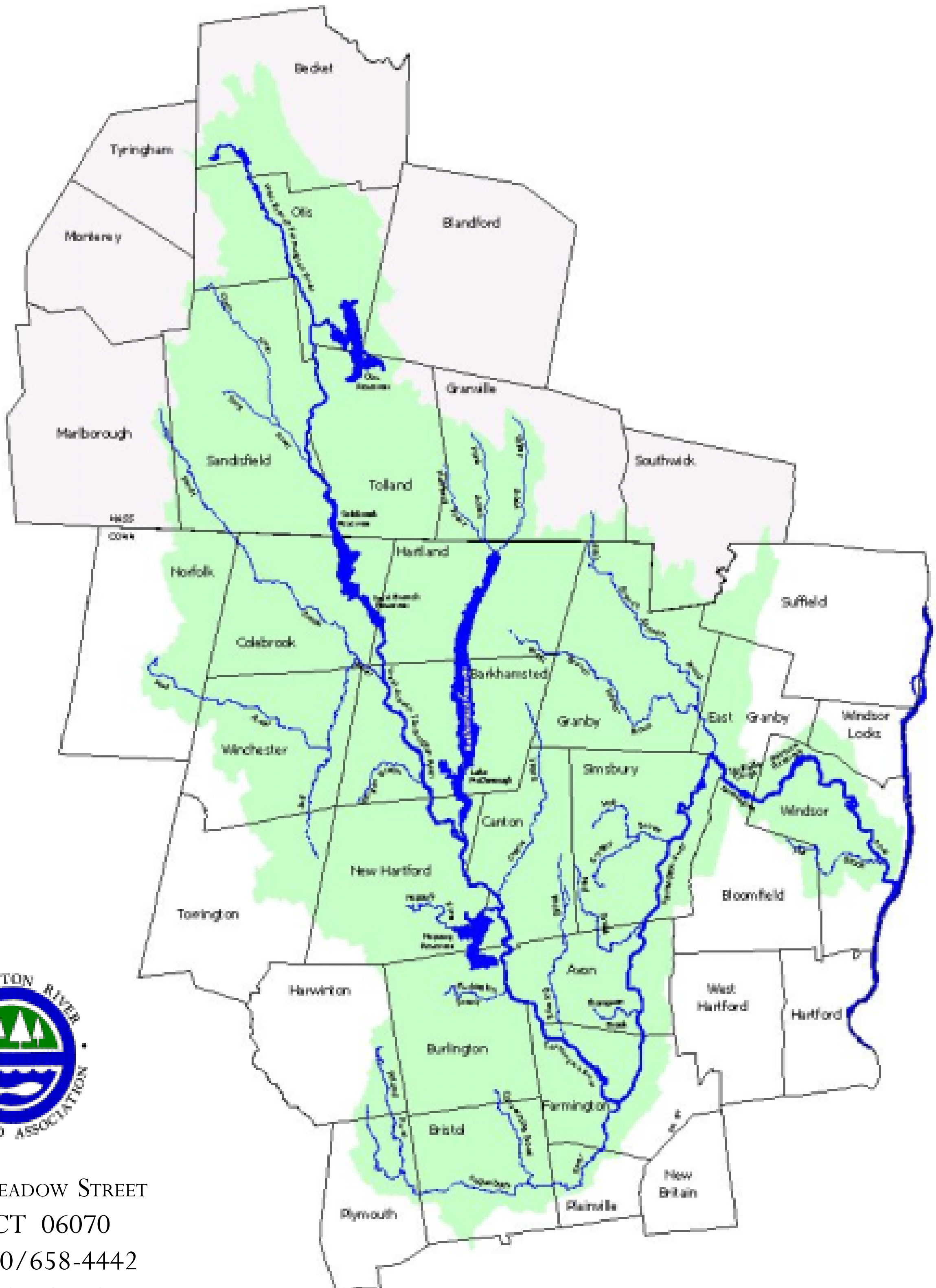
FARMINGTON RIVER WATERSHED EDUCATION CURRICULUM:

HIGH 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 – High 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.

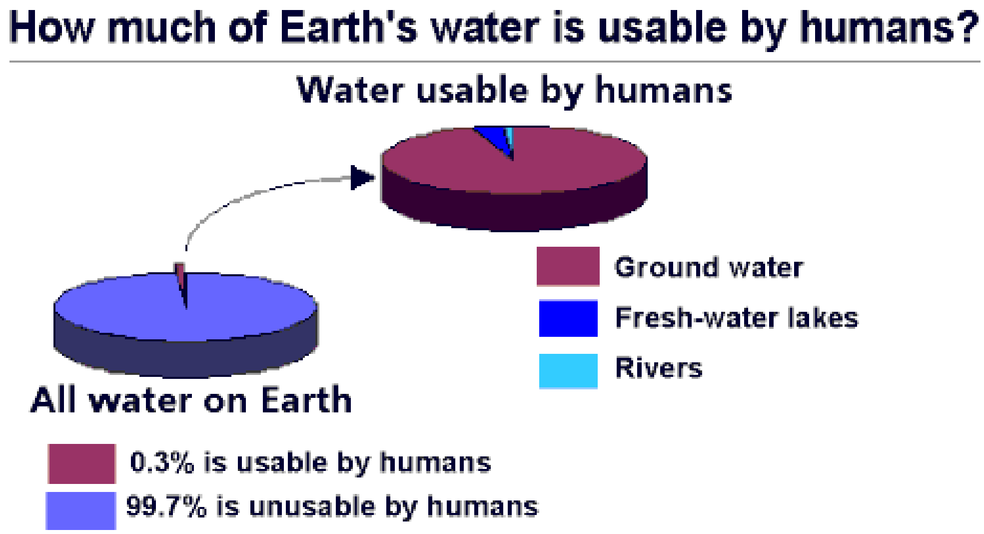
To a chemist, water is H_2O, a molecule composed of one oxygen and two hydrogen atoms.
To a biologist, water is nourishment necessary for all living things.
To an ecologist, water is a habitat hosting a world of interrelated species.
To municipalities and towns, water is a utility to be managed and sustained.
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

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



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:

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.

<u>Food Facts</u>:

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:

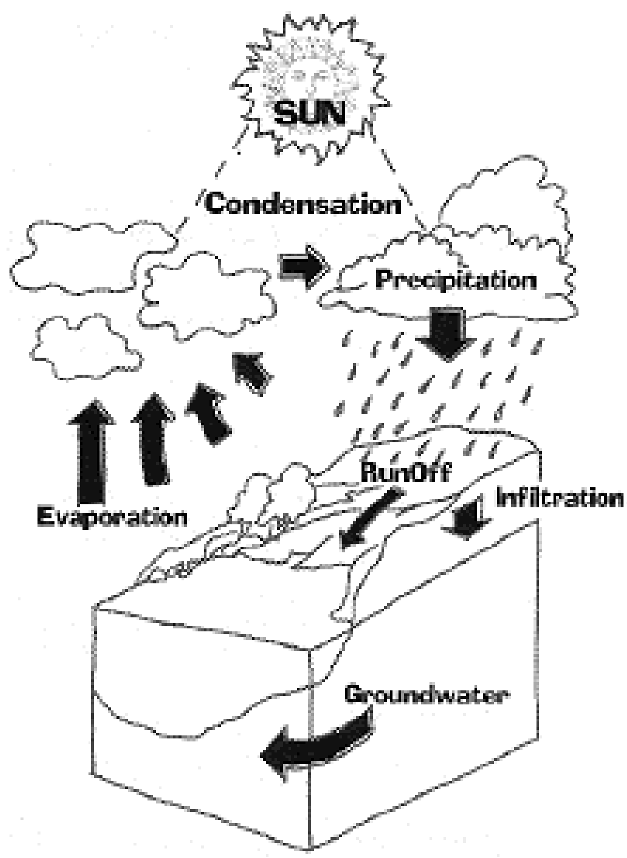
1. Only 7 % of the country's landscape is considered riparian, or alongside water— only **2 % of which still supports riparian vegetation**.
2. Of the 1200 species listed as threatened or endangered, **50% are dependant on wetland habitats.**
3. Freshwater species are disappearing **5 times faster** 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



Source U.S. Geological Survey

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!

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 treatment facilities. Metropolitan District Commission (MDC) treatment facilities in West Hartford and Bloomfield 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 Values

How much water is available for human consumption? What is the connection between surface and groundwater? In what ways can drinking water be conserved?

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

OBJECTIVES Students will:

- ✓ conduct a demonstration showing the amount of water available
- ✓ examine the interaction between surface and groundwater
- ✓ think of ways to protect water

MATERIALS **three 5 gallon plastic containers, eyedropper, gravel (two - three cups), sand (one cup), two paper cups, food coloring, one plastic quart size container**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(4)**
- **Math 1(1,2,4), 2(1), 4(1,2), 7(9)**
- **Science 1(1,6), 7(7), 8(2)**
- **Social Studies 10(2,3), 12(3,5), 13(4)**

VOCABULARY **finite, resource, percolate, groundwater, surface water, hydrologic cycle, recycle, reservoir, aquifer, hypothesize, stratified drifts, recharging**

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. Discuss and list ways they use water.
2. Conduct a demonstration to the class having a student help.
   a. Present a container filled with five gallons of water. This container represents all the water on Earth.
   b. 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 2.8% (2 ¼ cups) of the water.
   c. 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. 2% of this fresh water is located in glaciers and ice caps and is not available, leaving a ½ cup.
   d. Remove ½ cup from the 2nd container and place into another five gallon clear container. This is what is left for us to use. Explain that part of the water is trapped underground or is polluted, so therefore, unsuitable for drinking.

   e. That leaves approximately 5 drops of water for us to use.
      Remove 5 drops of water with dropper and place into another container. The five drops represent the water available for all uses. Have students think of all the ways they use water. List on board.

3. 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?
4. Ask students to think about where their *drinking water* comes from.
   a. Drinking water either comes from surface *reservoirs* or underground sources, such as *aquifers.* Water is stored beneath the surface of the land in aquifers, which are rocks with pore spaces or breaks in bedrock that are filled with water. Major aquifers are in the floodplains between New Hartford and Tariffville because of stratified drift (*layered glacial deposits*). When groundwater enters a water body, it is called *re-charging*. Groundwater can recharge a river with new water and the surrounding riparian area or wetlands. The interaction between surface water (rain water, lakes, wetlands, rivers) and groundwater (aquifers) is important because the water quality of one may affect the other.
5. Break students into groups and have them participate in an activity that illustrates the interaction between *ground water* and *surface water*.
   a. Have the groups fill a plastic container with gravel until it is a few inches from the top.
   b. Then, have them pour water into the container until it reaches the top of the gravel.
   c. Have students 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 represents an aquifer.
   f. Have students hypothesize what will happen if they add a pollutant.
   g. Place several drops of food coloring on top of the sand in the cup.
   h. The food coloring represents a contaminant or pollutant that went into the soil.
   i. The students simulate rain by pouring water into the second cup, holding the second cup over the cup with the sand and food coloring. Ask student groups the following questions:
      1. What is happening to the water? (*percolates* down through the sand)
      2. How is the contaminant impacting the soil on land and groundwater?
      3. Can the ground water affect the surface water? Explain.
      4. Where does your drinking water come from? (aquifer, reservoir)
      5. Knowing that surface and groundwater impact each other, how does that change your attitude about your treatment of water?
6. Read the two statements:
   a. According to the *Farmington River Guide*, dated 2002 "approximately 90% of the towns in the Farmington River Watershed receive drinking water from aquifers."
   b. According to the *State of the Farmington River Watershed Report,* dated August 2003, "The river is a vital water supply and recharge area for drinking water for over 600,000 people in the greater Hartford region and Farmington Valley."
7. Have students think about the meaning of these two statements.
8. Have them reflect on how to protect the quality of water. Have students write down their ideas and discuss with the class.

EXTENSIONS

1. Have students conduct research on drinking water sources in Farmington River Watershed.

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
Rosselet, Dale A., *New Jersey Waters: Watershed Approach to Teaching the Ecology of Regional Systems*, 1999, New Jersey Audubon, Bernardsville, NJ 07924
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
finite - having bounds; limited
groundwater - water beneath the earth's surface, often between saturated soil and rock, 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 the water cycle
hypothesize - a tentative explanation for an obervation, phenomenon, or scientific problem that can be tested by further investigation
percolate - to cause (liquid, for example) to pass through a porous substance or small holes filter
recharging - water overflow from precipitation into surface and groundwater receptacles
recycle - to extract useful materials from garbage or waste; to extract and reuse useful substances found in waste
reservoir - a natural or artificial pond or lake used for the storage and regulation of water
resource - something that can be used for support or help
stratified drifts - having its substance arranged in strata, or layers; as in stratified rock
surface water - water above the surface of the ground

Lesson 2

Water Observations

What observations can be made about the stream and its habitat?
What does "reading" the landscape mean?
How is the presence of animals recognized if they are not visually seen?

GOAL To understand that observational skills are important to develop when examining a watershed

OBJECTIVES Students will:
- ✓ observe animal and plant life
- ✓ complete the worksheet
- ✓ draw a sketch of the land
- ✓ write about water; a finite resource

MATERIALS **worksheets, pencils, clipboards, paper for writing**
optional: magnifying lenses, binoculars, field guides

CORE CURRICULUM CONTENT STANDARDS

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

VOCABULARY **observation, reflection, conserve, protect**

PROCEDURES

1. Begin by explaining to students that using observational skills is important to studying the river and its watershed.
2. Have students visit a river in their area. If unable to, have students go outside on school grounds to conduct activity.
3. Distribute clipboards, pencils, worksheets, and optional equipment.
4. Have students walk along stream area and complete the student sheet.
5. After sheet is completed, have students "read" the landscape. Have them observe the topography, their surroundings, and the primary use of the land. Have students sketch the site on the opposite side of worksheet.
6. Discuss findings with the rest of the group.
7. To conclude lesson, have students refer to the previous lesson. Have them reflect on what it means to have water as a finite resource. After observing the river or stream (or school grounds), have them write down ideas on how they can help to conserve and to protect water.

EXTENSIONS

1. Have students explore another area such as a forest. Have them participate in a sensory hike. Discuss how using different senses, such as hearing and touching, might change or broaden their exploration experiences.
2. Have students test their observational skills. Have several students place ten misplaced items out in a field, forest, or by a stream in a pre-marked area. Items should be objects that do not belong there such as a marker, pencil, ruler, or other item. The objects can be camouflaged, or be conspicuous, but not be hidden, or be obstructed from view. After the students have set out the objects, have the remainder of students try to find the items. Have them write down the objects they were able to locate. Once completed, have another set of students place the items in different spots in a pre-determined area. Have the remainder of the students search for them. Continue until everyone has had a turn participating in both activities. When exercise is completed, ask students which objects they had more difficulty finding. Ask which ones were easier to locate.

RESOURCES

Journey to the River

GLOSSARY

conserve - to protect from loss or harm; preserve
observation - the act of noting and recording something, such as a phenomenon, with instruments
protect - to keep from being damaged, attacked, stolen, or injured; guard
reflection - a thought or opinion resulted from careful consideration

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 by or in a stream.)

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 at land and water dweller (amphibians) – They live in the water when they are young and on land when they are adults.

3. 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 lives in the water and part out of the water.

Lesson 3

Recycled Water

How is water recycled?
How does a terrarium demonstrate the water cycle?
How does vinegar simulate acid rain?

GOAL To understand that a terrarium demonstrates the hydrologic cycle

OBJECTIVES

Students will:
- ✓ formulate a hypothesis
- ✓ assemble two terrariums
- ✓ spray one terrarium with vinegar and the other with water
- ✓ observe the effects
- ✓ understand the significance of pH as an indicator of water quality

MATERIALS **two aquarium tanks or large glass jars, five pound bag potting soil, plants, spray mist bottle, plastic wrap, tape or rubber band, observation sheet, vermiculite (optional), activated charcoal (optional), gravel**

CORE CURRICULUM CONTENT STANDARDS

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

VOCABULARY **recycle, hydrologic cycle, acid rain, hypothesis, hydrogen, oxygen**

PROCEDURES

1. Using the scientific method of experiment, pose a question to the students and identify a problem. Discuss whether *acid rain* affects plant growth and whether it recycles through the *hydrologic cycle (water cycle).*
2. Have students confirm or deny the following *hypothesis*: Acid rain will negatively affect plants because it cycles through the hydrologic cycle.
3. Explain to students that they will create two terrariums for their experiment. Label Terrarium number #1 and Terrarium number #2 on the outside of their containers.
4. Students may use a glass jar or aquarium tank. Planting instructions follow:

Planting Instructions:

- **Place a 1/2 inch layer of small gravel in bottom.**
- **Sprinkle some activated charcoal on top. (Optional)**
- **Fill to proper height with a good draining potting soil. If soil "clumps" when squeezed, add some Perlite, or Vermiculite to lighten it up. These can usually be found in garden shops.**
- **Install plants. The number will depend on the size of the plants, and the container. Don't overplant. Leave room to grow. Push the soil aside, place a plant in the depression, and firm the soil around it.**
- **Repeat for each plant.**
- **Water lightly. (3 or 4 ounces; see #'s 5 and 6))**
- **Cover with plastic wrap and rubber band, or masking tape.**
- **Repeat exercise for second terrarium.**

5. Spray Terrarium #1 with a mixture of white vinegar and water (½ part vinegar, ½ part water)
6. Spray Terrarium #2 with water.
7. Explain to students that spraying terrarium plants with vinegar in Terrarium #1 simulates acid rain (low pH). Spraying water on terrarium plants in Terrarium #2 simulates precipitation.
8. Discuss pH with students. Because humans and organisms are dependent on water with pH levels near neutral, pH then becomes an important indicator of water quality. Explain that pH measures the concentration of hydrogen ions. A water molecule (H_2O) consists of one hydrogen ion (H+) and one hydroxide ion (OH). Simply stated, a solution is more acidic when it contains more hydrogen ions (H+). The ions are what give water its ability to bond with and dissolve just about any substance (given the right conditions). On the pH scale, a substance is an acid when it has a low pH and is a base (alkaline) with a high pH.
9. Ask students what they think vinegar is.
10. Observe plants for a set amount of time (I week, 1 month, etc.), continuing to spray plants with appropriate solution. Record observations on data collection sheet (end of lesson).
11. Ask students how this activity relates to the water cycle (*water evaporates and transpires through plant stomata, becomes water vapor and precipitates*).
12. Ask what they can conclude. Record conclusions and confirm or deny hypothesis.
13. Complete scientific method chart.

EXTENSIONS

1. Have students draw the hydrologic cycle in a diagram. Label and explain the process.
2. Have students research the causes of acid rain. Determine what can be done to decrease or eliminate them.
3. Have students test different substances to determine whether they are acidic or basic. Use litmus paper and test solutions such as ammonia, distilled water, baking soda, lemon juice, etc.
4. Have students test the pH level in a stream or river near an area in which they live.

RESOURCES

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

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

hydrogen - colorless, odorless gaseous chemical element; lightest and most abundant element in the universe; present in water and in all organic compounds

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 the water cycle

hypothesis - a tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation

oxygen - colorless, odorless gaseous element belonging to group 16 of the periodic table; it is the most abundant element present in the Earth's crust; it also makes up 28% of the Earth's atmosphere

recycle - to extract useful materials from garbage or waste; to extract and reuse useful substances found in waste

Observation Sheet

1. Record your observations of the health of the plants:

	Terrarium 1	Terrarium 2
Week 1		
Week 2		
Week 3		
Week 4		

2. Explain the water cycle based on your observations of the plants.

Scientific Method Chart

Scientific Method Steps	Experiment
Observation Identification of a problem or question	
Hypothesis A prediction of the expected result	
Procedure How hypothesis is tested	
Data Collection and Analysis Take detailed notes of observations	
Conclusions Confirm or deny hypothesis	

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 from altering the flow of a river.

OBJECTIVES Students will:

- ✓ research facts about dams in the FRW
- ✓ 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 from CD, pencil, paper, butcher block paper, markers, clay, cardboard, and other re-used art materials**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(11,12) 2(4)**
- **Science 1(1), 5(3), 7(5), 8(1-3,6), 9(7), 14(1-3, 7)**
- **Social Studies 10(1,6), 11(1-6), 12(1-3), 13(2,4,5)**
- **Arts 1(1-3)**

VOCABULARY **hydroelectric, dam, impoundment, anadromous, generator, electricity**

PROCEDURES

1. Begin the lesson by asking students if they know what dams are (*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 for storing 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. Discuss how the force of water can provide another type of power (*hydroelectric = "hydro" (water) + electric = water power*). 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 know the names of any dams (Hoover). Ask if there are any dams in the Farmington River Watershed (Saville, Rainbow, Goodwin, etc.). Ask if any help to generate electricity.
4. Discuss that a series of dams or impoundments have been constructed in the

Farmington River Watershed. They are listed as follows (from upper to lower water-shed):

a. **Colebrook Dam** – constructed in 1969 – maintained by U.S. Army Corp of Engineers – hydropower facility – flood control – Colebrook Reservoir – recreation – 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 Dam** – 1963 & 1970 – located in 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 (*migrates from ocean or sea to spawn in fresh waters*) fish (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. How much electricity is generated? How many households does it serve?
   f. Are there any other unique or interesting facts about the dam?
   g. As an added option, students may build a model of a dam (use a variety of re-used, and art materials).

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 as well. Have them debate the issue in class.
8. Have students research how electricity is generated at power plants. Have students go to http://www.themdc.com/hydropower.htm. Draw diagrams explaining the process. Ask if there are advantages to using water power as opposed to another type of power source (*oil, coal, trash to energy*).

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 returning to spawn.

RESOURCES

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

GLOSSARY

anadromous - migrating up rivers from the sea to breed in fresh water
dam - a barrier constructed across a waterway to control the flow or raise the level of water
electricity - electric current used or regarded as a source of power
generator - one that generates, especially a machine that converts mechanical energy into electrical energy
hydroelectric - or or relating to or used in the production of electricity by waterpower
impoundment - the act of accumulating and storing water in a reservoir

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
- ✓ simulate "pollution" in their models

MATERIALS **plastic 2-liter bottle, gravel (two cups), two paper cups, sand (two cups), food coloring, piece of nylon, a pump from lotion or soap dispenser, rubber band, paper to record observations, pencil**

CORE CURRICULUM CONTENT STANDARDS

- **Science 1(1,6), 3(4), 7(5), 8(2-4,6)**
- **Social Studies 10(1,3,6) 11(1,5), 12(3), 13(4)**

VOCABULARY **run-off, (im)permeable, percolate, aquifer, water table, effluent, penetrate**

PROCEDURES

1. Begin by asking students where does water flow to 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. 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. Examples of permeable soil include sand and gravel because there are pore spaces in the soil. Clay is an example of an impermeable surface because it can effectively block water from flowing through it. 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 and many provide the supply of drinking water to many households. Wells are drilled to pump water from aquifers. Protecting this resource is extremely important as pollutants may contaminate water supplies. The interaction between surface water (rain water, lakes, wetlands, rivers) and groundwater (aquifers) is important because the water quality of one may affect the other

2. Break students up into groups and have them conduct the following exercise so as to illustrate the interaction between ground water and surface water: Distribute materials and have student groups assemble ground water models as a class.

a. Have students cut the 2-liter bottle in half. Then, place a thin layer of clay on the bottom of the bottle to represent the impermeable layer.

b. Have students fill one-third with gravel or rocks.

c. Afterwards, have groups secure a piece of nylon over the bottom end of the pump sprayer with a rubber band.

d. Place pump sprayer into rocks and fill container with sand two inches from the top.

e. To demonstrate how groundwater accumulates, have students add water into container, observing how the water affects the water table. Water can be poured into cup (with holes in bottom) while holding it over the 2-liter bottle so that it percolates through the soil. Have students continue pouring water until it accumulates to just past the top of the gravel (*water table)*

f. Instruct groups to make a depression in the sand by scooping it from one side of the model and piling it on the other side. Have students dig the depression down to the gravel. This represents a reservoir.

g. Discuss with students how surface water (reservoir) can interact with ground water. Have students simulate pollution into their models. Have each group follow different scenarios or instructions:

    i. A sewage plant is working to its capacity. The plant requires new equipment and upgrades so as to keep up with technology. It was revealed that the effluent, or discharge from the plant is not meeting the appropriate standards. Have students pour two drops of food coloring into reservoir. Have it “rain” from the cup. Repeat four times. Have students pump water out of the ground using the lotion pump. Record their observations.

    ii. An underground oil tank was removed from a property recently sold. After careful inspection, oil leakage was found in areas of the surrounding soil. Have students dig a hole in the sandy portion of the model. Place two drops of food coloring to simulate oil in the soil. Re-cover the hole. Have it “rain” from the cup with holes in the bottom. Repeat four times. Have students pump water out of the ground using the lotion pump. Record their observations.

    iii. A new housing development was situated on a hill overlooking the reservoir and surrounding terrain. Many trees were cut down and a road was built reducing the amount of pervious surfaces. Sediment and run-off were spilling into the waterways. Place two drops of food coloring on the surface of the sandy portion of the model. Have it “rain” from the cup with holes in the bottom. Repeat four times. Have students record observations.

3. Conclude the lesson by having each group present their scenarios. Have them address where they placed the pollution and the effect it had on the surface water and ground 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*, The Watercourse 2003, Bozeman, Montana 59717 - 0575

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

aquifer - an underground layer of earth, gravel, or porous stone that yields water
effluent - an outflow from a sewer or sewage system
impermeable - preventing especially liquids to pass or diffuse through
penetrate - to enter into and permeate
percolate - to cause (liquid, for example) to pass through a porous substance or small holes; filter
permeable - that which can be permeated or penetrated, especially by liquids or gases: *permeable membranes; rock that is permeable by water*
run-off - rainfall not absorbed by water
water table - the level below which the ground is completely saturated with water; also called the water level

FRWA Curriculum Guide

Week II - High 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 the New Hartford/ Canton line 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 to the Farmington at the New Hartford/ Canton 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 Farmington 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 Lines

How is a river formed?
How do the hills of land direct the flow of water?
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 and 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
- ✓ become familiar with the flow of rivers
- ✓ understand that land and water are part of the watershed

MATERIALS **copies of watershed maps, topographic maps (on CD) or relief map, butcher block paper, newspaper (two pieces each student), spray mist bottle, masking tape, permanent markers, water soluble markers**

CORE CURRICULUM CONTENT STANDARDS

- **Science 7(5,6), 8(1-4, 6), 12(6)**
- **Social Studies 9(1,3,4), 10(1-3,5,6), 11(5), 12(1-3), 13(4)**
- **Arts 2(1)**

VOCABULARY **ridge lines, topography, flow, model, man-made, dam, confluence, 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. Explain that each line represents a certain elevation or height above sea level. To move from one contour line to the next, they must go uphill or downhill. By noting the shape and distance between the contour lines, hills, mountain ridges, and other landforms can be identified.
2. 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.
3. Have students look at topographic 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 a reservoir appear on the map (*a stream is narrower, pond is wider).*
4. 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.
5. 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 Connecticut.
   c. Follow the river south through Barkhamsted to the northeastern corner of New Hartford. This is where the west and east branches 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 back towards Avon and then up to Simsbury. Draw this part of the river, reflecting the change in direction. Place an "x" on the Farmington 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.
   i. After student groups have followed the path of the river, have them conduct the following activity.
2. 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.
3. 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.
4. 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.
5. Have the students predict where they think the major rivers might be. Have students mark those areas with permanent markers.
6. 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.
7. Ask students how the hills (topography) of the land affected the way the water flowed.
8. If this model included 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)*
9. Ask students how the model relates to their maps they created.

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.
Farmington River Watershed Association, August 2003, *State of the Farmington River Watershed Report*, Farmington River Watershed 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
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
map - a representation, usually on a plane surface, of a region of the earth or heavens
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 representations 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

Carrying Capacities

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

GOAL To understand the enormity of reservoir carrying capacities

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 maps, paper, plastic gallon jug for five groups, rulers, pencils, calculators**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1,2,4), 2(3), 4(1), 5(1), 7(9)**
- **Science 8(2,6) 14(1-4, 6,7)**
- **Social Studies 2(2), 9(1-4),10(1), 11(1,2,4,5) 12(3), 13(2,4,5)**

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)*.
2. Discuss carrying capacities of reservoirs (*amount of water they are able to hold*). Explain that the Farmington River Watershed has ten reservoirs and three are used solely for drinking water storage (*Barkhamsted, Nepaug and Whigville Reservoirs*). They are able to store billions of gallons of water. Have students comprehend the enormity of the volume through math calculations.

3. Distribute watershed maps (from CD Selected_Dams_Mapr) 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

Highland Lake - 482 million gallons

Rainbow Reservoir - 4 billion gallons

Whigville Reservoir - 37 million gallons

4. After completing activity, divide students into four groups. Provide each group with one gallon jug, a ruler, paper, pencil and calculator. Assign one reservoir 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 five reservoirs.
2. Have students identify wildlife at each of the reservoir locations. Have them indicate if particular species inhabit these areas.

RESOURCES

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

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

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
- ✓ 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

- **Language Arts 2(4)**
- **Math 1(1), 2(1)**
- **Science 1(1,6), 3(4), 7(15,6), 8(2-4,6)**
- **Social Studies 10(1,3), 12(3, 5)**

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

PROCEDURES

1. Conduct a demonstration on pervious and impervious surfaces. Have three aluminum trays set up with drainage holes on one side of the trays. Prop up the trays so that water will drain.
2. 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 lots or pavement, then the water “runs-off” the “impervious” surface into the storm drains.
3. The three trays each have a particular type of surface: one tray is empty, the second one has soil in it and the third has soil with grass, hay or leaves on top of it.
4. 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.
5. 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. Conduct this calculation for each of the three types of surfaces.
6. 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.

7. Lead a discussion on 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.)
8. Inform students that they have been asked to recommend ways to increase the amount of pervious surfaces at a shopping mall. Recently, after rains, the parking lot has become flooded and the shoppers have been complaining. It is particularly a problem with runoff. There are many cars parked and there is a potential hazard for that amount of water to flow into the storm drains.
9. Instruct students to come up with ways to reduce the flow of water in the parking lot and present to the merchants.
10. Break students in groups. Students may conduct research on the web. A potential site is http://www.nemo.uconn.edu/reducing_runoff/index.htm.
11. Have students develop exhibits and diagrams to present their ideas to the class.

EXTENSIONS

1. Have students walk around school yard and list pervious and impervious surfaces. Have them make recommendations to the local administration.
2. Ask students why wetlands are able to filter the runoff.
3. Ask how floods are prevented.
4. Ask if there is anything designed to curtail the flow of water down the storm drain.

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
storm drain - a storm sewer

Lesson 9

Land Use

How is run-off affected when land is developed?
How can run-off be calculated?
What is the impact of land development on the watershed?

GOAL To understand that a small alteration in the land can greatly affect the flow of water.

OBJECTIVES Students will:

- ✓ calculate cubic feet of run-off on a 100 acre parcel of land
- ✓ compare pre and post development scenarios
- ✓ realize the impact of development on the watershed

MATERIALS **calculators**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1,2), 2(1), 4(1), 10(1)**
- **Science 1(6), 7(5), 8(2-4), 14(1, 8)**
- **Social Studies 9(1-3), 10(1,3), 11(1) 12(3,5)**

VOCABULARY **hydrologist, curve numbers**

PROCEDURES

1. Begin by explaining to students that runoff increases as land development increases. Hydrologists use curve numbers to calculate the expected amount of runoff from land uses. Values are assigned to curve numbers based on soil type and their permeability. The lower the number, the more water can infiltrate, and the less water runs off. A parking lot will have a higher curve number than a field.
2. Explain that they were asked to calculate the amount of runoff for a potential development area. The information will be used to plan and incorporate more pervious surfaces in the development.
3. For the activity, have students use the following data:

pre-development land use	curve #	area (acres)
forest	55	30
pasture	79	40
organic farm	81	30

post – development land use	curve #	area (acres)
roads	98	3
homes	75	27
pasture	79	40
organic farm	81	30

1. Write the data on the board and have students identify the area of development (30 acres of forest was developed into 3 acres of roads and 27 acres of homes).
2. Have students calculate an average curve number for the whole area of the land. Multiply the curve # x area for each land use in the pre-development scenario. Refer to pre-development land use chart.
   a. 55 x 30 = 1650
      79 x 40 = 3160
      81 x 30 = 2430
   b. The sum of the number equals 7240. To calculate the weighted average curve number, divide 7240/100 acres = 72.4
3. Next, have students find the amount of run-off, using the curve number graph. Rainfall is on the x-axis and run-off is on the y-axis. Assume the average rainfall is 5 inches. Find 5 inches on the x-axis and follow up the graph until the curve number (72.4) is intersected. Follow horizontally across to the y-axis to find the inches of runoff. In this scenario, the answer is 2.2 inches.
4. To calculate the total runoff for the 100 acre parcel, multiply the inches of the run-off by the total area. Have students convert inches to feet and acres to square feet to compute a cubic foot value.

   a. 2.2 inches x $\frac{\text{1 foot}}{\text{12 inches}}$ = 0.183 feet of runoff

   b. 100 acres x $\frac{\text{43560 square feet}}{\text{1 acre}}$ = 4,356,000 square feet of runoff

   c. 0.183 feet x 4,356,000 square feet = 798,000 cubic feet of runoff

   d. To convert to gallons:

   To convert to gallons:

   798,000 cubic feet x $\frac{\text{7.48 gallons}}{\text{1 cubic foot}}$ = 5,969,040 gallons of runoff

5. To calculate the runoff for the post-development scenario, repeat procedure 4, using the post-development data.

   a. 98 x 3 = 294
      75 x 27 = 2025
      79 x 40 = 3160
      81 x 30 = 2430

   b. The sum of the number equals 7909. To calculate weighted average curve number equals 7909 divided by 100 acres equals 79.
   c. Using the graph, 5 inches of rainfall with a curve number of 79 corresponds to 2.8 inches of runoff.

6. To compute total runoff:

   a. 2.8 inches x $\frac{1 \text{ foot}}{12 \text{ inches}}$ = 0.233 feet of runoff

   b. 100 acres x $\frac{43560 \text{ square feet}}{1 \text{ acre}}$ = 4,356,000 square feet

   c. 0.233 feet x 4,356,000 square feet = 1,016,400

7. To convert this figure to gallons:

   1,016,400 cubic feet x $\frac{7.48 \text{ gallons}}{1 \text{ cubic foot}}$ = 7,602,672 gallons of run-off

8. Discuss the difference in volume of runoff between the pre- and post- development calculations. Remind the students that only 30 acres was developed.

9. Have students discuss ways to add more pervious surfaces to reduce runoff.

EXTENSIONS

1. Have students calculate estimated runoff in their backyard. Visit the Shodor Educational website to estimate runoff based on soil condition. Soil condition, hydrologic condition and storm information will have to be researched.
   http://www.shodor.org/cgi-bin/envsci/runoff/runoffstateunits.cgi

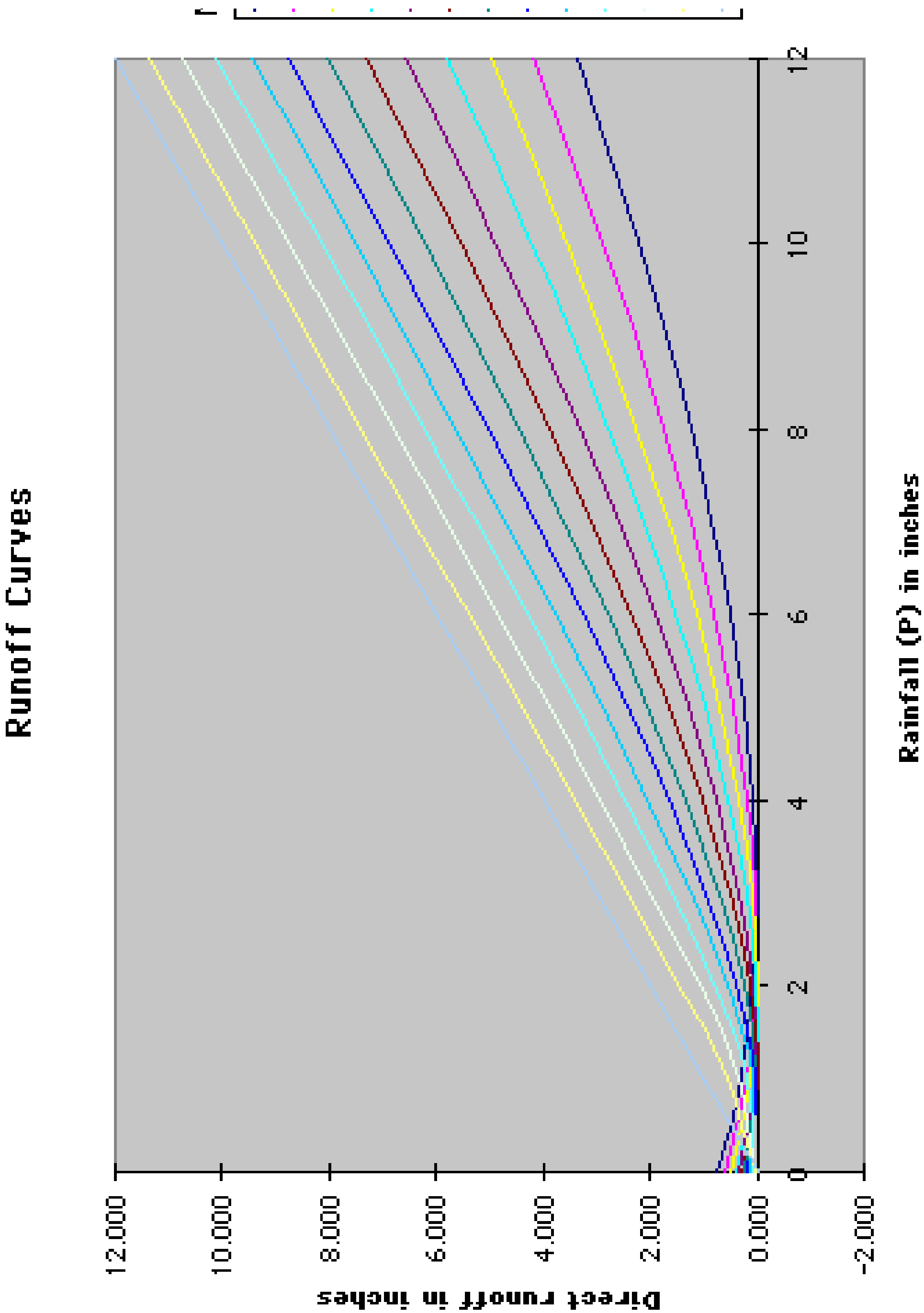
RESOURCES

Bechdol, Michael, Cheo, Martha S., O'Neal, Vicky, Slater, Meredith, The Pawcatuck Watershed Education Program; 1993, The Southern Rhode Island Conservation District and The University of Rhode Island Department of Natural Resources Science, Hope Valley, RI.

Shodor Education Foundation, Inc.; The Science of Surface Water Runoff; 1998; http://www.shodor.org/master/environmental/water/runoff/index.html

GLOSSARY

curve numbers - numbers on a line representing data on a graph
hydrologist - a scientist who studies the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere


Runoff Curves
Direct runoff in inches
12.000
10.000
8.000
6.000
4.000
2.000
0.000
-2.000
0
2
4
6
8
10
12
Rainfall (P) in inches

Lesson 10

Water Models

How is the land impacted by its use? What impact does the population have on land use and water quality? How is water quality impacted by land use?

GOAL To understand that Farmington River Watershed is comprised of a variety of land uses

OBJECTIVES Students will:

- ✓ identify the land use of their particular section of the river
- ✓ create a model
- ✓ determine land use and water quality of area
- ✓ design a presentation

MATERIALS **assortment of re-used and art materials for models, paper, pencils, markers**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(2,4)**
- **Science 7(1,4,5), 8(2-4,6), 14(7)**
- **Social Studies 2(2), 9(1-5), 10(1-4, 6)11(4,5), 12(3)**
- **Arts 1(2), 4(1,2) 6(3)**

VOCABULARY **Precambrian rock, abutments, bedrock, Triassic, flatwater, gorge, floodplain, alluvial, oxbow**

PROCEDURES

1. Explain that the Farmington River Watershed is comprised of different types of land use, topography, and scenery along its various sections of the river.
2. Break up students into 8 groups or teams.
3. Distribute descriptions of their particular section of the watershed. (Descriptions are listed after lesson)
4. Explain that descriptions are not complete but provide an overall understanding of land use. Have students conduct additional research if time permits.
5. Have students undertake the following activities:
   a. Read descriptions of land.
   b. Create a model of their section of the watershed. Use materials such as clay, cardboard, plastic, construction paper, etc.
   c. Determine whether area is populated or not and why.
   d. Indicate type of industry that can be supported in area.
   e. Indicate what type of wildlife can be supported in area.
   f. Determine what is man-made or natural in area.
   g. Indicate whether topography of land affect and/or determine use of land.
   h. Guess what the quality of water is and indicate why.

i. Determine impact of land use on water quality of Farmington River.
j. Discuss whether humans play a role in impacting water quality.
k. Support all statements.
l. Design a presentation to rest of class.

6. When presentations are completed have students connect watershed models to display in classroom(s), and/or other areas of school.

EXTENSIONS

1. Ask students if they were requested to come up with a build-out plan for a town within the Farmington River Watershed what considerations would they take. Ask what factors they would consider when determining where development would or should take place.
2. Ask students to visit their town planner. Find out how development of a town takes place. Are there guidelines, laws, etc. that need to be considered? Is the impact on resources a consideration for a town planner?

RESOURCES

Farmington River Guide, 2002, Farmington River Watershed Association

GLOSSARY

abutment - the part of a structure that bears the weight or pressure of an arch; a structure that supports the end of a bridge
alluvial - relating to the deposits made by flowing water; washed away from one place and deposited in another; as, alluvial soil, mud, accumulations, deposits
bedrock - the solid rock that underlies loose material, such as soil, sand, clay or gravel; solid unweathered rock lying beneath surface deposits of soil
flatwater - of or on a level or slow-moving watercourse
floodplain - a plain bordering a river and subject to flooding
gorge - a deep, narrow passage with steep rocky sides; a ravine
oxbow - a U-shaped bend in a river and the land within such a bend of a river
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, compris ing most of the earth’s history and marked by the appearance of primitive forms of life
Triassic - of or belonging to the geologic time, system of rocks, or sedimentary deposits of the first period of the Mesozoic Era, characterized by the diversification of land life, the rise of dinosaurs, and the appearance of the earliest mammals

SPECIAL LAND-USE CONSIDERATIONS IN DIFFERENT SECTIONS OF THE FARMINGTON RIVER WATERSHED

1. **From Otis, MA to Colebrook, CT**
   - **Steep ridges**
   - **Big boulders**
   - **Vertical cuts in bedrock overlooking Colebrook Reservoir**
   - **Wintertime – huge accumulation of ice along the rocks**
   - **State Forests**
   - **Most rigorous and challenging section (rapids)**
   - **Bridge**
   - **reservoir**

2. **Goodwin Dam, Hartland to New Hartford, CT**
   - **Dam**
   - **Hitchcock Chair Factory, Inn**
   - **"wild and scenic" designation**
   - **hemlock forest**
   - **stone bridge abutments**
   - **High Bank, rapids**
   - **Ski Sundown**
   - **Old Precambrian rock**
   - **forests**

3. **Satan's Kingdom, New Hartford to Collinsville**
   - **Upper Collinsville Dam**
   - **High iron bridge**
   - **Original buildings of Collins Company – dated 1826**
   - **Indian Hill**
   - **Bedrock steps – Indian fishing rocks**
   - **Sand bars**
   - **Cherry Brook enters Farmington River**
   - **Ancient Triassic rock**
   - **Companies**

4. **Burlington to Farmington**
   - **Roaring Brook**
   - **Flatwater stretches**
   - **Restaurants**
   - **White church steeple**
   - **Hiking trails/soccer fields**
   - **Pequabuck River**
   - **Bridge**
   - **Lower Collinsville Dam**
   - **State forest**

5. **Farmington to Simsbury**
   - **Flatwater**
   - **Floodplain**
   - **Golf courses**
   - **Ruins of Farmington Canal**
   - **Talcott Mountain**
   - **Largest tree in Connecticut**
   - **Historical bridges**
   - **Salmon Brook enters**
   - **Meadows**
   - **Opening in traprock cliff**
   - **Restaurants**
   - **Oxbow**
   - **State forest**

7. **Tariffville to Windsor**
   - **Gorge**
   - **Bridge**
   - **Old lace factory**
   - **Rapids**
   - **Big drops**
   - **Old dam abutements**
   - **Reservoir**
   - **Trails**
   - **Parks**

8. **Rainbow Reservoir to Connecticut River**
   - **Dam**
   - **Fish ladder**
   - **Bridges**
   - **Flatwater and rapids**
   - **Hydroelectric company**
   - **Alluvial deposits**
   - **Trails/park**
   - **industry**

FRWA Curriculum Guide

Week III - High 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% of 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 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

Water Ecotones

What is an ecotone? Why is it important?
What can negatively affect an ecotone?
What can positively affect an ecotone?

GOAL To understand that a healthy ecotone has more diversity than an ecosystem, itself.

OBJECTIVES Students will:
- ✓ examine the plants and animals of two ecosystems
- ✓ study an ecotone (two ecosystems overlapping)
- ✓ determine whether the ecotone has more or less diversity.

MATERIALS **Ecotone study sheet, pencils, clipboards, magnifying lenses (optional)**

CORE CURRICULUM CONTENT STANDARDS

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

VOCABULARY **ecosystem, ecotone, diversity, hypothesis, hypothesize**

PROCEDURES

1. Explain to students that they will be investigating an ecotone. An ecotone is an area where two ecosystems meet and interact. It encompasses all organisms as well as inorganic (non-living) substances such as water, rocks, etc. The area of overlapping ecosystems tends to be more complex and diverse than the ecosystem, itself. Animals common to both ecosystems are brought together. Even though they may not be seen, there are clues such as tracks, dropping and feathers to indicate the animals' presence.
2. Have the students formulate a hypothesis based on the information provided. For example, the hypothesis might be that the ecotone will have more diversity than the ecosystem, itself.
3. Decide on a site. The riparian area on the edge of a forest or two mini ecosystems on the school grounds are examples of sites for students to examine.
4. Have students work in two groups. Have one group study a ten foot area in one ecosystem and the other group will examine the other ecosystem (ten feet). Have students list different plants and animals (or evidence of) they observe and tally what they find. Have them include rocks and other non-living items found.
5. Ask students to discuss differences and similarities of the different ecosystems.
6. Next ask them to examine and study the overlap of the two ecosystems. Have them list the plants, animals and non-living items they observe and any indirect evidence of animals there.
7. Have students compare the diversity of plants and animals they find in the ecotone and compare to the diversity they identified in the two separate ecosystems.
8. Have students interpret their findings. Instruct them to confirm or deny hypothesis and present findings.

EXTENSIONS

1. Have students identify additional ecotones and explore the habitats.
2. Have students identify wildlife that travels through different ecotones. Instruct students to write a story about the animal and its experiences.

RESOURCES

Samples, Bob, *Project Wild Aquatic Education Activity Guide*, 1992, Council for Environmental Education, Gaithersburg, MD 20878.

GLOSSARY

diversity - variety or multiformity
ecosytem - an ecological community together with its environment, functioning as a unit
ecotone - a transitional zone between two communities containing the characteristic species of each
hypothesis - a tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation
hypothesize - to believe especially on uncertain or tentative grounds

Ecosystem/Ecotone Study Sheet

1. Describe your surroundings.

2. Is there any running water (stream, river) or standing water (pond, lake, wetland) in your ecosystem?

3. What type of plant life exists in your ecosystem? Are there trees? Are they coniferous or deciduous? Are they large, grow together, or by itself? Describe and try to identify plant life in your ecosystem.

4. Do you see or hear of any signs of wildlife, or any other animals?

5. Are there any other organisms or evidence of (insects)?

6. How does the ecosystem # 2 compare to ecosystem #1?

7. Repeat questions # 1 – 6, for ecotone (edge of two ecosystems) and compare results.

Lesson 12

Plant Concerns

What is an endangered plant species in Connecticut?
Why is it endangered?
What can be done to protect it?

GOAL To understand that the loss of plants results in a threat to the biodiversity of the watershed

OBJECTIVES Students will:

- ✓ identify a threatened or endangered plant in Connecticut
- ✓ use web site to conduct research on plant species
- ✓ conduct presentation on plant
- ✓ create plant mural
- ✓ conduct mini-biodiversity study

MATERIALS **poster board or butcher block paper, paper, pencils, clipboards, plant field guides, markers or colored pencils, string, flag markers for five groups, measuring tape**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(1,2,4)**
- **Science 1(1,2,6), 5(1-3), 6(4), 8(3,6)**
- **Social Studies 9(1-3), 10(1,3,4), 11(1), 12(5)**
- **Arts 1(2), 4(1,2) 6(3)**

VOCABULARY **threatened, endangered, extirpated, biodiversity, quadrant**

PROCEDURES

1. Begin lesson by asking students to define terms, “threatened”, “endangered,” and “special concern” in reference to plants.
2. Explain that there are endangered plants as well as endangered wildlife. Some plants in Connecticut are extirpated. (*no longer exist; destroyed*) Discuss meaning.
3. Break up class into five smaller groups. Have students identify plants that are endangered, etc. Instruct students to find www.dep.state.ct.us/cgnhs/species, click on plants and scroll down to preview plant species.
4. Have students conduct research on the following plants:
   a. basil mountain mint (*Pycnanthemum clinopodioides*), virginia copperleaf (*Acalypha virginica*), slender mountain rice (*Oryzopsis pungens*), sedge (*Carex bushii*) and purple giant hyssop (*Agastache soropnulaniifolia*).

5. Have students answer the following questions. List on board.
   a. Is this plant species endangered, threatened or of special concern?
   b. What type of habitat requirements does it need?
   c. How can you identify plant? What are some of its characteristics?
   d. Why is it endangered, threatened or of special concern?
   e. Find species in the Farmington River Watershed?

6. Have students draw their plant and present findings to class. Have them combine plants pictures and create a mural for the class.
7. After presentations are completed, have groups go outside and conduct a mini-biodiversity study. Explain that they will select random sites and measure ten by ten feet quadrats or areas.
8. Have students use measuring tape, flag markers (or sticks) and string to establish quadrats.
9. After measuring ten by ten feet areas, have students place four flag markers in corners. Attach and tie string to flags and connect to all four to establish boundaries.
10. Have students conduct studies by the stream (floodplain), in the forest or in the schoolyard. Have them identify and count the plants and species within the quadrant.
11. After they complete the project, have students tally data and determine level of biodiversity in area.

EXTENSIONS

1. Have students find www.frwa.org. Have students click on programs and then biodiversity study. Have students read about Farmington River Watershed Association's Farmington Valley Biodiversity Project.
2. A rare plant species was found in an area that is being developed. Have students determine what can be done (if anything) to protect the plant within the confines of the law.

GLOSSARY

biodiversity - the number and variety of organisms found within a specified geographic region
endangered - to be threatened with extinction
extirpated - eradicated; root out; destroyed; exterminated; annihilated; extinguished
quadrant - one of the four parts into which a plane is divided by the coordinate axes; the upper right-hand part is the first quadrant, the upper left-hand part the second; the lower left-hand the third, and the lower right-hand part the fourth quadrant
threatened - to express a threat against

Lesson 13

Endangered Wildlife

How does endangered wildlife impact food chains and food webs in an ecosystem?
What are examples of endangered wildlife in Connecticut?
Why are wildlife endangered and what can be done to protect them?

GOAL To understand that habitat loss and other factors effect wildlife potentially resulting in a threatened or endangered species

OBJECTIVES Students will:

- ✓ research an endangered wildlife in Connecticut
- ✓ examine why it became endangered
- ✓ design a presentation
- ✓ create a food chain and a food web

MATERIALS **paper, pencils, poster board or butcher block paper, crayons, markers**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(1,2,4)**
- **Science 1(1,2,6), 5(1-3), 6(4), 8(3,6)**
- **Social Studies 9(1-3), 10(1,3,4) 11(1), 12(5)**
- **Arts 1(2), 4(1,2) 6(3)**

VOCABULARY **food chain, food web, habitat destruction**

PROCEDURES

1. Discuss endangered species with students. Ask if they are familiar with any particular species. Inquire if they are familiar with any endangered animal that lives in Connecticut. Explain that one of the reasons animals become threatened or endangered is because of habitat destruction.
2. Discuss how animal habitats are destroyed. (*development, natural disasters*)
3. Break up students into smaller groups.
4. Instruct student groups to identify an endangered animal in Connecticut. Have students go to www.dep.state.ct.us/burnatr/wildlife/pdf.htm and choose an animal that is listed on the website.
5. Have student groups research information and answer questions that follow regarding the particular animal. List questions on board.
   a. What are the habitat requirements of this endangered animal?
   b. What are its physical features? (size, length, color, etc.)
   c. What is the history of the animal in this region?
   d. Why is it endangered?
   e. What measures are being taken to reintroduce and protect this animal?
   f. Is there any other interesting information about this animal?
   g. In what region or habitats of Farmington River Watershed can this animal live?

6. Have students create a food chain and food web on the food requirement needs of the animal.
   a. Have them write the name of the animal in the center of a poster board.
   b. On a separate piece of paper, have students list a possible food chain with the endangered animal chosen.
   c. Then, have students add to the list to create a food web. Have students connect words with arrows.
7. Have groups present all information to class.
8. Have students write a story from the animal's perspective about a "typical" day of the endangered wildlife chosen.

EXTENSIONS

1. Have students research laws surrounding endangered animals. Have them write letters supporting habitat restoration and protection to their representatives.
2. Have students go on a wildlife exploration. Have them choose an area to examine the wildlife and use binoculars to observe birds and other animals far away.
3. Have students write why diversity in the watershed is important to its health. Have students explain the term biodiversity.

GLOSSARY

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
habitat destruction - the area or environment where an organism or ecological community normally lives or occurs where the main cause of habitat destruction is the rise of human population; types of habitat destruction include complete loss of an area by wild species, degradation and fragmentation

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

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 **macroinvertebrate, 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. 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 and on CD*) 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 an 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

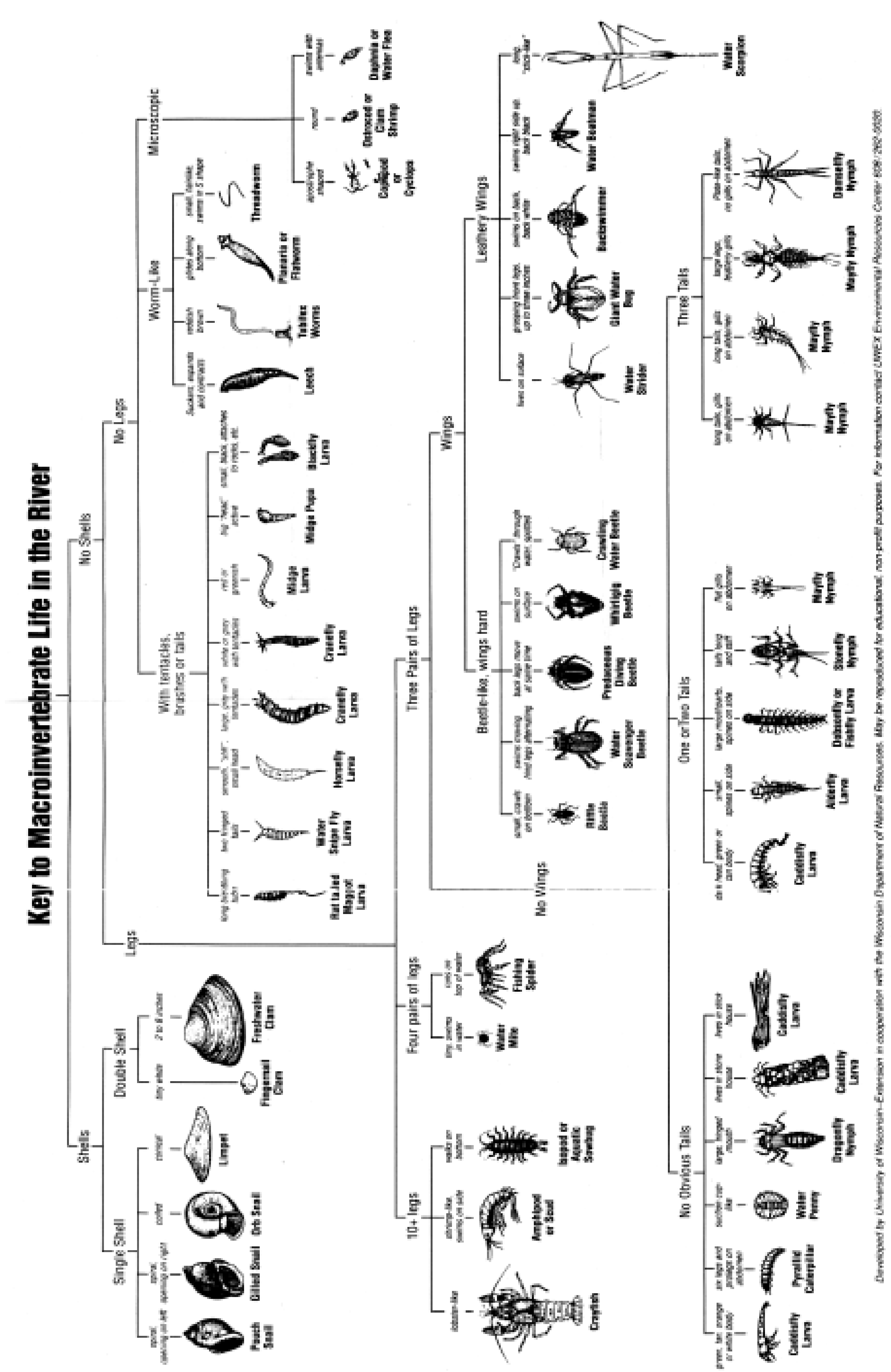
Edelstein, Karen, *Pond and Stream Safari: A Guide to the Ecology of Aquatic Invertebrates*, 1993, Cornell University Media Services.
Etgen, John, *Healthy Water, Healthy People, Water Quality Educators Guide*, 2003, The Watercourse, Bozeman, Montana 59717 - 0575

GLOSSARY

biotic index - an index of or having to do with life or living organisms
benthic - organisms living on or in river, sea or lake bottoms
identify - to ascertain the origin, nature, or definitive characteristics of
macroinvertebrate - invertebrate animals (animals without a backbone) large enough to be seen without magification
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
Four pairs of legs
10+ legs
Three Pairs of Legs
Wings
No Wings
Leathery Wings
Beetle-like, wings hard
Three Tails
One or Two Tails
No Obvious Tails
Crayfish
Water Mite
Fishing Spider
Water Scorpion
Water Boatman
Backswimmer
Water Strider
Leech

Macroinvertebrate Data Sheet

Pollution Tolerance Index

Group 1 **<u>Very Intolerant</u>**	**Group 2** **<u>Intolerant</u>**	**Group 3** **<u>Tolerant</u>**	**Group 4** **<u>Very Tolerant</u>**
___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

Microscopic Organisms

How are microscopic organisms beneficial to a food chain and/or food web?
What are special adaptations that allow organisms to survive in a stream?

GOAL To understand that microscopic organisms have special adaptations that enable them to survive.

OBJECTIVES Students will:

- ✓ examine microscopic organisms with a magnifying lenses or pocket microscope.
- ✓ identify adaptations of organisms
- ✓ construct a food chain and a food web

MATERIALS **two gallon tanks, petri dishes, pocket microscopes or magnifying lenses, eyedroppers, paper, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Science 1(1,6), 3(3), 5(1-3), 7(5), 8(2,3)**
- **Social Studies 9(1-4), 10(1,3,4),11(5)**

VOCABULARY **microscopic, food chain, food web, producer, primary consumer, secondary consumer, tertiary consumer, herbivore, carnivore**

PROCEDURES

1. Have students collect samples of stream water, one or two gallons.
2. Explain that they will be examining microscopic plants and animals that live in the water and are essential to the food chain and food web.
3. Have students work in groups. Distribute equipment.
4. With an eyedropper, have students place a small amount of water in a petri dish.
5. Instruct students to examine a water droplet under hand lenses and pocket microscopes.
6. Tell them they can create sketches of the animals they observe. They may note how the animals look, move, and interact.
7. Explain that some of the microscopic plants include diatoms and can be food to tiny creatures such as mites, rotifers, protozoans, worms, and water bears. They may feed off of mosses, liverworts and other aquatic plants.
8. Have students try to identify some of the creatures seen under the microscopes. Have them determine its role in the food chain. Is it a predator, prey or both?
9. Return water to stream when finished with observations.

10. Discuss with students that animals and plants that inhabit the stream have certain adaptations that help it survive. Many begin their life cycle in the water and end in the air and land, such as dragonflies, mayflies and stoneflies. Discuss the following adaptations with the students.
    a. Snails scrape algae off rocks with tongue-like organs called radulae.
    b. Some of the insects have suction-cup feet that attach to rocks, especially adapted to fast, flowing streams (black fly larva).
    c. Some of the larva or nymphs are streamlined and can swim upstream more easily (mayfly nymph, water penny larva, black fly larva).
    d. Some of the larva drink in the water and filter out detritus or decaying plant material (caddisfly larva, crayfish, aquatic sowbug).
    e. Some insects feed on other insects or other animals (dragon fly nymph, dobsonfly larva, water strider, giant water bug).
    f. Some have big jaws to capture prey (dragonfly nymph, damselfly nymph, dodsonfly nymph).
    g. Some of the insects fill up with water and expel it to swim across the water (dragonfly nymph).
    h. Some make their houses out of sticks and rocks to weigh them down in the stream and to ward off predators (caddisfly nymph).
11. Have students create a list of adaptations and aquatic insects. Include the microscopic plants and animals. Have student groups create and draw a food chain and food web based on their adaptations. Have them determine which animals are plant eaters (herbivores or primary consumers), and which ones are meat eaters (carnivores or secondary consumers), and which one are at the top of the food chain (tertiary consumers).

EXTENSIONS

1. Have students design a predator/prey activity.

RESOURCES

Edelstein, Karen, *Pond and Stream Safari: A Guide to the Ecology of Aquatic Invertebrates*, 1993, Cornell University Media Services.

Samples, Bob, Project Wild Aquatic: Education Activity Guide, 1992, Council for Environmental Edcuation, Gaithersburg, Maryland 20878.

GLOSSARY

carnivore - any various predatory, flesh eating organism; a predator
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
herbivore - an animal that feeds chiefly on plants
microscopic - too small to be seen by the unaided eye but large enough to be studied under a microscope
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

FRWA Curriculum Guide

Week IV - High 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 in 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 were located there when English settlers arrived in the 1600's. In Simsbury, the meadows that line the river were planted by the Indians 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 moved to other areas, such as plantations in Simsbury (known as Massaco) and at Tunxis (known now as Farmington). They depended on river for food. They planted crops and used 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 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 Wampanoags.

In New Hartford, the name of "Satan's Kingdom" comes from the lawlessness of the local population, as it was inhabited by prisoners and exiles. 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. The1955 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 Farmington 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

Clues to the Past

What clues do land formations provide to the past?
What are indicators of pre-glacial activity in the Farmington River Watershed?
What are indicators of glacial activity in the Farmington River Watershed?

GOAL To simulate a canoe trip down the Farmington River to the mouth of the CT River citing geological and historical features.

OBJECTIVES Students will:

- ✓ read a narrative that provides clues to the past
- ✓ identify land formations that demonstrate particular times
- ✓ follow the Farmington River to the mouth of the Connecticut

MATERIALS **copies of narrative, pencils, paper for writing answers, background information sheet**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(3), 2(1,2,4)**
- **Science 3(3), 6(1,3), 7(1,4,5), 8(4), 12(6)**
- **Social Studies 3(3,6,7), 9(1-5), 10(1-4),11(1,5)**

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

PROCEDURES

1. Begin by explaining that they will be taking a (simulated) journey down the Farmington River to the Connecticut River. They will be riding in a canoe that will take them through rapids, riffles and pools of water.
2. Ask if any of the students have had an opportunity to paddle in a canoe. Have them recount their experiences.
3. Explain that during their simulated canoe trip, they will “see” clues to a past time frame. Each clue will correspond to a time period. It might be during pre- glacial times, the result of glacial activity, Native American times, or Colonial Period/Industrialism.
4. Explain that the clues to the past are numbered in the narrative. Have students try to determine what time period the clues indicate. (They may refer to background student information sheet at end of lesson).
5. Have students read the “Journey Down the Farmington” scenario (end of lesson):

6. Have students research a particular geological phenomenon or historical time period and describe to class.
7. If possible, visit an area of the Farmington River that has historical significance. Conduct a walk through a historical area of a town, or visit a geological formation, such as the Talcott Mountain.

EXTENSIONS

1. Take a canoe trip down a particular area of the Farmington River (with an adult's permission).
2. Research the history of your town and note any historical areas. Create a simulated tour of the area and present to class.

RESOURCES

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
fault - a dislocation caused by a slipping of rock masses along a plane of fracture; also the dislocated structure 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 reaches 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 and mountains
talus slide - sloping mass of rock debris at the base of a cliff

Journey Down the Farmington

You will begin your journey in Otis, Massachusetts and continue along this stretch to Colebrook, CT. Winding through woods and fields, you will enter the most rigorous stretch of the Farmington River. The river twists and turns through rapids and you will narrowly avoid (1) big boulders and ledges. (2) White streaks of magma protrude from the steep rocks. After ending this segment of the river, you will enter the area designated as the "Wild and Scenic" Section of the River. This is a 14 mile stretch of the Farmington River from the bottom of the Goodwin Dam in Hartland to New Hartford. Receiving federal protection from dams, bridges, hydroelectric facilities that can negatively impact the flow of the river, the distinction is awarded to outstanding rivers for their beauty and wildlife.

Your canoe will flow through two state forests with large hills that are made of (3) Precambrian rock. Further down, you will notice remnants of abandoned (4) water powered mills, that were one time bustling as (5) iron, paper, cloth or wood furniture factories.

Paddling through Satan's Kingdom section of the river, you will travel through rapids to a gorge. Careful that you do not capsize! (6) Mountains seemed like they could block water flow, but water was able to pass through the gorge to create the rapids. Below the falls, you will get a glimpse of (7) Indian Hill and an area of bedrock called (8) fishing rocks.

Once past this area, you will travel through a few rapids and then be able to sit back and relax as you travel through Canton, Avon, Burlington and Farmington. You will notice (9) huge gravel pits used for construction material. Long stretches of slack water provide the perfect time for fishing! (10) The river turns north away from the Pequabuck as you head towards Simsbury.

You will pass remnants of an (11) aqueduct in Farmington and the Talcott Mountain in Simsbury is seen in the distance.(12) Huge accumulations of the rock debris can be seen at the foot of the cliffs. This easy flow of the section of the river provides an excellent opportunity to take in the wildlife, floodplains and meadows along the river.

The last section of the river brings you to the (13) Tariffville Gorge, a gap in the Talcott Mountain and a dangerous section of the river with big drops and rapids. Hold on!

After this section, you will pass an old (14) 250 foot dam that powered water wheels that connected to electric generators. Going through Windsor, you will pass (15)old textile manufacturing mills. The end of the Farmington River is marked by an island just past Loomis Chaffee School. At this point, you will enter the Connecticut River, which is around 400 feet wide. Your 81 mile journey has ended.

Background Information Sheet
Geology and History of land

Pre-glacial

- **Otis, MA to Barkhamsted,CT**
- **Steep ridges with white streaks of molten rock (produced by collision, noted below)**
- **Farmington River flowed into Quinnipiac River, New Haven**
- **Crystalline uplands (Berkshires south to northwestern CT) ranges in age from 800 to 424 million years old**
- **Precambrian rock – one billion year old rock (Cameron line, a fault joining 500 million year old rock of pre-Atlantic Ocean floor, collision occurred 400 million yrs ago)**
- **Talcott Mountain Ridge – divides the valley floors of Farmington and CT Rivers – ridge a result of molten rock solidifying and tilting because of a fault (a break in the earth's crust)**
- **Mountains at Satan's Kingdom blocked water flow, creating a lake extending northwest**

Result of glacial activity

- **Big boulders and ledges**
- **Wedged-shaped deposit of glacial debris, slowed the Farmington's flow to south, causing it to turn north**
- **Lake formed as a result of wedge**
- **Huge sand and gravel pits formed because of retreating glacier**
- **White silicon-rich sand eroded from Crystalline Uplands**
- **Other sand pits are reddish, erosion from iron-rich sandstone to the east and northeast**
- **Lake grew in size until it reached Tariffville – able to top ridge and cut a gorge that enables Farmington to flow into CT River**
- **Talus slides (huge accumulations of rock debris)**
- **Old glacial lake – alluvial deposits (Windsor)**

Native American Times

- **Virgin pines grew in Hartland to New Hartford**
- **Indian Hill – 20 wigwams, Tunxis Indians (New Hartford to Collinsville)**
- **Indian Fishing Rocks (bedrock steps where Indians speared fish)**
- **Northerly bend of river – Tunxis Indians located**
- **Meadows lining river in Simsbury planted by Massaco Indians**
- **Salmon in river; no dams**
- **Larger trees, no pastures, mostly woods**
- **Clear, rocky river**
- **Wildlife, such as beaver, fox, deer, moose, different species of birds thrived**

Colonial/Industrialism

- **Otis, MA to Barkhamsted – iron industry**
- **Hartland to New Hartford – remnants of water powered industry (Hitchcock Chair Co., Ward's Paper Co., Wilcox Puddling Mill - iron purification)**
- **Virgin pines used for ship masts English navy ("Mast Swamp")**
- **Bridge in Satan's Kingtom section – marched across by soldiers on way to Boston**
- **Collin's Company (tool and axe co.)**
- **Farmington Canal – 1825 – 1847**
- **Remnants of dam washed away during 1955 flood – dam built in 1800's**
- **Cowles Manufacturing Co. – power wheel**
- **River Mills near Windsor – manufacturing, three electricity plants (dam remnants)**
- **River becoming polluted**
- **Fenced pastureland**
- **Farmlands – trees clear cut**
- **Beaver and other animals hunted for pelts, decline in populations**

Lesson 17

Drawing from the Past

How did the watershed appear in different time periods?
What are indicators of glacial activity in the Farmington River Watershed?
How can watershed alterations be depicted?

GOAL To understand that the watershed appeared differently throughout its history

OBJECTIVES Students will:
- ✓ draw a map of how the land appeared in different time periods
- ✓ identify geological changes to the watershed

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

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(2,4)**
- **Science 6(3,4), 7(1,4,5), 8(2-4, 6), 14(3)**
- **Social Studies 3(3,6,7), 9(1-5), 10(1-6), 11(1,4-6), 12(1-3), 13(1)**
- **Arts 1(1-3), 3(1), 4(1-3), 6(1)**

VOCABULARY **glacial**

PROCEDURES

1. Begin by passing out copies of the Farmington River Watershed map. In lesson 16, students were able to follow the Farmington to the Connecticut River and they gained insight into aspects of how the land formed and appeared during other times of history.
2. Instruct students to imagine that they have gone back to the different time periods. Ask them how they think the land changed.
3. Break students up into four groups. Each team will be responsible for depicting a time period. The times noted are pre-glacial, post glacial activity, Native American times, Colonial/Industrialism.
4. Distribute a large piece of butcher block paper and markers to each group. Have them draw the Farmington River (in blue) as it appeared during the time period they are given (*difference will be during pre-glacial time, river flows south to New Haven area)*
5. Continue drawing aspects of the time periods according to how students envision the land. (Forests/farmlands in green, build up areas in gray).
6. Present to class.
7. Discuss what they the land might be like in the future. Have students draw their visions.

EXTENSIONS

1. Have students contact historical society or other organization to view historical maps or other interesting historical documents.

GLOSSARY

glacial - having to do with a huge mass of ice slowing flowing over a land mass, formed from compacted snow in an area where snow accumulation exceeds melting

Lesson 18

Drawing on the Present

How does the land appear in different areas of the watershed?
What are geological phenomenon's in the watershed?
How can watershed alterations be depicted?

GOAL To understand that the geology of the Farmington River appears differently throughout the watershed.

OBJECTIVES Students will:

- ✓ draw a cross section of how the geology of the land appears in different areas of the watershed
- ✓ identify geological changes to the watershed
- ✓ research geological phenomenon and their affect on water storage capabilities

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

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 2(2,4)**
- **Science 6(3,4), 7(1,4,5), 8(2-4, 6), 14(3)**
- **Social Studies 3(3,6,7), 9(1-5), 10(1-6), 11(1,4-6), 12(1-3), 13(1)**
- **Arts 1(1-3), 3(1), 4(1-3), 6(1)**

VOCABULARY **glacial, ridge, basalt, lava, fault, talus slide, boulder0, Precambrian rock**

PROCEDURES

1. Begin by passing out copies of the Farmington River Watershed map. As previously noted, students were able to follow the Farmington to the Connecticut River. After the simulated canoe trip and drawing on the past activity, they gained insight into aspects of how the land formed and appeared during other times of history.
2. Instruct students to imagine that they are following the Farmington River as it appears today. Ask them how they think the geology of the land appears along the different sections of the river. Have students imagine the geology of the land above the surface and below the surface of the land.
3. Break students up into four groups. Each team will be responsible for depicting the geology of an area along the river. Have students think about a cross section of the river and choose a section of the river from Becket, MA to Windsor, CT.
4. Before drawing aspects of the river, have students research Farmington River geology for their particular section. Examples might include alluvial floodplains, talus slopes, trap rock ridges, steep ridges and ledges, Precambrian rock, stratified drift, etc.
5. Have students discuss findings of research within group.

6. Distribute a large piece of butcher block paper and markers to each group. Have them draw a cross section of the Farmington River depicting the area above and below the surface of the land.
7. If alternate materials are available, have students create models from re-used materials or clay.
8. Have student groups discuss how the geological formations affect water storage. Have them discuss with rest of the group.
9. Have student groups present to class.

EXTENSIONS

1. Have students visit areas of the Farmington River watershed that demonstrate different geological formations.

Background Information

Becket, Ma to Pleasant Valley, CT – steep ridges, boulders, ridges, ledges, rough waters

Pleasantvalley, CT to New Hartford, CT – widens, islands form and re-form as river moves sediment

Unionville to Tariffville - accumulation of sand, gravel and silt; debris left by melting glacier plugged the course forcing an abrupt change in a northerly direction at the river's southern most point in Farmington.

Farmington to Avon, Tariffville – a great lake grew in size; toppped the ridge and cut a gorge permitting the Farmington to flow into the Connecticut River. Bedrock material changes to sedimentary rock, such as red sandstone (in Avon and Tariffville); alluvial floodplains

Avon to Simsbury – large faults tilted as a result of lava flows, leaving edges visible as north/south ridges, A trap rock ridge, Talcott Mountain is most prominent result of tilted lava flows; stratified drift

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
fault - a dislocation caused by a slipping of rock masses along a plane of fracture; also the dislocated structure 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 reaches 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, compris ing most of the earth's history and marked by the appearance of primitive forms of life
ridge - a long, narrow area of hills and mountains
talus slide - sloping mass of rock debris at the base of a cliff

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(1,5), 2(1,3,4)**
- **Science 8(2,6), 14(1-3)**
- **Social Studies 1(4(, 2(2,3), 3(7), 9(1-5), 11(1,3,4), 12(3), 13(2,4)**

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 waterwat 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

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

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 (letter at end of lesson). 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.
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 settler 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

FRWA Curriculum Guide

Week V - High 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 the 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 conducted 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 do 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

- **Math 1(1,2), 2(2,3)**
- **Science 1(1-6), 3(4), 5(3), 7(1,5-7), 8(2-4,6), 14(1,2,7)**
- **Social Studies 9(1-3), 10(1-4,6), 11(1,5), 12(1-3,5)**

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 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

Riffle – shallow areas with fast, running water over rocks Pool – deep area with slow water Run – deep area with fast water

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 ("wood is good")?

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

- **Math 1(1,2), 2(2,3)**
- **Science 1(1-6), 3(4), 5(3), 7(1,5-7), 8(2-4,6), 14(1,2,7)**
- **Social Studies 9(1-3), 10(1-4,6), 11(1,5), 12(1-3,5)**

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** – 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
   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 greater than 7; having a relatively low concentration of hydrogen ions
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 in use 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

Development Debate

How does planning and zoning decide land development use?
How does analyzing a problem from different perspectives help?

GOAL To compare and contrast lifestyles of the colonists and Native Americans

OBJECTIVES Students will:
- ✓ read Riverway story
- ✓ analyze problem from different perspectives
- ✓ provide alternatives

MATERIALS **Riverway study, paper, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(13), 2(2,4), 3(3)**
- **Science 1(1,2,5,6), 6(4), 7(5,6,7), 8(2-4,6), 14(1)**
- **Social Studies 3(5), 6(3-5), 8(3), 9(5), 11(1,4), 12(3,5)13(2,4)**

VOCABULARY **planning and zoning, bordering, vernal pool, protection**

PROCEDURES

1. Explain to students that they will be taking part in a planning and zoning meeting. The topic concerns a proposal for a new development. Instruct student groups that they will receive a role to play. They must stay with their assigned characters for the duration of the simulation.
2. Explain that the planning and zoning commissioner will run the meeting and at the end of the debate provide his/her recommendations to the council.
3. After the meeting, student groups will discuss how well they worked together.
4. Explain that the meeting concerns a town called Riverway. The narrative at the end of the lesson provides a synopsis.

GLOSSARY

bordering - the line or frontier area separating political divisions or geographic regions; a boundary
planning and zoning - a program, or method, or guided worked out beforehand for the accomplishment of an objective for an area or a region distinguished from adjacent parts by a distinctive feature or characteristic
protection - the act of defending
vernal pool - a contained basin depression lacking a permanent above ground outlet; in the northeast, it fills with water with the rising water table of fall and winter or with the meltwater and runoff of winter and spring snow and rain; some organisms such as salamanders, fairy shrimp and frogs are obligate vernal pool species, since they must use a veranl pool for various parts of their life cycle (http://www.vernalpool.org/vpinfo_1.htm)

Riverway

Riverway is a community that has enjoyed many years of little development. It has remained the same, except for the last several years. Situated on a river, the townspeople have enjoyed the fishing and beauty that it has offered to them. Acres of forestland surround the area and people from all over have hiked the many miles of trails.

Recently, it has become more populated and a scarcity of new homes has been a concern. Taking advantage of a business opportunity, a developer decided to purchase acres of land with one side of the land bordering a protected area. This section can not be developed.

Ideal woodland lots entice potential homeowners to the area and the developer is looking forward to beginning construction. The area is zoned residential. The site, itself, is located on a hill overlooking a panoramic view of the forest and river. Roads will need to be cut through the forest to reach the homeowner sites.

In the woodland, there are areas of land depressions that fill up with water during the spring (a type of wetland, known as vernal pools). Salamanders and frogs lay their eggs in these breeding areas. As the vernal pools dry up, the salamanders migrate to higher elevations on land. This type of habitat is essential to the salamander and other amphibians because it protects them from many predators, such as fish. The vernal pools border the site proposed. Also, the potential loss of this habitat will result in a decrease in the diversity of species in the area.

The Developer
The proposed site is perfect for development. It has a great view and with the scarcity of homes in this area, this development serves a need. The land is zoned residential and the developer is willing to work with the officials and people of the community.

The Environmentalist
Concerned with the proposed plan as it is; the land bordering the development is an important habitat to certain species' survival. Already, markers have been placed and it appears that the trees close to the vernal pool will be cut down. This will severely impact the ecology of the area. Also, with the river as close as it is, the sediment run off can be a potential problem.

The Farmers
Have a small farm in the community and sometimes, use the river to irrigate crops. Concerned that there will be a drain on resources in the community. Also, uneasy about potential runoff problems. However, as a small farmer and who sells produce to the locals, you are hoping that more people will purchase your produce.

The Planning and Zoning Commissioner
The land is zoned as residential, but there is concern about the drain on resources and town services. Houses are scarce and the commission wants new people to live in the town to bring more income and taxes to the town.

The Water Inspector
Responsible for ensuring that the water quality remains high. Since the river recharges the groundwater, you want to make sure that it is not contaminated with sediment.

Lesson 24

Unidentified Sources

What is the difference between point source pollution and non-point source pollution?
How can non-point source pollution be prevented from flowing into the waterways?

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

OBJECTIVES Students will:

- ✓ examine potential sources of non-point source pollution
- ✓ read “pollution” scenarios
- ✓ determine the source of “pollution”

MATERIALS **scenarios, paper, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Language Arts 1(13), 2(2,4), 3(3)**
- **Science 1(1,2,5,6), 6(4), 7(5,6,7), 8(2-4,6), 14(1)**
- **Social Studies 3(5), 6(3-5), 8(3), 9(5), 11(1,4), 12(3,5), 13(2,4)**

VOCABULARY **point source pollution, non-point source pollution, pollution, improper disposal, leakage, acid deposition, sediment, hazardous**

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 water-ways. Pollution can mix with the run-off and potentially seep into the soil, surface and ground waters.
4. Examples of non-point source pollution to be discussed with students:
   - **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 deple-tion 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. Have students read the following scenarios and determine potential sources of pollution in the waterway. Sources of pollution may be point or non-point source pollution.

a. The area in the watershed is not very developed. Woodland stretches over much of this area and covers the hills that rise up from the valley. The river meanders around forested land, farms and pastures. Several of the towns in this section have had increases in populations because of the desire to relocate to such a scenic area. When the river was last monitored, higher levels of turbidity were recorded. The amount of macroinvertebrates declined and a noticeable amount of sediment run-off in the stream was prevalent

Have students answer the following questions:

What can account for the changes in water quality and why?
What is happening in this section of the watershed?
What is happening in the town(s)?

b. The area is developing into a prosperous business district. Business entrepreneurs have created a hub of retail stores, restaurants, and theaters for the public to patronize. The new stores are situated in what was formerly known as the old warehouse district. Located on the river, patrons can enjoy the view of the boats from the renovated factories. Upstream from this center is an old sewage treatment plant and a state of the art trash to energy facility. When the water was last monitored, there was an increase in nitrates and phosphorous in the water as well as a lower pH, indicating increases in water acidity.

Ask students the following questions:

What can account for the changes in water quality and why?
What is happening in this area and what impact is it having on the watershed?
Is there more than one source of pollution?

EXTENSIONS

1. Simulate "polluting" a river or stream by filling up canisters with "sources of pollution". Have students pour water into a large plastic container. Then, have each student group "pollute" the waters with different items, such as green food coloring symbolizing fertilizer. Other examples consist of balsamic vinegar for oil, vegetable oil for pollution, mustard for factory wastes, sand for sediments, etc. Discuss when contaminants are thrown into the river the concentration is higher, when there is more than one polluter or type of 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 deposition - acidic pollutants that can be deposited from the atmosphere where industrial gas emissions combine with water
hazardous - a substance, such as an industrial byproduct, that is potentially damaging to the environment and harmful to humans and other living organisms
improper disposal - the act or process of getting rid of something and not conforming to legality, moral law or social convention
leakage - the unwanted discharge of a fluid from some container
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 polluntants; finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water
point source pollution - pollution from industrial and sewage treatment plants with an identifiable source
pollution - the state of being contaminated with harmful substances
sediment - fine soil or mineral particles, resulting from the run-off from the land, which either settle to the bottom of a water body or are suspended in the water

Lesson 25

Build Out Dilemma

How are towns planned regarding development?
How is build - out determined?
What is being done to protect open space areas?

GOAL To calculate development of a hypothetical town

OBJECTIVES Students will:
- ✓ calculate the amount of development
- ✓ determine open space

MATERIALS **calculator, paper, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1,2), 2(2,3)**
- **Science 1(1,2,5,6), 6(4), 7(5,6,7), 8(2-4,6), 14(1)**
- **Social Studies 3(5), 6(3-5), 8(3), 9(5), 11(1,4), 12(3,5), 13(2,4)**
- **Arts 1(1-3), 6(3)**

VOCABULARY **build-out, development, open space**

PROCEDURES

1. Begin by telling students they were asked by a town to develop a "build-out" plan. This is a plan to determine how much of the town can be developed. The following information is provided to the students regarding the town. Have them determine a final percentage. The information may be written on the board for students.
2. The town is rural in character, less than 10,000 in population. During the last five years, the town has seen a large increase in population. The growth is the result of the town's location. It is situated close to a pristine river, major urban areas and the schools have consistently shown high standards.
3. Break students up into groups. Begin by providing them with total acres of land. The town is spread out over 26,000 acres. Land that can not be developed includes 4,000 acres of open space land and 2,000 acres of wetlands (*Those figures are subtracted from the 26,000*). One fourth of the total land has already been developed with houses and commercial buildings. (*subtract ¼ or 6,500 acres*). Have students subtract 10% of subtracted figure (*26,000 – 4,000 – 2,000 -6,500 =* ***13,500*** *– 1,350 =* ***12,150***). Divide 12,150 by total amount (*26,000*) to calculate percentage (*46.7%*). This is the percentage amount left for development.

4. After groups complete their calculations, have them answer the following questions:
   a. What does the term, “build-out” mean?
   b. How will building-out the town affect town services such as schools, fire, water, sewage disposal, waste collection, etc.?
   c. What can be done to protect the river during and after construction?
   d. The open space land is undeveloped but not yet protected. It will need to be purchased or donated to be protected through a conservation easement (also known as a conservation restriction) which will retire the development rights on the property. How will this be managed by the conservation commission?
   e. Many of the houses will be constructed close to woodlands. The trees will be cut down for the development. The unprotected soil may result in runoff sediment into the river. What can the town planner do to protect the river?
5. Have groups discuss their answers.
6. If you were to look at the river bank from a side view, how would the town appear now and in the future? Illustrate how you think it will look.

EXTENSIONS

1. Have a town manager, planner or assistant town planner address these issues with the class.
2. How are rivers protected when towns are developed?
3. What measures are being taken to protect the Farmington River Watershed?

GLOSSARY

build-out - a glimpse at the possible future of a community when all land is developed to the maximum extent allowed under law
development - the act of making some area of land or water more profitable or productive or useful; such as a housing development
open space - land that remains in its natural space or is used for farming or forestry; a body of water or watercourse that remains in its natural state

FRWA Curriculum Guide

Week VI - High 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

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), 2(2), 4(1), 5(1)**
- **Science 3(4), 7(7), 8(2,3,6)**
- **Social Studies 11(1,4,5),12(3), 13(2,4)**

VOCABULARY **calculate, measurement**

PROCEDURES

1. Students will find how much water (in cups) they use/can conserve for daily activities.
2. Have them measure and calculate the amount of water they use for daily activities, such as washing their hands, brushing their teeth, showering, etc.
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) vs. stop faucet to soap or take 5 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 vs. how much saved.
7. Calculate how much each student's family uses vs. how much can be saved.

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 estimte of; evaluate
measurement - the extent, size, capacity, amount, or quantity ascertained by measuring or calculating; as its measurment is five acres

Lesson 27

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), 2(2), 4(1), 5(1)**
- **Science 3(4), 7(7), 8(2,3,6)**
- **Social Studies 11(1,4,5),12(3), 13(2,4)**

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 family's average shower?______

How many times is the toilet flushed every day?______

6. Bathroom Use

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

Toilet 5 gal (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 28

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

- **Math 1(1,2), 2(2), 4(1), 5(1)**
- **Science 3(4), 7(7), 8(2,3,6)**
- **Social Studies 11(1,4,5),12(3), 13(2,4)**

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 29

The Value of Water

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 **copies of water dollars, paper, scissors, pencils**

CORE CURRICULUM CONTENT STANDARDS

- **Math 1(1,2), 2(2), 4(1), 5(1)**
- **Science 3(4), 7(7), 8(2,3,6)**
- **Social Studies 11(1,4,5),12(3), 13(2,4)**

VOCABULARY **finite, conservation, consumption**

PROCEDURES

1. 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?
2. Explain that starting today and for 2 days they are going to have to examine how they use their water by paying for it.
3. Students will receive a chart with water use categories, amount in liters that is used, and the amount of water dollars required.
4. 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.
5. Have students cut out water dollars and write his or her name on the dollars.
6. They may make payments by placing dollars in a container labeled "Water Bank".
7. Instruct students to keep track by recording how they spent their dollars and mark it in a log.
8. 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 Watershed 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 utilization of economic goods or natural resources in the satisfaction of wants

finite - having bounds; limited

Lesson 3 – student sheet

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
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 needs

$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
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Lesson 30

Water Actions

What are ways to help protect your 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 3(4), 7(7), 8(2,3,6)**
- **Social Studies 11(1,4,5), 12(3), 13(2,4)**

VOCABULARY **organizations, 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

EXTENSIONS

1. Create a brochure for the watershed, highlighting the recreational aspects, such as canoeing, kayaking, fishing, etc.

GLOSSARY

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

Appendix A:

10th Grade Curriculum Content Standards

Language Arts

1-1 Students will describe the thoughts, opinions and questions that arise as they read, view or listen to a text, demonstrate a basic understanding of the text, and identify inconsistencies and ambiguities.

1-3 Students will demonstrate literary and aesthetic appreciation of the text, awareness of the author's style, understanding of textual features, and ability to challenge the text and think divergently.

1-5 Students will ask and answer their own and each other's text-related critical and analytical questions.

1-11 Students will entertain, explore and defend multiple interpretations of all fiction and nonfiction they read.

1-12 Students will apply collaborative skills to elaborate on concepts being addressed and to describe processes used in achieving results.

1-13 Students will describe theme, symbolism, tone and other complex elements of fiction, and identifying point of view, manipulative language and other elements of bias in nonfiction materials.

2-1 Students will select from the complete variety of text structures the appropriate organizational pattern for addressing audience, purpose and point of view.

2-2 Students will identify and use effectively the salient features of all appropriate oral, visual and written discourse.

2-3 Students will determine which primary and secondary sources are appropriate to the task and will integrate and elaborate upon information effectively in the final product.

2-4 Students will identify and use the most effective process for them to create and present a written, oral or visual piece.

3-3 Students will evaluate the language they use in written and oral tasks for its suitability for the audience being addressed.

4-4 Students will determine the various influences on authors and analyze the impact of those influences on the text.

Mathematics

1-1 Use real-life experiences, physical materials and technology to construct meanings for rational and irrational numbers, including integers, percents and roots.

1-2 Use number sense and the properties of various subsets of real numbers to solve real-world problems.

1-4 Select an appropriate form to represent and use numerical data as they arise from real-world situations involving magnitude, order, measures, labels, locations and scales.

2-1 Use arithmetic operations to solve problems encountered in everyday consumer situations.

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

2-3 Use appropriate methods for computing, including mental math, estimation, paper-and-pencil and calculator methods.

4-1 Understand and explain the need for proportions and percents.

5-1 Extend, apply and formalize understandings of measurement, including strategies for determining perimeters, areas and volumes, and the dimensionality relationships among them.

7-9 Use simulations to estimate probabilities.

10-1 Represent problem situations using finite graphs, matrices, sequences and recurrence relations.

Science

1-1 Gather and synthesize information concerning a problem.
1-2 Operate and revise hypotheses based upon empirical data and requirements of logical reasoning.
1-3 Interpret the results of experimentation using statistical reasoning.
1-4 Critique scientific experiments or research by seeking out possible sources of bias in the design and analysis of data.
1-5 Suggest alternative ways of explaining data and criticize arguments in which data, explanations or conclusions are represented as the only ones worthy of consideration.
1-6 Prepare and present oral and written scientific reports that communicate in a logical sequence the process, results and validity of scientific experiments and research.
3-1 Explain chemical bonds and metabolic processes, such as photosynthesis and cellular respiration, as the use of energy by organisms.
3-2 Explain that the distribution and abundance of organisms and populations in ecosystems are ultimately governed by the availability of matter and energy and the ability of the ecosystem to recycle organic materials.
3-3 Describe the movement of matter and energy through different levels of organizations of living systems and show how matter and energy are transformed and conserved.
3-4 Explain ways in which humans can minimize their impact on biomes.
5-1 Understand that the present diversity of life is a result of natural selection and other evolutionary processes that have been at work for long periods of time.
5-2 Explain how representative organisms in different phyla are able to maintain a stable internal environment.
5-3 Describe why diversity in a species is important for its survival in a changing environment.
6-3 Understand how fossil, anatomical, molecular and other observable forms of evidence provide support for the theory of natural selection.
6-4 Explain that preservation of the Earth's biological diversity is critical to the future of human beings and other living things.
7-1 Illustrate how the formation, weathering, sedimentation and reformation of rock constitute a continuing "rock cycle".
7-4 Describe how geological time can be determined using evidence from fossils, rock sequences and radiometric dating.
7-5 Interpret geological features within the community and state(e.g., road cuts, rivers, shorelines).
7-6 Explain interactions between the Earth's lithosphere, hydrosphere, atmosphere, and biosphere.
7-7 Analyze the costs, benefits, alternatives and consequences of natural resource exploration, development and consumption.
8-1 Recognize that the ocean is a complex system of important chemicals which cycle through other Earth systems over various periods of time.
8-2 Recognize that fresh water is limited in supply and can be depleted or polluted, becoming unavailable or unsuitable for life.
8-3 Explain interactions between water and other Earth's systems (e.g., the biosphere, lithosphere and atmosphere).
8-4 Recognize that water is an erosional force that can rapidly and slowly change the landscape.
8-6 Describe how the physical and chemical properties of water affect the environment and life.
9-7 Explain the impact on human activities of global phenomena, such as El Nino, global warming and the depletion of ozone in the atmosphere.
12-6 Understand that every object exerts gravitational force on every other object.
14-1 Analyze benefits and limit costs and consequences involved in using technology or resources.

14-2 Analyze how the introduction of new technology has affected or could affect human activity.
14-3 Recognize that technological innovations may produce unanticipated problems of their own.
14-4 Apply their knowledge and understanding of chemical and physical interactions to explain present and anticipated technologies.
14-5 Recognize that science and technology often develop faster than society can comprehend their ethical implications.
14-6 Explore the scientific and technological aspects of contemporary problems.
14-7 Understand that science strives to understand the natural world and seeks explanations for natural phenomena, while technology seeks solutions to human problems and needs.
14-8 Understand that science, mathematics and technology are interdependent human endeavors with strengths and limitations.

Social Studies

1-1 Formulate historical questions and hypotheses from multiple perspectives using multiple sources.
1-2 Gather, analyze and reconcile historical information, including contradictory data, from primary and secondary sources to support or reject hypotheses.
1-4 Evaluate data within the historical, social, political and economic context in which it was created, testing its credibility and evaluating its bias.
2-2 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.
2-3 Explain relationships among events and tends studies in local, national and world history.
3-3 Demonstrate an understanding of the ways that cultural experiences and the interaction of people of different cultures in pre-modern as well as modern times have shaped new identities and ways of life.
3-5 Describe, explain and analyze political, economic and social consequences that came about as the resolution of a conflict.
3-6 Demonstrate an understanding of the ways race, gender, ethnicity and class issues have affected individuals and societies in the past.
3-7 Analyze the causes and consequences of major technological turning points in history, e.g., their effects on people, societies and economies.
6-3 Establish, explain and apply criteria to evaluate rules and laws.
6-4 Monitor and influence the formation and implementation of policy through various forms of participation.
6-5 Take a position on a current policy issue and attempt to influence the formation, development and implementation.
9-1 Explain and describe the natural and cultural characteristics of one place to distinguish it from another.
9-2 Apply the concept of region to organize the study of a complex problem.
9-3 Explain that regions are interconnected and may also overlap.
9-4 Explain why places and regions are important to human and cultural identity and stand as symbols for unifying society.
9-5 Analyze ways different groups in society view places and regions differently.
10-1 Describe regional variations of physical processes.
10-2 Explain the operation and interaction of different natural systems (such as climate and oceans) to understand global change.
10-3 Analyze the distribution of ecosystems by interpreting relationships between soil and climate, and plant and animal life.
10-4 Evaluate ecosystems in terms of biodiversity and productivity and show how they are dynamic and interactive.
10-6 Use geographic tools to represent and interpret Earth’s physical and human systems.

11-1 Describe the consequences of human population patterns and growth trends over time.
11-2 Explain the characteristics, distribution and relationships of economic systems at various levels.
11-3 Explain and analyze how various populations and economic elements interact and influence the spatial patterns of settlement.
11-4 Explain and analyze the causes of change in the political, social and economic division of the Earth's surface at different scales.
11-5 Use geographic tools to represent and interpret Earth's physical and human systems.
11-6 Draw a freehand map demonstrating political, cultural or economic relationships.
12-1 Use maps, globes, charts and databases to analyze and suggest solutions to real-world problems.
12-2 Create appropriate maps and other tools to solve, illustrate or answer geographic problems.
12-3 Analyze how human systems interact, connect and cause changes in physical systems.
12-5 Apply concepts of ecosystems to understand and solve environmental problems.
13-1 Compare the resources used by various cultures, countries and/or regions throughout the world.
13-2 Analyze the impact of economic choices on the allocation of scarce resources.
13-4 Define, defend and predict how the use of specific resources may impact the future.
13-5 Analyze how technological change can affect long range productivity.

Arts

1-1 Apply media, techniques, and processes with sufficient skill, confidence and sensitivity that their intentions will be realized.
1-2 Conceive and create original works of art that demonstrate a connection between personal expression and the intentional use of art materials, techniques and processes.
1-3 Communicate ideas consistently at a high level of effectiveness in at least one visual arts medium.
2-1 Judge the effectiveness of different ways of using visual characteristics in conveying ideas.
3-1 Use, record and develop ideas for content over time.
4-1 Analyze and interpret artworks in terms of form, cultural and historical context and purpose.
4-2 Analyze common characteristics of visual arts evident across time and among cultural/ethical groups to formulate analyses, evaluations and interpretations of meaning.
4-3 Compare works of art to one another in terms of history, aesthetics and culture, justifying conclusions made in the analysis and using these conclusions to inform their own art making.
6-3 Create and solve interdisciplinary problems using multimedia.

New Science Standards

HSI.3 Energy Resources: How can we meet global Energy Needs?
Current fuel resources are limited and renewable energy sources should be explored.

HSII.3 The Environment: How can we sustain its health?
The environment becomes degraded due to the increased consumption of natural resources and use of synthetic materials.

HSVI.2 Earth History: How and what can we learn from it?
Interactions among the solid Earth, the oceans, the atmosphere and organisms have resulted in the ongoing evolution of the Earth system.

APPENDIX B:
GLOSSARY

abiotic - nonliving
abutment - the part of a structure that beats the weight or pressure of an arch; a structure that supports the end of a bridge
acid deposition - acidic pollutants that can be deposited from the atmosphere to the Earth’s surface in wet and dry forms
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
alkaline - having a pH greater than 7; having a relatively low concentration of hydrogen ions
alluvial - relating to the deposits made by flowing water; washed away from one place and deposited in another; as, alluvial soil, mud, accumulations, deposits
aquifer - an underground layer of earth, gravel, or porous stone that yields water
anadromous - migrating up rivers from the sea to breed in fresh water
basalt - a rock of igneous origin
bedrock - the solid rock that underlies loose material, such as soil, sand, clay, or gravel; solid unweathered rock lying beneath surface deposits of soil
benthic - organisms living on or in river, sea or lake bottoms
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/bordering - 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
build-out - a glimpse at the possible future of a community when all land is developed to the maximum extent allowed under law
calculate - to make an estimate of; evaluate
canal - an artificial waterway or artificially improved waterway used for travel, shipping or irrigation
carnivore - any various, predatory, flesh eating organism; a predator
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
conservation - preservation or restoration from loss, damage, or neglect
conserve - to protect from loss or harm; preserve
consumption - the utilization of economic goods or natural resources in the satisfaction of wants
curve number - number on a line representign data on a graph
development - the act of making some area of land or water more profitable or productive or useful; such as a housing development
dissolved oxygen - measurement of oxygen that is passed into a solution or water
diversity - variety or multiformity
dam - a barrier constructed across a waterway to control the flow or raise the level of water
ecosystem - an ecological community together with its environment, functioning as a unit
ecotone - a transitional zone between two communities containing the characteristic species of both
endangered - to be threatened with extinction
effluent - an outflow from a sewer or sewage system

electricity - electric current used or regarded as a source of power
extirpated - eradicated; root out; detroyed; exterminated; annihilated; extinguished
fault - a dislocation caused by a slipping of rock masses along a plane of fracture; also the dislocated structure resulting from such slipping
finite - having bounds; limited
flatwater - of or on a level or slow-moving watercourse
floodplain - a plain bordering a river and subject to flooding
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
generator - one that generates, especially a 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
gorge - a deep, narrow passage with steep rocky sides; a ravine
groundwater - water beneath the earth's surface, often between saturated soil and rock, that supplies wells and springs
habitat destruction - the area or environment where and organism or ecological community normally lives or occurs where the main cause of habitat destruction is the rise of human population; types of habitat destruction include complete loss of an area by wild species, degradation and fragmentation
hazardous - a substance, such as an industrial byproduct, that is potentially damaging to the environment and harmful to humans and other living organisms
herbivore - an animal that feeds chiefly on plants
hydroelectric - of or relating to or used in the production of electricity by waterpower
hydrogen - colorless, odorless gaseous chemical element
hydrologist - a scientist who studies the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere
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
hypothesis - a tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation
hypothesize - to believe especially on uncertain or tentative grounds
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
improper disposal - the act or process of getting rid of something and not conforming to legality, moral law, or social convention
infiltration - the act of permeating (a porous substance) with a liquid or gas
involvement - the act of engaging or including a participant
lava - the rock formed by the cooling and solidifying of molten rock that reaches Earth's surface though volcanic activity or fissure
leakage - the unwanted discharge of a fluid from some container
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 - invertebrate animal (animal without a backbone) large enough to be seen without magnification

magnify - to increase the apparent size of, especially by means of a lens
man-made - made by humans rather than occuring in nature; synthetic
map - a representation, usually on a plane surface, of a region or the earth or heavens
measurement - the extent, size, capacity, amount, or quantity ascertained by measuring or calculating, as its measurement is five acres
microscopic - too small to be seen by the unaided eye but large enough to be studied under a microscope
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
observation - the act of noting and recording something, such as a phenomenon, with instruments
open space - land that remains in its natural space or is used for farming or forestry; a body of water or watercourse that remains in its natural state
organization - 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
oxbow - a U-shaped bend in a river and the land within such a bend of a river
oxygen - colorless, odorless gaseous element belonging to group 16 of the periodic table; the most abundant element present in the Earth's crust; makes us 28% of the Earth's atmosphere
penetrate - to enter into and permeate
percolate - to cause (liquid, for example) to pass through a porous substance or small holes; filter
permeable - that which can be permeated or penetrated, especially by liquids or gases: permeable membranes, rock that is permeable by water
pervious - capable of penetrating or pervading
pH level - a measure of the acidity or alkalinity of a solution, numberically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity; the pH scale commonly in use ranges from 0 to 14
planning and zoning - a program, or method, or guided worked out beforehand for the accomplishment of an objective for an area or a region distinguished from adjacent parts by a distinctive feature or characteristic
point source pollution - pollution form industrial and sewage treatment plants with an identifiable source
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 Archean and Proterozoic eras, comprising most of the earth's history and marked by the appearance of primitive forms of life
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
protect - to keep from being damaged, attacked, stolen or injured; guard
protection - the act of defending
quadrant - one of the four parts into which a plane is divided by the coordinate axes; the upper right-hand part is the first quadrant; the upper left-hand part the second; the lower left-hand part the third and the lower right-hand part the fourth quadrant
recharging - water overflow from precipitation into surface and groundwater receptacles
recycle - to extract useful materials from garbage or waste; to extract and reuse useful substances found in waste
reflection - a thought or opinion resulted from careful consideration
reservoir - a natural or artificial pond or lake used for the storage and regulation of water

resource - something that can be used for support or help
ridge - a long, narrow area of hills and mountains
ridge lines - a long, narrow chain of hills and mountains
riffle - a shallow, gravelly area of a streambed with a swift current; used by spawning of trout and other fish
run - straight course of a river
run-off - rainfall not absorbed by soil
secondary consumer - an animal that feeds on smaller plant-eating animals in a food chain
sediment - fine soil or mineral particles, resulting from the run-off from the land, which either settle to the bottom of a water body or are suspended in the water
storm drain - a storm sewer
stratified drifts - having its substance arranged in strata, or layers; as in, stratified rock
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
threatened - to express a threat against
Triassic - of or belonging to the geologic time, system of rocks, or sedimentary deposits of the first period of the Mesozoic Era, characterized by the diversification of land life, the rise of dinosaurs, and the appearnce of the earliest mammals
tributary - river or stream flowing into a larger river or stream
velocity - rapidity or speed of motion; swiftness
vernal pool - a contained basin depression lacking a permanent above ground outlet; in the northeast, it fills with water with the rising water table of fall and winter or with the meltwater and runoff of winter and spring snow and rain; some organisms, such as salamanders, fairy shrimp and frogs are “obligate” vernal pool species, so called because they must use a vernal pool for various parts of their life cycle (http://www.vernalpool.org/vpinfo_1.htm)
water table - the level below which the ground is completely saturated with water; also called water level
water tips - helpful hints about preserving water
water usage - the act of using water

Celebrating 51 Years of Accomplishment
1953 - 2004

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