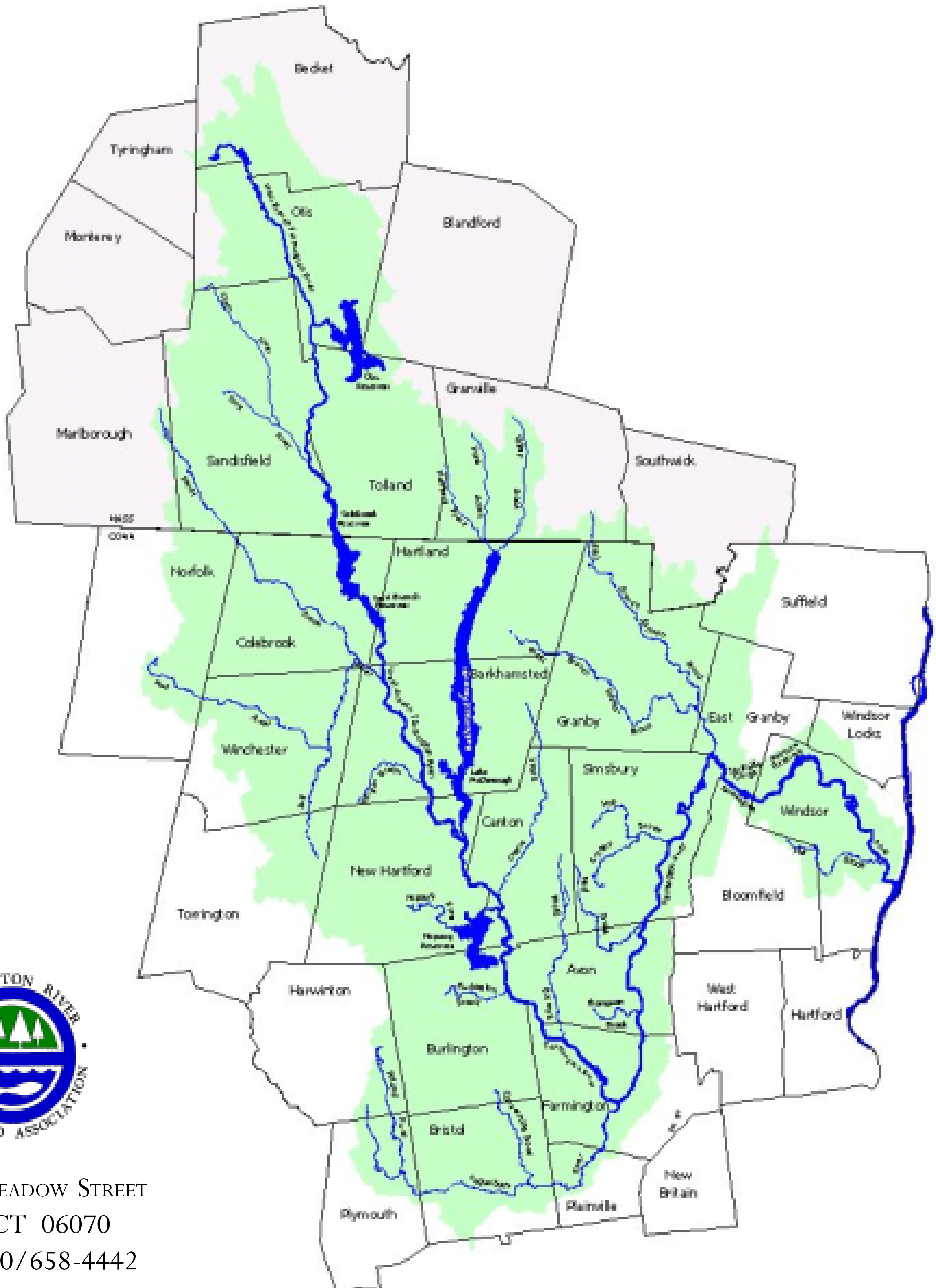
FARMINGTON RIVER WATERSHED EDUCATION CURRICULUM:

MIDDLE SCHOOL



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INTRODUCTION

The Farmington River Watershed Association (FRWA) has been offering educational programs for schools, civic organizations, and the general public for over 50 years. However, FRWA has typically provided one-day or one-event presentations to meet the specific requests of various organizations. Though FRWA will continue to be responsive to requests from the public, FRWA made a strategic decision to develop materials that could be available to public school teachers who are the most effective day-to-day disseminators of watershed information to children at the elementary, middle, and high school levels.

A strong watershed education curriculum provides a means to help students and teachers better understand the natural world, and to make connections between themselves and the resources they use so that they may make informed decisions and take responsible actions. Most residents of Hartford, for example, don't realize that 100 percent of their drinking water comes from the Farmington River. Indeed, over 600,000 people in the Greater Hartford area and the Farmington Valley receive their water from the Farmington River each year. This means that protecting water quality in the Farmington River is clearly in the region's best interest, but until this connection is made apparent through education, protecting the River will remain a remote rather than an immediate priority. If river protection remains only a priority for environmentalists, the chances of sustaining river protection are greatly reduced. Towns like Simsbury and Windsor have taken efforts to actively recognize the importance of the Farmington River. Hartford students may be least aware of the importance of the Farmington River, but, ironically, depend on it the most.

Why put together a Watershed Education Curriculum?

The following Watershed Education Curriculum was assembled for several reasons:

1) The Farmington River Watershed Association has offered educational programs for over 50 years, but had never assembled a guide for teachers on the Farmington River Watershed. Teachers are invaluable stewards of young minds and a logical choice for effectively disseminating information to students on water;

2) Although there are many water-focused curriculum guides available at the national level – Project WET, Project Wild-Aquatic, the Watershed Educator's Guide, etc. – these guides are most meaningful if they have a LOCAL connection to a LOCAL watershed;

3) Schools and teachers are responsible for meeting state curriculum and core content standards for many subject areas. These materials have been assembled to complement state curriculum standards including the new science core content standards. The following matrix shows where each lesson addresses different content standards; and

4) Innovative teachers are always looking for new ideas, new materials, and new professional development opportunities that might further an integrated approach to science, language arts, social studies, art, and mathematics in their classrooms. This curriculum can be used to replace existing lessons that may not accomplish this goal, or serve as a means to complement existing lessons that do.

How will these materials be made available to schools?

In 2004, FRWA is contacting schools to offer a 15-minute presentation on the availability of the watershed education curriculum materials, OR to offer two hours of teacher training as part of already-scheduled in-service training for teachers at the 2nd, 7th, and 10th grade levels. We recognize that even though we have geared the materials to those grade levels, you may have additional teachers from additional grades who may wish to attend training sessions and/or receive watershed education curriculum materials. FRWA will provide 1 paper copy and 1 CD-Rom copy of the watershed education curriculum materials to each school at no cost. The schools and individual teachers will be responsible for making additional copies and sharing the CD-Rom materials at your school.

How can we learn more about the Farmington River Watershed?

FRWA literally maintains a library of materials on the Farmington River at its office as well as supports staff expertise that we are very willing to share. Please visit our website (www.frwa.org) for an updated list of watershed events and opportunities to learn, or feel free to contact us directly by phone (860/658-4442) or via email (apetras@frwa.org) with questions, to provide input, or to request additional information. If you are interested, of course, consider becoming a member of FRWA to support our ongoing river protection efforts.

What is contained in the Farmington River Watershed Education Curriculum?

The Farmington River Watershed Association partnered with Sotoria Montanari at the Holcomb Environmental Literacy Center in Granby to assemble 30 lessons geared toward 2nd, 7th, and 10th grade teachers respectively. These lessons are grouped into 6 categories: 1) Water, its Uses and Importance; 2) the Watershed; 3) Watershed Ecosystems; 4) Going Back to the Past; 5) Water Pollution and Monitoring; and 6) Water Conservation. The curriculum materials were developed from national environmental curricula such as Project WET, Project Wild-Aquatic, and the Conserve Water Educator's Guide. The curricula is age-appropriate, easy to implement, complementary with state curriculum standards, and is supported by facts and data from the FRWA.

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FRWA Curriculum Guide

Week I – Middle School

Water

Its Uses and Importance

Background Information
Water– *Its Uses and Importance*

"It is water, in every form and at every scale, that saturates the mind. All the water that will ever be is, right now." National Geographic, Oct. 1993

Water – nero – vatten – agua – wasser – Water means different things to different people.

To a chemist, water is H2O, a molecule composed of one oxygen and two hydrogen atoms.
To a biologist, water is nourishment necessary for all living things.
To an ecologist, water is a habitat hosting a world of interrelated species.
To municipalities and towns, water is a utility to be managed and sustained.
To a farmer, water is necessary for strong and productive crops.
To a firefighter, water is a useful tool for extinguishing flames.
To a tanker captain, water is a means of transporting goods.
To a young child, water is a refreshing way to cool off on a summer day.
To many areas of the world, water is not as accessible.
To all of us, water is life.

What makes water so important to so many people?

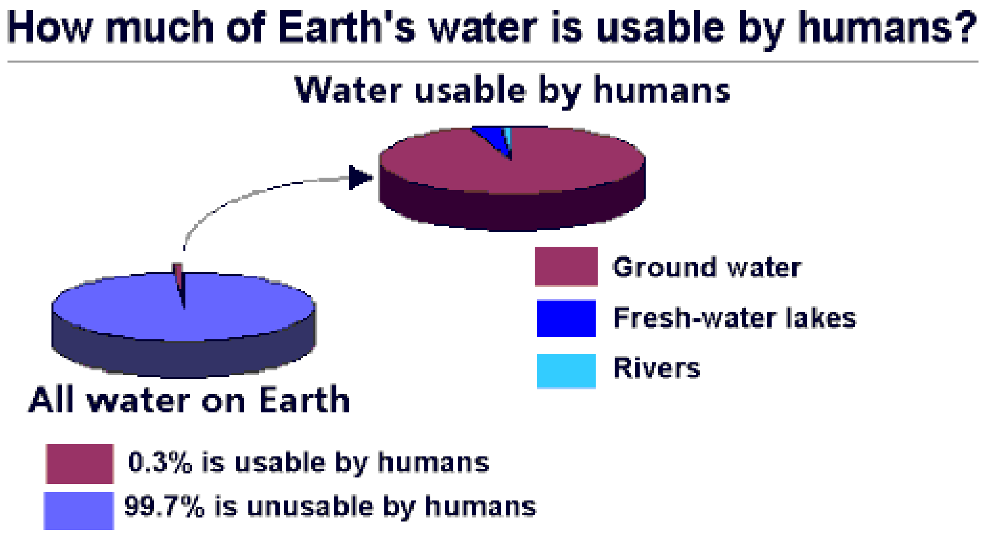
Adapted from Haskin, Kathleen M. Claryville, *1995, The Ways of the Watersheds: An Educators Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies*, NY: The Frost Valley YMCA

BACKGROUND:

Water is essential to all living creatures. It is a precious natural resource, but a limited one. Although the earth is 75% water, it is not all available to us. The global distribution of water breaks down as follows:

Water source	Water volume, in cubic miles	Percent of total water
Oceans	317,000,000	97.24%
Icecaps, Glaciers	7,000,000	2.14%
Ground water	2,000,000	0.61%
Fresh-water lakes	30,000	0.009%
Inland seas	25,000	0.008%
Soil moisture	16,000	0.005%
Atmosphere	3,100	0.001%
Rivers	300	0.0001%
Total water volume	**326,000,000**	**100%**

Source: Nace, U.S. Geological Survey, 1967 and
The Hydrologic Cycle (Pamphlet), U.S. Geological Survey, 1984



This means that there is less than one percent of fresh water available to us for drinking, washing, brushing our teeth, etc.

Some interesting water facts follow:

- There is approximately the same amount of water on Earth today as there was when the Earth was formed. Water is continually recycled in the Earth's hydrologic cycle. The dinosaurs once drank the same molecules as those that are from your faucet.
- The human brain is 75% water.
- Each day, the sun evaporates 1,000,000,000,000 (one trillion) tons of water (United States Geological Survey).
- At least one billion people must walk three hours or more to obtain drinking water (National Geographic Society).
- One inch of rain falling on one acre of land is equal to about 27,154 gallons of water (United States Geological Survey).
- The 250 million residents of the U.S. have access to the same amount of fresh water as residents did 200 years ago, when the population was four million (National Drinking Water Alliance).
- One percent of the water on earth is available for human consumption.
- Seventy – five percent of a living tree is water.
- You can survive a month without food, but only 5 to 7 days without water.

Food Facts:

1. It takes **6 gallons** of water to make **one order of french fries.**
2. More than **2,600 gallons** of water are needed to produce **one serving of steak.**
3. The average American consumes **1,500 lbs. of food** annually. It takes **1.5 million gallons** to produce food for just one person!
4. Approximately **6,800 gallons of water** are used to feed a **family of four** for one day.
5. **100 gallons** of water are needed to grow **one watermelon.**

Environmental Facts:

1. Only 7 % of the country's landscape is considered riparian, or alongside water— only **2 % of which still supports riparian vegetation**.
2. Of the 1200 species listed as threatened or endangered, **50% are dependant on wetland**

habitats.

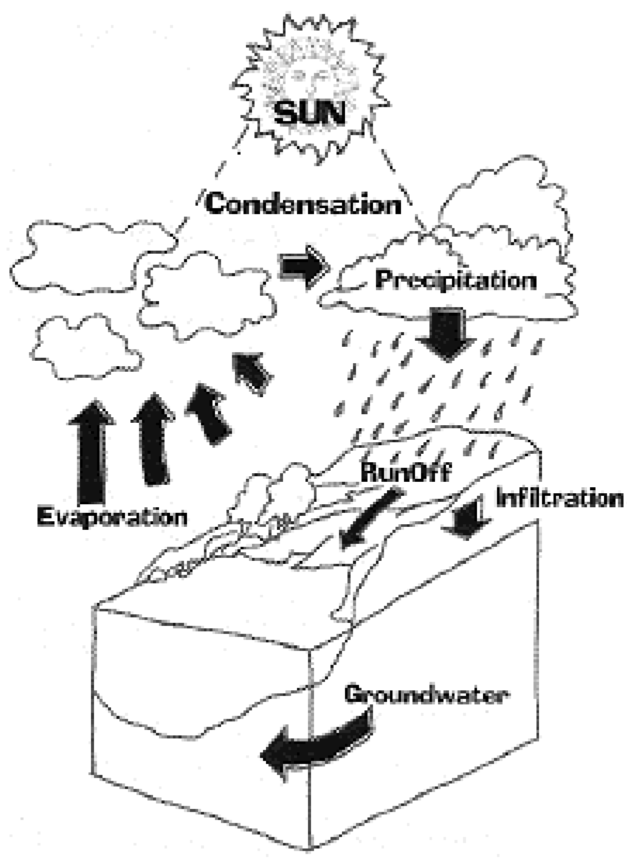
3. Freshwater species are disappearing **5 times faster** than land animals.
4. **53,000 cubic miles** of water pass through Earth's lakes and streams.
5. If all of the water in the world were to fit in a gallon jug, the available freshwater would equal only **1 teaspoon.**

Human Facts:

1. **1.2 billion** of the world's people do not have access to clean water.
2. The United States consumes water at **twice the rate** of other industrialized countries.
3. **6.8 billion gallons** of water are flushed down American toilets each day.
4. **80 %** of freshwater used in the United States goes to irrigating crops and creating hydroelectric power.
5. To survive, the average person needs **2 quarts** of water a day.
6. An average person will drink about 16,000 gallons of water in their lifetime.

THE WATER CYCLE:

The Earth's surface water is recycled among the plants, animals, and atmosphere in a process known as the hydrologic or water cycle. The water cycle refers to the movement of water through the environment by the process of evaporation and condensation. The heat from the sun causes water to evaporate into the atmosphere, and precipitation brings it back down to the earth's surface. The water evaporates, which means that it changes to water vapor. Water vapor rises because it is lighter than cold air. It then cools and turns into liquid water, called condensation, and forms into clouds. Eventually, the rains, snow or hail falls (precipitation) and the cycle begins again!



Source U.S. Geological Survey

The water cycle controls the distribution of the earth's water as it evaporates from bodies of water, condenses, precipitates, and returns to those bodies of water. Water may be used by plants and animals, frozen in glaciers, evaporated back into the atmosphere, or flow through our waterways. Waterways are part of a watershed.

A watershed, or drainage basin, is a region that drains into a particular body of water. It is an area of land where water from precipitation drains into an individual stream, lake or other body of water. It includes all the water, land, animals, plants, and people within a certain area. Any precipitation that falls that is not used by plants, animals, or people, flows into the watershed in a specific manner. The elevations and topography of the land determine the direction and flow of the water. The bodies of water within a watershed all play a part in how the water flows through the watershed.

Water that stays on the surface of the land is termed surface water and water that seeps into the ground is termed groundwater. Groundwater seeps down through the soil until it reaches rock material. The rock material that is below the surface of the Earth is called bedrock. Bedrock consists of many types of rocks, such as sandstone, granite and limestone. As spaces develop between the rocks, water can then accumulate for water storage. Humans play a vital role in the protection of this essential resource.

Farmington River Watershed is a sub-basin of the Connecticut River Watershed. The Farmington River, itself, is a water supply and recharge area for drinking water for over 600,000 people in the greater Hartford region and Farmington Valley. According to the *State of the Farmington River Watershed Report,* dated August 2003, water resources of the Farmington River Watershed provide 100 percent of the drinking water for about 600,000 people in the Greater Hartford area, including Bloomfield, East Hartford, Farmington, Glastonbury, Hartford, Portland, Newington, Rocky Hill, South Windsor, West Hartford, Wethersfield and Windsor. Many of the towns are not located within the watershed, but rely on drinking water stored within the watershed.

Drinking water may be stored in a variety of ways. Reservoirs are one way in which water is stored within the watershed. Dams prevent the flow of water and therefore, collection basins, or reservoirs, are established.

Water travels through an intricate system in order to reach our faucets. Beginning in the northwest hills, two surface water suppliers, Barkhamsted Reservoir and Nepaug Reservoir hold 30.3 and 9.5 billion gallons of water, respectively. Water flows by gravity through pipes to two tMetropolitan District Commission (MDC) treatment facilities in West Hartford and Bloomfield, which filter 50 and 21 million gallons of water a day. Once treated, this water flows to the towns previously mentioned.

Approximately 90 percent of the towns in the Farmington River Watershed use groundwater as a drinking water supply, with 32 public water supply wells producing about 8 mgd (million gallons per day). In Simsbury, for example, the Aquarion Water Company provides drinking water to approximately 14,000 residents from groundwater. This groundwater is recharged by the Farmington River Valley aquifer that is intimately connected to the Farmington River.

An aquifer is an underground storage area for water. Water in aquifers is stored in spaces or pores of rocks below the surface of the ground. Wells can be drilled into the aquifer and water may be pumped out. Rain can eventually recharge, or add, water to the aquifer. The Farmington River helps to recharge the Farmington River Valley aquifer, but at the same time, the aquifer helps to maintain base flows in the Farmington River. Protecting the Farmington River reduces the pressures on the Farmington River Valley aquifer, and vice versa.

Lesson 1

Water Connections

How are connections important to learning and understanding?
How do bodies of water connect?
What is the connection between surface water and ground water?

GOAL To understand that connections are important to learning.

OBJECTIVES Students will:

- ✓ create connections with water words
- ✓ expand water knowledge through developing associations
- ✓ recognize the flow of water bodies in Farmington River Watershed

MATERIALS **butcher block paper for 5 student groups, markers, pencils, Farmington River Watershed maps**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(10,12), 2(4)**
- **Science 7(7), 8(1-3), 9(1,5)**
- **Social Studies 9(3),10(1-3), 12(4,5)**

VOCABULARY **ground water, water quality, tributary, erosion, reservoir, lake, hydrologic cycle, drinking water, surface water.**

PROCEDURES

1. Inform students that they will be participating in an activity that helps create water connections.
2. Post a large piece of butcher block paper in front of the classroom. Write the word “river” enclosed in a circle, in the middle of the paper (or on the board). Ask how rivers are formed. (*from a spring in the mountains, melting glacier, or precipitation*). Depending on what they answer, prompt students to continue to next step.
3. For example, if they answered precipitation, then write the word *precipitation* in a circle and connect to the *river* circle. Have students think of a verb that connects “river” and “precipitation” and write on the connecting line (*evaporate*).
4. Continue by asking students what the source of precipitation is (*clouds*). Write the word *cloud* in a circle and draw a line connecting the two words. Continue the process as long as it takes for students to understand water connections.
5. Break students into cooperative groups. Provide each group with a starting word and a piece of butcher block paper. Have them circle the word and create connections. The starting words are associated with water. Examples that may be used are: *underground water, water quality, tributaries, erosion, reservoirs and lakes, hydrologic cycle, drinking water, surface water.*
6. After students create connections, have them explain the connections to the class.
7. Discuss additional connections if they were not addressed in presentations, with stu-

dents. Ask what the connection of underground water is to a river. (*Rivers form under the ground in places where rocks pores or spaces are so full of water that they can not hold anymore water. The top layer is called the water table. If the water table reaches above ground levels because of rain etc. then a spring appears*.)

8. Discuss why the river water needs to be protected so that the underground water is not contaminated. (*Underground pockets of water held in rocks are called aquifers. This type of storage provides drinking water to many communities; if contaminated or polluted then there would be a problem with drinking water. Rivers can recharge aquifers and aquifers may recharge rivers.*)
9. Explain that surface water is stored in reservoirs. (*Reservoirs are man-made lakes that collect and store billions of gallons of water. Dams prevent the flow of water and establish catch basins*.)
10. Instruct students to formulate connections among some of the water way names in the Farmington River Watershed. Explain that a river within a watershed flows according to the topography or elevation of the land. It begins in higher elevations and continues downward connecting with other bodies of water. The main stem of the river has many tributaries or branches that flow into it.
11. Write the names of the following bodies of water on the board (listed in #12). Explain to students that these are water bodies that are in areas that they live. The Farmington River begins in Massachusetts and flows through Connecticut for 81miles.
12. Instruct students to create a connection among three bodies of water.
    The water ways include: Clam River (Otis, MA), Barkhamsted Reservoir (Barkhamsted, CT), Farmington River, Connecticut River (Hartford), Rainbow Reservoir (Windsor), Pequabuck River (Plymouth, Farmington), and Nod Brook (Avon, Simsbury).
13. Students may refer to a map of the watershed to help create connections and verify answers. Farmington River and Connecticut River may be used more than once. An example of a connecting waterway is Clam River, Farmington River, and Barkhamsted Reservoir. Clam River flows into Farmington River which connects to the Barkhamsted Reservoir.

EXTENSIONS

1. Have students refer to watershed map and create additional connections of waterways. List and identify.
2. Have students draw a diagram of the hydrologic cycle.

RESOURCES

Charles, Cheryl and Samples, Bob, *Project Wild Aquatic Educational Guide,*1992, Council for Environmental Education, Gaithersburg, MD 20878
Etgen. John, *Healthy Water, Healthy People, Water Quality Educators Guide*, 2003, The Watercourse, Bozeman, Montana 59717 - 0575

GLOSSARY

drinking water - a clear, odorless liquid suitable for drinking or swallowing
erosion - the group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface
ground water - water within the earth that supplies wells and springs
hydrologic cycle - the cycle of evaporation and condensation that controls the distribution of the earth's water as it evaporates from bodies of water, condenses, precipitates, and returns to those bodies of water; also called water cycle
lake - a large inland body of fresh water or salt water
reservoir - a natural or artificial pond or lake used for the storage and regulation of water
surface water - water above the surface of the ground
tributary -a river or stream flowing into a larger river or stream
water quality - the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs; specifically broad designations of surface and ground water

Lesson 2

Water Expressions

How can people identify with water through written expressions or poetic quotes? What water words are associated with quotes and what emotions are evoked?

GOAL To be moved by differing interpretations and reactions to water.

OBJECTIVES Students will:

- ✓ read a variety of quotes in classroom
- ✓ connect particular water words with poetic expressions
- ✓ answer questions about the quote
- ✓ create a poster and conduct presentation to class

MATERIALS **butcher block paper for 17 quotes, poster board for 5 groups, markers, pencils, paper for writing answers to questions**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(1,9,10,12), 2(4)**
- **Science 8(1-3)**
- **Arts 1(1-3)**

VOCABULARY **quotations, pollution, conservation, ecosystem, watershed**

PROCEDURES

1. Prior to students arriving in classroom, have "quotes" written on construction paper, butcher block paper or any other type of available paper. (*quotations are listed at the end of lesson.*) Hang paper with expressions around classroom for students to see upon arrival to class.
2. Begin by having students read quotes silently. Discuss with students that sometimes poetry, quotations and expressions evoke memories, associations, and/or emotions.
3. Ask if they identify with any of the expressions. Have volunteers share their reason(s) why they chose particular expressions.
4. Separate students into groups and have the each group choose one quote.
5. Once they have decided on a quote, have students pick one or more of the following word(s) that best fit their expression:
   a. pollution
   b. watershed
   c. conservation
   d. water cycle
   e. uses of water
   f. ecosystem

6. Have student groups complete the following:
   a. Define the word chosen.
   b. Explain the reason(s) why the particular word(s) was chosen to correspond with quote.
   c. What is their interpretation of quote? Are any thoughts, emotions or memories evoked?
   d. Who wrote the quote? If it is a person, discover who that person is. If it is a cultural saying or proverb, what does it suggest about that culture?
   e. Discuss whether sentences evoke particular images.
   f. Write the expression in the middle of a poster board. Draw interpretations and present to class.
7. Have individuals write their interpretations of a favorite quotation from the list provided.

EXTENSIONS

1. Have the class visit a stream, brook, river, or other body of water on the Farmington Watershed. Have them sit quietly. Have students close their eyes and listen to the sounds. When they open their eyes, have them use observational skills to examine how the sunrays reflect upon the water, the surrounding land and vegetation area, and any other observations. Have students write their thoughts. Have them describe the setting and their reaction to it.
2. Have students write a quotation about water.

RESOURCES

http://members.tripod.com/~copper80/quotes.html

GLOSSARY

conservation - preservation or restoration from loss, damage, or neglect
ecosystem - an ecological community together with its environment, functioning as a unit
pollution - the state of being contaminated with harmful substances
quotations - an explicit reference or allusion in an artistic work to a passage or element from another, usually well-known work
watershed - a ridge of high land dividing two areas that are drained by different water systems

SAMPLE WATER QUOTATIONS

1. *"The frog does not drink up the pond in which he lives." - American Indian Saying*

2. *"Filthy Water can not be washed." - African proverb*

3. *"A river seems a magic thing, a magic, moving, living part of the very earth itself, for it is from the soil, both from its depth and from its surface that a river has a beginning." – Laura Gilpin*

4. *"I came where the river ran over stones; My ears knew an early joy. And all the waters of all the streams sang in my veins that summer day." – Theodore Roethke, The Waking, 1948*

5. *"The river moves from land to water to land, in and out of organisms, reminding us what the native peoples have never forgotten; that you cannot separate the land from the water or the people from the land." - Lynn Noel, Voyages Canada's Heritage Rivers*

6. *"To trace the history of a river or raindrop, as John Muir would have done, is also to trace the history of the soul, the history of the mind descending and arising in the body. In both we constantly seek and stumble, our divinity, which, like the cornice feeding the lake and spring becoming a waterfall, feeds, spills, falls and feeds itself over and over again. – Gretel Ehrlich, Sisters of the Earth*

7. *"It is water, in every form and at every scale, that saturates the mind. All the water that will be is, right now." - National Geographic, October 1993*

8. *"Any river is really the summation of the whole valley. To think of it as nothing but water is to ignore the greater part." - Hall Boland, This Hill, This Valley*

9. *"We forget that the water cycle and the life cycle are one." - Jacques Cousteau*

10. *"For many of us, water simply flows from a faucet, and we think little about it beyond this point of contact. We have lost a sense of respect for the wild river, for the complex workings of a wetland, for the intricate web of life that water supports." - Sandra Postel, Lost Oasis: Facing Water Scarcity*

11. *"...Good luck and Good work for the happy mountain raindrops, each one of them a high waterfall in itself, descending from the cliffs and hollows of the clouds to the cliffs and hollows of the rocks, out of the sky-thunder into the thunder of the falling rivers."*
    John Muir, My First Summer in the Sierra

12. *"The noblest of the elements is water"*
    Pindar, 476 B.C.

13. *"If there is magic on this planet, it is contained in water" - Loren Eiseley, Anthropologist*

14. *"You could not step twice into the same rivers; for other waters are ever flowing on to you."*
    - Heraclitus of Ephesus

15. *"When you drink the water, remember the spring." - Chinese Proverb*

16. *"When the well is dry, we learn the worth of water." - Benjamin Franklin*

17. *"Children of a culture born in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it." - William Ashworth, Nor Any Drop to Drink, 1982*

18. *"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*

Lesson 3

Water Values

How much water is available for human consumption?
How much is used during the day?
Are there ways that water can be conserved?

GOAL To understand that water is a finite resource to be conserved.

OBJECTIVES Students will:

- ✓ conduct a demonstration showing the amount of water available
- ✓ examine how they use their water by "paying" for it
- ✓ think of ways to conserve water

MATERIALS **three 5 gallon plastic containers, one 1-Cup plastic container, eyedropper, water dollars (to be copied), water use chart, log notebook, water bank, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1-3), 2(1,2), 3(1,3)**
- **Science 8(1-3)**
- **Social Studies 10(2-4), 13(2,5)**

VOCABULARY **finite, conservation, consumption**

PROCEDURES

1. Begin by explaining to students that water is a finite resource to be conserved. There are many ways that water is used and water we use today has been recycled through the water cycle. We have the same amount of water today as we had millions of years ago.
2. Conduct a demonstration to the class, having a student help.
3. Present a container filled with 5 gallons of water. This container represents all the water on Earth.
4. Explain to students that 97.2% of all the water is contained in the oceans. This is salt water and unsuitable for drinking or irrigating crops, etc. Remove 2 ¼ cups of water and leave approximately 97.2% of the water.
5. Place the 2 ¼ cups of water in another five gallon clear container or have a student conduct this part of the activity. This amount represents the amount of fresh water. However, 2% of the fresh water is located in glaciers and ice caps and is not available to us, leaving a ½ cup.
6. Remove ½ cup from second container and place into another five gallon clear container. This is what is left for us to use. Explain that part of this water is trapped underground or is polluted, so therefore, unsuitable for drinking. That leaves approximately 5 drops of water for us to use. Remove 5 drops of water with a dropper and place in the 1-Cup container. The five drops represent the water available for all those uses. Have students think of all the ways they used water. List on board.

7. Now that students are aware of how much water is available to them, have them think of how their day would be without water. What could they not do?
8. Explain that starting today and for 2 days they are going to have to examine how they use their water by paying for it.
9. Students will receive a chart with water use categories, amount in liters that is used, and the amount of water dollars required.
10. They will receive five sheets of water dollars that they will use. The “play money” will be used each time a student uses water at school or at home during this 2-day period. The dollar amount represents the amount of liters. They will receive 400 water liter dollars.
11. Have students cut out water dollars and write his or her name on the dollars.
12. They may make payments by placing dollars in a container labeled “Water Bank”.
13. Instruct students to keep track by recording how they spent their dollars and mark it in a log.
14. The next day, students discuss how they spent their water dollars. Questions to consider include: Did they have enough water for the two days? Did they need to conserve? How do they think they did?

EXTENSIONS

1. Read the following statement: “Farmington River Watershed provides 100% of drinking water to 600,000 people in the Greater Hartford area.” How would they think or react differently knowing that how they protect or take care of their water and land could affect the water they drink? Have students discuss in groups and present to class.
2. Is water a renewable or non-renewable resource? Discuss terms.

RESOURCES

Denver Water Department, Colorado River Water Conservation District, Denver, Colorado

Farmington River Watershed Association, August 2003, *State of the Farmington River Watershed Report*, Farmington River Association, Inc.

Haskin, Kathleen M*, The Ways of the Watersheds: An Educators Guide to the Environmental and Cultural Dynamics of New York City’s Water Supplies*, 1995, Claryville, NY: The Frost Valley YMCA

GLOSSARY

conservation - preservation or restoration from loss, damage, or neglect
consumption - the using up of goods and services by consumer purchasing or in the production of other goods
finite - having bounds; limited

Water Use Chart

Use Category	Amount (liters)	Assumptions	Water dollars required	Potential savings	Water saving suggestions
Drinking	3	Daily requirement	3	None	
Water fountain	1	Each trip	1	None	
Toilet	20	Each flush	20	5	Tank displacement
Brushing teeth	40	Water on 2 minutes	40	35	Turn water off while brushing
Washing hands	20	Water on 1 minute	20	15	Turn off water while soaping hands
Shower	100	Water on 5 minutes	100	40	Take shorter shower/ turn off while soaping
Washing clothes	120	1 load	120	20	Wash full loads
Washing dishes	100	1 load, automatic dishwasher	100	17	Wash full loads, or Soap first then rinse if hand-washing dishes
Washing car	100	Water on 5 minutes	100	60	Turn off water when not washing, wash less frequently
Lawn watering	250	Full lawn	250	150	Use native plants to reduce water usage

$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR
$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR
$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR
$1 WATER DOLLAR	$1 WATER DOLLAR	$1 WATER DOLLAR	$5 WATER DOLLAR	$5 WATER DOLLAR	$5 WATER DOLLAR
$5 WATER DOLLAR	$5 WATER DOLLAR	$5 WATER DOLLAR	$5 WATER DOLLAR	$5 WATER DOLLAR	$5 WATER DOLLAR
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$20 WATER DOLLAR	$20 WATER DOLLAR	$20 WATER DOLLAR	$20 WATER DOLLAR	$20 WATER DOLLAR	$20 WATER DOLLAR

Lesson 4

Water Power

What are the positive and negative impacts of dams on a community? What are names and locations of dams in Farmington River Watershed? Why are dams built?

GOAL To understand that there are negative and positive effects of altering the flow of a river.

OBJECTIVES Students will:

- ✓ research facts about dams in the FRWA
- ✓ realize that a dam is an unnatural impoundment and creates diversions that positively and negatively impact the watershed
- ✓ debate the issue

MATERIALS **Selected Dams Map (on CD), pencil, paper**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(4,5)**
- **Science 7(6,8), 8(2,3), 12(4), 14(1-4,6-7)**
- **Social Studies 9(1,2), 12(4,5,7,8), 13(5,7)**
- **Arts 1(3)**

VOCABULARY **dam, hydroelectric power, impoundment, turbine, generator**

PROCEDURES

1. Begin the lesson by asking students if they know what a dam is. (*strong, thick wall across a river valley to hold back water*). Ask students why they are used to hold back water. (*create lakes, called reservoirs, that store water safely for drinking; flood control; hydropower*). Water can then be gradually released downstream.
2. Continue by asking if they know of any other uses. Ask them if the force of water is able to generate any type of power. (*hydroelectric – "hydro"(water) and electric = waterpower*). Explain that a power station that uses water to make electricity is called a hydroelectric power station. Water from reservoirs behind dams move turbines that make electricity. In the powerhouse at the bottom of the dam, fast-flowing water pushes huge turbines. They in turn drive generators that create electricity. Cables then carry electricity to homes and factories.
3. Ask if they are familiar with names of any dams. (*Hoover*) Determine if they are familiar with any dams in the Farmington River Watershed. (Saville, Rainbow). Ask if any of them help generate electricity.
4. Provide the following information to the students. A series of dams or impoundments have been constructed in the Farmington River Watershed. They are as follows (from upper to lower watershed):

- **a. Colebrook Dam** – constructed 1969 – maintained by U.S. Army Corp of Engineers – hydropower facility – flood control – Colebrook Reservoir – recreation – possible drinking water storage
- **b. Goodwin Dam** – constructed in 1960 – West Branch Reservoir – hydroelectric power
- **c. Saville Dam** – constructed in 1940 - Barkhamsted Reservoir – drinking water - hydroelectric
- **d. Richards Corner Dam –** constructed in 1920 – Lake McDonough – recreation – compensating reservoir
- **e. Nepaug Dam –** constructed in 1916 - Nepaug Reservoir – drinking water
- **f. Mad River Dam & Sucker Brook Dams** – 1963 & 1970 – Winchester
- **g. Robertsville Dam** – hydropower (unlicensed) – stream flows not adequately managed
- **h. Upper and Lower Collinsville Dams** – last major impediment to fish migration – redevelopment would include a fish ladder
- **i. Hartford Electric Light Company Dam** – 1899 - East Granby – electricity - washed away in flood of 1955 – remnants still obvious – safety hazard below Tariffville Gorge
- **j. Rainbow Dam** – Rainbow Reservoir – 1976 – hydropower – fish ladder for anadromous (*fish that return from sea or ocean to breed or spawn fish, such as salmon*) – largest generator of electricity on Farmington River

5. Have students break up into groups. Each group will conduct research on one of the dams. Have students use the Farmington River Watershed Association website to research their information. (www.frwa.org). Find the "State of the Watershed" Report. Click on it and go to the body of the report to research information about impoundments or dams. Students will answer the following information and present to the class:
   - a. Locate the dam on a watershed map. In what town(s) is the dam located?
   - b. If there is a reservoir, what is the name of the reservoir? What is the carrying capacity of the reservoir?
   - c. When was the dam built? Why was it built? What are its dimensions (if available)?
   - d. Is hydroelectric power available as a result of the dam being built?
   - e. Are there any other unique or interesting facts about the dam?
   - f. As an added option, students may build a model of a dam.

6. Students will debate different sides of the dilemma of building dams. The following information may be provided to students:
    - Dams are constructed for flood control
    - Hydropower can be a result of dams
    - Water storage for drinking water
    - Alters the entire river system
    - Natural flow is eliminated
    - Negatively impacts aquatic life
    - Sediments and nutrients are trapped behind dams, where flowing rivers flush them out
    - Provide reservoirs for recreation
    - Can cause low flows in other parts of the rivers
    - Regulated cold water releases can help support aquatic life and river habitat.
    - Can prevent migrating fish from returning to spawn
    - Fish ladders can help migrating fish
7. Have half the students support the building of a dam and the other half provide the negative effects of building a dam. Students will work together to provide reasons to support their view on the issue. Students may use the information provided above and also conduct additional research. Have students debate in class.

EXTENSIONS

1. Have students visit a dam and/or reservoir in the Farmington River Watershed.
2. Have students explain why the fish ladder at Rainbow Dam is vital to the salmon and shad returning to spawn.

RESOURCES

Farmington River Watershed Association, August 2003, *State of the Farmington River Watershed Report*.

GLOSSARY

dam - a barrier constructed across a waterway to control the flow or raise the level of water
generator - machine that converts mechanical energy into electrical energy
hydroelectric power - the cycle of evaporaton and condensation that controls the distribution of the earth’s water as it evaporates from bodies of water; also called water cycle
impoundment - the act of accumulating and storing water in a reservoir
turbine - machine in which the kinetic energy of a moving fluid is converted into mechanical energy by causing a bladed rotor to rotate

Lesson 5

Water Underground

How do surface water and ground water interact?
What happens if a pollutant enters the surface water?
From where does drinking water come?

GOAL To understand that surface water and ground water should be monitored and protected from contamination.

OBJECTIVES Students will:

- ✓ create a model that demonstrates the interaction between surface and ground water
- ✓ determine how surface water and ground water interact

MATERIALS **plastic container, 2 paper cups, sand (one cup), food coloring, water, gravel**

CORE CURRICULUM CONTENT STANDARDS

- **Science 7(2,5,8), 8(2), 14(1)**
- **Social Studies 9(1,3), 10(1-3), 13(5)**

VOCABULARY **run-off, permeable, impermeable, percolate, aquifer**

PROCEDURES

1. Begin by asking students, “Where does water go when it rains?” Some of the water may evaporate, flow over land as runoff into the waterways, or soak into the soil and become ground water.
2. Explain to students that as rain water soaks into the ground it slowly percolates down into the soil through layers of soil and rock. The permeability of the soil affects how quickly or slowly the water is able to pass, or soak, through the soil.
3. Examples of permeable soil include sand and gravel because there are pores or spaces between the soil. Clay is an example of an impermeable surface because it can effectively block water from flowing through it.
4. Water percolates downward until it reaches an impermeable layer. Then, the water begins to accumulate, or fill up. The underground pockets of water held in the rocks are called aquifers. Aquifers are important sources of fresh water. The drinking water supply of many households comes from aquifers. Wells are drilled to pump water from aquifers.
5. Protecting this resource is extremely important as water carrying pollutants may contaminate water supplies.

6. The interaction between surface water (rain water, lakes, wetlands, rivers) and ground-water (aquifers) is important because the water quality of one may affect the other.
7. Break students into groups and have them conduct the following exercise so as to illustrate the interaction between ground water and surface water.
    a. Fill a plastic container with gravel until it is a few inches from the top.
    b. Pour water into container until it reaches the top of the gravel.
    c. Poke small holes in the bottom of two paper cups.
    d. Place an inch of sand in one of the cups. Set this cup in the bowl, resting on the gravel.
    e. Explain that the cup in the gravel represents soil on land and the plastic container with the gravel and water represent an aquifer.
    f. Place several drops of food coloring on top of the sand in the cup.
    g. The food coloring represents a contaminant or pollution that went into the soil.
    h. The students simulate rain by pouring water into the second cup, holding the second cup over the cup with the sand and food coloring.
8. Students may answer the following questions:
    a. What is happening to the water? (*percolates down through the sand*)
    b. How is the contaminant impacting the soil on land and groundwater?
    c. Can the ground water affect the surface water? Explain.
    d. Where does your drinking water come from? (*aquifer, reservoir*)
    e. Knowing that surface and groundwater impact each other, how does that change your attitude about your treatment of water?

EXTENSIONS

1. Have students research the geological formations, such as stratified drift and bedrock that help in the storage of underground water reserves.
2. Have students try different types of soil in the cup to test percolation of the various types of soil.

RESOURCES

Etgen, John*, Healthy Water, Healthy People, Water Quality Educators Guide*, 2003,The Watercourse, Bozeman, Montana 59717 - 0575

GLOSSARY

aquifer - an underground layer of earth, gravel, or porous stone that yields water
impermeable - preventing especially liquids to pass or diffuse through
percolate - to cause (liquid, for example) to pass through a porous substance or small holes; filter
permeable - that can be permeated or penetrated, especially by liquids or gases: *permeable membranes; rock that is permeable by water*
run-off - rainfall not absorbed by soil

FRWA Curriculum Guide

Week II - Middle School

Watershed

Watershed – Background Information

"The river moves from land to water to land, in and out of organisms, reminding us what the native peoples have never forgotten; that you cannot separate the land from the water, or the people from the land. – Lynn Noel, Voyages Canada's Heritage Rivers

A watershed consists of an area of land and water where water drains into particular water basins, such as rivers, lakes, ponds, wetlands, or streams. It encompasses all the land, animals, plants, buildings, towns and people within the area. The precipitation that falls that is not used by the plants or animals travels within the watershed. Land elevation determines the flow of water, while surrounding ridge areas define the boundaries.

Farmington River Watershed is a sub-basin of the Connecticut River Watershed. All the tributaries of the Farmington River are included in the watershed. The area of land encompasses 386,000 acres, or 609 square miles, which drains into the Farmington River and its tributaries. Included in the watershed are 10 towns in Massachusetts and 23 towns in Connecticut. The Farmington River, in turn, drains into the Connecticut River.

The 81 miles of river begin at an elevation of 2,180 feet in the Berkshire Hills of Becket, MA, traveling 16 miles through Otis and Tolland, and enter Connecticut in Colebrook at 1,300 feet. The west branch river flows through land areas that feature hills, ponds, wetlands and lakes.

The river continues in a southeasterly direction, entering the towns of Barkhamsted and New Hartford. The confluence of the west and east branches occurs, creating the main stem of the Farmington River. As the main stem flows through New Hartford, a deep gorge, known as Satan's Kingdom, results in the formation of significant rapids.

As the river continues downstream, into Farmington, the river turns north and enters a section known as the "bathtub" because of slower, moving waters. It then meanders through Farmington, Avon and Simsbury. The Tariffville Gorge restricts the flow as the river turns east towards the towns of East Granby, Bloomfield and Windsor. Meeting the Connecticut River downstream of the Loomis Chaffee School in Windsor, the Farmington River has joined the biggest river in New England.

In 1994, the federal government designated 14 miles of the Farmington River as a National Wild and Scenic River. The designation highlights the section from Hartland to Canton as an area of particular beauty, importance to wildlife, and recreational value, and grants federal protection to the river. Visitors canoe, kayak, fish, visit historic mills and state parks, and observe bald eagles and other wildlife that call this section of the river "home".

There are many tributaries and water bodies within the watershed that contribute to the flow and health of the Farmington. One of the major ones include Otis Reservoir, located in Otis, MA. It was originally a series of three ponds (Messenger, Little, and Rand) until a dam was built in 1865 to provide water to downstream mills. It encompasses1,050 acres and is a vacation spot that offers fishing and camping facilities.

The Clam River, approximately 8 miles south of Otis, supports timbering and fishing industries and has a number of dams for flood control and recreational purposes. Sandy Brook flows in a southeasterly direction from Colebrook, CT and joins Still River between Robertsville and Riverton. The terrain runs through rocky glens or valleys in the Algonquin State Forest.

Continuing south, The Mad River joins Mill Brook above Winsted and contributed to the destruction of Winsted during the flood of 1955. Since then, it has been contained by a flood control dam built under the direction of the U.S. Corps of Engineers. The Highland Lake outlet connects with the Mad River at Winsted and joins the Still River in East Winsted. Still River also flows through Winsted, connects with Mad River before joining Sandy Brook.

Once a whitewater boating stream, the East Branch originally ran through a deep, forested area. Numerous mountain streams fed into the river, but in 1940, Metropolitan District Commission impounded the entire Connecticut section to create the Barkhamsted Reservoir. Its sole purpose is to supply drinking water to the Greater Hartford area; therefore, no recreational activities are allowed. It still affords a fine view from the Saville Dam.

Below the Saville Dam, Lake McDonough provides a recreational area for boating, fishing and swimming. Cherry Brook flows through North Canton into the Farmington at the New Hartford/ Canton town line. Starting in New Hartford, the Nepaug River meanders through open country and woods, flowing through a deep glen to the Nepaug Reservoir. This area comprises another closed reservoir administered by Metropolitan District Commission.

Roaring Brook flows through Secret Lake in Canton into the Farmington in Unionville. The Pequabuck River originates in Harwinton, and flows southeasterly through, Plymouth, Bristol, Forestville and Plainville. It then connects with the Farmington River in Farmington, where the Farmington reaches its most southerly point. The Talcott Range forces the river to change direction to flow north.

The Thompson Brook flows through Avon into the Farmington and the Nod Brook runs through Avon and Simsbury to join the Farmington at the Avon/Simsbury town line. Stratton and Hop Brook both meander through Simsbury before linking up with the Farmington. The east branch and west branch of the Salmon Brook run through Granby and flow through East Granby before connecting with the Farmington.

The Massachusetts portion of the watershed consists of mostly forested land and hilly terrain. Wetland resources are abundant and current land use is limited to forest and agriculture. Overall, the watershed is rural, but there have been substantial changes in land use in Connecticut as residential development has expanded into agricultural areas. The communities most greatly affected by the change in land use include Farmington, Avon, Simsbury, Bloomfield, and Windsor.

Lesson 6

Water Ways

Where does the Farmington River flow?
Where does the Farmington meet the Connecticut River?

GOAL To follow the path of the Farmington River from Massachusetts to Connecticut

OBJECTIVES Students will:
- ✓ become familiar with the flow of rivers
- ✓ understand that land and water are part of the watershed

MATERIALS **copies of watershed maps, topographic map (on CD), butcher block paper**

CORE CURRICULUM CONTENT STANDARDS

- **Science 7(6), 8(2), 14(1)**
- **Social Studies 9(1,3), 10(1-3), 12(1-6)**

VOCABULARY **confluence, topography, tributary, map, border**

PROCEDURES

1. Divide students into small groups and distribute a copy of the topographic map of the Farmington River Watershed (on CD). Instruct students to find contour lines. The lines correspond to elevations of the land.
2. Provide a copy of sample contour lines, elevations and topography.
3. Explain that a watershed consists of an area of land and water where water drains into particular water basins, such as rivers, lakes, ponds, wetlands or streams, etc. Show a relief map if available.
4. Have students look at map and determine whether they are able to identify rivers, tributaries, reservoirs, lakes. Discuss differences and similarities of how of the bodies of water such as a pond, stream, or reservoir appear on map. (*a stream is narrower, pond is wider).*
5. Instruct students to follow the path of the Farmington River from Massachusetts to where it flows into the Connecticut River. Distribute large pieces of butcher block paper to groups.
7. Explain to students that they will be drawing the path of the river on the butcher block paper by referring to the copy of the map.
6. Write the following instructions on the board for the students to follow:
   a. Mark an “x” where the west branch of the Farmington River begins at Becket, Mass. This is the source of the river. Note the elevations at this area. Draw the source.
   b. Follow the Farmington River with your finger or pencil down to Colebrook, Connecticut. Draw the river to the wider body of water in Colebrook. This is called the Colebrook Reservoir. Label. Identify the boundary line of Massachusetts and Con-

necticut.

c. Follow the river south through Barkhamsted to the northeastern corner of New Hartford. This is where the west and east branches of the Farmington River meet, the confluence. Mark an “x”. Draw this section of the river.
d. Follow the river in a southeasterly direction through Canton, Burlington and Farmington. A stretch of 14 miles through Barkhamsted, New Hartford and Canton is designated as a “National Wild and Scenic” section, a designation that recognizes its value to recreation, wildlife and beauty. Draw this section.
e. Still flowing in a southeasterly direction, the Farmington River goes through Farmington and turns to head in a northeasterly direction towards Avon and Simsbury. Draw this part of the river, reflecting the change in direction. Place an “x” on the Simsbury section of the Farmington River.
f. Past Simsbury, the Farmington River makes a turn in an easterly direction towards Windsor. Place an “x” on the Windsor section of the Farmington and draw this area of the river on your paper.
g. The Farmington River connects with the Connecticut River eight miles from the Rainbow Dam in Windsor. Draw a portion of Connecticut River to show the connection to the Farmington.
h. Referring to the FRWA map, add the reservoirs and tributaries of the watershed.

EXTENSIONS

1. Have students imagine an eagle flying over the watershed. Have them create a narrative story from the eagle’s perspective. Discuss its habitat and what it eats.

RESOURCES

Farmington River Watershed Association, August 2003, *State of the Farmington River Watershed Report*, Farmington River Association, Inc.

GLOSSARY

border - the line or frontier area separating political divisions or geographic regions; a boundary
confluence - a flowing together of two or more streams
map - a representation, usually on a plane surface, of a region of the earth or heavens
topography - graphic representation of the surface features of a place or region on a map, indicating their relative positions and elevations
tributary - a river or stream flowing into a larger river or stream

Lesson 7

Water Lines

How is a river formed?
How do hills direct the flow of water?

GOAL To understand that the elevation of the land determines the flow of water

OBJECTIVES Students will:

- ✓ create a model watershed
- ✓ determine flow of water in a watershed
- ✓ create "pollution" and identify how it flows through the watershed

MATERIALS **newspaper (two pieces each student), spray mist bottle, masking tape, permanent markers, water soluble markers**

CORE CURRICULUM CONTENT STANDARDS

- **Science 7(6,8), 8(2,3), 14(1)**
- **Social Studies 9(1,3), 10(1-3), 12(1-5)**

VOCABULARY **ridge lines, topography, flow, model, man-made, dam**

PROCEDURES

1. Explain to students that they will be making a simple model of a watershed to simulate or demonstrate river flows. The flow and direction of the water is determined by the elevation of the land. Hills, ridgelines, mountains all influence the flow of water. Students will create a paper watershed (*based on "What is a Watershed?" from Global River's Environmental Education Network*). Students may work in small groups.
2. Each group will receive two sheets of paper. Instruct students to crumple one sheet of paper, then open it up but do not straighten it all the way. Tape the edges of the crumpled sheet to the surface of the other sheet of paper. The model should resemble a relief map. Show a relief map if available.
3. Identify the land that the model represents. The higher elevations are hills and mountains, and the lower levels represent valleys. Instruct the students to trace the ridgelines (the border) with blue soluble markers.
4. Have the students predict where they think the major rivers might be. Have students mark those areas with permanent markers.
5. Place models on newspaper to absorb water. Provide students with spray bottles. Instruct students to spray mist onto their models. Observe and discuss where the water collected, how it flowed, etc.
6. Ask students how the hills (topography) of the land affected the way the water flowed.
7. If this model were to include towns, people, parks, etc. what natural and man-made elements might these be? (*trees, soil, animals, people are examples of natural elements; buildings, dams, malls, shops, etc. are examples of man-made elements)*

8. Have students imagine that several towns have developed in the watershed. Have students determine where the school, shopping centers, landfill, trash-to-energy plant, roads, soccer fields and parks would be. Mark the areas with different colored permanent markers.
9. Place a drop of food coloring at each of the sites to represent pollution coming from the particular sites. Have students predict what will happen next time it rains. Have them predict what will happen to the surface water and ground water. Spray mist onto the watershed model to observe.
10. Ask students where they would want to live and why.

EXTENSIONS

1. Ask students what the highest point of elevation in the Farmington River Watershed is (2,180 feet in Becket, Massachusetts). Have students look at the contour lines on map to confirm high elevation.
2. Ask students if there had ever been a flood in their town or surrounding area. Ask why it happened and what can be done to prevent another flood.
3. Ask students how individuals can reduce the amount of pollution made.

RESOURCES

Rosselet, Dale A., *New Jersey WATERS, A Watershed Approach to Teaching The Ecology of Regional Systems,1999* New Jersey Audubon Society, Bernardsville, New Jersey 07924.

GLOSSARY

dam - a barrier constructed across a waterway to control the flow or raise the level of water
flow - to move or run smoothly with unbroken continuity, as in the manner characteristic of a fluid
man-made - made by humans rather than occuring in nature; synthetic
model - a small object, usually built to scale, that represents in detail another, often larger object
ridge lines - a long narrow chain of hills or mountains
topography - graphic representation of the surface features of a place or region on a map, indicating their relative positions and elevations

Lesson 8

Water Absorption

> What is the difference between a pervious and an impervious surface?
> How does the type of surface in a watershed impact water quality?

GOAL To understand that the type of surface affects the flow and quality of water

OBJECTIVES Students will:

- ✓ conduct an experiment demonstrating pervious and impervious surfaces
- ✓ predict where puddles will form on school grounds
- ✓ determine how surfaces affect water quality

MATERIALS **three aluminum trays (with drainage holes cut on one side), bricks or boards to prop trays, soil, grass, leaves, hay (optional), paper, pencils, clipboards, two cups, measuring cup, watering can, water**

> **CORE CURRICULUM CONTENT STANDARDS**
>
> - **Math 1(1-3), 2(1), 4(1), 9(2)**
> - **Science 1(1), 8(1-3), 14(1)**
> - **Social Studies 9(1), 10(1-3), 12(5,7,8)**

VOCABULARY **pervious, impervious, run-off, infiltration, orient, buffer zones**

PROCEDURES

1. Begin by explaining that an experiment demonstrating two different types of surfaces will be completed.
2. Conduct a demonstration on pervious and impervious surfaces. Have three aluminum trays set up with drainage holes on one side of the tray. Prop up the trays so that water will drain.
3. Explain to students that when precipitation falls on a woodland, grass or field, it filters through a *pervious* surface into the soil. When water falls on the road, parking lot, or pavement then the water *runs-off* the surface into the storm drains. This type of surface is considered *impervious*.
4. Set up three trays for a demonstration a particular type of surface; one tray is empty, the second one has soil in it and the third one has soil with grass, hay or leaves on top.
5. Ask students to predict which surface will shed the most water and which will absorb the most water. Assign students to pour a measured amount of water from a watering can onto the surfaces. Another student can collect the water coming out of the hole of the aluminum tray using a cup or jar.
6. Have students measure the amount of water collected from each tray. Determine the percentage of runoff by dividing the original amount of water into the amount collected and multiply by 100.
7. The amounts will provide the level of infiltration from least to most. Discuss how water infiltrates through the soil and recharges the ground water aquifer.

8. Discuss how real surfaces in the natural environment and man-made environment would react in the same manner as the trays (*empty tray – pavement; soil – bare surfaces; covered tray – grass, etc.)*
9. Break students into groups to survey school grounds. Have them create a sketch of the school grounds, orienting the school building properly. Have them place an “N” with an arrow pointing in the direction of North.
10. Have students predict where puddles will form after it rains.
11. Have them mark an “x” on their sketches where they predict the puddles will form. After it rains, have students match up “x’s”.
12. Continue surveying school grounds. Ask students where the impervious and pervious surfaces are.
13. Ask if pervious surfaces affect water quality and quantity.
14. Ask if impervious surfaces affect the water quality and quantity.
15. After observing the area, have students think of ways to improve the impervious surfaces at their school.

EXTENSIONS

1. Have students measure how far the puddles formed from the school. Have them measure depth, width and length.
2. Have students observe the flow of water during a rainstorm to determine areas in need of buffer zones or more pervious surfaces.

RESOURCES

Rosselet, Dale A., *New Jersey WATERS, A Watershed Approach to Teaching The Ecology of Regional Systems,1999,* New Jersey Audubon Society, Bernardsville, New Jersey 07924.

GLOSSARY

buffer zones - an area that lessens or absorbs a negative environmental impact
impervious - incapable of being penetrated
infiltration - the act of permeating (a porous substance) with a liquid or gas
orient - to align or position with respect to a point or system of reference
pervious - capable of penetrating or pervading
run-off - rainfall not absorbed by soil

Lesson 9

Riparian Banks

What do the riparian banks indicate about overall health of the river?
What causes riparian banks to change?
What is the impact of the change(s)?

GOAL To understand that riparian banks provide insight into the overall health of a river

OBJECTIVES Students will:

- ✓ draw a side view of a riparian bank
- ✓ show the changes to the banks
- ✓ discuss how the changes affect the water

MATERIALS **butcher block paper for 5 student groups, markers, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(2)**
- **Science 1(7), 7(7,8), 8(2,3), 14(1,2,6)**
- **Social Studies 9(1,4,8), 10(1,2), 12(2,5,7,8)**
- **Arts (1(1), 6(2)**

VOCABULARY **riparian areas**

PROCEDURES

1. Begin the activity by explaining to students that the *riparian areas* change as the river meanders through different sections of the watershed. In this activity, have students illustrate some of the changes in river habitats.
2. Divide the class into four groups and provide each group with a large piece of butcher block paper.
3. Assign each group one of the following sections of the river:
   a. woodland area with floodplain nearby
   b. farming area with grazing cattle
   c. housing development with lawns
   d. urban area with businesses
4. Have each group of students draw a side view section of the river. Include any animals, plants, or non-living item along the bank. Have students include what they think would be seen along the riverbank.
5. After pictures are completed, find a place for the pictures to be placed so that all the profiles of the river edges can be displayed. Have students look for differences in riparian areas.

6. Now provide the following changes that could occur along the river.
   a. development is encroaching into the woodland area, causing pockets of clear cut areas.
   b. grazing cattle have caused erosion, resulting in sediment changes in the river
   c. people living in housing development using riparian areas for recreation; swimming, picnic lunches, and fishing.
   d. increase in run-off due to impervious surfaces; businesses hired a landscape architect to create more pervious areas around business to control flooding.
7. Have student groups use the other side of paper to reflect changes to particular area. Display profiles again and discuss changes.
8. Ask students if activity in one area of watershed affects the habitat and health of the river in another. Discuss within groups and present ideas to class.

EXTENSIONS

1. Have students visit several sites along the Farmington River. Have them sketch the area from a side view. Discuss the health of the river based on what was observed.
2. Discuss why it is important to preserve the riparian areas. Ask what positive or negative effect or impact humans have on an area.

GLOSSARY

riparian areas - the vegetative area or bank by a river

Lesson 10

Carrying Capacities

What is a reservoir and how is it used?
What is the name of the largest reservoir in the Farmington River Watershed?
What are carrying capacities?

GOAL To understand the enormity of carrying capacities of reservoirs

OBJECTIVES Students will:

- ✓ identify and locate reservoirs on a watershed map
- ✓ conduct calculations to understand the size of a reservoir
- ✓ relate size of reservoir to school gym

MATERIALS **watershed reservoir maps (selected_dams_map on CD), paper, plastic gallon jug for four groups, rulers, pencils, calculators**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(2,3), 2(1,2), 3(1), 4(1), 5(1,3)**
- **Science 7(6,8), 8(1- 3), 14(1-3)**
- **Social Studies 12(1,2,4,7,8), 13(5)**

VOCABULARY **reservoir, carrying capacity**

PROCEDURES

1. Begin by discussing the term reservoir with students. Ask students what they are and their purpose
(*artificial lakes made by impoundments; storage for drinking water or flood control)*.
2. Discuss carrying capacities of reservoirs (*amount of water they are able to hold*). Explain that Farmington River Watershed has ten reservoirs and three (Nepaug, Barkhamsted, and Whigville Reservoirs) are used solely for drinking water storage (*listed below*). They are able to store billions of gallons of water. Have students comprehend the enormity of the volume through math calculations.

3. Distribute watershed reservoir maps and have students identify the locations of the following reservoirs:

Otis Reservoir - 5.8 billion gallons

Colebrook Reservoir - 32.1 billion gallons

West Branch Reservoir - 6.5 billion gallons

Barkhamsted Reservoir - 30.3 billion gallons

Lake McDonough - 2.9 billion gallons

Nepaug Reservoir - 9.5 billion gallons

Mad River Detention Reservoir - 3 billion gallons

Sucker Brook - 482 million gallons

Whigville Reservoir - 37 million gallons

Rainbow Reservoir - 4 billion gallons

4. After completing activity, divide students into four groups. Provide each group with a one gallon jug, a ruler, paper, pencil and calculator. Assign two reservoirs listed above to each of the four groups.
5. Initially, have students practice calculations to determine how much space is needed for the Colebrook Reservoir (32.1 billion gallons).
   a. Have students calculate how much room is used by 32.1 billion jugs. Have them measure the volume of the gallon jug with a ruler. Measure and multiply the length, width and depth in inches. For example, if the amounts were 5 inches × 6 inches x 10 inches, the total would equal 300 cubic inches or .17 cubic feet/gallon.* (*300 inches ÷ (12in/ft x 12 in/ft x 12 in/ft) = .17 cubic feet) To calculate the amount of space used by the 32.1 billion containers, have students multiply .17 cubic feet/gallon x 32,100,000,000 gallons. This is an area of 5,457,000,000.
   b. Have students calculate how many gallons would fit in school's gymnasium. Have them measure the volume of the gym and divide that number by the volume of one jug. For example, if the room is 20ft x 50ft x 50ft, the total volume equals 50,000 cubic feet. 50,000 cubic ft ÷ .17 cubic ft equals 294,118 gallons in one gym.
   c. Have students measure how many gyms it would take to store the 32.1 billion gallons. 32,100,000,000 gallons ÷ 294,118 gallons = 109,140 gyms filled with gallon jugs. This is the amount of space used by the Colebrook Reservoir to store the 32.1 billion gallons of water.
6. Have student groups continue with the other calculations for the remaining reservoir carrying capacities.

EXTENSIONS

1. Have students visit one of the reservoirs to view its size. Instruct them to research and determine what water-related activities are allowed at each of the ten reservoirs.
2. Have students identify wildlife at each of the reservoir locations. Have them determine if particular species inhabit these areas.

RESOURCES

Farmington River Watershed Association, August 2003, *State of the Farmington River Watershed Report*.

Haskin, Kathleen M., *The Ways of the Watersheds: An Educators Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies*, 1995, Claryville, NY: The Frost Valley YMCA

GLOSSARY

carrying capacity - the ability or amount that can be held or stored
reservoir - a natural or artificial pond or lake used for the storage and regulation of water

FRWA Curriculum Guide

Week III - Middle School

Watershed Ecosystems

Watershed Ecosystems Background Information

"For many of us, water simply flows from the faucet, and we think little about it beyond this point of contact. We have lost a sense of respect for the wild river, for the complex workings of a wetland, for the intricate web of life that water supports." – Sandra Postel, Lost Oasis; Facing Water Scarcity

An ecosystem encompasses a community of plants and animals that can exist simultaneously within a certain area. The health of an ecosystem depends upon the health of the water and the diversity of plant and animal populations is indicative of overall health. Aquatic life supports a variety of life: plants, fish, reptiles, insects, mammals, birds etc. Proper water temperature ranges, preventing erosion along the riparian bans with trees and vegetation, shading effects of trees, fast, moving cool waters with riffles and pools all support a diversity of aquatic life.

Evidence of benthic macroinvertebrates provide an indication of the health of the stream and river. *Benthic* refers to animals that live on the bottoms of streams, rivers, or ponds and spend part of their lives in a body of water. *Macroinvertebrates* do not have backbones and are large enough to be seen without a microscope. Such insects are sensitive to conditions of the water and the existence of certain insects in streams can indicate water quality.

Different organic and inorganic components comprise the ecosystem. The manner in which interaction takes place among these components all contribute to the state of the ecosystem. Organic components include producers, primary consumers, secondary consumers, tertiary consumers, and decomposers. Producers, or plants, make their own food through the process of photosynthesis while plant eaters, also called primary consumers or herbivores, eat the plants within an ecosystem. Secondary consumers, known as carnivores or meat eaters, are predators to plant eaters. Lastly, tertiary consumers are at the top and eat secondary or primary consumers. Also included are decomposers: organisms that return nutrients to the soil to be re-used by the producers. Two examples of inorganic components include rocks and water.

An ecosystem can be represented by food chains, food pyramids, and food webs. A food chain shows the flow of energy through the trophic levels. For example, the sun begins the food chain. Producers are plants that need the sun to make food, consumers eat the plants, and so on. Food chain models demonstrate how energy passes through an ecosystem.

A food pyramid demonstrates the amount of food required to sustain an organism at each trophic level. For example, plants are at the base and obtain their energy from the sun. They are eaten and 90% the energy from the plant is lost as the consumer uses the energy to survive. As a result, less energy is available to the carnivores higher up on the food chain. Therefore, it takes many plants to sustain fewer herbivores and even fewer carnivores.

A food web, meanwhile, demonstrates the connectedness of all the organisms and illustrates the many possibilities of energy flow. The larger the diversity of organisms within an ecosystem, the better an ecosystem is able to withstand natural or man-made disruptions.

The Farmington River Watershed provides habitats where many species thrive. 400 different animals, endangered species and others inhabit the area between Otis, MA and Colebrook Lake in Colebrook, CT. State-endangered swollen wedge mussel, which are highly sensitive to pollution, bears, beavers, peregrine falcons inhabit this area.

The Barkhamsted Reservoir area hosts bobcat, bear, fisher, and beaver. Beaver were eliminated in the late1800's due to farming and trapping. Additionally, porcupine and muskrat, as well as eagles, turkey vultures, osprey, flycatchers, warblers, swallows, and songbirds have been spotted. Aquatic insects, state-threatened spring salamanders, waterfowl, trout, and salmon abound in the riffles and pools of the river.

In the area of New Hartford and Satan's Kingdom, trout, salmon, beavers, and muskrats can be seen. Cherry Brook provides a haven for songbirds, including cedar waxings, vireos and orchard orioles. Nighthawks, Canadian geese, common and hooded mergansers, and an occasional red-breasted merganser dot the sand bars, as do gulls, and shorebirds. Killdeer, solitary and spotted sandpipers, great blue heron, and great egrets are regulars at the reservoir.

At the Lower Collinsville Dam and in Unionville, songbirds are prevalent. Osprey, otters, mink, eastern hog-nosed snake, and trout are found and in warmer sections of the river, yellow perch, calico bass and other breeds are caught.

Throughout the sixteen mile riparian stretch from Farmington to Simsbury, rare-billed cuckoo songbird, hooded warbler, American woodcock, eastern screech owl, eastern bluebird, kingfisher, willow flycatcher, and orchard oriole are prevalent. Other species of wildlife that inhabit this section of the Farmington include bats, otters, beavers, deer, musk and wood turtles. Painted turtles bask at an oxbow lake and frogs and dragonflies all contribute to the diversity of the ecosystem.

Along the riparian banks of Tariffville, Simsbury, and Windsor, crows, red-tailed hawks, great horned owls, red-wing blackbirds, and great blue herons abound. Additionally, trout are stocked for fishing enthusiasts. Blueback herring, salmon, American shad, alewife spawn at the Rainbow Reservoir in Windsor. Double-crested camorants fly close to water and ospreys, herons, kingfishers, eastern screech owls, red-tailed hawks, muskrats, wood ducks, and leopard frogs can all be spotted.

Because of dam construction and other restrictions to waterways, salmon and other *anadromous (return from the sea or ocean to where they were originally born to spawn)* fish populations declined. Fish use the fish ladder at Rainbow Reservoir as a passageway to return to spawn. In order to promote the proliferation of salmon, CT DEP Whittemore fish hatchery, housed one-mile downstream of the Goodwim Dam, produces 150,000 to 300,000 Atlantic salmon eggs.

Connecticut DEP and its partners continue to help restore Atlantic salmon to the Connecticut River watershed. The program involves incubating Atlantic salmon eggs in a chilled aquarium tank beginning in early January. These eggs were previously harvested from salmon that returned to the Connecticut River. The eggs hatch around mid-February into alevin, a small fish of about one to one and half inches. Supported by a yolk sac (the egg residual), its sole source of food supply, the salmon alevin approaches the “fry” stage at the end of April or early May.

At this point, the sac will be gone and the fish look like streamlined small minnows. The fish are ready for stocking in the Farmington River and tributaries in late April or early May. Many schools participate in programs that involve raising salmon and releasing them into rivers as fry. The salmon restoration project for the Connecticut River Watershed and the subsequent stocking of the Farmington River and its tributaries are helping to retain the salmon and other types of fish in this area.

Lesson 11

Diversity Walk

Why is diversity important to an ecosystem?

GOAL To understand that diversity protects an ecosystem

OBJECTIVES Students will:

- ✓ use search cards to identify items in an ecosystem
- ✓ discuss the importance of diversity in an ecosystem
- ✓ create a mural based on their observations of plant, and wildlife

MATERIALS **butcher block paper for mural, markers, pencils, paper, search cards, clipboards**

CORE CURRICULUM CONTENT STANDARDS

- **Science 3(1-5), 4(1,2), 5(3)**
- **Social Studies 9(1), 10(2,3), 13(5)**
- **Arts 1(1), 6(2)**

VOCABULARY **biodiversity, preservation**

PROCEDURES

1. Begin by explaining to students that diversity in a river ecosystem is important to the health of the river. Maintaining biodiversity has become a vital issue in the protection and preservation of plants and animals.
2. In an ecosystem, plants and animals are interconnected. Have students explore the concept of diversity by visiting a riparian area or a schoolyard area may be substituted.
3. Distribute one or more search cards (*may be copied onto oak tag*) to each student. Students may work with partners or partner groups. Choose an area that has more than one habitat: a forest and stream; or a field and meadow.
4. Ask students to find items on their cards and be prepared to describe them. Remind them not to pick, or remove any plants.
5. Items on cards may be obvious or they may have to look for signs (of wildlife) in area.
6. After they have found items on the cards, gather students and ask them to share what they found.
7. Discuss concept of biodiversity (biological diversity - the variety of life in all its forms and inter-relationships) while planning a community.

What is Biodiversity

There are millions of species of plants, birds, reptiles, mammals, fish, shellfish, amphibians, insects, and microorganisms such as bacteria living on earth. Try to imagine them all, and don't forget to put yourself in the picture! Now think about what makes each one of those species different from each other. Think about what makes them look and act differently, what different kinds of habitats and climates they live in, what their different needs are, and how they interact with one another. Now think about your community and the many kinds of people, animals, plants, insects, etc. you find there. Think about what it takes for these critters to co-exist, and think about how you might planforcommunity growth (more colored boxes) while protecting biodiversity in your town.

(Adapted from endangered.fws.gov/kids/biodivrs.htm)

	Search Cards	
Find two or more animal homes (animal smaller than a dog)	What is the most common plant in this area	Listen for or look for a sign of a bird
Find three different colored plants	What is the most common animal in this area	Look for plants that are dead or dying
Find a plants that grows in a stream	Find at least two signs of insects	Find an item that is not alive
Find a tree with three plants living beneath its branches	Find an animal or plant that lets you know the season is changing	Find as many different leaves as you can
Find a sign that an animal has been here	Count how many different plants are in one small area	Find a plant that is smaller than your foot
Find a sign that an animal has eaten something	Find a sign that tells you an animal lives underground	Find a sign of erosion
Find a plant with a pattern on it	Find a sign that tells you an animal lives in a tree	Find three different shaped leaves
Find a plant that needs sun and one that requires shade	Find items that are unnatural in this area	Find animal tracks

EXTENSIONS

1. Instruct students to imagine this area at night. Discuss the types of animals that might live here.
2. Discuss how this area would appear during other seasons.
3. Have students conduct a mini-biodiversity project. Have them study, identify, and count the number of plant species in a marked area.

GLOSSARY

biodiversity - the number and variety of organisms found within a specified geographic region
preservation - kept alive, intact or free from destruction; for the protection of wildlife or natural resources

Lesson 12

Water Webs

What is a food web and a food chain?
How are animals and plants interconnected in an ecosystem?
How can natural or man-made impacts affect the balance of an ecosystem?

GOAL To understand that food chains and food webs are essential to an ecosystem

OBJECTIVES Students will:

- ✓ identify animals and plants in a food chain and food web
- ✓ create food webs
- ✓ conduct research on a type of wildlife

MATERIALS **butcher block paper, markers, pencils, web chart copies**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(4,10), 2(3)**
- **Science3(1-4), 5(3)**
- **Social Studies 9(1), 10(2,3), 13(5)**

VOCABULARY **producer, primary consumer, secondary consumer, tertiary consumer, trophic levels, decomposer, food chain, food web**

PROCEDURES

1. Explain to students that they will be examining food chains and food webs. Food chains demonstrate how energy can be passed through the *trophic* levels of an ecosystem. For example, a food chain begins with the sun. Plants, or *producers,* use the sun's energy to make food through the process of photosynthesis. Herbivores, or *primary consumers,* eat plants, carnivores, or *secondary consumers* eat plant eaters and *tertiary consumers* are at the top of the food chain. Animals eat a variety of items and not just one, as a food chain depicts. Food webs, therefore, more closely demonstrate the interconnectedness of animals and plants in an ecosystem.
2. Have students use the words in the web chart (at end of lesson) to create food chains and food webs.
3. Break students into groups, distribute paper, and have them create as many food webs as possible.
4. Have them connect the words with arrows to demonstrate the flow of energy.
5. Have students create one food chain from the animals on the list and determine habitat requirements for the plant(s) and animals. Ask students if there are areas along the Farmington River that are more suitable for particular species than other areas.
6. Have students research one type of aquatic insect, fish, mammal, bird or other type of animal found on the Farmington River. List its adaptations and habitat requirements. Ask if it is an endangered species and if it is, what is being done to protect its habitat.

EXTENSIONS

1. Discuss with students that beaver were abundant before the settlers arrived in the area. Have them determine reasons for their decline in the 1700's.
2. Discuss why it is important to maintain a diversity of plants and animals. Discuss naturally and unnatural occurrences that have an impact on animals and plants.

WEB CHART

Mammals	**Fish**	**Birds**	**Insects**	**Plants**	**Microscopic org.s**
Fisher	Trout	Kingfisher	Mayfly nymph	Algae	Algae
Black Bear	Salmon	Merganser	Dragonfly	Grasses	Plankton
Beaver	Smolts	Cormorant	Caddisfly larva	Leaves	Bacteria
Muskrat	Parr	Heron	Caterpillar	Trees	Larvae
White-tailed deer	Eggs	Osprey	Water strider	**Reptiles**	**Amphibians**
Mink	Alevin	Bald eagle		Wood turtle	Wood frog
Bobcat	Perch	Vireo		Hog-nosed snake	Salamander

GLOSSARY

decomposer - an organism, often a bacterium or fungus, which feeds on and breaks down dead plant and animal matter, thus making organic nutrients available to the ecosystem

food chain - a succession of organisms in an ecological community that constitutes a continuation of food energy from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member

food web - a complex of interrelated food chains in an ecological community

primary consumer - an animal that eats grass and other green plants in a food chain; an herbivore

producer - a photosynthetic green plant or chemosynthetic bacterium, constituting the first trophic level in a food chain

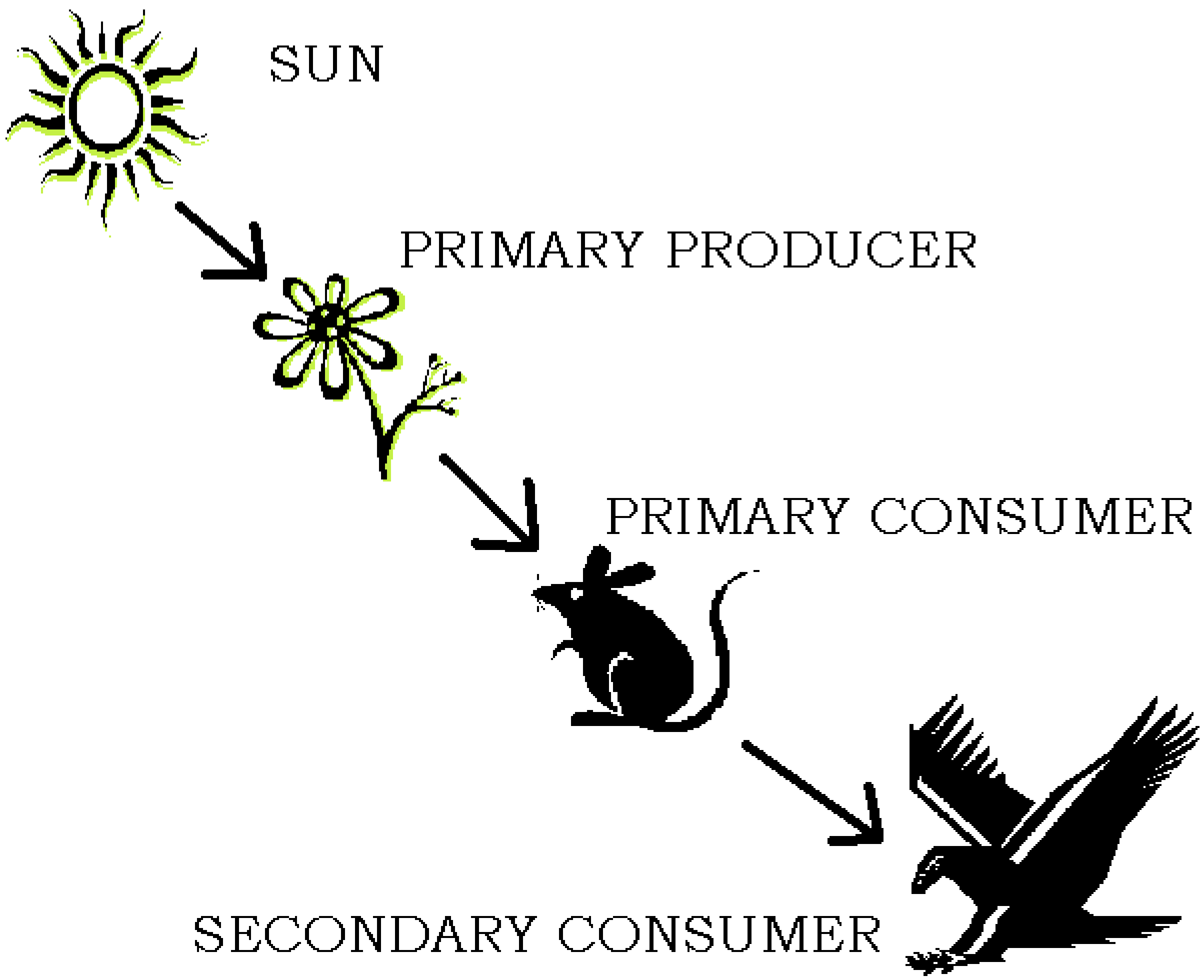
secondary consumer - an animal that feeds on smaller plant-eating animals in a food chain

tertiary consumer - third in place, order, degree or rank

trophic levels - of or involving the feeding habits or food relationship of different organisms in a food chain

FOOD CHAIN

Energy flows from the Sun to the plants (primary producer). The plants are eaten by a mouse (primary consumer) which is then in turn eaten by the hawk (secondary consumer).



Lesson 13

Riparian Explorer

What can be observed along the riparian banks?
What do observations indicate about the health of the river?
What are some special adaptations of macroinvertebrates?

GOAL To understand that observing a riparian bank can provide insight into the waterways health

OBJECTIVES Students will:
- ✓ use observational skills to determine health of river
- ✓ complete worksheet
- ✓ create a creature using different adaptations

MATERIALS **observation sheets, pencils, clipboards, adaptation cards (to be copied), a variety of art materials**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(1)**
- **Science3(2,4,5), 6(3)**
- **Social Studies 9(1), 10(2-4), 13(5)**

VOCABULARY **adaptations, riparian bank, observation, macroinvertebrate**

PROCEDURES

1. Have students explore an area of the river bank to determine what lives there. Distribute observation sheets for students to record their observations.
2. If the edge of a stream is not available for students to explore, they may explore an area close to the school (or their schoolyard) to determine the type of creatures that live there.
3. After explorations, discuss observations with students.
4. Discuss *macroinvertebrates* and their adaptations upon return to classroom.
5. Distribute two adaptation cards of aquatic creatures in their larva or nymph stage. Review with students what those stages mean (*first stage of life lives in water*).
6. Adaptations may include how the insect moves, how it breathes, how it swims, or other features. Examples of features include a flat body, builds its own house, can stick to rocks with special hooks, has three tails, fills up with water and expels out of abdomen and propels itself through water, breathes through gills, etc. (*Features are listed on a separate sheet for teachers to copy and cut out for students.)*

7. Have students create a three-dimensional aquatic creature based on its adaptations. Have students use a variety of materials such as modeling clay, toilet paper rolls, Styrofoam, construction paper, plastic, and other re-used materials.
8. Have students write a story about their creature. Have them name it, explain its adaptation(s), discuss its habitat, what it eats, etc.

GLOSSARY

adaptations - special features that allow an organism to survive in its environment
macroinvertebrate - an invertebrate animal (animal without a backbone) large enough to be seen without a microscope
observation - the act of noting and recording something, such as a phenomenon, with instruments
riparian bank - of, on, or relating to the banks of a natural course of water

Lesson 13 – Student Sheet 1

Life Along the River (or School grounds)

(If the type of animal or habitat is not applicable to school ground, write down examples of animals that could live in a stream habitat.)

1. Study the plants and vegetation along the river banks (or school). What types of plants hold in the soil and prevent erosion? Students may describe, identify or draw.

2. Look for land and water dwellers (amphibians) – They live in the water when they are young and on land when they are adults.

3. Look for air dwellers – Look for birds or signs of birds and insects.

4. Look for plants and animals that float on or swim in the water.

5. Look for land dwellers (mammals, reptiles, and plants).

6. Look for insects that spend part of their lives in the water and part out of the water.

Has a large appetite	Has hard armor
Lives in a protective house that it builds	Breathes through the surface of its body
Uses three tails at the end of its abdomen to swim	Has paddle shaped legs to help it move through water
Moves by expelling water from its body	Has a flat shape
Is camouflaged	Has feet that feel the vibrations of other creatures
Must live where there is lots of oxygen	Can eat an animal fifty times bigger than itself
Attaches to rocks	Breathes through gills
Hides from other animals	Eats decaying things
Can fly through the water	Avoids bright lights

Lesson 14

Water Finds

Why do we examine aquatic insects?
Why are they important to determining the health of the stream?
What other observations about the stream indicate health?

GOAL To understand that aquatic insects indicate health of stream.

OBJECTIVES Students will:

- ✓ find and identify aquatic insects
- ✓ work together to search for and collect insects
- ✓ use equipment in the proper manner

MATERIALS plastic containers, clipboards, identification chart (Macroinvertebrate Chart.gif on CD), pollution tolerance index, biotic index sheets, pencils, magnifying lenses, wading boots (optional), lenses, pocket microscopes

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1,2), 2(1)**
- **Science 1(1), 3(1,2,4), 6(3), 8(2,3)**
- **Social Studies 9(1), 10(2,3), 13(5)**

VOCABULARY **biotic index, magnify, identify, observation**

PROCEDURES

1. Select a site within the watershed for a field trip. Students will study site to determine health of stream through the study of presence (or absence) of various macroinvertebrates.
2. Prior to site visit, safety considerations and access to stream need to be determined.
3. Upon arriving at site location, distribute instructions and equipment.
4. Explain to the students how to look for and identify aquatic insects. Have students work in groups (with an adult leader) and look under rocks, in vegetation, and at the bottom of streams for aquatic creatures. Distribute plastic containers, nets, clipboards, pencils, and biotic index sheets. Some of the students may wear wading boots, if available. Have students use magnifying lenses or pocket scopes to observe some of the smaller insects.
5. Have students fill plastic containers with water and place macroinvertebrates in the containers for further study. Have students draw creature on identification chart.
6. Have students identify insects with the help of the biotic index key (Macroinvertebrate Chart.gif on CD). Have them determine the type of macroinvertebrate found through this key. Have them calculate the pollution tolerance index by multiplying index value by number of species. (*Sheet at end of lesson.*) This will help students determine the health of the stream.
7. After insects are identified and examined, have students release macroinvertebrates back into the stream.

8. If students are not able to visit a stream, or as a follow-up activity, have students participate in a simulated stream field trip:
   a. Instruct students to imagine they are going on a field trip to a stream bank. They walk down to the edge of the stream and listen to the ripples of the water. The current of the stream flows rapidly over the rocks and carries cool, clear water downstream.
9. Have students draw a picture of the stream bank. Have students reflect on appearance of the stream that they observed or imagine how a healthy stream might look.
10. Have students listen to two descriptions of insects. They may use on-line dichotomous key (www.people.virginia.edu/~sos-/w/a/stream-study/keyintro.html) to determine insect type.
11. Descriptions are:
    a. insect has segmented legs, six legs, long body, 3 tails, and gills (*mayfly*)
    b. insect has segmented legs, six legs, long body, no tail, hard, wide abdomen and large eyes (*dragonfly*)
    c. Go to website listed above, click on (a) to identify mayfly and (b) to identify dragonfly.
12. Have students complete worksheet if they did not visit an actual stream.

EXTENSIONS

1. Have students use water thermometers to take temperature of water. Ask what conclusions can be made regarding the temperature and insects that live there. Ask if insects require a cool or warm environment.
2. Ask what the absence of insects tells about the stream (*problem with water quality).* If the stream has only one type of insect, have students determine health of the stream.

RESOURCES

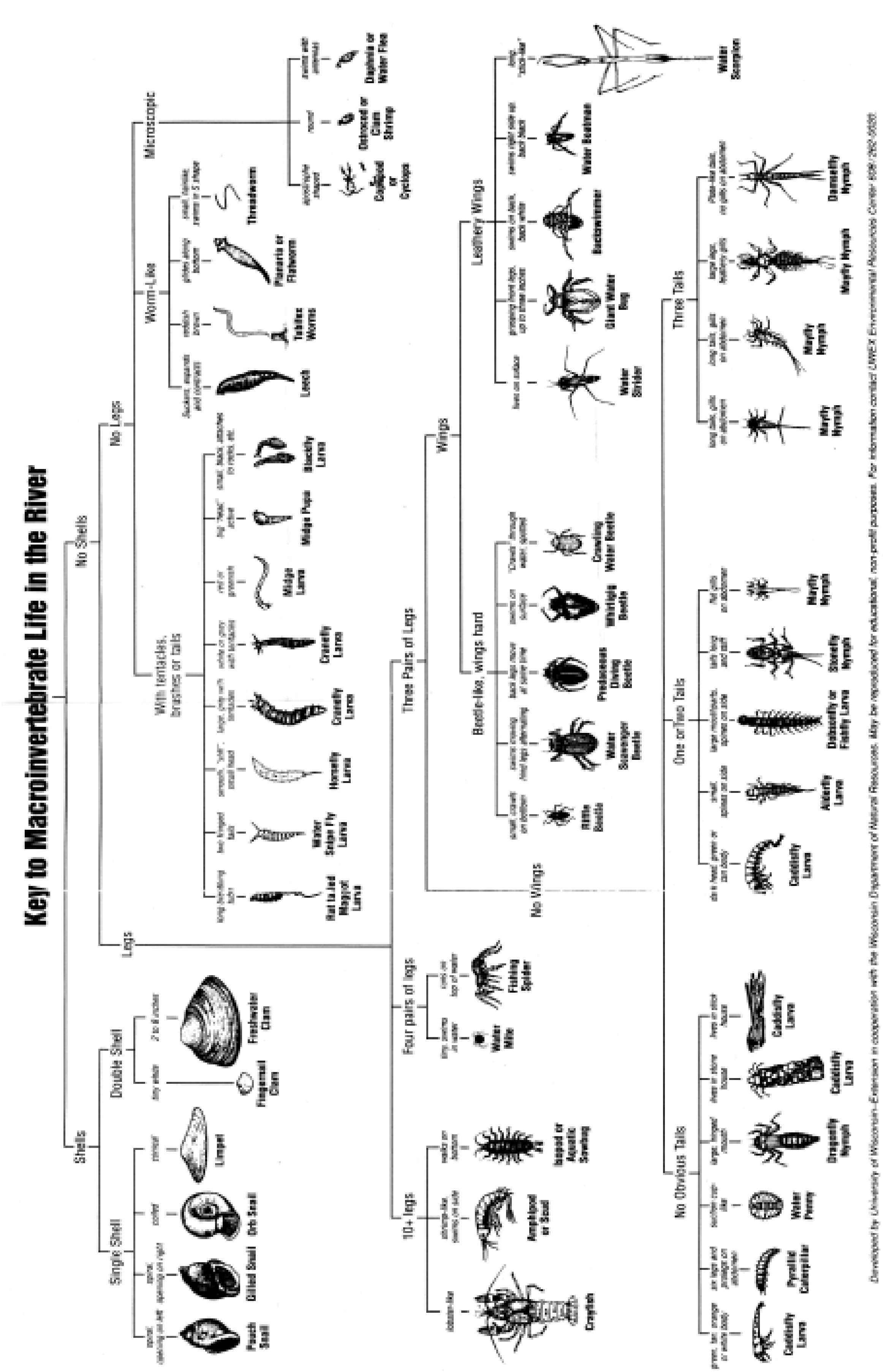
Edelstein, Karen, *Pond and Stream Safari: A Guide to the Ecology of Aquatic Invertebrates*, 1993, Cornell University Media Services.
Etgen, John, *Healthy Water, Healthy People, Water Quality Educators Guide*, 2003, The Watercourse, Bozeman, Montana 59717 - 0575

GLOSSARY

biotic index - an index of or having to do with life or living organisms
identify - to ascertain the origin, nature, or definitive characteristics of
magnify - to increase the apparent size of, especially by means of a lens
observation - the act of noting and recording something, such as a phenomenon, with instruments

Macroinvertebrate Identification Chart

Macroinvertebrate	**Draw how it looks**
Mayflies (Order *Ephemeroptera*)	
Stoneflies (Order *Plecoptera*)	
Caddisflies (Order *Trichoptera*)	
Dobsonflies (Order *Megaloptera)*	
Dragonflies (Order *Odonata)*	
Snails (Class *Glastropoda*)	
Craneflies (Order *Diptera*)	
Midges (Order *Chironomidae*)	
Tubifex worms (Class *Oligochaeta*)	
Scuds (Order *Amphipoda*)	
Leeches (Class *Hirudinea*)	


Key to Macroinvertebrate Life in the River
Shells
No Shells
Single Shell
Double Shell
Legs
No Legs
Microscopic
Worm-Like
With tentacles, brushes or tails
Three Pairs of Legs
Four pairs of legs
10+ legs
Wings
No Wings
Leathery Wings
Beetle-like, wings hard
Three Tails
One or Two Tails
No Obvious Tails
Pouch Snail
Gilled Snail
Orb Snail
Limpet
Fingernail Clam
Freshwater Clam
Crayfish
Amphipod or Scud
Isopod or Aquatic Sowbug
Water Mite
Fishing Spider
Leech
Threadworm
Water Scorpion
Water Boatman
Backswimmer
Giant Water Bug
Water Strider
Riffle Beetle
Crawling Water Beetle
Mayfly Nymph
Stonefly Nymph
Damselfly Nymph
Dragonfly Nymph
Caddisfly Larva
Water Penny

Macroinvertebrate Data Sheet

Pollution Tolerance Index

Group 1 **Very Intolerant**	Group 2 **Intolerant**	Group 3 **Tolerant**	Group 4 **Very Tolerant**
___Mayflies ___Stoneflies ___Caddisflies ___Dobsonflies ___Dragonflies ___Other	___Dragonflies ___Scuds ___Craneflies ___Other	___Midges ___Leeches ___Other	___Snails ___Tubifex Worms ___Other
# of checks =___ X 4 Group score = __ Total Score = ___	# of checks =___ X 3 Group score = __	# of checks =___ X 2 Group score = __	# of checks =___ X 1 Group score = __

Water Quality Assessment:

Excellent quality = 23+
Good Quality = 17 – 22
Fair Quality = 11 – 16
Poor Quality = Less than 10

Instructions:

a. Place a check next to each macroinvertebrate found (not the number found).
b. Complete the chart for all macroinvertebrates found.
c. Calculate group scores by multiplying numbers provided.
d. Total score and compare to assessment.

Adapted from Healthy Water, Healthy People Water Quality Educators Guide

Lesson 15

Wetland Wonders

Why are wetlands important?
How are wetlands identified?
What types of animals and plants live in wetlands?

GOAL To understand that wetlands are significant to the health of a watershed

OBJECTIVES Students will:

- ✓ simulate a wetland flow of water
- ✓ identify the importance of wetlands
- ✓ visit a wetland and observe the plants and animals
- ✓ compare a wetland to another type of ecosystem

MATERIALS **aluminum tray with hole cut out, four sponges, wetland worksheet, clipboard, pencils, field guides, Wetland pictures from CD**

CORE CURRICULUM CONTENT STANDARDS

- **Science 1(1,2), 3(4,5), 7(7), 8(2,3)**
- **Social Studies 9(1), 10(2,3), 13(5)**

VOCABULARY **wetland, saturate, filter, sediments**

PROCEDURES

1. Begin by asking students if they are familiar with the term *wetland* (Elicit responses). Provide them with some background information about wetlands.

   Wetlands can form at edges of rivers, streams, ponds, and low-lying woods and are areas that are saturated with water for all or part of the year. They have qualities of both aquatic and terrestrial habitats and a diversity of plant and animal life. Surface water, ground water, and precipitation all contribute to the formation of wetlands. Water collects in low spots, such as rivers, ponds, and lakes. When the water saturates the surrounding land, then wetlands form. Wetlands are important to the watershed because they hold water, store it, and slowly release it over time. Because they have both land and aquatic characteristics, wetlands are some of the most diverse ecosystems on earth. The different plant species of a wetland provide habitat for a variety of animals. Microorganisms, invertebrates, and reptiles are common in wetlands. Additionally, many amphibians live in wetlands during at least part of their life cycle. A large number of fish species require wetland habitat for spawning, feeding, or protection from predation. Abundant food resources and sites for nesting, resting, and feeding attract many species of birds. Many breeding and migratory birds, especially waterfowl, are associated with wetlands, as are mammals such as muskrats, mink, raccoons, and beavers. About one-fourth of the plants, one-half of the fishes, two-thirds of the birds, and three-fourths of the amphibians listed as threatened or endangered in the United States are associated with wetlands.

Wetlands help to control floods by storing water and slowly releasing it to downstream areas after the flood peaks. Wetlands slow the flow of water, lessening erosion and causing sediments to settle out of the water. This improves water quality, as does the removal of nutrients and contaminants from the water by growing wetland plants and by chemical processes in wetland sediments. Wetlands act as natural filtering systems. They trap and neutralize sewage waste and promote the decomposition of many toxic substances. Wetlands also serve as sites where surface water can seep into the ground and replenish groundwater. Since the late 1700s, over half of the wetlands of the United States, (excluding Alaska), have been lost. Approximately 35 percent were lost by the 1950s; wetland destruction during the next two decades resulted in an additional loss equal to the combined area of Massachusetts, Connecticut, and Rhode Island. Wetland losses have resulted in greater flooding and erosion, reduced water quality, and reduced populations of many plants and animals.

2. Have students view pictures of wetlands from CD. Divide class into groups to demonstrate how wetland is able to store and filter water through an ecosystem.
3. Provide each group with an aluminum tray. Have them pour a shallow layer of water into bottom. Place a sponge in tray. Watch how it absorbs the water as soil does. Have a student place his finger on the sponge to create a depression.
4. Ask what happens to water once it reaches the wetland. Have students compare a watershed to one that has a wetland and one that does not.
5. Have students in groups poke a hole in one end of the aluminum tray and prop the tray up at an angle with a board or brick. Place 4 sponges in tray and pour two cups of water over the “wetland.” The sponges act like a wetland in that they absorb the water and slow the runoff.
6. Have students remove and wring out sponges, remove and empty water from tray. Have them repeat the demonstration without the sponges and compare the water flows.
7. Have student groups visit a wetland. Provide clipboards, pencils, and student worksheets (sample at end of lesson) to student groups to complete. Also, provide a field guide for students to use to identify plants and animals.
8. Have students look for the following in a wetland:
   a. Observe plant species – spot and identify the dominant species.
   b. Weather conditions – observe temperature of the soil and air, cloud cover, wind speed and direction.
   c. Describe the soil and identify what lives there.
   d. Identify various insect species.
   e. Names of bird species and a description of what they are doing
   f. Identify other animals and describe what they are doing.
   g. Identify other animal signs.
   h. Tally total number of species identified.
   i. Compare the wetland to another ecosystem.
9. After students have completed their worksheets, have groups discuss their findings.

EXTENSIONS

1. Discuss with students the significance of the following scenario:

   A development is being considered in an area with wetlands. Wetlands are to be filled in with soil before construction begins. The wetlands are not in a protected area. Discuss the impact of this action with students. Ask if anything can be done to prevent this action.

2. Have students create a mural of the animal and plant species found in the wetland they observed.

RESOURCES

Nelson, Dennis, *Project WET Curriculum and Activity Guide*, The Watercourse and Council for Environmental Education, 1995, Bozeman, Montana 59717 – 0570

Ranger Rick's Nature Scope *Wading Into Wetlands*, National Wildlife Federation, 1992, Washington, DC 20036-2266

"Wetland," Microsoft® Encarta® Online Encyclopedia 2003
http://encarta.msn.com © 1997-2003 Microsoft Corporation. All Rights Reserved

GLOSSARY

filter - to pass through a filter; to percolate
saturate - to soak, fill, or load to capacity
sediments - fine soil or mineral particles, resulting often from the run-off from the land, which either settle to the botton of a water body or are suspended in the water
wetland - a lowland area, such as a marsh or swamp, that is saturated with moisture, especially when regarded as the natural habitat of wildlife

Wetland Worksheet

1. Describe the weather conditions.

   Air Temperature ______

   Soil Temperature______

   Cloud Cover Percentage______

   Wind Speed_______

   Wind Direction_______

2. Identify plant species and list. Name the dominant species.

3. Describe the soil. What is living there?

4. Identify insect species observed.

5. Identify any animal observed and describe what it is doing.

6. Identify birds and describe what they are doing.

7. List any animal signs observed.

8. Count number of species observed.

9. Compare the wetland to another type of ecosystem.

FRWA Curriculum Guide

Week IV - Middle School

Going Back to the Past

Going Back to the Past
Background Information

"I came where the river ran over stones; my ears knew an early joy. And all the waters of the streams sang in my veins that summer day" – Theodore Rothke, The Waking, 1948

The Farmington River Watershed is rich with history. Evidence of early inhabitants is shown throughout the watershed and the formation of the land, itself is reflected in its geology. The Farmington River provided a home for early inhabitants of the valley. The Native Americans called the river, Wattunkshausepo, "the fast, flowing winding river". The Europeans later shortened it to Tunxis, "the beautiful river that ripples down through the hills". The land was forested and the river abounded in salmon, American shad, alewives, sea lamprey, sturgeon and other fish that fed the tribes that lived here. Native Americans lived in different areas of the watershed and some tribes were considered nomadic. They lived by the river to fish, planted corn in small, forest clearings and hunted in the woods.

In the area going through Avon, Burlington, Canton, and Farmington, through the abrupt northerly bend in the river, a large group of Tunxis Natives lived there when English settlers arrived in the 1600's. In Simsbury, the meadows that line the river were planted by the Native Americans and called Nod Lands.

In the 1600's English settlers moved to valley where Poquonock Natives lived at the mouth of Farmington River, known today as Windsor. Settlers also moved to other areas, such as plantations in Simsbury (known as Massaco) and at Tunxis (known now as Farmington). They depended on the river for food. They planted crops and used the river for transportation.

When building dams and mills, settlers disturbed Native American fishing and prevented salmon and other fish from moving upstream to spawn. The forests were clear cut for farmland and pastures were fenced off. This created a hostile situation, and wars emerged. The Indians were no match to the settlers' rifles, so they retaliated by burning towns. King Phillip (Anglicized name) or Native American Chief Metacomet gave the orders to burn the city of Simsbury in 1676 in retaliation to the settlers. The Tariffville Gorge was once traversed by settlers from Windsor going to Simsbury and back again to escape the raids of the Wampanoag Indians.

The name of "Satan's Kingdom" comes from the lawlessness of the local population, as it was inhabited by prisoners and exiles in the 1700's. One of the first bridges to go across the river in this section was marched across by soldiers on their way to Boston during the Revolutionary War.

During the 1800's, industrialism emerged. The invention of machinery and the development of mass production in factories were prevalent during this time period. In 1820, the quality of the water was degraded because of paper and cotton mills, tanneries, and saw mills dumping wastes into various rivers (Clam, Sandy Brook, Nepaug). In Windsor, the river was a port-of-entry for trade with England and the West Indies until a bridge was constructed crossing the Connecticut River in 1809. Mills were situated along the river in Windsor, similar to other towns in the 1800's. Factories manufacturing textiles, yarns, and paper goods were located in Windsor as well as three electricity generating plants.

One historical landmark still visible today is the remnants of an aqueduct in Farmington. As part of the Farmington Canal built on July 4,1825, it stretched from New Haven, CT to Westfield, MA and then 10 years later to Northampton, MA. The transportation link remained in operation until the railroad made it obsolete. Now all the tracks have been removed from the rail bed and it is being slowly converted to a park area. The path is being paved much of the way and is frequented by cyclists and hikers.

During the mid-19th century, depression caused mills to shut down along the Farmington River. The east and west branch of Salmon Brook were, however, spared pollution. The trout located in the Salmon Brook helped sustain renewal of upper river stocking programs because it was not polluted during the industrialism as other rivers had been.

There has been an active effort to protect the river since 1950's to present. The 1955 flood, carried away houses, railroad bridges and buildings. The devastation inspired the construction of major flood control reservoirs. Additionally, factories installed waste water treatment systems to reduce pollution, floodplain regulations were implemented, and laws went into effect, such as the Clean Water Act of 1972. Because of the laws and other factors affecting the protection of the rivers and waterways being instituted, the Farmington River conservation and renewal efforts have been met with success.

Geological formations and remnants from glacial activities provide a look into the past. According to the Farmington River Guide, dated 2002, "the steep ridges from Otis to Colebrook literally tumble into the Farmington forcing it to twist and turn and often obstructing it with boulders". The vertical cuts in bedrock overlooking the Colebrook Reservoir are more than 500 million years old, showing white streaks of magma in the rock. Continuing downstream through Barkhamsted approaching People's State Forest, the river turns east. Large hills rise up on both sides of the river. The south side of the hills are made of one-billion year old Precambrian rock.

In New Hartford, the mountains at Satan's Kingdom blocked water flow, creating a lake extending northwest for miles. Later, geological pressures forced water to cut through the rock, creating the formation of the gorge. During pre-glacial times, the Farmington flowed to join the Quinniapiac and emptied into New Haven. A glacial phenomenon was responsible for changing the direction of the river's flow. A wedge-shaped glacial deposit of debris or rock, called a moraine, slowed the Farmington's flow to south, causing the river to turn north.

A glacial lake eventually grew in size until it reached as far north as Tariffville. It was then was able to top the ridge and cut a gorge which now permits the Farmington to drain into the Connecticut River in Windsor. A reminder of past times are the sand and gravel pits, effects of river and glacial deposits as well as Tariffville Gorge.

From Farmington to Simsbury, huge accumulations of rock debris, called talus slides, can be seen at the foot of Talcott Mountain. The mountain divides the valley floors of the Farmington and Connecticut Rivers and the ridge is the result of molten rock forced through the earth's crust.

Lesson 16

Colonial Times

What did the settlers think of America when they arrived?
How did settlers alter the landscape?
How has the land changed in modern times?

GOAL To understand that the settlers altered the landscape

OBJECTIVES Students will:

- ✓ read a letter written by a colonist upon his arrival to New England
- ✓ describe the land then and compare to modern day changes
- ✓ write a letter describing current land usage

MATERIALS **letter copies, pencil, lined paper for writing, construction paper for drawing, crayons or markers**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(1,12), 2(1,3), 5(4,6)**
- **Science 8(2)**
- **Social Studies 1(1,2,5,8), 2(4), 4(1,5), 9(1,6,7)**
- **Arts 6(1,2)**

VOCABULARY **colonist**

PROCEDURES

1. Begin by explaining that when the settlers arrived from Europe, they found a land inhabited by the Native Americans. The Native Americans lived in tribes and taught the colonists many things about the land and water: how to care for it, how to plant, how to hunt and how to fish.
2. Distribute copies of a letter from William Hilton after his arrival to New England. Have students read letter and write down descriptions of Hilton's perception of the area.
3. Instruct students to draw a picture of what he saw and imagine the sounds he heard.
4. Then, instruct students to imagine they are arriving at the town in which they live. They have arrived by ship and/or other means and are waiting by the river. Have students write a letter to someone they left behind. Describe the scene.
5. Ask the students to compare how the area has changed from Native American times as a result of the Colonist settlements.

EXTENSIONS

1. Have students conduct research to find other letters written during the 1600's or 1700's. Have them describe what was written in the letters.
2. Ask students how the land changed with the colonists' arrival in New England.
3. Ask what the colonists' primary occupation were (*farmers*).
4. Discuss how houses were built by both Native Americans and colonists.
5. Compare colonial hunting to Native American methods.
6. Trace the history of the Farmington River from Native American times through Industrialism. Explain how the river was affected.

RESOURCES

http://members.aol.com/calebj/hilton.html

GLOSSARY

colonist - an original sttler or founder of a colony

A letter written by William Hilton after his arrival in New England on the ship *Fortune*, 1621

Loving Cousin,

At our arrival at New Plymouth, in New England, we found all our friends and planters in good health, though they were left sick and weak, with very small means; the Indian round us were peaceable and friendly; the country very pleasant and temperate, yielding naturally, of itself, great store of fruits, as vines of sorts, in great abundance. There was likewise walnuts, chestnuts, small nuts and plums with much variety of flowers, roots and herbs, no less pleasant than wholesome and profitable. No place hath more gooseberries and strawberries, nor better. Timer of sorts you have in England doth cover the land, that affords beasts of diverse sorts, and great flocks of turkeys, quails, pigeons, and partridges; many great lakes abounding with fish, fowl, beavers and otters. The sea affords us great plenty of all excellent sorts of sea-fish, as the rivers and isles doth variety of wild fowl of most useful sorts. Mines we find, to our thinking; but neither the goodness nor quality we know. Better grain cannot be than the Indian corn, if we plant it upon as good ground as a man need desire. We are all freeholders; the rent-day doth not trouble us; and all those good blessings we have, of which and what we list in their seasons for taking. Our company are, for the most part, very religious, honest people; the word of God sincerely taught us ever Sabbath; so that I know not any thin a contented mind can here want. I desire your friendly care to send my wife and children to me, where I wish all the friends I have in England; and so I rest

Your loving kinsman,

William Hilton

Lesson 17

Geology Formations

How has the watershed changed over the years?
What geological formations provide clues to another time period?

GOAL To recognize that natural and man-made causes alter the flow of the river and the surrounding terrain

OBJECTIVES Students will:

- ✓ imagine going on an airplane ride through time periods
- ✓ draw and describe the watershed during different time periods
- ✓ present their findings to the class

MATERIALS **butcher block or poster board for each group, pencils, markers or crayons, lined paper**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(2)**
- **Science 7(2, 5-8), 8(2)**
- **Social Studies 1(1,2,5-8), 2(4), 9(1,2,4,5,7)**
- **Arts 5(1,3), 6(2)**

VOCABULARY **glacial, crust, ridge, basalt, lava, fault, talus slide, boulder, Precambrian rock**

PROCEDURES

1. Explain that the students will be embarking on a journey through the past. Instruct them to imagine flying up in an airplane over the Farmington River Watershed. Explain that the simulated airplane ride will take them through time zones so they may view the Farmington River and surrounding land from above and from different perspectives.
2. Inform the students that their task will be to describe and draw what they see.
3. Break up students into groups and have group choose one person to read the pilot's descriptions.

4. Instruct the students to listen as the pilot describes how the river flowed and items they might see during a particular time period.
    a. **PRE-GLACIAL**
    The river flowed from Becket, Massachusetts downstream to connect with the Quinnipiac River to empty into what is now the New Haven harbor. The high ridges outlined the narrow valleys. Talcott Mountain was formed from *basalt* lava as it flowed through the *faults* or breaks in the earth's *crust*. *Precambrian rock* jutted out through the *ridges*.
    b. **GLACIAL ACTIVITY**
    Huge boulders and ledges obstruct the Farmington forcing it to twist and turn. Huge accumulations of rock debris or talus slides are found at the foot of Talcott Mountain. A melting glacier left a huge wedge blocking the flow of the river forcing it to turn north in the town of Farmington. A resulting lake was formed that reached up to Tarriffville eventually forming a gorge.
    c. **NATIVE AMERICAN TIMES**
    Virgin pines rose up through the mountains. Wigwams were situated along the river in areas such as Farmington, Simsbury and Windsor. Clear water from the river revealed rocks in the riffles and salmon fish swimming. Small areas of trees were cut for planting gardens of corn, beans and squash. Wildlife of all sorts were free to roam the forested areas.
    d. **COLONIZATION/INDUSTRIALISM**
    Forested areas were clear cut for farm fields. Houses made from the tree logs were built around small towns. Dams were constructed to control the floods and to provide water power to the mills and factories developing close to water ways. The river was becoming polluted from the factory waste discharging into the river. Virgin pines were cut to create masts for ships and beaver and other animal pelts were sent to England resulting in a decrease in wildlife. A large canal, called the Farmington spanned an area from New Haven to Northampton, Massachusetts.

3. Have student groups create drawings and descriptions of how they think the area looked from an aerial view during each of these four time periods. Have students present to class.
4. Ask students to write about one of the time periods they would have liked to have seen and why.

EXTENSIONS

1. Have students research a geological formation and present to the class.
2. Have students visit an area of the Farmington River Watershed that shows evidence of a time past. Contact the historical association in their town for information.
3. Have students take a historical walk.

RESOURCES

The Farmington River Guide 2002, Farmington River Watershed Association

GLOSSARY

basalt - a rock of igneous origin
boulder - a large rounded mass of rock lying on the surface of the ground or embedded in the soil
crust - the hard, outer part of a planet, moon or asteroid
fault - a dislocation caused by a slipping of rock masses along a plane of fracture; also the dislocated structure resulting from such slipping
glacial - having to do with a huge mass of ice slowly flowing over a land mass, formed from compacted snow in an area where snow accumulation exceeds melting
lava - the rock formed by the cooling and solidifying of molten rock that reached Earth's surface through volcanic activity or fissure
Precambian rock - rock traces belonging to the geologic time period between Hadean Time and the Cambrian Period, often subdivided into the Archean and Proterozoic eras, comprising most of the earth's history and marked by the appearance of primitive forms of life
ridge - a long, narrow area of hills or mountains
talus slide - a sloping mass of rock debris at the base of a cliff

Lesson 18

Water Threats

Why have salmon populations declined?
Why is the Rainbow Dam fish ladder in Windsor important to the salmon?
What are Farmington River Watershed and DEP doing to help the salmon?

GOAL To understand that salmon were once plentiful in the Farmington River Watershed and restoration projects are ongoing.

OBJECTIVES Students will:

- ✓ become familiar with the life cycle of the salmon
- ✓ understand the reasons for the decline of salmon
- ✓ identify ways that schools and organizations participate in the restoration of salmon to this area
- ✓ create and participate in a salmon game

MATERIALS **butcher block paper, markers, scissors,** Salmon Life Cycle diagram on CD

CORE CURRICULUM CONTENT STANDARDS

- **Math 2(1)**
- **Science 3(4,5), 6(4), 7(8), 8(2), 14(1,2)**
- **Social Studies 10(1-3), 12(7,8), 13(5)**

VOCABULARY **fish ladder, incubating, alevin, fry, restoration, anadromous, pollutant**

PROCEDURES

1. Discuss the salmon restoration project with students. Explain that the Connecticut River Watershed and the stocking of the Farmington River and its tributaries are helping to restore Atlantic salmon to the Connecticut River watershed. Because of dam construction and other restrictions to waterways, salmon and other *anadromous (return from the sea or ocean to where they were originally born to spawn)* species of fish population declined. With the construction of the fish ladder at the Rainbow Reservoir, fish use the ladder as a passageway to return to spawn. In order to promote the proliferation of salmon, CT DEP Whittemore fish hatchery, housed one-mile downstream of the Goodwim Dam, produces 150,000 to 300,000 Atlantic salmon eggs. Connecticut DEP and its partners continue to help restore Atlantic salmon to the Connecticut River watershed. The program involves incubating Atlantic salmon eggs in a chilled aquarium tank beginning in early January. Show Salmon Life Cycle Diagram from CD. These eggs were previously harvested from salmon that returned to the Connecticut River. The eggs hatch around mid-February into alevin, a small fish of about one to one and half inches. Supported by a yolk sac (the egg residual), its sole source of food supply, the salmon alevin approaches the “fry” stage at the end of April or early May.

At this point, the sac will be gone and the fish look like streamlined small minnows. Many schools participate in programs that involve raising salmon and releasing them into rivers as fry. Many species of salmon are anadromous—they spawn, or lay their eggs, in fresh water; the young migrate to salt water and grow up there; and the fish return to fresh water to breed after they reach maturity. The migratory instinct of members of the salmon family is remarkably specific, each generation returning to spawn in exactly the same breeding places as the generation before it. Some salmon migrate hundreds or even thousands of miles to reach their spawning grounds. Even those species that do not migrate from fresh water to salt water spawn in the same freshwater streams as did their ancestors.

2. Inquire about the reasons salmon populations decline. Provide time for students to reflect on this. Before the colonization when Native Americans inhabited this area, salmon fish were plentiful in the rivers. Since salmon migrate to the ocean and then return, an unobstructed passageway is necessary to its survival. Also, salmon are sensitive to changes in water quality.
3. Discuss with students and explain that paper factories and other industries grew along the river, and a lot of pollutants flowed into the river from the factory wastes. Environmental laws did not exist, so plants were not regulated or restricted as they are today.
4. Also, dams were built to control the river flow and in some cases, to prevent flooding. This wall or dam prevented the salmon from returning to their original home.
5. The salmon's diet consists of microscopic plants and small animals, such as insects, which are often sensitive to changes in Water Quality.
6. In order for students to understand the challenges of a salmon, have them participate in a salmon game that demonstrates the migratory route.
    a. Have students create 16 circles out of butcher block paper. Inside circles, have them write the information listed at the end of this lesson. Have circles arranged on floor to demonstrate the migratory route of the salmon.
    b. Ask if the salmon will make it to the CT River and return to its original habitat. Explain that the purpose of the game is for salmon to be able to return to its original habitat.
    c. Have students make several games so more students can participate. Have them use one die to determine amount of spaces.
    d. The information for the circles follows:

1. Small fry are released in Stratton Brook, Simsbury CT. Go forward 5 spaces.
2. Salmon continue to Hop Brook and feed on lots of water insects. Go forward 2 spaces.
3. Salmon connect to Farmington River. Go forward 3 spaces.
4. Salmon take wrong turn and head towards Salmon Brook, Granby. Go back 1 space.
5. They enjoy the cool waters in a shaded area and decide to remain in this habitat for awhile. Lose a turn.
6. High river levels cause turbulence in river waters. Salmon head in opposite direction. Go back two spaces.
7. Perfect conditions to head towards East Granby and Windsor. Go forward 6 spaces.
8. Salmon make it to Rainbow Reservoir in Windsor. Go forward 4 spaces.
9. The water is calm. Salmon remain for two weeks. Lose a turn.
10. Salmon continue on their journey making it to the CT River through Long Island Sound and to the Atlantic Ocean. Go forward 10 spaces.
11. Salmon returns to head back to original release area. Go forward 1 space.
12. Low levels near the CT River turn to Rainbow Fish Ladder. Go back 5 spaces.
13. Goes up fish ladder. Go forward two spaces.
14. Gets caught in turbine. Go back 3 spaces.
15. Salmon continues on Farmington River in Windsor. Go forward 2 spaces.
16. Stream flows enable salmon to make turn towards Simsbury. Go forward 2 spaces.

6. Ask students what a fish ladder is.(passageway that helps the salmon go upstream when there is a dam).
7. Ask why the Rainbow Reservoir in Windsor and fish ladder are important to the continuation and restoration of salmon.

EXTENSIONS

1. Have students create their own salmon game and migratory route.
2. Have students read a salmon story and write a story from the salmon's viewpoint.
3. Draw a poster of the salmon's life cycle, research the Atlantic Salmon Federation's website at www.asf.ca
4. Follow a salmon's route on a map.

RESOURCES

Atlantic Salmon Life Cycle Diagram. J.O. Pennanen, Atlantic Salmon Federation, www.asf.ca

GLOSSARY

alevin - young fish; fry
anadromous - migrating up rivers from the sea to breed in fresh water
fish ladder - a series of pools arranged like ascending steps at the side of a stream, enabling migrating fish to swim upstream around a dam or other obstruction
fry - small fish, especially young, recently hatched fish
incubating - to maintain (eggs, organisms, or living tissue) at optimal environmental conditions for growth and development
pollutant - the state of being contaminated with harmful substances
restoration - the act of restoring or bringing back to a former place, station, or condition; the fact of being restored; renewal

Lesson 19

Farmington Canal

Why was the Farmington Canal important?
What was its path?
How long did it take to build?

GOAL To understand that the Farmington Canal is of historical significance

OBJECTIVES Students will:

- ✓ read about the Farmington Canal
- ✓ answer questions about the canal
- ✓ complete a writing assignment

MATERIALS **paper, pencils, student questions, Farmington Canal Map from CD**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(1,2,12), 2(2,3), 5(4,6)**
- **Science 2(1), 3(5), 7(8), 14(1,2)**
- **Social Studies 1(1,2,5,8), 2(4), 3(9), 4(1,5), 9(1), 10(5), 12(7,8)**

VOCABULARY **canal, locks**

PROCEDURES

1. Begin by asking students what a *canal* is. Ask if they can name a canal, where is it located, why it was built.
2. Discuss that canals have been built since the ancient times. Refer them to a website to gather information about canals. (http://www.du.edu/~jcalvert/tech/canhist.htm#A)
3. Ask students if they are aware of any canals that were built in the Farmington River Watershed. Elicit answers (*Farmington Canal*). Show map of Farmington Canal on CD.
4. Explain that the canal was built during the 1800's and its route was from New Haven to Northampton, Mass. Have students read the following excerpt from http://www.kelseypub.com/ct-guide/historic/farmcanl.shtml.

The Farmington Canal

In the early 1800's, Middletown and Hartford were becoming very wealthy cities because of their proximity to the Connecticut River. The goods that were produced in the interior rural areas of Connecticut could be loaded onto boats and barges and easily shipped off to places where they could be sold. The boats and barges would, of course, arrive full with goods and supplies to, in turn, supply those same rural areas. These cities were booming because of trade.

New Haven had enjoyed good trade by ship throughout the world, but they were hard pressed for trading to the northern inland communities. The roads of that day not were very good for travel and it must have been near impossible to send any amount of goods loaded into a wagon very far at all without destroying the wagons contents. New Haven had an asset in their port and was receiving goods from the West Indies as well as other portions of the American east coast.

That old yankee ingenuity brought on the idea of a canal that would extend north and furnish the towns along the way with goods, as well as be an easy route for their manufacturing and produce to return to New Haven for sale there as well as to be shipped elsewhere. This may sound like an outrageous undertaking, that would never work, but if you consider history many canals have been built and many have been successful. Canals were in use in Italy as far back as 1500. Actually it was an outrageous undertaking. Can you imagine digging a ditch 4 feet deep, 20 feet wide stretching some 80 miles all the way to Massachusetts in the early 1800s? The tools of choice at that time were shovels and wheelbarrows. I'm sure they had a pick or two also. If that's not outrageous ... I don't know what is!

At this time the Erie Canal was being built. Perhaps this spawned the idea to build the Farmington Canal. At the time there were big plans that would connect Boston to Albany, NY by canal. Of course the Farmington would be part of that plan. They also wanted to connect it through the Erie Canal and into the Great Lakes. This was an ambitious plan that never came to be realized. Times were changing back then, as they always will, and newer and better ways of transportation were on the horizon. The locomotive was around, but it wasn't in widespread use yet.

In 1822 the 17 towns along its proposed route conducted a survey and were told that it was a promising project. Stock was sold to the public to raise enough capital for its construction. On July 4th, 1825 with much pagentry and ado the first shovelful of dirt was unearthed and the construction began. Three years later the channel from New Haven to Farmington was complete. The first canal boat to travel it was called the "*James Hillhouse* and started it's float downstream from Farmington.

It took until 1835 to finish construction to Northhampton, MA and connect to the Connecticut River. There were many problem associated with the building of the canal. The type of soil that the canal ran over was not suited to holding water and the canal would run dry. The task itself of hauling the sandy loam and rock was an immense chore. The expense of building proved to be more than expected and costs were cut in constructing the banks of the canal. This proved a big mistake as the banks washed out during storms. Nature itself was quite a problem. A drought in 1843 closed the canal for four months encompassing the summer. Ice would block the canal and prevent shipping.

Some land was basically just taken from landowners who, of course, were not at all happy about that. Lawsuits were filed as well as some of these people taking more immediate action such as blocking off feeder streams and breaking down the embankments. The landowners often complained of the canal. Bridges were constructed over the canal in those places where the canal cut farms in two, but they were not constructed in such a way as to make the transport of wagons loaded with harvests to easily use them. The canal leaked in many places and turned some pastures into swamps.

There were many locks on the route. Although there were many flat stretches between New Haven and Northhampton the canalboats had to be lifted and then lowered over the rises and falls in the landscape. There were 21 locks between New Haven and Southington. The locks would be flooded lifting the boats up and then as they progressed along the route they would be drained to lower the boats. Throughout the entire canal the boats had to be lifted 310 feet and lowered 213 feet.

The canal boats were powered by horses. The entire route had a tow path next to it. The horses were frequently changed and usually were locally owned. Boats powered by steam were common in this day, but it was considered a risk to operate them on the canal, as the wake would disrupt the embankments. Although the canal operators did try to entice steamboat traffic none ever emerged.

The canal was a very interesting entity to the public. Watching the boats go by was a favorite way to pass the time. The boats did become a means of travel and people would take the boats to town and on outings such as picnics along the banks.

In the late 1830s repairs to the canal cost more than the canal produced. The canal did better as a business in the early 1840s but problems were everywhere. The general idea of the times was that rail transport would be a better way to move goods along the route of the canal. By 1847 construction of a rail bed was underway and the end of the Farmington Canal was written upon the banks that made the canal both a success and a failure.

The Railroad operated successfully along this route for many, many years. It certainly had its ups and downs but not nearly as much as the Canal had. As time has gone by and our highways much improved trucking has taken over much of the railroads business. I can recall trains running regularly over the canal line in the 1960s. Between then and now however business failed.

Now all the tracks have been removed from the rail bed and it is being slowly converted to a park area. The path is being paved much of the way and is frequented by cyclists and hikers alike. It’s a very historic route and a walk along its path will bring to mind many pictures of how life must have been in the heyday of the canal.

5. Separate students into groups and have them answer the questions collectively to discuss with the rest of the class.
   a. What was the route of the canal?
   b. What tools were used to build it?
   c. When was it built? (beginning, completion)
   d. Why was it built?
   e. What were challenges of building the canal and using it?
   f. Why was the railroad built at the same time?
   g. What are locks and how are they used?
   h. Was the canal a success and/or failure?
   i. What evidence of the canal do we notice today?
   j. What is it used for today?

6. After answering questions, have students choose from the following writing assignments:
   a. Imagine you are a worker for the canal. Describe a day at work.
   b. The canal is completed and you are watching the boats. Describe the canal and surrounding areas. What are your thoughts about it?
   c. You are the publisher of a newspaper. Write an article demonstrating the excitement of the opening of the Farmington Canal.

EXTENSIONS

1, Have students describe what life was like during the time the canal was built.
2. Suggest that the students visit the aqueducts in Farmington that are remnants of the canal.

GLOSSARY

canal - an artificial waterway or artificially improved waterway used for travel, shipping or irrigation
locks - a section of a waterway, such as a canal, closed off with gates, in which vessels in transit are raised or lowered by raising or lowering the water level of that section

Lesson 20

Water Wheel

How did the Industrial period impact the river?
What type of power was used?

GOAL To understand that Industrialism impacted the water and surrounding terrain

OBJECTIVES Students will:

- ✓ imagine being a factory worker during the Industrial period
- ✓ writing about their experiences
- ✓ design and create a water wheel

MATERIALS **paper, pencils, butcher block paper, markers, popscicle sticks, modeling clay, assorted art materials for water wheel (Styrofoam, plastic, etc.)**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(4)**
- **Science 3(5), 7(8), 8(2), 14(1,2)**
- **Social Studies 1(1), 4((5), 9(1), 10(5,7,8)**
- **Arts 1(3)**

VOCABULARY **factory, Industrialism, water wheel**

PROCEDURES

1. Discuss the term, “Industrialism” with students. Ask what was significant during that time period (*factories, mass production, pollution*).
2. Ask students to describe what they would have observed by the river during that time (industry).
3. Discuss that pollution being discharged into the rivers was not as prevalent an issue as it is today. Ask them why (*no laws, pollution effects unknown).*
4. Instruct students to imagine being a worker at a factory. Describe the building inside and its exterior, how it is powered, and the health of the river.
5. Break students into groups. Distribute paper and have them describe a “typical day” at the factory. Present to class.
6. Have student groups design and create a water wheel. Have them test it.

EXTENSIONS

1. Have students visit an old factory and create a model.

GLOSSARY

factory - a building or group of buildings in which goods are manufactured.
industrialism - an economic and social system based on the development of large-scale industries and marked by the production of large quantities of inexpensive manufactured goods and the concentration of employment in urban factories
water wheel - a wheel propelled by falling or running water and used to power machinery

FRWA Curriculum Guide

Week V - Middle School

Pollution and Monitoring

Watershed Pollution and Monitoring Background Information

"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

Pollution is defined as contamination; something that causes harm to an area of the natural environment, the air, soil, or water, usually by introducing damaging substances such as chemicals or waste products. Pollutants can enter the environment either naturally or by human activities. When the source of the pollution is identified, it is termed point source pollution. Examples of source point pollution are drainage from factory pipes, exhaust from a car, leakage from an underground oil tank or smoke from a power plant.

When it is difficult to identify the source or location of the pollution, then it is considered non-point source pollution (NPS). The pollution may stem from run-off water. Impervious surfaces refer to pavement, parking lots and roadways. The water "runs-off" the surfaces and is not absorbed into the ground to recharge groundwater. The surfaces may also contain oil or gas leaks that can flow into the waterways, causing non-point source pollution. Other examples including motor oil are as follows:

1. **motor oil** – improper disposal or leakage of motor oil can seriously pollute ground water and surface waters. It can kill plants, smother animals and contaminate fish and drinking water.
2. **acid rain or deposition** – when rain, snow or dry particles from the atmosphere is more acidic than normal (normal is usually a pH of 5.6). Carbon dioxide combines with the water droplets to form carbonic acid. Sources can stem from the burning of fossil fuels, such as oil, and emissions from industry and cars. Acid rain can contribute to the depletion of nutrients in the soil and the addition of metals into the water.
3. **animal wastes** – livestock, pets and concentrated populations of wildlife can cause diseases in the water.
4. **excessive nutrients** – oversupply of nitrogen and phosphorous can come from leaking septic tanks, fertilizers or manure from farms and lawns, sewage, laundry detergents and some grass clippings and leaves.
5. **household hazardous waste** – toxic or poisonous substances in the home, such as gasoline, nail polish remover, paints, and oven cleaners should not be dumped down sinks or drains.
6. **litter** – roadside trash, unswept parking lots, and wind blown trash can cause hazards to wildlife and contamination of waterways.
7. **pesticides** – these substances contain chemicals that are used agriculturally (farms) and on lawns. The chemicals harm both the environment (soil) and can also impact human health.
8. **road salts** – used to de-ice highway surfaces, parking lot pavements and other road surfaces and paved areas. Too much going into waterways can change the salinity of water that support certain animals and plants.
9. **sediment** – tiny soil and rock particles are carried away by rain into the waterways, increasing turbidity and reducing light penetration; sedimentation can occur as a

result of erosion.

10. **toxic metals** – metals such as mercury, nickel, zinc and lead are toxic to human organisms because they can accumulate and become concentrated in the body. The metals can originate from cars, industry and pesticide misuse.

Changes in land use and increases in population correlate to declines in water quality. The loss of open space, buffer zones, increases in impervious surfaces, contaminants from identified and unidentified sources, decreases in water supply and increases in wastewater treatment all contribute to the health of our waterways.

Monitoring the streams and rivers becomes the first step in protecting this valuable resource. Monitoring can be accomplished in a variety of ways; physically, biologically and chemically. The stream or river itself, along with the riparian banks and surrounding area may be visually or physically monitored. Stream watch groups may observe erosion or vegetative buffers along the banks to determine health of the stream. If there is substantial erosion along the river banks, then there may be a higher turbidity level in the water way.

Vegetative buffers along stream banks provide protection by controlling soil erosion, filtering pollutants at potential access points, supplying habitats for aquatic and land life, and keeping water temperatures lower with shade. Unchecked stream bank erosion can lead to excess sedimentation and disturb the macroinvertebrates and spawning fish

Monitoring the diversity of plant and animal life are biological or biotic indicators. Macroinvertebrates are indicators of the stream health because of their high oxygen requirement. Streams and rivers that are swift moving have higher levels of oxygen compared to stagnant ponds. Temperature also influences the health of the stream as cool waters are able to hold onto dissolved oxygen longer than warm water does.

Macroinvertebrates are a good measure of water quality since many are pollution sensitive. Samples of insects are best taken in riffles, where water is flowing over rocks, and is well-aerated with higher dissolved oxygen levels .The most sensitive to water quality are caddisfly, mayfly and stonefly.

Since aquatic plants and animals require oxygen to live, dissolved oxygen tests are c onducted to measure the amount of oxygen in the water. Chemical tests are abiotic indicators of the health of the stream. Measuring pH, dissolved oxygen, nitrates and phosphorous levels are all ways to monitor stream health.

Lesson 21

Water Studies

How can streams and rivers be monitored?
How can water characteristics, riparian banks and watershed habitats indicate stream health?

GOAL To examine and record physical characteristics of specific body of water and surrounding land to assess a more complete picture of overall health of water body.

OBJECTIVES Students will:

- ✓ examine and record observations of riparian banks
- ✓ measure velocity, take temperature, measure depth of water body
- ✓ determine human impact

MATERIALS **data recording sheets, clipboards, pencils, plastic containers, stop watch, meter sticks or another type of measuring stick, measuring tape, water thermometer**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(4)**
- **Science 3(4), 8(2), 11(6), 14(1)**
- **Social Studies 10(1,2)**

VOCABULARY **velocity, riffle, pool, run**

PROCEDURES

1. Prior to lesson, choose three sites students will study. Group students into three teams. Each team will be responsible for collecting data that will later be shared with classmates. Have students design a presentation based on the data collected. Have them determine the health of the stream through their observations.
2. The three data collecting teams include:
   A. General Water Characteristics
   B. Bank and Sediment Characteristics
   C. Watershed Habitats and Human Impact
3. Distribute appropriate forms and equipment (forms located at the end of lesson).
4. Teams will examine the three sites and use the data to compare the areas.
5. After data is collected, discuss results with students.

EXTENSIONS

1. Have students join and participate in an adopt-a-stream or stream watch program and monitor certain sections of the river. Local monitoring programs are offered through Project Search and FRWA.

RESOURCES

Rosselet, Dale A., *New Jersey WATERS, A Watershed Approach to Teaching The Ecology of Regional Systems,* New Jersey Audubon Society, 1999, Bernardsville, New Jersey 07924.

GLOSSARY

pool - a deep or still place in a stream
riffle - a shallow, gravelly area of a streambed with a swift current; used by spawning of trout or other fish
run - straight course of a river
velocity - rapidity or speed of motion; swiftness

FRESHWATER STREAM OR RIVER
Group A Data Collection Form
Water Characteristics

Water body Name ________________

Watershed Name ________________

Team Members:

1. **Circle stream habitats present (more than one may be applicable)**

   Riffle pool run

2. **Water Appearance (Circle the best description)**

   Clear foamy oily brown

   Other color, describe ____________________

3. **Odor** ____yes ____no

   If yes, describe____________

4. **Water Temperature**

   Sunny area_______degrees Fahrenheit or Celcius

   Shady area_______degrees Fahrenheit or Celcius

5. Volume

a. Measure a length of a stream (stream reach) to calculate volume. _______ft

b. Calculate the average width of the stream reach

Width at upstream end of test site ________ft.
Width at midpoint of the test site ________ft.
Width at downstream end of test site ________ft.
Average = ________ft.

c. Calculate the average depth of the stream reach. Take three measurements.

Depth at upstream end of test site _________in.
Depth at midpoint of test site _________in.
Depth at the downstream _________in.
Average depth _________in.
Convert average depth to feet. _________ft.

d. Multiply **length** x **average width** x **average depth** to determine volume of water in test section.

Volume = ________cu.ft.

d. Convert cubic feet to gallons. One cubic foot equals eight gallons of water:

________gallons of water in test section

6. Water Velocity

Measure a 50 foot section of the stream.
Select a small object that will float (stick, leaf, tennis ball)
Measure the time it takes the object to float to the selected section.
Repeat the process three times and average times.

Time #1________
Time #2________
Time #3________
Average________ (add the times together and divide by 3)

Divide the distance (50 ft.) by the average time to determine the velocity (in feet per second)

Stream velocity = _________ft./sec.

FRESHWATER STREAM OR RIVER
Group B Data Collection Form
Valley Profile, Stream Bank, Channel and Sediment Characteristics

Water body Name ___________________

Watershed Name ___________________

Team Members:

1. From the furthest area downstream in your study area, look upstream to the left and to the right to determine the stream valley's profile. Circle the letter that best describes the profile.

    a. U - shaped – glacially scoured
    b. V – shaped – young stream
    c. floodplain valley – mature stream

2. From the same point, pick the description that best fits the stream and stream channel.

    a. stream bank

stream bank	left bank	right bank
vertical cut	?	?
steeply sloping (more than 30 degrees)	?	?
gradual, no slope (less than 30 degrees)	?	?

    b. stream channel (width - bank to bank; depth - top of bank to bottom of channel)

    narrow, deep (width less than 6 ft.; depth more than 3 ft.)

    narrow, shallow (width less than 6 ft.; depth less than 3 ft.

    wide, deep (width more than 6 ft.; depth more than 3 ft.)

    wide, shallow (width more than 6 ft.; depth less than 3 ft.)

5. Describe the stream side cover. Circle the one that fits the best.

a. Along the stream's edge and bank

	not present	present	plentiful
trees	?	?	?
bushes, shrubs	?	?	?
grasses, ferns	?	?	?
lawn	?	?	?
rocks/boulders	?	?	?
gravel/sand	?	?	?
bare soil	?	?	?
pavement, structures	?	?	?

b.Measure out 25 yards from stream bank.

	not present	present	plentiful
trees	?	?	?
bushes, shrubs	?	?	?
grasses, ferns	?	?	?
lawn	?	?	?
rocks/boulders	?	?	?
gravel/sand	?	?	?
bare soil	?	?	?
pavement, structures	?	?	?

6. Circle the category that best describes the percentage of shde that the stream provides

0% 25% 50% 75% 100%

7. From the same point in the study site, look upstream and check if the following conditions are present. Circle if applicable to site area.

Plant cover degraded	Bank collapsed, eroded	garbage
Foam on bank	yard waste	livestock
Discharging pipes	ditches	other pipes

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

9. Are there organic materials in the stream? (leaves, twigs etc.)

FRESHWATER STREAM OR RIVER
Group C Data Collection Form
Watershed, Habitat, and Human Impact Characteristics

Water body Name ____________________

Watershed Name ____________________

Team Members:

1. Describe the visible impact on the stream.

Present — Impact

- ☐ Single family housing______________________________
- ☐ Multifamily housing______________________________
- ☐ Lawns______________________________
- ☐ Commercial______________________________
- ☐ Other______________________________
- ☐ Paved roads/bridges______________________________
- ☐ Unpaved roads______________________________
- ☐ Housing development______________________________
- ☐ Commercial development______________________________
- ☐ Road construction______________________________
- ☐ Grazing land______________________________
- ☐ Cropland______________________________
- ☐ Boating______________________________
- ☐ Golfing______________________________
- ☐ Camping______________________________

- ☐ Swimming____
- ☐ Hiking____
- ☐ Logging____
- ☐ Landfill____
- ☐ Industry____

2. Note the types and number of structures that alter the natural flow of the stream.

_____none _____dams _______bridges

_____waterfalls _____beaver dams

3. Any evidence of:

_____litter _____erosion

4. Any special problems?

_____chemical spills _____flooding ______fish kills

_____periods of no flow _____wildlife kills

5. wildlife

a. wildlife around water body ☐
amphibians ☐
waterfowl ☐
reptiles ☐
mammals ☐
invertebrates ☐

b. fish ☐
barriers to fish ☐

c. aquatic plants ☐

Lesson 22

Water Checks

What abiotic tests will indicate the health of a stream?
What factors contribute to higher levels of dissolved oxygen in a stream?
Why is it important to monitor the stream?

GOAL To understand that chemical tests provide a snapshot of the health of a stream

OBJECTIVES Students will:

- ✓ conduct abiotic tests at a stream site
- ✓ collect data that can be used to determine the health of a stream
- ✓ compare sites

MATERIALS **water and air thermometers, dissolved oxygen kits, pH kits, nitrate kit (optional), clipboards, data collection sheets, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(4)**
- **Science 3(4), 8(2), 11(6), 14(1)**
- **Social Studies 10(1,2)**

VOCABULARY **abiotic, dissolved oxygen, pH level, acidic, alkaline**

PROCEDURES

1. Select a site within the watershed for a field visit. Have students study site to determine health of stream by conducting abiotic or chemical tests. Prior to site visit, consider safety precautions and access to stream.
2. Before the site visit, lead a discussion about the tests that will be conducted at the site and their significance.
   a. Dissolved oxygen (DO) – Aquatic organisms such as the macroinvertebrates require high levels of dissolved oxygen. Swift, well aerated rivers and streams usually have higher levels of dissolved oxygen than slower, meandering rivers. Additionally, photosynthesis from aquatic plants produce dissolved oxygen in the water. Healthier streams tend to have higher levels of dissolved oxygen.
   b. pH – Aquatic organisms adapt to certain pH ranges and any fluctuation in the levels could lead to stress or death to the organism. A pH scale of seven is neutral. If the pH is above seven, then the water is more alkaline, whereas if the pH is lower then it becomes more acidic. The scale is logarithmic, therefore for one unit of change on the scale, there is a tenfold change. For example if a river has a pH of 5, it is 10 times more acidic than a pH of 6 and 100 times more acidic than a river with a pH of 7.

c. temperature – temperature influences the water body because cold water is able to hold more dissolved oxygen than warmer waters. Aquatic organisms' metabolic rates increase in warmer waters, thereby demanding even more dissolved oxygen. If cool waters are replaced with warmer waters, then cool water species are replaced as well. The organisms would either have to adapt, move on or perish.

d. turbidity levels – Turbidity levels test the clarity of the water. Turbid waters would indicate a greater level of sediments in the water. Since some species of benthic macroinvetebrates are bottom dwellers, a higher turbidity level would adversely affect their survival.

3. Have students break up into smaller groups.
4. Upon arrival at the site, distribute pH kits, dissolved oxygen kits, water and air thermometers, turbidity tubes, nitrate kits (if available), data collection sheets, clipboards, pencils and wading boots (optional).
5. Choose different areas of sites for students to test. Have different groups conduct tests.
6. After completion of tests, lead discussion on results and significance.
   a. a DO higher than 5 can support aquatic life
   b. pH between 5 and 9 can support aquatic life
   c. temperature ranges should be between 48°F and 78°F
   d. turbidity – water that is clear allows sunlight to penetrate through
7. Discuss the health of the stream with the students based on the results.
8. Compare results.

EXTENSIONS

1. Find out how streams are monitored in your area and join a stream monitoring group.

RESOURCES

Wow! The Wonder of Wetlands, Environmental Concern, Inc., St. Michaels, Maryland 21663
www.globe.gov.

GLOSSARY

abiotic - nonliving
acidic - having a pH of less than 7
alkaline - having a pH of greater than 7
dissolved oxygen - measurement of oxygen that is passed into a solution (or water)
pH level - a measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity; the pH scale commonly used ranges from 0 to 14

Stream Study – Data Collection Sheet

Names in group____

Name of stream/brook/river____________________________________

Name of Watershed____

Data Collected

Air temperature

Water temperature

Dissolved Oxygen

pH

Nitrates

Lesson 23

Water Mystery

What is the difference between point source and non-point source pollution?
What are possible sources of non-point source pollution?
What can be done to prevent pollution?

GOAL To understand that non-point source pollution is not easily identifiable

OBJECTIVES Students will:
- ✓ identify causes of non-point source "pollution"
- ✓ solve pollution problems

MATERIALS **case studies, pollution sources listed on board, pencil, papers**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(4)**
- **Science 3(4,5), 7(8), 8(2), 14(1,2)**
- **Social Studies 6(5), 9(1), 10(5,7,8)**

VOCABULARY **non-point source pollution, source point pollution, acid rain, nutrient, pesticide**

PROCEDURES

1. Begin by asking students if they know the difference between point source pollution and non point source pollution. (*point source - identifiable source of pollution; non-point source pollution - non-identifiable source of pollution*)
2. Ask for examples of each. (*point source – factory, oil spill; non-point – see list below*)
3. Explain that rain or precipitation that falls to the ground, runs-off over the soil to the waterways. Pollution mixes with the run-off and seeps into the soil, surface and ground waters.
4. Examples of non-point source pollution to be discussed with students are (may be listed on board):
   a. **motor oil** – improper disposal or leakage of motor oil can seriously pollute ground water and surface waters. It can kill plants, smother animals and contaminate fish and drinking water.
   b. **acid rain or deposition** – when rain, snow or dry particles from the atmosphere is more acidic than normal (normal is usually a pH of 5.6). Carbon dioxide combines with the water droplets to form carbonic acid. Sources can stem from the burning of fossil fuels, such as oil, and emissions from industry and cars. Acid rain can contribute to the depletion of nutrients in the soil and the addition of metals into the water.
   c. **animal wastes** – livestock, pets and concentrated populations of wildlife can cause diseases in the water.

d. **excessive nutrients** – oversupply of nitrogen and phosphorous can come from leaking septic tanks, fertilizers or manure from farms and lawns, sewage, laundry detergents and some grass clippings and leaves.
e. **household hazardous waste** – toxic or poisonous substances in the home, such as gasoline, nail polish remover, paints, and oven cleaners should not be dumped down sinks or drains.
f. **litter** – roadside trash, unswept parking lots, and wind blown trash can cause hazards to wildlife and contamination of waterways.
g. **pesticides** – these substances contain chemicals that are used agriculturally (farms) and on lawns. The chemicals harm both the environment (soil) and can also impact human health.
h. **road salts** – used to de-ice highway surfaces, parking lot pavements and other road surfaces and paved areas. Too much going into waterways can change the salinity of water that support certain animals and plants.
i. **sediment** – tiny soil and rock particles are carried away by rain into the waterways, increasing turbidity and reducing light penetration; sedimentation can occur as a result of erosion.
j. **toxic metals** – metals such as mercury, nickel, zinc and lead are toxic to human organisms because they can accumulate and become concentrated in the body. The metals can originate from cars, industry and pesticide misuse.

5. Explain to students they are experts in the field of water quality. Inform the students that the town manager has approached them because the town has experienced problems with the surface water. The town officials are not able to identify the sources of pollution. They have called in a team of experts (students) to help them identify the pollution sources.
6. Break up students into groups. They represent the experts and are provided with a challenge. Have them come up with possible solutions to the town's dilemma to solve the pollution mystery. Explain to students the town can not clean up the hazards until the "experts" are able to identify the sources.
7. Explain to students that there are three sites of concern. Provide three possible scenerios (student sheets) to the student groups to read and discuss. Have students review case studies and decide what the cause of pollution is for the three sites and their recommendations.

EXTENSIONS

1. Have students research ways to prevent non-point source pollution.

RESOURCES

Haskin, Kathleen M.,*The Ways of the Watersheds: An Educators Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies*, 1995, Claryville, NY: The Frost Valley YMCA

GLOSSARY

acid rain - rain containing acids that form in the atmosphere when industrial gas emissions combine with water
non-point source pollution - pollution caused by rainfall or snowmelt moving over and through the ground; as the run-off moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water
nutrient - a source of nourishment, especially a nourishing ingredient in a food
pesticide - a chemical used to kill pests, especially insects
source point pollution - pollution from industrial and sewage treatment plants with an identifiable source

Case Studies

Case 1 – Dirty Dilemma

A section of the river has a higher level of sediment and turbidity. A noticeable decrease in the amount of macroinvertebrates was prevalent. Rocks seem to be covered with silt causing the aquatic life to be smothered. The water temperature during the summer months has increased. The team was requested to go to several sites along the river bank that the town had pinpointed to try to determine a cause. They visited two of the sites and were on their way to the third. Along the riparian banks, they noticed trees down from storms and floods, causing the banks on the river to be free of vegetation.

What did they see?
What can be the cause of the sediment increase?
What can be done to improve this situation?
Was this a manmade situation or natural?

Case 2 – Nitrate Rising

The results of chemical tests indicated there was a rise in the pH level, nitrates and phosphorous in water. Algal blooms were on the rise causing a lower level of oxygen rich water. They were concerned about the aquatic life because there was a noticeable decrease in organisms. The area was close to an organic farm that utilized manure as fertilizer. Additionally, there was a partially finished development going in close by. The new houses were situated on top of a hill and some of the home owners were experiencing problems with faulty septic tanks. To make matters worse a sewage treatment plant was situated upstream. The team went to the site to conduct a survey. They noticed a pipe with a possible "contaminant" flowing into the river.

What could be the cause of the problem?
What can be done to improve the situation?
What could be the cause of the increase in pH, nitrates and phosphorous levels?
Was this a manmade situation or natural?

Case 3 – **Fowl Litter**

Aquatic wildlife seemed to abound in this area, but lately, the water fowl and other wildlife were getting caught in pieces of litter and plastic strewn around the lake beach areas. An influx of tourists visited during the summer months in an attempt to cool off. Many families would come and bring picnic lunches to enjoy on those hot days. Due to the sudden increase in tourism, the town was not able to keep up and had not placed more receptacles in this area. The wind would sometimes blow items away. Not too far in the distant was a closed landfill and paper recycling facility. On their way to the lake area, the team noticed a paper recycling truck with the tarp not securely tied.

What is the cause of the problem?
What can be done to improve the situation?
Was this manmade or natural?

Read the three case studies.
Try to determine the cause of pollution.
Is it point or non-point source pollution?
Provide your input to the town manager (present to class).

Lesson 24

Turbid Tides

What is turbidity?
Why are streams tested for turbidity?
What are causes of turbidity in a stream?

GOAL To understand turbid waters can affect the water quality.

OBJECTIVES Students will:

- ✓ conduct a turbidity test
- ✓ receive an erosion problem to solve
- ✓ develop solutions to stream bank problem
- ✓ assess a stream bank on the Farmington River Watershed

MATERIALS **plastic quart jar, gravel, rocks, sand**

CORE CURRICULUM CONTENT STANDARDS

- **Science 3(4,5), 7(8), 8(2), 14(1,2)**
- **Social Studies 6(5), 9(1), 10(5,7,8)**
- **Arts 1(3)**

VOCABULARY **turbidity, sediment, penetrate, erosion**

PROCEDURES

1. Explain to students that erosion increases the amount of sediment or soil particles in water. The increase in soil particles influences *turbidity,* which is how much light can *penetrate* through the water. Measuring the turbidity is one way to measure stream health and subsequently assessing water quality. Aquatic organisms are susceptible to changes in water quality, especially to the effects of increased sediments. Macroinvertebrates require oxygen flowing waters to survive. Plants also require the sun to produce food through the process of photosynthesis. Cloudy water absorbs more of the sun's rays, thereby increasing the temperature of the water. This can adversely affect organisms that require certain water temperatures to survive.
2. Explain to students that they are recipients of a problem to solve. Break them up into groups to discuss the problem and come up with possible solutions.
3. Discuss that they are responsible for monitoring a stream or riparian area. Explain that they have received news that the heavy rains during the spring and summer has severely affected the side of the stream banks. Have students develop a plan that would help prevent the amount of erosion and sediment going into the river.
4. Have students arrive at the site and take notes on the condition of the area.

5. The following are examples of observations:
   a. Plants and shrubs that were previously on the side of the river are gone. They were probably washed down the river during the last remnants of a hurricane.
   b. A tree had fallen and the roots were exposed, causing much damage to the bank. There were rocks by the edge of the banks.
   c. The water appeared cloudy and murky. Many of the species require oxygen rich water live in this area of the stream. Water clarity affects living organisms and may be tested by a turbidity test .
6. Have students conduct a test to show how turbidity may affect aquatic life. Have groups fill a clear, plastic quart jar with rocks, pebbles, and soil. Add water until jar is full. Cover container and shake until water becomes muddy. Have students record what happens (*The rocks settle, mud is difficult to see through).* Ask how this would affect the organisms that live on the bottom of the stream? (*They could suffocate*).
7. Have student groups brainstorm ideas on how to prevent additional damage to the riparian bank.
8. Some possibilities:
   a. Mulches, blankets and mats – covering the soil with these protects the soil surface, reduces runoff velocity, increases infiltration, slows soil moisture loss, and improves seed germination.
   b. Rocks – rocks placed along the stream bank protects soil from direct contact with erosive stream flows.
   c. Straw bale barrier – a temporary sediment barrier of anchored straw bales.
   d. Trees shrubs vines and ground cover – can provide low-maintenance long term erosion protection.
   e. Vegetative stream bank stabilization – planting trees or shrubs along stream bank to stabilize them.
9. Students present ideas to class. Have them display diagrams on how to implement these preventive measures.
10. Have students research ways riparian zones in their area or areas are protected from erosion.
11. Have them visit a stream bank and determine health of stream by assessing erosion.

EXTENSONS

1. Have students measure turbidity at a stream site in their area.

RESOURCES

Etgen, John, *Healthy Water, Healthy People, Water Quality Educators Guide*, 2003, The Watercourse, Bozeman, Montana 59717 - 0575

GLOSSARY

erosion - the group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface
penetrate - to enter into and permeate
sediment - fine soil or mineral particles, resulting often from the run-off from the land, which either settle to the bottom of a water body or are suspended in the water
turbidity - having sediment or foreign particles stirred up or suspended; muddy

Lesson 25

Potential Polluters

What can cause pollution?
What is the impact of pollution in a watershed?
What are ways to prevent or reduce pollution?

GOAL To understand that pollution adversely impacts the watershed

OBJECTIVES Students will:
- ✓ analyze information to identify a potential polluter
- ✓ understand that contaminants in surface water can potentially contaminate ground water

MATERIALS **facts and culprit sheets, pencils, paper**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(4)**
- **Science 3(4,5),7(8), 8(2),14(1,2)**
- **Social Studies 6(5), 9(1),10(5,7,8)**

VOCABULARY **pollution**

PROCEDURES

1. Present facts to students about non-point source pollution before starting this activity. Explain to students that surface water that flows in rivers, lakes, and streams is easy to see, but groundwater fills up spaces between rocks and soil underground. Pollutants can seep down through the soil into the ground water and potentially contaminate it. Pollutants that are easily identified are called point source pollution; when the exact source can not be identified, it is called non-point source pollution. Non-point source pollution includes run-off from the streets that carry material from lawns, air pollution and streets.
2. Present a pollution problem to the students. Distribute information about five potential polluters and the facts to help them solve the problem. The facts and people/company descriptions are listed separately at end of lesson.
3. Break up students into groups. Have students work together to come up with solutions and reasons why.
4. Have students answer the following questions:
   a. Who are potential polluters?
   b. How are they polluting?
   c. How can they reduce the amount of pollutants?
   d. Is there anyone that can help?

EXTENSIONS

1. Monitor a stream or river area to identify potential contaminants.

RESOURCES

Braus, Judy, Nature Scope Pollution: Problems & Solutions, 1990, National Wildlife Federation, Washington, DC 20036 - 2266

GLOSSARY

pollution - the state of being contaminated with harmful substances

Facts about Pollution - yes or no?

1. Gasoline storage tanks may develop leaks after 20 years.
2. Crops grown with pesticides often look "too good to be true".
3. When substances percolate through the soil, they can contaminate groundwater.
4. Many powdered laundry detergents contain phosphates.
5. Pesticides that are used on crops to kill insects can wash into waterways and poison fish and other animals.
6. Thick, green lawns often look that way because they are treated with chemicals.
7. Rain and snowmelt that wash off the land may flow directly into streams, lakes, rivers, etc. Or they may flow into storm drains that empty into waterways.
8. Gas stations store gasoline in underground tanks.
9. To repair or replace a leaking tank, someone must dig up the tank.
10. Sewage treatment plants treat wastewater to remove many of the pollutants in it, such as disease-causing organisms and food waste. Then, the treated water is dumped into rivers and other waterways.
11. Most sewage treatment plants can't remove all of the phosphates in the wastewater.
12. Fertilizers, road salt, animal waste, car fluids, and other materials that wash into waterways can poison aquatic plants and animals, decrease the amount of oxygen in water, or create other problems.
13. Phosphates and other chemicals can cause problems for aquatic life. Phosphates act like fertilizer and cause algae to grow at a tremendous rate. Algal "blooms" deplete the water of oxygen used by aquatic organisms.

Who's Pollution Is It?

The town water inspector discovered pollutants in the nearby waterway. Using the facts, determine who the culprit could be. Since it is non-point source pollution, it could be more than one person/ company.

Lou's Lawn Care

Lou prides himself on how he cares for his client's lawns. He uses the best chemicals and trains his employees to use extra care when they fertilize the lawns. He started his company from scratch and works long, hard hours. The grass at his main client's place, the golf course at the Country Club, is known for being lush green and thick.

Frank's Farm

Frank's farm is a great place to bring kids. They can ride on the hay wagon and choose from a variety of beautiful vegetables. During the fall, people choose perfect pumpkins from the patch to display at their homes. The kids also get a chance to see the cows and other animals down by the stream.

Tonya Teenager

Tonya was very excited about getting her license and buying a new car. She had worked hard at babysitting and doing other jobs to save enough money. She even took a class on how to change the oil and antifreeze. She was well on her way to being a responsible driver, taking care that the car is well-maintained. After she finishes changing the oil, she dumps it down the storm drain.

Gladys Gas Station

Gladys' Gas Station has been around for 25 years. It has been in her family and she has recently taken it over after her father's retirement. Gladys was thinking about expanding the store where she sells sodas, snacks and candy. Drivers from all over stop here because it is halfway between two urban areas.

Rhoda Recycler

Rhoda has been a long time advocate of environmental issues. She participated and organized clean-ups long before others had done it. She educates others about the benefits of recycling at community workshops and plants organic vegetables at her house, taking care to use the compost as fertilizer. Rhoda heard rumors that pollutants were found in the nearby stream and wants to help.

FRWA Curriculum Guide

Week VI - Middle School

Water Protection and Conservation

Water Protection and Conservation Background Information

"Children of a culture born in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it." – William Ashworth, Nor Any Drop to Drink, 1982

The average person needs two and a half quarts of water a day to maintain good health. In the United States, the average person uses 120 to 150 gallons of water for cooking, washing, flushing and watering. When water is readily available, people do not think about conserving water. Water wasting habits are difficult to change, but the average household can save up to 50,000 to 100,000 gallons a year.

Along with conservation practices, protection of this vital resource is essential. Stream monitoring and testing are ways that students and volunteers can help maintain the quality of the water. Educating others as community service, decreasing negative impacts on water quality and a commitment to insuring that water is clean are all ways to insure that water quality is preserved.

Food Facts:

- It takes **6 gallons** of water to make **one order of french fries.**
- More than **2,600 gallons** of water are needed to produce **one serving of steak.**
- The average American consumes **1,500 lbs. of food** annually. It takes **1.5 million gallons** to produce food for just one person!
- Approximately **6,800 gallons of water** are used to feed a **family of four** for one day.
- **100 gallons** of water are needed to grow **one watermelon.**

Environmental Facts:

- Only 7 % of the country's landscape is considered riparian, or alongside water— only **2 % of which still supports riparian vegetation**.
- Of the 1200 species listed as threatened or endangered, **50% are dependant on wetland habitats.**
- Freshwater species are disappearing **5 times faster** than land animals.
- **53,000 cubic miles** of water pass through Earth's lakes and streams.
- If all of the water in the world were to fit in a gallon jug, the available freshwater would equal only **1 teaspoon.**

Human Facts:

- **1.2 billion** of the world's people do not have access to clean water.
- The United States consumes water at **twice the rate** of other industrialized countries.
- **6.8 billion gallons** of water are flushed down American toilets each day.
- **80 %** of freshwater used in the United States goes to irrigating crops and creating hydroelectric power.
- To survive, the average person needs **2 quarts** of water a day.
- An average person will drink about 16,000 gallons of water in their lifetime.

Lesson 26

Making the Connection

How is a river connected to other water bodies?
How do upstream pollution events impact water quality downstream?

GOAL To understand that the towns are connected by the river

OBJECTIVES Students will:
- ✓ draw a community
- ✓ determine locations of buildings
- ✓ connect the river drawings

MATERIALS **butcher block paper, markers, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Science 7(8), 8(2),14(1,2)**
- **Social Studies 9(1-3,8), 10(1,2), 12(5,6), 13(5)**
- **Arts 1(1-3)**

VOCABULARY **connections**

PROCEDURES

1. Break students into smaller groups. Distribute markers and large piece of butcher block paper.
2. Inform students that they will be creating a town and name it. The town has a river that flows through the center of it. Have students draw a meandering river through the center of the paper. Color it blue.
3. Have students choose and place (draw) the following items on the paper: a school, house, forest, park, soccer fields, grocery store, police and fire stations, recycling facility, trash-to-energy and sewage plant. Provide enough time for students to think about where in their town they want those items to be. They may use different markers to designate places. Have students label items.
4. After completing this portion of the assignment, have student groups explain why they chose the particular places.
5. Once students have explained their “maps,” instructor will place papers so that students can view. Tape each paper and connect to the other to show that the river is the one connection. The flow is downstream, therefore whatever is built at the end of the town is the beginning of the next town.
6. If they were town planners, how would they plan their towns. Illustrate and discuss with the class.

GLOSSARY

connections - links

Lesson 27

Water Watchers

How can water be conserved?
How can daily usage be reduced?

GOAL To understand that

OBJECTIVES Students will:
- ✓ calculate flow of water when washing hands, etc.
- ✓ determine how much water is used

MATERIALS **bucket, cups, pencils, paper**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1), 2(1,4)**
- **Science 7(8), 8(2),14(1,2)**
- **Social Studies 12(7,8), 13(5)**

VOCABULARY **calculate, measurement**

PROCEDURES

1. Have students determine how much water (in cups) they actually use for daily activities and how much they can conserve.
2. Have them measure and calculate the amount of water they use for daily activities, such as washing their hands, brushing their teeth, showering and any others they want to calculate.
3. The following is a brief list of activities they may conduct:
   a. brushing teeth with water running vs. stopping the faucet while brushing
   b. washing hands with water running vs. stopping the faucet to soap up hands
   c. showering for ten minutes (run the tap for one minute to calculate the amount of water, in cups - multiply by ten or number of minutes) vs. stop faucet to soap and/or taking a five minute shower
4. Have them place a bucket in sink to catch the water as they wash hands or brush teeth.
5. Afterwards, have students take measurement of how many cups they used to wash hands, shower, or brush teeth. Re-calculate at a later time using conservation methods.
6. Calculate how much water was used in a day/how much saved.
7. Calculate how much each student's family uses/how much can be saved.

EXTENSIONS

1. Calculate how much water is used by class/how much can be conserved.

RESOURCES

Haskin, Kathleen M.,*The Ways of the Watersheds: An Educators Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies*, 1995, Claryville, NY: The Frost Valley YMCA

GLOSSARY

calculate - to make an estimate of; evaluate
measurement - the extent, size, capacity, amount, or quantity ascertained by measuring or calculating; as in, its measurement is five acres

Lesson 28

Water Survey

How much water do I use?
How much does my family use?

GOAL To understand how much water is used in their family

OBJECTIVES Students will:

- ✓ calculate how much water they used for a week
- ✓ calculate how much each member of their family uses
- ✓ calculate a total family water usage

MATERIALS **water survey, pencil, calculator**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1), 2(1,4)**
- **Science 7(8), 8(2),14(1,2)**
- **Social Studies 12(7,8), 13(5)**

VOCABULARY **water usage**

PROCEDURES

1. Begin by asking students how well they are able to conserve water. Have students bring home a survey to determine how much water they use.
2. Have students return the following day to tally water usage for the total class.

RESOURCES

Haskin, Kathleen M.,*The Ways of the Watersheds: An Educators Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies*, 1995, Claryville, NY: The Frost Valley YMCA

GLOSSARY

water usage - the act of using water

How much water do I use?

1 What type of home do you have? ______house ________apartment __________other

How many people live in your home?

If you have a dishwasher, how full do you usually load and run it?
______full ______1/2 full _____less than ½

If you have a washer, how full do you load it?
______full _______1/2 full _____less than ½

How many of each of the following do you have at home?

___sinks ____showers _____bathtubs_____toilets_____outside spigots

How many showers are taken in your home in one week? _____how many baths?____

How many minutes is your famiy's average shower?______

How many times is the toilet flushed every day?______

6. Bathroom Use

Shower 5gal/mim x ____min/day x ____ days/week = _____

Toilet 5gal (1.6 gal) x ______flushed /day x ____ days/week = _____

Brushing Teeth 2 gal/min x ______min/day x ____ days/week = _____

Shaving 2 gal/min x ______min/day x ____ days/week = _____

Bath tub 36 gal x _____min/day x _____days/week = _____

Subtotal______

7. Kitchen

Wash dishes 2 gal/min x ______min/day x ____ days/week = _____

Dishwasher(full cycle=16 gal/short cycle 7 gal) x _____washes/week_____

8. Other

Laundry (full cycle = 60 gal/short = 27 gal) x washes/week =_____

Total water used in your home = _______________

Water used per person =_______________

Lesson 29

Drought Dilemma

How can water be conserved in the event of shortages?

GOAL To understand that conservation habits can be started now

OBJECTIVES Students will:
- ✓ list ways they can conserve water
- ✓ access a website on water saving tips

MATERIALS **paper, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Science 7(8), 8(2),14(1,2)**
- **Social Studies 9(1), 10(2), 12(7,8), 13(2,5)**

VOCABULARY **water tips**

PROCEDURES

1. Students are faced with a water shortage dilemma. They have been told that effective immediately, they have to find ways of reducing the amount of water they use in their families.
2. Break students up into groups. Have them brainstorm ways they can decrease the amount of water they use during the day.
3. Have them present to class and have class list their ideas.
4. Have students research water saving tips on web site www.wateruseitwisely.com/regions/100tips/ne_index.html
5. Use tips to educate others in family or at school.
6. Have students try to implement one change that week.
7. Assess at the end of week. Determine how challenging it was.

GLOSSARY

water tips - helpful hints about preserving water

Lesson 30

Water Actions

What are ways to help protect the watershed?

GOAL To understand that they can become proactive and formulate a water conservation plan

OBJECTIVES Students will:
- ✓ list ways they can help with water protection and conservation
- ✓ devise a plan of action

MATERIALS **paper, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Science 7(8), 8(2),14(1,2)**
- **Social Studies 12(8), 13(5)**

VOCABULARY **organization, involvement**

PROCEDURES

1. Break students into groups.
2. Have them think of ways they can protect and conserve their watershed.
3. Have students devise a plan of action.
4. The following are few suggestions for the students:
   - Adopt-a-Stream
   - Help with a clean-up day
   - Monitor water quality in a local river or stream
   - Educate the community about dumping toxic substances down the storm drains
   - Help others learn about endangered or threatened species
   - Help protect habitats by supporting organizations that do
   - Encourage the community to recycle, re-use and reduce waste
   - Help prevent erosion by planting vegetation on stream banks (would need to check with local authorities)
   - Create a native habitat in your own backyard
   - Learn about your watershed
   - Become involved with Farmington River Watershed Association and organizations that help manage and protect watersheds

GLOSSARY

involvement - the act of engaging or including a participant
organization - a group of persons organized for a particular purpose; an association

Appendix A:

7th Grade Curriculum Content Standards

Lesson	Language Arts	Math	Science	Social Studies
#1 "Water Connections"	1(10,12), 2(4)		7(7), 8(1-3), 9(1-5)	9(3), 10(1-3), 12(4,5)
#2 "Water Expressions"	1(1,9,10,12), 2(4)		8(1-3)	
#3 "Water Values"		1(1-3), 2(1,2), 3(1-3)	8(1-3)	10(2-4), 13(2,5)
#4 "Water Power"	1(4,5)		7(6,8), 8(2,3), 12(4), 14(1-4,6-7)	9(1,2), 12(4,5,7,8), 13(5,7)
#5 "Water Underground"			7(2,5,8), 8(2), 14(1)	9(1,3), 10(1-3), 13(5)
#6 "Water Ways"			7(6), 8(2), 14(1)	9(1,3), 10(1-3), 12(1-6)
#7 "Water Lines"			7(6,8), 8(2,3), 14(1)	9(1,3), 10(1-3), 12(1-5)
#8 "Water Absorption"		1(1-3), 2(1), 4(1), 9(2)	1(1), 8(1-3), 14(1)	9(1), 10(1-3), 12(5,7,8)
#9 "Riparian Banks"	2(2)		1(7), 7(7,8), 8(2,3), 14(1,2,6)	9(1,4,8), 10(1,2), 12(2,5,7,8)
#10 "Carrying Capacities"		1(2,3), 2(1,2), 3(1), 4(1), 5(1,3)	7(6,8), 8(1-3), 14(1-3)	12(1,2,4,7,8), 13(5)
#11 "Diversity Walk"			3(1-5), 4(1,2), 5(3)	9(1), 10(2,3), 13(5)
#12 "Water Webs"	1(4,10), 2(3)		3(1-4), 5(3)	9(1), 10(2,3), 13(5)
#13 "Riparian Explorer"	2(1)		3(2,4,5), 6(3)	9(1), 10(2-4), 13(5)
#14 "Water Finds"		1(1,2), 2(1)	1(1), 3(1,2,4), 6(3), 8(2,3)	9(1), 10(2,3), 13(5)
#15 "Wetland Wonders"			1(1,2), 3(4,5), 7(7), 8(2,3)	9(1), 10(2,3), 13(5)
#16 "Colonial Times"	1(1,12), 2(1,3), 4(4,6)		8(2)	1(1,2,5,8), 2(4), 4(1,5), 9(1,6,7)
#17 "Geology Formations"	2(2)		7(2, 5-8), 8(2)	1(1,2,5-8), 2(4), 9(1,2,4,5,7)
#18 "Water Threats"		2(1)	3(4,5), 6(4), 7(8), 8(2), 14(1,2)	10(1-3), 12(7,8), 13(5)
#19 "Farmington Canal"	1(1,2,12), 2(2,3), 5(4,6)		2(1), 3(5), 7(8), 14(1,2)	1(1,2,5,8), 2(4), 3(9), 4(1,5), 9(1), 10(5), 12(7
#20 " Water Wheel"	2(4)		3(5), 7(8), 8(2), 14(1,2)	1(1), 4((5), 9(1), 10(5,7,8)
#21 "Water Studies"	2(4)		3(4), 8(2), 11(6), 14(1)	10(1,2)
#22 "Water Checks"	2(4)		3(4), 8(2), 11(6), 14(1)	10(1,2)
#23 "Water Mystery"	2(4)		3(4,5), 7(8), 8(2), 14(1,2)	6(5), 9(1), 10(5,7,8)
#24 "Turbid Tides"			3(4,5), 7(8), 8(2), 14(1,2)	6(5), 9(1), 10(5,7,8)
#25 "Potential Polluters"	2(4)		3(4,5), 7(8), 8(2), 14(1,2)	6(5), 9(1), 10(5,7,8)
#26 "Making the Connection"			7(8), 8(2), 14(1,2)	9(1-3,8), 10(1,2), 12(5,6), 13(5)
#27 "Water Watchers"		1(1), 2(1,4)	7(8), 8(2), 14(1,2)	12(7,8), 13(5)
#28 "Water Survey"		1(1), 2(1,4)	7(8), 8(2), 14(1,2)	12(7,8), 13(5)
#29 "Drought Dilemma"			7(8), 8(2), 14(1,2)	9(1), 10(2), 12(7,8), 13(2,5)
#30 "Water Actions"			7(8), 8(2), 14(1,2)	12(8), 13(5)

Language Arts

1-1 Students will describe the thoughts, opinions and questions that arise as they read, view or listen to a text, then identify the central idea, purpose or theme of a work.

1-2 Students will use what they know to identify or infer important characters, settings, themes, events, ideas, relationships or details within a work and draw conclusions about the author's purpose.

1-4 Students will determine and use the structure of a written work to construct meaning and to select the best comprehension tool (retelling, using graphic organizers or story frames, writing to find meaning, etc.) for their purpose.

1-5 Students will ask and answer their own and each other's evaluative and interpretive questions.

1-9 Students will apply all appropriate word recognition strategies to perfect reading fluency.

1-10 Students will read extensively and apply a variety of vocabulary strategies to ensure advanced levels of comprehension.

1-12 Students will interact in a variety of groupings to develop further the skills of collaboration to enhance their understanding of works read, written and viewed.

2-1 Students will determine purpose, point of view and audience, then use the appropriate features of persuasive, narrative, expository and poetic writing to achieve desired results.

2-2 Students will plan, organize, create and revise visual, written and oral pieces at a level of elaboration appropriate for middle school.

2-3 Students will identify and use primary and secondary sources to paraphrase, elaborate on and integrate information into a final product, e.g., search paper, historical fiction, news article, research paper, and documentary.

2-4 Students will use and examine the effectiveness of multiple ways of generating ideas (brainstorming, listing, writing, talking, webbing, drawing), then compose, revise, edit and present a variety of products.

4-4 Students understand that authors and readers are influenced by their times and experiences and identify those influences in the works they read, listen to and view.

4-6 Students will read works from different literary periods to determine how literature represents the human experience.

Math

1-1 Use real-life experiences, physical materials and technology to construct meanings for whole numbers, commonly used fractions, decimals and money amounts, and extend these understandings to construct meanings for integers, rational numbers, percents, exponents, roots, absolute value and scientific notation.

1-2 Model, represent and use numbers in a variety of equivalent forms (integer, fraction, decimal, percent, exponential and scientific notation) as they arise from real-world situations.

1-3 Use the equivalence of fractions, decimals and percents to select appropriate and efficient ways to write, order, compare, estimate and compute.

2-1 Maintain proficiency with basic addition, subtraction, multiplication and division facts through the use of a variety of strategies and contexts.

2-2 Develop, use and explain procedures for performing calculations with whole numbers, decimals, fractions and integers.

2-4 Select and use an appropriate method for computing from among mental math, estimation, paper and pencil and calculator methods.

3-1 Develop, apply and explain a variety of estimation strategies in problem situations involving quantities and measures.

3-2 Use estimation to predict outcomes and determine reasonableness of results.

3-3 Recognize when estimation is appropriate and understand the usefulness of an estimate as distinct from an exact answer.

4-1 Understand and use ratios, proportions and percents in a wide variety of situations.

5-1 Estimate, make and use measurements to describe and compare phenomena, and explore the structure and use of systems of measurement, including converting units within systems.

5-3 Solve problems involving the concept of, calculation of, and relationships among length, perimeter, area, volume, angle measure, capacity, weight, mass and temperature.

9-2 Use concrete materials, tables, graphs, verbal rules and symbolic expressions to represent situations and patterns.

Science

1-1 Conduct scientific investigations which generally involve the collection of relevant evidence, the use of logical reasoning and creativity in devising hypotheses and explanations to make sense of the evidence.

1-2 Identify and control variables in an experiment.

1-7 Use scientific knowledge and ways of thinking in personal decision making.

2-1 Recognize the important contributions to the advancement of science, mathematics and technology that have been made by men and women in different cultures at different times.

3-1 Describe the roles of producers, consumers and decomposers in an ecosystem and provide specific examples of each.

3-2 Explain the need for sunlight and other abiotic factors, such as water and air, in an ecosystem.

3-3 Explain that while matter is recycled in an ecosystem, there is one-way flow of energy in ecosystems.

3-4 Explain that the number and variety of organisms and populations are dependent on the resources and physical factors of their environments.

3-5 Explain how both organisms and ecosystems can change if the physical conditions of an ecosystem change (e.g., pond dries, forest is destroyed by fire).

4-1 Identify similarities and differences that characterize different types of cells (e.g. plant, animal muscle, nerve, bone)

4-2 Recognize that basic life processes, such as photosynthesis and respiration, occur at the cellular level.

5-3 Describe and analyze ways in which scientists determine the relatedness of organisms.

6-3 Recognize that individual organisms with certain traits are more likely than others to survive and have offspring.

6-4 Understand that the extinction of a species occurs when the environment changes and the species is not able to adapt to the changes.

7-2 Explain how rock buried deep enough may be reformed by pressure and heat into different kinds of rocks and minerals.

7-5 Describe the formation and movement of glaciers.

7-6 Use maps (e.g., topographic, hydrographic, highway) to identify land features and their locations.

7-7 Recognize that some changes in the Earth's surface, such as earthquakes and volcanic eruptions, are abrupt, while other changes happen very slowly (e.g., uplift and wearing down of mountains).

7-8 Explain how human activities (such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and waste disposal) have altered the Earth's land, oceans and atmosphere.

8-1 Recognize how the cycling of water in and out of the atmosphere plays an important role in determining climatic patterns and is responsible for constantly changing the phase and location of water.
8-2 Recognize that water falling to Earth flows over the surface as runoff and collects in ocean basins, rivers, lakes, icecaps and underground.
8-3 Recognize that water stored underground (subsurface) and water stored above ground (surface) form a continuum, each supplying water to the other.
9-1 Describe air as a mixture of gases, including water vapor and other liquid and solid particles.
9-2 Recognize that air exerts pressure and expands and contracts in relation to temperature.
9-3 Explain wind as a function of the unequal heating of the Earth's surface.
9-4 Know that water changes form as a function of energy transfer.
9-5 Infer that water vapor condenses out of cooling air.
11-6 Show how features such as the temperature and acidity of a solution can influence reaction rates.
12-4 Recognize that energy exists in many forms (e.g., light, heat, chemical, electrical and mechanical) and that energy can be transformed from one form to another.
14-1 Investigate and describe human uses of renewable and nonrenewable resources (e.g., forests, fossil fuels).
14-2 Explain interrelationships between science and technology (e.g., building a bridge, etc.)
14-3 Describe how the use of technology can contribute to the solution of an individual or community problem.
14-4 Recognize that science and technology cannot solve every problem faced by society.
14-6 Identify and analyze ways in which advances in science and technology have affected each other and society.
14-7 Recognize that issues related to science, technology and society are often complex and involve risk/benefit trade-offs.

Social Studies

1-1 Formulate historical questions based on primary and secondary sources, including documents, eyewitness accounts, letters and diaries, artifacts, real or simulated historical sites, charts, graphs, diagrams and written texts.
1-2 Gather information from multiple sources, including archives or electronic databases, to have experience with historical sources and to appreciate the need for multiple perspectives.
1-5 Examine data to determine the adequacy and sufficiency of evidence, point of view, historical bias, distortion and propaganda, and to distinguish fact from opinion.
1-8 Develop written narratives and short interpretative essays, as well as other appropriate presentations from investigations of source materials.
2-4 Locate the events, peoples and places they have studied in time and place(e.g.,on a time line and map) relative to their own location.
3-9 Explain how economic factors influenced historical events in the United States and other regions of the world.
4-1 Initiate questions and hypotheses about historic events being studied.
4-5 Describe relationships between historical subject matter and other subjects they study, current issues and personal concerns.
6-5 Research an issue of interest and be able to take and defend a position on that issue.
9-1 Describe human and natural characteristics of places and how they shape or place identity.
9-2 Describe the process and impact of regional change.
9-3 Examine ways in which regions are interconnected.
9-4 Identify and evaluate various perspectives associated with places and regions.
9-5 Explain and assess how culture affects perception of places and regions.

9-6 Use latitude and longitude to locate and calculate differences between places.
9-7 Locate natural and cultural features in their own and nearby communities, in the United States and in other regions of the world, as needed, to answer geographic questions.
9-8 Demonstrate how personal knowledge and experiences influence an individual's perception of places.
10-1 Understand how concepts of physical geography can be applied to explain natural processes.
10-2 Understand and apply how natural processes influence the formation and location of resources.
10-3 Use basic climatic and other physical data to understand how natural processes shape environmental patterns.
12-1 Explain the essential features and functions of maps, globes, photographs, geographic models and satellite images.
12-2 Make maps, globes, models, charts and geographic databases.
12-3 Compare and contrast differences among maps, globes, photographs, models, satellite images for solving geographic problems.
12-4 Use maps, globes, models, graphs, charts, and databases to analyze distributions and patterns.
12-5 Describe human and natural characteristics of places and how they shape and place identity.
12-6 Draw a freehand map from memory of increasing and appropriate complexity to display geographic information and answer geographic questions.
12-7 Demonstrate and explain ways that humans depend on, adapt to and alter the physical environment.
12-8 Identify the ways ecosystems are transformed through physical and human activities, and can predict the consequences of these activities.
13-2 Explain that households, businesses, governments and societies face scarcity just as individuals do.
13-5 Illustrate how resources can be used in a variety of ways.
13-6 Explain how technological change and innovation improves a society's productivity and economic growth.

Arts

1-1 Select media, techniques and processes to communicate ideas, reflect on their choices, and analyze what makes them effective.
1-2 Improve the communication of their own ideas by effectively using the characteristics of a variety of traditional and contemporary art media, techniques and processes (2-dimensional and 3-dimensional)
1-3 Use different media, techniques, and processes – 2 dimensional and 3-dimensional, including media/technology to communicate ideas, feelings, experiences and stories.
5-1 Compare and contrast purposes for creating works of art.
5-3 Compare a variety of individual responses to, and interpretations of, their own works of art and those from various eras and cultures.
6-1 Identify connections between characteristics of visual arts and other arts disciplines.
6-2 Identify connections between visual arts and other disciplines in the curriculum.

New Science Standards

7.3 The elements combine to produce compounds which account for the living and nonliving substances we encounter.
7.6 The Earth is layered with a lithosphere, hot mantle and dense metallic core.
7.7 The rock cycle and soil formation are evidence that the Earth is continuously changing.

APPENDIX B: GLOSSARY

abiotic — nonliving
acidic — having a pH of less than 7
acid rain — rain containing acids that form in the atmosphere when industrial gas emissions combine with water
adaptations — special features that allow an organism to survive in its environment
alevin — young fish; fry
alkaline — having a pH greater than 7
anadromous — migrating up rivers from the sea to breed in fresh water
aquifer — an underground layer of earth, gravel, or porous stone that yields water
basalt — a rock of igneous origin
biodiversity — the number and variety of organisms found within a specified geographic region
biotic index — an index of or having to do with life or living organisms
border — the line or frontier area separating political divisions or geographic regions; a boundary
boulder — a large rounded mass of rock lying on the surface of the ground or embedded in the soil
buffer zones — an area that lessens or absorbs a negative environmental impact
calculate — to make an estimate of; evaluate
canal — an artificial waterway or artificially improved waterway used for travel, shipping or irrigation
carrying capacity – the ability or amount that can be held or stored
colonist — an original settler or founder of a colony
confluence - a flowing together of two or more streams
connections — links
conservation — preservation or restoration from loss, damage, or neglect
consumption — the using up of goods and services by consumer purchasing or in the production of other goods
crust – the hard, outer part of a planet, moon or asteroid
dam — a barrier constructed across a waterway to control the flow or raise the level of water
decomposer — an organism, often a bacterium or fungus, which feeds on and breaks down dead plant or animal matter, thus making organic nutrients available to the ecosystem
dissolved oxygen – measurement of oxygen that is passed into a solution (or water)
drinking water – a clear, odorless liquid suitable for drinking or swallowing
ecosystem — an ecological community together with its environment, functioning as a unit
erosion — the group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface
factory — a building or group of buildings in which goods are manufacture; a plant
fault — a dislocation caused by a slipping of rock masses along a plane of fracture; also the dislocated structure resulting from such slipping
filter — to pass through a filter; to percolate
finite — having bounds; limited
fish ladder — a series of pools arranged like ascending steps at the side of a stream, enabling migrating fish to swim upstream around a dam or other obstruction
flow — to move or run smoothly with unbroken continuity, as in the manner characteristic of a fluid
food chain — a succession of organisms in an ecological community that constitutes a continuation of food energy from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member
food web — a complex of interrelated food chains in an ecological community
fry — small fish, especially young, recently hatched fish
generator — machine that converts mechanical energy into electrical energy

glacial – having to do with a huge mass of ice slowly flowing over a land mass, formed from compacted snow in an area where snow accumulation exceeds melting
groundwater – water within the earth that supplies wells and springs
hydroelectric power — of or relating to or used in the production of electricity by waterpower
hydrologic cycle — the cycle of evaporation and condensation that controls the distribution of the earth's water as it evaporates from bodies of water, condenses, precipitates, and returns to those bodies of water; also called **water cycle**
identify — to ascertain the origin, nature, or definitive characteristics of
impermeable – preventing especially liquids to pass or diffuse through
impervious — Incapable of being penetrated
impoundment – the act of accumulating and storing water in a reservoir
incubating — to maintain (eggs, organisms, or living tissue) at optimal environmental conditions for growth and development
Industrialism — an economic and social system based on the development of large-scale industries and marked by the production of large quantities of inexpensive manufactured goods and the concentration of employment in urban factories
infiltration – the act of permeating (a porous substance) with a liquid or gas
involvement — the act of engaging or including a participant
lake — a large inland body of fresh water or salt water
lava — the rock formed by the cooling and solidifying of molten rock that reaches Earth's surface through volcanic activity or fissure
locks — a section of a waterway, such as a canal, closed off with gates, in which vessels in transit are raised or lowered by raising or lowering the water level of that section
macroinvertebrate – an invertebrate animal (animal without a backbone) large enough to be seen without a microscope
magnify — to increase the apparent size of, especially by means of a lens
man-made — made by humans rather than occurring in nature; synthetic
map — a representation, usually on a plane surface, of a region of the earth or heavens
measurement — the extent, size, capacity, amount, or quantity ascertained by measuring or calculating; as, in its measurement is five acres
model — a small object, usually built to scale, that represents in detail another, often larger object
non-point source pollution — pollution caused by rainfall or snowmelt moving over and through the ground; as the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water
nutrients — a source of nourishment, especially a nourishing ingredient in a food
observations — the act of noting and recording something, such as a phenomenon, with instruments
organizations — a group of persons organized for a particular purpose; an association.
orient — to align or position with respect to a point or system of reference
penetrate — to enter into and permeate
percolate — to cause (liquid, for example) to pass through a porous substance or small holes; filter
permeable — that can be permeated or penetrated, especially by liquids or gases: *permeable membranes; rock that is permeable by water*
pervious — capable of penetrating or pervading
pesticide — a chemical used to kill pests, especially insects
pH level — a measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity; the pH scale commonly used ranges from 0 to 14
pollutants — something that pollutes, especially a waste material that contaminates air, soil, or water

pollution — the state of being contaminated with harmful substances
pool — a deep or still place in a stream
Precambrian rock – rock traces belonging to the geologic time period between Hadean Time and the Cambrian Period, often subdivided into the Archean and Proterozoic eras, comprising most of the earth's history and marked by the appearance of primitive forms of life
preservation – kept alive, intact or free from destruction; for the protection of wildlife or natural resources
primary consumer — an animal that eats grass and other green plants in a food chain; an herbivore
producer — a photosynthetic green plant or chemosynthetic bacterium, constituting the first trophic level in a food chain
quotations — an explicit reference or allusion in an artistic work to a passage or element from another, usually well-known work
reservoir — a natural or artificial pond or lake used for the storage and regulation of water
restoration — the act of restoring or bringing back to a former place, station, or condition; the fact of being restored; renewal
ridge — — a long narrow area of hills and mountains
ridge lines — a long narrow chain of hills or mountains
riffle – a shallow, gravelly area of a streambed with a swift current; used by spawning of trout and other fish
riparian areas — the vegetative area or bank by a river
riparian bank — of, on, or relating to the banks of a natural course of water
run – straight course of a river
run-off — rainfall not absorbed by soil
saturate — to soak, fill, or load to capacity
secondary consumer — an animal that feeds on smaller plant-eating animals in a food chain
sediment – fine soil or mineral particles, resulting often from the run-off from the land, which either settle to the bottom of a water body or are suspended in the water
source point pollution — pollution from industrial and sewage treatment plants with an identifiable source
surface water — water above the surface of the ground
talus slide — a sloping mass of rock debris at the base of a cliff
tertiary consumer — third in place, order, degree, or rank
topography — graphic representation of the surface features of a place or region on a map, indicating their relative positions and elevations
tributary – a river or stream flowing into a larger river or stream
trophic levels — of or involving the feeding habits or food relationship of different organisms in a food chain
turbine — machine in which the kinetic energy of a moving fluid is converted into mechanical energy by causing a bladed rotor to rotate
turbidity — having sediment or foreign particles stirred up or suspended; muddy
underground water – water that runs under the surface of the land
velocity — rapidity or speed of motion; swiftness
water quality – the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs; specifically broad designations of surface and ground water

watershed — a ridge of high land dividing two areas that are drained by different river systems
water tips — helpful hints about preserving water
water usage — the act of using water
water wheel — a wheel propelled by falling or running water and used to power machinery
wetland — a lowland area, such as a marsh or swamp, that is saturated with moisture, especially when regarded as the natural habitat of wildlife

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