Water Resources

Geography & Geology

Ecosystems

Human History

Culture & Arts

The Catskills

A Sense of Place

Standards-based lessons that promote appreciation and stewardship of the unique natural and cultural resources of the Catskill Mountain region.

Module I: Water Resources of the Catskills

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Module I:
Water Resources of the Catskills

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State of the Arts
NYSCA

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Water Resources

The human body is about 70 % water, and water is essential to the processes of life. Even though most of the Earth's surface is covered with water, only a fraction of one percent is fit for human consumption. One focus of this program is to provide youth with information that will enable them to make informed decisions about regional resources. There are dozens of reasons why we should be concerned with water quality in the Catskills, not just for the sake of New York City's water supply. The water that the city drinks is the water upstate residents drink. Just like the 1.2 billion gallons of water per day that travel from the Catskill watersheds downhill to New York City, the water from your house, farm, business, or school has moved on to someone else's before you realize it. Many years ago, most people knew of the term *watershed*, but did not know much more about it than that. Today, with concern for the well-being of the environment on the rise, *watershed* is a commonplace word. Everywhere we stand, sit, or sleep is inside a watershed, and every action that humans take has an effect on it. Adverse actions fifty miles upstream from a drinking water supply will have detrimental effects downstream. Ask yourself who or what is upstream and downstream from you.

A component of this program, appropriately called *Streamwatch*, gives youth a chance to enjoy water in a more hands-on way than otherwise possible. These students get to enjoy (and monitor) the same Catskills streams that fly-fisherman have been bragging about for more than a century. One thing we have discovered while implementing the *Streamwatch* program is that kids enjoy water for many different reasons than adults do, but both age groups rely on clean, pure water to have their fun. These streams that most of us take for granted each day when we pass over or drive along them are some of the purest in the world. Let's help preserve the water quality and be proud of it.

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USING THIS BOOK

- Vocabulary words that are *italicized* throughout this module are later defined in the Glossary.

- Following each activity are listed NYS Learning Standards that are met by the activity. There is a good possibility that the activity may meet more standards than those listed. The number of the standard, its title, and the topic heading are written out. Some topic headings are divided into key ideas, and their numbers are listed where applicable.

ACKNOWLEDGEMENTS

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Introduction to Water

Water is a vital nutrient for our survival. All living things need water to survive. Human beings can live for only a few days without water, but we can live for weeks without food. In fact, some bacteria can even live without oxygen, yet they cannot survive without water. Water is essential for every system in the human body. The human body is 70% water, and water makes up 83% of our blood. Although water covers almost 80% of the Earth, 97% of that is salt water, which we cannot drink. In addition, glaciers hold about 2% of the Earth's water in glacial ice. Therefore, less than *1%* of all water on Earth is fresh water that humans can use -- making it an invaluable resource. Knowing more about water is an important first step in keeping water sources in the Catskill region free from contamination.

The Water Molecule

Atoms are the smallest particles of elements such as hydrogen and oxygen, and when atoms join together, they form molecules. The water *molecule* is made up of two hydrogen (H) atoms, and one oxygen (O) atom: giving us H_2O. Water is the most common *solvent* in nature. A *solvent* is a liquid with the ability to dissolve other substances. For example, water can dissolve the minerals found in our bodies. Pure water is colorless, tasteless, and odorless, and can occur in three states: solid, liquid, and gas.

- *Water as a solid* - When water freezes, it turns to ice. The molecules move farther apart, so ice is less dense than water and it floats. Water freezes at 0°C or 32°F.
- *Water as a liquid* - This is the state most familiar to us. We use water in many ways in its liquid form for washing, drinking, and as a solvent.
- *Water as a gas* - After liquid water evaporates, it becomes an invisible vapor. Water becomes a gas when it reaches 100°C or 212°F. In the atmosphere, the vapor *condenses* onto dust particles, and depending on the air temperature, it falls as either rain or snow.

The Water Cycle

The amount of water on Earth is finite. The *hydrologic cycle* or *water cycle* is how water is recycled on Earth. The sun heats up liquid water found in streams, ponds, lakes, and oceans, which then evaporates into the sky. This evaporated water can form clouds in the atmosphere and then return to Earth as precipitation. In what form the water drops to the ground, what it does when it hits the ground, and how the water evaporates back into the sky vary. When water falls on land, it can either seep into the ground or stay on the surface to become "runoff", such as in streams and rivers. Surface water in smaller streams eventually collects into larger streams, and then into basins such as ponds, lakes, reservoirs, or rivers.

Groundwater

Water that goes into (*infiltrates*) the ground is called *groundwater*. Groundwater is the Earth's underground supply of water. It moves (*percolates*) through the pores or spaces between soil particles at different speeds, depending upon soil type. For example, sandy, porous soil would have a very fast rate of percolation, while thick, clay-like soil would slow the movement of the water. If a polluting substance such as oil were released into the ground, the percolation rate of soil would determine how quickly the surrounding areas are contaminated. Additionally, in the Catskills, knowing the "perc" rate of soils is required for septic tank installation.

As water seeps into the ground, some of it clings to soil particles and plant roots near the surface. Plants draw in water from their roots to use when making food, a process called *photosynthesis*. Trees also use a tremendous amount of water -- they draw water in by their roots, transport it up their trunks, and then release water vapor from the underside of their leaves. This evaporation of water from the leaves is called *transpiration*. Forests in the Catskills are being studied right now to understand their effects on the quality and amount of water in the New York City Watershed.

Water percolating into the ground will eventually reach a zone of saturation called an *aquifer*. This level of water (commonly called the *water table*) rises or falls depending on precipitation and the amount withdrawn. The water table is what well drillers look for when drilling wells. Wells may be less than 100 feet or more than 700 feet deep, depending upon the level of the water table in a given area. If there were heavy precipitation for an extended period, the water table would be high. Similarly, a drought would lower the water table. The shape of the land surface (*topography*), soil porosity, depth to bedrock, and type of bedrock also influence the water table. In the Catskills, since glacial soils predominate, the depth of the water table varies significantly from one area to another. Springs form where groundwater comes to the surface.

Watersheds

A watershed divide marks the boundary between different basins of water collection. That invisible boundary is located at the tops of ridges and mountains and directs the flow of water into one basin or another. By studying these basins and the land use within them, one can make plans to keep the streams clean. Watersheds can be studied in different ways and on different scales. For example, using a cake pan and rocks covered with foil, students can make and study a miniature watershed. Or, on a much larger scale, students can study the Hudson River and all of its tributaries, including ponds, lakes, forests, farms, towns, and wetlands, as a collection of sub-basins or sub-watersheds.

To research a watershed, you must first determine the size of the basin to be studied and identify its boundaries. Then, gather information on the watershed, including all the physical, biological, geological, and social data that can be collected. By studying the current uses and the history of a watershed, one can begin to understand it. Examining the effects that industry and agriculture have on the watershed will help us understand what steps need to be taken to insure good water quality. The final part of the "information gathering" step is to go out into the field and verify the material collected by personal observation. Then it's possible to formulate plans for the future of that watershed. Monitoring streams and establishing baseline data throughout the watershed support discussion about different types of development.

Watersheds are studied for their geology, climate, erosion, slope, vegetation, and political boundaries. According to Karen Edelstein's *Watershed Monitoring Handbook,* there are approximately 70,000 miles of rivers and streams in New York State, which drain 17 major watersheds. The Catskill region supplies water to the Delaware, Susquehanna, Mohawk, and Hudson Rivers.

Several watersheds in the Catskills supply water to New York City's six reservoirs in the region. This major water use has had dramatic effects on Catskills communities, from the loss of towns to make way for the reservoirs, to the ongoing regulations needed to maintain water quality. Water has influenced the Catskills in many other ways as well -- not just as a water supply for New York City. The Catskill Mountains are actually famous for their streams. For example, the Hudson River School of landscape painting made the creeks and valleys of the Catskills famous throughout the world for their scenic beauty. American fly-fishing also began in the Catskills, and our streams are considered among the best in the world for that sport. Yet the streams are only as healthy as their surrounding watersheds. The study of water pertains not only to the streams themselves, but also to the surrounding land and the people living on that land.

Note: Portions adapted from Bock, Rosalie, *The Story of Drinking Water*, American Water Works Association, 1990.

Watershed Poetry

Grades:

4th - 7th

Objective:

Students gain a greater appreciation for water resources.

Method:

Students write poems about water.

Materials:

Sample poems (enclosed).

Time:

Preparation Time: 10 minutes
Class Time: 30 minutes

Procedure:

1. Review parts of speech and the definition of a syllable, as the concepts are used in writing certain types of poetry.

2. Distribute a copy of the sample poems and formats. Go over the examples with the students, stressing that poems follow particular formats. (An exception is free verse, which you may wish to disallow so students will try a more challenging format.)

3. Have students close their eyes and visualize a stream or other body of water. Ask them to write down or share with the class what the stream and its surroundings look like, sound like, smell like, or feel like. You may also bring students to the stream for this exercise, in which case they would share their observations about the real stream instead of visualizing a stream.

4. Give students time to write their own poems about water. Because it is hard to rush creativity, you may wish to give the students some time to work on their poems at home or allow more than one class session.

5. You may wish to have students write poems again after they have participated in more water-related activities. Their level of interest and the quality of their poems may increase along with their knowledge and appreciation of water.

6. Submit your students’ poems to River of Words, a national contest for water-related poems and art. See appended materials for instructions about how to enter. Entering the contest will give students a sense of pride as they represent our region and share the beauty they see in our local environment.

Assessment:

Are students interested in writing poems about water? Do students use vivid images related to water?

NYS Learning Standards:

English
Standard 2 - Language for Literary Response and Expression: Speaking and Writing

Math, Science, and Technology
Standard 4 - Science: Physical Setting 2

Source: This activity adapted from Project Learning Tree’s *Environmental Education Activity Guide*.

WATER POETRY

Haiku. This is a kind of poem from Japan.
All haiku poems have three lines.
The first line has five syllables.
The second line has seven syllables.
The third line has five syllables.

- Stand very still, look,
  under cold waters fish cruise
  slowly, silently.

- Gurgle, burble, splash.
  Peace of mind is what I find
  listening to streams.

Windspark. This poem has five lines.
It follows this pattern:
Line 1: "I dreamed"
Line 2: "I was" plus a noun
Line 3: where you were
Line 4: an action that took place there
Line 5: how the action was done

- I dreamed
  I was water
  In the mountains
  Collecting leaves and pebbles
  Swiftly

Cinquain. Also has five lines, but they are different than in a Windspark.
Line 1: two-syllable title
Line 2: four-syllable description
Line 3: six-syllable action
Line 4: in eight-syllables, describe a feeling
Line 5: two syllables related to the title

- Mountains
  Towering green
  Rising above the stream
  Aching to be explored by feet
  Catskills

Acrostic. Start with a word such as "water." For each letter of the word, a line of the poem begins with that letter.

- **W**e
  All
  Treasure
  Earth's
  Resources

Diamante. This poem has seven lines that always follow this pattern:

noun
adjective adjective
participle participle participle
noun noun noun noun
participle participle participle
adjective adjective
noun

- water
  wavy wet
  flowing tumbling rolling
  rocks boulders sand silt
  scouring churning eroding
  rainy soaked
  woodland

WATER POETRY

Rhyming Verse. There are several kinds of rhyming verse. Every other line may rhyme, or each pair of lines may rhyme, or rhymes may be two or more lines apart.

There was a time...
There was a time when all waters ran clean
and fish leaped from every stream
to catch the hovering mayfly.
There was a time when birds and bees
stirred summer air with wings of ease,
but now that time has gone by.
The time I've known, and seen, and felt,
has been a time when man have dealt
with the world like a belligerent child.
In the name of the great money race,
they've taken Earth's pristine face,
and with muck, and smoke, and oil, defiled.
Still I pray for the time to come,
when recleansed water sparkles in the sun,
and the moon shines down sublime
on a world that was lost and found,
and we can all feel justified and proud,
to tell of the passing of that former time.

Free Verse. Poetry does not always rhyme or even follow a particular format. Free verse poems do not follow any rules.

The pond was a mirror this morning,
and mists seeped up from the hollows.
The trees are by now almost bare of leaves,
and inside, the clocks that tick away
the seconds of my life, seemed to slow.
I walked out into the quiet morn,
listening to the drip drip of last night's rain
falling from the forest roof.
Trickles of little brooks that appear only
at magical times such as this
rang like bells over the rocks, and
soothing the static of my everyday thoughts,
put the rest of the world on hold.

Poems by: *Mark Burch, Nathan Chronister, and Aaron Bennett*

Where Is All of the Water on Earth?

Grades:

4th – 12th

Objective:

Students learn just how little water is available to everyone and every living thing on this planet to share. Students will realize that because so little water is readily available, it is imperative to keep water bodies clean and free of pollution not only for our use, but for future generations.

Method:

A visual representation using water containers will convey the point of this exercise more clearly than a list of numbers.

Materials:

A chart with percentages (below), 1-gallon jug of water, a small container, a cotton ball, an ice cube tray, a cup with sand or soil, an empty cup, an eye-dropper, a tablespoon, and some salt.

PERCENTAGES OF WATER ON EARTH

OCEANS	**97.5%**
FRESH WATER	**2.5%**
Glaciers / Polar Ice Caps	79%
Groundwater	20%
Lakes, Streams, etc.	1%
ATMOSPHERE	**.001%**

Time:

Preparation Time: 20 minutes
Class time: 25 minutes

Procedure:

1. Explain to students that the full gallon of water represents all of the water on Earth. Ask them to guess how much of the surface of the Earth is covered with water. The surface of the Earth is 78% water and 22% land. (A picture of the Earth from space or a globe might be useful when explaining this.

2. Use the eyedropper to take one drop of water out of the gallon. Put the drop into the cotton-ball, which represents the atmosphere (clouds). This is 1/1000 of 1% of the total.

3. Show how much water is readily available by taking 7 Tbs (3.2 oz.) out of the gallon of water and placing it in the small container. The 7 Tbs represent all the 2.5% of fresh water on Earth, while the remaining water in the gallon (125 oz.) represents the 97.5% in the oceans. Add the salt to the gallon jug.

4. Out of all the fresh water, 79% (5 Tbs) is frozen in polar ice caps and glaciers. Disperse the 5 Tbs into the ice cube tray to represent the frozen water.

5. The remaining 2 Tbs represent the groundwater and surface water on the planet. Use the eyedropper to get two drops of water to represent the water in lakes, streams and other water bodies (1% of the fresh water). The remaining water (20% of the fresh water) can be placed in the cup with sand to represent groundwater.

6. Show the students the two drops of water (the surface fresh water). This is all of the fresh water that is readily available to us. Discuss why clean water is imperative to everyone.

Optional: A simpler way to achieve the objective of this exercise uses a meter stick. Tell the students that the 100cm length of the ruler represents 100% of the Earth's water. Color two spaces (2cm) green, representing the 2% in glaciers, and color another space (1cm) blue to represent fresh water -- groundwater and surface water collectively. Color the rest (97cm) yellow to illustrate the 97% that is salt water.

Assessment:

1. Many people believe that the water on this planet is an "unlimited" resource, and that we do not have to worry about how much we waste. Do you feel the same way?

2. In this activity, we have talked about water naturally occurring in many places: oceans, lakes, streams, the atmosphere, and glaciers. Where else might water be found naturally?
(plants and animals - biomass)

NYS Learning Standards:

Math, Science, and Technology
Standard 3 - Mathematics: Mathematical Reasoning; Number and Numeration
Standard 4 - Science: Physical Setting 2
Standard 7 - Interdisciplinary Problem Solving: Connections

Source: This activity was adapted from Southern Rhode Island Conservation District's *Active Watershed Education Curriculum Guide.*

The Water Cycle

Grades:

4th - 7th

Objective:

Students will learn that all water on Earth is part of a continuous process driven by natural forces such as the sun and gravity. This activity will explain how water moves and changes from one form to another, as well as how our water supplies are continuously replenished.

Method:

Students receive an incomplete diagram of the water cycle on which they label and color the different paths and processes of water movement. Either an overhead of the diagram is used, or it can be drawn on a blackboard, and filled in as students fill in the blanks.

Materials:

Handouts of the diagram (enclosed), an overhead (optional), crayons or markers for each student.

Time:

Preparation Time: 15 minutes
Class Time: 30 minutes

Procedure:

1. Explain that all water on Earth is currently in one of the stages of the water cycle. Randomly pick a beginning point, stressing that there is no beginning or end to the water cycle. Be sure the students understand that the sun is the driving force behind this process.

2. Hand out a copy of the unlabeled water cycle diagram, one per student.

3. Let's say we started in the ocean. Have students label the ocean. Then, have them color the arrow above the ocean blue (for water). Ask them what process the arrow represents, and have students label EVAPORATION. Explain that when the sun heats water it turns to water vapor. Water also evaporates from land or even from plants (called *transpiration*). Students write water vapor in the empty space since it's invisible.

4. Next is the atmosphere. Label the cloud, and have students color the arrow and label it CONDENSATION. As water vapor cools, it returns to its liquid state, forming clouds.

5. Have students label the arrow PRECIPITATION, and color it blue. PRECIPITATION occurs when clouds become saturated with water -- consequently, rain or snow is released.

6. Briefly explain the concept of topography and how water can do one of two things once it falls on land: flow above ground until it reaches a water body (RUNOFF -- label and color) or percolate down through soil due to gravity (INFILTRATION -- label and color).

7. Explain how RUNOFF eventually evaporates, beginning the cycle again. It may reach the ocean before it evaporates, or it may not.

8. The water that soaked into the ground does not stay still. It moves as GROUNDWATER FLOW. The water eventually returns to the surface at a spring or water body, allowing the cycle to continue.

Assessment:

1. Use the enclosed quiz as an assessment. Quiz answers:

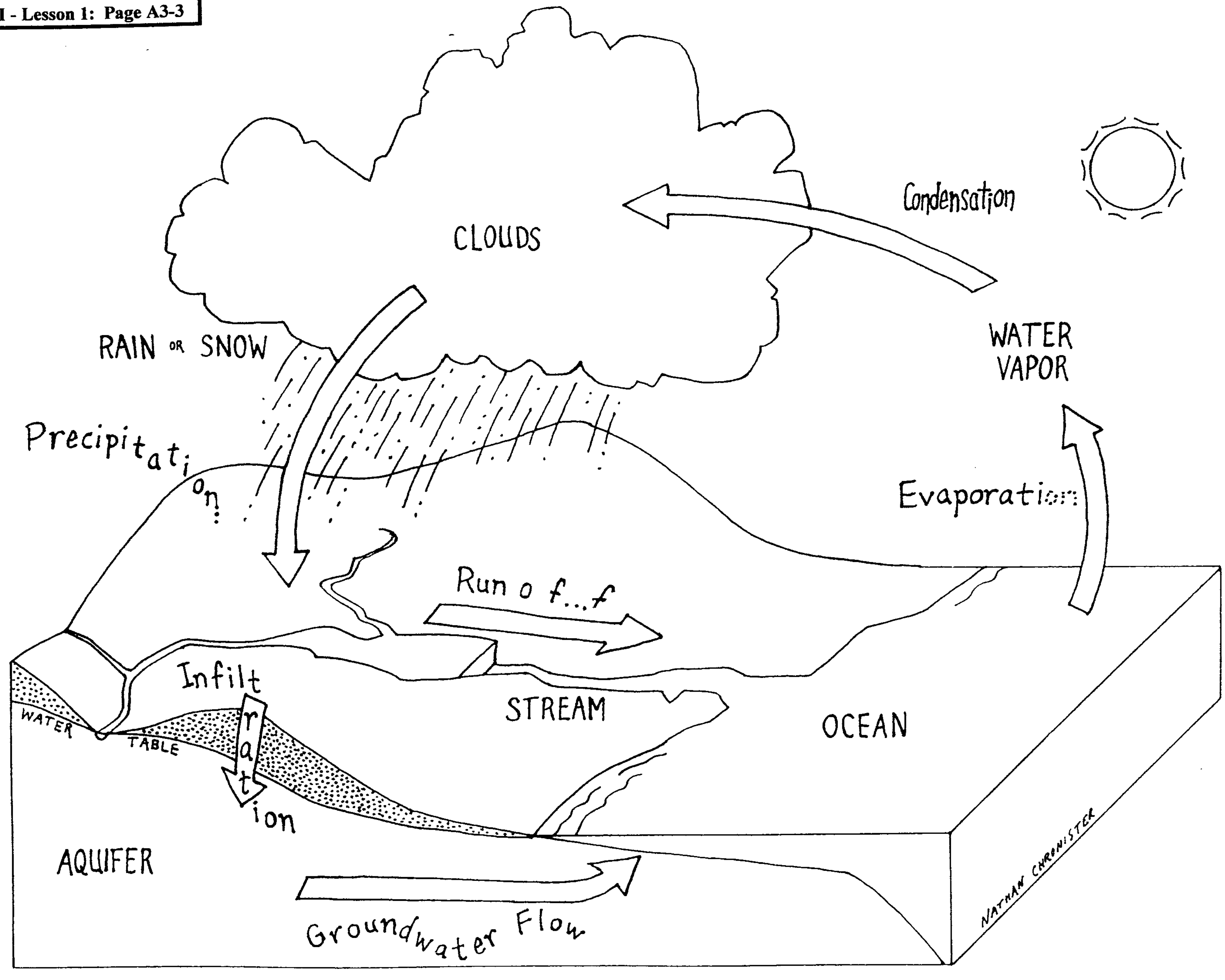
   1. Yes, all water on Earth is part of the water cycle.
   2. No, cycles do not have a beginning or an end.
   3. Water does not always follow the same route through the water cycle. It can skip over one phase in the diagram and move to another.
   4. A raindrop could skip infiltrating or running off the ground in a number of ways. Two ways are: 1. The drop could evaporate before it reaches the ground. 2. The drop could land directly in a lake, stream, ocean, etc.
   5. Liquid, gas (water vapor), and solid (ice crystals in clouds).

NYS Learning Standards:

English
Standard 1 - Language for Information and Understanding: Listening and Reading

Math, Science, and Technology
Standard 4 - Physical Setting 2,3; The Living Environment 6

Source: This activity developed by Nathan Chronister and MJ Reiss.


CLOUDS
Condensation
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VAPOR
Precipitation
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WATER
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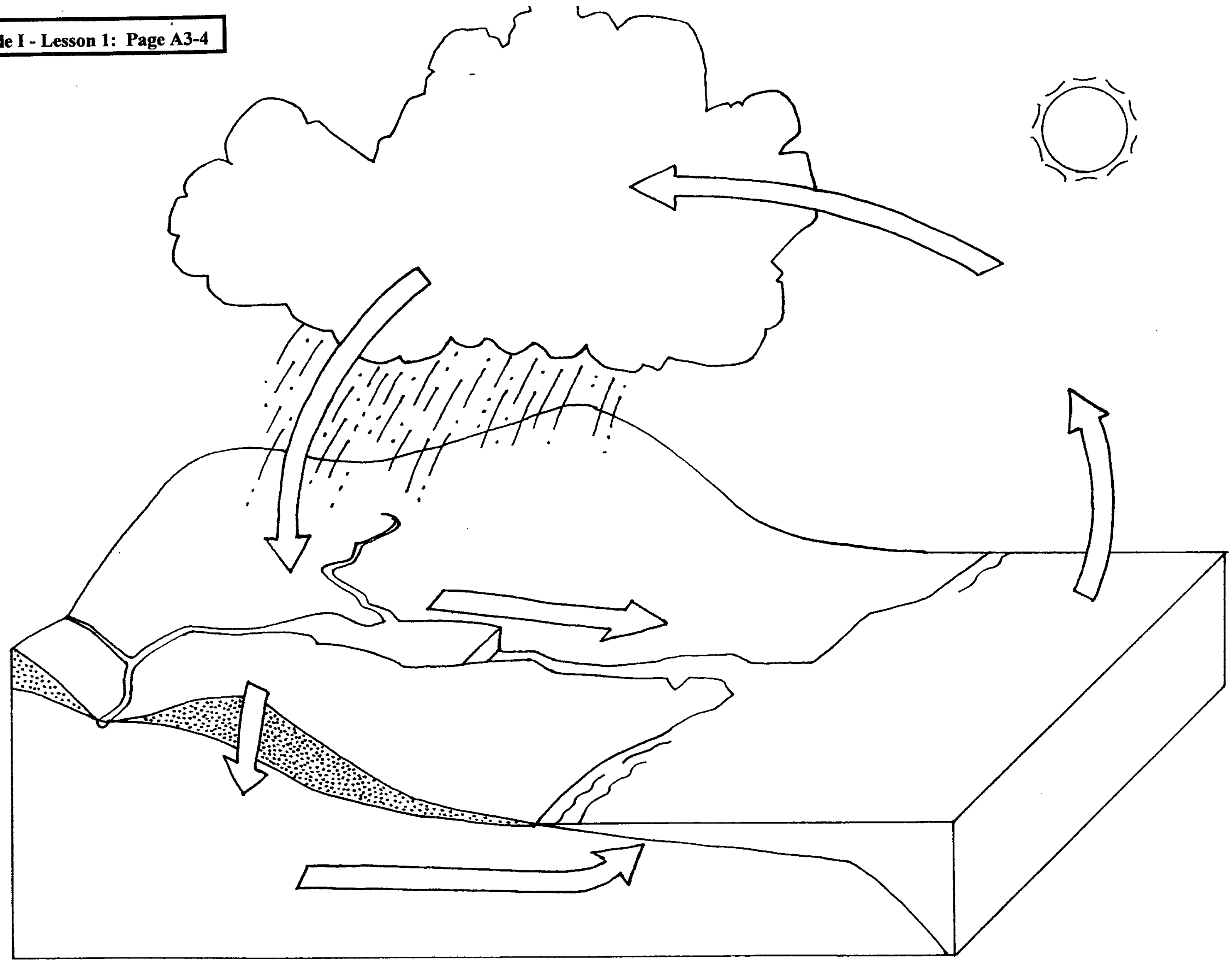
STREAM
OCEAN
AQUIFER
Groundwater Flow
NATHAN CHRONISTER



The Water Cycle Quiz

Name: ___________________________ **Date:** __________ **Teacher:** ___________________

Directions: Answer the questions below using the information you learned in the activity.

1. Is all water on Earth part of the water cycle?

2. Is there a specific point where the water cycle begins? If so, where?

3. As water travels through the water cycle, does it always follow the same path, or can it skip over certain parts of the cycle?

4. Give an example of how a drop of rain could skip the next part of the water cycle (Infiltration or Runoff) and go directly to another part of the cycle.

5. Water occurs in three different states (forms) in the water cycle, what are they?

A Day in The Life of a Drop of Water

Grades:

4th - 7th

Objective:

Students will understand the water cycle and the path that water travels through in a groundwater delivery system, from atmosphere to groundwater, to their tap.

Method:

Guided imagery helps students understand the water cycle and a water delivery system by taking them through the birth of a raindrop, and the route that this drop might take through the ground, into a well, and up into a tap in a house.

Materials:

A copy of the fantasy, “A Day in the Life of a Drop of Water” (enclosed).

Time:

Preparation Time: 5 minutes
Class Time: 20 minutes

Procedure:

1. Ask students to close their eyes, relax, take three deep breaths and slowly exhale to clear their minds of all thoughts. Read the story, “A Day in the Life of a Drop of Water”, and have them imagine that *they* are the main character in the story.

2. After you finish reading the story ask students how they felt about it. Have them describe (or even draw) some of the things they imagined during the story.

3. Discuss what was happening at different points throughout the story. What was happening when the drop started to “fly” off the blade of grass? (evaporation) What did the drop of water turn into at that point? (water vapor) What was happening when the character started to feel wet again, up in the sky? (condensation) What happened next? (precipitation: the drop fell as rain) What are these transformations an example of? (the water cycle)

4. Why did other water molecules stick to the character as it started flowing on the ground? (liquid water molecules adhere to each other) What happened when it became dark? (the

drop went underground) Why were there different textures under the ground: Why was it soft first, and then hard? (drop traveled first through soil, then through underlying sand and gravel) Why did the water move less slowly as it went deeper underground? (pore spaces are larger in sand and gravel, and water movement is faster)

5. Why did the drop start moving sideways instead of down? (aquifer flow is parallel to the underlying bedrock) What was the huge hole filled with millions of water drops? (well) What was the force that started to suck the water drop upward? (pump) At what point did the water drop enter a pipe? (when it heard echoing sounds and smelled rust) What happened when the drop hit its head on a hard metal wall -- why did it switch traveling directions? (pipe joints)

6. What happened when the drop plunged into a blinding light? (came out a faucet) What was the "clear pool?" (a drinking glass) What were the strange flesh-like smudges and reddish/pink oval creature with wart-like bumps? (a person's hand through the glass, and the person's tongue) Where did the drop end up? (inside a person's stomach!)

7. An alternate procedure: stop the story somewhere in the middle. Have students write their own endings and share them with the class.

NYS Learning Standards:

English
Standard 1 - Language for Information and Understanding: Listening and Reading

Math, Science, and Technology
Standard 4 - Science: Physical Setting 2,4; The Living Environment 6

Source: This activity was taken from Southern Rhode Island Conservation District's *Active Watershed Education Curriculum Guide*.

A Day in the Life of a Drop of Water

You are a small drop of water sitting on top of a fresh blade of green grass. It is mid-summer and the sun is shining. You are wondering, “Will I ever become unstuck from this blade of grass?”

A playful summer breeze blows through the meadow, causing your blade of grass to wave back and forth. The sun feels very strong and you feel yourself becoming more and more full of energy. You feel so hot and alive that your insides are rushing around violently. Suddenly the energy is so great that you are lifted right up into the sky! Your body feels a whole new sensation... you are light, dry and flying! Your insides are still moving around furiously. The wind helps to carry you up and over the treetops.

As you rise higher and higher you feel light as a feather. Down below, the meadow that you came from looks like a dot on the Earth. The wind carries you into a dark gray cloud. You hear a loud cry and almost bump into a large, black bird with a white head. Here in the cloud there are millions and millions of other water vapor molecules rushing around and bumping into each other. “Hey, watch it!” you yell, as one of them bumps into you. “Ouch! It’s too crowded here!”

You are relieved when you begin to feel that familiar moisture feeling again. As you become wetter, you feel heavier, and you move much more slowly. Soon you become so heavy that you start to fall back to Earth. All around you other raindrops are falling. Lower and lower you sink. In every direction you look, there are raindrops. The whole world seems to be wet.

You look down again and the wet blur is becoming clearer. A long, black highway stretches below you, running beside a large expanse of evergreen forest. You hope to land on the forest! As the end of your fall draws near, you close your eyes, bracing yourself for the impact... SPLAT! OUCH! Was it the highway asphalt? But your movement doesn't stop. You just move much more slowly. As you open your eyes, you are trickling down the crack of a huge boulder on the edge of the forest. A few other raindrops have stuck onto you and you're all flowing together. More and more drops collide and join your blob, running down the rock. Your speed picks up, and then finally.... ttthump! You all have landed on the soft earth. The impact was gentler this time but it has broken the blob apart.

Once again you are alone and suddenly it is very dark... oops... one droplet friend has attached to you as you find yourself slowly creeping into a strangely shaped crevice between two fuzzy particles of soil. You feel yourself being pulled down, down, into crevice after crevice.... like little tunnels in the soil. Slowly twisting, turning, percolating, the musty smell of the soft, damp, cool earth comforts you. The softness is disappearing, though, as you go further down and the soil particles are getting harder and bigger with larger crevices that you flow through not quite so slowly now.

More of your droplet friends join you. You all notice that you now seem to be pulled sideways instead of down. A strange force is somewhere off to your right and you're getting sucked toward it, but you all still have to find your way through the twisting cave-like spaces between the grains of sand and gravel... the force becomes so strong that you get pulled... ffffttt! Splash! Into a huge hole filled with thousands... millions... of your water drop friends... You're all swishing and splashing about... but you can still feel the strange force sucking you... it is much stronger now, and upwards. It is still very, very dark... suddenly you hear a strange echoing sound... all your droplet friends splashing against metal... there is a faint smell of rust now. The force is still pulling you up, when suddenly...OUCH! Your head hits a hard metal wall and you get pulled sideways again, this time to your left. Faster and faster you travel... OUCH! Your left side hits another metal wall and the force pulls you straight up again. Now you are traveling as fast as you were the last time you saw the light of day... rolling down that boulder on the edge of the forest. But it is still dark and so it is pretty scary to be going so fast and not see where you are going...

Suddenly with a violent jerk you get flipped over and you plunge head first into a blinding light... SPLASH! When the turbulence settles, you turn yourself upright and you see that you're surrounded by your droplet friends, splashing, swishing about in a very clear pool. When you look around, you see these strange flesh-like smudges all around you. The sucking force is gone but you feel yourself and your friends being turned upside down, like you're in a swimming pool that a huge giant is flipping over... and whoosh... it goes completely dark once again. In your last glimpse of light, you were able to see that you were heading straight towards an extremely strange, reddish-pink oval creature with bizarre wart-like bumps all over it. After seeing such a sight, you're glad it's dark again. You're also glad to feel that wherever you are, the pace has slowed way down. Are you in the soil again? Gosh, it seems much warmer than the soil. It's sort of a cozy feeling after all the splashing and cold metal walls and weird sucking forces and strange sights... maybe it's time for a rest.

Note: Expanded from “Birth of a Raindrop”, from *Keepers of the Earth*, by Michael Caduto and Joseph Bruchac.

Becoming Wary of Watersheds

Grades:

4th - 7th

Objective:

Students will be able to predict the paths of water within a model watershed and be able to describe the various drainage patterns of the water. Students will understand what a watershed is, what it does, and that many sub-watersheds are linked to create a larger watershed.

Method:

Students build a model of a watershed or observe a model built by the teacher.

Materials:

A large tray or large piece of corrugated cardboard, newspaper, masking tape, aluminum foil, a spray bottle with water (dyed), a collecting bucket or plastic container (if needed). If students are to build their own models, have them bring materials from home (unless available at school).

Time:

Preparation Time: If choosing to construct and demonstrate the model yourself: 30 min.
If choosing to have class build the model: 5 min.
Class Time: If choosing to construct and demonstrate the model yourself: 15 min.
If choosing to have the class build the model: 45 min.

Procedure:

Decide if you or your class will construct the watershed model.

Intro: Begin by asking the class if they know what a watershed is. A watershed is an area of land that collects the precipitation that ends up in a particular body of water. For example, all of the land surrounding the Hudson River drains into the Hudson River. That land is the Hudson River watershed. Ask the class if they are in a watershed at this moment. Then explain that all land on Earth is part of some watershed.

Explain that you will be using a model watershed so they can visualize the path of water within a watershed.

1. Crumple up sheets of the newspaper, or any other scrap paper. Try to use various sizes. (These will represent mountains.)

2. Arrange the various shapes on the tray or cardboard, with the largest pieces near one side of the base, the medium-sized pieces next to that, and then the smaller ones. It should form somewhat of a “C” shape, with a low valley in the middle. This valley will become the stream.

3. Once you are happy with the shape of the watershed, tape the paper pieces to the tray or cardboard. Be sure to tape the paper down rather well, while still keeping the desired shape of the mountains.

4. Cover the entire mountain range with aluminum foil to prevent water from wetting the paper, and to improve the drainage patterns of the model.

5. Now you may wish to raise one end of your model in some manner to improve the drainage process. You may also wish to place a collecting container at the outlet of the future stream to prevent any spilling of water.

6. Once the model is ready to go and you have filled the spray bottle with colored water, tell the students that this area of land is now going to experience a precipitation event. Before applying the water, ask the students to predict where the water will flow. Point to several different locations, both inside and outside of the main watershed.

7. Begin spraying the foil model. Spray all areas as evenly as possible until a flow is generated. Point out the various *drainage patterns* that occur in the watershed. Make sure you spray outside the stream’s watershed and ask where that water will flow. Ask if the side of the mountain facing away from the stream is in the same watershed as the side of the mountain facing toward the stream.

8. Have students point out the various *drainage divides* that appear. How can they tell it is a drainage divide?

9. Be sure to point out to the class that all of the water from inside the main watershed is draining into one place, or common outlet. This is the mouth of the stream. Explain how this stream would feed into another stream, and so on, until the stream reaches the ocean. Hence, all watersheds are connected.

10. Review the major points to ensure that students understand the functions of watersheds: to collect, store, and eventually release water. Review drainage divides. Discuss the concept of sub-watersheds. All land on this planet is part of one watershed or another.

Extension: Have students look straight down on their model and draw a map of it. They should indicate where the mountains, streams, pools, and divides are located.

Assessment:

1. What might the watershed model look if it had two different watersheds on it?

2. How might pollution in one area of a watershed affect the drinking water in another part of the same watershed two miles away? How might the same pollution in your watershed affect a community in another watershed 20 miles downstream from you?

3. In what ways, other than a stream, might water leave a watershed? Hint: think of the water cycle diagram.

NYS Learning Standards:

Arts
Standard 1 - Creating, Performing, and Participating in the Arts: Visual Arts

Math, Science, and Technology
Standard 4 - Science: Physical Setting 1,2
Standard 5 - Technology: Tools, Resources, and Technological Processes
Standard 7 - Interdisciplinary Problem Solving: Connections

Source: Activity developed and written by Nathan Chronister and Aaron Bennett.

What Is Your Watershed Address?

Grades:

4th - 12th

Objective:

Students will learn where the water in the streams near their homes and villages comes from and where it eventually ends up. They will see how a pollution source near their homes could potentially affect other water bodies in their watershed.

Method:

Each student uses a map to figure out his or her watershed address -- the series of streams one would have to follow from the ocean to reach his or her home.

Materials:

Copies of the address form (enclosed), and at least one (preferably more) detailed map of NY.

Note: A map of your particular county, or a local topographic map, will not suffice because they would not allow students to follow their streams all the way to the sea.

Time:

Preparation Time: 15 minutes
Class Time: 20-30 minutes

Procedure:

1. Explain how all land is part of one watershed or another, and how everyone lives in a watershed. Explain how larger watersheds (e.g., the Delaware River Watershed) are comprised of many smaller watersheds (sub-watersheds). Local streams may pass through many sub-watersheds.

2. Pass out the address form, and have them write their street addresses on the left side.

3. Distribute the map(s) to the class and briefly explain what they are to do.

4. Have each student locate the road they live on (or the nearest road that appears on the map). Then have them find the closest stream to their house. If mountains appear on the map, students should find the nearest stream that is not on the other side of a mountain or watershed divide from where they live.

5. Students can now trace the path of the water. As they follow their stream, they should write the names of each larger stream it enters. Students should continue until they reach the ocean.

6. Have students draw a picture (map) of their watershed address so the rest of the class can visualize the course of their water.

7. Have each student pretend that there are no roadways in New York State. Each student must instruct the class on how to reach his or her house from the Atlantic Ocean, using only the names of the existing water bodies.

Assessment:

1. Use the enclosed quiz as an assessment. Quiz answers:

   1. A watershed is an area of land that collects water, stores it, and eventually releases (sheds) it to a common outlet, a stream.
   2. Mountains (and their ridges) separate one watershed from another, therefore forming their boundaries.
   3. Answers will vary. Your school will be in the watershed of the stream nearest the school, and also part of a larger watershed, i.e. the Hudson or Delaware River watershed.
   4. The pollution will runoff into the nearby stream or lake.
   5. Yes. Streams connect all places within a watershed, as well as connecting one watershed to another. What happens in one part of a watershed will affect the entire watershed.

NYS Learning Standards:

Math, Science, and Technology
Standard 4 - Science: Physical Setting 2; The Living Environment 7

Social Studies
Standard 3 - Geography

Source: This activity developed by Martha Cheo, Watershed Coordinator for Hudson Basin River Watch.

WHAT IS YOUR WATERSHED ADDRESS?

Street Address	Watershed Address
STREET	LOCAL STREAM / CREEK
TOWN / CITY	LARGER STREAM / CREEK
COUNTY	LARGE STREAM / RIVER
STATE	MAJOR RIVER
COUNTRY	OCEAN

- **Draw your watershed address in the space below, labeling each waterway.**

What Is Your Watershed Address? Quiz

Name: __________________________ Date: __________ Teacher: ___________________

Directions: Answer the questions below using the information you learned in the activity.

1. What is a watershed?

2. What separates one watershed from another watershed (what form their boundaries)?

3. What watershed is your school in?

4. A farmer used too much fertilizer on his/her crops. After a heavy rainstorm, where might the extra fertilizer (pollution) end up?

5. If you lived downstream from the farmer, could your way of life be affected by this pollution?

Streamwatch

Lesson 2 of the Water Resources Module concentrates on surface water bodies, and in particular, streams. A stream is any flowing water body. By looking at the physical, chemical, and biological aspects of water bodies, it is relatively easy to determine their health, assuming you know what to look for. Streams in the local area are fascinating, readily-accessible highways of biodiversity that interconnect many, if not all, living organisms in our environment. Watersheds, mini-ecosystems themselves, are determined by the topography of the earth and connect to each other via these highways of biodiversity.

This stream study is aimed at giving your students the ability to monitor the health of a stream. This important work does not need to be performed by state conservation employees -- in fact, there are too many streams for them alone to monitor. Any willing adult, or even conscientious students can do stream monitoring.

Data about a stream can be useful if properly recorded. Therefore, the activities in this section are organized around the data sheets used for Streamwatch. While learning to complete the data sheets, students also learn about critical thinking, measurement, and interactions in the environment, which helps meet the state learning standards. Student data are collected and shared with other schools. Not only can other teachers use your data for comparative study, the data are also available to NYSDEC through our participation in Hudson Basin River Watch (HBRW).

Hudson Basin River Watch

Hudson Basin River Watch is a volunteer river monitoring project whose goal is to improve the water quality of the Hudson River and all of its tributaries. HBRW is a vital and growing partnership of over 60 schools, dozens of environmental organizations, and water resource agencies. The project's objectives are to train volunteers on how to identify Hudson Basin water quality problems, to monitor the physical, biological, and chemical characteristics of Hudson Basin waters, and to use the information for river restoration and protection efforts. HBRW provides "regional coordinators" to support local efforts in their area and communicate with other regional coordinators. This way, activities happening in the schools and community can be supported locally, but with more communication and a larger thread of the watershed tying all of these efforts together. The data your students collect will be more useful if you follow the HBRW monitoring protocols. The Guidance Document has all of the information needed to begin monitoring today. If you have questions about, or would like to become a part of the HBRW network, contact Aaron Bennett, the Catskill Regional Coordinator, at The Catskill Center. You may also want to look at the HBRW web site (www.hudsonbasin.org), which includes a database where students can enter their data and compare it to other schools, or even to that entered previously. Some of HBRW's data sheets are included in the appendix.

Weather Conditions

Temperature. Data about the surroundings help put other monitoring data in context. Use an air thermometer to take the temperature. Use the Celsius scale exclusively. We believe students will never grow accustomed to Celsius if they must always convert it to Fahrenheit before they can understand it. By feeling cold water at 10°C and warm air at 20°C, students will learn to relate Celsius temperatures to their own tactile experience as they have done with Fahrenheit.

If your thermometer measures only Fahrenheit, be sure to convert it to Celsius. Here are the conversion formulae, though Fahrenheit should not be used in these activities.

$°C = 5/9\,(F-32)$ $°F = 9/5C + 32$ where $5/9 = 0.55556$ and $9/5 = 1.8$

For example, if your temperature measures 42°F, then subtract 32 and multiply by 5/9 to get °C:

$$45°F - 32 \times 5/9 = 7°C$$

or if your Celsius thermometer says 7°C, then multiply that by 9/5 and add 32 to get °F:

$$7°C \times 9/5 + 32 = 45°F$$

Cloud Cover. Determine the percentage of the sky that is covered by clouds. If the sky is either completely cloudy or completely clear, it is easy to tell the percent cloud cover. If there is some blue sky and some clouds, it is more difficult. It can be done by visualizing the sky divided into halves, then quarters, and so on until you can tell what percentage of the sky is clouds.

Precipitation. Depending on how far you are from the headwaters, it may take hours or days for rain to make it into your stream. Therefore, recording past weather conditions is as important as recording whether it is raining during your field trip. To keep things simple, the data sheet asks only whether or not it has rained or snowed in the last 24 hours. Students can make additional notes about the amount or timing of precipitation (e.g., “snowed 10 cm overnight”).

Physical Data

Water Temperature. Hold the thermometer at least four inches below the surface of the water for two minutes. Measure in the deep part of the stream, not in shallow areas along the bank, which can be warmed by the sun. Keep the thermometer in the water while reading it, and do not touch the bulb with your warm hands. Note whether the temperature was taken in the shade or in the sunlight and try to be *consistent* each time.

Depth and Width. Depth and width of the stream, as described here, refer to specific points along the stream and therefore can only be used to examine changes in the stream over time. Depth and width cannot be used in calculating the amount of water flowing in the stream; for that, one must use the full “Total Flow” procedure described in the appended materials. The depth and width measurements *are* useful for seeing how much the water level rises or falls. Depth and width should always be measured in the same place. Measure the depth at the deepest part of the channel if this can be done safely. Record the width in meters using a measuring tape or a cord marked at one-meter intervals stretched across the stream.

Turbidity and Color. Water color is a separate variable from turbidity (cloudiness), and this should be made “clear” to students. Some liquids, like apple juice or tea, are brown but not turbid. You can see through them easily. Other liquids, like milk, are turbid but not colored. A muddy stream is both turbid and colored (brown). Floating algae can cause water to be turbid and green.

In the Catskills, streams are usually clear and nearly colorless, but storms or erosion can make streams muddy. This is a problem for aquatic life, since it can clog and irritate gills. Sediment particles can also harbor harmful microbes, and when sediment settles in a reservoir it can decrease the capacity of the reservoir.

Judge the turbidity by looking at the bottom of the stream. If rocks half a meter below the surface are not visible, then the stream is “slightly turbid”. If rocks 10 centimeters below the surface are not visible, the stream is “very turbid”.

Chemical Data

Dissolved oxygen (DO) is required for many fish and invertebrates to survive under water, though some are adapted for low-oxygen environments and can breathe air from the surface.

Oxygen dissolves best in cold water, so cold water (resulting from shade along the stream) provides the best habitat for trout.

Dissolved oxygen is most easily measured using a snap-test kit. Follow kit instructions to obtain a measurement. It is difficult to use the comparator accurately, and a consensus between the teacher and several students will help insure accuracy. Other test kits use a titration method; they are more precise but harder to use. The sample can be chemically “fixed” in the field, and the procedure can be completed later, in the classroom. These test kits also pose a greater safety concern, as described in kit instructions. A healthy stream has 9 or more parts per million DO.

Percent oxygen saturation, although it does not in itself determine fish survival, is a good indicator of oxygen depletion because it compensates for temperature. Percent saturation describes how much oxygen is in the water compared to how much it could hold at the present water temperature. Use the chart to find percent oxygen saturation. First find the dissolved oxygen on the bottom scale. Then find the water temperature on the top scale. Draw a line from the oxygen to the temperature. The point where that line crosses the percent saturation scale shows the oxygen saturation of your sample. Saturation should be above 80%.

Acidity, measured in pH units, can be increased by acid rain or certain ecosystems like bogs or hemlock stands. Acidity can kill fish and invertebrates in the stream, and in lesser amounts it may prevent eggs from hatching or interfere with fish gill functions. It can also kill trees and affect other terrestrial organisms. Students should understand that pH ranges from 0 to 14. A pH of 7 is neutral, higher numbers are *alkaline* (also called *basic*), and lower numbers are acidic. The lower the number, the more acidic the water is! Most aquatic animals can tolerate a range from 6.5 to 8.

The pH of a water sample can be tested using pH paper or a chemical test kit. The test paper is the easier but less accurate method. Test kits, almost as easy, involve placing a few drops of an indicator solution into a sample vial and then judging the color using a comparator.

Biological Data

There are two methods we use for collecting macroinvertebrates (non-microscopic animals without backbones) from the stream. Most of the species we collect are benthic, meaning they live on the bottom of the stream, on or under rocks. They are abundant in many streams, a fact that surprises those who have never looked for the hidden and camouflaged creatures. Because of their abundance, students can catch quite a few by picking up rocks and searching the undersides of those rocks for invertebrates. They can be removed gently by using fingers or a soft foam brush. (Caution children about the risk of injury to carelessly handled organisms.) The invertebrates are then transferred to plastic containers full of stream water.

In the second collection method, a net is used. Since most of the invertebrates in our streams are benthic, they must be flushed from their hiding places before they can be caught. This is done by kicking the rocks so that they are overturned. Some of the insects will then be floating in the current, which sweeps them quickly into the net, held a few feet downstream from the kick-sampling area. We use two types of net, a D-net (D-shaped or rectangular frame at the end of a pole) and a seine net (stretched between two poles, each held by a different student). Both nets have a flat bottom-edge which fits against the stream bed. The D-net is best suited if there is a lot of current, since it is easier to control, but it is slightly harder to remove insects from.

On the data sheet, students should list the creatures by type, such as mayflies, stoneflies, caddisflies, aquatic worms, etc. In most cases, these broad categories correspond to the taxonomic *order*, as listed on the appended key from Izaak Walton League. Students do not have to identify individual families or species, but a more advanced key for family-level identification is available from The Catskill Center, if desired.

To ensure an accurate count, the group should avoid counting any insect twice. We divide the class into three small groups, each with its own data sheet, and we combine their results at the end. If the whole class is working together, have one student count all of the insects. The other students bring their insects to that person to be counted and then release them so they can't be counted again.

Use the Screening Criteria for Non-Impacted Streams to assess water quality based on number and type of invertebrates found. There are other, more reliable, methods that take into account more invertebrate groups, finer levels of classification, and the number of individuals within groups found. You may wish to try the Biotic Index Score if you teach middle school students. Our version of the Biotic Index Score was modified from the original. The original required a random sample of 100 macroinvertebrates, but our system will work with any number. Note however that the accuracy is somewhat compromised if you use fewer than 100 specimens.

Water Characteristics

Grades:

4th - 7th

Objective:

Students learn to make informed decisions about the health of a stream. They learn how to measure temperature, depth, width, pH, and dissolved oxygen using the metric system.

Method:

Students will practice taking water chemistry measurements in an imaginary stream in the classroom, which are the same as the measurements they will later make on the stream field trip. By learning the procedures and discussing the results, students will be more prepared when they are at the stream.

Materials:

Photocopies for each student: Physical & Chemical Data Sheet, % Saturation, Wind Scale.
Overheads: Physical & Chemical Data Sheet, % Saturation, Wind Scale. (all enclosed)

Meter stick
Measuring tape, 30 meters long with metric units, or a cord marked at one-meter intervals.
2 thermometers (with $^\circ$C)
Dissolved oxygen test kit (either Ward's Snap Test or LaMotte kit, depending on grade level)
pH test kit (either pH paper or LaMotte kit, depending on grade level)
Two plastic bottles: one with hot tap water, one with cold water.
A few ounces of white vinegar
4 clear plastic cups (8oz.)
4 large (16+ oz.) glass jars, prepared as follows:

Jar 1. Clear water.

Jar 2. Tea. Add about 15% isopropyl alcohol as a preservative if you plan to use it again.

Jar 3. Muddy water created by adding some fine mud or clay to a jar of water. Add about 15% isopropyl alcohol as a preservative.

Jar 4. Algae. Prepare well in advance. Collect stream water, which will normally contain a small amount of suspended, microscopic algae. Add about one teaspoon of garden fertilizer. Leave it in a sunny window, uncapped, for about a month.

Time:

Preparation Time: 45 minutes
Class time: 60 minutes

Procedure:

1. Ask the class: We use our five senses to learn about things around us, like streams. Characteristics are pieces of information that describe an object or place, such as a stream. How might one person describe a stream to another? What are some characteristics that we could use to describe a healthy stream?

What are data? Tell students they will use a data sheet to record data (characteristics) that describe the stream. Ask: Why would we want to write the information down?

2. Hand out copies of the Physical & Chemical Data Sheet to the class. Fill in the heading with the class and explain why the location is important (so anyone reading the data will know what stream and what part of the stream are being described). In the remaining steps, students will complete the data sheet using data obtained in the classroom.

3. **Weather Conditions.** Ask how these might affect a stream.

Air Temperature. Explain that we use °C because the scale (0°C = freezing, 100°C = boiling) is easier to remember than °F. Also, most thermometers in °F have a mark for every two degrees, while Celsius thermometers have a mark for every degree, making them easier to read. Have a volunteer measure the room temperature. Write it on the data sheet. *(Optional: Students can practice reading a thermometer by marking the air temperature on the thermometer illustrated on the data sheet. Some students might need help.)*

Wind Scale. Using the overhead of the Wind Scale, have students read each numbered item aloud. Then have two students go to the window and determine the correct number on the scale. All students should record this number on their data sheets.

Cloud Cover. Ask what is percent? Using a clear cup, point to different levels and have students guess what percent full the cup would be. Once they understand, have two students look out the window and see what percent of the sky is covered with clouds.

Precipitation. What is precipitation? Talk about how yesterday's precipitation can affect today's stream characteristics. Fill in the correct boxes.

4. **Physical Data.** These physical data describe the stream itself.

Water Temperature. Pour cold water into one cup and warm water into another. Put a thermometer in each. Ask students why we would want to measure temperature when talking about a stream's health. Some animals like cold water (trout, stonefly nymphs), but others like warm water (carp, dragonfly larvae). Have two volunteers come up and read the temperatures (°C). Discuss the freezing and boiling points of water in °C compared to °F.

Depth. What tool do we use to measure depth? What units? How many centimeters are in a meter? Tell the class that the classroom has now become a stream, and the level of the water is up to the top of their desks. Have a volunteer measure stream depth (in meters).

Width. What tool do we use to measure width? What units? The stream is still flowing through the classroom. Have two students measure the width of the stream. Record the data in the metric system, to the nearest centimeter. Inform students that there are two ways to record measurements in the metric system: e.g., 1m 25cm is the same as 1.25m.

Turbidity & Color. These characteristics are familiar to students, but the terminology is new. Turbid simply means cloudy. Cloudiness is caused by tiny solid particles. Use the four jars to demonstrate that cloudiness and color are independent. Show the plain water first and ask the class to tell you the color and the turbidity. Proceed with the others in the same manner. Explain that if they can see through the water (see your fingers behind the jar), then the water is not turbid. When asked if the tea and muddy water are both the same color, students should say they are both brown, but the tea isn't turbid.

5. **Chemical Data.** This section deals with the chemical make-up of stream water.

Dissolved Oxygen (DO). What do we breathe? What part of our body do we use to breathe? What do fish breathe? What part of their body do they use? Air is 23% oxygen. How much oxygen is in water? About 1/1000 of 1%, or 10 parts per million (ppm). What are ppm? One unit out of every 1,000,000 units. One second in 12 days of your life or 1 inch in 16 miles. Oxygen gets into water in several ways. Two ways are through photosynthesis and by air mixing with water (like when water splashes over rocks). DO is generally higher in riffles and lower in pools of water. Cold water can hold more oxygen than warm water. 12ppm is common in cold water, while 6ppm may be found in warm water. Nine or more ppm is considered healthy. Perform the dissolved oxygen test that you have chosen by following the instructions in the test kit. If you use the snap test, have the students come to a consensus on the color in the tube and record the ppm. It may be best to have students only observe while you perform the Lamotte test. Discuss the results.

Oxygen Saturation. Place the Oxygen Saturation chart on the overhead. Explain that this chart will tell how saturated with oxygen the water is. Does it have all the oxygen it can hold? The water can be supersaturated (above 100%) only for a brief time. To use the chart, draw a straight line from the water temperature to the dissolved oxygen. The point where the line intersects the % saturation scale indicates the oxygen saturation.

Acidity (pH). What is an acid? (lemon juice, vinegar) What is a base? (bleach, drain cleaner) Explain that the pH scale ranges from 0 to 14, from acidic to neutral to basic. What can cause high levels of acidity in streams? (acid rain due to car exhaust and industrial pollution) A healthy stream's pH is between 6.5 and 8.0. Prepare two cups of water, one plain, and the other with about 30% vinegar. If you are using pH paper, have a student dip the paper in each sample and match the colors to the comparison chart. If using the LaMotte kit, do the procedure yourself and then have the class decide on the pH. Explain that in the field, at least two tests of pH and dissolved oxygen will be performed, and the average will be taken. This allows a more representative stream sample. *(Optional: Before testing the pH, allow a student to taste the vinegar water. Ask students to describe the acid and ask what it would be like for fish to live in it all the time.)*

Assessment:

Use the enclosed quiz as an assessment. Quiz answers:

1. Data is, quite simply, information.
2. In warmer weather, streams will be warmer. Colder weather, streams will be colder. Heavy precipitation will increase total flow, and possibly lower the pH (acid rain). Windy conditions may cause excess debris in streams.
3. Turbidity is un-healthy for streams because it will clog fish gills, impair their sight when searching for food, and will also increase a stream's temperature by trapping sunlight.
4. Colder water has the ability to hold more oxygen (and gases in general). Oxygen gets into water in many ways: 1. The splashing of water over rocks traps air in water, and air is 21% oxygen. 2. Aquatic plants give off oxygen as a result of photosynthesis. 3. Diffusion across the air-water interface.
5. The opposite of an acid is a base (bleach, baking soda, sea water). Pure (de-ionized) water has a pH of 7.0.

NYS Learning Standards:

English
Standard 1 - Language for Information and Understanding: Listening and Reading

Math, Science, and Technology
Standard 3 - Mathematics: Measurement; Uncertainty
Standard 4 - Science: Physical Setting 2,3
Standard 6 - Interconnectedness: Magnitude and Scale

Source: Activity developed by Nathan Chronister and Aaron Bennett.

WIND SCALE

To determine how hard the wind is blowing, look at the trees and bushes. Use the scale below as your guide. Write the *number* that best describes the conditions during your trip.

❶ *No wind*: Nothing is moving. Even the leaves are still.

❷ *Very light wind*: Leaves are gently rustling.

❸ *Light wind*: Leaves and branches are moving slightly.

❹ *Windy*: Leaves and branches are moving a lot.

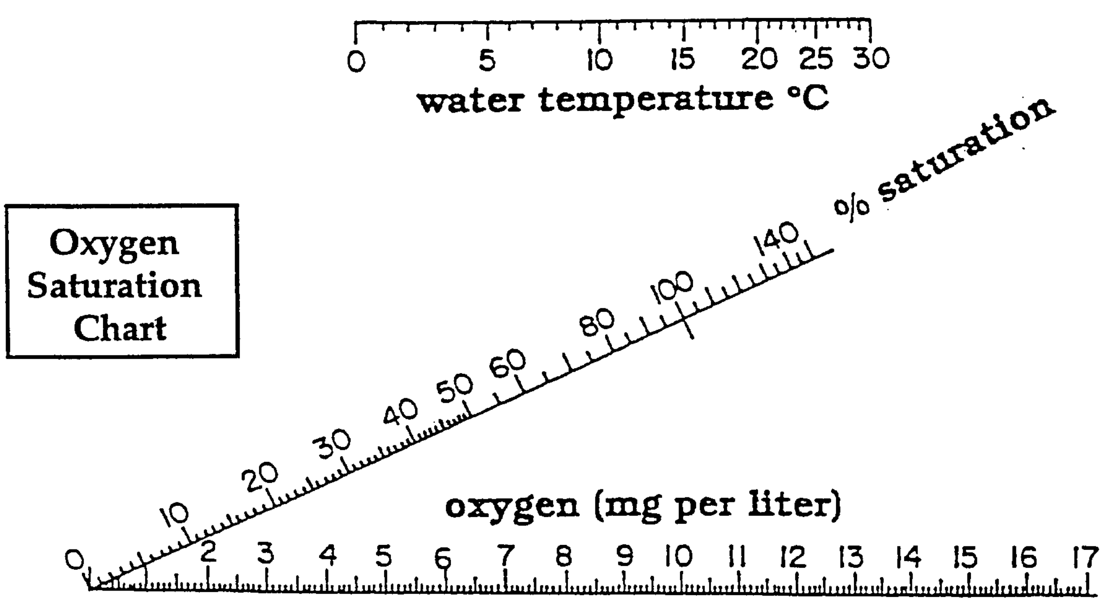
❺ *Heavy wind*: Large branches are bending.

❻ *Gale*: Leaves and small branches are breaking off of the trees.

❼ *Heavy gale*: Large branches are breaking off of the trees.

❽ *Hurricane or tornado*: Trees and houses are falling down. No school!

PERCENT OXYGEN SATURATION



Water Characteristics Quiz

Name: _________________________ Date: __________ Teacher: __________________

Directions: Please answer the questions below using the information you learned in this activity.

1. What is data?

2. How could different weather conditions affect streams?

3. If a stream's water is *turbid*, is that healthy for a stream? Why or why not?

4. A high amount of oxygen in a stream is very good. How could oxygen get into water, and what kind of water holds more of it, warmer or colder?

5. The pH scale tells us how *acidic* water is. What is the opposite of an *acid*? Pure water would have a pH of what? (Hint: Remember, the pH scale goes from 0-14)

Buckets of Bugs

Grades:

3rd - 12th

Objective:

Students become familiar with several types of the macroinvertebrates they may find in a stream. This activity also shows students how to determine the level of impact that pollution has had on a stream. By looking for certain types of macroinvertebrates, students will be able to decide if a stream is “impacted” or “non-impacted”.

Method:

Each group of students will be given a fictitious stream sample on cards. They will identify each specimen and follow a set of screening criteria to analyze their stream’s health.

Materials:

Six (or more) plastic containers (16 oz.), cut-outs of the macroinvertebrates (sheets enclosed), copies of the Biological Data Sheet (see appendix) stonefly, mayfly, or caddisfly picture (enclosed) for each student, overheads (Biological Data Sheet, caddisfly), identification key from appendix for each group (two versions depending on grade level), and crayons.

Time:

Preparation Time: 30 minutes
Class Time: 30-45 minutes

Procedure:

1. Preparation: Make six copies of each macroinvertebrate card sheet. Cut out along the lines. Divide up the cards into the different buckets, putting at least 10 in each bucket. We suggest that you purposely create one or two buckets representing *non-impacted* streams, and at least one group have an extremely *impacted* stream. This is accomplished by strategically placing certain cards. *Non-impacted* streams would include: mayflies, stoneflies, caddisflies, water pennies, and hellgrammites. A very *impacted* stream would consist mostly of aquatic worms. A moderately impacted sample would have a random assortment of the various creatures.

2. Begin by reviewing the three body segments of an insect, as well as the differences between the mayfly, stonefly, and caddisfly. Hand out the large drawings so that each student has either a mayfly, stonefly, or caddisfly. Students will color each segment a different color: head=red, thorax=green, abdomen=blue. Legs, wing pads, antennae, etc. are part of the segment to which

they attach and should be colored accordingly. Use the overhead to point out the three segments. The thorax/abdomen boundary is less clear on the caddisfly, so you need to emphasize that the part *with legs* is the thorax; everything behind that is the abdomen.

3. Explain how the body segments are used for identification: The STONEFLY has gills on its *thorax*, whereas the MAYFLY has gills on its *abdomen*. You can't always go by the number of tails; some mayflies have only two. Have students who have colored their body segments correctly stand up and point out the segments and gill locations to the class.

4. Tell the class that they are going to be given a bucket with specimens collected from a stream. Their job is to sort through the aquatic insects and determine whether their stream is IMPACTED or NON-IMPACTED. Introduce these two terms. IMPACTED means a stream has had some impact from pollution. NON-IMPACTED means that there is no sign of pollution. These streams have the highest water quality. There are many degrees of how impacted a stream is, from very impacted, to just slightly impacted, to not impacted at all.

5. Once the difference between impacted and non-impacted is clear, divide the class into groups of no more than four. The number of groups should equal the number of buckets.

6. Give each student a copy of the Biological Data Sheet. Give each group an identification key and a container with cards. Put up the overhead of the Biological Data Sheet, and have students fill out the upper portion of their own data sheets. Explain how to fill out the data sheet based upon their sample, *up to* the Screening Criteria section. This section will be done as a class.

7. Instruct the groups to sort and identify the invertebrates. They can use their knowledge of mayflies, stoneflies, and caddisflies, plus the identification key. After they have the types and numbers recorded, they can add up the totals for their group.

8. When all of the groups are finished and the buckets have been collected, explain the section on the data sheet entitled *Screening Criteria For Non-Impacted Streams*. This method for classifying streams is used by the Department of Environmental Conservation (DEC).

Note: Ignore the requirement for 3 species of mayflies since we aren't really at the stream. Also, make sure the students understand they should only check the box that deals with worms if they do *not* have any. It is the opposite of the other four boxes.

9. After you have gone through each criterion with the class, ask each group how many boxes they have checked and what that means in terms of impacted and non-impacted.

Options:

1. The last two pages in this activity provide a more advanced option for practicing identification skills. Using the sheet of actual size insect drawings, students complete the Hudson Basin River Watch “Biotic Index” data sheet found in the appendix. Use this activity with the more advanced identification key, also found in the appendix.

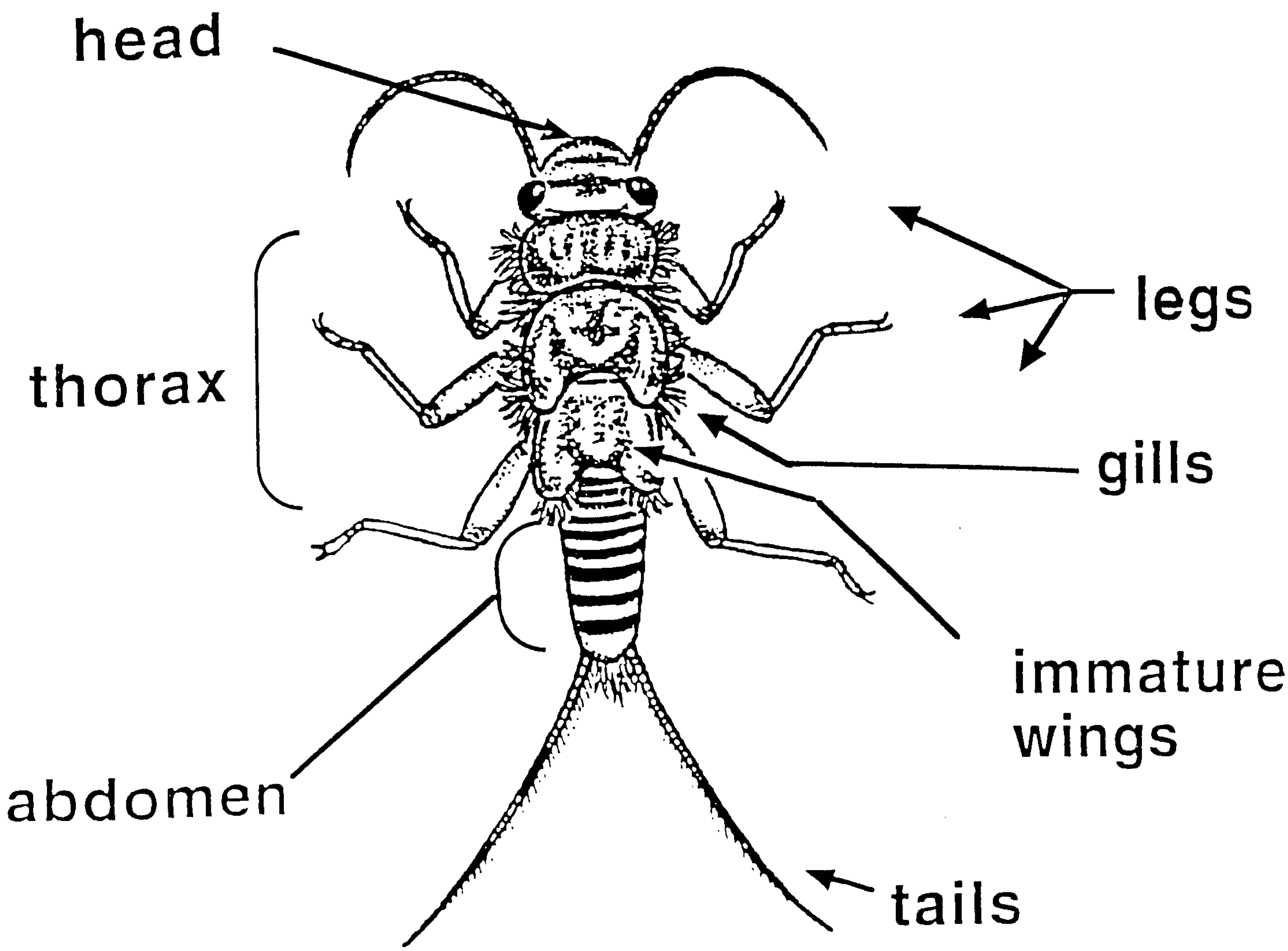
Assessment:

1. Use the enclosed quiz as an assessment. Answers are provided on the answer key.

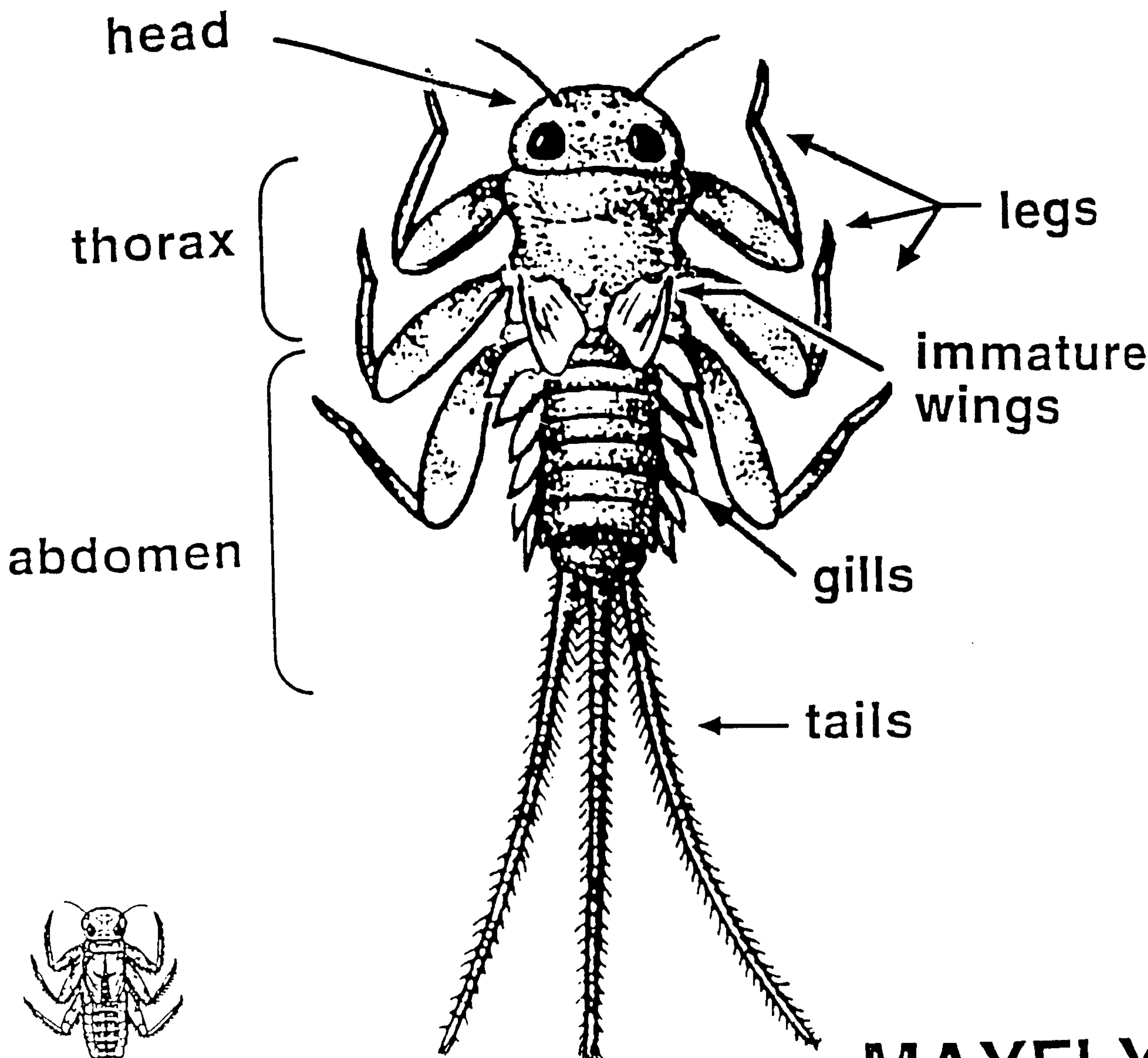
NYS Learning Standards:

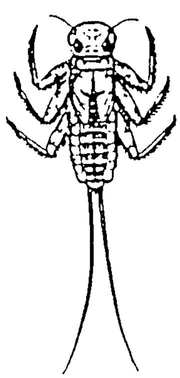
Math, Science, and Technology
Standard 1 - Analysis, Inquiry, and Design: Scientific Inquiry 1
Standard 4 - Science: The Living Environment 1, 5, 7

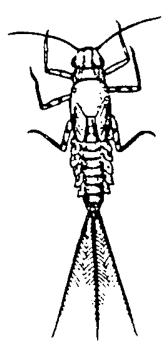
Source: Activity developed by Nathan Chronister and Aaron Bennett.



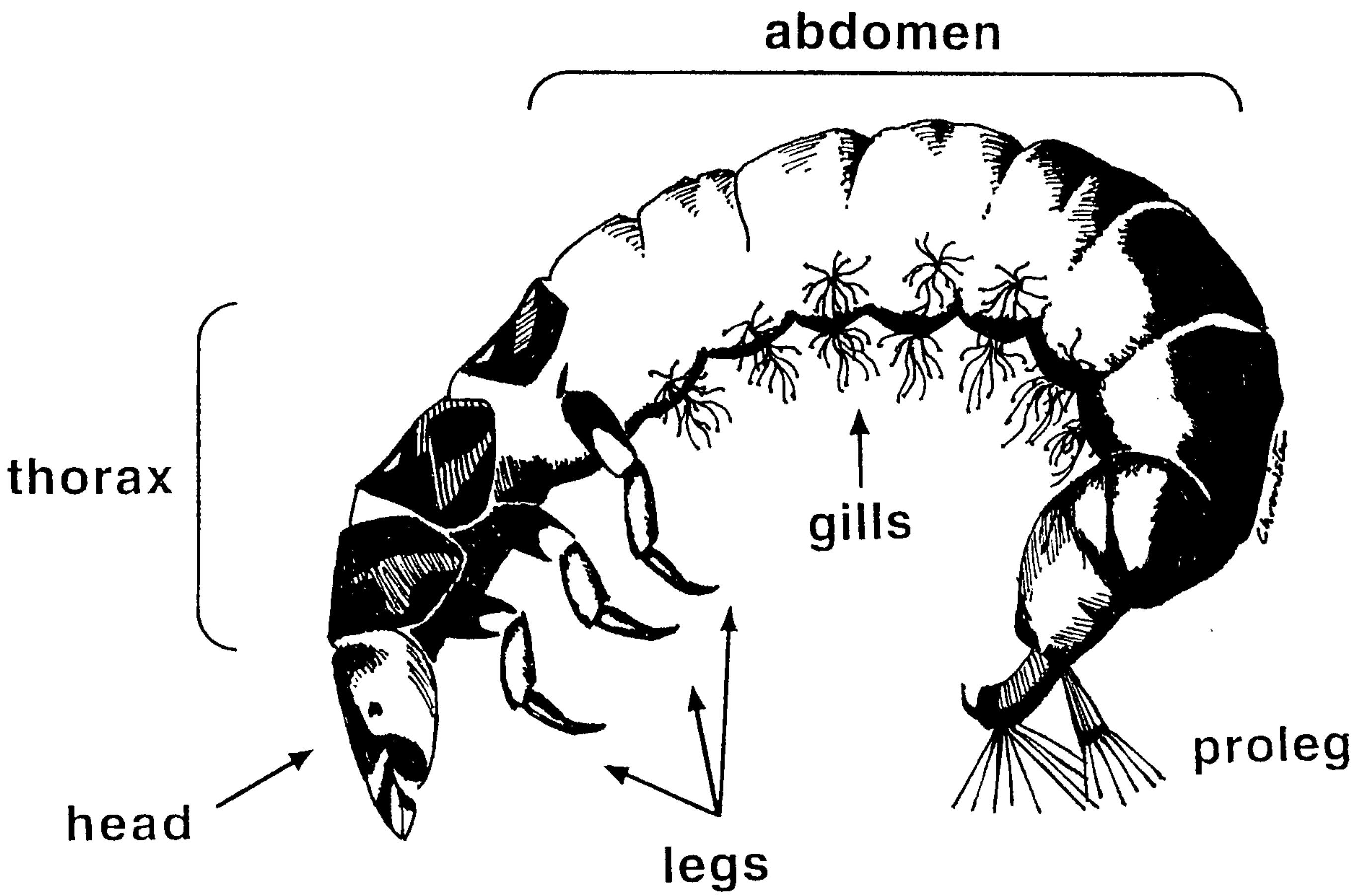
STONEFLY NYMPH



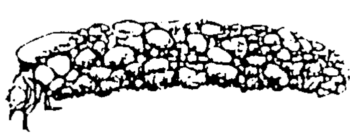


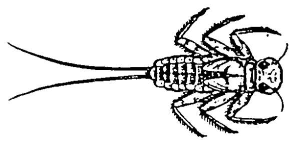
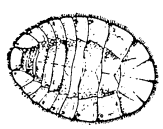
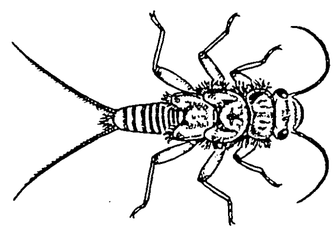
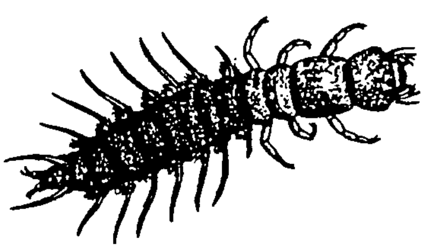
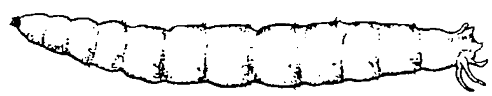


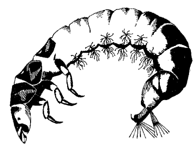
MAYFLY NYMPH

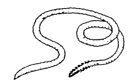


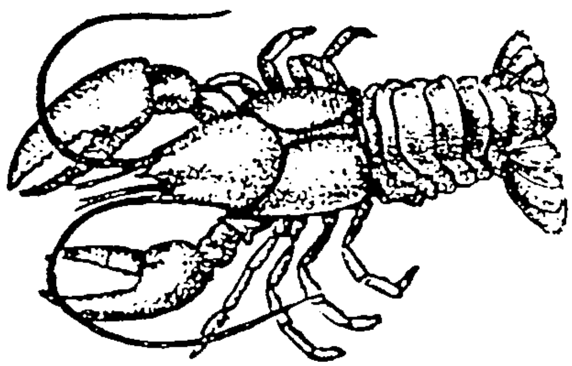
CADDISFLY LARVA

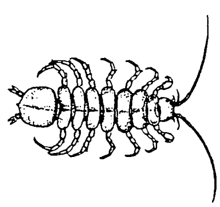


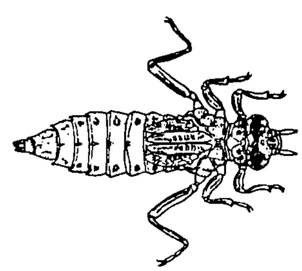
	
	
	











Buckets of Bugs Quiz

Name: ________________________ **Date:** __________ **Teacher:** __________________

Directions: Answer the questions below using the information you learned in the activity.

1. What is the difference between an *impacted* stream and a *non-impacted* stream?

2. List three types of aquatic insects you would expect in a non-impacted stream?

3. What is the *best* way to tell stoneflies and mayflies apart?
   (Hint: It is not by counting their tails!)

4. What is a *macroinvertebrate*?

5. Do all macroinvertebrates that live in streams and ponds breathe oxygen from the water?

Buckets of Bugs Quiz

ANSWER KEY

Name: ________________________ **Date:** __________ **Teacher:** __________________

Directions: Answer the questions below using the information you learned in the activity.

1. What is the difference between an *impacted* stream and a *non-impacted* stream?

An impacted stream has pollution in it and a non-impacted stream doesn't.

2. List three types of aquatic insects you would expect in a non-impacted stream?

Any three of these: mayfly, stonefly, caddisfly, water penny, beetle.

3. What is the *best* way to tell stoneflies and mayflies apart?
   (Hint: It is not by counting their tails!)

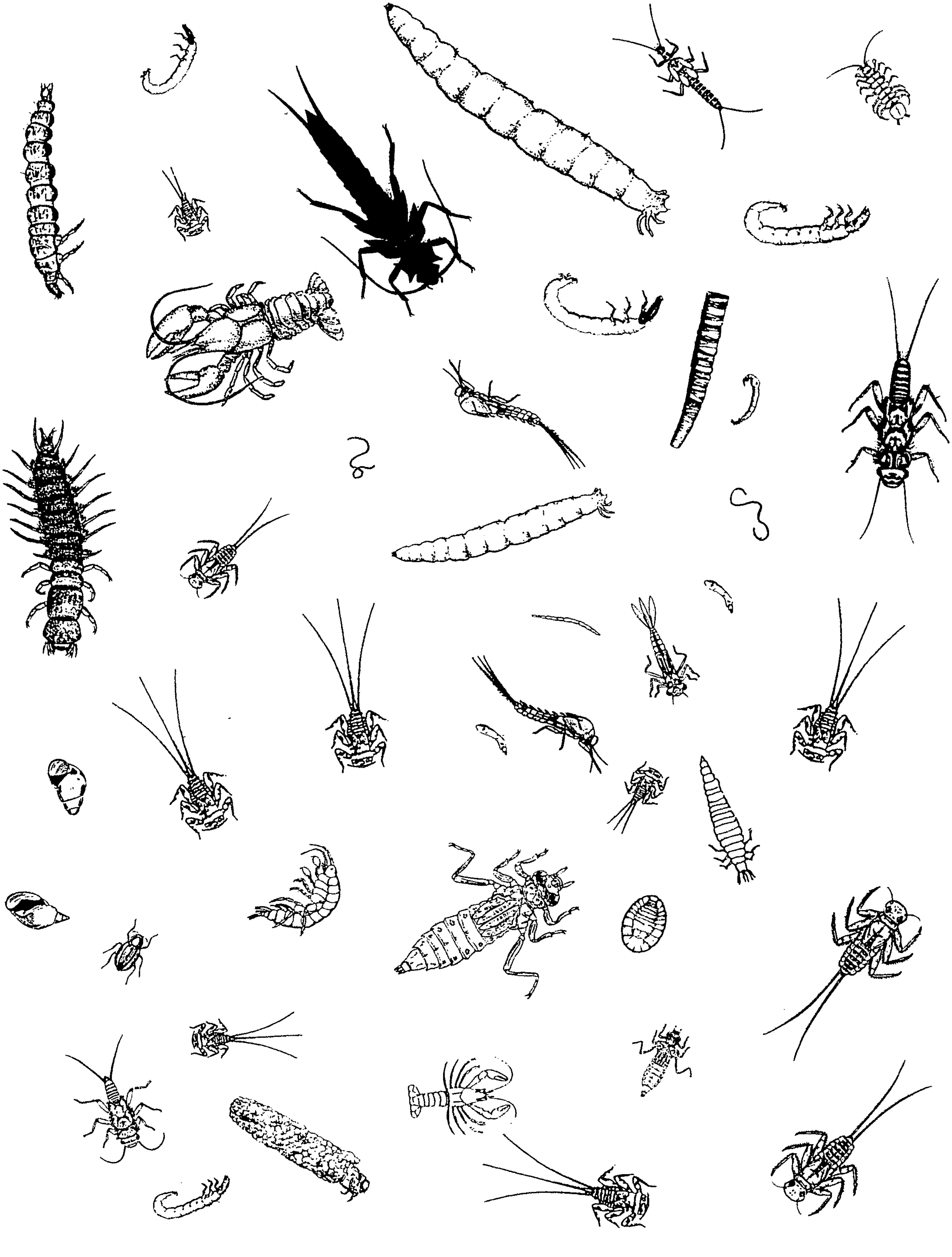
Mayflies have gills on their abdomens. Stoneflies do not.

4. What is a *macroinvertebrate*?

It's an animal without a backbone that you don't need a microscope to see.

5. Do all macroinvertebrates that live in streams and ponds breathe oxygen from the water?

No. Some breathe from the surface.



Benthic Macroinvertebrate

Major Group Biotic Index Worksheet

ANSWER KEY

Major group	A # of Organisms in Sub-sample	B Assigned Biotic Index	C Biotic Value for Group
Mayfly	12	2	24
Stonefly	4	1	4
All Caddisfly except Netspinner	3	3	9
Netspinner Caddisfly	4	5	20
Dobsonfly, Fishfly	1	4	4
Alderfly	0	4	0
Water Penny	1	4	4
Whirligig Beetle	0	4	0
Other Beetles	2	5	10
Crane Fly	2	4	8
Watersnipe Fly	0	4	0
Black Fly	2	5	10
Midge	2	6	12
Dragonfly	2	3	6
Damselfly	1	7	7
Crayfish	2	6	12
Scud	1	6	6
Sowbug	1	8	8
Clam	0	6	0
Snail	2	7	14
Leech	0	7	7
Aquatic Worm	2	9	18
TOTALS	D 44		E 183

Instructions: (Try to pick up at least 100 individual organisms.) Using the "BMI Sorting" worksheet, count the number of organisms for each major group identified in your sub-sample and record in column A. Sum the total of that column and record in D. Multiply the number of organisms in each Major Group by the assigned biotic index value (see column B) and record the results in column C. Sum the total of that column and record in E. To get the Biotic Index Score, divide E by D.

Biotic Index Score= $\dfrac{\text{E total biotic value}}{\text{D total \# organisms in your sample}}$ = **4.16**

Biotic Index:	0-4.5 non-impacted	4.51-6.50 slightly impacted	6.51-8.50 moderately impacted	8.51-10 severely impacted

Much Ado about Macroinvertebrates

Grades:

4th - 9th

Objective:

Students will become familiar with some of the macroinvertebrates they may find in local streams. This activity will provide the opportunity to learn specific traits about certain macroinvertebrates: where they live, what they eat, how they move, etc.

Method:

Students will choose or be assigned a macroinvertebrate, and they will work in groups to look up information about the macroinvertebrate. They will share the information they find with the rest of the class, emphasizing points that students find interesting.

Materials:

Several copies of The Catskill Center's *Guide to Freshwater Animals Without Backbones* (or similar books) and the cutout sheets of macroinvertebrates (enclosed).

Time:

Class Time: 20 minutes

Procedure:

1. Divide the class into groups. The number of student groups should equal the number of copies you have of the *Guide to Freshwater Animals Without Backbones.* Give a copy to each group of students.

2. Have each group choose a macroinvertebrate (starting on page 46 in the guide) that they are interested in, or use the cutouts to have students randomly pick bugs out of a hat.

3. After each group has chosen a macroinvertebrate, instruct them to write down the following information:

   What is their macroinvertebrate called?
   Where does it live?
   What does it eat?
   What kind of water does it live in?
   Write one more interesting fact about the animal.

4. After every group is finished, have one person from each group share their information with the rest of the class.

5. When everyone has shared their information, you may wish to compare and contrast some of the macroinvertebrates, emphasizing differences in how they survive, or ask students to pick their favorite and tell why. For an extension of this activity, ask students to draw the invertebrate and how it lives in its natural habitat.

Assessment:

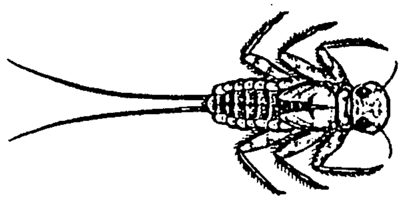
Gauge the participation of the students, as well as their understanding of some of the differences between each of the invertebrates.

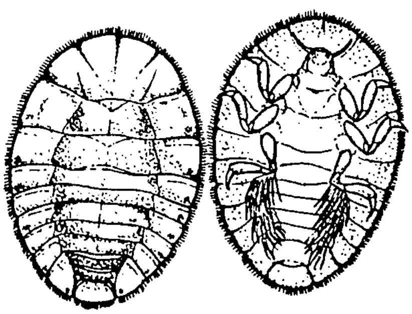
NYS Learning Standards:

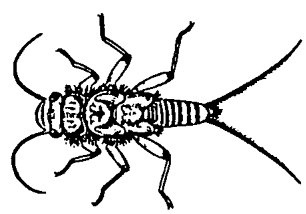
English
Standard 1 - Language for Information and Understanding: Listening and Writing; Speaking and Writing

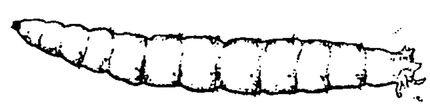
Math, Science, and Technology
Standard 4 - Science: The Living Environment 1,5

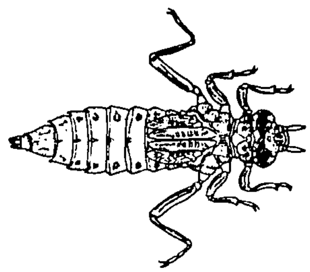
Source: This activity developed by MJ Reiss and Aaron Bennett.

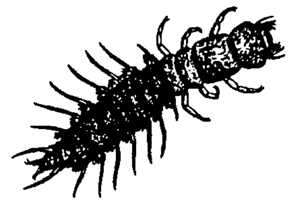


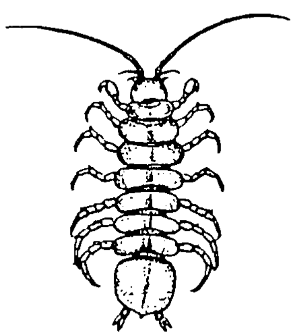


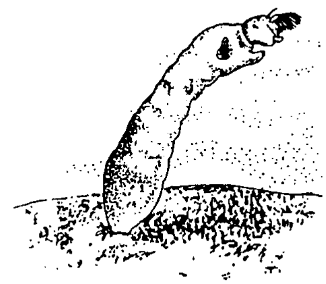


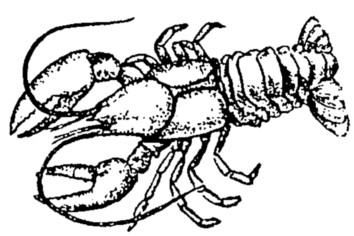












Stream Field Trip

Grades:

4th - 12th

Objective:

Gives students the opportunity to see in nature what they have been learning about in the classroom.

Method:

Transport students to a real stream to see living macroinvertebrates and collect water quality data.

Materials:

Boots (or old shoes), change of clothes.
Clipboards with: data sheets, wind scale, pencil, insect identification key (appended material).
Thermometer, measuring tape (or cord marked every meter), meter stick, seine or D-net, shallow containers for macroinvertebrates, dissolved oxygen test kit, pH test kit.
Optional: foam brushes.

NYSDEC requires a permit to collect aquatic invertebrates. Call The Catskill Center Director of Education for info at (845) 586-2611.

Time:

Field Trip: allow 60 to 90 minutes at the stream.

Procedure:

Note: Before beginning, the teacher should carefully read Lesson 2 Summary and complete Activities 1, 2, and 3.

1. Collect supplies needed for field trip. Visit the stream ahead of time to make sure it is safe and that there is room for your class to split into three groups along the stream bank. Note that heavy rain or rapid snowmelt can raise the water level overnight.

2. Send a note home with students saying what they should bring: waterproof boots or a pair of old shoes they can get wet, a change of clothes, and warm clothing even if it is a nice day. Invite parents to help with the field trip.

3. Before leaving, review basic safety rules such as listening, taking turns, and respect for others. Students must agree to these rules before going to the stream.

4. Divide students into about three groups (about 7 per group), one for each educator. A parent volunteer may lead a group if the parent is familiar with Streamwatch procedures and good with children.

5. Station each group at a pre-designated spot along the stream.

6. The group leader should assign tasks to individual students to insure completion of the data sheets. Sometimes we complete the physical & chemical data sheet before allowing all of the students into the stream to collect invertebrates. Other times this data sheet is completed by selected students while others are collecting. Choose the method that you feel will work best with your group.

7. Watch for kids getting too wet, especially in chilly weather. If there is a safety concern, have these individuals stay out of the water.

8. Allow time for students to return to the school and, if necessary, change their clothes.

9. To wrap up the field trip, have each group choose a representative to report to the class.

10. Compile the data from each group onto a single data sheet and send a copy to The Catskill Center to be shared with other schools.

Extension: A copy of Total Flow and Stream Habitat Survey data sheets are included in the appended material. This data can be collected if time permits, or on an additional field trip. This information helps to paint a better picture of the sampling area, and could help explain trends that may occur. The instructions for conducting total flow and the habitat survey are located on the data sheets.

Assessment:

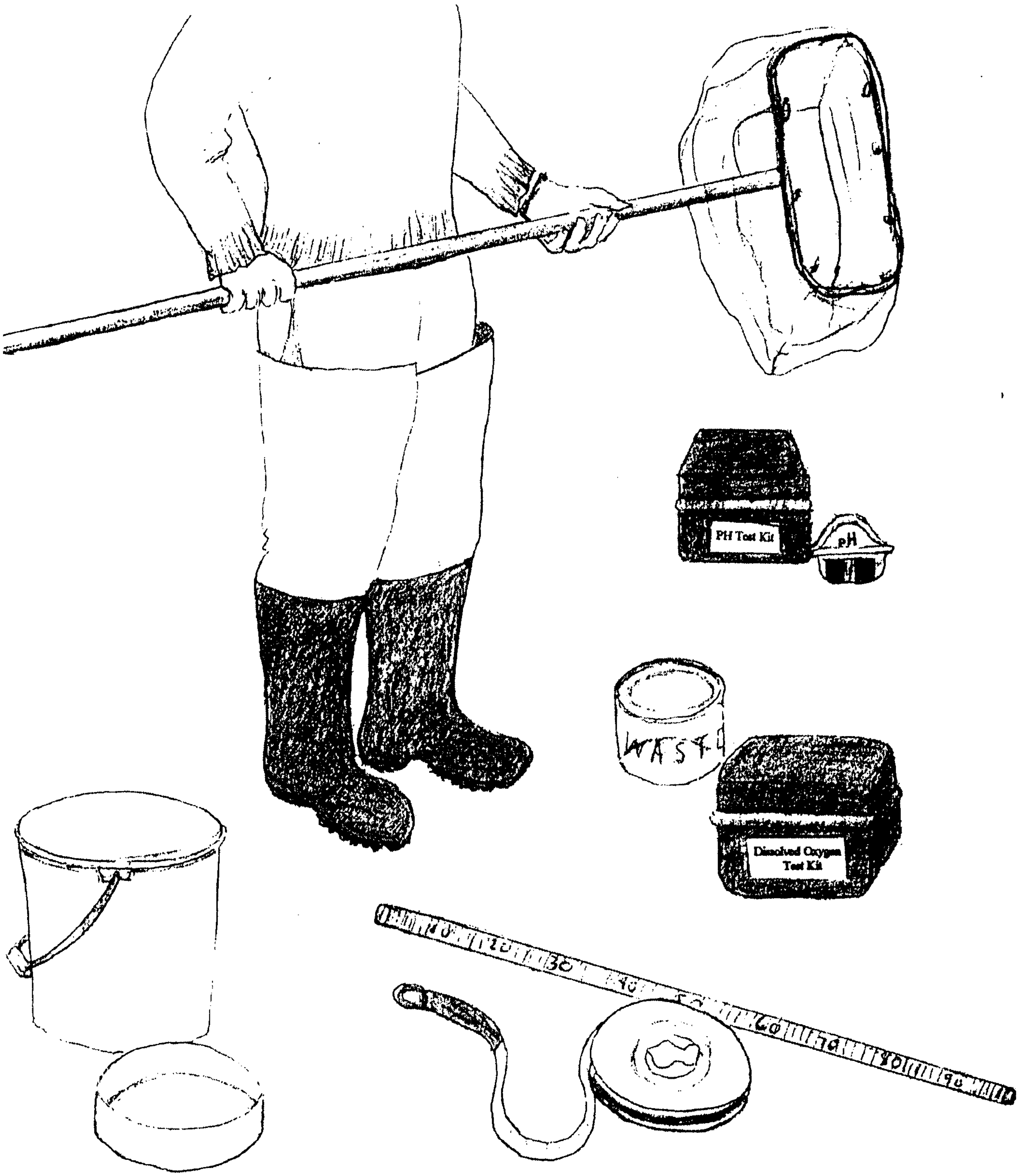
Completeness and accuracy of data sheets can be used to assess student participation and skills. Also observe student participation in field activities.

NYS Learning Standards:

English
Standard 1 - Language for Information and Understanding: Listening and Reading

Math, Science, and Technology
Standard 3 - Mathematics: Measurement; Uncertainty
Standard 4 - Science: Physical Setting 2; The Living Environment 1,3,6,7
Standard 6 - Interconnectedness: Magnitude and Scale
Standard 7 - Interdisciplinary Problem Solving: Connections; Strategies

Source: This activity developed by Nathan Chronister and Aaron Bennett.


PH Test Kit
pH
WASTE
Dissolved Oxygen
Test Kit

Taking Care of Our Watershed

The activities included in this lesson focus on various sources of pollution and how pollution can affect our daily lives. This lesson will also cover pollution prevention, and the role of industry in the pollution of fresh water. First we introduce pollution types and some terminology. Included as well will be groundwater pollution, which can result in contamination of drinking water, the role of wetlands as water filters, and the wastewater treatment process.

Many families, especially in the Catskill Mountains, use groundwater from a well or a spring to supply their homes with water. Because groundwater plays a large role in the water cycle and is relied upon by many homes, the necessity for protecting our groundwater is quite obvious. When water enters the ground, gravity moves it downward until an impervious layer stops it. The soil on top of this bedrock layer must become saturated first, before the soil above it can become saturated. The area of saturated soil (where all pores spaces between the soil are filled with water) is called the *zone of saturation*. The upper boundary of the zone of saturation is called the *water table*. The soil above the water table may be moist, but it is not saturated. The level of the water table fluctuates, especially during droughts and rainstorms. When a well “dries up” during the summer, this indicates the water table has dropped below the bottom of the well.

Groundwater pollution is next to impossible to clean up in part because you cannot clearly see how far the plume (the dispersing pollution) has traveled, and at what rate it is moving. Remember, groundwater flows but not always downhill. Landfills, underground waste dumps, leaky septic tanks, and underground storage tanks (e.g., gasoline, oil) are the major sources of contamination, and the only real solution is prevention.

Point vs. Non-point Source Pollution

Pollution is considered to be either *point source* or *non-point source* pollution. Point source pollution is defined as pollution that comes directly from a known source, like the end of a discharge or drainage pipe. Non-point source pollution is defined as pollution without a specific, single source; for example, acid rain results from many different pollution sources throughout the world. Storm drains are considered non-point sources because they collect runoff from many places, such as parking lots that are polluted by many different cars (sources). Point and non-point source pollution are also terms used to classify air pollution. Smokestacks are examples of point sources, while cattle herds, a source of the methane gas polluting our atmosphere, are considered a non-point source of air pollution.

Pollution at Home

A typical home in the Catskill Mountains (or elsewhere) can experience many types of pollution, and contribute to pollution in many ways people never realize. If your drinking water has high levels of various chemicals, you may be need to filter your water. Your daily activities can pollute your own water or that of other people who live in your watershed! Using excess fertilizer, car fuel leaks, washing your car, storing rusty metal outside, and other sources contribute to groundwater pollution and may eventually contribute to drinking water pollution. In villages and urban areas, these contaminants wash into storm drains, which eventually lead to a river or stream, usually without any form of treatment.

Wetlands

One way pollutants can be removed from a stream or river is by wetlands. Wetlands provide a service called *leaching*, a process that removes most or all of the impurities, nutrients, and silt or sediment. Wetlands are sometimes used as a primary treatment for wastewater before it even begins the normal treatment process. Wetlands function in many other amazing ways as well. Flood control may be the biggest asset of wetlands, because they can hold water even if the entire ground is saturated. The runoff from floods can be absorbed, as if by a sponge. Wetlands also provide habitat for some of the most interesting wildlife on the planet, especially migratory birds. The many species of flora in any wetland allow oxygen and nutrients to mix with the surrounding water. The New York City Department of Environmental Protection (NYCDEP) now focuses much attention on the importance of wetlands. Wetland field trips can be arranged through Beth Gelber of NYCDEP, whose contact information is provided in the appended material.

Forestry

The role of forestry in pollution prevention is an important one. Logging is often viewed by the general public as harmful to the logged area, and to the environment as a whole, but this is not always true. There are times when clear-cutting (logging every tree within a specific area) is necessary to make way for man-made structures, or for other land uses. Clear-cutting is one of the worst things that could possibly be done to a forest. It not only ruins the forest ecosystem, but if the land is sloped, it can cause erosion and aesthetic problems. Responsible loggers take necessary measures to prevent environmental degradation by constructing logging roads where the gradient is not very steep, and by reusing old logging roads when possible. Under those conditions, *selective* tree cuttings can be healthy for forests.

Fires are often considered good forestry practices because wild fires generally do not burn long enough or hot enough to kill trees before they run out of fuel. Burning the understory gives the larger trees and many smaller plants more room to grow. Certain fires are started on purpose (a controlled burn) and some naturally-occurring wild fires are left to burn themselves out if they do not spread out of control. The fire simply wipes out the smaller, often invasive understory that can sometimes prevent the formation of the ideal forest.

Agriculture

Much like logging, if agricultural practices are not kept in check, the repercussions on the environment are profound. Farmers, both crop and dairy, can completely destroy a local stream if proper farming practices are not used. With most farms being built in proximity to a watercourse, pollution can enter the stream easily from a number of sources. Fertilizers and pesticides that are applied in excess or just prior to a rainfall will wash into the stream. Oils and fuels from machinery that leak or spill will soak into the ground and wind up in the stream and groundwater. Runoff containing animal wastes from barnyards and pastures will flow untreated into a nearby stream. Now more farmers are adopting new technologies to meet recent state and federal pollution standards, but some farmers cannot afford the technology. They believe the incentive is not great enough for them to change farming practices which likely have been used for generations. Farmers must be willing to cooperate with the new standards being set; and state and federal government must understand that the farmers require money and incentives to undertake these improvements.

Wastewater Treatment

Wastewater treatment plays a large role in pollution prevention. Ideally, this means taking polluted water and making it clean. Wastewater enters a treatment plant through a screen that filters out all of the large debris, like pebbles, rocks, seeds, etc. These settle out in the *grit chamber*, before the water enters the *primary settling tank*, where the solids, or sludge, settle to the bottom. The wastewater is passed on to the *aeration tank*, where oxygen and bacteria are added. After aeration, the wastewater moves to the *clarifier* for secondary settling. After the sludge has settled, it is pumped to the *sludge digester*, and disposed of after by first drying it out and stabilizing it. Then it is deposited in landfills, composted, or used as fertilizer. The water from the clarifier has now been treated and is ready to be used once again or discharged into a nearby water body.

Wastewater from sanitary sewers and from sewers that gather stormwater are often linked. Many municipalities, during large storms, experience what is called a Combined Sewer Overflow (CSO). A CSO only occurs when there is a large storm, with a great deal of runoff, which combines with the city's sewage, resulting in too much wastewater for the treatment plant to handle. Most wastewater treatment facilities are near bodies of water, so when overflows occur, the water source takes a direct hit of untreated wastewater. The best solution to this problem would be to separate the stormwater drains from the sanitary sewers. Stormwater becomes polluted by many sources, most of which could be reduced in any household. Some ways are: 1) Use less fertilizer and pesticides. 2) Do not leave hillslope soil exposed. 3) Do not store rusty metal outside. 4) Maintain your car. 5) Do not use lead-based paint. 6) Do not litter.

The Significance of Wetlands

In their natural condition, wetlands supply numerous ecological, economic, and cultural benefits to local communities -- including water quality protection, flood control, erosion control, fish and wildlife habitat, aquatic productivity, and unique opportunities for education and recreation.

Water Quality Protection

Whether communities obtain their drinking water supply from groundwater wells or from reservoirs fed by surface waters, it is important to protect the many functions of wetlands in maintaining water quality. One of the most important functions of wetlands is the ability to maintain good surface water quality in rivers, streams, and reservoirs and to improve degraded surface waters. Wetlands do this several ways: 1) By removing and retaining nutrients. 2) By processing chemical and organic wastes. 3) By reducing sediment loads.

Wetlands are particularly good water filters. Due to their landscape position between uplands and deep water, wetlands intercept surface water runoff before it reaches open water and filter out nutrients, wastes, and sediments from flood waters. This function is important in both urban and agricultural areas.

In some places, wetlands contribute to the recharge of groundwater sources of drinking water. During periods of heavy runoff, such as major storms or snowmelt in the spring, wetlands adjacent to streams and in depressions collect excess water. When the water table drops, the water held in the wetlands infiltrates slowly back through the soil into the aquifer to replenish groundwater.

Flood Control

By temporarily storing and slowly releasing flood waters, wetlands help protect adjacent and downstream property owners from flood damage. Trees and other wetland plants help slow the velocity of floodwaters. This action, combined with water storage, allows wetlands to lower flood heights and reduce the water's erosive force.

Wetlands in and downstream of villages are especially valuable for flood protection, since the impervious surfaces associated with development increase the rate and volume of surface water runoff, thereby increasing the risk of flood damage downstream.

Erosion Control

Wetland plants such as willows buffer stream banks against the forces of erosion by binding soil with their roots and by reducing current velocity and wave action. Bioengineering techniques -- coconut fiber mats used in combination with willow cuttings -- provide habitat and aesthetic values not afforded by structural shoreline protection measures such as rock riprap.

Aquatic Productivity

Wetlands are among the most productive natural ecosystems in the world. Certain types of wetlands rival the best cornfields in biomass productivity. A large volume of plant material is produced annually by wetlands. The leaves and stems of wetland plants break down in the water to form small particles of organic material, called detritus. This enriched detritus serves as the base of an aquatic food chain, providing a principal food source for small aquatic invertebrates and forage fishes, which are in turn consumed by larger predatory fish, such as bass and trout.

Fish and Wildlife Habitat

Wetlands provide critical habitat for several animal species including the wood duck, muskrat, river otter, spotted salamander, and water snake. An estimated 43% of the nation=s threatened and endangered species rely directly or indirectly on wetlands for their survival. The bog turtle, a candidate species being considered for federal protection, may be found in wet meadows throughout the watershed region. The northern monkshood, a threatened plant, is associated with wetlands in seeps and the headwaters of streams in the Catskills.

Inland wetlands provide nursery grounds and feeding habitat for freshwater fish. A variety of birds are associated with inland wetlands, including ducks, geese, red-winged blackbirds, and a large number of nesting songbirds. Many important recreational fish, including bass, spawn in the aquatic portions of wetlands. Trout, a coldwater species, benefit from cooler water temperatures provided by streamside vegetation along Catskill streams.

Quality of Life

Several recreational activities take place in and around wetlands. Wetlands serve as a location for hunting, fishing, and trapping. Trout fishing is very popular with local residents and visitors to the Catskill region. Wetlands provide an opportunity for other recreational activities like hiking, bird watching, and photography. Many people may simply enjoy the beauty and sounds of nature, and spend time walking or boating around wetlands. They can observe plant and animal life, frogs and turtles along pond and lakeshores, or marsh marigold in spring or the crimson leaves of red maple in the fall. Wetlands provide unique educational opportunities for outdoor study and the appreciation of natural history, ecology, conservation, and biology by students of all ages.

Source: "The Significance of Wetlands" section excerpted from *Wetlands in The Watersheds of the New York City Water Supply System*, US Fish and Wildlife Service, 1996.

For more information on Catskill wetlands, please call Beth Gelber, Stream Management Program, New York City Department of Environmental Protection at (845) 340-7515.

Who Dirtied The Water?

Grades:

4th - 12th

Objective:

Students will learn about current sources of water pollution, how these sources bring about water quality issues, and ways that these sources of pollution are being controlled.

Method:

Students will actively participate in creating a visual representation of a body of water that receives pollution from various sources. Students will discuss what causes underlie the types of pollution represented and how alternatives can be found to help reduce pollution.

Materials:

Labeled film canisters filled with the various materials that represent different pollutants (refer to chart), a large, clear glass or plastic container, a spoon, “pollution clean-up tools”: sponge, paper towels, sieve, coffee filters, baking soda, pH paper, 2 plastic fish or other aquatic animals (optional).

Time:

Preparation Time: 20 minutes
Class Time: 30 minutes

Procedure:

Note: The purpose of using the plastic fish is to keep the students more focused on the activity. If you decide to use an animal, we recommend giving them names like Bobby the Bass and his cousin Betty the Bass.

1. **Preparation.** Set up the container (filled part of the way with water) where everyone can see.

2. Ask students: What is an issue? Emphasize that an issue is a problem caused by differing opinions based on different values that result in different ways of doing things.

3. Explain that this activity focuses on water quality issues, or water pollution issues.

4. Randomly pass out film canisters containing materials that represent different forms of point and non-point source pollution. Make sure each canister has a label that links it to a

character in the story (see table). Ask students to notice which character they are representing.

5. Show students the clear container (that now has a few inches of clean water in it), and tell them it represents a very clean lake. Ask if they would boat on the lake. How about swim in the lake? If water were treated first, would they drink it? Why or why not? If you chose to use plastic fish or other aquatic animals, place one in each container.

6. Explain that you will be telling them a story about the lake, and as their character is mentioned, they should come up to the lake and pour the contents of their canister into the lake. Tell the story of the lake, introducing each character from the chart, one at a time. After each character pollutes the lake, ask the students if they would still boat, swim, or drink water from the lake. Why or why not?

7. Discuss what happens to the animals you placed in the lake, and other organisms and plants living in the lake? At what point (after which pollutants) do they begin to become affected?

8. Draw the chart on the board to help discuss what real life source of pollution each character represents. Is it a point or non-point source? What ways can each source be prevented or reduced?

9. How would the pollution effects differ in a river?

10. Who is responsible for cleaning up the lake? Give students “pollution clean-up tools” and see if they can get the water clean again. (Baking soda can be used to neutralize the vinegar, pH paper to test for neutralization).

Assessment:

Use the questions throughout the activity as an assessment of students’ understanding.

NYS Learning Standards:

English
Standard 2 - Language for Literary Response and Expression: Listening and Reading
Standard 3 - Language for Critical Analysis and Evaluation: Listening and Reading

Math, Science, and Technology
Standard 4 - Science: Physical Setting 2; The Living Environment 7
Standard 7 - Interdisciplinary Problem Solving: Connections; Strategies

Source: This activity adapted from Southern Rhode Island Conservation District’s *Active Watershed Education Curriculum Guide.*

The "Who Dirtied The Water" Story

Note: *After each paragraph, after a substance is added to the container of water, ask the following questions to the class:*

- *Would you drink from the lake if it had a drinking water treatment plant?*
- *Would you swim in the lake? Would you boat on the lake?*

This is merely our version of this story; feel free to modify it to fit your needs.

Once there was a large lake surrounded by green forests and brush land. It was a clear lake, and the only pollution the lake received was natural, from **TREES**. This was not a problem since the lake was not being used for drinking water.

In a little while, though, the **1st HOME OWNER** moved in. They had a septic system, but did not use it wisely. The **1st home owner** used toxic household cleaners and dumped them down the drain. They ended up in the lake after passing through the septic system.

Not too long after that, a **2nd HOME OWNER** moved in, near the location of the first. They also had a septic system for their house. A few years went by and they did not keep their septic system maintained. The septic tank began to leak, and this also ended up in the lake.

At almost the same time, a **3rd HOME OWNER** moved in next to the second one. The family had a large green lawn, which the homeowner was quite proud of. Unfortunately, they used too much fertilizer and watered too often. A lot of the fertilizer washed down and away from the grass roots and eventually also ended up in the lake.

Now that there was a small neighborhood around the lake, people began to visit its beach. There weren't very many **BEACH GOERS**, but they did not pick up after themselves. They left litter on the shores and some of the litter ended up in the water of the lake, too.

There was a lot of flat, stone-free land around the lake, and two farms moved into the area. The **1st FARMER** practiced poor erosion control on his cropland and sediment from his fields made it's way to the lake, clouding it up. The **2nd FARMER** that moved in planted an apple orchard, used pesticides to keep insects from eating the apples. The farmer used too much of the pesticides, and they ended up in the soil. Eventually, they ended up in the lake too.

As the area around the lake became more and more developed, a shopping mall was built near the neighborhood. The shopping mall had a large parking lot, and it was always filled with cars from all around the area. Precipitation that fell on the **SHOPPING MALL LOT** was carried off, containing oil and rust from the cars, litter, and salt used for melting ice. The stormwater drainage system was not well designed and the stormwater runoff made its way to the lake.

Along a river that fed the lake, an industrial area built up. The first building was for the electric company. The **ELECTRIC COMPANY** burned coal to power its generators. The smoke that came from the smokestacks stayed in the clouds and formed acid rain, which fell onto the river and the lake.

The next two buildings contained a **CHEMICAL PLANT** and a **SEWAGE TREATMENT PLANT**. The chemical plant discharged heavy metals and organic chemicals into the river and the sewage treatment plant discharged raw sewage into the river, when the amount of sewage reaching the plant became too much to handle. Both types of pollution ended up in the lake.

The last thing to be built near our now-developed lake was a **GAS STATION**. To save on costs the gas station used low-quality underground tanks to store their gasoline. After a few years, the tanks began to leak. The gasoline flowed through the soil, reached the groundwater and flowed to the lake.

How can we possibly clean this up?

DISCUSSION CHART FOR "WHO DIRTIED THE WATER"

CHARACTER	CANISTER CONTENTS	POLLUTION	TYPE	ALTERNATIVES FOR PREVENTION
TREES	LEAVES	NATURAL ORGANIC	NON-POINT	NO PROBLEM EXCEPT FOR RESERVOIRS, CLEAR TREES/BRUSH FROM SHORES
1st HOME OWNER	A COLORED LIQUID	TOXIC CLEANERS	NON - POINT	USE BIODEGRADABLE CLEANSERS; IF YOU USE TOXICS, BRING TO SPECIAL WASTE SITES
2nd HOME OWNER	SLUDGEY COFFEE	LEAKING SEPTIC TANK	NON - POINT	MAINTAIN SEPTIC TANK PROPERLY
3rd HOME OWNER	SUGAR	LAWN FERTILIZERS	NON - POINT	LEAVE CLIPPINGS ON LAWN, USE ORGANIC FERTILIZERS
BEACH GOERS	SODA TOPS POPCORN	LITTER	NON - POINT	DON'T LITTER, PICK UP LITTER EVEN IF IT ISN'T YOURS
1st FARMER	SOIL	SEDIMENT (EROSION)	NON - POINT	PLANT COVER CROPS TO HOLD SOIL IN WINTER, CONTOUR PLOWING
2nd FARMER	SUGAR	PESTICIDES	NON - POINT	INTEGRATED PEST MANAGEMENT (IPM): MONITOR FIELDS, SPRAY ONLY THE MINIMUM AMOUNT NEEDED. ORGANIC FARMING: ORGANIC PESTICIDES, NATURAL PREDATORS, CROP ROTATION
SHOPPING MALL LOT	PENCIL SHAVINGS	STORMWATER RUNOFF, OIL, SALT	NON-POINT	DETENTION BASINS, CREATEDWETLANDS, SWALES, LOW-SODIUM SALTS
ELECTRIC COMPANY	VINEGAR	ACID RAIN	NON - POINT	CONSERVE ELECTRICITY, SMOKE-STACK SCRUBBERS, ALTERNATIVE ENERGIES
CHEMICAL PLANT	TURMERIC	HEAVY METALS, ORGANIC CHEMICALS	POINT	ALTER INDUSTRIAL PROCESSES, IMPROVE PRETREATMENT BEFORE DISCHARGE
SEWAGE TREATMENT PLANT	SLUDGEY COFFEE	ORGANIC NUTRIENTS, TOXIC CHEMICALS	POINT	BETTER SYSTEM DESIGN, DON'T THROW TOXIC MATERIALS DOWN THE DRAIN
GAS STATION	CORN OIL	LEAKING UNDER-GROUND TANKS	NON - POINT	BETTER TANK DESIGN & UPKEEP, CONSERVE GASOLINE

Non-Point Source Pollution on Stage

Grades:

4th - 7th

Objective:

To investigate the causes of non-point source (NPS) pollution, its effects on the environment, and ways that this pollution may be prevented.

Method:

Some students will learn about the various types of non-point source pollution by acting out examples of each, while the other students try to figure out what type of NPS they represent, and how to prevent future pollution of this sort.

Materials:

A copy of *Non-point Source Polluters* stories (enclosed)

Time:

Class Time: 30 minutes

Procedure:

"We use too many pesticides in this country -- a billion pounds a year. That's too many. It's put on the crops. It runs off into our rivers and lakes that become our drinking water."
- *USEPA Administrator, Carol Browner*

Intro: Non-point sources (NPS) of pollution are defined as sources dispersed over large areas of land that also discharge pollutants into the environment over a large area, like pesticides and acid rain. Water from precipitation falls to the ground and runs over soils following natural and human-made watercourses. Pollution mixing with the water as it runs off and seeps from land areas is a direct result of how we use the land. Animal wastes, litter, oils and greases, chemical residue, and soils from construction sites, plowed fields, and stream banks all wash from the land into our streams, lakes, estuaries, and groundwater. The following activity will help students become familiar with some examples of non-point source pollution in their everyday lives. Students are generally surprised to find that they contribute to this environmental concern. Therefore, it is important to include in this lesson the fact that through some minor changes in their lifestyles, they can help to lessen many causes of NPS pollution.

1. Begin by dividing the class into groups of three or four. Explain that you will be giving each group a card with a different example of non-point source pollution. Each group will need to act out their pollution story for the rest of the class. When performing, the students are not allowed to speak but they may make noises to simulate their actions. Give the groups a private space in the room and time to discuss and rehearse their performances.

2. When everyone is ready, have the groups perform their interpretations. After each performance, have the class discuss the following items: What type of NPS pollution was being acted-out? Discuss who and what might be affected by this pollution. List ways each example of NPS pollution can be prevented.

Assessment:

1. What sources of NPS pollution are present in your watershed?

2. What forms of NPS pollution can be avoided?

3. How are NPS pollutants like the sand in an hour-glass?

NYS Learning Standards:

Arts
Standard 1 - Creating, Performing, and Participating in the Arts: Theatre

English
Standard 3 - Language for Critical Analysis and Evaluation: Speaking and Writing

Math, Science, and Technology
Standard 4 - Science: The Living Environment 7
Standard 7 - Interdisciplinary Problem Solving: Connections; Strategies

Source: This activity was adapted from Frost Valley YMCA's *The Ways Of The Watersheds.* Adapted from *Nonpoint Source Pollution - Live!* in *Beneath the Shell*. New Jersey DEPE. Office of Communications, CN 402. Trenton, NJ 08625.

Non-Point Source Polluters

Examples of NPS pollution for use in *Non-Point Source Pollution on Stage*

1. “Bugs, bugs go away!”
Mr. Burch has two large trees near his porch that attract wasps, mosquitoes, and caterpillars. He sprayed the trees with a chemical that would kill the insects. Shortly after he sprayed the pesticide, a storm washed the chemical into the soil and down the driveway. From there it ran off into the nearby storm drain along with the rest of the rainwater.

2. “We have a problem with that stream.”
A small stream winds through a popular golf course. During heavy rains, the stream is filled with fast-flowing water. The sides of the stream are crumbling and the roots of the bordering trees are showing. The land near the stream banks is slowly collapsing. After each rain, fertilizers, soil, and small rocks are swept away with the water.

3. “Where should I put this old motor oil?”
Natara is proud to help her dad change the oil in the family station wagon. She clumsily carries the huge pan of black, thick oil to the storm drain where she dumps it. “It's gone!” she proudly exclaims. Soon the oil mixes with the water of a nearby stream. The oil that she spilled on the ground begins to seep into the soil and mix with the ground water.

4. “The raccoons are littering again!”
One snowy winter night the Horton family heard raccoons turning over their garbage cans out by the curb, but it was too cold to go outside and chase them away. The next morning, no one had time to clean up the garbage strewn all over the street. When the snow melted, some of the trash floated on the water into the storm drain.

5. “The Lawn Clipping Caper”
Debbie helps her grandparents by cutting the lawn. When her grass catcher is full, she dumps her grass clippings into a nearby storm drain. There, the clippings turn yellow and begin to smell until the next storm carries them away.

6. “Good Jack!”
Isabel enjoys walking the family dog, Jack. When Jack needs to go to the bathroom, Isabel is careful to make Jack go along the curb so that Jack is not messing the neighbors' lawns. She doesn't worry though; eventually the mess will go down into the storm drain.

7. “Don't mess up the car!”
The Martin family likes to stop at fast-food restaurants on the way to the beach. In order to keep the car clean, they throw their bags of trash out the car window into the streets.

Guessing for Groundwater

Grades:

4th - 7th

Objective:

Students learn how groundwater moves through the soil. They will also be able to see how the pollution from a source, such as a leaking septic tank, disperses and travels underground.

Method:

Students will work in groups to try to predict the path that pollution will travel, and how far the plume will spread. They will also see how a well works, and see how it is affect by underground pollution in the area.

Materials:

Two large, preferably clear, pan-like containers, sand, two clear plastic straws, cheesecloth to function as a filter for the end of each straw, food coloring, masking tape, two syringes, two watering cans or spray bottles, water.

Time:

Preparation Time: 20 minutes
Class Time: 30 minutes

Procedure:

1. Prior to the lesson in class, you must prepare two groundwater models in the clear containers. To do this, place a filter on one end of a straw. Tape the straw, vertically, to one end of the container, with the filter at the bottom, allowing 1/8” of space from bottom. Now simply pour three to four inches of sand into each container.

2. Pour water on the sand until a two-inch high water table is reached. See if the water in the straw, now a *piezometer* (an instrument used to measure water table depth), is at the same level as the water table.

3. After you have prepared the groundwater models, and given an introduction to groundwater to the class, have the students break into four groups, with two groups at each model.

4. Explain that for this activity, one group will secretly bury the food coloring somewhere in the model. This represents pollution from a leaky storage tank. Once the group has buried it, the

other group will try to determine its location and how it moves. They cannot dig it up. The groups will later trade roles.

5. Now have one group from each model secretly dig a little hole, put several drops of food dye in the hole, and cover it back up.

6. The group responsible for finding the pollution plume is now instructed to draw water out of the well using the syringe (which acts as the pump). Meanwhile, another group member should create rain by pouring or spraying water on the surface to expedite groundwater flow.

7. The students continue to draw water out until the food dye begins to show up in their well water.

8. Once they have discovered that the pollution exists, they must now determine where it has spread. There are two options: 1. If the containers are clear, they can pick it up, and look at the plume that has formed on the bottom. 2. If the containers are not transparent, students should use their fingers to dig at least five holes in the sand. In some holes, they should see the pollution, and not in others. Explain what they observed about where the pollution began and how it reached their well.

9. This group should now sketch the model, and draw in the plume of pollution that occurred.

10. Have the students spray the model, and pump the well until the color is gone. Then fill the model back up with two inches of water, reverse the group roles, and repeat the activity.

Assessment:

1. Through which type of ground layer, sand or pebbles, would polluted groundwater flow more quickly? How might the topography of the land change the pollution travel time?

2. Once the groundwater has been polluted, what is the best way to clean it up? Is there really a possible solution for clean up?

3. What is the best method to prevent of groundwater pollution from sources such as leaky septic and underground storage tanks?

NYS Learning Standards:

Math, Science, and Technology
Standard 1 - Analysis, Inquiry, and Design: Scientific Inquiry 2
Standard 4 - Science: Physical Setting 2; The Living Environment 7
Standard 6 - Interconnectedness: Models

Source: This activity developed by Nathan Chronister and Aaron Bennett.

House of Pollution

Grades:

4th - 7th

Objective:

Students learn about household products that may be pollutants. Students learn how to minimize environmental impact through proper disposal.

Method:

Students read about common household waste disposal methods and trace the paths they take on a drawing. Students then suggest better ways to dispose of these wastes.

Materials:

Copies (1 per student) of: the question sheet (enclosed), house diagram (enclosed), and water consumption table (enclosed).

Time:

Preparation Time: Copying, 10 minutes
Class Time: 35 minutes

Procedure:

Note: The *Daily Water Consumption Amounts* is not part of the activity; it is included as relevant information for students.

1. Have students read the information about storm drains, septic systems, and sewers on the worksheet.

2. Students trace the path of each pollutant shown on the house drawing. The motor oil and fertilizer flow into the storm drain and then the stream, or they can enter the groundwater. The toilet waste, drain cleaner, and paint (if disposed of improperly) are piped into the septic tank. From the septic drainage pipes, the pollutants enter the groundwater and from there flow to the stream or well.

3. Students now think of ways to avoid these types of pollution and write them down. Students may exchange ideas with a partner once they have finished.

4. Explain some ways communities can deal with these pollution threats. For example, household chemicals like paint can be taken to collecting sites where they are properly disposed of or their use is shared with other people. An alternative to a drain-opener is a plumber's "snake". Lawn chemicals are often unnecessary, may cause cancer in pets or humans, and should be used sparingly to reduce the amount that enters the stream. Over-watering lawns or plants or applying fertilizer before a storm causes chemicals to reach the stream more quickly. Motor oil or any fuel leaks should be fixed and used oil can be recycled at auto repair shops. Some communities' stencil their storm drains to let residents know they drain to local streams.

Assessment:

1. How would you dispose of used motor oil or an old can of paint?

2. Would you fertilize your lawn?

3. What would you do with a leaky gas can?

4. There are other pollution sources on the diagram that are not mentioned on the worksheet, find one that is not labeled, and draw it.

NYS Learning Standards:

Math, Science, and Technology
Standard 4 - Science: The Living Environment 7
Standard 5 - Technology: Technological Systems; Impacts of Technology
Standard 6 - Interconnectedness: Patterns of Change

Social Studies
Standard 5 - Civics, Citizenship, and Government 3

Source: This activity developed by Nathan Chronister.

HOUSE OF POLLUTION

Name ______________________

Look at your map (fig. A4-5). Find each of these objects and color them in:

1. **Storm drain**. If you live in a village, you may have a storm drain near your house. In most cases, the storm drain empties into a nearby stream.

2. **Septic tank**. All the wastewater from your home goes to a septic tank, unless you are on the village sewer system. Solids collect in the septic tank, but the wastewater itself soaks into the ground through leach field drainage pipes. Chemicals, like bleach or toilet cleaner, in your wastewater may kill the bacteria needed to break down the solid waste in your septic tank. They can also leach into the groundwater.

3. **Well**. Wells collect groundwater for people to use in their homes. Some homes have their own well. Many villages have wells shared by the whole village.

Many products a family uses are harmful if disposed of incorrectly. They can enter a nearby stream or well and contaminate drinking water. For each of the products labeled in the picture, draw an arrow showing how that product could end up in the nearby stream or well.

After you finish drawing arrows for all five products, try to imagine ways each of these kinds of pollution could be prevented.

Car leaking oil:

Fertilizer:

Drain opener:

Old cans of paint:

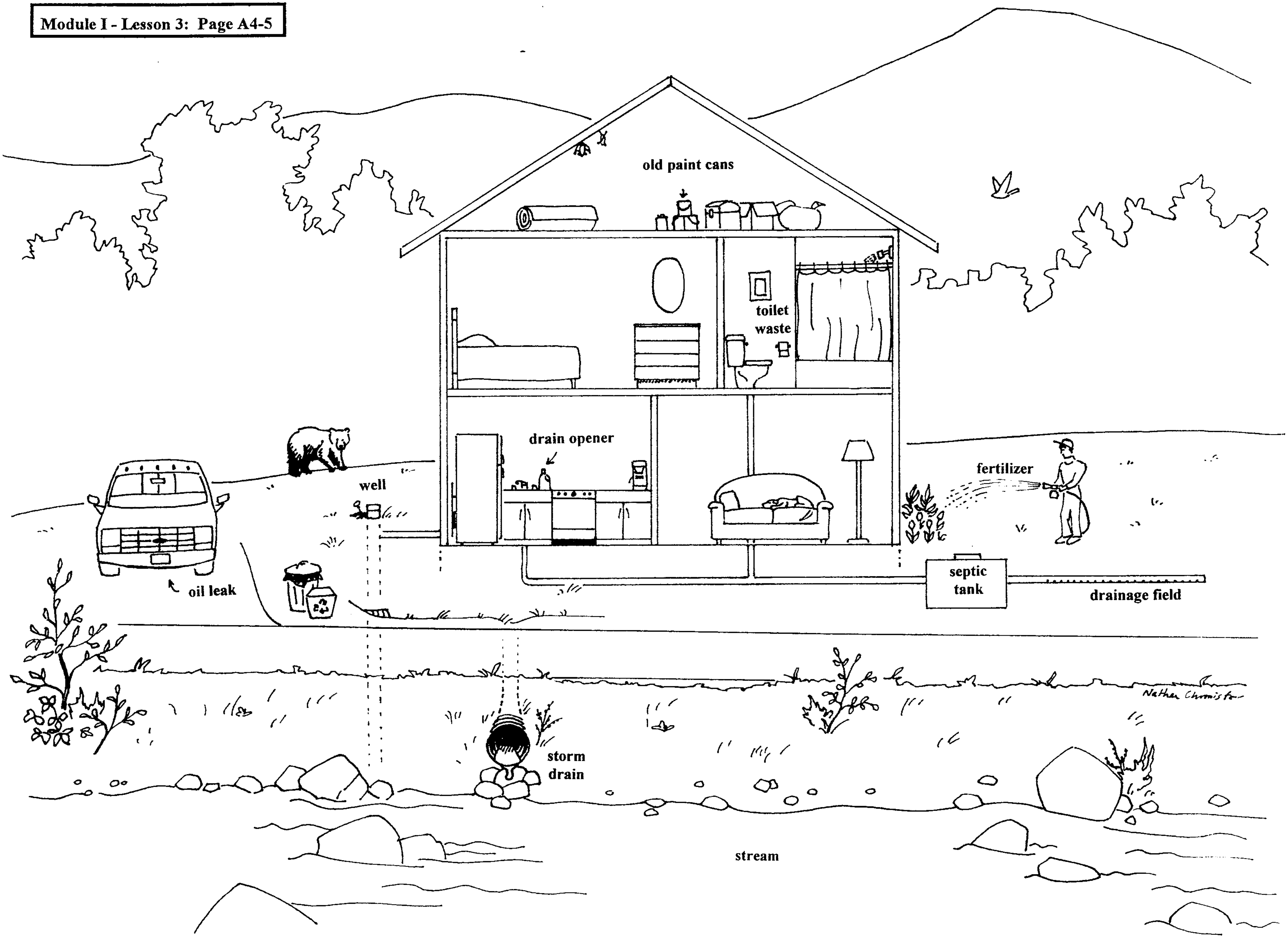
Toilet waste:

DAILY WATER CONSUMPTION AMOUNTS

Note: The figures below are the average daily amounts of consumption in the United States for common uses. Data are from the Environmental Protection Agency.

ACTIVITY	AVERAGE HOUSEHOLD	HOUSEHOLD USING CONSERVATION METHODS
Bath	**36 gallons**	**15 gallons**
Brushing Teeth	Tap Running = **2 gallons**	**½ gallon**
Dishwasher	**15 gallons**	Short Cycle = **7 gallons**
Hand Washing	Tap Running = **2 gallons**	**½ gallon**
Shaving	Tap Running = **20 gallons**	Using Bowl = **1 gallon**
Shower (5 min.)	Tap Running = **25-35 gallons**	Wet, Soap, Rinse = **5 gallons**
Toilet Flush	**5-7 gallons**	Low Flush Toilet = **2 gallons**
Washing Car	Tap Running = **180 gallons**	Stopping Tap = **40-50 gallons**
Washing Dishes by Hand	Tap Running = **20-30 gallons**	Wash, Rinse in sink = **5 gallons**
Washing Machine	Top Loading = **40 gallons**	Side Loading = **25 gallons**
Watering Lawn	Tap Running = **10 gal/min**	Stopping Tap = **10 gal/min**

- The average household of four people in this country uses about 243 gallons of water per day.
- The average person (per capita) in a town uses over 100 gallons of water per day.


old paint cans
toilet
waste
drain opener
well
fertilizer
oil leak
septic
tank
drainage field
storm
drain
stream
Nathan Chromister

Wetland in a Pan

Grades:

4th - 12th

Objective:

Students learn interrelationships between precipitation, runoff, and wetlands. Students will relate the importance of wetland functions to their own needs and daily lives. Students will be able to discuss practical, everyday issues concerning the beneficial functions of wetlands.

Method:

Students simulate a wetland (or watch as the teacher simulates one) using a clay model, and they test the functions of the wetland by mimicking a stormwater event.

Materials:

Modeling clay, long shallow pan (9” x 13” metal or glass baking pan or a paint rolling pan) scraps of indoor-outdoor carpeting, florist’s “oasis” foam or sponges, watering can or similar device, cup of soil, jar of muddy water.

Time:

Class Time: 90 minutes if students make model, 30 to 40 minutes for demonstration only.

Procedure:

Preparation.

- Spread a layer of modeling clay in half of the baking pan to represent land. Leave the other half of the pan empty to represent a lake, river, or ocean.
- Shape the clay so that it gradually slopes down to the ‘water’. Smooth the clay along the sides of the pan to seal the edges. You can also form meandering streams in the clay that lead into the body of water.
- Cut a piece of carpeting to completely fill the space across the pan along the edge of the clay. This represents a wetland buffer between dry land and open water. Make sure the wetland fits well. The model won’t work if there are large spaces under the wetland or between the wetland and the sides of the pan.

Intro: Review what students have learned about wetlands and their functional values. Show pictures of different types of wetlands including freshwater and salt marshes, swamps, and bogs. Have the students think about the animals and plants that might live in each kind of wetland.

1. Present the wetland model and point out its features. Explain that wetlands, like all habitats, are very complicated natural systems. They perform very important functions such as filtering pollutants, reducing flood damage, and preventing soil erosion. Some wetlands, at times, recharge underground water supplies. Explain that the model will show this in a very simplified way. Ask students: If I make it “rain” on the model, what will happen to the rainwater?

2. Fit the piece of carpeting or sponge into the wetland area, slowly sprinkle some “rain” on land, and let the students observe and describe what is happening. Some of the water is stored by the wetland (carpeting). The excess slowly flows into the body of water. Point out, if the students do not, that the wetland absorbed some of the water (pick up the wetland and squeeze some water out to prove it).

3. Ask: What do you think will happen if the wetland is removed? (The water will not be absorbed; it will flow more quickly into the body of water.) Remove the carpeting and water. Pour the same amount of water on the model at the same spot and rate as before. Have the students note any differences. The water will fill the body of water much more quickly and may eventually overflow and flood the land. That’s because it is no longer buffered by the wetland.

Explain that most wetlands are shallow basins that collect water, slow its rate of flow, and also retain water for a time. This slowing process helps reduce flooding and also helps prevent soil erosion.

Ask: If a wetland is destroyed and houses are built there, what might happen to the houses during a severe rainstorm? Why? (They might be flooded because the wetland will not be there to absorb and slow the rush of water from higher ground.) In many areas, wetlands are drained and filled in, and houses are built right along the water. Without a wetland buffer, these developed areas, particularly in flood plains, are subjected to severe flooding and erosion, especially during violent storms.

4. Pour the water from the last demonstration out of the model and put back the carpeting. Explain that this demonstration will be just like the first, except that soil will cover the clay. Ask: What do you think will happen to the bare soil when it rains? (The rain should pick up and carry some sediment over the land and into the body of water.)

5. Spread soil over the clay and make it rain, or pour muddy water from the jar over the soil. Explain that this water represents pollution runoff. Ask the students to compare the water that ends up in the body of water with the water in the jar. Explain that the soil particles were trapped by the carpeting; making the water in the body of water much clearer. The “uphill” side of the wetland should be coated with trapped sediment.

6. Remove the carpeting, pour out the water, and try the experiment again. What happens without the wetland in place? Ask the kids why all the dirt particles end up in the body of water this time. The thick mat of plant roots in a wetland help trap silt and some types of pollutants

much as the carpet did in the model. Without a wetland, excessive amounts of silt and pollutants can end up in lakes, rivers, and other bodies of water.

Extension: Students, individually or as small groups, can make their own, more detailed wetland models using small aluminum foil pans, clay, and florist's foam. Then students can draw plants and animals and attach them to the model with toothpicks. Students can use an assortment of materials; including natural ones they collect, to decorate their models. They can make a freshwater or salt marsh, freshwater or mangrove swamp, or bog. Provide reference books with pictures of different types of wetlands.

Assessment:

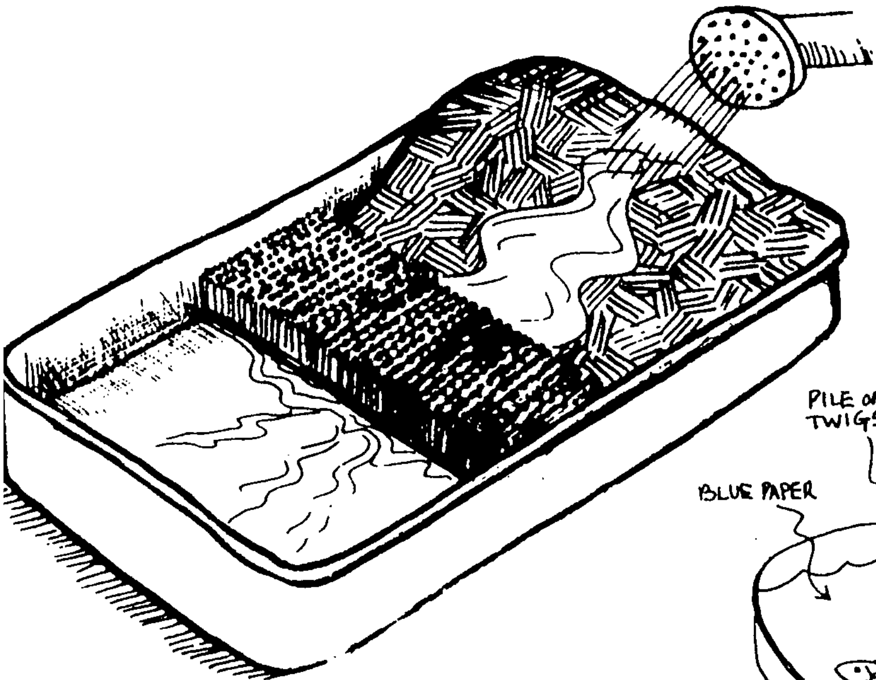
Use the enclosed quiz as an assessment. Quiz answers:

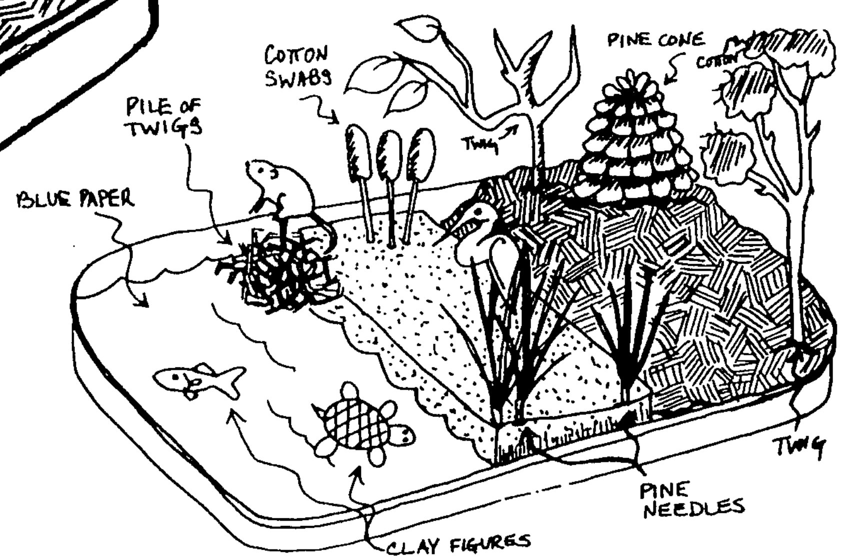
1. Wetlands provide a natural way of removing/retaining nutrients, reducing sediment loads, processing chemical and organic wastes, and controlling or reducing flooding.
2. Wetlands provide habitat for numerous wildlife species that depend on them for their survival. An estimated 43% of the endangered species rely directly or indirectly on wetlands for survival. Wetlands also improve our quality of life. People use wetlands for hiking, hunting, fishing, bird watching, and photography.
3. Natural stream banks are more aesthetically pleasing and provide natural habitat for aquatic animals in addition to riparian birds and mammals.
4. Plants might not get enough sunlight to survive. Fish will be affected because it is harder for them to see, can irritate their gills so they can't breathe easily, and could lead to their death. Sediment smothers oysters, and birds and other animals may have trouble seeing food in the muddy water, or food sources could die out.
5. The sand and silt settle out and sediment eventually fills channels that are needed for navigation.

NYS Learning Standards:

Arts
Standard 1 - Creating, Performing, and Participating in the Arts: Visual Arts

Math, Science, and Technology
Standard 1 - Analysis, Inquiry, and Design: Scientific Inquiry 1
Standard 4 - Science: Physical Setting 2; The Living Environment 7
Standard 5 - Technology: Tools, Resources, and Technological Processes
Standard 6 - Interconnectedness: Models
Standard 7 - Interdisciplinary Problem Solving: Connections





Source: This activity was adapted with permission from the activity "Wetland in a Pan," published in *WOW!: The Wonders of Wetlands*, 1995. Published by Environmental Concern Inc., St. Michaels, MD, (410) 745-9620, and The Watercourse, Bozeman, MT, (506) 994-1917.

Wetland in a Pan Quiz

Name: ___________________________ **Date:** __________ **Teacher:** ___________________

Directions: Answer the questions below using the information you learned in the activity.

1. There are numerous ways that wetlands protect or improve surface water quality. Name and describe two ways in which wetlands serve this function.

2. What is one benefit of wetlands that is not directly related to improving water quality?

3. The willow trees that are very common along stream banks and in wetlands provide the best protection against stream bank erosion. What advantages do these natural barriers have over the man-made ones like large boulders or riprap?

4. How might muddy water affect plants, fish, and other animals?

5. How might boats and ships be affected by muddy water?

Trees, Forests, and the Water Cycle

Grades:

4th - 12th; Extension: 7th - 12th

Objective:

Students will learn what role trees and forests play in the water cycle. Students will gain a greater understanding of the dynamics of a forest ecosystem by seeing that trees are dependent upon, and play a part in, Earth's processes, including the water cycle. They will also learn that the water cycle is the system by which Earth's fixed amount of water is collected, purified, and distributed from the environment to living things and back to the environment.

Method:

Students will act out the paths that water takes in the water cycle. They will describe the importance of the water cycle to living things and the importance of plants in the water cycle.

Materials:

Cut out paper strips for Catskill water cycle game, a different color for each destination; copies of “Water Cycle Score Sheet” (one for each student); envelopes for paper strips; watch or stopwatch; plastic bags; twist ties or string; small graduated cylinders; the Multiple Intelligences sheet (in the appended material).

Overview:

In addition to clouds, oceans, rivers, and valleys, living organisms are part of the water cycle. All living things need water to live because it is essential to their bodily functions. Plants and animals take in water and return it to the atmosphere as vapor (breathing, transpiring) or to the soil as liquid (excreting).

Forests greatly affect watersheds. Trees, small plants, and forest litter absorb rainwater, reducing erosion and runoff. Leaves capture up to 60 percent of precipitation. When rain falls on bare ground, the full force of raindrops can wash soil into streams, making them muddy. But when rain falls on the forest, it drips down through leaves and branches to the forest floor. The forest canopy, as well as layers of plant litter under trees, protects the soil from the full force of rain. Tree roots hold the soil in place so that it doesn't wash away.

Plants use water to transport nutrients and minerals necessary for growth. Plants also use water in photosynthesis. Since most photosynthesis takes place in leaves, and the leaves of a plant can be many feet above ground level, how does water from the soil get to these leaves? Transpiration (evaporation of water from pores, or stomata, on trunk, stem, and leaf surfaces) aids plants to transport water upward through their tissues. Root pressure, the cohesive and adhesive qualities of water (capillary action), and evaporation all contribute to water's circulation through a plant.

Evaporation is most likely the main process whereby water moves up the plant. When the water molecules reach the stomata of the leaves, they are exposed to air and the sun's energy. The exposed molecules receive heat energy from the sun and begin to move faster. This motion makes it easier for the molecules to break away and become water vapor. However, a tension still exists among the water molecules. As one molecule is drawn away, it pulls on the other nearby water molecules, pulling those molecules to the surface.

Plants can absorb large quantities of water; however, they lose most of this water through transpiration. Transpiration coupled with evaporation of surface water is called *evapotranspiration*. It plays a crucial role in the water cycle. Evapotranspiration returns water to its gaseous state, in which it is carried by winds through the atmosphere until it condenses and returns to Earth as precipitation.

Forests help improve water quality by filtering out impurities that could be potentially harmful in streams or groundwater. As water is absorbed by tree roots and then transpired through leaves, impurities (many of which are good for a tree) remain in the tree.

Although the gradual wearing down and erosion of soil is a natural process, without proper management human activities such as clearing vegetation for development, logging, dam building, farming, and draining wetlands will increase the rate of erosion in watersheds and can reduce water quality. By the same token, reforestation, use of best management practices in forestry and farming, certain types of landscaping, and restoring wetlands can reverse those trends.

Procedure:

Note: Photocopy each part of the Water Cycle game on a different color paper. Cut the strips apart. Mark each of six envelopes with a large label for each of the following: Cloud, Mountain, Stream, Groundwater, Ocean, and Plant. Put the strips in the corresponding envelope. Use the envelopes to set up six stations around the room.

Intro: Ask: “What is a cycle?” (A sequence of recurring events.) Invite students to name some cycles that are part of their lives (morning, afternoon, night; fall, winter, spring, summer). If you haven’t covered the water cycle, ask students whether they have heard of it before. Divide the class into pairs. Ask pairs to write down words that describe what they know about the water cycle or what they think the term water cycle might mean. Then ask them to write their own description of the water cycle. Ask for volunteers to share their descriptions with the class.

Show students the water cycle diagram in Lesson 1. Make sure that students understand the terms evaporation, groundwater, and condensation. Introduce the term *transpiration*. Use the following questions to focus students’ attention:

- If every living thing needs so much water, how come water isn't used up?
- Where does the water go when a puddle dries up?
- Why don't oceans and lakes dry up like puddles do?
- Where does rainwater come from?
- Do you think water always follows the same path as shown in the diagram?

1. Explain that the water cycle is really a simplified model for looking at the “journey” of a water molecule. So students may learn more about the different paths water might take, have them play a game in which each group will be a water molecule.

2. Divide students into five approximately equal groups, and have each group begin at one of the stations. Give each group a scorecard to record the path they will follow in the game. Later, students will have the chance to compare scorecards and will have the opportunity to depict their journey in a variety of ways (using multiple intelligences).

3. One student from each group should remove a strip from the envelope at their station. They should read the strip to the group and write the following on their water cycle score sheet: their station stop, what happens to them, and their destination. Have them return the strip to the envelope. When you call out “cycle”, groups should move to the next station as directed on the strip.

4. Groups should repeat step 3 above, continuing their journeys until their score sheet is complete.

5. Students can complete the activity in two ways:
   1. Have students go back to their seats and individually write a brief story from a water molecule's point of view that describes their journey through the water cycle.
   2. Groups can depict their journey using one of the following skills: verbal/linguistic, musical/rhythmic, bodily/kinesthetic, visual/spatial, or logical/mathematical. (See Multiple Intelligences sheet in the appended material)

Extension: This activity works best on sunny days after a rainstorm or after an area has been watered.

1. Divide class into small groups. Give each group an empty plastic bag.

2. Identify trees or shrubs on the school grounds. Assign each group a plant.

3. Have each group carefully place its bag over a limb of its tree or shrub. (Facing the sun works best) Tie the bag with a twist tie or string. Each group should count and record the number of leaves in its bag.

4. Challenge the students to develop a method to estimate the number of leaves on their tree or shrub. Have each group record the estimated number of leaves on its tree or shrub.

5. Leave the bags on the plants for 24 hours. Have the groups carefully remove the bags at the same time and take them back to the classroom.

6. Have each group carefully open their bag and transfer its contents to a small graduated cylinder. Measure the amount of water in the cylinder. Have students calculate the transpiration rate for their whole plant based on their estimation of the number of leaves on the plant.

7. Pool the class data on the chart. Have students estimate the number of days in the growing season. Calculate the transpiration rate for each plant for the growing season.

Assessment:

1. Where does rainwater come from? Do you think water always follows the same path as shown in the water cycle diagram? Where does the water go when a puddle dries up?

2. Make sure that all groups completed their score sheet. Does their story about their journey (or other depiction using multiple intelligences) follow their score sheet? Are the steps in their journey consistent with natural processes?

3. If the class completed the extension activity: Are their data somewhat reasonable? Ask if they are surprised by the transpiration rate they calculated. What are some of the many variables that could affect the data collected?

NYS Learning Standards:

Arts
Standard 1 - Creating, Performing, and Participating in the Arts: Theatre

English
Standard 1 - Language for Information and Understanding: Speaking and Writing
Standard 2 - Language for Literary Response and Expression: Speaking and Writing

Math, Science, and Technology
Standard 1 - Analysis, Inquiry, and Design: Scientific Inquiry
Standard 3 - Mathematics: Uncertainty
Standard 4 - Science: Physical Setting 2,4; The Living Environment 6

Source: Activities adapted from Project Learning Tree, Water Wonders, and Project WET, Thirsty Plants. Adapted by Donna Rogler, Catskill Forest Association.

Make one copy on white paper, then cut the strips apart.

Station 1 – CLOUD

You fall as rain onto a mountain. Go to Mountain.

You fall as snow onto a mountain. Go to Mountain.

You fall as rain into a stream. Go to Stream.

You fall as rain into an Ocean. Go to Ocean.

You fall as snow into an Ocean. Go to Ocean.

You fall as rain onto a parking lot. Go to Stream.

You fall as rain onto the leaves of a tree. Go to Plant.

You fall as rain into a freshly tilled field. Go to Groundwater.

Station 1 – CLOUD

You fall as rain onto a mountain. Go to Mountain.

You fall as snow onto a mountain. Go to Mountain.

You fall as rain into a stream. Go to Stream.

You fall as rain into an Ocean. Go to Ocean.

You fall as snow into an Ocean. Go to Ocean.

You fall as rain onto a parking lot. Go to Stream.

You fall as rain onto the leaves of a tree. Go to Plant.

You fall as rain into a freshly tilled field. Go to Groundwater.

Make one copy on purple paper; then cut the strips apart.

Station 2 – MOUNTAIN
You evaporate into the air. Go to Cloud.
You soak into the ground and become part of the groundwater. Go to Groundwater.
You soak into the ground and get absorbed by a plant's roots. Go to Plant.
You soak into the ground and get absorbed by a plant's roots. Go to Plant.
You roll downhill and become part of the stream. Go to Stream.
You get frozen in ice and stay there. Stay at Mountain.

Station 2 – MOUNTAIN
You evaporate into the air. Go to Cloud.
You soak into the ground and become part of the groundwater. Go to Groundwater.
You soak into the ground and get absorbed by a plant's roots. Go to Plant.
You soak into the ground and get absorbed by a plant's roots. Go to Plant.
You roll downhill and become part of the stream. Go to Stream.
You get frozen in ice and stay there. Stay at Mountain.

Make one copy on blue paper; then cut the strips apart.

Station 3 – OCEAN

You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.

You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.

You evaporate into the air. Go to Cloud.

You evaporate into the air. Go to Cloud.

A kelp plant takes you in, releases you through its leaf, and transpires you back into the ocean. Go to Plant, but do not draw a card. Return to Ocean.

You are one of countless water molecules in an ocean and you stay there. Stay in Ocean.

Station 3 – OCEAN

You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.

You are one of countless water molecules in an ocean and you stay there. Stay at Ocean.

You evaporate into the air. Go to Cloud.

You evaporate into the air. Go to Cloud.

A kelp plant takes you in, releases you through its leaf, and transpires you back into the ocean. Go to Plant, but do not draw a card. Return to Ocean.

You are one of countless water molecules in an ocean and you stay there. Stay in Ocean.

Make one copy on gray paper; then cut strips apart.

Station 4 – STREAM
You evaporate into the air. Go to Cloud.
You evaporate into the air. Go to Cloud.
You continue rolling downhill and become part of the ocean. Go to Ocean.
You continue rolling downhill and become part of the ocean. Go to Ocean.

Station 4 – STREAM
You evaporate into the air. Go to Cloud.
You evaporate into the air. Go to Cloud.
You continue rolling downhill and become part of the ocean. Go to Ocean.
You continue rolling downhill and become part of the ocean. Go to Ocean.

Make one copy on tan paper; then cut the strips apart.

Station 5 – GROUNDWATER

You become part of an underground stream that flows to an ocean. Go to Ocean.

You become part of an underground stream that flows to an ocean. Go to Ocean.

You become part of an underground stream that flows to a spring, where you become part of a stream. Go to Stream.

You become part of an underground stream that flows to a spring, where you become part of a stream. Go to Stream.

A plant takes you in through its roots. Go to Plant.

You are pumped out of the ground to irrigate a farm. Go to Plant.

Station 5 – GROUNDWATER

You become part of an underground stream that flows to an ocean. Go to Ocean.

You become part of an underground stream that flows to an ocean. Go to Ocean.

You become part of an underground stream that flows to a spring, where you become part of a stream. Go to Stream.

You become part of an underground stream that flows to a spring, where you become part of a stream. Go to Stream.

A plant takes you in through its roots. Go to Plant.

You are pumped out of the ground to irrigate a farm. Go to Plant.

Make one copy on green paper; then cut the strips apart.

Station 6 – PLANT
The plant transpires you through its leaves into the air as vapor. Go to Cloud.
The plant transpires you through its leaves into the air as vapor. Go to Cloud.
The plant transpires you through its leaves into the air as vapor. Go to Cloud.
The plant uses you for photosynthesis. Stay in Plant.
The plant uses you to grow. Stay in Plant.

Station 6 – PLANT
The plant transpires you through its leaves into the air as vapor. Go to Cloud.
The plant transpires you through its leaves into the air as vapor. Go to Cloud.
The plant transpires you through its leaves into the air as vapor. Go to Cloud.
The plant uses you for photosynthesis. Stay in Plant.
The plant uses you to grow. Stay in Plant.

WATER CYCLE SCORE SHEET

Name: ______________________________

STATION STOP	WHAT HAPPENS	DESTINATION
Ex. Cloud	Falls as rain	Mountain
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

TRANSPIRATION EXPERIMENT

GROUP	Plant name or description	Water Transpired (mL)	Water Transpired from entire plant	Transpiration per growing season
GROUP 1				
GROUP 2				
GROUP 3				
GROUP 4				
GROUP 5				

Questions:

1. Which plant transpired the most water?

2. Which plant transpired the least water?

3. Estimate the amount of water each plant would transpire in one growing season. Assume a constant rate of transpiration.

On the Farm

Grades:

7th - 12th

Objective:

Students learn about best management practices (BMPs) used to increase profitability and protect water quality on farms.

Method:

Students examine a fictional farm and decide which of the BMPs commonly used on real farms are most appropriate.

Materials:

The problem solving topic outline (enclosed), calculation of dollars to spend (enclosed), BMP chart (enclosed), soil descriptions (enclosed), the three maps: land use, topography, and soil types (enclosed).

Time:

Preparation Time: Copying, 10 minutes
Class Time: 45 minutes

Procedure:

1. Distribute instructions, worksheets, maps, etc. to students.

2. Divide class into groups of four.

3. Students follow the procedure, answer questions, and then hand in their answers.

Assessment:

1. Are there any trade-offs involved in selecting the right BMP?

2. Would every farm need the same BMPs? Why or why not?

NYS Learning Standards:

Math, Science, and Technology
Standard 1 - Analysis, Inquiry, and Design: Scientific Inquiry 2,3
Standard 3 - Mathematics: Mathematical Reasoning
Standard 4 - Science: The Living Environment 7
Standard 5 - Technology: Technological Systems; Management of Technology
Standard 6 - Interconnectedness: Optimization
Standard 7 - Interdisciplinary Problem Solving: Connections

Social Studies
Standard 3 - Geography 1,2
Standard 4 - Economics 2
Standard 5 - Civics, Citizenship, and Government 4

Source: Activity developed by Joe Farleigh (Watershed Agricultural Council) and Dan Flaherty (Sullivan County Cooperative Extension). Farm information provided by Brian Danforth (Delaware County Soil and Water Conservation District).

Problem Solving Topic Outline

You live in the small Catskill town of Fontanalis in the New York City watershed. The region has economic difficulty due to the lack of business, low population, and limited access. Dairy farming used to be the basis of a strong economy. In 1970 there were 25 farms in the township surrounding Fontanalis; now only one remains, the farm of Bill Jordan.

Bill Jordan is the son of a farmer, who is the son of a farmer, who is the son of a farmer. In fact Bill's family has lived on this farm for 175 years. Bill hopes that his son, Jed, will take over the farm when Bill is ready to retire.

The Jordans milk 50 cows, and they have 15 heifers (young cows) and 10 calves under six months old. Two small streams, Blueberry Brook and a smaller, unnamed stream, run through the farm. Bill's granddad Caleb Jordan, who first settled the valley, selected this site for the soil fertility and for the abundance of water. Having a stream adjacent to the barn was a great advantage in 1823, when Caleb purchased the land.

Today this location is cause for concern, due to the fact that the barnyard area accumulates high levels of manure, which is transported to the Blueberry by rainwater. Another concern is that the herd must cross Blueberry Brook to reach the pastures across the stream. Stream disturbance, stream bank erosion, and manure entering the stream raise environmental concerns about farming here today. There are 3,000 feet of stream bank to which the cows have access.

Blueberry Brook is a tributary of Cranberry Creek. Cranberry Creek empties into New York City's Cannonsville Reservoir. New York City water quality is the highest of any of the world's major cities. Retaining water quality is a concern of city water supply officials. To further protect water supply, city officials began discussions with the agricultural communities and other community members of the watershed in 1990. In the resulting agreement, the city will fund a program to help farmers make changes in their operations, thereby protecting the water supply and helping farms to be more profitable. This Whole Farm Planning program has become a national standard recognized by farmers and environmentalists.

Volunteer farmers work in conjunction with agricultural specialists to produce the Whole Farm Plan which addresses eleven pollutant categories commonly encountered on farms. Recommendations of the plan are completed with all costs being paid by New York City.

Each of the plan components is called a Best Management Practice (BMP). For example, fencing animals away from streams is a BMP. Barnyard changes to exclude water is a BMP. A list of the most commonly recommended BMPs is in this packet. Most BMPs have a cost associated with implementation; these costs are included as well.

Your team is asked to recommend BMPs that will both help protect Blueberry Brook and make the Jordan farm more profitable. The problems associated with environmental issues are listed below on a priority basis. Although all eleven items are important, number ten, Fuel Storage, is not as likely to be an environmental threat as number one, Parasites and Phosphorus.

The following is a discussion of some of the environmental categories of concern for the Jordan farm and all farms in the New York City watershed.

1) Parasites and Phosphorus - Animal waste storage.

Water supplies may become contaminated with *Cryptosporidium* or *Giardia*. Both cause intestinal illness in humans. Many mammals including beaver, deer, mice, humans, and cattle host these parasites. Research underway at Cornell University indicates that in cattle, the parasite is only found in calves during their first six months of life. Mature cattle seldom host these parasites.

Parasites are assigned the highest priority due to the consequences of water supply contamination. In 1993, Milwaukee's filtered water supply was contaminated and nearly 100,000 citizens were infected. About 100 people with compromised immune systems died as a result.

Remedy: Protect calves' health. Separate calves from other animals. Keep calf manure away from water. House calves in hutches or greenhouse to maintain isolation and protect health.

Associated cost: $1,000 per calf.

2) Pesticides - Storage facilities, handling areas. Remedy: Provide approved storage and handling areas. Associated cost, storage facility $1,200.

3) Phosphorus - Fertilizer storage.

4) Animal and Manure management for phosphorus.

Remedy: Provide storage area for manure until it can be used on fields. Provide the farmer with a manure-spreading plan to ensure that manure is only applied to those fields requiring fertilizer.

5) Nutrients - Concentrated sources.

6) Nutrients Management - Provide plan to minimize the amount of feed purchased.

7) Sediment - Diffuse. Provide plan to minimize erosion from plowed fields. Strip cropping, crop rotation, diversion. Remedy: Crop rotation initially to start corn 3 yr., hay 6 yr. May have to buy more grain.

8) Sediment - Concentrated. Protect areas such as farm road. Gully erosion, barnyard, etc.

9) Pesticides - Dairy farms use few pesticides. The most commonly used are herbicides to prevent weed growth in cornfields.

Remedy: Farm planners recommend that corn be planted away from watercourses. This BMP serves two purposes: keeping the herbicide away from the water and preventing diffuse sediment.

10) Fuel storage - Diesel fuel and gasoline needed to operate machinery are stored on farms to allow uninterrupted operation. Should a fuel tank for any reason leak, fuel reaching water or soil would have serious effects on the environment.

Remedy: Provide fuel storage tank and site, which will protect the soil and water if tank leakage or spillage occurs. Associated cost $1,000.

11) Other Material - Any other substances which may be found on the farm. This item allows for agricultural best management practices which may be developed in the future.

Fencing the stream and building a stream crossing would allow the herd to cross while protecting the water and stream banks. If this is done, a watering area must be created for the herd. The pasture has several areas that are constantly wet. By developing one of these areas for watering, the cattle wouldn't need stream access.

As the farm planning team, you are to recommend a plan which will assist the Jordan's to operate their farm in ways which provide better water protection. Your team should prepare a plan which prioritizes the environmental issues and recommends suitable best management practices to minimize environmental impact. The plan must also help the farm remain profitable.

The amount of money that may be spent on a farm is determined by the pollution threat and by the number of animals on that farm. Since smaller animals such as sheep produce less waste than cows, a method is used to compensate. One **animal unit** is 1,000 pounds of animal(s). A typical dairy cow weighs 1,200 pounds, therefore each dairy cow equals 1.2 animal units. Heifers, which are young cows, typically weigh 800 pounds or 0.8 animal units. A 150-pound sheep is 0.15 animal units.

You may make additional recommendations to protect water quality and to improve the economic viability of the Jordan farm. The maps provided show various information about the farm (which parts are forested, which are pasture, topography, soils types, etc.) that will help you determine which environmental concerns are the most relevant.

General Information:

50 dairy cows
15 replacement heifers
10 calves under 6 months of age
Farm has limited rotational grazing

Environmental Problems:

Cows have access to entire stream
Potential for high nutrient runoff on steeper slopes
Excessive phosphorous on fields close to barn
Fuel tank leaking
Milkhouse waste enters road ditch
Wet seeps breaking out of soil in three areas
Continuous corn on two fields

Calculation of Dollars to Spend

One animal unit is 1,000 pounds, e.g., 2,000 pound bull = 2 animal units.
One 150 pound sheep = 0.15 animal units.
This value is used to adjust program expenditure to the amount of animal waste produced.

JORDAN FARM ANIMALS

Animal type	Number	Weight	Animal Units
Mature cattle	50	1,200	
Immature cattle	15	800	
Calves	10	300	

TOTAL ANIMAL UNITS	

After the total number of animal units is determined, decide if the threat to the environment is high, medium, or low. Evaluation is made by location of the area with respect to wet areas. Streams, springs, marshes, and areas that are seasonally wet are located and highlighted on the farm map.

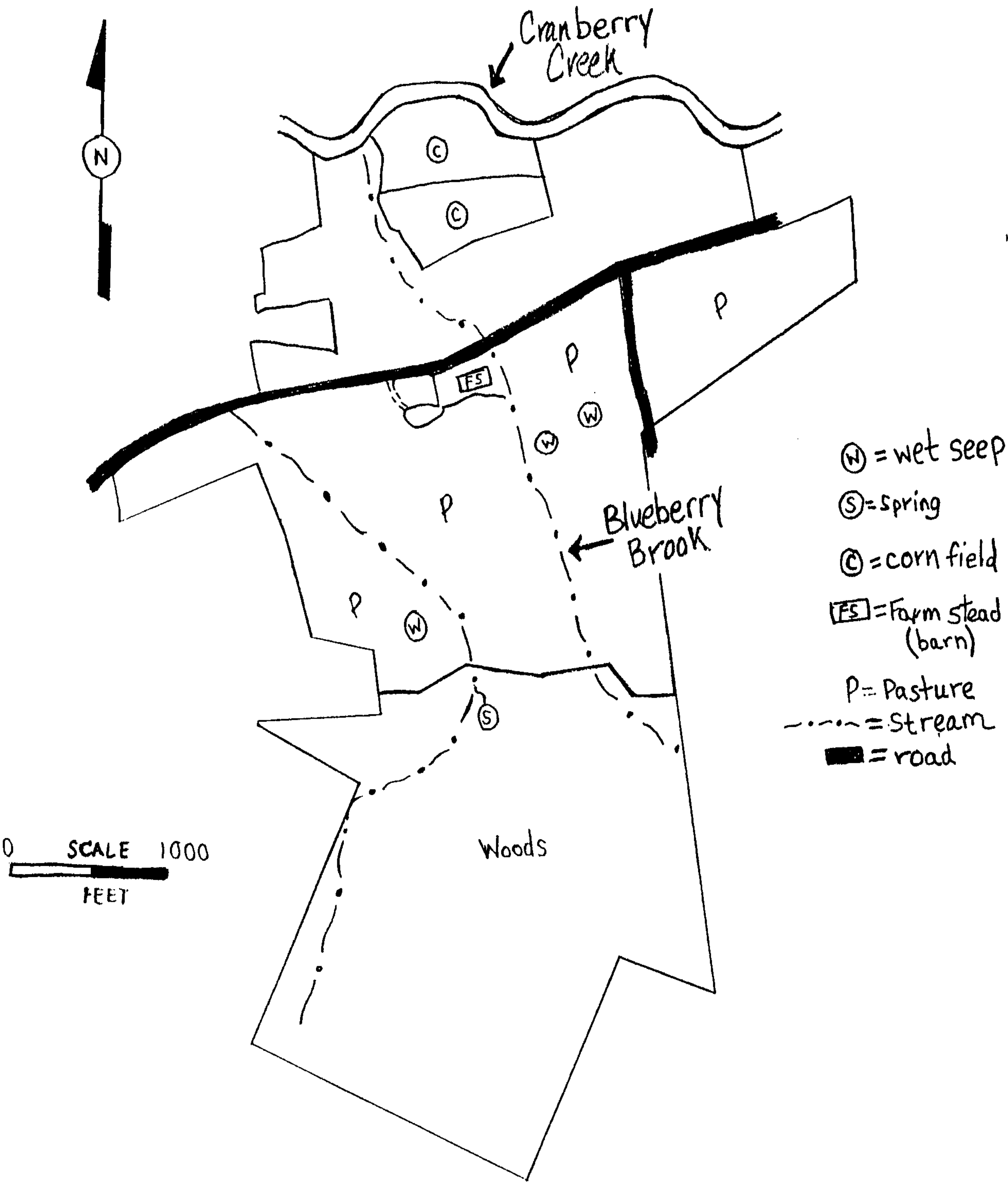
High level threats receive	\$750 - \$1,000 per animal unit
Medium level threats	\$500 - \$750
Low level threats	\$350 - \$500

Since this farm has a stream flowing through it, which eventually enters the Cannonsville Reservoir, we will classify the farm as a medium level threat and allow \$750 per animal unit to implement best management practices to reduce the threat of pollution.

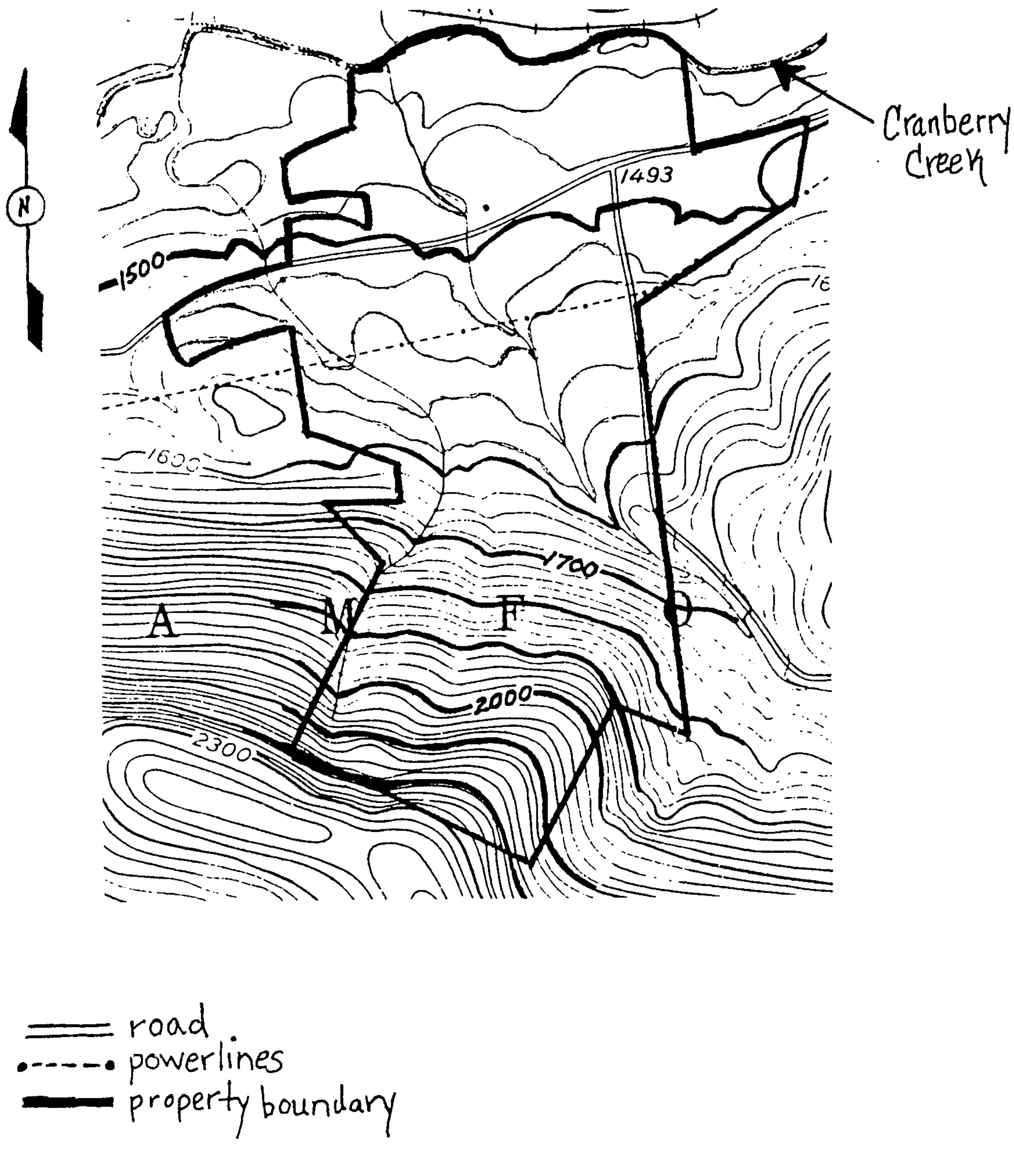
Animal units	**x \$750**	**= Total Allowed**
	\$	\$

BEST MANAGEMENT PRACTICE	GENERALLY ASSOCIATED COST
1. Strip cropping includes lime & seed	$75 per acre
2. Subsurface drainage	$3 per linear foot
3. Manure storage area	$20,000
4. Barnyard water management	$25,000
5. Filter field or strip	$5,000
6. Access road improvement	$5 per foot
7. Diversion channel	$5.50 per foot
8. Planned grazing	Fencing expenses
9. Fencing	$1.50 per linear foot
10. Nutrient management	None
11. Fuel storage	$2,500
12. Stream crossing culvert	$10,000
13. Spring development	$6,000
14. Silo leachate control	$4,000
15. Manure handling equipment	$10,000

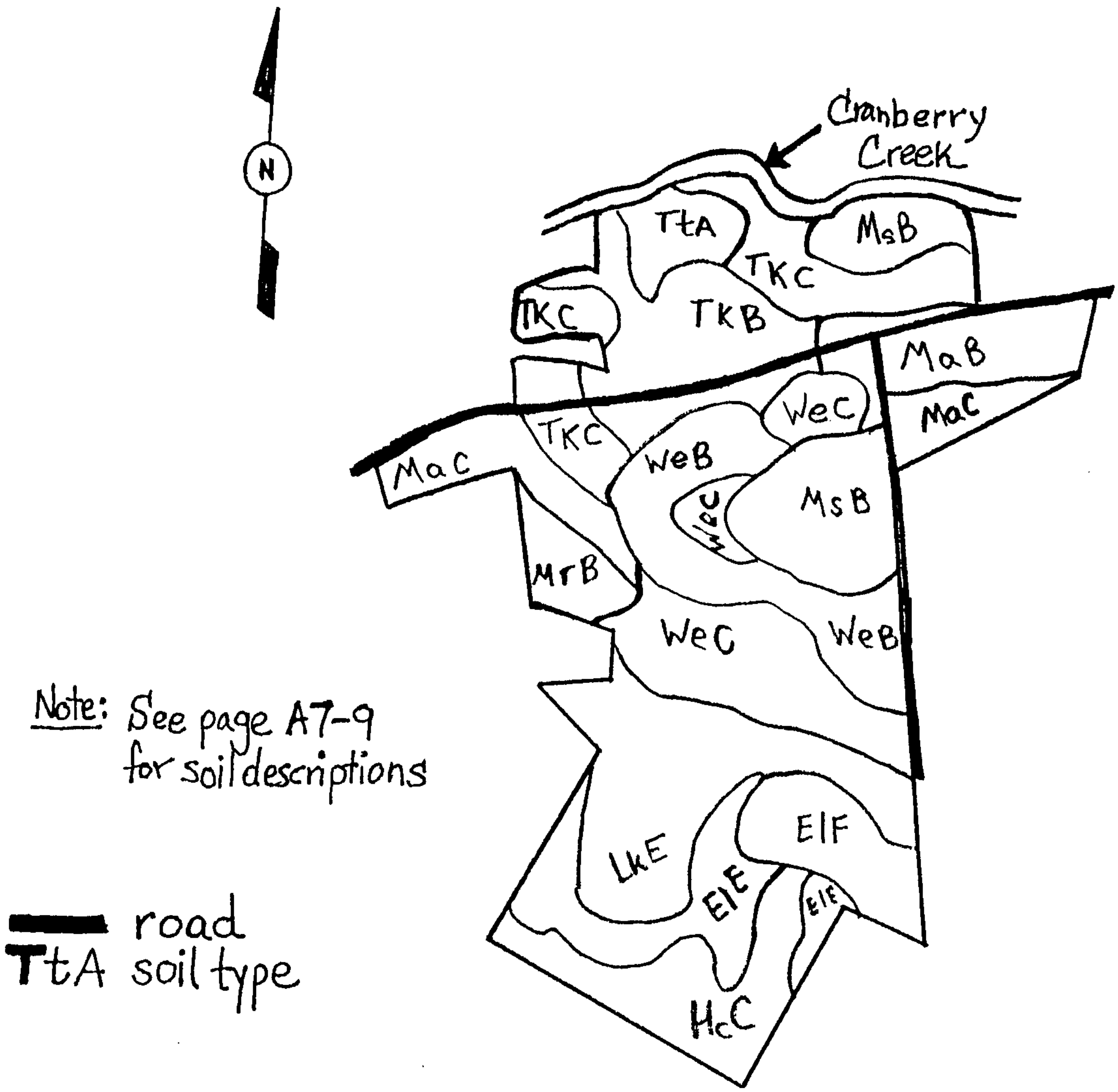
FARM LAND USE



FARM TOPOGRAPHY



SOIL TYPES


N
Cranberry Creek
TtA
MsB
TKC
TKB
TKC
MaB
MaC
WeC
MaC
TKC
WeB
MsB
WeC
MrB
WeC
WeB
LkE
ElF
ElE
ElE
HcC
Note: See page A7-9 for soil descriptions
road
TtA soil type

Soil Descriptions - Agricultural Uses

ElE - Elka-Vly: 15-35% slopes, very stony.
Occupy steep areas along sides of ridges and hills over 1,700' elevation.
Very strongly acidic to moderately acidic. Permeability is moderate.
Available water capacity is moderate. Use limited to woodland and pasture.

ElF - Elka-Vly: 35-70% slopes, very stony.
Occupy very steep areas along sides of ridges and hills over 1,700' elevation.
Very strongly acidic to moderately acidic. Permeability is moderate.
Available water capacity is moderate. Use limited to woodland and pasture.

HcC - Halcott, Mongaup and Vly: 2-15% slopes, very rocky.
Occupy ridgetops above 1,700' elevation. Shallow soil resulting in outcropping of bedrock.
Consists of both excessively drained and well drained soils.
Due to shallow depths and exposed bedrock, best uses are woodland and wildlife.

LkE - Lewbeach and Lewbath: 15-35% slopes, very stony.
Occupy moderately steep and steep areas over 1,700' elevation. Very deep, and well drained.
Very strongly to medium acidic soil. Permeability is moderate.
Available water capacity is moderate. Use limited to woodland and pasture.

MsB - Morris and Volusia: 3-12% slopes, very stony.
Occupy gently sloping and sloping areas. Very deep, poorly drained.
Very strongly to strongly acidic. Permeability is moderate. Available water capacity is moderate.
Stoniness and wetness limit use to woodland and wildlife.

TkB - Tunkhannock Gravelly Loam: 3-8% slopes.
Occupy undulating areas of terraces on sides of valleys. Very deep, well drained soil.
Extremely to medium acidic. Permeability is moderately rapid.
Available water capacity is low to moderate. Slight erosion hazard, but prime farmland.

TkC - Tunkhannock Gravelly Loam: 9-15% slopes.
Occupy rolling areas of terraces on sides of valleys. Very deep, well to excessively drained.
Extremely to medium acidic. Permeability is moderately rapid.
Moderate erosion hazard, droughtiness. Uses include crops, hay and pasture.

TtA - Tunkhannock and Chenango: 0-3% slopes, Alluvial Fan.
Occupy areas adjacent to floodplain, formed in outwash deposit where tributary enter valley.
Flooding can be from main stream or tributary stream. Permeability is moderately rapid.
Available water capacity is moderate. Soil suited to most crops, prime farmland.

WeB - Wellsboro Channery Silt Loam: 2-8% slopes.
Occupy gently sloping areas in uplands. Very deep, moderately well drained.
Very strongly to medium acidic. Permeability is moderate.
Available water capacity is moderate. Soil suited for cropland, hay and pasture.

WeC - Wellsboro Channery Silt Loam: 8-15% slopes.
Occupy sloping areas in uplands. Very deep, moderately well drained.
Very strongly to medium acidic. Permeability is moderate to slow. Available water capacity is moderate. Moderate erosion hazard. Uses are pasture or hay.

Treating Our Wastewater

Grades:

4th - 7th

Objective:

Discover two ways in which wastewater is treated.

Method:

A simple model provides a visual example of how wastewater arriving at a treatment plant or septic system is filtered and becomes usable again after it leaves the treatment facility.

Materials:

Muddy water, one clear plastic 2-liter bottle, two clear glass jars or clear plastic containers, fine sand, coarse sand, pebbles, a small piece of wire screen.

Time:

Preparation Time: 10 minutes
Class Time: 20 minutes

Overview:

"One third of the septic tanks in the U.S. are polluting water."
- *National Wildlife Federation*

Where does water go when it drains down our kitchen and bathroom sinks? It is surprising how many people today have no idea. To maintain safe ground and surface waters, wastewater from our homes and businesses must be treated before being released into the environment. Household sewage is a combination of wastewater from several sources: toilets - 40%, laundry - 15%, bathing - 30%, kitchen - 10%, and miscellaneous water uses - 5% (*Septic Systems,* 1989, University of NH Coop. Ext.*).* Many rural homes, such as in small Catskill Mountain communities, have septic systems. Larger villages and cities use wastewater plants or other forms of treatment to deal with community wastewater.

Improperly or inadequately treated wastewater can contaminate surface and groundwater supplies of drinking water. When wastewater is treated correctly, dangerous contaminates are removed, insuring the safety of the surrounding environment and the communities involved. The following experiments can be used to familiarize students with the specific steps taken in wastewater treatment systems for treating water safely and efficiently.

The Steps of a Wastewater Treatment Plant

Wastewater treatment plants go through several steps in a treatment process in order to safely treat large quantities of wastewater. When the water first arrives at the treatment plant, it passes through a **comminutor**, which screens, grinds up, and removes large floating objects like rags, sticks, cans, etc. After this screening process, the water passes through a **grit chamber**, where sand, grit, cinders, and small stones settle to the bottom. Once the screening is completed and the grit is removed, the sewage then moves on to the **sedimentation tank** where most of the solids settle to the bottom as raw sludge. The sludge is mechanically removed from the tank when necessary. These steps all constitute the first, or primary, stage of treatment.

In the past, this was often enough treatment for most communities. With the amounts and types of pollutants now entering our waste streams, secondary measures are often needed. After the sedimentation tank, secondary treatment involves moving the sewage to an **aeration tank**, where the sewage is mixed with air and bacteria and allowed to remain for several hours. During this time, the bacteria in the sludge break down any organic materials left in the water. The resulting sludge mixture, now teaming with millions of bacteria, can be combined with new sewage in the presence of additional supplies of fresh air. The next treatment commonly used after the wastewater leaves the aeration tanks is secondary sedimentation, which occurs in the **clarifier**. At this point, the water is allowed to settle out any remaining particulates before the final step. **Chlorination** is the final step before water is discharged through a pipe into a nearby stream, river, or ocean. Very small amounts of chlorine gas are added to the water to kill any remaining bacteria.

There are several other methods for treating wastewater for reuse, but the above techniques are the most commonly used. Other secondary treatments include combinations of aeration tanks or trickling filters with sedimentation tanks, or the use of lagoons or wetlands with natural ecosystems to absorb the impurities present. Advanced treatments, when necessary, include nutrient extraction, further filtration, disinfection, and chlorine removal before the effluent is discharged or reused. The amount of processing a municipality uses on its wastewater is set by the Federal Clean Water Act and New York State effluent standards.

The Elements of a Septic System

These two-part systems generally consist of an underground, watertight receptacle called a septic tank and a soil absorption or drainage field. As wastewater goes down the drain, it travels through pipes to the septic tank. Inside the tank, beneficial bacteria begin to break down some of the solids. The remaining heavy solids settle to the bottom of the tank and the lighter solids and grease float to the surface. This settling process inside the tank is called **sedimentation**. To maintain proper functioning inside the tank, the sludge and scum are periodically pumped out.

From the tank, sediment-free liquid flows through a distribution box to perforated pipes that have been laid in trenches filled with crushed stone. There, the partially-treated water flows through the surrounding material toward the groundwater. During its travels, bacteria, oxygen, and soil help purify the water through chemical and physical reactions. This penetration process is a form of filtration. Because the soil is the most critical factor in cleansing the wastewater when it leaves the tank, soil type determines what kind of system can be installed.

Procedure:

1. To demonstrate the primary stage treatment of sedimentation in a septic system and wastewater treatment plant, have students fill one of the clear containers with shaken muddy water. Allow particles to settle, and observe the water every five minutes. Record results.

2. To illustrate the filtration step, have the students cut the bottom off of the 2-liter plastic bottle. Turn the bottle upside down and put a piece of wire screen inside the neck. Next, place layers of clean soil materials in the bottle beginning with the coarsest materials such as pebbles, and ending with the fine sand on top. Run some tap water through the filter to clean it.

3. Slowly pour half of the settled water into the filter bottle. Record the results comparing filtered water with muddy water and the remaining settled water.

Assessment:

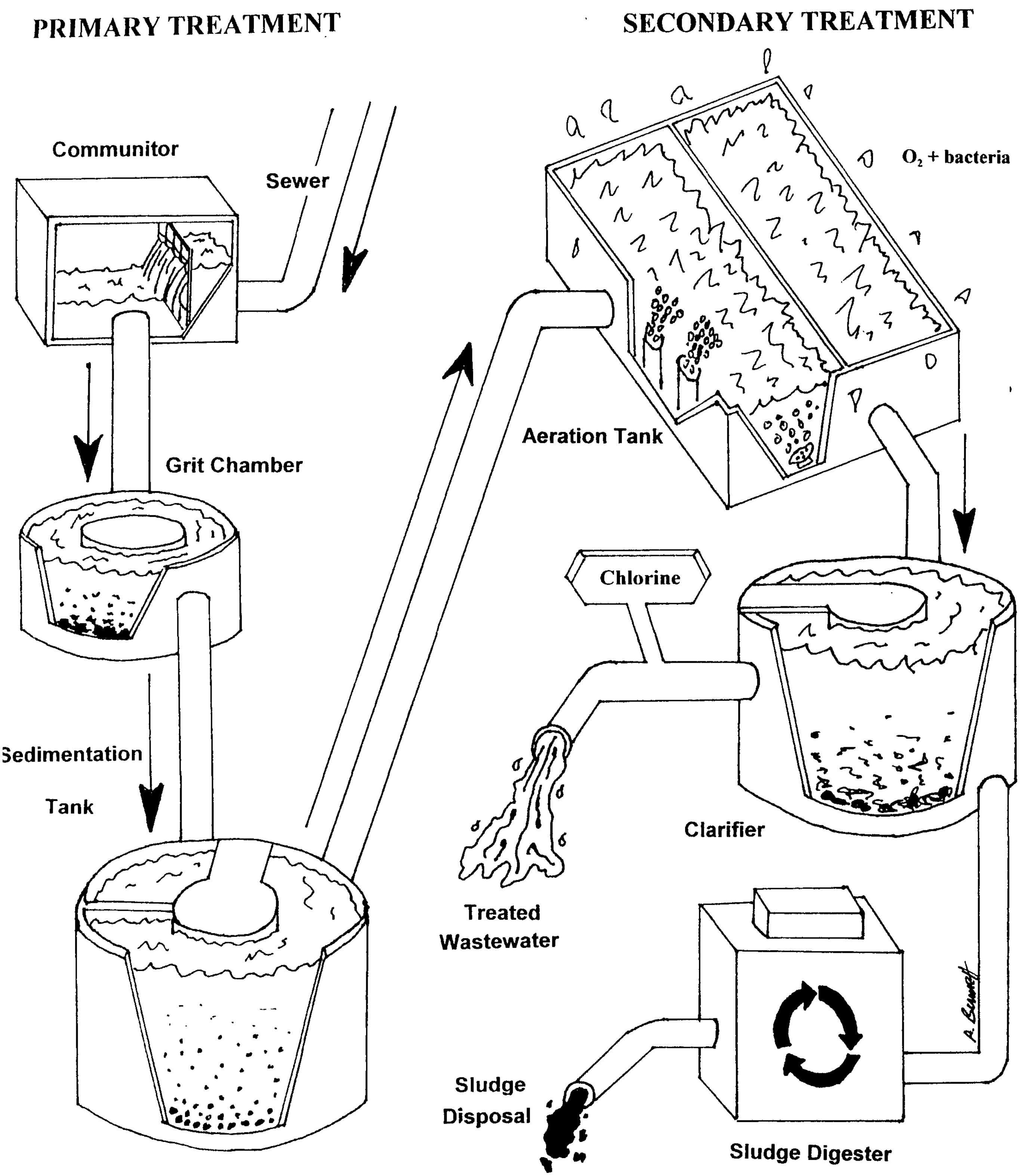
Use the enclosed quiz as an assessment. Quiz answers:

1. Answers will vary. Some houses have a septic tank; others may have only a leach field. Some homes, especially those within village and city limits, are likely hooked into the town sewage line. In that case, their wastewater goes to the local treatment plant.
2. It is important to pump out the septic tank every 3-4 years so it does not get too full. It may crack or work improperly if it is too full.
3. Sewage Treatment Plants collect all of the wastewater from local communities.
4. Oxygen and bacteria are added to the treatment process in order to speed up the decomposition of the sludge.
5. New York City is building these treatment facilities to protect the water quality of Catskill Mountain streams. These facilities properly cleanse the water before it is released into the streams. New York City uses 1.2 billion gallons of water daily that once flowed through the streams in the Catskills.

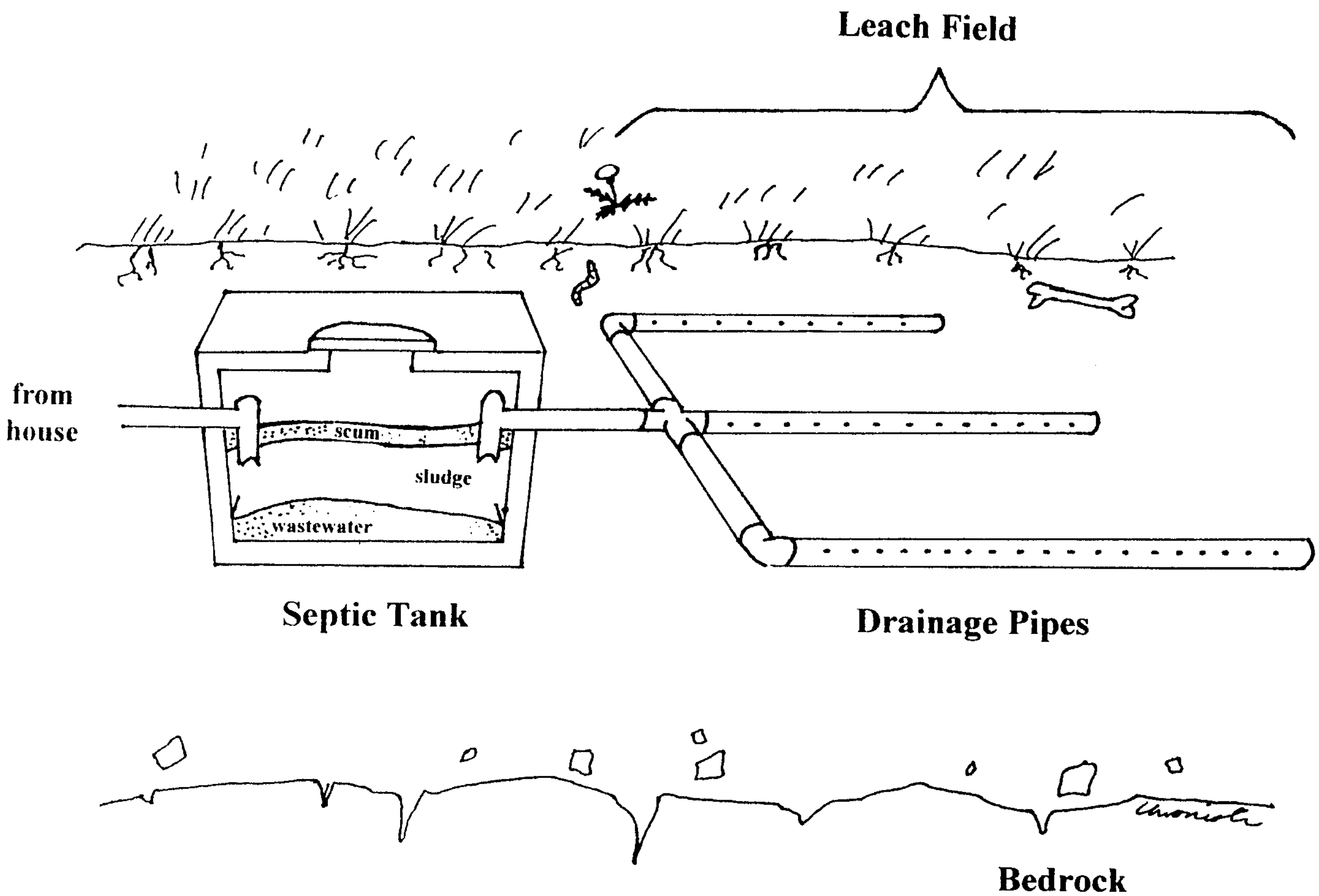
NYS Learning Standards:

Math, Science, and Technology
Standard 4 - Science: Physical Setting 2; The Living Environment 7
Standard 6 - Interconnectedness: Models

Sources: Activity adapted from Frost Valley YMCA's *The Ways Of The Watersheds.* Activity information obtained and lessons adapted from "Wastewater Treatment Worksheet" in *Captain Hydro Water Conservation Workbook* and *Pollution Prevention Through Watershed Management in Sullivan and Ulster Counties, New York Handbook.*


PRIMARY TREATMENT
SECONDARY TREATMENT
Communitor
Sewer
Grit Chamber
Sedimentation
Tank
Aeration Tank
O_2 + bacteria
Chlorine
Clarifier
Treated
Wastewater
Sludge
Disposal
Sludge Digester

Home Septic System



Treating Our Wastewater Quiz

Name: __________________________ Date: __________ Teacher: ___________________

Directions: Answer the questions below using the information you learned in the activity.

1. In your house, where does all of the water from your shower, sinks, and toilet go?

2. If your house has a septic tank, why is it important to pump it out every few years? What could happen if it isn't cleaned out?

3. Larger communities and cities have a _____________ ____________ Plant that collects all of the wastewater from the area.

4. During the wastewater treatment process, why are oxygen and bacteria added to the sewage?

5. In the Catskill Mountains, New York City has built and may continue to build wastewater treatment plants for the local communities. Why do you think New York City is doing this?

New York City Watershed

New York City's Need for Water

The New York City Watershed consists of 18 upstate reservoirs and 3 controlled lakes that cover some 1,900 square miles in the Catskill Mountains and east of the Hudson River. These systems within the NYC watershed boundary have ecological and political consequences for the residents. To keep the streams, lakes, and wetlands within this boundary clean, rules and regulations are applied to the watershed regions to benefit New York City's eight million residents and the one million residents of Westchester, Putnam, Orange, and Ulster Counties who rely on the same supply system. These nine million people consume 1.4 billion gallons of water daily. However, local people who live and run businesses under these rules often disagree with them. Septic systems, wastewater treatment, and economic development are all monitored to avoid impact on the water bodies. What constitutes "safe" development to the NYC Department of Environmental Protection may clash with what is locally thought to be responsible development. By understanding both sides of the issues, citizens can make informed decisions for the future of the Catskills. Historically, there has been a real interest on both sides to come to an agreement so each can benefit from an unlikely partnership.

Throughout this century, the New York City water supply system has been the envy of virtually all major drinking water supply systems around the country and throughout the world. This system is one of the engineering marvels of the modern world. Ninety-seven percent of the water supplied to the city travels by gravity; meaning changes in electrical energy costs do not affect the cost of water. The supply tunnels and aqueducts that feed water to New York City are amazing in themselves, as you will see.

In 1842 the first of the New York City reservoirs was created by damming the Croton River in Westchester County. The water was piped through a 40.5-mile aqueduct into Manhattan. Increasing demands caused the construction of other reservoirs in the Croton System before the turn of the century. Plans were in place by 1907 to tap the Catskill Mountains for clean water. The Ashokan Reservoir was finished in 1915, and the Schoharie Reservoir in 1926 completed the Catskill Supply System, built to meet the increasing demand for clean water.

The last and largest piece of the puzzle, the Delaware System, was completed in 1965. The Delaware System consists of four reservoirs: Neversink, Cannonsville, Pepacton, and Rondout. Water from the Catskill System flows, via the Catskill Aqueduct, under the Hudson River and then to the Kensico Reservoir in Westchester County. The Delaware Aqueduct collects the water from the Delaware System, carries it under the Hudson River, and deposits it into the West Branch Reservoir in Putnam County.

The landmark NYC Watershed Agreement that was signed between the towns of the Catskill / Delaware Watersheds and New York City allows the city to avoid EPA-mandated construction of a filtration plant. Every activity within the watershed affects New York City's water. All of the road salt, the fertilizer, the pollutants from leaky septic tanks eventually find their way into the reservoirs. Today, this water is virtually untreated. A large metal net, resembling a chain-link fence, is the only “filter” the city’s drinking water passes through. Usually the only chemicals used in the water are small amounts of chlorine and fluoride. When the water is cloudy, aluminum sulfate is added to allow particles to settle out, and copper sulfate is added when algae growth is a problem.

Overview of New York City Water Supply System

In the Catskill Mountains, the New York City drinking water supply area, or watershed, covers approximately 1,600 square miles, and includes six reservoirs located in five counties. The reservoirs located in the Catskills are part of either the Delaware System or the Catskill System. The remaining reservoirs and lakes comprise the East of Hudson Watersheds, or the Croton System. Of the 1.4 billion gallons of water supplied daily to over 9 million New York City and upstate residents, the Catskill and Delaware Systems provide 90 percent of it. Fifty percent originates in the Delaware System, and another 40 percent is supplied by the Catskill System.

Not all water collected from the Catskills ends up in the same place. There is a *drainage divide* running north to south through the Catskills. Precipitation on the western side flows into the Delaware River, and precipitation on the eastern side falls within the Hudson River Watershed. Consequently, this drainage divide separates the Delaware Supply System from the Catskill. As shown on the map provided, water from the Delaware System takes the most complicated journey. The Rondout Reservoir collects water from three other reservoirs: the Cannonsville Reservoir, via the West Delaware Tunnel (44 miles long, 11’4” diameter), the Pepacton Reservoir, via the East Delaware Tunnel (25 miles long, 11’4” diameter), and the Neversink Reservoir, via the Neversink Tunnel (6 miles long, 10’ diameter). The Delaware Aqueduct transports the water from the Rondout Reservoir, under the Hudson River (600’ below sea level) into the (East of Hudson) West Branch Reservoir. This 84-mile-long structure is the world’s longest continuous underground tunnel. It has an average depth of 623’ below ground, with the deepest section at 1,551’ (south of Kerhonksen). An aqueduct then carries the water from the West Branch Reservoir to the Kensico Reservoir, near White Plains. This is where water from the two systems, Delaware and Catskill, meet.

The Catskill Supply System consists of two reservoirs, the Schoharie and Ashokan. Water from the Schoharie Reservoir travels through the Shandaken Tunnel (18 miles) into the Esopus Creek, which travels 11 miles to reach the Ashokan Reservoir. The Catskill Aqueduct transports water under the Hudson River (1,114’ below the river bed!) and then to the Kensico Reservoir, a journey of 92 miles. The Catskill Aqueduct is actually seven miles longer than the Delaware Aqueduct, but it is not entirely underground. From the Kensico Reservoir, the water from the Delaware and Catskill Systems flows through two different tunnels into the Hillview Reservoir, located just outside New York City, which regulates water flow from the Kensico.

The New Croton Reservoir collects the water from all of the reservoirs within the Croton System and sends it off to New York City through the Croton Aqueduct. On the southern end of the Croton Aqueduct is the Jerome Park Reservoir, which water enters before distribution.

The History of the Lost Villages

The New York City Water Supply System continues to amaze people across the globe as an engineering feat. New York City does not have the drinking water concerns that other huge coastal metropolitan areas struggle with continually. The water is plentiful, with rare drought warnings, and the water is pure. Engineering projects of this magnitude always bring sacrifice and conflict with them. Sacrifices of land, history, homes, and businesses had to be made in order to build reservoirs in ideal locations. These sacrifices were hard to make and created great conflict between those who were forced to make the sacrifices and those who would benefit.

It is very important to remember those sacrifices. The construction of each reservoir resulted in the destruction and flooding of one or more villages; the Ashokan Reservoir alone flooded twelve. As years pass, the villages become more and more buried. Not by rising water levels, but buried in everyone's minds because the number of survivors of the villages is declining. Only recently have the younger generations begun learning about this important piece of local history.

Ashokan Reservoir

Around the turn of the century, when New York City needed more clean water for its growing population, the city turned to the Catskill Mountains, located some 100 miles to the north. The Esopus Valley in the Catskills was chosen mainly because test borings showed the presence of solid bedrock, necessary to prevent loss of water underground. The plans were in place by early 1907, and the purchase of land by New York City followed soon.

The eleven villages once located beneath the Ashokan Reservoir are: Boiceville, Glenford, Olive, Olive Bridge, Shokan, West Hurley, and West Shokan, which were relocated, and Olive City, Brown's Station, Brodhead's Bridge, and Ashton, which were destroyed and not rebuilt. The village of Olive was relocated across the present-day reservoir and renamed Ashokan. Ten years after construction began, the Ashokan Reservoir and the Catskill Aqueduct were completed. Ten thousand acres of land was cleared and more than 2,000 people forced to move their families. Five-hundred-four homes, 35 stores, 10 churches, 11 schools, and five railroad stations were either moved by the owners or burned by the City. All of the vegetation located on the site of the reservoir was cut down; stumps were dug out or blown up. Forty or so cemeteries located within the boundaries held 2,700 burial sites. New York City paid friends and relatives of the deceased $15 to move the graves. Those not moved by families or friends were relocated by the City.

All of the construction materials for the project were supplied from the Catskill Mountains and brought to the site via the Ulster & Delaware Railroad. The construction of this reservoir was such a huge undertaking that a workers' camp needed to be built, located on the former site of Brown's Station, for its central location. It was larger than any of the other villages in the area, with over 4,000 laborers in this 225-building camp. The camp was more modern than the local villages. A bank, a school, fire and police stations, a bakery, a church, and even a sewage treatment plant were available to the mainly-immigrant construction workers. Of the 4,000 laborers, 60% were Italian immigrants, with Austrians and Russians comprising the next largest groups. The Americans that worked on the project came from 27 different states. The unskilled workers' pay ranged from $1.20 - $1.60 per 8 hour day, which was a very good wage at the time. Plumbers, pumpmen, and pipe fitters earned $2 per day, and stonemasons $3 a day. Workers paid between $20 and $22.50 per month for room and board in the camp. The camp was the last site torn down before the Ashokan Reservoir was allowed to fill.

With the workers' camp housing thousands of people, conflict and crime were inevitable. A Board of Water Supply police force was deemed necessary to patrol the reservoir and aqueduct areas during construction. In their busiest year, the 377 patrolmen arrested over 1,500 people. Throughout their employment (through 1918), the patrolmen's testimony resulted in more than 5,000 convictions and seven executions. Most of the arrests were made south of the reservoir, along the Catskill Aqueduct, where working conditions were more dangerous and tensions were greater. This police force was organized and regulated by New York City officials; therefore, the methods used and the laws followed were different from neighboring towns. Today, the police force is a branch of the New York City Department of Environmental Protection (NYCDEP) that enforces regulations within the watershed.

The main dam, The Olive Bridge Dam, is 4,650' long and 210' high. The lake created by this dam has an average depth of 50', with the deepest point being 190'. The Ashokan Reservoir cost $30.5 million to construct. The Catskill Aqueduct, whose construction cost the lives of 283 men, cost over $160 million to build. When water was first sent to New York City, the Ashokan Reservoir was 42% full, nine months after water started filling the reservoir. When the project began, experts predicted the reservoir to last 90 years. Today, engineers feel it could have a life span of 250 years. This amazing engineering feat was accomplished with only the use of steam-powered engines, as the internal combustion engine had only recently been invented. The steam shovels, steamrollers, and steam-powered locomotives used in the construction process, appropriately name this, "the last of the handmade dams".

Schoharie Reservoir

The Town of Gilboa was founded in 1848, with the original settlement dating back to 1760. The late 1800s brought hard times for the citizens of Gilboa. In 1869, a flood destroyed almost half of the village, and in 1890 a terrible fire wiped out more than half of the village, forcing the citizens to rebuild their homes after each tragedy. Gilboa's luck did not seem to get any better after the turn of the century. In 1914, New York City selected an area near Prattsville for the location of a new water supply reservoir. After poor results from test-borings, to examine the underlying bedrock there, New York City decided that Gilboa was a better site for the reservoir. In 1918, New York City bought up all of the rights to the town and surrounding valley.

Three separate fires were needed to raze the village, before construction could begin. The New York City Board of Water Supply ordered the last two fires; the first was considered by some to be accidental, though others felt it was set deliberately. In all, 25 homes, 12 barns, a church, and a garage were destroyed, 1,330 graves were moved, and 350 Gilboans were forced to relocate. On December 4, 1925, eight years after New York City first started acquiring the land, and five years after construction of the dam began, the remaining buildings (the former Richmyer farm) below the water line were burned. The Schoharie Reservoir began to fill on July 24, 1926.

The construction of this reservoir required damming the Schoharie Creek that flows north, and essentially diverting the flow southward to New York City. The Shandaken Tunnel carries the water under mountains for 18 miles until it reaches the surface again, and from there it flows to the Ashokan Reservoir as part of the Esopus Creek. The Gilboa Dam cost $6.8 million of the entire project cost estimated at $22 million.

Rondout Reservoir

The Catskill Water Supply System (Ashokan and Schoharie Reservoirs) was completed by 1926, and already, New York City knew that even more water was needed to meet its growing demand. New York City began studies in the Rondout Valley in 1921, and by 1927, the Rondout Valley was chosen for the site of a new reservoir. When New York City began building the Rondout Reservoir in 1937, the future of three villages changed forever. In Eureka, Lackawack, and Montela lived over 1,200 people (250 families). They were forced to sacrifice over 1,000 buildings, including their homes, and move elsewhere. All the bodies from the eight cemeteries in the valley had to be moved. Of the three villages, only one, Lackawack, was relocated and still exists today. Building the reservoir required the work of over 400 laborers, while the construction of the aqueduct needed hundreds more. The main dam, called the Merriman Dam for the chief engineer, Thaddeus Merriman, who passed away during the construction of the reservoir, spans 2,400 feet from one side of the Rondout Valley to the other.

Construction began on June 21, 1937, was delayed twice, once for World War II, once for the Korean War, and was finally completed on July 18, 1955. When construction began, the village of Lackawack was the first and largest to be destroyed and the only one relocated. The largest village industry was a tannery that employed 350 men.

The historic village of Montela, known for the Battle of Chestnut Woods in 1778, was the next to be razed. Although settled in the mid-1700s, Montela wasn't officially established until 1886. This village was located on the border of Sullivan and Ulster Counties. The last village to fall was Eureka, the smallest of the three villages where a gristmill provided most of the jobs. Also founded in the mid-1700s, its post office closed forever on October 31, 1942, and like the rest, it disappeared under the water.

Neversink Reservoir

The construction of the Neversink, begun March 18, 1941, led to the relocation of another 350 people, forced to move from the settlements of Bittersweet and Aden, and the village of Neversink. The settlements of Bittersweet and Aden were never relocated; they were lost forever. The village of Neversink, which was moved, is still on the map today in its new location. Several boarding houses, schools, churches, stores, a bowling alley, and a casino were located where the reservoir now lies. The 1,500-acre reservoir, finally completed in 1953, took over 12 years to build due to construction delays during World War II. The Neversink is New York City's benchmark reservoir, the standard to which others are compared. Due to the very undeveloped watershed area, this reservoir has the highest water quality of all New York City reservoirs.

Pepacton Reservoir

In 1938, a location on the East Branch of the Delaware River was selected. This new reservoir would displace over 970 people from four different villages: Shavertown, Pepacton, Union Grove, and Arena. A dam was to be built just above the village of Downsville, about eight miles west of the village of Shavertown. Construction of the Downsville Dam began on November 11, 1948, and when complete it would hold back the largest of New York City's reservoirs.

Jacob and John Shaver first settled Shavertown in 1781. The first and foremost industry in Shavertown was timber, which supplied cities, like Philadelphia, with logs shipped down the Delaware River. The first post office was established in 1828, and the Delaware and Eastern Railroad reached Shavertown by 1906, bringing increasing numbers of people with it. By early 1954, the people of Shavertown had been evicted and the post office shut down.

The village of Pepacton, the reservoir's namesake, was a gathering place for Native Americans. In the late 1800s, shad fishing was the most prominent industry. Pepacton was located only four miles from the site of the future Downsville Dam. Due to its close proximity to the dam, it was the first village to be destroyed to make way for the Pepacton Reservoir. The village of Union Grove, nine miles from the site of the Downsville Dam, was founded in 1801. Once an established lumbering town and convention site for outdoor activities, Union Grove closed its post office doors on April 30, 1954.

The village of Arena, or "Lumberville" as it was called during the days of rafting timber down the East Branch of the Delaware River, was established in 1874. Arena was the largest and last village in the East Branch valley to succumb to New York City's drinking water needs. The village was the farthest from the Downsville Dam, about 12.5 miles east. Once Arena was evacuated and the dam completed in 1954, the Pepacton Reservoir began to collect water from the East Branch of the Delaware. The project was officially completed on November 18, 1955. In all, the Pepacton Reservoir forced 974 people to relocate. Ten cemeteries with 2,371 graves were moved, and over 150 buildings were destroyed within the East Branch valley, including eight stores, seven churches, two schools, and two railroad stations.

Cannonsville Reservoir

The last reservoir constructed was the Cannonsville. Due to the size of its watershed, the largest of all of the reservoirs', New York City was forced to purchase massive amounts of watershed land surrounding the reservoir (19,902 acres) to help protect the water quality. The Cannonsville Reservoir lies almost completely in the town of Tompkins. The only remaining village in the town is Trout Creek. The other five villages were condemned in the 1960s to make way for the water: Beerston, Cannonsville, Granton, Rock Rift, and Rock Royal. A total of 941 people lost their homes to the construction of the Cannonsville Reservoir. Eleven cemeteries were located in the valley, forcing the removal of 2,150 graves. The construction of the Cannonsville Reservoir took place from 1955-1967. It was in service by 1965.

Rock Rift was known most for its lumber industry, although there was a factory that produced charcoal, wood alcohol, and acetate of lime. The village of Granton, located under the

Eastern branch of the present-day reservoir was formerly a lumbering and rafting center. The village of Cannonsville was originally a lumbering community as well, which prior to the flooding was home to a creamery that was the largest employer in the village. Rock Royal was located in what is now the northern branch of the reservoir. Rock Royal also had a large creamery and dry milk plant before the village was forced to shut down in 1962. Beerston was located about 4.5 miles south of Walton and was home to an acid factory until World War I. It's post office opened in 1888 and closed in 1955.

Note: Albany, like New York City, had to remove a village to create its major water supply reservoir. The village of Indian Fields was located on the edge of the Catskill region in southern Albany County. In 1929, Albany ordered the evacuation of Indian Fields. Farms, a hotel, a church, a school, and a post office were destroyed to make way for the new reservoir, which resulted from damming the Hannacroix Creek just west of Alcove. A cemetery was moved to its present location east of the reservoir. The Alcove Reservoir holds 13.5 billion gallons, almost as much as New York City's Schoharie Reservoir. The smaller Basic Creek Reservoir also contributes to Albany's water supply.

Federal Clean Water Act - 1972

Following World War II, the need for water quality improvements became evident to Congress. The responsibility of improving the water quality would be divided between the states and the federal government. These responsibilities were addressed in the 1948 Water Pollution Control Act. The federal government would conduct surveys, provide research, and conduct investigations, while the states had control over their own pollution abatement methods.

The early 1970s spurred an era of environmentalism in this country. For example, in 1972, Congress passed the Water Pollution Control Amendments (PL 92-500). One of the goals of these amendments was to make all navigable waters "fishable and swimmable" by 1983, in addition to eliminating all discharge of pollutants into navigable waters by 1985. These amendments also increased administrative duties for the recently established (1970) Environmental Protection Agency (EPA).

In 1977 an amendment to PL 92-500 was enacted. The amendment dealt mostly with water allocation rights on the state level, but it had another purpose. This act and the original PL 92-500 were combined, and termed the 1972 Clean Water Act, considered a benchmark for all water quality protection efforts in this country. The act is a foundation that enables stricter water quality standards to be set each time they are needed.

The Watershed Agreement

The U.S. Environmental Protection Agency (USEPA) has the responsibility of setting and enforcing the drinking water standards in this country, set by the 1986 Safe Drinking Water Act. The 1989 Surface Water Treatment Rule (SWTR) was passed to ensure that all surface drinking water sources, like New York City's, would meet USEPA standards by 1993 or be filtered. New York City estimated the cost of building a filtration plant at $4 to $6 billion, ultimately causing NYC to more than double the current water rates. By 1990, the New York City Department of

Environmental Protection (NYCDEP) had put together a draft Watershed Protection Plan, which would allow the city to meet the EPA's standards without building a filtration plant.

In 1993, the USEPA granted a “Filtration Avoidance Determination” (FAD), which required that NYC begin acquiring land and upgrading sewage treatment plants within its watershed. The USEPA later granted another FAD that was effective until December 1996. The second FAD stipulated that the city have a satisfactory watershed protection program in place, establish a land acquisition program, and revise the current watershed regulations. After years of contention, in November 1995, an Agreement in Principle was reached between New York City and the upstate towns located within the NYC Watershed (the Coalition of Watershed Towns). The parties officially signed the Memorandum of Agreement on January 21, 1997, allowing New York City to begin the process of meeting EPA standards without having to filter the water.

Upstate / Downstate Perceptions & Perspectives

The upstate residents of New York lead very different lives than the residents of New York City. Ever since the early 1900s, when New York City constructed the Ashokan Reservoir in the Catskill Mountains, a conflict between these New Yorkers has been evident. The upstaters feel that New York City invaded the Catskills and took whatever land it wanted to supply its people with clean water, even if it meant uprooting people whose families had inhabited the land for generations. To add more fuel to the already-raging fire, New York City, in the early 1950s, purchased more land in the East Branch Valley of Catskills to make way for their newest water supply, the Delaware System.

New York City must protect its drinking water supply from pollution if they do not want to be forced to construct a filtration plant. This means regulating certain lands within the watershed, as well as purchasing land in order to insure its protection. These regulations limit the activities of local landowners within the New York City watershed. Obviously, some of these regulations do not sit very well with all of the local landowners. Upstaters tend to believe that the downstaters are pushy know-it-alls who think they can run the upstaters’ lives by imposing such regulations. Downstaters possess various misconceptions as well. City residents commonly believe that upstaters are uneducated, lower class people who do not care about the environment.

In the early 1990s, stricter national policies on water quality rekindled the hostility between the upstaters and downstaters, resulting in a lawsuit against New York City in 1994. The Coalition of Watershed Towns filed the suit because the upstaters were unhappy with early negotiation efforts, and underlying distrust had resulted in a communications breakdown. In January 1995, a survey conducted by Cornell University of 758 households within the NYC watershed attempted to record any changes in public opinion as the New York City watershed controversy grew. 73% of upstate residents felt that New York City was not offering enough money for watershed protection, and 79% felt that the upstate towns were not asking for enough money from New York City for protection. While this survey was only geared to the upstate view, some promising conclusions were reached. For example, 59% surveyed felt that New York City was more willing to cooperate in 1995 than it had been ten years earlier.

Despite some differences, all New Yorkers seem to want and enjoy similar things in life: A less hectic lifestyle, outdoor adventures, and being closer to nature. Ideally, the signing of the New York City Watershed Memorandum of Agreement in January of 1997 will enable both sides to see beyond the stereotypes and begin enjoying their similarities.

CATSKILL SYSTEM RESERVOIRS / DELAWARE SYSTEM RESERVOIRS

	Ashokan	Schoharie	Rondout	Neversink	Pepacton	Cannonsville
Year Completed	1915	1926	1951	1953	1954	1965
Elevation (feet)	580’	1,120’	840’	1,440’	1,280’	1,150’
Stream dammed	Esopus Creek	Schoharie Creek	Rondout Creek	Neversink River	East Branch Delaware R.	West Branch Delaware R.
County(s)	Ulster	Greene Schoharie Delaware	Ulster Sullivan	Sullivan	Delaware	Delaware
Miles from NYC	75 miles North	115 miles North	75 miles Northwest	80+ miles Northwest	100+ miles Northwest	120+ miles Northwest
Dam Name, Length & Height	Olive Bridge 4,650’ 210’	Gilboa 2,000’ 182’	Merriman 2,400’ 195’	Neversink 2,820’ 195’	Downsville 2,450’ 204’	Stilesville 2,800’ 175’
Watershed Area (sq. miles)	253	316	95	93	370	454
Capacity (billion gals.)	123	17.6	49.6	34.9	140.2	95.7
Length (miles)	12	5.8	7.5	5	18.5	16
Max. depth (feet)	190’	150’	175’	175’	180’	140’
Tunnel Exiting	Catskill Aqueduct	Shandaken Tunnel	Delaware Aqueduct	Neversink Tunnel	East Delaware Tunnel	West Delaware Tunnel
Tunnel goes to	Kensico Reservoir	Esopus Cr. to Ashokan Reservoir	West Branch Reservoir	Rondout Reservoir	Rondout Reservoir	Rondout Reservoir
Number of villages flooded	11	1	3	3	4	6

The Catskill System provides 40 percent of the City’s daily water demand, about 650 million gallons.

The Delaware System provides roughly 50 percent of the City’s water, about 890 million gallons per day.

The Mission of the Mighty Molecule

Grades:

4th - 7th

Objective:

Students learn a greater appreciation for the New York City watershed and all of its components. Students will gain knowledge of the complexity, the size, and an idea of how the parts of the supply system are connected. Students should also be able to visualize how a watershed works and how activities in a watershed affect the downstream areas.

Method:

Students "become" part of the water supply system using a story which prompts them to visualize themselves as water traveling through the system from the Catskill Mountains down to New York City.

Materials:

A copy of *The Mission of the Mighty Molecule* story (enclosed), and a quiet and comfortable area for the students.

Time:

Preparation Time: 15 minutes to read over the story and fill in the blanks by looking at the included map to determine the path of the water from your school.
Class Time: 35 minutes

Procedure:

1. Read through the story once, and fill in the blanks with the appropriate reservoirs or tunnels that the water from the stream near school will travel through. Also, circle the correct Catskill collecting reservoir, the correct aqueduct, and the correct East of Hudson reservoir. Use the map provided in the appendix.

2. Incorporate this activity into a class where the New York City supply system is being discussed. This activity is designed to allow students to use their imagination in order to learn how water might travel through the supply system. By completing this activity, students should be able to visualize the whole water supply system.

3. Have the students move to a comfortable location where they will not be disturbed. Ask the students to shut their eyes and listen to the story that you are about to tell them. Students should

also be encouraged to use their imagination to develop visions of the different parts of the story. When everyone is ready, read the story out loud.

4. When you have concluded the story, organize the class in such a manner as to discuss the story and the impact the story had on them.

Assessment:

Use the enclosed quiz as an assessment. Quiz answers:

1. A watershed is an area of land that collects, stores, and eventually releases all of its water to a common outlet. Drainage divides delineate watersheds. Consult the map in the appendix to see if you are in the NYC Watershed or, does the nearest stream eventually flow into one of the six reservoirs in the Catskills? If so, you are in it.
2. To provide the expanding population of NYC with a reliable and clean supply of drinking water.
3. If this area does not get its usual amount of precipitation, the reservoirs will not fill up enough to meet the demands of NYC's residents.
4. The water travels through streams and huge tunnels that carry the water downhill (due to gravity) all the way to New York City.
5. The water droplet evaporates, and enters another stage of the water cycle.

NYS Learning Standards:

English
Standard 3 - Language for Information and Understanding: Listening and Reading

Math, Science, and Technology
Standard 4 - Science: Physical Setting 2,3; The Living Environment 7
Standard 5 - Technology: Impacts of Technology
Standard 6 - Interconnectedness: Systems

Social Studies
Standard 3 - Geography 1

Source: This activity developed by Aaron Bennett.

The Mission of the Mighty Molecule

Imagine that you are about to embark on a fantastic journey that may last longer than a year, cover over 100 miles, begin in the mountains and end in the city, and consist of many tosses and turns, kind of like a roller coaster. In this story, it is a cold January up here in the Catskill Mountains and you are a snowflake on this particular cold, winter day.

Picture yourself, the snowflake, drifting along in a storm cloud several thousand feet above the Catskills. As other snowflakes keep cramming into your cloud, it becomes completely full of little snowflakes, and it begins to snow. You are one of the first to be released, and as you begin your journey, you can see all of the mountaintops, and as you get closer to the earth, you begin to see the streams and ponds. You are so close now that you can see houses and people, and eventually you can pick out the ______________________ School. You are heading right for it! Splat! You hit and stick to the side of the school. Unfortunately not enough other snowflakes fell this morning, so school was not canceled. Good thing you are a snowflake and not a student. Since the storm did not last very long, the sun comes out from behind the clouds.

The sun really warms you up quickly, and eventually, you melt into a liquid. Now that you are liquid, you begin to run down the side of the school, following every crack you encounter, until you reach the ground. The snow that once covered the lawn has also melted and is now liquid as well. But wait! You are now being forced by gravity along the ground, down a slope. As you twist and turn through the grass and over the rocks, you pick up tiny pieces of soil and carry them with you. You can't stop from rolling along down the hill no matter how hard you try. All of a sudden, the ground ends! Yikes! Splash! You just fell into the small stream outside of the school.

Due to all of the melting snowflakes, the stream is running a little faster than usual. The current is bouncing you off, around, and over rocks and twigs. You notice that the stream is getting wider and wider as you travel, until you make it all the way to the ___________________ River/Creek. Here you begin to pick up even more speed. You travel under bridges, around big bends, next to a family of deer that have stopped by for a drink, and alongside several really big fish that almost inhale you through their gills.

Aah! You have just been dumped by the stream into a large open lake and you notice that you are hardly moving anymore. You realize that you are now in the _____________ Reservoir. There are billions of gallons of other water surrounding you. During your stay here, you see boats with people trout fishing, and large birds, maybe eagles or ospreys, that swoop down to the water and catch fish from time to time. After gently making your way across the reservoir for many weeks, or even months, you see a huge opening.

Note: If you were in the Ashokan or the Rondout Reservoir, skip the next two paragraphs.

This hole must be over 8 feet wide and made out of cement. This must be the beginning of the ________________ Tunnel. Whoosh! You have been sucked into the tunnel, which is completely filled with water and very dark. You tumble and fall downhill in the tunnel for a long time. You then begin to see some light way up ahead in the distance.

As you get closer and closer, it seems like it might be another reservoir. It's the Ashokan / Rondout (circle one) Reservoir. You realize that all of the water from this side of the Catskills is mixing together in here. You figure that it will be a couple more months before you reach the far end of this reservoir. Finally, you see *another* large opening, and guess what!

Note: Everyone should read from here on.

Zoom! You are pulled into the opening, which must be 15 or more feet tall. This huge tunnel is the Catskill / Delaware (circle one) Aqueduct. This aqueduct will carry you for 80 miles or more. Near the end of the tunnel, you begin to fall faster and faster. Splash! You hit the bottom of your fall, some 1,100 feet below sea level. You are now underneath the Hudson River. Your space gets smaller and smaller because of the weight of all the water above you. You feel you are getting pushed from behind. Since you are getting pushed, you start pushing the water in front of you until you come back up again, on the other side of the Hudson River.

Yippee! You begin to flow downhill once again. The tunnel starts to get brighter and brighter as you flow. Up ahead there is another reservoir. Aah! You have almost come to a complete stop now that you are part of the Kensico / West Branch Reservoir (circle one). You notice that this one is much smaller than the last reservoir. Here you mix not only with water from the Catskills, but also water from the local watershed. This is a balancing reservoir where you'll stay for only a short time, so Whoosh! On to the next tunnel you go.

Splash! You are now in another reservoir. This is a distribution reservoir so it is very small. Zoom! After spending a short time in there, you are pulled into yet another dark tunnel. This tunnel leads right down into New York City. Along your journey, you notice that the tunnels keep getting smaller, and this tunnel isn't really a tunnel at all. It is only about 20 inches across, because it is a water main. You are now only four feet below the streets, and if you are quiet enough, you can hear people talking and traffic moving.

You've heard stories about the pipes in New York City, like the one you are in now. There are over 2 million feet of these pipes, and close to 30 million feet of even smaller ones. Then, you hear a faint sound, almost like a siren. It gets louder and louder as each second passes. It is a siren blasting from a fire truck. You hear the truck stop overhead and people begin yelling instructions to one another. You hear a connection being made between a fire hose and the hydrant. A fireman shouts "All ready on this end" and then another replies "Turn the water on". Swiftly you are sucked up into one of the 99,000 hydrants in New York City. You are spinning around and around so quickly you don't even know where you are anymore.
Whoosh! The next thing you know, you are shot through the air with incredible force. As you travel, you look down and see all of the people that live in the burning building. They are very worried about their home -- you can see that on their faces. You feel yourself getting hotter and hotter as you approach the flames.

You now know the purpose of this incredible journey. After falling thousands of feet, climbing back up a thousand feet, falling even further, splashing into numerous reservoirs, bouncing around off rocks and twigs and grass, and traveling over 100 miles, you have finally reached your destination. You, and the other molecules of water with you, began your journey in either the Catskill Mountains, or in the watersheds east of the Hudson River. Some drops will end up as drinking water, and some, like you, will be needed for other important uses. Your journey may have seemed like a great deal of work, but the people who live in the burning building really appreciate the effort it took for you to arrive here in New York City and save their home.

The Mission of the Mighty Molecule Quiz

Name: ___________________________ Date: __________ Teacher: ___________________

Directions: Answer the questions below using the information you learned in the activity.

1. What is a watershed? Is your school in the New York City Watershed?

2. Why were six reservoirs constructed in the Catskill Mountains?

3. Why is the amount of precipitation (rain and snow) in the Catskills very important to millions of people downstate?

4. How does water from the Catskills get down to New York City without having to use pumps to move the water along?

5. When the droplet of water reaches the fire, what happens? Where does the water droplet go?

NYC Watershed Time Line

Grades:

6th - 9th

Objective:

Students will become more familiar with the history of the various components of the New York City water supply system. Students will be able to see how and when the supply system began, and how it has expanded.

Method:

Students will visualize where the NYC reservoirs are located in relation to New York City, the Hudson River, and their own communities. Students will use scale representations to compare the volumes of water that each reservoir holds, and they will model the path water follows to reach New York City. A time line is used to depict the development of the system.

Materials:

A large, open space in the classroom; cut-out copies of the reservoir cards (enclosed); copies of the labels for the reservoirs, tunnels, Hudson River, and NYC (enclosed); an answer key to the time line (enclosed); string; blue yarn; tape; 7 clear, one-gallon milk jugs; 7 measuring cups (or 8-ounce containers); water.

Note: A time line should be prepared beforehand, showing these two events:

- 1626: New Amsterdam (present-day New York City) founded.
- 1997: Watershed Agreement signed by New York City and the Coalition of Watershed Towns to guarantee water quality protection efforts within the NYC watershed.
  Make index cards for these events, and tape one card to each end of a ten-foot string. (Students will add the other cards during the activity.)

Time:

Preparation: 30 minutes
Class Time: 45 minutes

Procedure:

Intro: Explain to the class the purpose and general idea of this activity and its various components (i.e., the different reservoirs, tunnels, NYC, etc.). Split the class into seven different groups, one group for each of the six Catskill reservoirs, and one group to represent the Croton Reservoir System, which includes all 12 reservoirs and 3 lakes in the East of Hudson Watershed.

1. In a part of the classroom, map out these areas on the floor: all seven reservoirs, the Hudson River, and NYC. Use masking tape to mark where the reservoirs should be (you can use the labels provided to make it easier), use the blue yarn to represent the Hudson, and some other object to represent NYC.

2. Give each group one reservoir card.

3. Have each group, one at a time, move to their correct area on the floor. If you choose not to label the reservoir areas on the floor, have the students look at the map and locate where their reservoir should be.

4. Distribute the gallon milk containers and the measuring cups to each group. Have the students look up the capacity of their reservoir on their info card and then measure out the correct amount of water for their reservoir. Use 1 cup of water = 10 billion gallons. (Pepacton = 14.5 cups, Ashokan = 12.75 cups, Cannonsville = 9.75 cups, Croton = 9.5 cups, Rondout = 5 cups, Neversink = 3.5 cups, and Schoharie = 2 cups). Gallon milk jugs should be used for the reservoir containers, and 8-ounce containers, or any larger container marked to indicate “one cup” can be used.

5. Students can now compare their reservoir’s capacity in relation to the other reservoirs.

6. Students should now look at the map and determine where their water will go after leaving their reservoir.

7. Each group can now “build” a tunnel from their reservoir to the next reservoir by cutting a piece of string and taping the appropriate label to it. Each group should work with the adjoining group(s). The two groups with the Catskill and Delaware Aqueducts should be sure to “dig” the tunnel under the Hudson River.

8. One student from each group can now trace the path their water takes until it reaches New York City.

9. A time line can now be created. Start and end points should already be marked on the time-line. Have the groups affix their info cards on the time line by the date of completion for each reservoir.

10. After all students have had a chance to look at the completed time line and ask questions regarding it, bring the class together in one large group for a discussion.

Assessment:

1. Why was it necessary for New York City to build the Ashokan Reservoir even though they already had the Croton Reservoir System? Why was it necessary for New York City to build the

Rondout, or any other reservoir in the Delaware System, after they had already built the Ashokan and Schoharie Reservoirs?

2. What do you think New York City would have to do in 20 to 25 years if its population were to increase substantially?

3. Three Catskill reservoirs each hold more water than the *entire* Croton Reservoir System. Which reservoir almost doubles the capacity of the Croton System by itself?

NYS Learning Standards:

Math, Science, and Technology
Standard 5 - Technology: Technological Systems; History and Evolution of Technology; Impacts of Technology
Standard 6 - Interconnectedness: Models

Social Studies
Standard 1 - History of the United States and New York 3
Standard 3 - Geography 2

Source: This activity developed by Nathan Chronister and Aaron Bennett.

INFORMATION CARDS FOR NYC WATERSHED TIME LINE

THE ASHOKAN RESERVOIR
Year Completed: 1915
Capacity: 123 billion gallons
Watershed Size: 253 square miles
Notes:

THE SCHOHARIE RESERVOIR
Year Completed: 1926
Capacity: 17.6 billion gallons
Watershed Size: 316 square miles
Notes:

THE CANNONSVILLE RESERVOIR
Year Completed: 1965
Capacity: 95.7 billion gallons
Watershed Size: 454 square miles
Notes:

THE NEVERSINK RESERVOIR
Year Completed: 1953
Capacity: 34.9 billion gallons
Watershed Size: 93 square miles
Notes:

THE RONDOUT RESERVOIR
Year Completed: 1951
Capacity: 49.6 billion gallons
Watershed Size: 95 square miles
Notes:

THE PEPACTON RESERVOIR
Year Completed: 1954
Capacity: 140.2 billion gallons
Watershed Size: 370 square miles
Notes:

THE CROTON RESERVOIRS
Years Completed: 1870 - 1915
Capacity: 85 billion gallons
Watershed Size: 375 square miles
Notes: This system consists of 13 reservoirs and 3 controlled lakes.

ASHOKAN RESERVOIR	**CATSKILL AQUEDUCT**
PEPACTON RESERVOIR	**DELAWARE AQUEDUCT**
NEVERSINK RESERVOIR	**SHANDAKEN TUNNEL**
SCHOHARIE RESERVOIR	**WEST DELAWARE TUNNEL**
CANNONSVILLE RESERVOIR	**EAST DELAWARE TUNNEL**
RONDOUT RESERVOIR	**NEVERSINK TUNNEL**
CROTON RESERVOIR SYSTEM	**CROTON AQUEDUCT**
HUDSON RIVER	**NEW YORK CITY**

Time Line for NYC Supply System

1626: NEW AMSTERDAM (PRESENT DAY NEW YORK CITY) FOUNDED*****

1870-1915: THE CROTON RESERVOIR SYSTEM IS BUILT

1915: THE ASHOKAN RESERVOIR AND CATSKILL AQUEDUCT ARE COMPLETED

1926: THE SCHOHARIE RESERVOIR IS COMPLETED

1951: THE RONDOUT RESERVOIR AND DELAWARE AQUEDUCT ARE COMPLETED

1953: THE NEVERSINK RESERVOIR IS COMPLETED

1954: THE PEPACTON RESERVOIR IS COMPLETED

1965: THE CANNONSVILLE RESERVOIR IS COMPLETED

1997: WATERSHED AGREEMENT SIGNED BY NEW YORK CITY AND THE COALITION OF WATERSHED TOWNS*****

*** Teacher should place the index card for this item on the time line.**

Here Comes the Flood... Maybe

Note: This is a fictitious scenario. New York City is not planning to build a new reservoir.

The Delaware and Hudson River watersheds in New York are in a drought. Throughout the fall, there was very little precipitation. The rainfall was well below average. During December and January, when the New York City reservoirs are normally collecting runoff from snowmelt, there was very little snowfall in the area. Due to the lack of precipitation, the New York City reservoirs are only 35 percent full, when normally they would be 65 to 70 percent full.

Scientists have been monitoring the precipitation in the New York City watershed for the past decade. They discovered a slight decrease in the water level of the upstate reservoirs over that time. They have concluded that with the continued decline in precipitation each year, and the increasing population of New York City, they will need another reservoir to supply enough drinking water.

Over the past year, the city has been looking at various locations throughout the Catskill Mountain area. After a great deal of research, the location they chose is a valley near the village of South Kortright. Scientists believe that constructing a reservoir at this location will supply enough water to meet their needs and cause the least amount of destruction and relocation of homes and businesses in upstate New York. The South Kortright Reservoir will be created by damming the West Branch of the Delaware River, just south of the village. New York City officials have determined the water level in the reservoir will be 1600 feet above sea level, meaning that all land below 1600 feet will be flooded.

The State Water Commission (SWC) is the agency with the final say on whether or not a reservoir is built here. You are the group of SWC officials that have to make this difficult decision. Your instructions for making this decision is to take a good look at five major groups that will be affected by your decision: 1. Local residents (farms, homesteads, businesses), 2. Environmentalists, 3. New York City officials and residents, 4. Construction engineers and planners, and 5. The New York State Department of Transportation. You will be assigned to one of the five groups. Think about what problems the reservoir might cause for your group. If those problems are difficult to solve, your group probably won’t want the reservoir built.

The Village of South Kortright

South Kortright was settled in 1770 and organized in 1793. Throughout the 1800s and early 1900s, the primary industries in South Kortright were gristmills (where they ground wheat into flour) and saw mills. Surrounding hardwood forests composed of maple, birch, and ash, as well as conifers like hemlock and pine, were logged for timber. Today, the population of South Kortright is about 350, many of whom own small businesses or dairy farms. The village and its two churches, one school, one cemetery, and over 100 homes would be lost.

The city of New York will also own all land within 300 feet of the water's edge (one tenth of an inch on the map), so all residents will be evicted and all buildings located within this boundary will be condemned.

The Activity

Your job is to step into in one of the interested party's shoes and look for solutions to the obvious problems that will arise. Listed on the next page are five of the groups involved in this event. You will be given some questions to think about and answer. There are more concerns than just those listed. If you know of one, discuss it with the rest of the class. If you can think of solutions for each of the problems that concern your group, then you may wish to build the reservoir. If no logical solutions are in sight, or if you can find a problem with the proposed location of the new reservoir, you must ask the state not to allow the South Kortright Reservoir. Whatever your group decides, be able to give reasons for that decision. Write down your decision and reasons so you can share them with the class.

The Decision

Your group will tell the State Water Commission (your class) what it decided. The class makes the final decision on whether to build the reservoir. If your class feels that building the reservoir is a reasonable solution to New York City's water supply problems despite the needs of the local village and its people, then vote in favor of New York City. If you feel that New York City's potential water shortage is a problem that they can solve elsewhere, then rule in favor of the Village of South Kortright.

The Five Groups

1. Local Residents (farmers, business owners, homesteads). These are people and families that live in South Kortright. Many of the families have lived there for generations.

- How would you answer the question, "Where are we supposed to go now?" What would you tell them?
- Think about the moral issues. Is it acceptable to relocate families and destroy a village for the good of a larger population? Should New York City stay away from upstate New York, and solve their water problem some other way? Can they?
- The residents forced to move will be compensated with money by New York City. Can any amount of money make up for the loss of a home where people have lived for their entire lives, and in many cases, for generations?

2. The Environmentalists / Preservationists. These are local organizations working to protect the environment. Local fish and game clubs and hiking clubs are also included.

- This group argues that the new reservoir will result in the loss of pristine forests and streams. Will this reservoir cause habitat destruction for trout and other stream life in the West Branch? What about the wildlife that lives in the forests? There would obviously be no more hunting and hiking on the area if the reservoir is constructed.
- This group has made efforts over the years to restore the natural beauty of the South Kortright area. Will this reservoir ruin those efforts? Will the reservoir detract from the natural beauty?
- The preservationists are opposed to the construction of more large-scale, man-made structures that would disrupt the natural beauty of South Kortright. This reservoir would be the largest man-made structure in this part of the state. How might this dilemma be solved? How would you convince one side to give in to the other?

3. New York State Department of Transportation. This state agency will be responsible for building and maintaining new roadways around the new reservoir. Parts of six roads will be underwater if the reservoir is constructed, so new ones must be planned and built.

- Where are the new roadways going to go? How will they connect with one another? Which roads will not be rebuilt?
- On your map, draw in where you think the new roadways will have to go. Keep in mind that New York City owns the land up to 300 feet from the water (one tenth of an inch on the map), so a road cannot go right alongside the reservoir edge. Also remember the steepness of the land. Look at the contour lines. Roads cannot go straight up the steepest parts of mountains. You can build no more than two bridges, if needed, and you must be realistic about their locations and length.

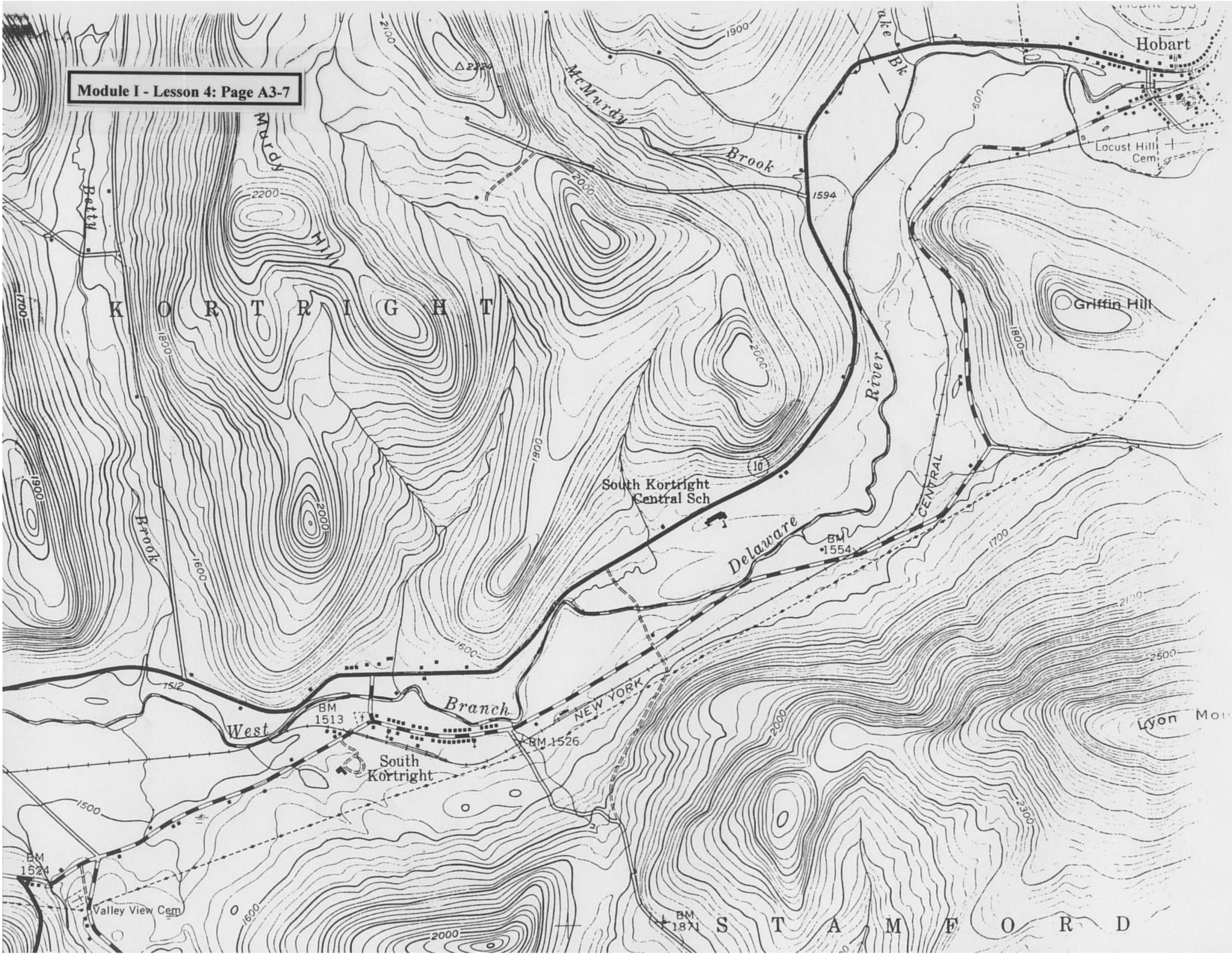
4. Engineers and Planners. This group of people will ultimately decide on how and when to build the reservoir. They will be responsible for destroying or moving the buildings and how and where to construct the Kortright Dam.

- How much notice should be given to the residents to vacate their homes and find a place to relocate?

- How should the buildings, once empty, be destroyed? Fire? Knock them down and leave the building remains in a pile? Leave them standing, just cleaned out?
- What would you do with the churches? How might you move them to prevent their destruction?
- What about the cemetery? You would have to dig up all of the graves and take them to a new location. On your map, where would you put them? If the whole village wanted to leave the graves in place, would the city allow that?

5. New York City. This group represents both the residents of New York City, and officials of the Board of Water Supply -- the agency in charge of making sure that New York City's residents have a clean and plentiful water supply.

- For what reasons did you choose South Kortright for a new reservoir? Look at the information you have been given and the reservoir location on your map. What is good about this location?
- How would you determine NYC's compensation to the villagers that are forced to relocate? Should NYC pay more for the homes and businesses in South Kortright than they are really worth? Would you provide anything else other than money? What could you give the farmers who are forced off the land they depend on to make a living?
- How important is a clean, continuous supply of drinking water? Picture yourselves living in New York City. How much do you depend on clean water? What would you do if there was no tap water for you to use, for a week, until the drought ended?
- As a New York City resident, if your parents or grandparents lived in South Kortright, would you be willing to sacrifice their land and home for the good of the millions of people in New York City?



KORTRIGHT
STAMFORD
Hobart
Locust Hill Cem
Griffin Hill
McMurdy
Brook
Murdy Hill
Betty Brook
South Kortright Central Sch
Delaware River
West Branch
NEW YORK
CENTRAL
South Kortright
Valley View Cem
Lyon
BM 1513
BM 1526
BM 1554
BM 1524
BM 1871
1594
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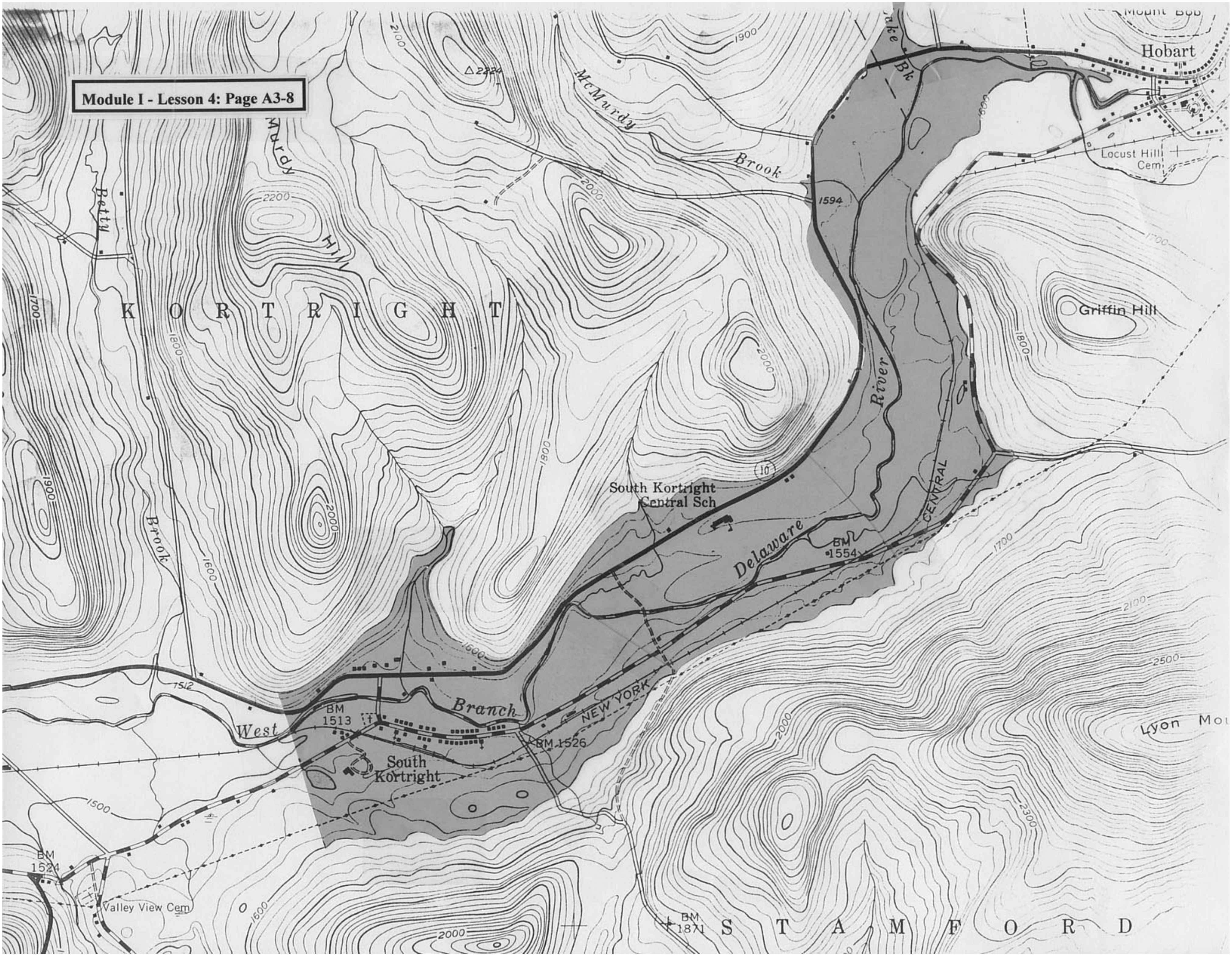
Module I - Lesson 4: Page A3-8



Here Comes the Flood... Maybe Quiz

Name: ___________________________ **Date:** __________ **Teacher:** ___________________

Directions: Answer the questions below using the information you learned in the activity.

1. If you were in a group that decided to construct the South Kortright Reservoir, what was major reason for doing so? If you were in a group that decided not to construct the reservoir, what was your major reason for not building it?

2. If your family was living in South Kortright, would that have affected your decision? Why or why not?

3. What would you want in return for your land if it were going to be flooded by a reservoir that New York City was building?

4. What might be some ways to resolve any disagreements between New York City and the people of South Kortright?

5. A man-made reservoir will change the natural flow and environment of a river. What are some changes to the natural environment that will happen, both upstream and downstream, if a new reservoir is built?

Water Quality Issues - Where Do You Stand?

Grades:

6th - 12th

Objective:

Students will learn how differing opinions and values become issues, and that understanding both sides is a key to successful resolution.

Method:

Students will take a survey of their opinions about water quality issues and compare and discuss the results.

Materials:

Survey (one for each student, enclosed)

Time:

Preparation Time: 5 minutes
Class Time: 20 minutes

Procedure:

1. Discuss how issues develop because people hold different beliefs and values on a particular topic. Have students list examples of environmental issues.

2. Explain that they will be filling out a survey that asks them about their beliefs and values as they pertain to certain water quality issues. Remind them that there are no “correct” answers; everyone is entitled to their own beliefs and values. For younger students, make sure they know what is meant by “development” and “neutral”.

3. After they fill out their surveys, use the chart to summarize the responses.

4. For which statements were there wide differences of opinion? Why do these differences exist?

5. Ask students to analyze the values that underlie their responses. Which of their responses reflect ecological values? Which reflect economic values? What other values are reflected?

6. Did the class responses favor the “neutral” category? If so, why? Might this change with more

information? If so, what information would be needed? For example, if in statement #4 you knew that the state regulates waste effluent to protect water quality, would this change your response?

7. Why is it difficult to resolve an environmental issue when there are strong and differing values? See if the class can come up with working compromises to any or all of the statements.

NYS Learning Standards:

English
Standard 3 - Language for Critical Analysis and Evaluation: Listening and Reading; Speaking and Writing

Math, Science, and Technology
Standard 1 - Analysis, Inquiry, and Design: Scientific Inquiry 1
Standard 4 - Science: The Living Environment 7
Standard 5 - Technology: Impacts of Technology

Source: This activity adapted from Southern Rhode Island Conservation District's *Active Watershed Education Curriculum Guide.*

WATER QUALITY ISSUES SURVEY

Below, you will find a list of belief statements with which you may agree or disagree. Following each statement, there are choices ranging from “Strongly Disagree” to “Strongly Agree”. Please circle the response that best reflects how you feel about the statement.

---

1 No development should occur along rivers.
Strongly Disagree Disagree Neutral Agree Strongly Agree

2 Only homes and farms should occur along rivers.
Strongly Disagree Disagree Neutral Agree Strongly Agree

3 Homes, farms, resorts, and shopping centers should be allowed along rivers, but not industrial factories.
Strongly Disagree Disagree Neutral Agree Strongly Agree

4 Factories should be allowed along rivers because they need the water for their operations and their waste disposal.
Strongly Disagree Disagree Neutral Agree Strongly Agree

5 Factories that pollute should be closed even if it means that people will lose their jobs.
Strongly Disagree Disagree Neutral Agree Strongly Agree

6 There is too much hype about water pollution and conservation these days. We have plenty of fresh clean water and don't need to worry.
Strongly Disagree Disagree Neutral Agree Strongly Agree

7 People have the right to use as much water as they want.
Strongly Disagree Disagree Neutral Agree Strongly Agree

8 It makes a difference when people conserve water by not leaving the tap running while doing dishes or brushing their teeth.
Strongly Disagree Disagree Neutral Agree Strongly Agree

WATER QUALITY ISSUES SURVEY

Summary Chart

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

Home in the Country

Grades:

9th - 12th

Objective:

Students will learn about regulations that pertain to building a house in the New York City watershed.

Method:

Students choose among four possible sites on which to locate a house. They consider how regulations such as septic system and setback requirements will affect the placement and cost of the house.

Materials:

Pages A5-3 through A5-10, copied for each student or group of students.

Time:

Preparation Time: Copying, 10 min.
Class Time: 45 min.

Procedure:

1. For background information, have students read about the New York City Watershed Agreement. For example, read the "Watershed Rules and Regulations" section in the Catskill Center's *Summary Guide to the Terms of the Watershed Agreement*.

2. Distribute instructions, maps, information tables, etc. to students.

3. Students should follow the procedure, answer questions, and then hand in their answers.

4. Ask students to discuss the activity. Are there any trade-offs involved in selecting the lot or house location within the lot? Would everyone want the same lot and location? Why or why not?

Assessment:

Have the student's hand in their completed activity sheet, which can be graded. Lot chosen in number #2 should meet criteria listed in #1 (uses map-reading skills). Answers to #4 and #5 should agree with the soil test report for the appropriate lot. Lot 1: standard system, 6 min., $4,000. Lot 2 or 4: fully engineered system, 6 or 7 min., $30,000. Lot 3: modified engineered system, 9 min., $12,000.

Required absorptive area in #5 depends on percolation rate and number of bedrooms (see table).

Students should mark one of the test sites as their chosen septic system location. They should also mark a house location that is uphill from the septic system. The house must be at least 100 feet from streams, 75 feet from road center lines, and 30 feet from side and rear property boundaries. Correct location shows map skills and an understanding of the requirements.

NYS Learning Standards:

English
Standard 4 - Language for Social Interaction: Listening and Speaking; Reading and Writing

Math, Science, and Technology
Standard 5 - Technology: Technological Systems; Management of Technology
Standard 6 - Interconnectedness: Optimization
Standard 7 - Interdisciplinary Problem Solving: Connections; Strategies

Social Studies
Standard 3 - Geography 2
Standard 4 - Economics 2
Standard 5 - Civics, Citizenship, and Government 4

Source: Activity developed by Mike Porter, Science teacher at Margaretville Central School, modified.

Home in The Country

Name ____________________

You have waited for this forever. You've always enjoyed living in the Catskills, and now you're finally old enough to move out of your parents' house and look for a piece of land where you can build your own home among these mountains. The real estate broker helps you identify four lots of interest. Each has a different character. You have to determine which lot suits your needs for space and topography.

Four Lots For Sale:

Lot 1: 5.51 acres with road frontage and a stream. Gentle side hill slope. Long, narrow lot.

Lot 2: 5.46 acres with road frontage. Gently sloping up from the road. Lot is nearly square.

Lot 3: 8.7 acres with road frontage and a stream. Gently sloping up from the road. Lot is deeper than it is wide.

Lot 4: 21.13 acres with road frontage, road through property, and a stream. Gentle side hill slope up and down from road through property. This is a fairly large lot that is deeper than it is wide.

Each lot is in the New York City Watershed and is subject to town regulations and New York City watershed regulations, enforced by the New York City Department of Environmental Protection (NYCDEP). Each lot must have soil tests to determine if they meet septic system requirements. You will find the results of soil tests in your packet for your chosen lot. There will also be information on setbacks from roads, streams, and side and rear property boundaries. Complete the procedure on the next page to see where you can build your house.

Instructions:

1. Decide what you want in a piece of land. Write down some of your criteria:

2. Choose a lot to buy, from the four options. Lot #: _________

3. Using the Home Selection table, pick a home you would like to build. Make it one that suits your needs. The number of bedrooms will affect septic requirements.

- Number of bedrooms: _________ Cost: _________

4. Refer to the map to see where the soil tests were done, and find the appropriate soil test report for your lot. NYCDEP requires two tests on each lot in case the first location is not suitable. Use site A or B, whichever has better drainage as indicated by percolation time and soil profile.

- Site A or Site B? ____
- Which type of septic system was recommended? _____________________
- Percolation time: ____

5. Using the tables provided, find the cost of the system and the size of the septic drainage area. After finding cost, use percolation rate and number of bedrooms to find absorptive area. Notice that the slower the percolation (more minutes per inch) the less sewage (gallons per square foot) can be applied, hence more area is needed.

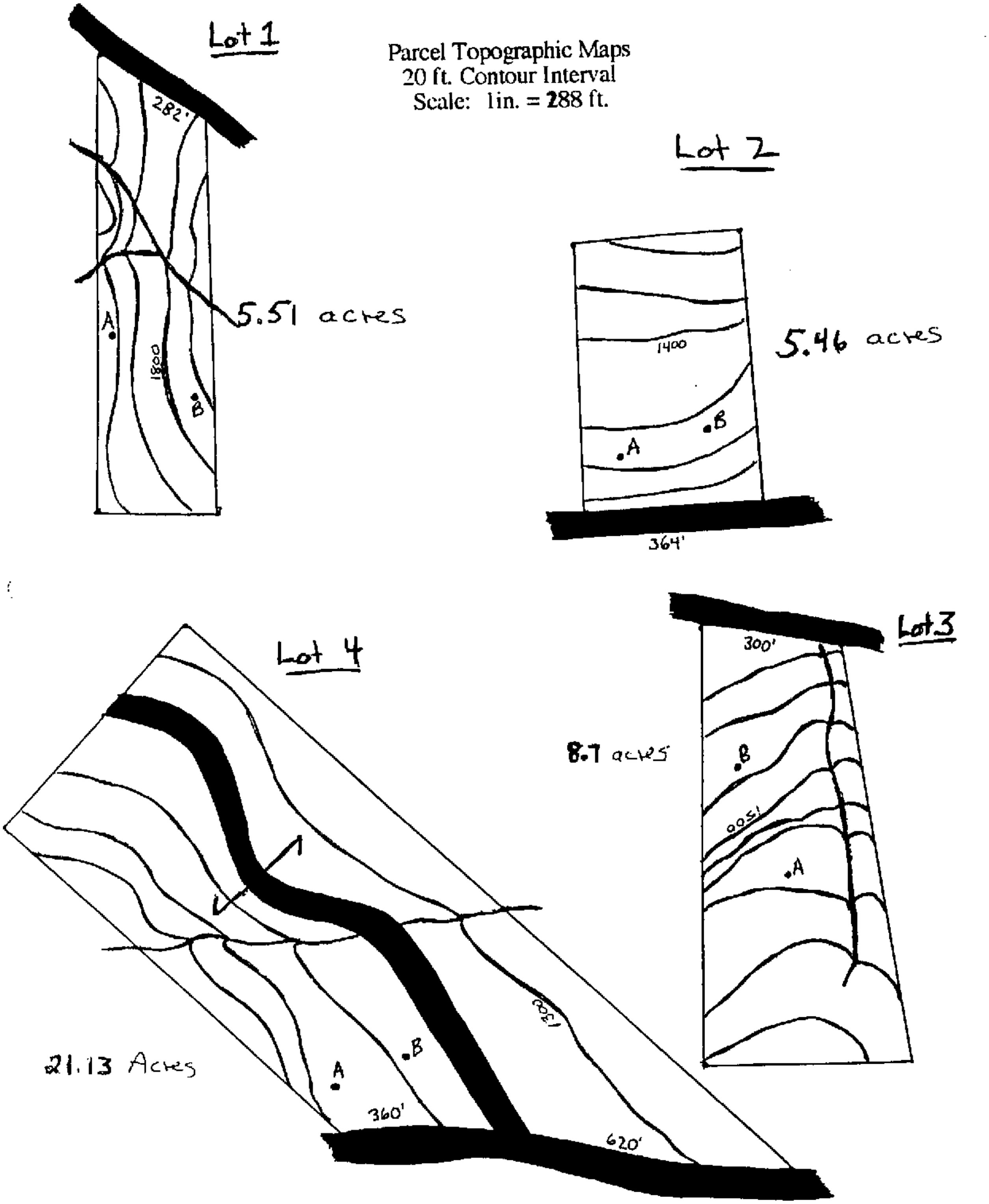
- Cost: _________ Required absorptive area: _______square feet

6. Pick a location for your house based on the septic locations. Remember that you must not have your septic uphill from the house since septage flows downhill.

7. Check the setback maps to see if your intended location is compatible with the watershed regulations and local zoning. If not, you will have to try a different location on the lot.
Mark your final septic and house locations on the first map.

8. Permits required to begin construction: building permit, sewer system approval (required for building permit), driveway access approval (may be a formal permit requiring inspection). Inspections required prior to occupancy: final inspection by building inspector, electrical inspection, and sewer system inspection.

Parcel Topographic Maps
20 ft. Contour Interval
Scale: 1in. = 288 ft.



HOME SELECTION:

BEDROOMS	BATHROOMS	AREA COVERAGE	BASIC	BETTER
2 Bedrooms	2 Bathrooms	1500 sq. ft.	$75,000	$105,000
3 Bedrooms	2 Bathrooms	1700 sq. ft.	$85,000	$119,000
4 Bedrooms	3 Bathrooms	2000 sq. ft.	$100,000	$140,000
5 Bedrooms	3 Bathrooms	2100 sq. ft.	$105,000	$147,000
6 Bedrooms	4 Bathrooms	2400 sq.ft.	$120,000	$168,000

ROUGH ESTIMATES BASED ON
LOCAL CONTRACTORS INPUT

SOIL TEST REPORT: LOT #1

PERCOLATION TEST DATA

TEST HOLE	DEPTH	REMARKS	SOAKING 1ST	SOAKING 2ND	TIME	PERCOLATION TEST RUNS 1	2	3	4	5	6
A	30"	STANDARD SYSTEM PROPOSED	3/30 PM		F 12:06 S 12[illegible] T 6 MIN	12:14 12:08 6 MIN		> 6 MIN			
B	30"	STANDARD SYSTEM PROPOSED (RESERVE)	3/30 PM		F 12:07 S 12:02 T 5 MIN	12:15 12:10 5 MIN					
					F S T						
					F S T						

DEEP HOLE TEST

PITS DUG TO 60+- "	TEST PIT	DEPTH TO SEASONAL HIGH WATER TABLE (Gray Mottling)	DEPTH TO FRAGIPAN	DEPTH TO BED ROCK	SOIL SLOPE	Comments:
PROPOSED SYSTEM	A	>48"	>48"	N.F	10%	BOTH TEST PITS A&B HAD THE SAME SOILS PROFILE - NO EVIDENCE OF MOTTLING NOR ANY RESTRICITIVE BARRIERS
RESERVE SYSTEM	B	>48"	>48"	N/F	8%	

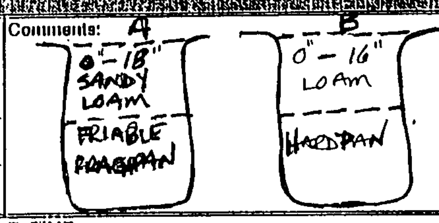
3/11/91 F=FINISH S=START T=TIME

SOIL TEST REPORT: LOT #2

PERCOLATION TEST DATA

TEST HOLE	DEPTH	REMARKS	SOAKING 1ST	SOAKING 2ND	TIME	PERCOLATION TEST RUNS 1	2	3	4	5	6
A	8"	FULLY ENGINEERED SYSTEM	3/30 PM		F 1:17 S 1:10 T 7 MIN	1:26 1:20 6 MIN	1:36 1:30 6 MIN	> 7 MIN			
B	8"	FULLY ENGINEERED (RESERVE)	3/30 PM		F 1:30 S 1:25 T 5 MIN	1:40 1:31 9 MIN	1:52 1:42 10 MIN	2:05 1:55 10 MIN			
					F S T						
					F S T						

DEEP HOLE TEST

PITS DUG TO 40"+-	TEST PIT	DEPTH TO SEASONAL HIGH WATER TABLE (Gray Mottling)	DEPTH TO FRAGIPAN	DEPTH TO BED ROCK	SOIL SLOPE	Comments:
PROPOSED SYSTEM	A	18"-20"	20"	40"	14%	
RESERVE SYSTEM	B	16"-18"	19"-20"	42"+-	10%	

3/11/91 F=FINISH S=START T=TIME

SOIL TEST REPORT: LOT #3

PERCOLATION TEST DATA

TEST HOLE	DEPTH	REMARKS	SOAKING 1ST	SOAKING 2ND	TIME	1	2	3	4	5	6
A	12"	MODIFIED SYSTEM PROPOSED	3/30 PM		F 11:08	11:19	11:28				
					S 11:00	11:10	11:20				
					T 8 MIN	9 MIN	8 MIN				
B	8"	FULLY ENGINEERED (RESERVE SITE)	3/30 PM		F 11:51	12:02					
					S 11:45	11:55					
					T 6 MIN	7 MIN					
					F						
					S						
					T						
					F						
					S						
					T						

DEEP HOLE TEST

PITS DUG TO 60"+-	TEST PIT	DEPTH TO SEASONAL HIGH WATER TABLE (Gray Mottling)	DEPTH TO FRAGIPAN	DEPTH TO BED ROCK	SOIL SLOPE	Comments:
PROPOSED SYSTEM	A	27"–29"	30"	>60"	4-5%	A: 0"–27" LOAM; 27"–60" HARDPAN
RESERVE SYSTEM	B	18"	20"	> 60"	10-12%	B: 0"–18" LOAM; 18"–48" HARDPAN; 48"–60" GRAVEL

3/11/91 F=FINISH S=START T=TIME

SOIL TEST REPORT: LOT #4

PERCOLATION TEST DATA

TEST HOLE	DEPTH	REMARKS	SOAKING 1ST	SOAKING 2ND	TIME	1	2	3	4	5	6
A	8"	FULLY ENGINEERED SYSTEM PROPOSED	3/30 PM		F 1:17	1:26	1:36	> 7 MIN			
					S 1:10	1:20	1:30				
					T 7 MIN	6 MIN	6 MIN				
B	8"	FULLY ENGINEERED (RESERVE SITE)	3/30 PM		F 1:30	1:40	1:52	2:05			
					S 1:25	1:31	1:42	1:55			
					T 5 MIN	9 MIN	10 MIN	10 MIN			
					F						
					S						
					T						
					F						
					S						
					T						

DEEP HOLE TEST

PITS DUG TO 40"+-	TEST PIT	DEPTH TO SEASONAL HIGH WATER TABLE (Gray Mottling)	DEPTH TO FRAGIPAN	DEPTH TO BED ROCK	SOIL SLOPE	Comments:
PROPOSED SYSTEM	A	18"–20"	20"	40"	14%	A: 0"–18" SANDY LOAM; FRIABLE FRAGIPAN
RESERVE SYSTEM	B	16"–18"	19"–20"	42"+-	10%	B: 0"–16" LOAM; HARDPAN

3/11/91 F=FINISH S=START T=TIME

SEPTIC CONSTRUCTION:

SEPTIC SYSTEM CONSTRUCTION BASED ON SOIL TEST RESULTS	
Standard System	$4,000
Modified Engineered System	$12,000
Fully Engineered System	$30,000

SEEPAGE PITS - REQUIRED ABSORPTIVE AREA
FOR HOUSEHOLD SYSTEMS (IN SQUARE FEET)

PERCOLATION RATE MIN./IN	SEWAGE APPLICTION GPD/SQ.FT.	300 GPD 2 BR	450 GPD 3 BR	600 GPD 4 BR	750 GPD 5 BR	900 GPD 6 BR
1 TO 5	1.2	250	375	500	625	750
6 TO 7	1	300	450	600	750	900
8 TO 10	0.9	333	500	667	833	1000
11 TO 15	0.8	375	563	750	938	1125
16 TO 20	0.7	429	643	857	1071	1286
21 TO 30	0.6	500	750	1000	1250	1500
31 TO 45	0.5	600	900	1200	1500	1800
46 TO 60	0.45	667	1000	1333	1667	2000

The prescribed area must be set within setback requirements documented here.

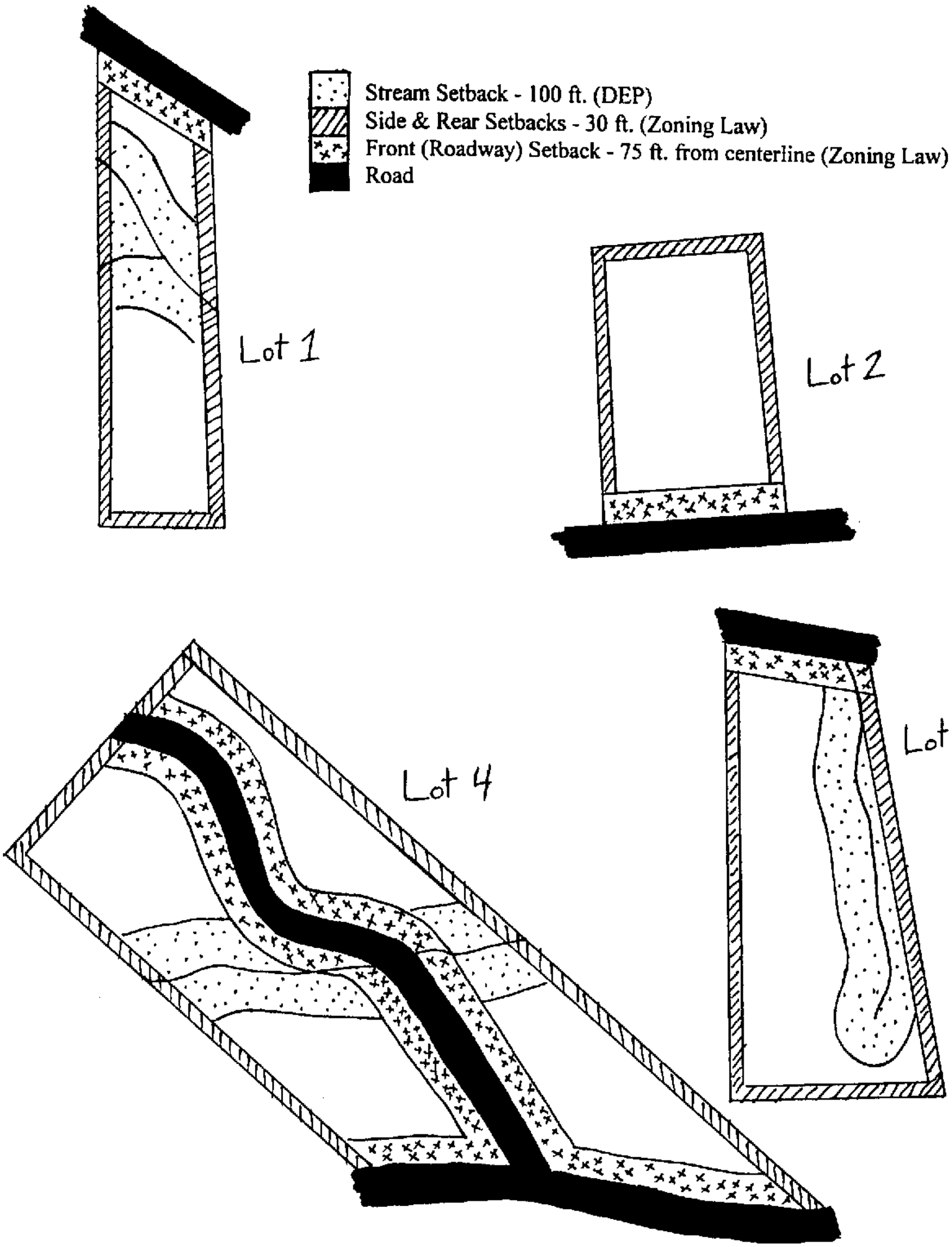
WELL COSTS:

WELL DRILLING AND PUMP EXPENSES:	
200 ft. deep well	$4,000
400 ft. deep well	$5,000
500 ft. deep well	$5,500

Hidden Costs

Homeowners Insurance - Based upon value of home and type of fire protection available.
Fire Protection - Part of your January tax bill. Is there water nearby in case of fire?
Well and Pump Maintenance - Including electricity to run pump.
Septic System Maintenance - Periodic pumping and repair. Septic system will fail periodically if not adequately planned.
Electric Access - You may have to pay for installation of poles and electric line if more than a certain distance from main line. Underground installation could cost more.

Setback Maps of Parcels
Scale: 1 in.= 288 ft.



Note: All words that appear in *italics* are defined within this glossary.

Abdomen - the last of the three body segments of an insect. The tail is part of the abdomen.

Acid (Acidic) - anything with a *pH* of less than 7. Lemon juice, vinegar, and soda are acids.

Aeration tank - the first stage of secondary treatment of wastewater. Here, sewage is mixed with air and bacteria so that any organic material is broken down.

Aquifer - a large underground water source that can readily transmit its water. The upper surface of the aquifer marks the *water table*.

Base (Basic or **Alkaline) -** anything with a *pH* of greater than 7. Bleach, baking soda, sea water, and ammonia are bases.

Best Management Practices (BMP's) - a set of field activities that provide the most effective means for reducing pollution from a *non-point* source.

Catskill System - part of the NYC water supply system, it consists of the Ashokan and Schoharie Reservoirs, the Catskill Aqueduct, and the Shandaken Tunnel.

Chlorination - the final step before the discharge of treated wastewater, where chlorine is added. Chlorine is also used to kill bacteria in drinking water supplies.

Clarifier - the final place where solids settle out of the wastewater before discharge. Chlorine is usually the only thing added after this stage.

Comminutor - the initial step of the wastewater treatment process. Large objects are screened out before the next step, the *grit chamber*.

Condensation - a change in state where *water vapor* becomes a liquid.

Contour Lines - lines drawn on a map so that every point along that line is the same elevation above sea level.

Croton System - the oldest part of the NYC water supply system. Currently, it consists of 13 interconnected reservoirs, three controlled lakes, and the Croton Aqueduct.

***Cryptosporidium* -** a disease that is transmitted through contact with animals (especially cattle and sheep), other humans, or contaminated water supplies. Diarrhea is the most common symptom.

Delaware System - part of the NYC water supply system, it consists of the Cannonsville, Neversink, Pepacton, and Rondout Reservoirs, the East and West Delaware Tunnels, the Neversink Tunnel, and the Delaware Aqueduct.

Dissolved Oxygen (DO) - the amount of oxygen that is present in water. Cold and flowing water usually contains more DO than warm, stagnant water. Measured in parts per million (*ppm*) or mg/l.

Drainage Divide - the raised land that separates two *watersheds*.

Drainage Pattern - the network of streams that drain a *watershed*(*s*). A “branched” pattern is the most common, and found throughout the Catskills.

Evaporation - a change in state where water as a liquid becomes a gas (vapor).

Evapotranspiration - collectively, the processes that return liquid water to the gaseous state. This includes *evaporation* and *transpiration* (evaporative water loss from plants).

Giardia **-** a waterborne disease resulting from the intake of the Giardia protozoan. Symptoms include abdominal cramps, intermittent dysentery, and weight loss.

Grit Chamber - the place where sand, small stones, and grit are settled out of the wastewater in a treatment plant.

Groundwater - water under the ground. It accounts for 20 % of the earth’s freshwater, or ½ of 1% of all the water on Earth.

Head - the first of the three body segments of an insect. Eyes and antennae are part of the head.

Hydrologic Cycle - the continuous process by which water is recycled on Earth. Also called the *water cycle.*

Impacted - the NYSDEC’s term for a stream that does not meet all of its pollution screening criteria.

Infiltration - the sinking or soaking of water from the atmosphere into the ground.

Leaching - the process by which impurities in groundwater are naturally filtered out by the soil over a period of time.

Macroinvertebrates - non-microscopic animals without backbones. Most are insects.

Memorandum of Agreement (MOA) - a contract signed in 1997 by the Coalition of Watershed Towns, New York City, the State of New York, The US EPA, and various non-profit environmental organizations. This agreement allows NYC to begin the process of meeting the EPA's drinking water standards without having to build a filtration plant.

Molecule - the result of atoms joining together, the smallest unit of an element or compound. The water molecule is composed of two hydrogen atoms and one oxygen atom.

New York City Watershed - a 1,900-square-mile (1,600 mi^2 in the Catskills) area of land that collects and stores water for the City to use. It consists of the *Catskill, Delaware,* and *Croton* Systems.

Non-Impacted - the NYSDEC's term for a stream that meets all of its pollution screening criteria.

Non-point Source (NPS) - pollution resulting from more than one source, and usually over a very large area. Examples include: acid rain, runoff, and animal waste.

Parts per million (ppm) - a unit of measurement (used for *dissolved oxygen*). 1 ppm is equal to 1 mg/l.

Percent Oxygen Saturation - the amount of *dissolved oxygen* in water relative to how much it can store at a particular temperature.

Percolation - the process of water moving through pores (spaces between soil particles) in the soil. Water percolates faster where pore spaces are larger.

pH - a measurement of the number of hydrogen ions (H^+) or hydroxide ions (OH^-) in a solution. *Acids* produce hydrogen ions and *bases* produce hydroxide ions.

pH Scale - the range from 0 to 14 of *pH* units. Neutral solutions have a pH of 7, while *acidic* solutions approach 0, and *basic* ones approach 14.

Photosynthesis - the process by which plants make food using sunlight carbon dioxide and water.

Piezometer - a type of well that is used to find the depth of the *water table* by measuring the level of the water in it.

Point Source - pollution that comes from a known source. An example is a discharge pipe.

Precipitation - rain, snow, sleet, or hail.

Sedimentation - the process by which larger, denser particles settle to the bottom and lighter particles stay suspended in water for a longer period of time.

Sedimentation tank - the stage of the wastewater treatment process where the solids settle to the bottom as pure sludge, and the remaining water is moved on to the *aeration tank*.

Solvent - a liquid with the ability to dissolve other substances. Water is the most common solvent, and often called the “universal solvent” because it can dissolve many substances.

Sub-Watershed - a smaller *watershed* that is a piece of a much larger watershed. For example, the Esopus Creek watershed is a sub-watershed of the Hudson River watershed.

Surface Runoff - water flowing above ground that enters surface water bodies.

Thorax - the middle segment of an insect. Includes the legs and wings if present, and sometimes the gills.

Topography - the shape of the surface of the Earth.

Transpiration - the process of plants losing water through their leaves due to *evaporation*.

Turbidity - a measurement of how “cloudy” water is. Suspended soil particles in water will make it turbid.

Water Cycle - the continuous process by which water is recycled on Earth. Also called the *hydrologic cycle*.

Water Table - the top level of the underground *aquifer*. Which is also the top of the *zone of saturation*.

Water Vapor - water in the gaseous state in the Earth’s atmosphere. Water vapor is invisible.

Watershed - the area of land that collects water and releases it to a common outlet. After collecting water, a watershed will temporarily store it, and subsequently release its water to a particular surface water body.

Zone of Saturation - the area below the Earth’s surface where all pore spaces in soil are completely filled with groundwater.

Books and Articles:

Books:

Beneath Pepacton Waters. Jacobson, Alice, H. Pepacton Press, 1988. RR1 Box 151, Andes, NY 13751.

*Catskills, The: An Illustrated Historical Guide With Gazetteer.*Adams, Arthur G. 1990. Fordham University Press. New York, NY.

Conservation of Water and Related Land Resources. Black, Peter E. 1987. Rowman & Littlefield. 81 Adams Drive, Totowa, NJ 07512.

Drinking Water Quality Concerns of New York City, Past and Present. Iwan, Gerald R. New York City Department of Environmental Protection, Bureau of Water Supply. New York, NY 10003.

Environmental Education Activity Guide: Pre K-8. Project Learning Tree. 1993. American Forest Foundation, 1111 19th Street, NW, Washington DC 20036.

A 400-page activity book that is entirely devoted to topics that deal with the environment and the importance of our natural resources.

Environmental Education Program: Curriculum in Science Field Studies Grades K-6. 1997. Mohonk Preserve, Inc. New Paltz, N.Y. 268 pp. 8.5x11" $31.00 three-ring notebook. (845) 255-0919.

Designed to supplement environmental education programs offered at Mohonk Preserve. Activities, based on NYSED science requirements, are grouped by fall and spring and cover a variety of topics, including plant and animal life in various habitats, water, Native Americans, and geology.

Guide to Freshwater Animals Without Backbones. de Strulle, Arlene, Johnson, Tora. The Catskill Center for Conservation and Development, Inc., 1997. Route 28, Arkville, NY 12406.

A copy of this guide may be purchased by teachers from the Center for $10.95. This guide was written for middle and high school teachers and their students who wish to collect and identify aquatic invertebrates from local streams, lakes, and ponds. A great book for combining fun and academic learning.

A Guide to New York City's Reservoirs and Their Watersheds. Goldstein, Eric A., Marx, Robyn. Natural Resources Defense Council, 1993.

Liquid Assets, The Story of the New York City Water Supply System. Galusha, Diane. Purple Mountain Press, 1999. Main Street, Fleischmanns, NY 12430.

This 300 page book, including over 180 photographs, provides an in-depth history to the NYC water supply system, from it's very beginnings in the 1800's through the debates in the 1990's, and the signing of the MOA in 1997. The historical development is even traced through many first person accounts, and provides not only the social history of the communities, but engineering and technical information as well. Included in the appendix is a statistical summary of the entire system (East and West of Hudson Watersheds).

Lost Villages. Robinson Sive, Mary. Delaware County Historical Society, 1998. Route 2, Box 201C, Delhi, NY 13753-9648.

The Official Captain Hydro Water Conservation Workbook. Homitz, Marilynne, Homitz, Wallace, Johnson, Bob. East Bay Municipal Utility District, 1992. P.O. Box 24055, Oakland, CA 94623.

Old Neversink and Surroundings. Kortright, Agnes R. 1996.

Project WET: Curriculum & Activity Guide. The Council for Environmental Education. 1995. Bozeman, Montana. (406) 994-5392

An excellent guide on teaching strategies, curriculum and activities for all grade levels on water education. The book is only available at Project Wet workshops.

Schoharie County Historical Review. Schoharie County Historical Society. Spring-Summer 1975. No. 1, vol. XXXIX.

Stories of Old Gilboa. 1988-89 4th Grade Class of Gilboa-Conesville Central School. P.O. Box 6, Wycoff Rd, Gilboa, NY 12076.

A collection of news articles from the past and interviews of local residents who lived though the construction of the Schoharie Reservoir, and consequently, the loss of their village. Book organization and interviews conducted by 4th grade students of Gilboa-Conesville Central School.

Stormwater Runoff: Solving the Problems. New York State Department of Environmental Conservation, Division of Water Quality. Public Participation Section. 50 Wolf Road, Albany, NY 12233-3501.

The Story of Drinking Water. Bock, Rosalie. 1990. American Water Works Association. 6666 West Quincy Avenue, Denver, CO 80235.

Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods. Cheo, Martha, Murdock, Tom and O'Laughlin, Kate. 1991.1996 Adopt-A-Stream Foundation. Everett, WA. 296 pp. 8.5 x 11" soft cover $29.95 (206) 316-8592.

How streams and their surrounding watersheds function, detailed methods on watershed inventory and stream monitoring for volunteers, tips on presenting data, and how putting watershed inventory and stream monitoring is used in the protection and restoration of our nation's streams. Excellent source book on stream monitoring for teachers and community members.

Summary Guide to the terms of the Watershed Agreement. Budrock, Helen. The Catskill Center for Conservation and Development, Inc. 1997. Route 28, Arkville, NY 12406.

Time and The Valley. Grace, Barbara and Thomas, Gridley, Inez George, Low, Frank E, Terwilliger, Katherine. Town of Neversink Bicentennial Commission. 1978.

Township of Neversink 1798-1998. Ackerley, Loretta. 1998

Water For Millions: At What Cost?. Lee, Cara. Scenic Hudson, Inc. 9 Vassar Street, Poughkeepsie, NY 12601.

Watershed Views- a public opinion survey on the New York City Watershed. Pfeffer, Max J., Stycos, J. Mayone. Report #6. Cornell University, 1996. Warren Hall, Ithaca, NY 14853.

A survey conducted by Cornell University in which over 700 interviews were conducted in order to trace a change in public opinion as the controversy grew between NYC and the upstate towns. The survey addresses issues of concern, knowledge of watershed-related issues, and people's attitudes towards NYC.

The Ways of the Watersheds. Haskin, Kathleen M. Frost Valley YMCA. Claryville, N.Y. 248 pp. 8.5x11" $30.00 unbound. (845) 985-2291.

An educator's guide to the environmental and cultural dynamics of New York City's water supplies. Curriculum material includes hydrology, geology, ecology, pollution, development and technology of NYC's watershed.

Periodicals:

The Catskill Mountain News. "Loss of East Branch Valley Has Been Greatest Change". Centennial Edition. August 15, 1963. Margaretville, NY 12455.

Teaching Materials:

Videos:

West Hurley Library Presents: The Ashokan Reservoir. West Hurley Library. 1998. 42 Clover Street, West Hurley, NY 12491.

This is an excellent 35-minute video displaying the building of the Ashokan Reservoir. It covers all of the bases some great photos. It can be purchased from the library for $8 for schools/non-profit organizations, or $15 for the public, $12 for seniors. Shipping is an extra $4, or it can be picked up from the West Hurley Library. If purchasing for the school, you must send a school check. 845) 679-6405.

Building of the Ashokan Reservoir, 1906-1916: A Photographic Exhibition. Empire State Railway Museum, Inc. 1998. High Street, Phoenicia, NY 12464.

This video is based on an exhibit of historic photos that was displayed at the Empire State Railway Museum in 1998. It is available from the museum, (845) 688-7501, open 11 to 4 weekends and holidays.

Posters:

Bob Dibble
Natural Resource Conservation Service
Time Square Office Park, Suite 202
652 Route 299, Box 1475
Highland, NY 12528
(1-888-LANDCARE)

Maps:

United States Geological Survey, Map Sales
Box 25286, Federal Center, Bldg. 810
Denver, CO 80225
Telephone: 1-800-435-7627

Other:
The Groundwater Foundation
PO Box 22558
Lincoln, NE 68542-2558

The Groundwater Foundation has a free catalog including inexpensive groundwater flow models, activity books, water trivia game, publications on (for example) how to put on a water festival.

Web Sites:

The Catskill Center for Conservation and Development www.catskillcenter.org
Visit our web site to see what we are currently involved in and view the Water Resources module, and future modules on the Internet under the Education Program page.

Adopt Your Watershed: (US Environmental Protection Agency) www.epa.gov/adopt
Adopt Your Watershed allows you to learn about organizations active in your watershed! Over 5,500 watershed groups are listed. Also includes tools and resources to help new groups get started.

American Museum of Natural History www.amnh.org/science/biodiversity/index.html
The Center for Biodiversity web site includes interesting information on aquatic insects and plants that are discussed within the Water Resource module.

Benthic Ecology and Aquatic Entomology www.chebucto.ns.ca/Science/SWCS/benthos.html
A homepage with a comprehensive set of links to various sites for macroinvertebrates, biomonitoring, and water quality impacts.

Catskill Fly Fishing Center and Museum www.cffcm.org
Located in Sullivan County, the Fly Fishing Center and Museum offers educational programs and exhibits. Visit this site to learn what is going on there and about their programs.

Catskill Watershed Corporation www.cwconline.org
Established to carry out watershed protection programs of the Watershed Agreement. Web site contains some historical photos.

Common Aquatic Insects http://members.tripod.com/tdriskell/insecta.html
A page with pictures of orders of aquatic insects and links to other sites with images and identification keys of macroinvertebrates.

Delaware River Basin Commission www.state.nj.us/drbc
DRBC coordinates the annual Delaware Water Snapshot, a student watershed monitoring effort you can take part in.

Delaware River Basin's Ed. Web! www.state.nj.us/drbc/edweb/edweb.htm
An educational resource to help teachers and students of all ages learn about the Delaware River Watershed and general water issues. Sections on the site include: watershed maps, educational resources (lesson plans), upcoming opportunities, environmental field trip ideas, links to some informative web sites, and general information about the Delaware River Basin.

Department of Environmental Protection (NYCDEP) www.ci.nyc.ny.us/dep
This site has important information on the NYC Watershed, recent press releases, and tons of educational material for teachers and kids.

The Groundwater Foundation www.groundwater.org
This organization advocates groundwater protection and provides resources for teachers.

Guide to Freshwater Invertebrates www.seanet.com/~leska/Online/Guide.html
A simple guide to the orders of macroinvertebrates, along with some ecological information, and images.

Hanford Mills Museum Old-Engine.com/hanford.htm
This museum, located in northern Delaware County, exhibits the some of the oldest working sawmills, gristmills and woodworking shops. A huge, working, waterwheel is another attraction. Visit this site to learn more about this unique historic attraction.

The Hudson Basin River Watch www.hudsonbasin.org
The goal of Hudson Basin River Watch (HBRW) is to improve the ecological integrity of the Hudson River and all its tributaries through education, monitoring, and stewardship. HBRW is a vital and growing partnership of over 100 school and citizen groups and dozens of environmental organizations and water resource agencies. This new web site's future plans include an area for data posting and exchange by schools that sample throughout the watershed.

Izaak Walton League of America Save Our Streams www.iwla.org
This is one of the oldest and largest volunteer monitoring programs in the country. This web site has all types of information. You will find what you are looking for here.

Kentucky Water Watch Key http://fluid.state.ky.us/ww/bugs/orderkey.htm#2
This is a great online key that provides identification down to the order level of the various benthic macroinvertebrates you may find in streams.

Missouri Stream Team www.rollanet.org/~streams/macroinv/
A fantastic site that has images of all major macroinvertebrates and information on them. In addition, a lot of other water quality monitoring material can be found on this site.

Neartica – Insects www.neartica.com/nathist/insects/aquatic.htm
This site focuses in on mayflies, stoneflies, and caddisflies and provides information and images of each.

Ohio State University Extension www.ag.ohio-state.edu/~waternet
This site provides information about how to get involved in volunteer monitoring in your state's Cooperative Extension program and an information exchange area.

River Network www.teleport.com/~rivernet/
This site is a journey beneath the surface of a dynamic organization that's developed a blueprint for river conservation based on cooperative strategies and grassroots energy. Their approach is largely based on macroinvertebrate and chemical monitoring protocols.

Rivers Online rol.freenet.columbus.oh.us/Insects.html
A web site that contains images of various aquatic insect larva and adult forms, stream monitoring information, and a macroinvertebrate identification key that can be downloaded.

Theodore Gordon Fly Fishers www.tgf.org
This conservation and fly fishing group whose dual mission is to preserve and enhance the coldwater fisheries that sustain our sport as well as to promote and nourish the rewards of fellowship derived from a unique company of friends.

United States Geological Survey www.usgs.gov
Get live stream flow data, participate in Frogwatch, and locate GIS data. The education portion of the site is at www.usgs.gov/education. Learn how biology, geology, hydrology, and geography can help us understand our changing world. Classroom activities. Free posters.

Volunteer Monitoring Homepage: (US EPA) www.epa.gov/owow/monitoring/vol.html
This site provides electronic versions of many of the EPA's volunteer methods manuals and brochures, as well as The Volunteer Monitoring newsletter.

Water What-Ifs www.ncsu.edu/sciencejunction/depot/experiments/water/macro/
This web site was designed to be a teaching and learning tool for teachers as well as students, and encourages inquiry investigations of water quality. Several lesson plans are provided; for pH, temperature, dissolved oxygen, nitrates/phosphates, and macroinvertebrate surveys.

Watershed Agricultural Council www.nycwatershed.org
Information on WAC and whole farm planning in the New York City watershed.

Resource People:

Aaron Bennett, Catskill Region Watershed Coordinator, Hudson Basin River Watch / The Catskill Center, Route 28, Arkville, NY 12406. (845) 586-2611, or educat@catskill.net. Coordinates volunteer and student water quality monitoring efforts in the West-of-Hudson NYC Watershed and the Catskill Mountain region. Stream monitoring equipment available for loan. Contact if you are interested in setting up monitoring programs at your school, or would like assistance on field trips.

Martha Cheo, Mid-Hudson Coordinator, Hudson Basin River Watch, P.O. Box 37G, East Greenwich, NY 12865. (845) 256-9316, or mcheo@email.msn.com. Coordinates stream monitoring programs in schools throughout the Hudson Valley region and organizes a “Mid-Hudson Watershed Congress” annually. Monitoring equipment for can be borrowed from HBRW for use during field trips.

Nathan Chronister, Director of Education, The Catskill Center for Conservation and Development, Route 28, Arkville, NY 12406. (845) 586-2611, or educat@catskill.net. Coordinates the Catskills Sense of Place program. CCCD educators are available for classroom visits and field trips.

Sandra Dawson, Education & Outreach Program, Watershed Agricultural Council, RR1 Box 74, Walton, NY 13856. (607) 865-7790. Offers presentations on agriculture in the New York City watershed.

Kim Estes-Fradis, Director of Education, NYCDEP, 59-17 Junction Blvd., Corona, NY 11368. (718) 595-3506. Contact to arrange tours of DEP water supply and wastewater treatment facilities. Publications available on water conservation and the NYC supply system.

Diane Galusha, Education Coordinator, Catskill Watershed Corporation, Main Street, Margaretville, NY 12455. (845) 586-1400, or galusha@cwconline.org. Offers school programs on the watershed, its history, and what CWC is doing to protect it. Author of *Liquid Assets, The Story of the New York City Water System*.

Beth Gelber, Stream Management Program, NYCDEP, 71 Smith Avenue, Kingston, NY 12401. (845) 340-7515, or bgelber@catgis.dep.nyc.ny.us. Beth Gelber can talk to your class about the important role of wetlands in protecting water quality or lead a field trip to a nearby DEC wetland.

Nancy Levine, Director of Community Affairs, 465 Columbus Avenue, Valhalla, NY 10595. (914) 742-2086 or levinen@water.dep.nyc.ny.us. Levine can aid in arranging class trips to DEP facilities or to have guest presentations by NYCDEP staff.

Kyle Babbitt Myers, Cornell Cooperative Extension, Sullivan County, 69 Ferndale-Loomis Rd., Liberty, NY 12754-2903. (845) 292-6180, or kmyers@cce.cornell.edu. Cooperative Extension offers various education programs, including Home-A-Syst which addresses environmental threats in the home.

Richard Parisio, Environmental Educator, Department of Environmental Conservation, PO Box 313, Highmount, NY 12411. (845) 254-5600, or rparisio@hotmail.com. Parisio is the DEC educator for the Catskill Park. His programs for children include natural history, environmental poetry writing, and more.

Rebecca Perry, Education Facilitator, Catskill Forest Association, PO Box 336, Arkville, NY 12406. (845) 586-3054. The CFA remains active in forestry education by putting on workshops, visiting classrooms, and providing education material.

Doug Reed, Director, Hudson Basin River Watch, P.O. Box 37G, East Greenwich, NY 12865. (518) 677-5029, or reed@netheaven.com. Coordinates the HBRW program throughout the Hudson River watershed, and organizes an annual "Clean Water Congress" in Albany, highlighting student monitoring projects. Monitoring equipment can be borrowed from HBRW for use during field trips.

David Scherf, Frost Valley YMCA, 2000 Frost Valley Rd., Claryville, NY 12725. (845) 985-2291, or dscherf@frostvalley.org. Frost Valley YMCA has overnight facilities and environmental education opportunities including a streamside classroom and GIS lab.

Places to Visit:

Theodore Gordon Fly Fishing Center, (845) 439-4810, Main Street, Livingston Manor. This small museum on the Willowemoc Creek charges no admission. The exhibit includes fly-fishing equipment, memorabilia, and photographs. Holds special events including presentations by noted fly-fishers.

Hanford Mills Museum, (607) 278-5744, Route 12, East Meredith. Open May through October, charging admission. Although this museum has more of a historic than watershed focus, it demonstrates the use of waterpower, and land use, in the Delaware watershed as they were around the turn of the century. The mill was the industrial center for the surrounding farm community, producing wooden products, electricity, and flour were major products of the mill, which was powered by a water wheel supplemented later with other power sources. The museum hosts special events such as a children's fair, fly-fishing, ice cutting, and July 4th celebration.

New York Power Authority Visitors' Center, (607) 827-6121, Route 10, Blenheim, NY. New

York Power Authority operates a major hydroelectric power facility in Blenheim. It pumps water into a mountaintop reservoir and uses this water to generate power during the daytime when

demand for power is greatest. The visitors' center houses a variety of hands-on exhibits allowing students to learn about scientific principles related to electricity generation and supply.

Catskill Reservoirs. Permission from New York City Department of Environmental Protection is required before visiting reservoirs if you wish to enter city property. From the road, however, students will get a feel for the scale of the reservoirs, and they will be able to see the commemorative displays planned for each reservoir (only some reservoirs have informational signs at the time of writing).

Ashokan Reservoir, Routes 28 and 28A, Boiceville to West Hurley.

Cannonsville Reservoir, Route 10, Walton to Deposit.

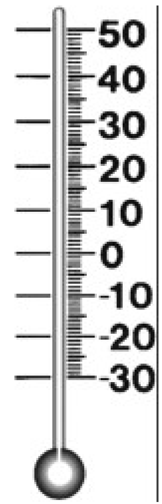
Neversink Reservoir, Route 55, Neversink.

Pepacton Reservoir, Route 30, Margaretville to Downsville.

Rondout Reservoir, Routes 55 and 55A, Grahamsville to Napanoch.

Schoharie Reservoir, County Route 7, State Route 342, Prattsville to Gilboa.

PHYSICAL & CHEMICAL DATA SHEET



NAME ________________________

TEACHER ________________ SCHOOL ______________

DATE ___________________ TIME _______________

NAME OF STREAM _______________________________

LOCATION ______________________________________

WEATHER CONDITIONS

AIR TEMPERATURE _____ °C

WIND SCALE ____________

CLOUD COVER ___________ %

PRECIPITATION Now: ‘ rain ‘ snow or ice ‘ none
Last 24 hours: ‘ rain ‘ snow or ice ‘ none

PHYSICAL DATA

WATER TEMPERATURE _____ °C ‘ shade ‘ sunlight

DEPTH ___________ centimeters

WIDTH ___________ meters

TURBIDITY ‘ clear ‘ slightly turbid ‘ very turbid (can't see into water)

COLOR OF WATER ‘ colorless ‘ green ‘ brown ‘ other _______________

CHEMICAL DATA

DISSOLVED OXYGEN

1 ________ ppm

2 ________ ppm

Average _________ ppm

ACIDITY (pH)

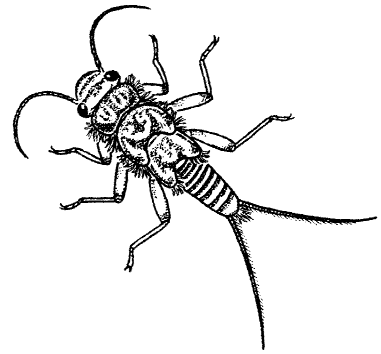
1 ________

2 ________

Average _________

Saturation _________ percent

BIOLOGICAL DATA SHEET



NAME ________________________

TEACHER ________________ SCHOOL ______________

DATE ___________________ TIME _______________

NAME OF STREAM _______________________________

LOCATION ______________________________________

BIOLOGICAL DATA — MACROINVERTEBRATES

type of invertebrate	**how many**
__________________________	_________
__________________________	_________
__________________________	_________
__________________________	_________
__________________________	_________
__________________________	_________
__________________________	_________

number of types ______________

number of individuals _____________

SCREENING CRITERIA FOR NON-IMPACTED STREAMS

criteria	**check here**
Mayflies numerous; at least 3 species.	
Stoneflies present.	
Caddisflies present, but not more abundant than mayflies.	
Beetles (water penny, etc.) Present.	
Worms absent or sparse.	

Your stream is: ‘ non-impacted (all 5 boxes are checked).

‘ impacted (at least 1 box is not checked).

TOTAL FLOW DATA SHEET

NAME ____________________ DATE/TIME ______________

TEACHER ________________ SCHOOL ________________

NAME OF STREAM ________________________________

LOCATION ____

CURRENT SPEED

Along the stream, mark off a distance such as 10 meters, and write the distance below.
Throw an orange in the water and time how long it takes to go that distance.
Throw it 3 times near the stream's left side, 3 times in the middle, and 3 on the right.
For each trial, write the time in seconds (s). Then calculate the average time.

Time 1	_______	Time 7	_______
Time 2	_______	Time 8	_______
Time 3	_______	Time 9	_______
Time 4	_______	**Sum**	_______
Time 5	_______		
Time 6	_______	**Avg.**	_______

Find the current speed in meters per second (m/s). A car travels about 25 m/s.

Distance ÷ Average Time = Current Speed

_______ ÷ ___________ = ___________

CROSS-SECTIONAL AREA

Cross-sectional area indicates the amount of water in the stream. Measure the depth at regular intervals such as every meter or every half meter. Write the interval below. For each depth measurement, record the depth in meters (m). Add up all of the depth measurements. Find the cross-sectional area of the stream in square meters (m^2).

Depth	0m												

Sum of Depths ________ × Interval ________ = Cross-Sectional Area ________

TOTAL FLOW

How much flow is one cubic meter per second? It's like drinking 500 two-liter soda bottles in a single gulp! Use your current speed and cross-sectional area to find the total flow, in cubic meters per second (m^3/s), of your stream.

Current Speed ________ × Cross-Sectional Area ________ = **Total Flow ________**

Catskill Center Streamwatch Program
Permission Slip

Dear Parent or Guardian,

Soon, the field trip season for The Catskill Center's Streamwatch program will begin. In the Streamwatch program, students learn about the ecology of Catskill region streams through a series of hands-on activities. These activities include several field trips to a local stream for collecting water quality data which will be shared with other schools.

For field trips to the stream site, students should bring:
1. An extra pair of shoes or waterproof boots they can wear in the stream.
2. An extra set of clothing appropriate to the weather.

Permission for your child to participate in the Streamwatch program is needed for field trips for the entire school year. If you have any questions about the Streamwatch program, please contact your child's teacher or The Catskill Center's Director of Education: (845) 586-2611.

Please fill out this form and return by _______________ .

— — — — — — — — — — — *tear off and return to school* — — — — — — — — — — — — — —

The Catskill Center Streamwatch Program

______________________ has my permission to participate in Streamwatch program field trips throughout the school year.

Parent or Guardian __________________________ Daytime phone

Signed ________________________________ Date
(parent or guardian)

Insect allergies or other pertinent medical information:

In an emergency, if unable to reach parent, contact:

Name ________________________________ Daytime phone

Volunteers are needed to help with your school's Streamwatch program!

This year, your child will be participating in The Catskill Center's Streamwatch program. In the Streamwatch program, students learn about the ecology of Catskill region streams through a series of classroom visits and hands-on activities. These activities include several trips to a local stream to collect water quality data. Students who participated in the Streamwatch program in previous years enjoyed themselves immensely while learning important lessons in science and environmental issues.

You can help! To provide students with this valuable experience, the Streamwatch program relies on volunteers to help during field trips. Special skills or experience are not necessary. However, volunteers should be eager, interested in the program, and willing to get wet.

Volunteering for the Streamwatch program is a fun and exciting way to help your kids learn about the Catskill region and all it has to offer.

If you can help, please fill out the form below and return it to your child's teacher.

Thank you!

— — — — — — — — — *tear off and return to school* — — — — — — — — — — — —

Please contact me about volunteering to help in my school's Streamwatch program.

Name ________________________________

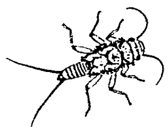
Address ________________________________

City ______________________ State ______ Zip _______________

Phone (day) __________________ (evening) _________________________

Simplified Key for Benthic Macroinvertebrates


Mayfly (gills on abdomen, 2 or 3 tails, many different kinds)

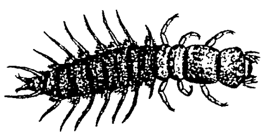

Stonefly (no gills on abdomen, 2 tails)

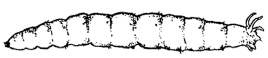

Case-Building Caddisfly


Free-Living Caddisfly


Water Penny (beetle larva)

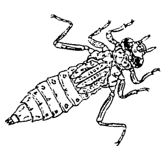

Water Beetle

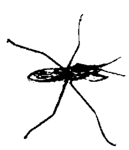

Dobsonfly (also called Hellgrammite)

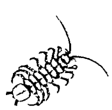

Crane Fly

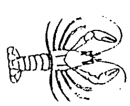

Black Fly (often clustered on rocks)


Midge (a type of fly)


Dragonfly

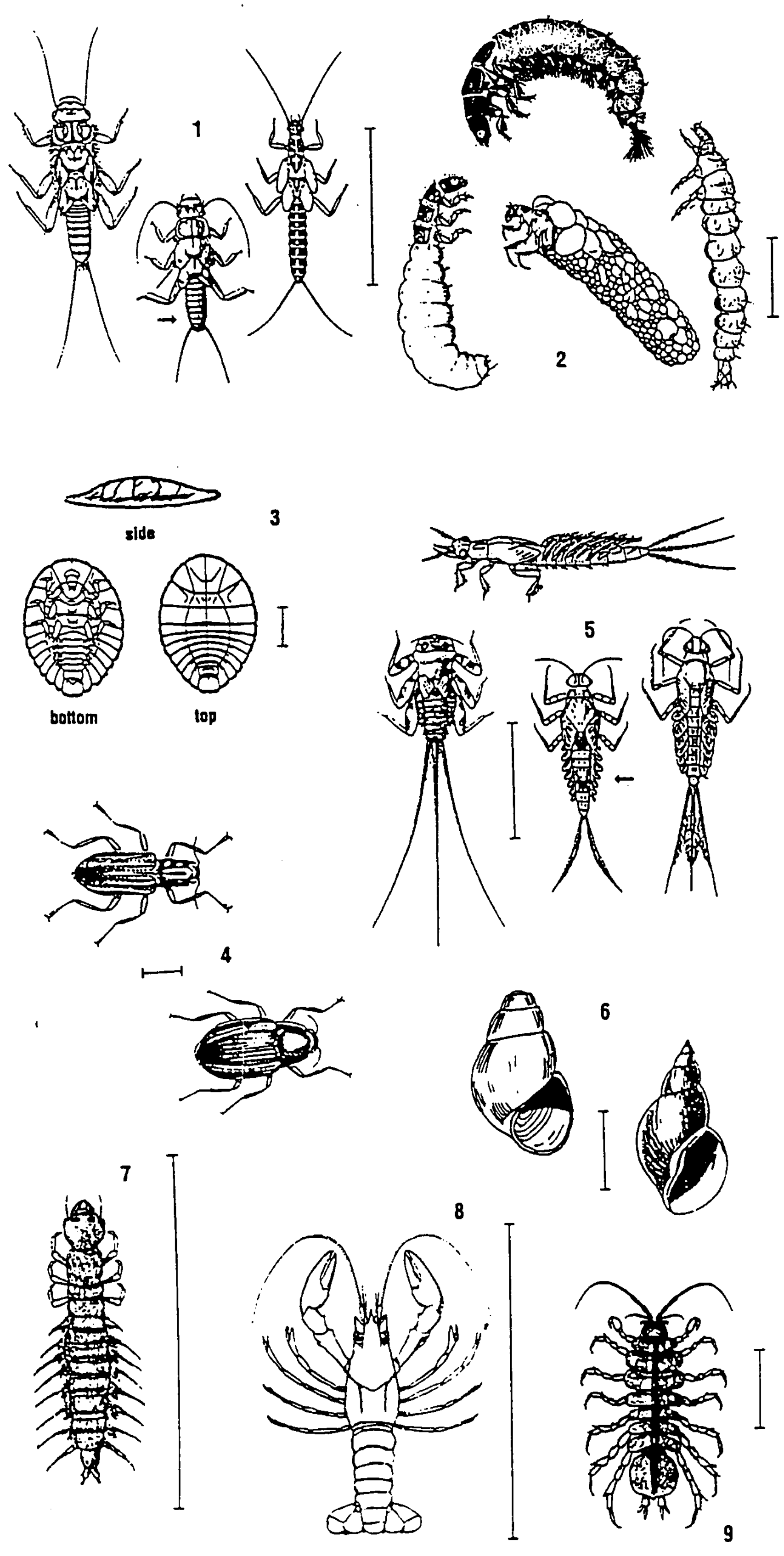

Water Strider (walks on top of the water)


Aquatic Sowbug


Crayfish


Snail


Aquatic Worm (very long and narrow)



Bar lines indicate relative size

Stream Insects & Crustaceans

GROUP ONE TAXA

Pollution sensitive organisms found in good quality water.

1 ***Stonefly: Order Plecoptera.*** 1/2" - 1 1/2", 6 legs with hooked tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (See arrow.)

2 ***Caddisfly: Order Trichoptera.*** Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on underside.

3 ***Water Penny: Order Coleoptera.*** 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs and fluffy gills on the other side. Immature beetle.

4 ***Riffle Beetle: Order Coleoptera.*** 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 ***Mayfly: Order Ephemeroptera.*** 1/4" - 1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

6 ***Gilled Snail: Class Gastropoda.*** Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

7 ***Dobsonfly (Hellgrammite): Family Corydalidae.*** 3/4" - 4", dark-colored, 6 legs, large pinching jaws, eight pairs feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, 2 tails and 2 pairs of hooks at back end.

GROUP TWO TAXA

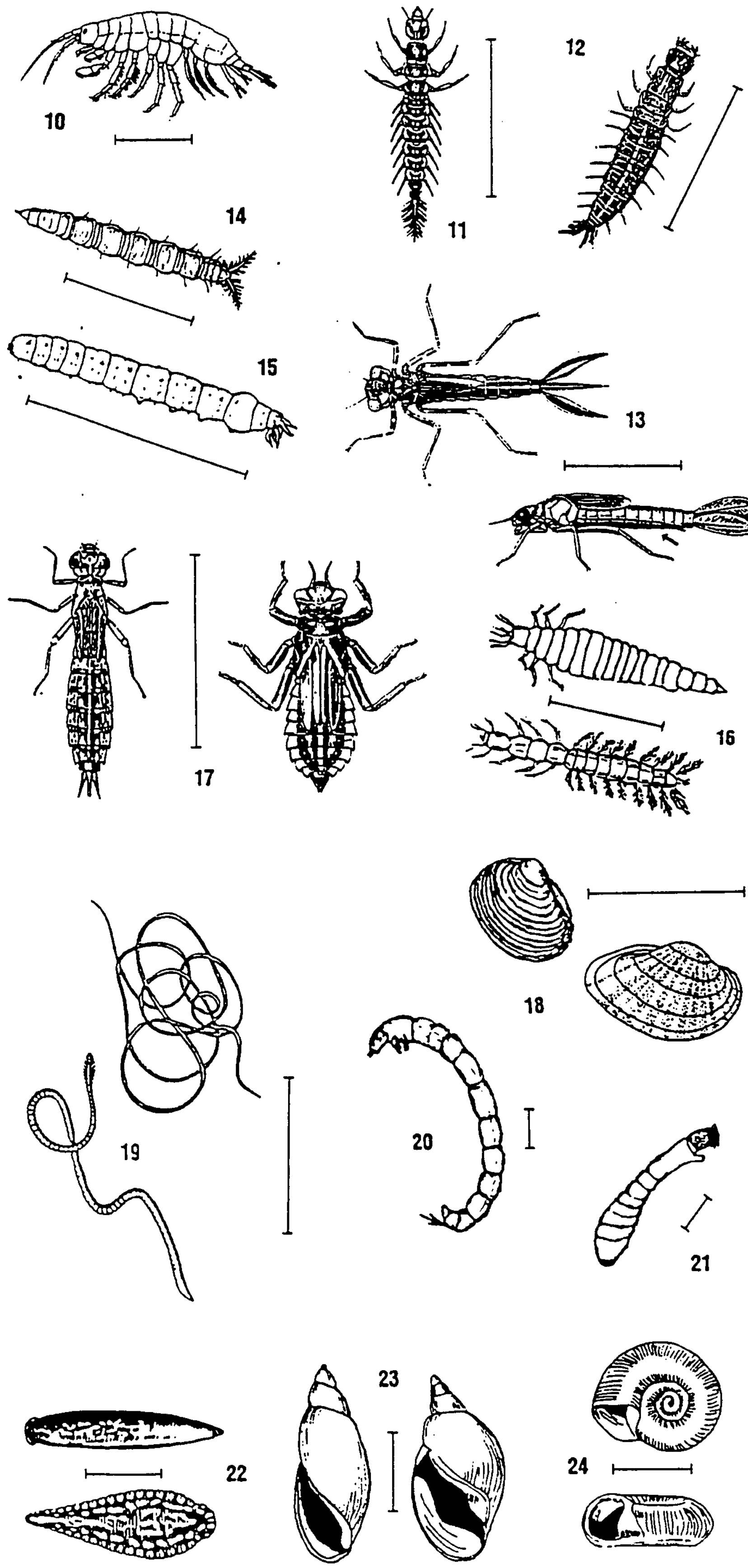
Somewhat pollution tolerant organisms can be in good or fair quality water.

8 ***Crayfish: Order Decapoda.*** Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 ***Sowbug: Order Isopoda.*** 1/4" - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Save Our Streams

Izaak Walton League of America
707 Conservation Lane
Gaithersburg MD 20878-2983
1(800)BUG-IWLA



Bar lines indicate relative size

GROUP TWO TAXA CONTINUED

10 ***Scud: Order Amphipoda.*** 1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 ***Alderfly Larva: Family Sialidae.*** 1" long. Looks like small hellgrammite but has 1 long, thin, branched tail at back end (no hooks). No gill tufts underneath.

12 ***Fishfly Larva: Family Corydalidae.*** Up to 1 1/2" long. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

13 ***Damselfly: Suborder Zygoptera.*** 1/2" - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body. (See arrow.)

14 ***Watersnipe Fly Larva: Family Athericidae (Atherix).*** 1/4" - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 ***Crane Fly: Suborder Nematocera.*** 1/3" - 2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

16 ***Beetle Larva: Order Coleoptera.*** 1/4" - 1", light-colored, 6 legs on upper half of body, feelers, antennae.

17 ***Dragon Fly: Suborder Anisoptera.*** 1/2" - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 ***Clam: Class Bivalvia.***

GROUP THREE TAXA

Pollution tolerant organisms can be in any quality of water.

19 ***Aquatic Worm: Class Oligochaeta.*** 1/4" - 2", can be very tiny; thin worm-like body.

20 ***Midge Fly Larva: Suborder Nematocera.*** Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 ***Blackfly Larva: Family Simulidae.*** Up 1/4", one end of body wider. Black head, suction pad on other end.

22 ***Leech: Order Hirudinea.*** 1/4" - 2", brown, slimy body, ends with suction pads.

23 ***Pouch Snail and Pond Snails: Class Gastropoda.*** No operculum. Breathe air. When opening is facing you, shell usually opens on left.

24 ***Other Snails: Class Gastropoda.*** No operculum. Breathe air. Snail shell coils in one plane.

DEFENDERS OF SOIL, AIR, WOODS, WATERS AND WILDLIFE · THE IZAAK WALTON LEAGUE

HBRW Tier 1

Physical/Habitat Survey

Assess a 200 foot segment up and down stream from your sample site.

Name(s)____ Date__________ Time_________

School/Group___________________ Stream_________________________ Site_______________________

Weather: Today ______________________________________ ***Temperature:*** Air______________°C

Past 2 days:__________________________________ Water_____________°C

Stream Width: The stream is on average ____________ meters wide and __meters deep.

Water Level: Compared to the height of the stream channel, the water level seems relatively: _______high ______medium ______low

Water Appearance/Odor

- ☐ clear
- ☐ foam
- ☐ tea-brown
- ☐ multi-color
- ☐ milky
- ☐ muddy
- ☐ other (describe):
- ☐ unusual odor (describe):

Velocity: Average time it takes to flow 3 meters:

(0.15-0.75 m/sec is optimal for BMI collection sites)

a) 3 meters/ ______ sec = v1 __________

b) 3 meters / ______ sec = v2 __________

AVERAGE: ___________ m/sec

Habitat Features:

The site has:	Many	Some	Few or None
Riffles (fast areas, <2' deep)			
Runs (fast areas, >2' deep)			
Pools (slow areas, >2' deep)			
Glides (slow areas, <2' deep)			
Shelter for fish (logs, stumps, and/or undercut banks)			
Patches of aquatic plants			

Substrate Size: Rank the substrate sizes from most common (1) to least common (6)
(Cobbles are optimal for macroinvertebrates)

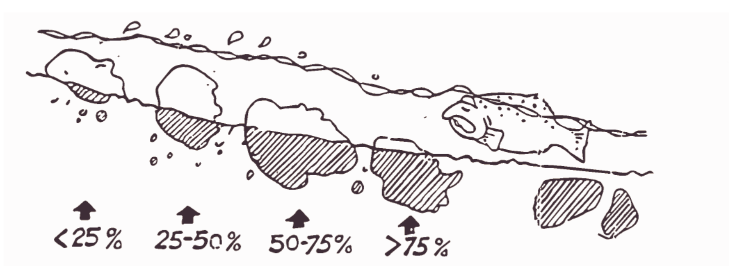
Silt/Clay/Mud (makes the water cloudy if disturbed)	**Sand (up to 0.1")**	**Gravel (0.1-2")**	**Cobbles (2-10")**	**Boulders (>10")**	**Bedrock** (solid rock covering the stream bottom)

Cobble Embeddedness:

Pick up several cobbles (if present) to estimate the average embeddedness of your site:

Average Embeddedness: _____%

(50% embeddedness indicates doubtful habitat for many macroinvertebrates, trout and egg survival)



Natural Vegetation extends beyond the banks for: ______ < 6 yards ___6-12 yards
(if the 2 banks are different, evaluate the worse side) ______ 12-35 yards ___> 35 yards

Stream Banks: They are:	In no or few areas	In some areas	In many areas
Covered with vegetation			
Eroding			
Mowed			
Artificially protected			

Human Impacts and Land Uses*: (check boxes that are present)*

- ☐ Stream channel altered
- ☐ Storm drain pipes
- ☐ Sewage treatment plant pipes
- ☐ Dams
- ☐ Farms
- ☐ Recreation
- ☐ Garbage
- ☐ Stores
- ☐ Culverts
- ☐ Mining
- ☐ Roads
- ☐ Industry
- ☐ Houses
- ☐ Logging
- ☐ Other:

Describe how they may be impacting the stream:

Site Drawing:
Draw a "birds-eye" sketch of the 200' long segment of your river up and downstream from your stream site, recording specific physical and habitat features, including:

1. Your sampling sites—include where you collected water quality and macroinvertebrate samples and measured velocity and cross section area.
2. In-Stream Habitat – riffles, pools, runs, large woody debris, boulders, organic material, aquatic plants, overhanging vegetation, etc.
3. Streambanks – steep & gently sloping areas, naturally vegetated areas, bare, eroding, clear-cut, or mowed areas, artificially protected areas, etc.
4. Channel – wide & narrow areas, meanders, shaded & exposed areas, unnatural alterations, dams, culverts, etc.
5. Human Land Uses – roads, houses, driveways, parking lots, storm drain pipes, sewage pipes, factories, farms, livestock crossings, recreational use, logging, etc.

Indicate direction of streamflow with arrow

Physical Survey / Habitat Assessment

(Assess a 200 foot segment up & down stream from your sample site)

Name(s)________________________________ Date__________ Time__________

School/Group________________________ Stream____________________ Site________________________

Current Weather Conditions____

Past 48 Hours Weather Conditions: ____

Sampling Site Type (Select one from each row)									
Stream Size	Headwater Tributaries (<20 cfs)			Creeks and Streams (20-150 cfs)			Larger Rivers (>150 cfs)		
Gradient	FAST (primarily riffle)			VARIED (pools and riffles)			SLOW (low gradient)		
Surrounding Land Use	Forested		Agricultural		Residential			Urban	
	dense	sparse	pastureland	cropland	rural	village	suburban	residential	Comm/indust

Upstream Dam: Yes No How far up stream: __________ The stream is on average ____feet wide and ____ feet deep

Compared to the height of the stream channel, the water level seems relatively High Low Average

Turbidity is substantially greater than natural conditions Yes No Algal or weed growth: __________% of bottom covered

Oily film, grease globules, or unusual odor or color present Yes No Describe:________________________________

Assessment Factor	Excellent	Good	Fair	Poor
Attachment Sites for Macroinvertebrates cobbles are 2-10" boulders are >10" gravel is 0.1-2"	Well-developed riffle, as wide as stream & as long as 2x stream width; cobble predominates; boulders, gravel common	Riffle as wide as stream but riffle length < 2x stream width; cobble less abundant; boulders and gravel common	Riffle not as wide as stream and length < 2x stream width; gravel, boulders or bedrock prevalent; some cobble	Riffles or run virtually nonexistent; large boulders and bedrock prevalent; cobble lacking
Shelter for Fish	Snags, submerged logs, undercut banks, or other stable habitat are found in over 50% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in 30-50% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in 10-30% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in < 10% of the site
Embeddedness (for tier 3, use *Stream Bottom Survey*)	Rocks in stream not embedded; very little sand, silt, or mud	Rocks partly embedded; can easily turn over rocks	Rocks > 50% embedded and firmly stuck in sediments	Rocks deeply embedded; bottom mostly sand, silt, or mud
Flow Pattern (deep is > 2 ft)	All 4 patterns present: slow/deep, fast/shallow fast/deep, slow/shallow	Only 3 of 4 flow patterns present	Only 2 of 4 flow patterns present	Dominated by 1 flow pattern
Channel Alteration	Stream straightening, dredging, artificial embankments, dams or bridge abutments absent or minimal; stream with meandering pattern	Some stream straightening, dredging, artificial embankments, or dams present, usually near bridge abutments; no recent channel alteration	Artificial embankments present to some extent on both banks; and 40-80% of stream site straightened, dredged, or otherwise altered	Banks shored with gabion or cement; over 80% of the stream site straightened and disrupted
Stream bank cover and stability	Banks stable; no evidence of erosion; bank covered by vegetation or rock	Moderately stable; small areas of erosion; most of bank covered by vegetation or rock	Largely unstable; almost half of bank has areas of erosion or is not covered by vegetation or rock	Unstable, eroded; < half of bank covered by vegetation or rock, or rock slumping into creek
Disruption of riparian bank coverage (land bordering stream bank)	Mature trees and vegetation; most growing naturally; no disturbance by forestry, grazing, or mowing	Trees, woody plants, soft green plants dominate; some disruption but not affecting full plant growth potential	Obvious disruption; patches of bare soil, cultivated fields or closely cropped vegetation are the norm	Not much natural vegetation left or it has been removed to 3" or less in height
Width of riparian vegetation zone	More than 35 yards wide; human activities have not impacted zone	Zone 12-35 yards wide; marginal impact from human activities	Zone 6-12 yards wide; impact from human activities evident	Zone <6 yards; lots of nearby human activities
Litter	No litter (metal or plastic) in area	Very little litter; accidentally dropped	Litter fairly common; purposely dropped	Lots of littler present; obviously dumped

* Please record any other factors (pipes, bridges, sample sites, etc.) on a brief site drawing on back.

Chemical Sample/Data Reporting Sheet

Name of Group/Program____________________________ River/Stream__________________________________ Sampling Site_________________________________

Date/Time Sampled_______________ Weather Today: (circle all that apply) Light Rain Heavy Rain Snow Snow Melt ___% Cloud Cover Other:

Weather Past 2 days: ____ Today's Air Temperature: ____°C

Water level (indicate observation here): ❒ high ❒ medium ❒ low Flow Data Sheet attached for this date ____Yes ____No

Indicator	Test Apparatus	Test Method Sensitivity and Range	Calibration (All QAQC levels: at beginning & end of run each sampling day)			Sample & Duplicate*				External Checks (QAQC level C only)			
			Blank results	Standard		First Sample	Duplicate Sample*	Avg.	Rel.% Diff.*	Unknown		Split Sample	
				Result	Actual					Result	Actual	Result	Actual
Temperature ^{0}C			Check here if calibrated										
pH (blank=7, std=4 or 10)													
Alkalinity (mg/L)													
Dissolved Oxygen (mg/L)				Meters only	Super-saturated sample								
% Oxygen Saturation													
Nitrate-N* (mg/L)													
Ammonia-N (mg/L)													
Orthophoshpate as P* (mg/L)													
Conductivity (microsiemens/cm)													
Chloride (mg/L)													
Turbidity (NTU)													
Total Suspended Solids (mg/L)													
Fecal Coliforms (colonies/100 ml)													

* For QAQC level A, test one duplicate sample for each indicator per day; for levels B & C, test one duplicate for each indicator per sample; retest if relative % difference (RPD) is greater than 20%

**For Tier 3 N and P, simply indicate under calibration that standard curve was used and attach curve results RPD = (difference between first sample and duplicate sample ÷ first sample) x 100

QC Checks: ___ If not analyzed immediately, samples were refrigerated and/or preserved according to instructions in Guidance Document

___ Glassware clean ___ Test reagents not expired ___ Physical Survey attached with sketch indicating collection point

Name of person(s) analyzing sample____

Name, address, phone, email of person completing this sheet____

Name, address, phone of outside lab (Level C only)____

Benthic Macroinvertebrate
Major Group Biotic Index Worksheet

Name(s)____
School/Group______________________________________ Stream_______________
Date(s) Sampled____________________ Site__________________ Replicate __________

Major group	**A** **# of Organisms in Sub-sample**	**B** **Assigned Biotic Index**	**C** **Biotic Value for Group**
Mayfly		2	
Stonefly		1	
All Caddisfly except Netspinner		3	
Netspinner Caddisfly		5	
Dobsonfly, Fishfly		4	
Alderfly		4	
Water Penny		4	
Whirligig Beetle		4	
Other Beetles		5	
Crane Fly		4	
Watersnipe Fly		4	
Black Fly		5	
Midge		6	
Dragonfly		3	
Damselfly		7	
Crayfish		6	
Scud		6	
Sowbug		8	
Clam		6	
Snail		7	
Leech		7	
Aquatic Worm		9	
TOTALS	D		E

Instructions: (Try to pick up at least 100 individual organisms.) Using the "BMI Sorting" worksheet, count the number of organisms for each major group identified in your sub-sample and record in column A. Sum the total of that column and record in D. Multiply the number of organisms in each Major Group by the assigned biotic index value (see column B) and record the results in column C. Sum the total of that column and record in E. To get the Biotic Index Score, divide E by D.

Biotic Index Score= $\dfrac{\text{E total biotic value}}{\text{D total \# organisms in your sample}}$ **=** [ ]

Biotic Index:	0-4.5 non-impacted	4.51-6.50 slightly impacted	6.51-8.50 moderately impacted	8.51-10 severely impacted

HBRW Tier 2

Benthic Macroinvertebrate
Major Group Percent Composition Worksheet

Name(s)____

School/Group__________________________________ Stream______________

Date(s) Sampled_________________ Site________________ Replicate ________

Calculating Percent Composition

$$\% \text{ Composition} = \frac{\text{\# individuals of major group}}{\text{total \# individuals in sub-sample}} \times 100$$

Major group	**# individuals of major group**		**total # of all organisms in sub-sample**		**Percent Composition**
Mayfly		÷		x 100 =	
Stonefly		÷		x 100 =	
Caddisfly		÷		x 100 =	
Midge		÷		x 100 =	
Beetle		÷		x 100 =	
Worms		÷		x 100 =	
Others		÷		x 100 =	

Total # in sub-sample [   ] This is “D” from “Major group biotic index” worksheet

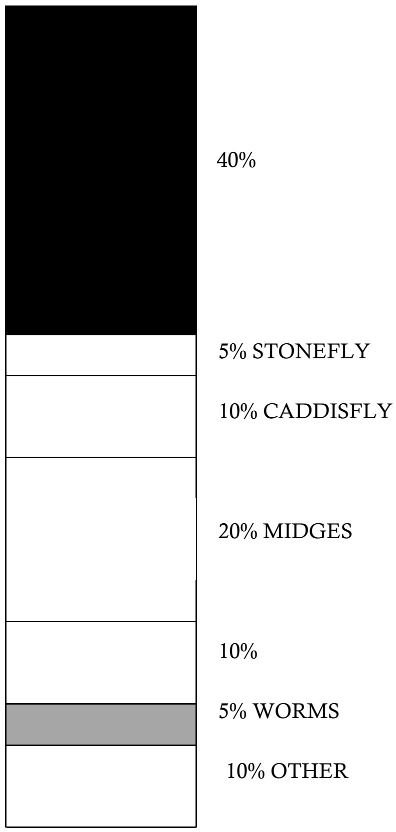
Steps:

1. Try to pick at least 100 organisms or ¼ of your sample. This is your sub-sample. See directions in the analysis section for more details.
2. Fill in the number of individuals you have identified in each group from your sub-sample using the “BMI Sorting” worksheet.
3. Sum the total number of organisms in your sub-sample.
4. For each major group, divide the number of individuals for that group by the total number in your sub-sample. Multiply by 100 to calculate percent composition.
5. Graph the percent composition in the “Graphing Percent Composition” worksheet to compare sites, and use your results to compare your site with the reference community for NY State.

HBRW Tier 2

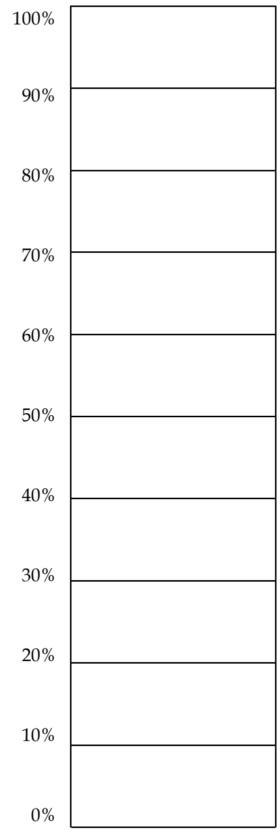
Graphing Percent Composition Worksheet

NY "model community"



Your Sample:

(color in appropriate %'s)



APPLE LEAF

Educational Tips by Cindy Ybos and Patty Watts

THE THEORY OF MULTIPLE INTELLIGENCES

A different kind of smart – that's the hottest topic of discussion in classrooms across the country today. For many years, educators believed that "intelligence" was fixed and, therefore, individuals die with the same intelligence with which they were born. Another misconception was that there was only one way to define and measure intelligence. Modern research has seriously challenged those ideas, however. The currently accepted theory of multiple intelligences, which is based on research about how people learn, has changed how teachers facilitate and assess learning. Educators no longer focus on "how smart students are" but on "how students are smart."

The theory of multiple intelligences, developed by Howard Gardner and his associates, holds that every individual possesses several different and independent capacities for solving problems and creating products. Gardner has named these capacities "intelligences" and has scientifically identified eight of them. To facilitate understanding and implementing them, Gardner has grouped some of these intelligences into three categories.

The *language-related* intelligences, verbal/linguistic and musical/rhythmic, reflect the structures of individual languages. These two intelligences are "object free," meaning that thoughts are represented through sound-based communication and symbolic representations of those sounds. Yes, car salesmen do have this intelligence. There's a frightening thought.

The second category, *personal* relationships, consists of interpersonal and intrapersonal intelligences. These are the people-centered intelligences. They reflect the personal vision of self, expectations of others, accepted norms of thinking and acting, and the cultural pressures that shape behavior.

The third category is *object related* intelligences. These include bodily/kinesthetic, visual/spatial, and logical/mathematical. The designation of object-related means that the basic concepts and procedures are rooted in physical manipulation of concrete objects that results in a defined product. These intelligences are subject to the "rules of the game" for using the objects to solve a problem or make a product.

The newest intelligence to be identified is naturalist intelligence. This is the ability to differentiate the patterns and characteristics among natural objects in the environment. Charles Darwin and PLT facilitators are often cited as examples of people who have naturalist intelligence.

Researchers say that each of us is born with all eight intelligences and no one intelligence is superior to another. Every individual possesses a unique blend of the seven intelligences that was determined by the cultural environment in which the intelligences developed. It, therefore, becomes the responsibility of the educator to provide students the means for developing and using all eight intelligences to build knowledge. As with other instructional strategies, PLT has already incorporated many of the key aspects of multiple intelligences theory into its activities.

One of the simplest ways to include multiple intelligences in your workshop is to ask participants to "represent" the data they have collected during a PLT activity, such as Water Wonders, using one of the eight intelligences. Each group can be invited to use the intelligence with which they are most comfortable or you can assign an intelligence to each group. By doing this, you encourage them to really let their personalities shine! We have found that groups will dance, sing, draw pictures, make models, create graphs, or do calisthenics to report their findings from PLT activities. Using the multiple intelligence techniques such as this not only helps educators focus on the individuality of their students, it also provides an excellent opportunity to really have a fun workshop.

While all of this information about Multiple Intelligence Theory may seem overwhelming, the main idea we would like for you to get from this article is that PLT activities already incorporate a great deal of this theory. Just by doing the activities, you are modeling some aspects of Multiple Intelligence Theory in your workshops and with some small modifications, you can model all aspects of it. It also is important that you think about how combinations of activities will address all of the intelligences when planning your workshops.

In future articles, we will examine each category of intelligence, share specific tips and strategies for livening up your workshops using multiple intelligences, and suggest activities that highlight each intelligence.

As always, you can contact Patty Watts by e-mail at agwatts@alpha.nlu.edu, by fax at (318) 342-1779 or by mail at Northeast Louisiana University, Dept. of Agriculture CNSB 310, Monroe, LA 71209-0510 and Cindy Ybos by e-mail LYbos42829@aol.com, by fax at (504) 643-4509 or by mail at 802 Freedom Lane, Slidell, LA 70458.

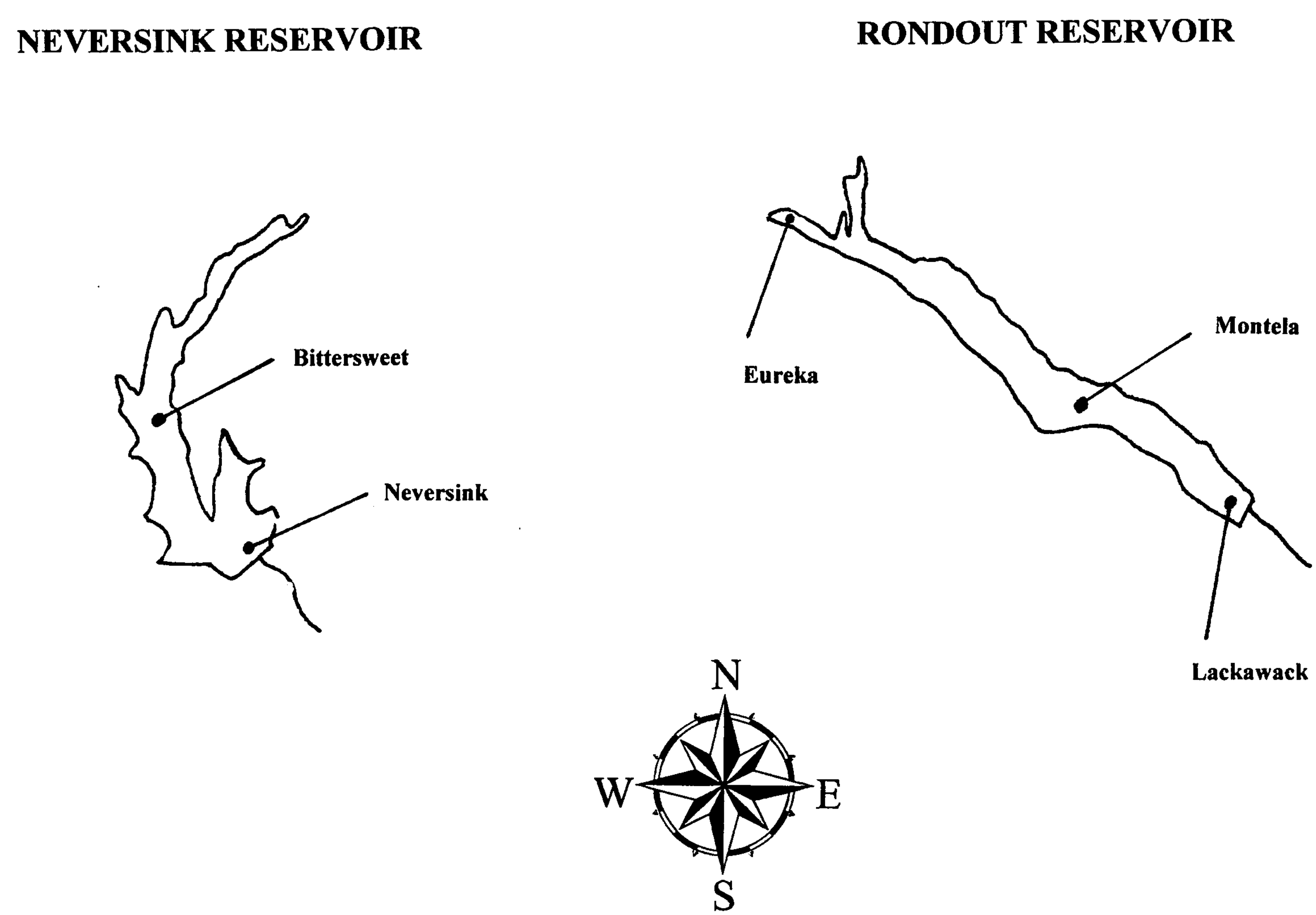
GREENWORKS! GRANTS AVAILABLE

What is GreenWorks!?

GreenWorks! is Project Learning Tree's (PLT) environmental community action component. It encourages students to participate in community based partnerships by developing and implementing environmental action projects, such as graffiti paint overs, tree plantings, stream clean-ups, and recycling projects.

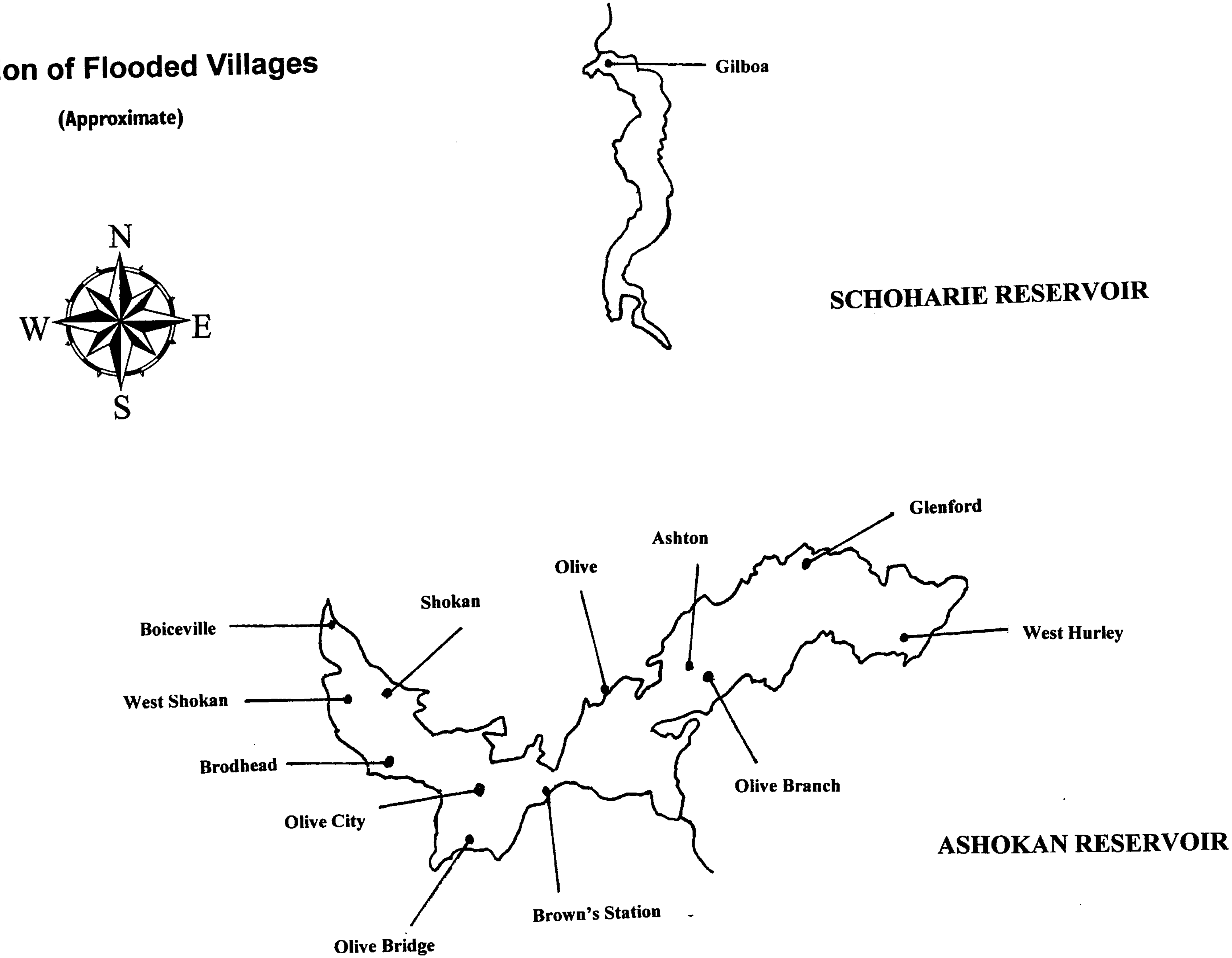
Location of Flooded Villages

(Approximate)



Location of Flooded Villages

(Approximate)



Location of Flooded Villages

(Approximate)