Map

Neuse River Basin Statistics

Area: 6,235 square miles

Stream Miles: 3,440

No. of Counties: 24 (17 counties with more than 5% of their area in basin)

No. of Subbasins: 14

Population (1990): 1,015,511

Est. Population (1996): 1,175,032

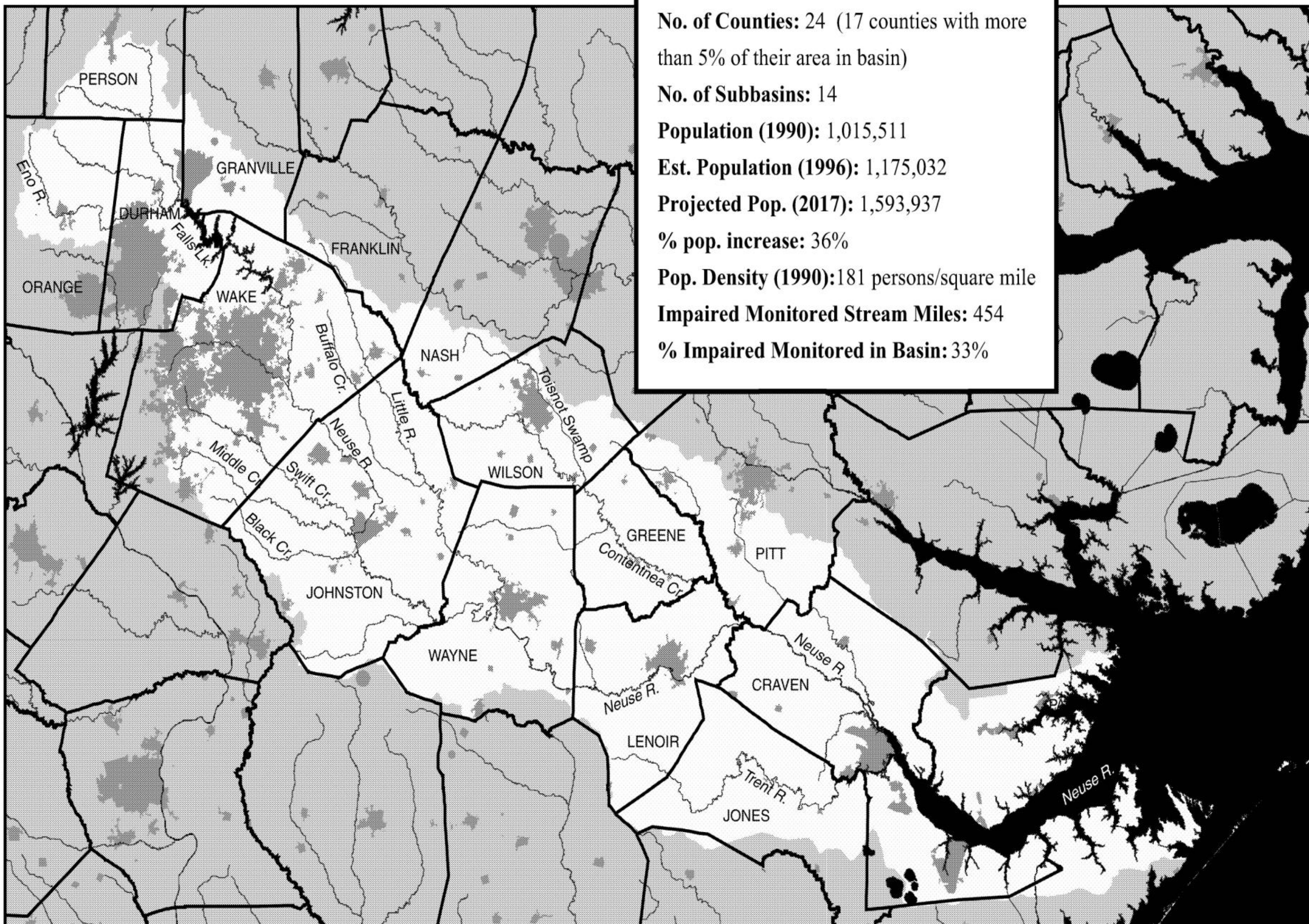
Projected Pop. (2017): 1,593,937

% pop. increase: 36%

Pop. Density (1990): 181 persons/square mile

Impaired Monitored Stream Miles: 454

% Impaired Monitored in Basin: 33%



Note: Lakes, rivers and sounds are shown in black.
Major cities and towns are dark gray.

Map Courtesy of Department of Environment and Natural Resources, Division of Water Quality

Map Trivia Worksheet

Instructions: Using the North Carolina transportation map, answer the following questions.

1. What is the name of the county where the Eno River begins?
   ____

2. Name the 5 counties surrounding Orange County.____________
   ____
   ____
   ____
   ____

3. Name the river that joins the Eno River near Camp Butner (northwestern end of Falls Lake)?
   ____

4. List the counties the Eno River flows through before becoming the Neuse River near Camp Butner (northwestern end of Falls Lake).
   ____
   ____

5. Approximately how long is the Eno River?
   in miles___________
   in kilometers________

6. What is the name of the reservoir into which the Eno River flows?
   ____

7. What is the name of the river which eventually carries the water from the Eno to the ocean?
   ____

8. What is the first town with a population over 2,000 through which the Eno flows?
   ____

9. What is the name of the sound into which the water from the NEUSE River flows?
   ____

10. Approximately how many miles are there between Durham and New Bern in a straight line? ______________
    In kilometers________

11. List the three state parks and recreation areas located along the path that the Eno River takes to the ocean.
    ____
    ____
    ____

12. What is the approximate distance from Ranger, NC to Whalebone, NC?
    in miles____________
    in kilometers________

13. A major tributary that drains parts of Greene, Pitt and Wilson counties enters the Neuse River just below what city (with a population over 10,000)?
    ____

14. What is the closest **latitude** and **longitude** to Eno River State Park?
    ____
    ____

15. New Bern is closest to what latitude and longitude?
    ____
    ____

16. What is the name of the national forest found along the Neuse River.
    ____

17. Name the river located west and south of the Eno River near Burlington.
    ____
    To what river basin does it belong?
    ____

18. Near what large city does the river from question 17 reach the ocean?
    ____

19. Name the river located north and east of Falls Lake.
    ____

20. List the cities with populations over 10,000 along the Eno and Neuse River?
    ____
    ____
    ____

Answers for Map Trivia

1. Orange County
2. Caswell, Person, Durham, Alamance, Chatham
3. Flat River
4. Two - Orange and Durham
5. Approximately 33 miles Approximately 53 kilometers
6. Falls Lake
7. Neuse River
8. Hillsborough
9. Pamlico Sound
10. Approximately 120 miles Approximately 193 kilometers
11. Eno River State Park, Falls Lake State Recreation Area, Cliffs of the Neuse State Park
12. Approximately 500 miles Approximately 805 kilometers
13. Kinston Note: The tributary, not named on the DOT map, is Contentnea Creek.
14. 79 degrees longitude, 36 degrees latitude
15. 77 degrees longitude, 35 degrees latitude
16. Croatan National Forest
17. Haw River; Cape Fear River Basin
18. Wilmington, NC
19. Tar River (or Tar-Pamlico River Basin)
20. (Nine) Durham, Raleigh, Wake Forest, Clayton, Smithfield, Goldsboro, Kinston, New Bern, Havelock.

Pre-Visit Activity #2 The Key to Water Quality

Major Concepts:
- Dichotomous key
- Indicator species
- Water quality
- Aquatic food webs

Learning Skills:
- Observing, classifying, and communicating
- Reading taxonomic keys

Subject Areas:
- Science
- English Language Arts

* See **Activity Summary** for a Correlation with NC Essential Standards

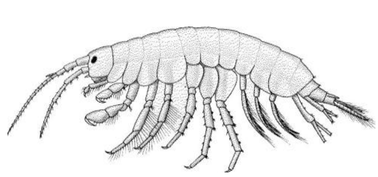
Location: Classroom

Group Size: 30 students

Estimated Time: 50 minutes

Appropriate Season: any

Materials:
Provided by educator:
Per student or group: One copy of the following—
Student's Information; Key to 10 Common Leaves; 10 Common Leaves; Key to Common Macroinvertebrates Found at Fews Ford, Eno River State Park; and Aquatic Life Illustrations.



Objectives:
- Use simple dichotomous keys to identify pictures of ten unknown leaves and five unknown macro-invertebrates.
- Name at least two aquatic macroinvertebrates that are tolerant of pollution and two that are intolerant of pollution.
- Give at least two reasons why macroinvertebrates are important to humans.

Educator's Information:
This activity introduces students to **dichotomous keys**. Students will key out several **macroinvertebrates** using the same key that they will use at the park during On-Site Activity #4, "Water Bugs." Students will also learn that macroinvertebrates are **indicator species** that help us determine water quality. A discussion of their role in aquatic **food webs** is included in the Student's Information.

Instructions:
Have the students read the Student's Information and use the Key to 10 Common Leaves to identify the leaves on the 10 Common Leaves worksheet. As a class, go over the answers and discuss and difficulties encountered. Next, give each student (or group) a copy of Aquatic Life Illustrations and the Key to Common Macroinverte-brates. As a class, work through the key to identify animal #1, then have the students identify the rest of the macro-invertebrates on their own.

When everyone is done, have individual students or groups share how they iden-tified one of the macroinvertebrates. Ask them to use the Key to Common Macro-invertebrates to determine if their organism is tolerant, intolerant or moderately tol-erant of pollution. Discuss the importance of macroin-vertebrates as indicators of water quality and members of food webs.

Assessment:
Use the test found at the end of this activity. Can stu-dents follow the "text only" key to identify the five un-known macroinvertebrates? On the back of their papers, ask students to write, in paragraph form, two reasons why macroinvertebrates are important to humans.

Test Answers: 1caddisfly larva, 2-scud, 3-mayfly nymph, 4-ramshorn snail, and 5-riffle beetle adult. The scud is moderately tolerant of pollution. All the others are intolerant.

Student's Information: They Key to Water Quality

Name That —Bug"!

One important method for determining water quality is to look at what lives in the **water**. When you visit Eno River State Park, you'll be doing just that—identifying water "bugs"!

The numbers of **organisms** you find in the river and the diversity of **species** will tell you if the river is healthy. Excellent water quality is indicated by the presence of a large number of different kinds of organisms, especially those intolerant of pollution. Examples of animals that require excellent water quality are stoneflies, freshwater **mussels** and water pennies. Only certain kinds of animals are able to live in polluted water. If the acidity of the water is too high or if **dissolved oxygen** is too low, most aquatic animals cannot survive. Examples of animals that are tolerant of pollution are black fly **larvae**, leeches and certain types of worms.

In this activity, you'll meet some of the animals that live in the Eno River. You'll also learn how to identify or classify them using a **dichotomous key**. A dichotomous key divides characteristics that describe organisms into two choices. At each level of the key, you will pick the choice that best describes the organism you are trying to identify.

How a Dichotomous Key Works

Practice using the Key to 10 Common Leaves first. Notice that the list of leaf characteristics is arranged as a series of either/or statements. For each pair of statements, only one will be the correct description of the unknown leaf. For example, if you are handed a leaf from a pine tree to identify, you would start at the top of the key with these two choices:

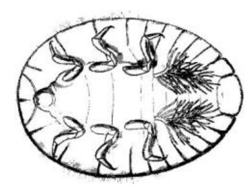
1. Leaf long and needle-like, or
2. Leaf not needle-like.

A pine needle is long and needle-like, so you would choose statement 2 and continue to the next pair of choices under that side of the dichotomous key.

After you have mastered the leaf key, you can try the Key to Common Macroinvertebrates. A **macroinvertebrate** is an invertebrate (animal without a backbone) that can be seen with the naked eye. Many of them are **insects** or insect larvae, but only a few are true bugs. Macroinvertebrates also include many non-insect groups—mollusks (example: snails and **mussels**) and crustaceans (example: crayfish). Notice that each macroinvertebrate's name on the key is followed by a letter "T" (Tolerant of pollution), "I" (Intolerant) or "M" (Moderately tolerant).

Food Webs

Many of the macroinvertebrates are predators that eat other animals; for example, the dobsonfly larva and the dragonfly **nymph**. Others, like freshwater mussels, scuds and caddisfly larvae, eat **detritus** (decaying materials) in the water. Some, like leeches, are parasites on fish, reptiles or mammals. All the macroinvertebrates play an important role in the **food web** of a river or stream. For example, many fish depend on aquatic insects for food. Without them, most of the fish would starve and the food web would begin to collapse. Mussels, snails and crayfish are eaten by a wide variety of animals, including more terrestrial species such as the raccoon.

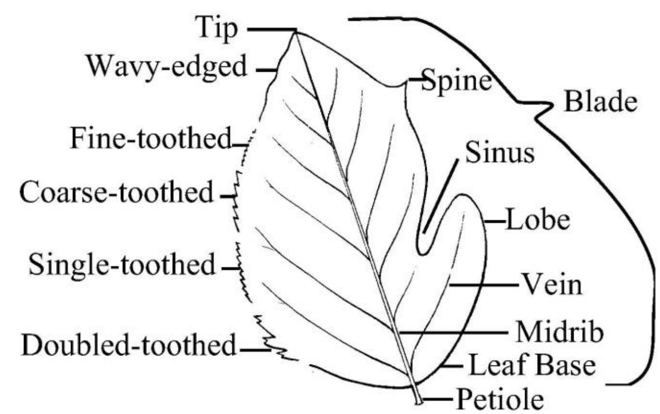


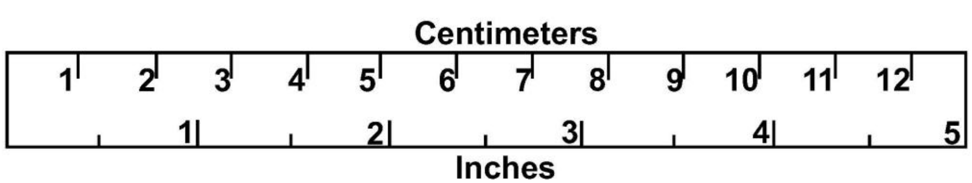
So the next time you see an "ugly bug" in the water, don't turn away in disgust. Learn its name by keying it out! This little animal can tell you what's happening to your favorite swimming hole or to the water supply for your town. That's why we call it an **indicator species**—its presence or absence can be used to determine the health of a particular environment. Remember that "beauty is in the eye of the beholder"!

Key to 10 Common Leaves

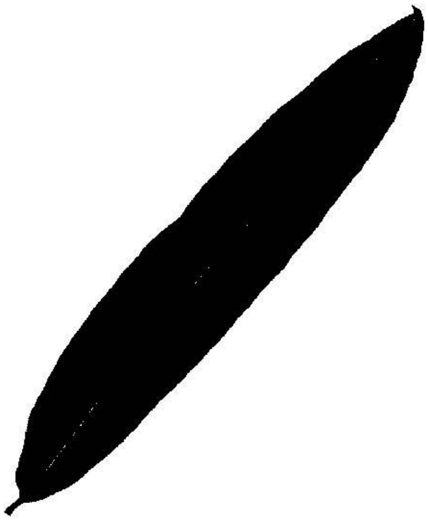
(Tree Leaves)

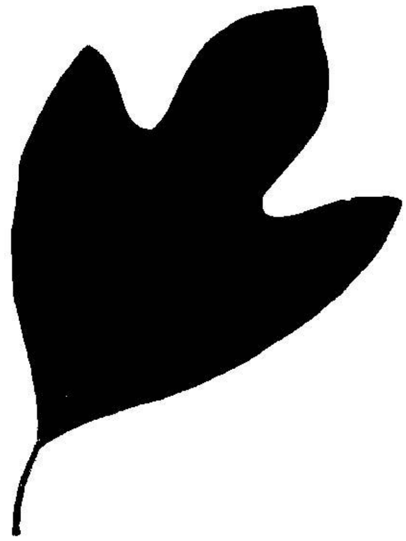
- Leaf long & needle-like
  - Leaves in group of 2; less than 10 cm long — *Shortleaf pine*
  - Leaves in group of 3; more than 10 cm long — *Loblolly pine*
- Leaf not needle-like
  - Leaf with lobes
    - Edge of leaf without teeth
      - Petiole of leaf 1 cm or longer
        - Leaf petiole less than 2 cm — *Sassafras*
        - Leaf petiole longer than 2 cm — *Tulip poplar*
      - Petiole of leaf less than 1 cm — *White oak*
    - Edge of leaf with teeth
      - Leaf with 5 lobes; petiole 3.5 cm or longer — *Sweet gum*
      - Leaf with 3 lobes; petiole shorter than 3.5 cm — *Red maple*
  - Leaf without lobes
    - Leaf edge with teeth
      - Each tooth with spine — *American holly*
      - Teeth without spines — *River birch*
    - Leaf without teeth — *Willow oak*

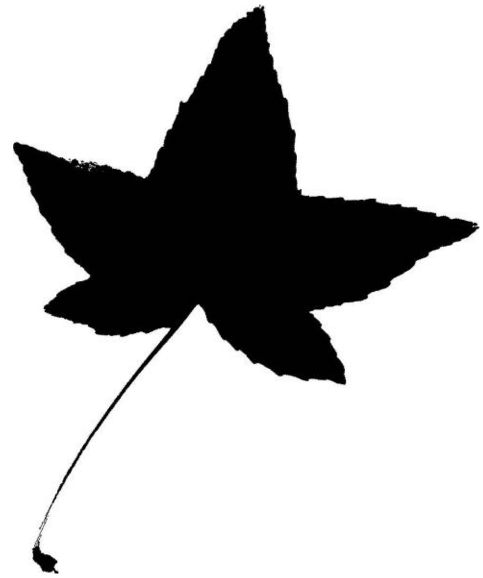




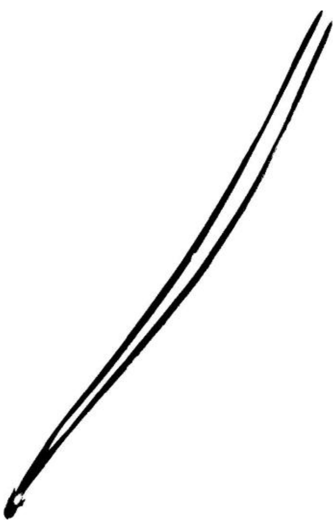
10 Common Leaves

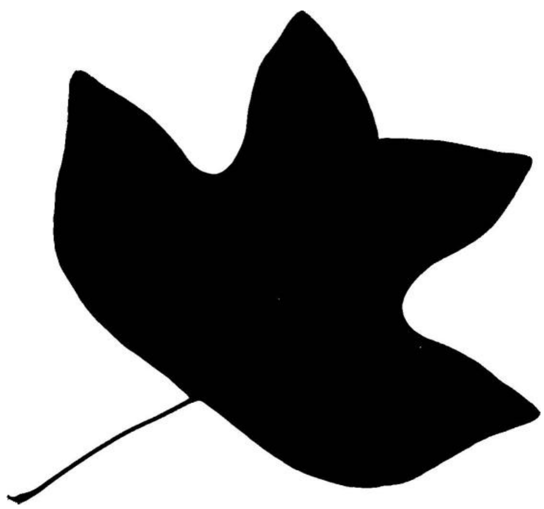


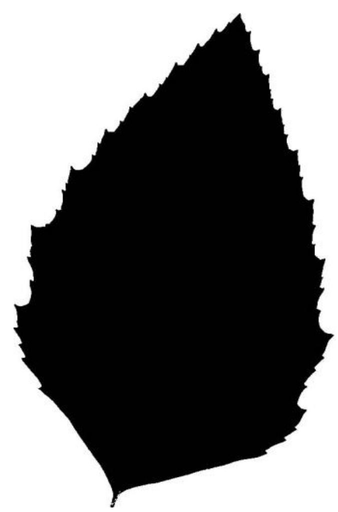




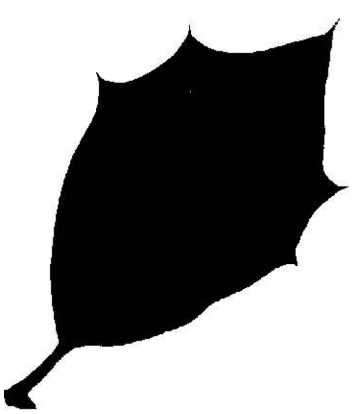
1.________________ 2.________________ 3.________________

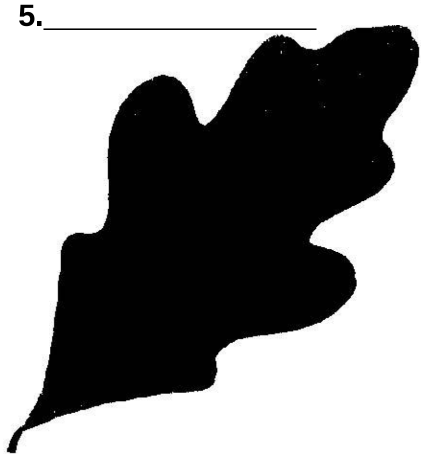


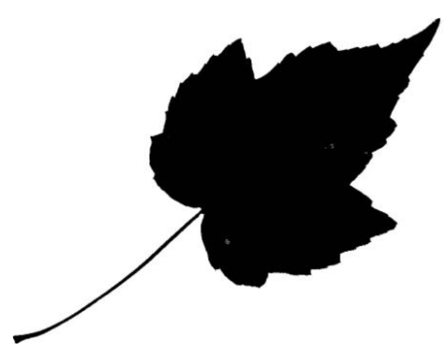




4.________________ 5.________________ 6.________________





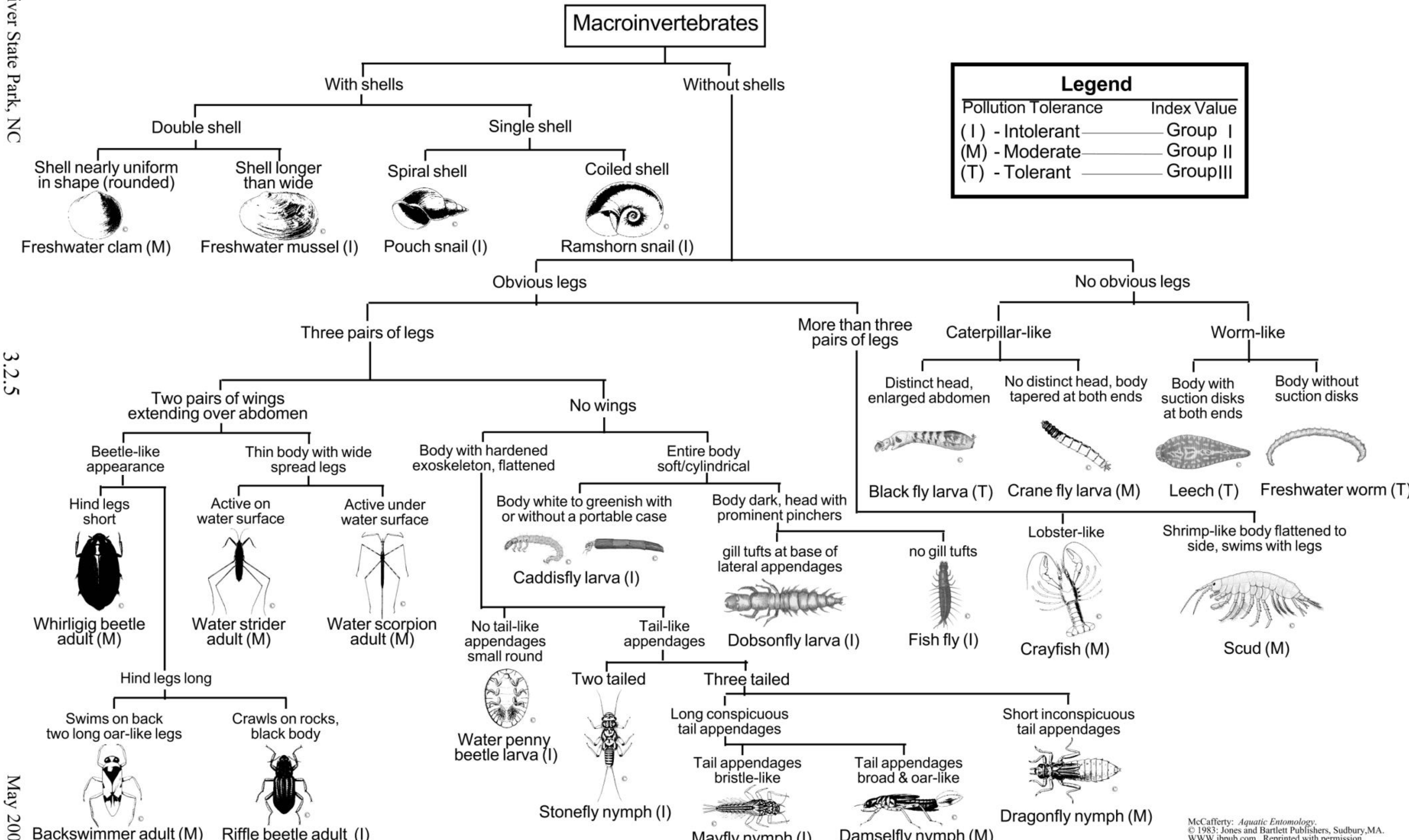


9.________________

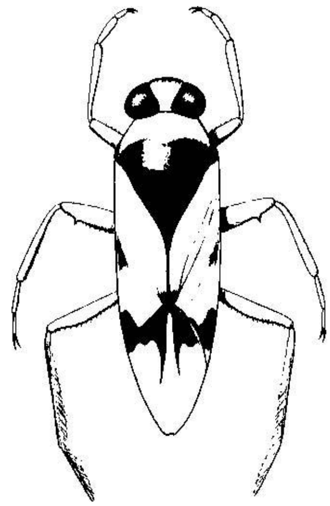
7.________________ 8.________________

10.________________

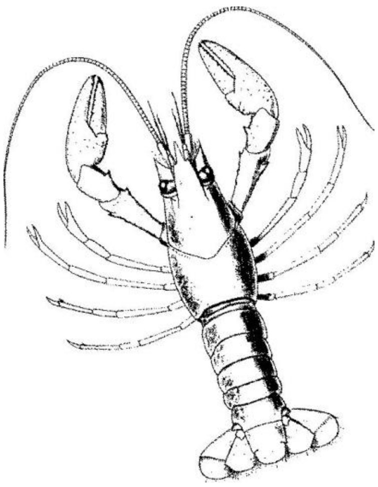
Key To Common Macroinvertebrates
Found at Fews Ford, Eno River State Park



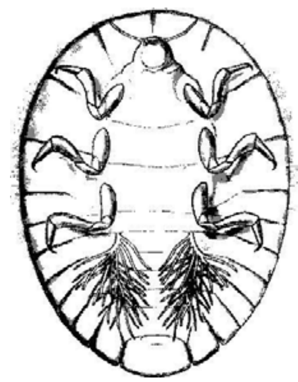
Aquatic Life Illustrations



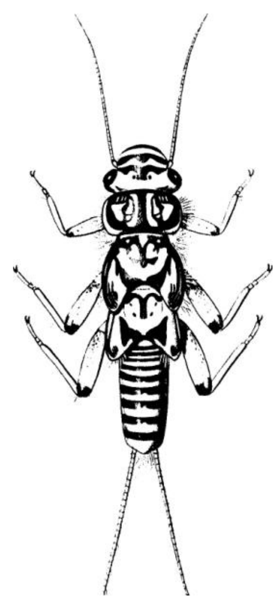
1. ____________________



2. ____________________

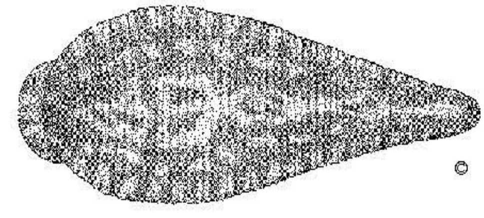


3. ____________________



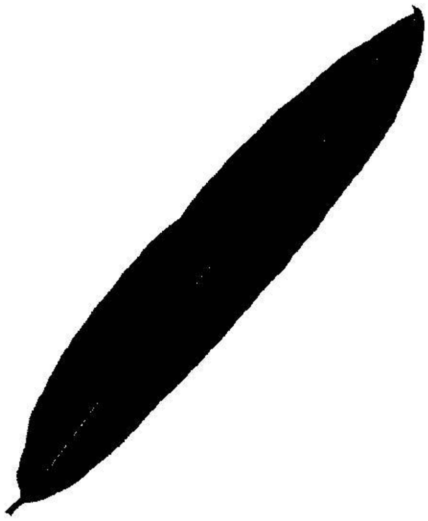
4. ____________________

5. ____________________

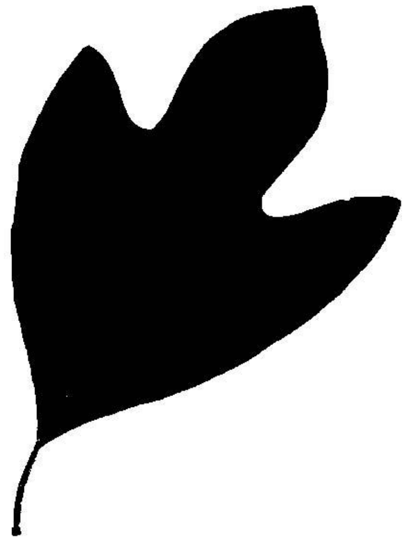


6. ____________________

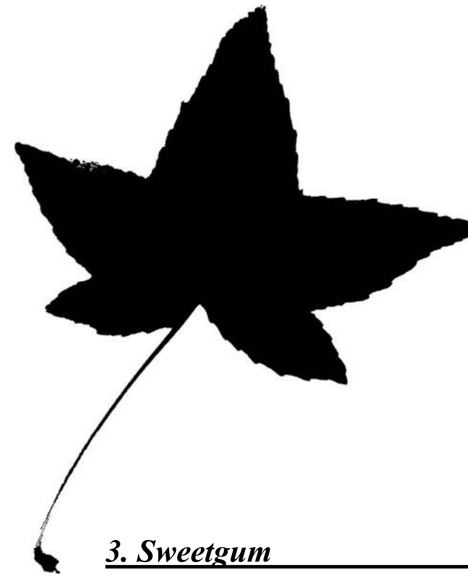
Answer Sheet to 10 Common Leaves



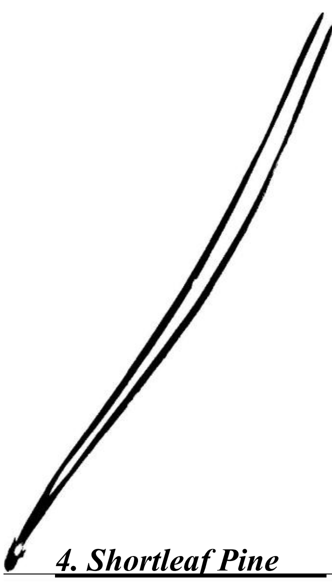
1. Willow Oak



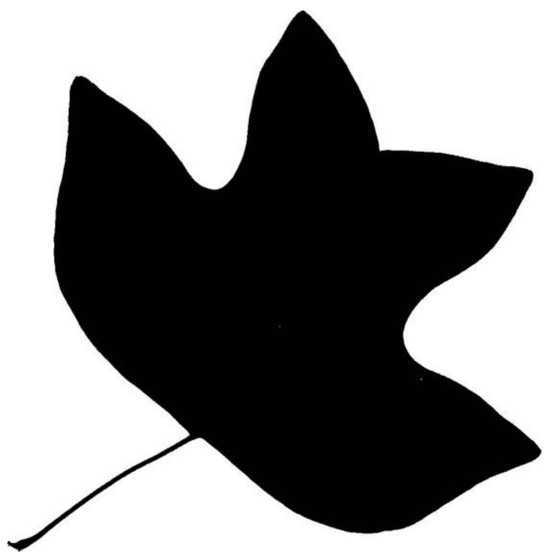
2. Sassafrass



3. Sweetgum

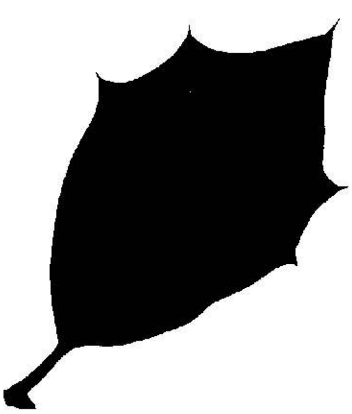


4. Shortleaf Pine

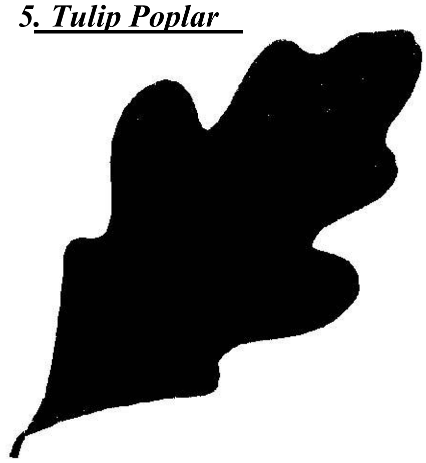


5. Tulip Poplar

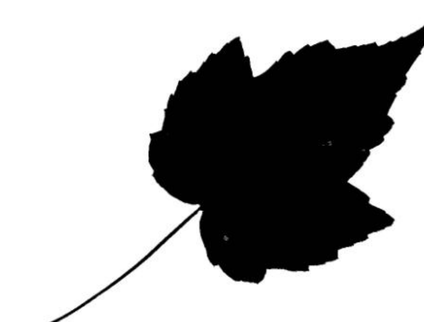
6. River Birch



7. Americah Holly



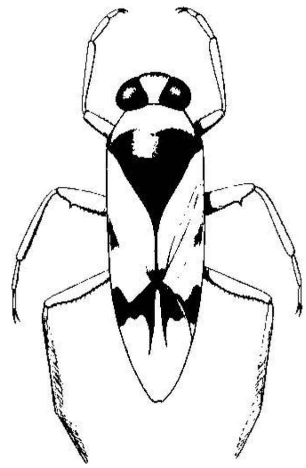
8. White Oak



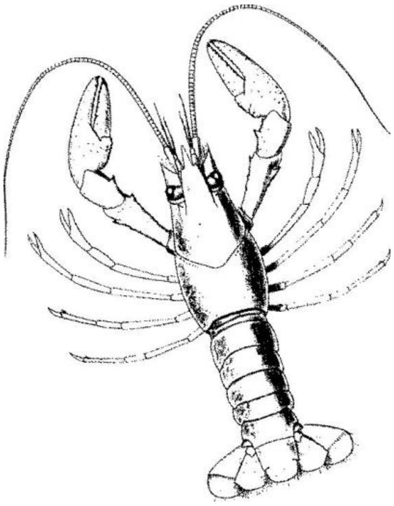
9. Red Maple

10. Loblolly Pine

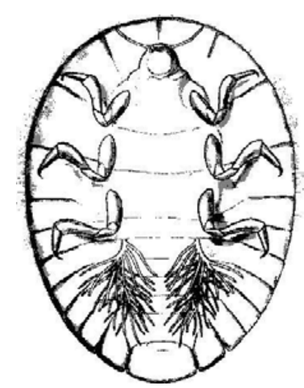
Answer Sheet to Aquatic Life Illustrations



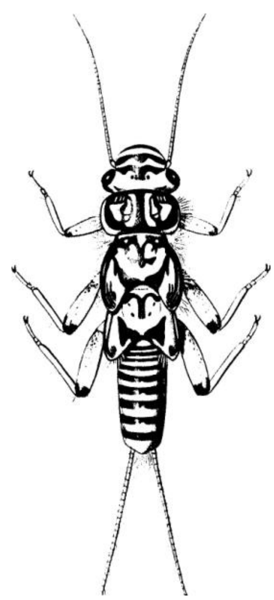
1. Backswimmer Adult



2. Crayfish

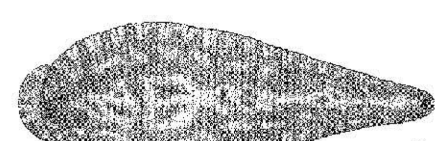


3. Water Penny



4. Stonefly Nymph

5. Freshwater Museel

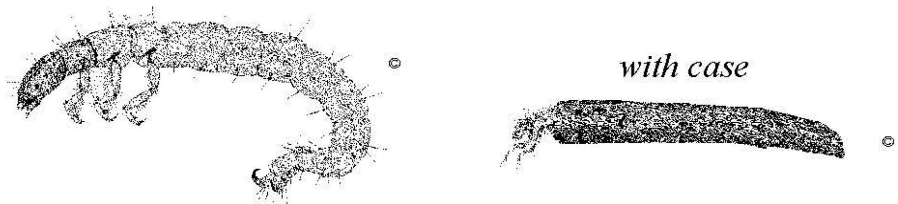


6. Leech

The Key to Water Quality – Test

Can you identify these five macroinvertebrates? Use the key to help you.

1.



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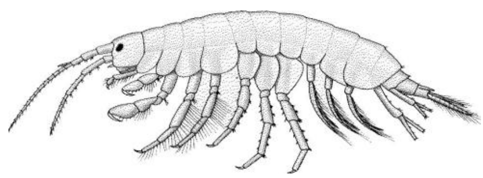
2.



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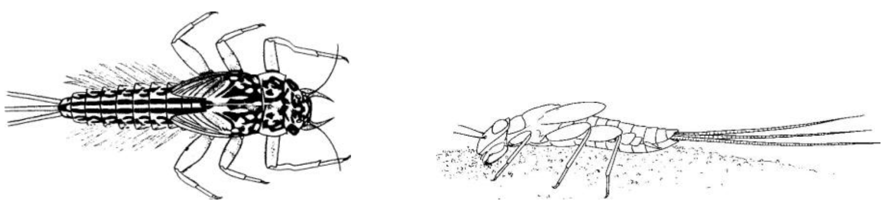
3.



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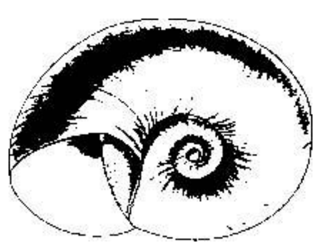
4.



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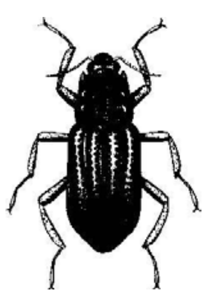
5.

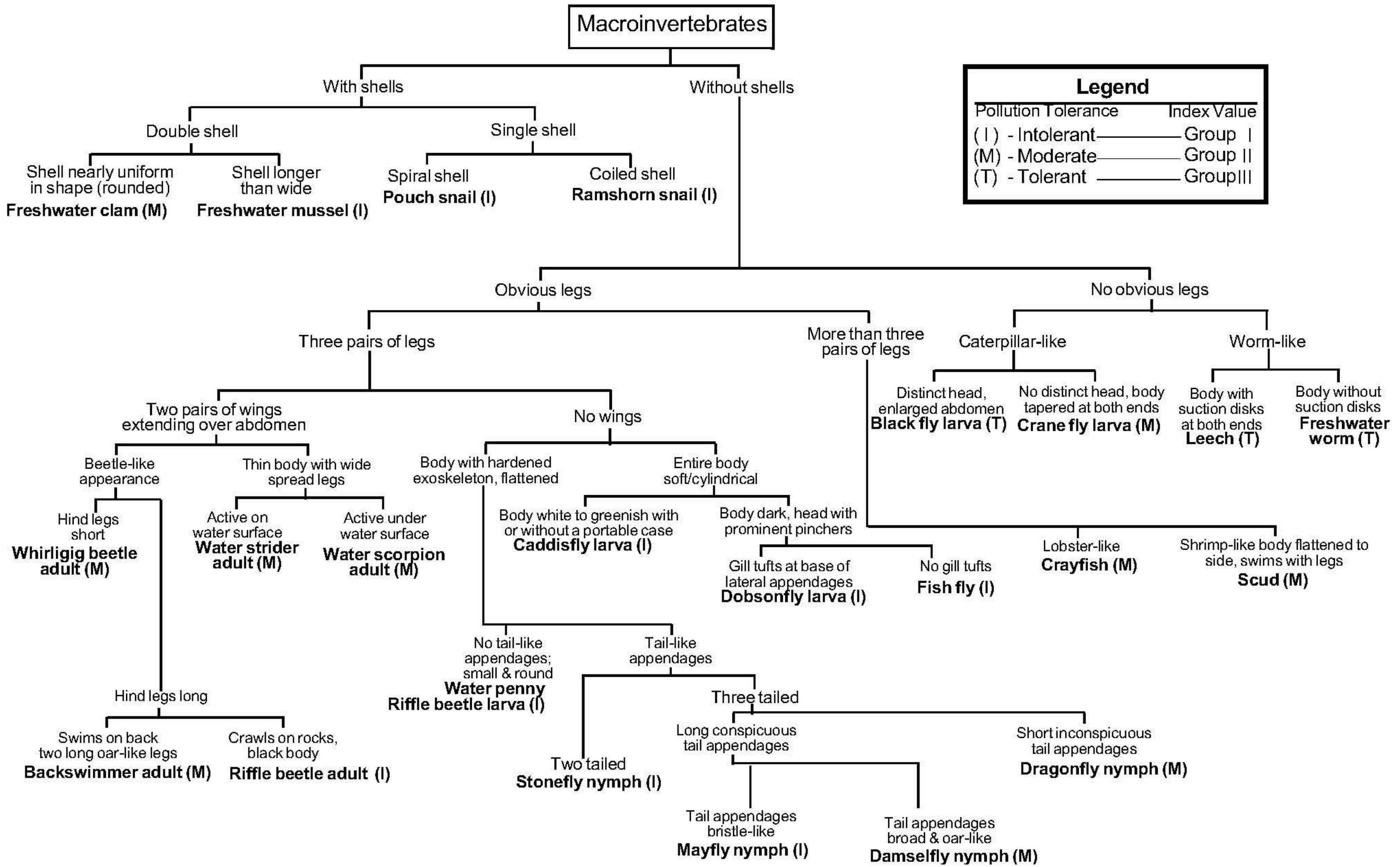


____

Which of the five animals above could live in water that is somewhat polluted?

____

The Key to Water Quality - Key for Test



On-Site Activity #1 Go With The Flow

Major Concepts:
- Water flow
- Water quality
- Natural and human influences on water flow
- Aquatic habitats

Learning Skills:
- Observing, using numbers, collecting data in the field
- Measuring, averaging numbers, calculating water flow

Subject Areas:
- Science
- Mathematics
- English Language Arts
- Social Studies

* See **Activity Summary** for a Correlation with NC Essential Standards

Location:
Few's Ford Access Area

Group Size:
8 students per group

Estimated Time: 30 minutes

Appropriate Season:
April through October

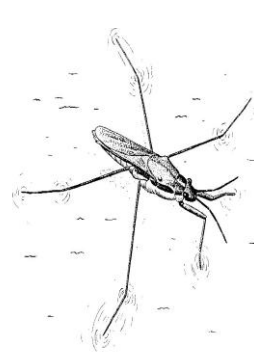
Materials:
Provided by park: life jackets, throw ropes, 100 ft. tape measure, metal yardstick, stopwatches, tennis balls, boundary ropes, charts, activity sheets, clipboards, pencils
Provided by educator: worksheets (one per student), pencils

Special Considerations:
See the safety message on the Introduction page.

Calculating Water Flow in the Eno River

Objectives:

- Calculate the rate of water flow using measurements and a mathematical formula.
- List three human actions that affect water flow.
- List three natural influences on water flow.
- Describe the important relationship between water quantity and quality.
- Describe three problems that can result from river water quantity extremes.
- Describe three problems that can result from river water quality changes.
- Discuss at least two things people can do to help protect rivers and water quality.



Educator's Information:

In this activity, the students will learn a simple method for determining water flow. They will then use this information to explore the ways that water flow and water quality are affected by human and natural factors. They will also be asked to think of ways they can influence local governments to protect water quality.

To prepare your students for their visit we recommend Pre-visit Activity #1, "Map Trivia."

Instructions:

1. Prior to your visit to the park, have students read the Student's Information. Lead a brief discussion concerning the importance of **water** flow in maintaining water quality. Explain that in this activity, the students will learn how to calculate water flow and thus be able to evaluate this aspect of the Eno River's water quality.

2. Explain the method for measuring water flow and safety procedures that must be followed.

3. Select three students to get into the water. Have two students measure the length and width, and one student measure the depth of the flow space. Have the other students write down the measurements on their worksheets.

4. Select four students to measure the rate of flow. Have two students, each with a ball go to the upstream end of the flow space. Have two other students, each with a stopwatch go to the downstream end of the flow space.

The student with ball should place it in the river upstream from the beginning of the flow space and hold his/her hand in the air. As the ball passes the beginning of the flow space, he/she quickly drops his/her hand. This is the signal for the student with stopwatch to start the stopwatch.

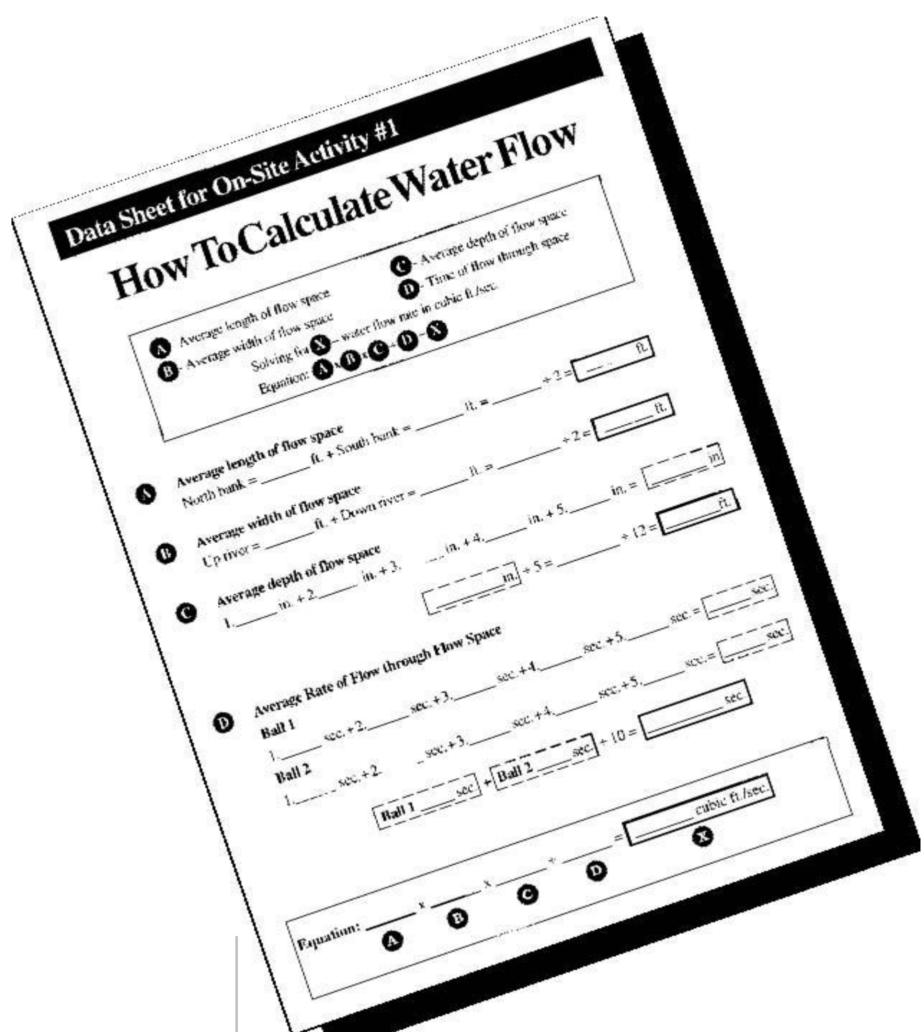
The stopwatch is stopped the moment the ball passes out of the flow space. He or she will then retrieve the ball, and they will repeat this four more times.

The students with ball and stopwatch will follow the same procedure. The other students will record the flow rates on their worksheets as the students with the stopwatches announce them.

5. Have all the students determine the four averages and then calculate the water flow rate in cubic feet/second. Discuss these results and what they might mean to the Eno River's water quality.

6. Lead a discussion of factors that affect water flow (natural and human), and how these factors in turn affect aquatic life. (Natural factors affecting water flow include drought, flooding and natural stream obstruction, i.e., beaver dams or log jams. Human activities include dams, **irrigation**, and industrial use. These natural and unnatural water controls can adversely impact aquatic **organisms** by reducing water flow and decreasing water quality. See "Water Flow Basics" under Student's Information for specific examples of how changes in water flow alter aquatic **habitats**.)

7. Discuss how low (or high) water flow can affect aquatic **food webs**. (When the aquatic habitat changes as a result of water flow decrease or increase, some animals may die. Other animals that depend on them for food will also eventually die)



8. Ask the students how they can influence the government to protect our water resources. Be sure to emphasize the importance of everyone being involved in caring for our resources (**stewardship**). The Eno River Association is an organization that exemplifies stewardship. If time allows, the leader will briefly explain how the park was created with the help of the Eno River Association.

Assessment:

Pencil and Paper Test—

1. Create your own post-test by filling in the sections A, B, C, and D on the worksheet in this activity. Can students calculate the water flow with the data you have provided?

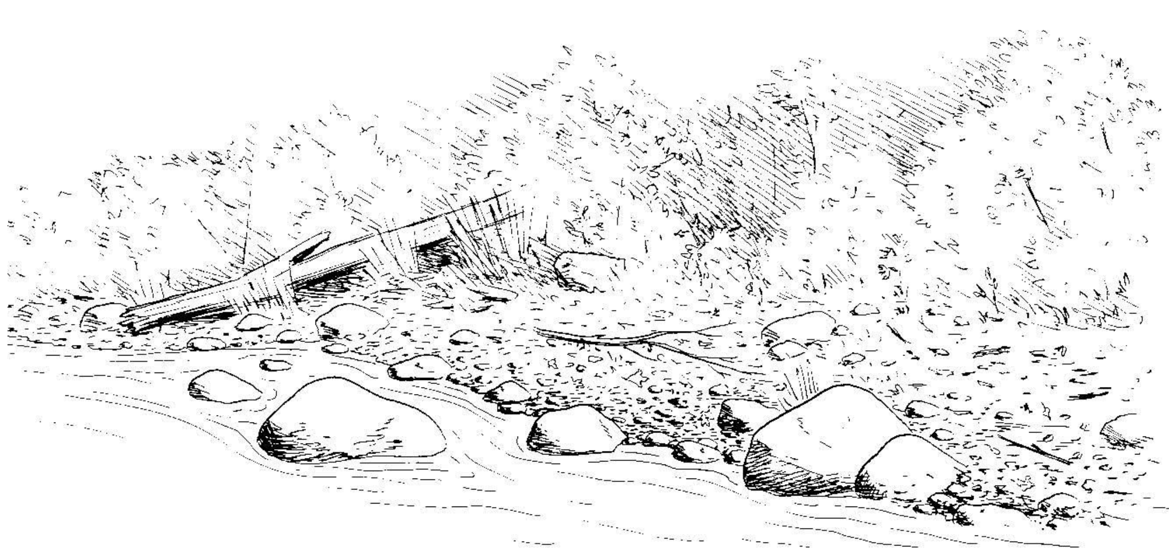
2. Ask students to list three natural causes and three human causes for changes in water flow.

3. Have students describe two ways that low flow can affect water quality. Repeat for high flow.

4. Finally, ask your students to give several ways that people can protect rivers and water quality.

Extension:

Although water flow is more often expressed in cubic feet per second, you can ask your students to convert this to the metric system. To convert cubic feet per second to cubic meters per second, multiply by 0.03. Example: 371 cubic feet per second becomes 11.13 cubic meters per second.



Student's Information: Water Flow

Water flow refers to the amount of **water** moving in a river or stream. Some of the ways that we express the rate of flow are gallons per second, cubic feet per second, or acre feet per second. (An acre foot is equal to one acre of water one foot deep, or 325,850 gallons of water.) When you visit Eno River State Park, you will participate in an activity to estimate the water flow in cubic feet per second. Why is this important? Read the following story and discover why water flow is such an important concept.

The river is the Colorado. It begins in the Colorado Rockies and empties 1,450 miles later into Mexico's Gulf of California. The Colorado provides water for seven western states. This includes water for human consumption as well as **irrigation** for farms and domestic livestock. The Colorado is one of the most controlled rivers in the world. It has scores of dams, hundreds of miles of aqueducts and tunnels, dozens of pumping stations, thousands of miles of canals, and more than 30 hydroelectric plants. Water is pumped from the Colorado to cities like San Diego, California; Las Vegas, Nevada; Denver, Colorado; and Phoenix, Arizona. Each year 16.5 million acre feet of water are diverted from the Colorado! (Multiply 16.5 million by 325,850 to see how many gallons are taken from the river each year—over five trillion gallons!) Sometimes the water level is so low that rafters cannot run certain rapids in the Grand Canyon.

Dams above the canyon control how much water moves through the canyon. This has had a big impact on **aquatic life**. For example, before the Colorado was dammed, the river flowed cold and carried lots of mud and silt during the spring floods. In the fall, it slowed to a warm clear trickle. Native **species** were well adapted to these conditions. Now dams trap **sediment** in huge reservoirs and constantly release clear cold water from the bottom of the lake. This creates excellent **habitat** for introduced species, like trout, but is contributing to the near extinction of several native species of fish that do not tolerate the cold water.

By the time the Colorado River reaches the Gulf of California, it is barely a trickle. At times the river dries up before it reaches the gulf. Even if there is water flowing, **evaporation** has caused it to become very salty. At this point, the salt content averages 700 parts per million, which is much too salty for irrigation.

A huge **delta** and **estuary** at the mouth of the Colorado used to be one of the most productive in the Southwest. However, the decrease in water flow has caused many changes. In 1922 ecologist Aldo Leopold explored the delta. He described it "as a milk and honey wilderness where egrets gathered like a premature snow storm, jaguars roamed, and wild melons grew." Since that time two marine animals have become **endangered**—one a porpoise and one a large fish called a totoaba. (The totoaba spawned in the estuary, and the tide carried their eggs up into the natural nursery of the delta.)

According to saltwater agronomist Nicholas Yensen, "The river was like the Nile in its importance to the delta; unknown species may have disappeared..." As a result of the decrease in water flow, entire aquatic **communities** have disappeared and **food webs** have collapsed.

Water Flow Basics

You might be surprised to learn that even the Eno is affected by low water flow. Such conditions can have adverse affects on the entire aquatic community.

- When water levels are low, the water temperature can increase and result in less **dissolved oxygen** being available. This can be deadly to **macroinvertebrates** and fish.

- **Algae** can spread rapidly during low water flow, and these plants use tremendous amounts of oxygen as they decay. Fish kills can occur because of insufficient dissolved oxygen.

- During low water levels there is less habitat for river animals, and they become more vulnerable to predators.

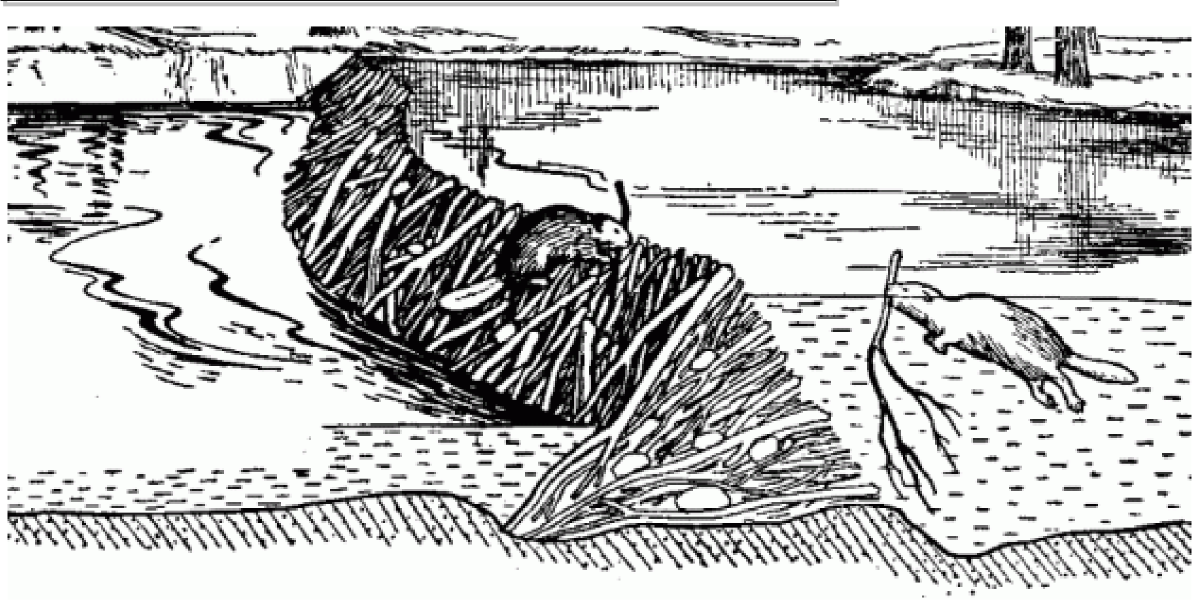
- Low water flow also means low water volume. With less water available to dilute pollutants, toxic levels are reached more quickly.

- Last but not least, you might be forced to conserve water during low flow periods to make sure you have enough to drink and bathe.

We have talked a lot about low water levels but high flow levels affect us also. Heavy rains wash exposed soil into the river. This sediment can suffocate macroinvertebrates, kill fish eggs, and alter habitat. A lot of towns and cities divert rainwater into storm drains that empty into rivers. This stormwater can bring toxic materials into the river: vehicle oil and gas from pavement; chemicals used in farming and lawn care; overflow from **wastewater treatment plants;** and trash from dumps and other sources.

As you can see, water flow is very important to us. Using water wisely and protecting our river's **watershed** from unwise use are two ways we can help maintain a healthy and more natural water flow.

A beaver dam reduces water flow downstream while providing a wetland habitat upstream. How does a beaver dam differ from a manmade dam?



Worksheet for On-Site Activity #1

How To Calculate Water Flow

A - Average length of flow space
B - Average width of flow space
C - Average depth of flow space
D - Time of flow through space

Solving for X = water flow rate in cubic ft./sec.

Equation: A x B x C ÷ D = X

A **Average length of flow space**

North bank ________ ft. + South bank ________ ft. = _______ ÷ 2 = $\boxed{\text{\_\_\_\_\_\_\_ ft.}}$

B **Average width of flow space**

Up river ________ ft. + Down river ________ ft. = ________ ÷ 2 = $\boxed{\text{\_\_\_\_\_\_\_ ft.}}$

C **Average depth of flow space**

1.______ in. + 2.______ in. + 3.______ in. + 4.______ in. + 5.______ in. = _______ in.

__________ in. ÷ 5 = ______ in. ÷ 12 in. = $\boxed{\text{\_\_\_\_\_\_\_ ft.}}$

D **Average rate of flow through flow space**

Ball 1

1._____sec. + 2._____sec. + 3._____sec. + 4._____sec. + 5._____sec. = _____sec.

Ball 2

1._____sec. + 2._______sec. + 3._______sec. + 4._______sec. + 5._____sec. = _____sec.

Ball 1 ____ sec. + **Ball 2** _____sec. ÷ 10 = $\boxed{\text{\_\_\_\_\_\_\_\_\_\_\_ sec.}}$

Equation: ______ ft. x ______ ft. x ______ ft. ÷ ______ sec. = $\boxed{\text{\_\_\_\_\_\_\_\_\_ cubic ft./sec.}}$

A B C D X

Answer Sheet for On-Site Activity #1 (An Example)

How To Calculate Water Flow

A - Average length of flow space
B - Average width of flow space
C - Average depth of flow space
D - Time of flow through space

Solving for X = water flow rate in cubic ft./sec.

Equation: A x B x C ÷ D = X

A Average length of flow space

North bank __80__ ft. + South bank __95__ ft. = __175__ ÷ 2 = __87.5__ ft.

B Average width of flow space

Up river __75__ ft. + Down river __83__ ft. = __158__ ÷ 2 = __79__ ft.

C Average depth of flow space

1. __10__ in. + 2. __18__ in. + 3. __24__ in. + 4. __12__ in. + 5. __6__ in. = __70__ in.

__70__ in. ÷ 5 = __14__ in. ÷ 12 in. = __1.17__ ft.

D Average rate of flow through flow space

Ball 1

1. __20__ sec. + 2. __22__ sec. + 3. __18__ sec. + 4. __23__ sec. + 5. __21__ sec. = __104__ sec.

Ball 2

1. __21__ sec. + 2. __26__ sec. + 3. __24__ sec. + 4. __21__ sec. + 5. __22__ sec. = __114__ sec.

Ball 1 __104__ sec. + **Ball 2** __114__ sec. ÷ 10 = __21.8__ sec.

Equation: __87.5__ ft. x __79__ ft. x __1.17__ ft. ÷ __21.8__ sec. = __371__ cubic ft./sec.

A B C D X

On-Site Activity #2 Mind Your p's and H's

Major Concepts:
- Water quality
- pH range (acid-neutral-base)
- Acid precipitation

Learning Skills:
- Observing, classifying
- Reading informational materials with complex vocabulary
- Expanding on information

Subject Areas:
- Science
- English Language Arts

* See **Activity Summary** for a Correlation with NC Essential Standards.

Location:
Few's Ford Access Area

Group Size:
8 students per group

Estimated Time: 30 minutes

Appropriate Season:
April to October

Materials:
Provided by the educator: pencils, student worksheet (one copy per student)
Provided by the park: Test paper, LaMotte Test Kit, "pH Ranges That Support Aquatic Life" poster, "Sample pH Range" poster, sample items (distilled water, Eno River water, vinegar, lemon juice, Liquid-Plumbr™, Rolaids™, Coca-Cola™, soap, Formula 409™, baking soda)

Special considerations:

Chemical reagents are used in water quality testing. Because misuse of these chemicals can be hazardous, standard chemical protection procedures will be required. Goggles and rubber gloves will be provided for all students handling testing kits. These must be worn at all times during test procedures. The educator will assist in seeing that all safety precautions are followed.

Objectives:
- Demonstrate the use of litmus paper and the LaMotte test kit for determining pH.
- Find the pH of at least three common substances.
- List two natural influences that can affect the pH rating of a river.
- List two human influences that can affect the pH rating of a river.
- State the North Carolina Environmental Management Commission's pH range for aquatic macro-invertebrates (6.0-9.0).

The Power of Hydrogen

Educator's Information:

In this activity, students will test the **pH** of several household products, as well as river water. Park staff will lead a discussion focusing on the **pH scale**, what pH ranges **aquatic life** will tolerate, and natural and human influences that can change the pH of a river or stream. The students will use litmus paper to test the pH of several items and record their results on the "Sample pH Range" worksheet. They will also use a LaMotte test kit to test the pH of distilled water and Eno River water and record their results on the "Sample pH Range" worksheet. Park staff and students will discuss their results and compare them to the "pH Ranges That Support Aquatic Life" poster. They will note the extreme ranges of the samples and be able to determine which **organisms** might be able to live in water with those pH's.

Have the students read the Student's Information prior to the park visit.

Instructions:

1. Review the pH information provided in the Student's Information. Discuss what the term pH means and how it is measured. Be sure to use an example—if the river's pH changes from 6 to 5, this means the river is now 10 times more acidic; from 6 to 4 would mean it is 100 times more acidic.

2. Have two students test the pH of the Eno River water using the LaMotte Test Kit. Have one student read how it is done from the instructions with the test kit while the other student does the test. Have the students then test the pH of the distilled water and the pH of the rainwater using the LaMotte Test Kit.

3. Discuss the results, reinforcing the Student's Information. The Eno River water should fall between 6.0-9.0 to meet the standards for fresh

water set by the N.C. Environmental Management Commission. Generally 6.5-7.5 is the best range for **macroinvertebrates**.

Review how aquatic life is affected by pH. Be sure to cover the concept of tolerance ranges for different organisms. Use an example such as the one on mayfly **nymphs**. Also, discuss the range of pH tolerance found on the "pH Ranges That Support Aquatic Life" poster.

4. Discuss with the students that the rainwater, collected in a park rain gauge, will have a varying pH. (Results for the park have been from 5.4 to 6.5.) Review the **acid precipitation** section of the Student's Information. Emphasize that rain is naturally acidic, with a pH around 5.5. Rain is buffered by the soil, resulting in stream water with a pH between 6 and 8. Note that there are naturally acidic bodies of water, particularly in the eastern part of the state. Finally discuss what acid precipitation is, where it comes from, and how it changes the pH of the water.

5. Discuss other ways the pH of streams is changed, reinforcing the Student's Information, particularly:

- pH increases with increases in **effluent** from **sewage** treatment plants (effluent is high in ammonia which neutralizes **acids**)
- pH increases with **photosynthesis** in plants (photosynthesis removes carbon dioxide, CO_2)
- pH increases with **aeration** by **riffles** and rapids (aeration adds oxygen, O_2)
- pH decreases with an increase in rainfall (rainwater is typically more acidic)
- pH decreases with **decomposition** of plants (decomposition removes O_2)
- pH decreases with **respiration** (animal breathing releases CO_2)

6. Discuss the pH of household products (the pH of many products used for cleaning is basic, while the pH of items that taste sour is acidic). Explain the test procedure using litmus paper. Note that litmus paper can test a broad range of pH and that each litmus paper type covers a specific range within the pH scale.

7. Have one student come forward and pick a product to test. Prior to testing, have the student decide if the product will be basic, acidic or neutral. Have the student select a strip of litmus paper from within the range they think appropriate and place it in the product. Match the color on the litmus paper chart. Discuss the results and have the student mark the class poster. All students should mark their own worksheet.

8. Continue this process until all products are tested.

To test Rolaids™, soap and baking soda, dissolve the products with an equal amount of distilled water. Remind the students that pure, deionized water contains equal numbers of H^+ and OH^- ions and is considered neutral, pH of 7. Note that this will slightly buffer the true pH of these products, but the products will still provide examples of basic pH's. Point out that Rolaids™ and baking soda are both basic (pH of 9) and that baking soda could be used for acid indigestion just as well as Rolaids™. Discuss some of the foods that give us acid indigestion. [Pizza (tomatoes), chili (tomatoes), orange juice (citric acid), etc.] We, too, are living organisms and can not tolerate drastic changes in pH! To test "you," have a student place the tip of a strip of paper on his or her tongue. Have the class decide if the student is acidic, basic, or neutral prior to the test.

9. Sum up the activity by emphasizing that aquatic life is affected when the pH varies a great deal from neutral.

A change in the pH of a river can be one of the first indicators of water quality problems and can quickly affect the aquatic life in the stream.

Volunteers and park rangers test the Eno River several times each month for pH, **dissolved oxygen**, temperature, water flow and macroinvertebrate population and diversity. Several years ago, this vigilant testing of the river identified a chemical spill that put the pH over 12 for a period of time! Dedicated volunteers have also provided data to help establish water flow regulations controlling the amount of water that can be removed from the river. The Eno River is fortunate to have so many good stewards!

Assessment:

If you have litmus paper, or other method of testing for pH in your classroom, set up lab stations and ask students to find the pH of a variety of substances. Then, discuss, or ask students to write their answers to the following questions:

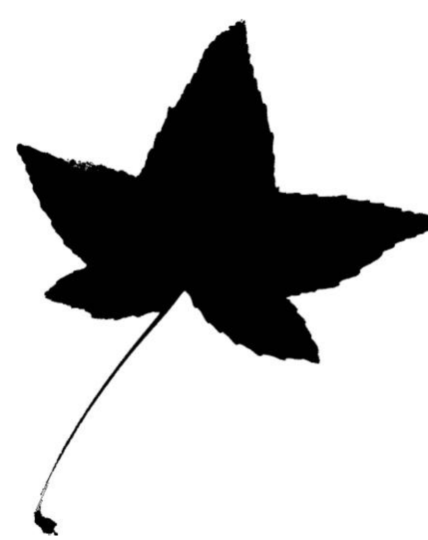
1. Describe two events, one natural and one human-caused, that will <u>increase</u> the pH of a stream or river. Explain why.

2. Describe two events, one natural and one human-caused, that will <u>decrease</u> the pH of a stream or river. Explain why.

3. Give the Environmental Management Commission's acceptable pH range for North Carolina fresh waters.

Modification:

If time permits, take a short hike upriver and test the pH of the Eno at different sites along the trail. Ask the park staff for trail suggestions.



Student's Information: Mind Your p's and H's

The term **pH** means (p)ower of (H)ydrogen ion activity. Scientists use the **pH scale** to define the degrees of acidity/basicity in soil and water. On one end of the scale, a pH of 0 is extremely acidic (many number hydrogen ions, H^+), whereas at the other end of the scale, a pH of 14 is extremely basic (many hydroxide ions, OH^-).

A pH of 7 is neutral (equal numbers of H^+ and OH^- ions), representing a factor of ten. Thus, a change in a river's pH from 6 to 5 means that the river is ten times more acidic; from 6 to 4 means it is 100 times more acidic.

North Carolina has established water quality standards. For all fresh waters, except swamps, the acceptable pH range is 6.0 - 9.0 (swamps can have a pH as low as 4.3).

Aquatic life is affected when the pH varies a great deal from neutral. Different **organisms** tolerate varying ranges of pH, and the population of aquatic organisms will change if the pH changes favor certain **species**. For example, mayfly **nymphs** do best when the pH is around 6.5, but they usually cannot survive if the pH drops below 5.0. Most **macroinvertebrates** do best if the pH is between 6.5 and 7.5.

The pH of rainfall is naturally acidic, usually registering from 5 to 5.5. However, many soils are somewhat basic and "buffer" the rainwater by raising its pH, making it less acidic. As a result, despite the pH of non-polluted rain being around 5.5, the pH of most stream water is between 6 and 8. However, you can find naturally acidic water in swamps, bogs, Carolina bays, and blackwater rivers in the eastern part of the state. There, the soils contain large amounts of peat (partially decayed plant material) which is acidic.

Some acidic waters are not natural, but the result of **acid precipitation**. Acid precipitation falls in the form of rain, snow, fog, sleet and hail. The acidity results primarily from the mixing of water vapor with sulfur dioxide (from coal burning power plants) and nitrous oxides (from cars and trucks) in the atmosphere. Acid precipitation can cause changes in the pH of our waterways.

The pH of water increases (becomes more **alkaline** or basic) with increases in the following: **effluents** from **sewage** treatment plants (the effluent is high in **ammonia**), **photosynthesis** in plants (photosynthesis removes carbon dioxide, CO_2), and **aeration** by **riffles** and rapids (aeration adds oxygen, O_2).

The pH of water decreases (becomes more acidic) with each of the following: increases in rainfall (allowing little or no buffering from the soil), **decomposition** of plants (decomposition removes O_2) and **respiration** (animal breathing releases CO_2).

Changes in pH can give valuable clues to water quality changes. A pH change, either an increase or decrease, may be an indication of biological processes such as decomposition of organic matter, photosynthetic activity or an increase/decrease in pollutant levels.

Monitoring the pH of our streams and rivers is of great importance. It can alert us to changes in our water quality and help us to protect our waters by giving us clues to the source of the changes.

pH Scale

Acid														Base
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
STRONG			MODERATE		WEAK		NEUTRAL	WEAK			MODERATE			STRONG

Worksheet for On-Site Activity #2

Sample pH Range

	Acid						Neutral						Base	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
H_2O (Distilled)														
H_2O (Eno River)														
H_2O (Rain)														
Vinegar														
Lemon Juice														
Liquid-Plumbr™														
Yourself														
Rolaids™														
Coca-Cola™														
Baking Soda														
Formula 409™														
Soap														

pH Ranges That Support Aquatic Life