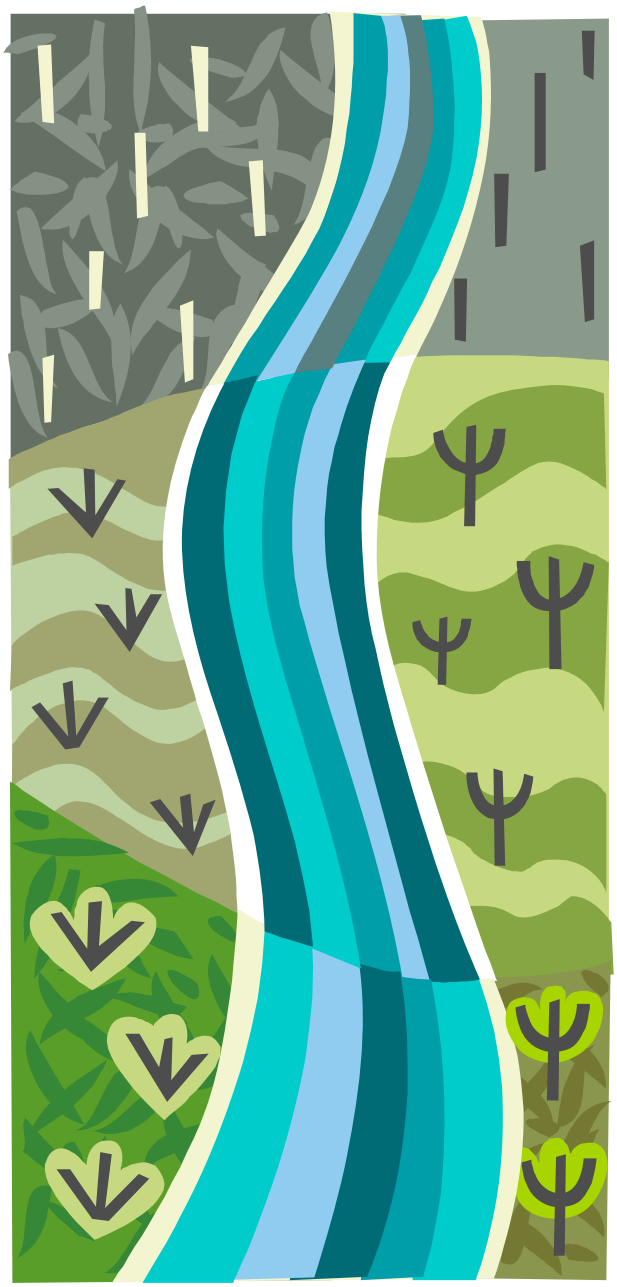
When It Rains It Drains



Stormwater Education Curriculum

Prepared by

NRPC

for the

Nashua Region Stormwater Coalition

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Introduction

When it rains, it drains

Gone are the days when it was easy to identify sources of water pollution in our country's rivers, lakes, streams, and ponds. Point-source pollution was the first targeted source of pollution under the Clean Water Act. We are now in a new era where water pollution primarily comes from sources not-so-easy to see or even to regulate. Land use practices, increased urbanization, and ever-increasing amounts of impervious surface are today's challenges.

Urban areas are particularly sensitive to non-point sources of pollution and are more strictly regulated by the US Environmental Protection Agency to focus on stormwater as the number one water quality problem today. Most urbanized areas are required to participate in a permitting process which gives cities and towns the authority and responsibility to clean up stormwater runoff and improve the quality of surface waters and streams. Many communities in the Nashua area including Amherst, Hollis, Hudson, Merrimack, Nashua, Pelham, and Windham must participate in a 6-tiered stormwater program in order to comply with the Clean Water Act permitting requirements, called the Phase II requirements of the National Pollutant Discharge and Elimination System (NPDES) Permit.

Public education is one of the six major components of the permit requirements, and school-aged children are an obvious target audience. Children are often more able and willing to adopt environmentally sensitive attitudes and behaviors than are their adult counterparts, so the idea for a stormwater education curriculum was born.

We all live downstream

The curriculum is designed to be presented to seventh and eighth grade students. Extensions to sixth grade and high school are possible through modification of some of the assessment activities. Ultimately, the goal of the curriculum is to allow students to understand that we all live in a watershed, we are all responsible for keeping our watersheds healthy , and we all live downstream from somebody else. It is in our interest to behave accordingly, and to teach our children to be protect water resources for future generations.

Stormwater matters

Many waterbodies in the greater Nashua region are already impaired by pollutants that are commonly transported and delivered to surface waters though stormwater. Many individuals rely on both the Pennichuck Brook and Merrimack River for surface drinking water supplies, so the problems presented by stormwater are real and timely.

Who can help?

The Nashua Regional Planning Commission (NRPC) designed this curriculum to be as flexible as possible given the need for increased public education surrounding the stormwater topic, and the demanding expectations that teachers face today. The curriculum includes specific Grade Level Expectations adopted by the NH Department of Education for each lesson activity in order to help teachers meet their broad curriculum goals.

Activities in this curriculum do not have to be presented in order, or even in entirety. The NRPC recognized that different teachers will have different classroom needs in terms of scheduling, fit with existing lesson plans, and availability of materials to conduct a specific activity. In this light, we tried to make activities flexible and accommodating for a range classroom circumstances.

Finally, many people at the local, regional, and statewide level are interested in helping teachers present stormwater concepts. Municipal planners, engineers, public works superintendents, and environmental professionals all share an interest in seeing an increased focus on stormwater education. Many are available for in-class presentations on specific topics. Contact Minda Shaheen, Environmental Planner, NRPC (mindas@nashuarpc.org; 424-2240) for further information and local contact persons in your city or town.

Activity 1: Water Log

Process and Procedure: Ask students to keep a log book or journal of observations about water in their environment for a designated period of time. Encourage students to note water in its different forms and settings, and how they utilize water in their daily lives. Students may record observations, feelings, questions, or opinions about water in the environment. Have students estimate their own personal water usage and compare their use to other individuals or groups. Have students describe how water in all of its forms is part of one or more systems; describe how those systems interact and influence each other. Encourage students to be creative in their observations and entries (including use of drawings, photos, news clippings, etc.)

Materials Needed: Log book or journal (may be constructed out of available materials).

Discussion Questions:

1. In what environmental processes is water essential?
2. In what ways can people influence how water cycles through the environment?
3. How does your water usage compare to your classmates, parents, people in other parts of the country, or people in other parts of the world?

Understandings:

- Water is essential in living organisms and abiotic environmental processes.
- Human activities influence how water cycles through the environment.
- Through individual choice and technological mechanisms, human populations can contribute to healthier environments.

Key Concepts:

- Water cycle: how water moves through its system components

Science Process Skills Utilized:

- S:SPS2:6:2.3—Estimate or predict the effect that making a change in one part of the system will have on other parts, and on the system as a whole.
- S:SPS2:8:2.1—Understand that any system is usually connected to other systems, both internally and externally; thus a system may be thought of as containing subsystems and being a subsystem of a larger system.
- S:SPS4:8:7.1—Keep a journal of observations and investigations, and periodically evaluate entries to assess progress toward achieving the understanding of key ideas.

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Activity 2: What's a Watershed?

Background: A watershed is an area of land draining into a lake, stream, or marsh area, often located at the lowest elevation in the area. Depending on the size of the watershed, they can contain numerous tributary streams and ditches or ponded areas such as natural ponds and wetlands.

As rainwater falls onto the watershed, it either evaporates back up into the atmosphere, is absorbed into the soil, or runs off into a nearby tributary. Eventually it will flow into the main stream or lake within that watershed, and ultimately will end up in the ocean as it travels from stream to larger stream to river, etc.

Runoff within the watershed is the main concern in stormwater management. Runoff is stormwater in the most basic sense. Because pollution problems often result from land practices in the watershed, addressing stormwater from a watershed perspective is important to protecting streams and waterbodies.

Materials Needed: Copies of a topographic map, preferably showing the location of the school and a local stream and associated watershed area; colored markers or pencils.

Process and Procedure:

1. Have students develop a working definition of a watershed.
2. Locate the school on the topographic map and mark it.
3. Find the closest major stream [YOUR STREAM] to the school and determine the elevation of the stream.
4. Find all other waterbodies (streams, creaks, lakes, etc.) and mark them in blue.
5. Trace the route of YOUR STREAM and determine where water comes from and where it goes. All water, including stormwater, follows the path of least resistance as it travels downslope, represented on topographic maps by locations where contour lines are very close together. The highest points are

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Understandings:

- The watershed is the basic unit for understanding the physical and chemical processes occurring within surface streams and waterbodies.
- Every point on the land surface is within one watershed or another.
- Streams are influenced by the natural and manmade features found within their watersheds.

Key Concepts:

- Topographic Maps: interpreting topographic map symbols and map reading.
- Watershed Boundaries: locating and determinining where they are; relationships between watershed size and stream size.

Science Process Skills Utilized:

- S:ESS1:8:7.1—Describe how water flows into and through a watershed, falling on the land, collecting in rivers and lakes, soil, and porous layers of rock, until much of it flows back into the ocean.
- S:SPS4:8:3.3—Make sketches, graphs, and diagrams to explain ideas and demonstrate the interconnections between systems.

What's a Watershed? (continued)

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"break points" where water either flows to one waterbody or another. These areas often form watershed boundaries.

6. Locate the highest points around YOUR STREAM and mark with Xs. Determine the elevation of the highest points in the watershed.
7. Define the boundary of YOUR STREAM's watershed by connecting the dots with a purple line.
8. Take the maps outside to see if they can observe any landmarks they found on the watershed map. Have students record any features that might affect the flow of water through the watershed (hills, buildings, ditches, culverts, etc.) Where possible, take a walking tour of the watershed, or a portion of the watershed. Note areas where potential water pollutants might collect or be located. Note areas where wildlife might live. Note areas where people predominate the landscape.

Discussion Questions:

1. What natural and human-made features exist within the watershed?
2. Where is the highest point in the watershed? Can you see it?
3. What features on the landscape speed up and slow down water flow?
4. How would the watershed function differently if only manmade features were present? If only natural features were present?

Further Assessment:

1. Have students picture that they are a leaf, piece of trash, or insect, etc. that has fallen into water at the highest point in the watershed. Develop a story that describes how the watershed changes from the character's perspective as it moves down through the watershed.
2. Have students locate their own home on a topographic map and delineate the watershed around their home using the same process as with the school watershed. Ask students to describe how water moves onto and off of their own property in relation to the larger watershed area, using drawings or pictures to describe the flow. Ask students to compare and contrast the similarities and differences between their home watershed and the school watershed.

Activity 3: Pesticide Patrol

Background: Each year, about 3 billion pounds of pesticides are used in the United States. Pesticides help to improve crop yields by controlling weeds, insects, and control plant disease. Farmers are the largest users of pesticides, but homeowners also use pesticides to make lawns grow thick and green and for home garden vegetables and flowers. Homeowners over-apply pesticides more often then farmers.

Because pesticides are designed to kill living organisms, such as fungi, bacteria, insects and worms, they can cause serious health problems if not stored, applied, or used appropriately. Some pesticides take a very long time to decompose in the environment, and can travel from soil into groundwater and surface water. Some pesticides enter the food chain through single-celled organisms and insects to birds and mammals and humans.

The US Environmental Protection Agency is responsible for controlling the risks of pesticides by prescribing specific uses and amounts where pesticides can still be considered safe, but it is up to the person using the pesticide to follow these instructions. The best way to ensure safety from pesticides is to limit their use and substitute safer alternatives to pesticides.

Process and Procedure:

1. Have each student interview at least one farmer, gardener, horticulturalist, nursery employee, agricultural extension agent, or other person involved in agriculture. Interview questions might include:
   - What crops do you grow?
   - How many acres or square feet of land do you cultivate?
   - What chemicals or pesticides do you use to grow your crops?
   - What is the purpose of each of the chemicals?
   - How are the chemicals applied?

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Understandings:

- Pesticides can be either beneficial chemicals or harmful pollutants, depending on how they are used and applied.
- Pesticide alternatives exist, but there may be tradeoffs from using traditional chemicals versus alternative products.
- Regulation and personal responsibility both play a role in maintaining safe and healthy environments.

Key Concepts:

Pesticides uses, benefits, and risks. Alternatives to pesticide use. Personal responsibility in pesticide use.

Science Process Skills Utilized:

- S:SPS3:6:2.1—Develop, focus, and explain questions about the environment and do environmental investigations.
- S:SPS3:6:3.1—Identify problems / issues that can be addressed by design technology.
- S:SPS:8:3.1—Design a product or solution to a problem.
- S:SPS:8:1.1—Use a variety of information access tools to locate, gather, and organize potential sources of scientific information to answer questions.

Pesticide Patrol (continued)

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- What precautions do you take when applying them?
- How do you know how much of the chemical to use? Is this the amount you use?
- Are there alternatives to the chemicals? Are they costly? Are they effective?

2. Have students compile the information into a chart:

Chemical Name	Use	Who Uses It?	How applied?	Precautions Taken
Chemical A				
Chemical B				
Chemical C				

3. Assign groups of students to investigate each chemical to determine what the chemical is usually used for, who uses it, if it requires a license for use, for how long it can persist in the environment, and if it is approved by the EPA. Students should also investigate what alternatives exist for this chemical and whether there are any risks from overuse of this chemical. Have students or teacher obtain Materials Safety Data Sheet information from www.hazard.com/msds.
4. As a class, compare the information gathered in the interviews to the information gathered in the research.
   - Are the people interviewed using the chemicals correctly?
   - Are the chemicals used dangerous?
   - Can the person be successful without the use of these chemicals?
   - What might happen if these chemicals were to wash into streams, lakes, or groundwater?
   - What impacts might these chemicals have on fish, wildlife, or humans?
   - How can people reduce the harmful impacts of pesticides?
   - What technologies can students think of that might help in reducing the use of pesticides?

Further Assessment:

1. Have students produce a brochure, news article, poster, or video regarding the beneficial and harmful aspects of pesticides and suggest alternatives.

Activity 4: What Do You Think?

Background: Environmental problems and issues are complex. Developing solutions to environmental problems often involves learning about other people's beliefs and relative knowledge about a problem. Sometimes providing individuals with additional information will help them understand a problem more, and they might develop a new opinion about that problem. Other times, people have lots of information about a problem, but they still do not choose to behave in certain ways.

An example that we can all relate to is healthy eating. Many people know that a healthy diet includes certain amounts of fruits and vegetables, proteins, carbohydrates, and limited amounts of sugars and fats. But many people ignore this type of knowledge and instead choose foods that may not be healthy for them, or choose improper amounts of healthy foods.

In order to understand many environmental issues, it is important to consider the attitudes, knowledge, and behaviors that people possess or display in order to provide effective solutions to the problem. One way to help understand people's attitudes of, knowledge about, and behaviors towards an environmental issue is to conduct a questionnaire or personal interview about a problem.

Materials Needed: Copies of the "What Do You Think" Questionnaire

Process and Procedures:

1. Ask students to consider the relationship between knowledge and behavior. Ask them to come up with personal examples of where their knowledge about a topic or activity conflicts with how they actually behave (ex. Staying up too late and being tired; not saving up allowance money for an expensive item; not studying for an important test). Ask students to come up with reasons why they behave differently than expected, given their level of knowledge, and brainstorm solutions to the problems they have

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Understandings:

- Environmental problems can be difficult to solve due to the attitudes, knowledge, and behaviors that people may have.
- There may be more than one solution to environmental problems; environmental problems may need more than one solution.
- Questionnaires and Interviews are helpful tools in understanding people's perspectives about environmental issues, but they may not provide all the solutions or answers.

Key Concepts:

Knowledge, attitudes, and behaviors; questionnaire design and distribution; survey data analysis; bias.

Science Process Skills Utilized:

- S:SPS1:6:1.2—Plan observations based on a given purpose.
- S:SPS1:6:1.3—Identify and investigate similarities and differences among observations and sets of observations.
- S:SPS4:8:1.2—Collect real-time observations and data, synthesizing and building up on existing information to solve problems.
- S:SL4:6:1.3—Provide examples of how humans make judgements about new situations based on memories of past experience.
- S:SPS3:8:1.2—Work collectively within a group toward a common goal.

What Do You Think? (continued)

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listed.

2. Ask students to brainstorm a number of environmental problems that have obvious solutions (examples; beach pollution = provide additional garbage cans; air pollution from traffic jams = carpool, bike, or walk instead of drive; not enough recycling = charge more for garbage containing recyclables, etc.). As a class, vote on which problem and associated solution will be used to conduct a community survey. The survey will be used to learn about people's knowledge about the problem and behaviors surrounding the solution.
3. Make copies of the "What Do You Think" Questionnaire and have students either fill in the problem and solution into the appropriate blanks, or fill it in for them in advance. Each survey should contain the same content regardless of the student distributing the survey.
4. Ask students to think about what people's responses might be before distributing the survey. Discuss as a group why students think people will respond a certain way.
5. Require students to gather at least five responses—more if you would like a more robust data pool. Provide students with guidelines on whether they will be interviewing the candidates and writing down responses, or whether survey participants will provide their own written answers. Provide students with age-appropriate guidelines on where and from whom they may conduct surveys (on school grounds only, within their neighborhoods, family members or personal friends only, etc).
6. Have each student tabulate their survey responses into a chart. Then as a group, combine all student data into a single data set. (Teachers may wish to do this either in class or outside of class depending on how complicated the environmental problem appears.) Use graphs to depict the data when possible.
7. Ask students to evaluate the data collected:
   - Is the data complete?
   - Were the responses surprising or as expected?
   - Are there any questions you wish you could ask, now that you see the results?
   - Did survey respondents exhibit a high degree of sameness in their responses, or were their responses highly variable and diverse?
   - Are there any conclusions that can be made regarding the environmental problem or solution given the data collected?

Further Assessment:

1. Ask students to consider who might like to know about the information that they have collected. Have students individually write letters to a person/organization discussing the environmental problem, the survey data, the environmental solution and how that person / organization could help in solving the problem. Where possible, actually send a student(s) letter to the appropriate audience and request a formal response.
2. Introduce students to the topic of bias in survey design and response. Ask students to identify any areas where their survey might have been biased or led to improper conclusions about the environmental problem or its solution. Ask students to consider whether they did enough surveys to understand the problem, or if they asked enough different kinds of people to fully represent their community or school.

What Do You Think Questionnaire?

1. Are you aware that some people think _____ is a problem in our community?
environmental problem

2. Do you think that _____ is a problem?
environmental problem

3. Do you know that you can _____ to help solve the problem?
solution to the problem

4. Do you already _____ as much as you should?
solution to the problem

5. If you answered no, why not?

_____
_____
_____
_____
_____

6. Would you like to know more about our community's _____ problem?
environmental problem

7. If you answered yes to the above question, what would you like to know? If no, why don't you want any more information?

_____
_____
_____
_____
_____

8. What could be done make you act differently towards the problem?

_____
_____
_____
_____
_____

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Activity 5: Work It Out

Background: As illustrated in Activity 4, environmental issues can be complex. People can have strong feelings and opinions about environmental problems and what to do about them. Crafting solutions to problems can be difficult due to lack of knowledge, cost, differing needs of affected people, and the level of risk people are willing to take in implementing a solution that may or may not work.

Usually, choices must be made when solving environmental problems. Choices involve ranking of preferences. Sometimes it is possible to develop a solution that will satisfy everyone's preferences, but in other cases there end up being "winners" and "losers" when choices are made.

In this activity, students adopt a character role to fulfill in making an environmental decision about water use.

Materials Needed: 3 x 5 index cards containing character role-playing information.

Process and Procedures:

Part I:

1. Introduce students to the topic of surface water as a renewable, but finite, resource that has limitations in how much water can be used for various purposes. Have students brainstorm the types of water uses with which they are familiar (drinking water, wildlife habitat, hydroelectric power, recreational boating, swimming, etc.). Choose a water resource familiar to students (Pennichuck Brook, Nashua River, Merrimack River, Purgatory Brook, etc.) as a real-world example with which they can work, if desired. List the uses and have students label whether the uses they come up with are consumptive uses or non-consumptive uses of water.
2. Have each student then rank, in order of priority, the water uses that the class came up with, with 1 be-

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Understandings:

- A person's perspective helps to influence the choices they make; broadening perspective can help to reduce conflict between people.
- Ranking skills can help people to prioritize thoughts, opinions, and actions in their lives.
- Regulation and personal responsibility both play a role in maintaining safe and healthy environments.

Key Concepts:

Priority ranking systems; perceptions and choices in environmental decision-making; consumptive vs. non-consumptive resource uses

Science Process Skills Utilized:

- S:SPS3:8:1.2—Work collectively within a group toward a common goal.
- S:SPS1:6:1.8—Ask questions about relationships between and among observations.
- S:SPS4:8:1.3—Use appropriate tools to analyze and synthesize information to draw conclusions and implications based on investigations of an issue or question.
- S:LS4:8:1.3—Explain how all behavior is affected by both inheritance and experience.

Work It Out (continued)

ing most important water use.

3. Divide students into groups and have them determine their group's AVERAGE ranking for each of the water uses.

4. As a class, display all of the average group rankings together and discuss the similarities and differences. Are there individuals in the class who feel that the group ranking is unfair? Why or why not? Ask students to discuss why the exercise was difficult or easy for them to conduct.

Part II

1. Divide students now into 10 small groups. Let students know that they will be participating in a community forum with the purpose of deciding how to utilize the water that is in a local river (again, using a familiar example may help with the exercise). At the forum, each group will be given a chance to discuss their wants and needs in relation to the river's water use. Let students know that they are allowed to bargain or coordinate with other groups if they think it will be useful to the overall goal of determining how water should be utilized in the river.
2. Distribute character role-playing cards to student groups. Give groups a few minutes to study and discuss their roles internally. Let them know that they will by trying to make a plea to the community of why their role is important and worth considering when water is allocated throughout the community.
3. Allow each of the groups 2-3 minutes to introduce their character role and make a plea to the community at large. While groups are speaking, the teacher should take note of the CONSUMPTIVE USES of water that are discussed (Aquatic species needs, agricultural uses, and drinking water, and wastewater-utility), and keep a running tally of how much water is needed for each of the uses described. (Consider making a display chart in advance of the exercise to illustrate user needs.)
4. When all the groups have had a chance to make their plea, let them know that only 100 cfs of water is available in the stream and that there is not enough water to go around to meet everyone's needs.
5. Send students back into their small group discussions and have them think about whether there is anything that they would like to do to help solve the problem. Groups at this point should be encouraged to think creatively and can come back to the forum with technological ideas, conservation measures, political promises, or any other means of either getting what they want (an adversarial standpoint) or trying to solve the water shortage problem as a whole (a conciliatory standpoint). Groups may choose to either compromise or not, as this is how people in real situations may actually behave.
6. Allow groups to give their final pleas, making any necessary changes to the tally of consumptive uses or other consequences on a board for all to see. Tabulate the conclusion of the water allocation problem and discuss who has been affected, and how. Who will benefit from this solution? Who will be negatively affected? Which groups seemed to have the most power in the discussion and why? Does the allocation match the water use priorities discussed in Part I of the exercise? Why or why not?

Further Assessment:

1. Have students share the classroom water allocation solution with family members and ask them to determine to what extent family members agree or disagree with the classroom solution. Ask students to explain how the allocation was determined. After the explanation, are family members in further or less agreement? What made them change their mind? Or why did their family member choices remain the same? What does this mean for public officials and public opinions in real-world decision-making?

Aquatic Species	Hydroelectric Dam
Residential Homeowner	Waste Water Treatment Plant
Recreational Fisherman	Kayaker
Drinking Water Utility	Bird Watcher
Agricultural Farmer	Environmental Activist

• You produce 15% of the total power demand for your community and have been doing so for the past 75 years. • The dam can only operate when the gauge of the river is greater than 40cfs.	• You are the fish, plants, and invertebrates that live in the river and comprise a healthy functioning aquatic ecosystem. • You can tolerate periods where flows range between 15 and 20 cfs, but ideally you thrive when flows are greater than 30 cfs. Species will die off in large numbers when flows fall below 15 cfs.
• You provide wastewater treatment services to all of the community businesses and residents. • The plant requires a steady flow of 20cfs from the river in order to operate. • If the plant does not get this flow, it is possible for untreated sewage to enter directly into the river.	• You are one of 10,000 community residents. • You utilize water for cooking, cleaning, watering your lawn and garden, and washing your car(s). • You do not have any direct rights to the river water and instead rely on the local water utility company to supply the water you need.
• You enjoy kayaking on the river and can only do so when flows are greater than 60 cfs. • You also introduce boy scouts, girls clubs, and children from low income families to the joy of kayaking, all for free, because you think kayaking is awesome!	• Fishing is something that you enjoy and use to provide supplemental food for your family. • You also participate in a volunteer group that helps track the health of the river; you get to find new fishing holes AND collect data for a worthwhile cause. • Fish are really hard to find and catch when flows are less than 30 cfs.
• You enjoy taking pictures of birds and watching them in their natural habitats – the river is their natural habitat which they will frequent when flows are greater than 40 cfs. • You also contribute $1,000,000 annually to your town's Conservation Commission because you appreciate their efforts to provide healthy bird habitats.	• You supply all of the drinking water for all of the town's water customers. • The amount of water demand varies based on time of year and whether or not they conserve. People use more water during the summer months for their gardens, lawns, and swimming pools. • In summer, you need to supply 60 cfs. In the winter you only need to supply 30 cfs.
• You are a professional scientist and collect data on the health of the river. • You know that the water quality of the river suffers the most when flows are lowest, below 30 cfs. • When flows go below 30 cfs, more money must be spent by the wastewater treatment plant and at the drinking water utility for drinking water and discharge water to be safe.	• You own a large farm on the banks of the river that supplies fresh produce to local grocery stores. Your family has been farming here for the past 120 years. • You need water during the dry times of the year when crops are growing, primarily June – September. • On average, you utilize 20 cfs, but in times of drought, you need 35 cfs to produce healthy crops.

Activity 6: What's in the Water?

Background: Stormwater pollution is the number one threat facing surface waters today. Prior to point-source environmental regulations, factories and industries discharging pollutants into the nations waterways were the biggest polluters. But now, pollution problems are primarily the result of activities that are broadly located across the landscape and do not involve a pipe or "point" that puts pollution into water. Instead, pollutants are picked up off the landscape when it rains, and rainwater carries pollutants to gullies and ditches which drain into storm sewer systems, which drain into streams and rivers, without receiving any kind of treatment at all.

In this activity, students will learn what the common sources of stormwater pollution are and learn to recognize these pollutants in the landscape and in their own personal lives.

Materials Needed:

- large glass jar or pitcher filled 2/3 with water
- red food coloring = HOUSEHOLD HAZARDOUS WASTE
- green food coloring = FERTILIZER
- five small plastic cups containing:
  - soil = SOIL
  - brown sugar = PET WASTE
  - pancake syrup = OIL
  - salt = ROAD SALT
  - paper dots/shreds = LITTER
  - detergent in warm water = SOAPY WATER
- masking tape for labeling cups
- needle and thread
- pencil or ruler
- index cards numbered 1-9 containing activity script
- sponge cut into a fish shape
- metal nut

Preparation:

- Thread a string through the bottom of the sponge fish and attach the metal weight so it hangs below the fish.
- Thread another string through the top of the fish and suspend it in the jar of water, halfway, and tie string to a pencil or ruler positioned across the mouth of the jar.
- Prepare index cards with script information, or cut out script sheet.

Understandings:

- Stormwater pollution is the number one threat to surface water quality.
- Water pollution has direct impacts on aquatic species and may affect how humans are able to utilize water resources for their own purposes.
- Stormwater pollution is everyone's responsibility, since it cannot be traced to any one single source.

Key Concepts:

Stormwater pollution causes and sources, eco-

Science Process Skills Utilized:

- S:LS3:6:1.2—Explain how changes in environmental conditions can affect the survival of individual organisms and entire species.
- S:LS3:8:1.1—Describe the type of impact certain environmental changes, including deforestation, invasive species, increased erosion, and pollution containing toxic substances could have on local environments.

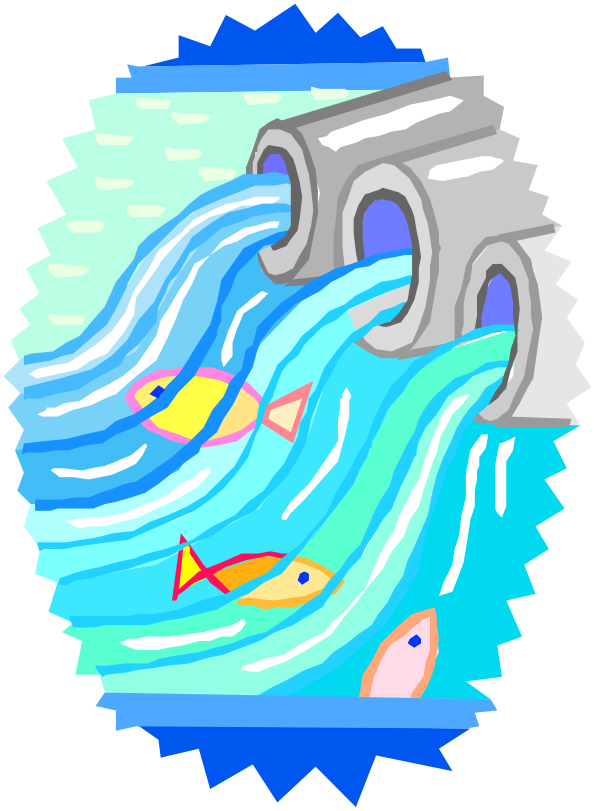
What's in the Water? (continued)

Process and Procedure:

1. Introduce the sponge fish to the class (they may provide a name for the fish, if desired). Let students know that he hatched from an egg in a protected stream in a nature preserve, but is now about to make a journey down to the ocean.
2. Ask for 17 volunteers; distribute script cards, cups containing "pollutants," and food coloring to students. Ask the remaining students to label a piece of paper from 1-9 in order to list a descriptive adjective of the fish or his environment every time a script piece concludes.
3. Have students read the script cards in order, and those with the appropriate ingredients should dump them into the fish jar. Observing students should write down a different adjective every time the question, "How is the Fish?" is read.
5. After all of the ingredients have been dumped in the jar, ask for one final volunteer to lift the fish out of the jar and to discuss the change in his appearance and that of his environment. Ask students to compare their list of adjectives.
6. Recap with students each of the pollutants and their sources. Ask students to think of which pollutants might be common in their area, or others that were not included in the story. Have them think about ways in which these pollutants could be prevented from entering the fish habitat.

Further Assessment:

1. Allow students to pick one or more of the common stormwater pollutants and do research outside of class on where the pollutant comes from, how it can affect water quality, and what individuals can do to help prevent the pollutant from ending up in surface waters.
2. Take a field trip around the school grounds or ask students to survey their own neighborhoods to locate potential stormwater pollutants. Ask students to note the location of storm sewers or surface ditches which would bring pollutants to the local surface water.
3. Allow students to design a stormwater brochure or poster to educate their community about a stormwater pollutant and what to do about it.



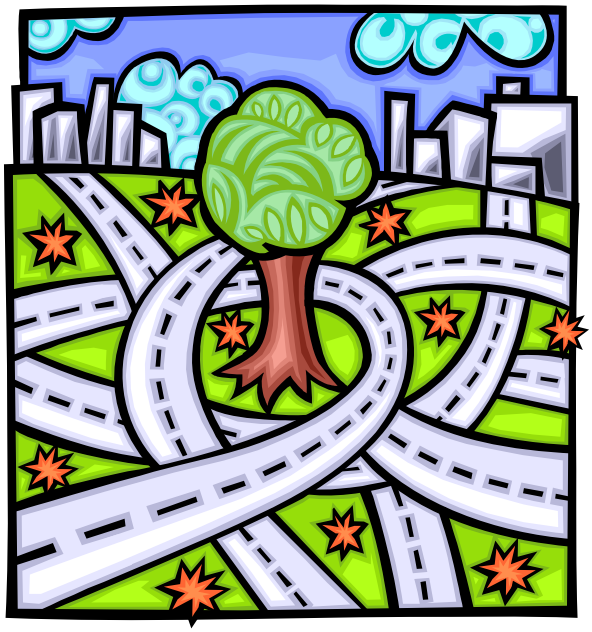
1	2
3	4
5	6
7	8
9	

What's in the Water? Script Sheet

2. The fish swims past a large construction site, where a new mall will be built. There is a lot of loose SOIL where the land has been leveled and cleared. It begins to rain and some of the soil washes into the river. (DUMP soil into the Fish jar.) HOW IS THE FISH?	1. Imagine a clean river as it meanders through a protected natural area. In this river lives our fish. HOW IS THE FISH? He has lived in this stretch of the river all his life. But now he's going on an adventure, traveling downstream.
4. The Fish swims under a highway bridge. Some cars traveling across it are leaking OIL. The rain is washing the OIL into the river below. (POUR syrup into the fish jar.) HOW IS THE FISH?	3. The Fish nears a suburban neighborhood. Some FERTILIZER from the gardens and lawns washed into the river a few months back. (SQUIRT 2 drops green food coloring into jar.) The fertilizer made the plants grow fast and thick, but eventually the plants died and started to decay. The decomposition is using up some of the fish's oxygen. HOW IS THE FISH?
6. The Fish swims past the city park. Some picnickers didn't throw their trash or cigarette butts into the garbage can, instead allowing it to be LITTER. The wind is blowing it into the river. (SPRINKLE paper dots into the jar.) HOW IS THE FISH?	5. During a recent cold spell, ice formed on the bridge. City trucks spread SALT on the road to prevent accidents. The rain is now washing salty slush into the river. (SPRINKLE salt in the jar.) HOW IS THE FISH?
8. Up ahead, a stream joins the river. The fish wants to swim fast through this stretch because he knows that the stream runs along a trail where people don't pick up after their pets, and PET WASTE goes right into the river. PLACE brown sugar into the jar. HOW IS THE FISH?	7. As the fish nears another neighborhood, he sees bubbles floating in the water. They are soap bobbles coming from a storm drain pipe that runs from the neighborhood to the river. Someone in the neighborhood is washing her car in her driveway and the SOAPY WATER is running into the river. POUR warm, soapy water into the jar. HOW IS THE FISH?
	9. Finally, the fish swims past a trash pile, where people have dumped everything from bottles to TVs to paint cans. Much of the trash is HOUSEHOLD HAZARDOUS WASTE that should have gone to the regional collection, so it wouldn't pollute the river or groundwater. SQUEEZE 3 drop red food coloring into the jar. HOW IS THE FISH?

Activity 7: Covered Up

Background: Under natural conditions, when precipitation hits the land surface, it first meets plant materials, a layer of leaf or organic material, or the soil surface itself where it is then infiltrated downward through the soil column into the groundwater system. Precipitation may also fall directly into a stream or waterway where it immediately becomes a part of surface water systems.



Humans have dramatically altered the land surface by constructing roads, parking areas, buildings, and other forms of impervious surfaces. Impervious surfaces are those which do not allow water to infiltrate directly into the land or soil. Impervious surfaces redirect the natural flow of water to other locations. In areas where constructed environments are common, engineers design storm drainage networks to help move water away from impervious surfaces quickly, to keep water from ponding or flooding roadways, yards, or other areas.

Areas that have higher amounts of impervious surface represent areas where the natural flow of water is affected the most. Scientists estimate that water quality begins to deteriorate when the amount of impervious surface in a watershed approaches 15 percent. At this level, enough water is redirected directly to storm sewer systems that the natural process of infiltration, which acts to clean and purify water, is disrupted. In addition, impervious surfaces can be areas where certain pollutants accumulate. Roadways and parking areas often contain large amounts of petroleum products, sediment, debris, litter, and road salts, which are transported directly through the storm sewer system to surface waters.

(Continued on page 20)

Understandings:

- Amount of impervious surface can be an indirect measure of surface water quality.
- Estimating impervious surface for an entire watershed is difficult due to each property being unique and different.

Key Concepts:

Impervious surface; infiltration; purposes, benefits, and problems with storm drainage systems; evaluating aerial photographs, creating a proportional map.

Science Process Skills Utilized:

- S:SPS3:6:2.4—Explore how humans shape and control the environment while creating knowledge and developing new technologies.
- S:LS3:8:1.1—Describe the type of impact certain environmental changes, including deforestation, invasive species, increased erosion, and pollution containing toxic substances could have on local environments.

Covered Up (continued)

(Continued from page 19)

Understanding the amount of impervious surface present in a watershed can be a useful tool for indirectly measuring the health of a stream. This activity has students estimate the impervious surface cover of their school or home property and asks them to draw conclusions about the larger watershed area as a whole.

Materials Needed:

- Graph paper
- Colored pencils, markers, or pens
- Overhead transparency of aerial photo of school property as classroom example: paper copies can also be distributed for students to work along with teacher demonstration.

Process and Procedure:

1. Present students with the definition of an object that is impervious. Ask students to think of examples of items that are pervious and impervious. Explain that objects in the human and natural environment can be thought of as either pervious or impervious to precipitation. Brainstorm a list of impervious objects in the landscape.

2. Explain how impervious surfaces change the flow of water through the landscape and discuss how the storm drain system delivers stormwater much more quickly and with increased pollutant loads to surface waters than water would be delivered under natural conditions. Explain that the more impervious surface present in a watershed, the more likely that water quality will be reduced in surface waters.

3. IN-CLASS ACTIVITY: Present copies of an aerial photograph and/or an overhead transparency of the school to students. Describe the features present so students can orient to the aerial view. Explain that we are going to calculate the amount of impervious surface on the school property as a percentage of the total property area.

   A. outline or lightly shade each of the impervious surface areas shown on the property. Include buildings, parking areas, roadways, sidewalks, etc.
   B. Draw an even grid pattern over the entire school property area at a scale small enough to pro vide meaning, but large enough to make counting squares easy. An ideal grid will have around 100 total squares.
   C. Color-code the squares containing impervious surface.

      - Put a RED DOT in any square completely filled by impervious surface.
      - Put an ORANGE DOT in any square approximately 75% filled by impervious surface.
      - Put a BLUE DOT in any square approximately 50% filled by impervious surface.
      - Put a GREEN DOT in any square containing approximately 25% impervious surface.

   D. Count up the number of squares containing impervious surface and calculate the percentage of the property covered by impervious surface.

      - Number of RED DOT squares
      - Number of ORANGE DOT squares. Multiply this number by .75.
      - Number of BLUE DOT squares. Multiply this number by .5
      - Number of GREEN DOT squares. Multiply this number by .25

(Continued on page 25)

Covered Up (continued)

(Continued from page 20)

E. Add all of the numbers to get the total "squares" of impervious surface. Divide this number by the total number of squares in the whole grid. This equals the properties percent impervious sur face cover.

4. Discuss the amount of impervious surface found on the school property. What does this mean for the amount of water being infiltrated onsite versus leaving the property? What could the school do to reduce the amount of impervious surface?

5. HOMEWORK ACTIVITY: Allow students to map their own properties and calculate the amount of impervious surface on their own properties at home. Allow them to work from aerial photographs (available on Google Earth and other online sites) or to measure and map property features by hand.

   Explain to students that there are different methods they can use to illustrate their own properties They can use an aerial photo and overlay a grid, or they can use actual field measurements of their home property. Field measurement would involve measuring the length of buildings, sidewalks, and other features in relation to the property boundary. Field measurements can also be made by "pacing off" the distances and showing these on graph paper. Ex. One square of the graph paper could equal 1 foot or 1 stepping pace.

   It is important that students remember that regardless of the method they choose to use to depict their home properties, the features pictured must be in proportion to the overall property area.

6. IN-CLASSROOM FOLLOW-UP: Have students list the amount of impervious surface that they calculated for each of their own homes. How do these numbers compare to each other? How do they compare to the school's amount of impervious surface? How are these numbers likely to compare to other development types in the community such as agricultural properties or industrial properties? Discuss ideas on how a person might go about calculating impervious surface for an entire neighborhood or town or the entire watershed? Why might these calculations be difficult or inaccurate? Discuss how the following might affect the overall level of impervious surface in a community or development:

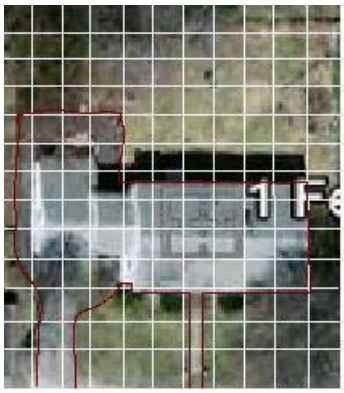
   - single story homes versus two-story homes
   - homes set back far from the street versus close to the street
   - pervious pavements or gravel driveways
   - wood deck area versus concrete patio area

FURTHER ASSESSMENT: Have students research stormwater Low Impact Development techniques that help to reduce the impact that impervious surfaces have on overall development designs. Low Impact Development techniques include use of pervious pavements, rain gardens, rain barrels, green roofs, and bioretention areas. Information can be found online through the US Environmental Protection Agency, University of New Hampshire Stormwater Center, and the Center for Watershed Protection. Allow students to present the Low Impact Development techniques in class, and lead a discussion on how effective or practical these techniques might be in your community.

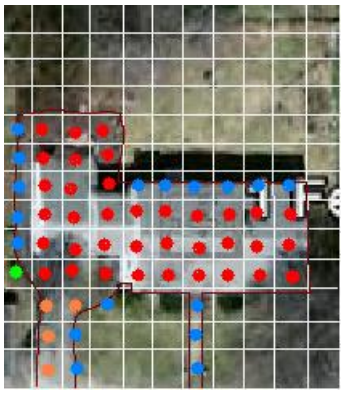
Covered Up (continued)

Sample Property: Calculating Impervious Surface

1. Image copied from Google Earth (into Microsoft Paint for electronic display and manipulation—may instead be printed or put on transparency film for classroom display and discussion). Property boundaries are represented by the edge of the aerial photo.



2. A grid is applied to the photograph (in white), and the impervious surfaces have been outlined (in brown). Note that shadows sometimes make it difficult to interpret where the impervious surface truly ends. Site-specific knowledge will help in accurately determining edges.



3. For each of the grids containing an impervious surface, a colored dot indicating the approximate amount of impervious surface is given. The dots are then counted and cover calculations applied:

Red dots = 36
Orange dots = 4 (x .75) = 3
Blue dots = 17 (x .5) = 8.5
Green dots = 1 (x .25) = .25

After applying the calculation, add up the total = 47.75
Total number of squares in the grid = 143

Percent impervious surface for this property = 47.75/143 = 33.4%

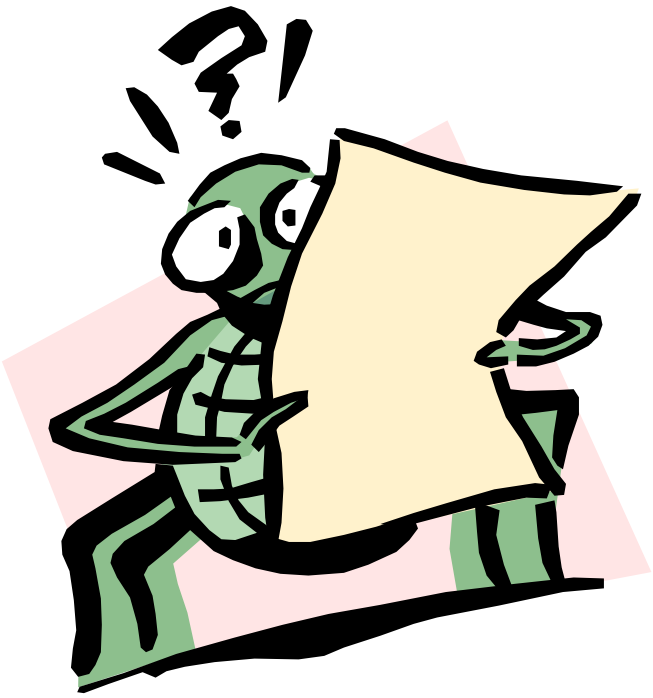
Activity 8: Stream Stroll and Watershed Walk

Background: Streams and water features are connected to their adjacent land uses and parent watershed areas. Understanding the land uses present in a watershed and along the banks of a stream will help in understanding how that stream functions. It is important to realize that what happens elsewhere in the watershed will eventually impact downstream areas.

In this activity, students will walk along a portion of a stream or water body to assess the kinds of impacts that the land uses surrounding the waterbody may be having on it. Teachers may want to divide students into groups and assign them a section of a stream or creek, rather than having the entire class walk along the same portion. Where possible, choose contrasting portions of a stream or creek in a remote and then urban portion of the watershed.

Materials Needed:

- Copies of the Stream Stroll and Watershed Walk surveys
- Camera (if possible)



Preparation:

- Be sure to walk the area to be surveyed and note any dangerous areas, location of private property, etc. Make sure that you have appropriate permissions to allow students to walk on private property. Provide adult chaperones for each group, if possible.
- Brief students both on safety when walking along a stream corridor and "leave no trace" behaviors that will not unduly disturb the area to be surveyed.
- Consider performing *Activity 2 – What is a Watershed?* prior to performing this activity as background / review.

Understandings:

- Real-world observations can help inform understanding of natural systems.
- Surface water quality is influenced directly by land use practices adjacent to the stream and within the larger watershed area.

Key Concepts:

Form and function of stream channel and bank; recognizing environmental conditions; determination of habitat and water quality from field observations.

Science Process Skills Utilized:

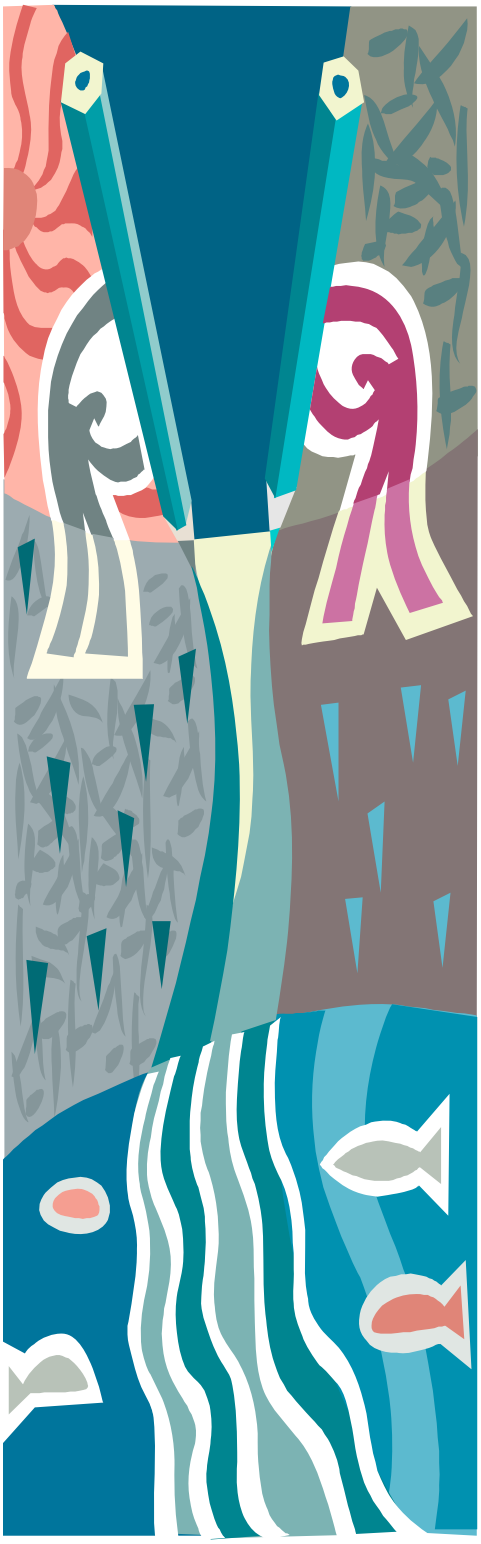
- S:SPS2:6:2.1 – Recognize that thinking about things as systems means looking for how every part relates to others.
- S:LS3:8:1.1 – Describe the type of impact certain environmental changes, including deforestation, invasive species, increased erosion, and pollution containing toxic substances could have on local environments.
- S:SPS3:8:2.4 – Synthesize observations and findings into coherent explanations about natural resources and the environment.
- S:LS3:6:1.1 – Provide examples of how all organisms, including humans, impact their environment; and explain how some changes can be detrimental to other organisms.

Stream Stroll and Watershed Walk (continued)

Process and Procedure:

PART I—STREAM STROLL

1. Discuss the purpose of the Stream Stroll survey with students and divide students into groups. Choose a team scribe for each group who will be responsible for recording observations. Make time limitations clear to students for how much time they will have to complete the survey.
2. Students should walk along the stream noting the land uses on their survey forms. Unique characteristics about each land use should also be recorded such as oil running off parking lots, discharge pipes into the stream, and debris or litter. In addition, stream characteristics should be recorded, such as eroding banks, lack of vegetation, channelized or dammed areas.
3. After returning to the classroom, discuss group findings:
   - What land uses were present?
   - Are there areas with little or no signs of human impact?
   - Were there any signs of wildlife or wildlife sightings?
   - Was there anything unexpected or unusual?
   - List and rank pollution problems form least to most impact. How do they impact you and me? Does the pollution impact other living things? Could the source of the pollution be identified? How might these problems be prevented?
   - Were there areas that might be impacted by future development activities that are not yet present (shopping malls, golf courses, residential neighborhoods, etc.)?



PART II—WATERSHED WALK

1. Distribute watershed survey as homework. Encourage students to conduct the survey with a partner or parent, relative, or friend. Discuss the survey and the types of observations they should be making during their walk.
2. Students should complete the survey at home by investigating the area around their home and by walking through their neighborhoods. Students should record land uses (gas stations, shopping areas, green spaces) and any unique characteristics about each (excess fertilizer on sidewalks, leaking vehicles, prominent pet waste, etc.)
3. When students have finished assignment, discuss findings as a class. Compare the Watershed Walk findings to the Stream Stroll information.
   - What land uses were present?

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Stream Stroll and Watershed Walk (continued)

(Continued from page 24)

- Are there areas with little or no signs of human impact?
- Were there any signs of wildlife or wildlife sightings?
- Was there anything unexpected or unusual?
- List and rank pollution problems form least to most impact. How do they impact you and me? Does the pollution impact other living things? Could the source of the pollution be identified? How might these problems be prevented?

Further Assessment:

1. Ask students to list potential pollution sources around their homes and behaviors they could take to reduce or prevent pollution.
2. Have students imagine that they were responsible for the management of the section of the water body surveyed. Have them develop a management plan that would protect water quality. Encourage students to develop chapters specific uses such as residential, agricultural, commercial, and natural areas.

Stream Stroll Survey

DESCRIBE THE STREAM:

1. Does the stream flow in a straight line or does it curve?	2. Is the stream channel natural? Was it changed by people? How?	What is on the bottom of the stream?
4a. What color is the water?	4b. Can you see any pollution which might have altered the water color?	5. Are there any unusual smells (oil, sewage, sulfur, etc.) coming from the stream?
6. Do you see trash in the stream? Describe:	7. Are there any other observations you think should be noted?	

DESCRIBE THE LAND USES:

1. Do you see any of the following?
2. If you see any pipes along the stream bank, where might the pipes be coming from and what do you think they carry? Describe any discharge, if there is any.

_____ roads	_____ houses	_____ apartments	_____ trash dump
_____ farms	_____ shopping area	_____ golf courses	_____ farm
_____ effluent pipes	_____ storm drains	_____ sewer	_____ parking lot
_____ natural areas	_____ vacant lots	_____ school	

DESCRIBE THE WILDLIFE:

1. Describe the animals, birds, or other wildlife you see.

2. Do you see any signs of animals (tracks, nests, droppings, etc.) Describe what you see.

3. Do you see fish in the stream? Do you know what kinds of fish live in the stream?

SKETCH THE STREAM: On the back of this sheet, sketch your survey section of the stream. Include streets or other landmarks, land uses along the stream, locations of pollution, wildlife, and other important findings.

Watershed Walk Report

Answer these questions in a notebook or in the space provided.
Be sure to record your observations as well as thoughts or questions you might have.

1. Is most of the land around you open space, or is it developed for people?	2. What is any open space used for? (Parks, lawns, vacant lots, farms, etc.)?
3. What is the main type of vegetation on open land?	4. Do you see many surfaces covered by concrete or asphalt?
5. What is the developed land used for?	6. Where does rain go when it falls? Are there many areas where rainwater can soak into soil or would most of it run on paved areas?
7. Do you see storm drains? Where does the water go after it enters the storm drain?	8. Are rooftops flat or sloped? Where does water flow from rooftops? Where do gutters or downspout lead?
9. Do you see manhole covers in the street or sidewalk? What do manhole covers say on top?	10. Do you see tributary streams, creeks, or ditches? Where do they flow? What condition are they in?
11. Do you see trash in the streets? What happens to trash when it rains?	12. Do you see any hazardous wastes or illegal dumping areas where people have disposed illegally of unsafe materials?

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Curriculum Glossary

Aquifer—an underground bed of saturated soil or rock that yields significant quantities of water.

Aquatic Life—all the life forms living in water including invertebrates, fish, and plants.

Attitude— a feeling or emotion towards a fact or idea.

Behavior—the way in which a person functions, operates, or conducts oneself.

Bias—type of error introduced into sampling or testing by selecting or encouraging one outcome or answer over others.

Contour Lines—lines on maps that pass through points of the same elevation.

Discharge—an outflow of water from a stream, pipe, groundwater system, or watershed.

Ecosystem—the biotic community (living organisms) and its abiotic environment (non-living factors) functioning as one system.

Elevation—the distance, measured in feet or meters, above sea level that a specific point lies. Contour lines indicate elevation.

Erosion—the wearing down or washing away of soil or land surface by the action of wind, water, or ice.

Eutrophication—the process by which a body of water becomes rich in dissolved nutrients.

Fertilizer—any substance used to add nutrients to the soil and thereby make it more fertile. Fertilizers may be either organic or chemical.

Groundwater—water found in spaces between soil particles underground and located within the Zone of Saturation.

Habitat—the water, shelter, food, and space an organism needs to live.

Herbicide—an agent used to inhibit or destroy plant growth.

Impervious surface— A surface that does not contain significant space between particles to allow water to travel through the surface.

Insecticide—an agent that destroys insects.

Landform—a natural feature of a land surface such as a hill, valley, cliff, or canyon.

Nonpoint Source Pollution—widespread overland runoff containing pollutants; the contamination does

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Curriculum Glossary

(Continued from page 29)
not originate from one specific location and discharges over a wide land area.

Nutrient—an element or compound such as nitrogen, phosphorous, and potassium, that is necessary for plant growth.

Pervious surface—A surface containing cracks, holes, spaces, or pores that allows water to flow through the surface.

Pesticide—any chemical or biological agent that kills plant or animal pests; herbicides, insecticides, fungicides, rodenticides, etc. are all types of pesticides.

Point Source Pollution—pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers.

Pollution—the alteration of the physical, chemical, or biological properties of water by the introduction of any substance that renders the water harmful for a particular use.

Precipitation—water falling in a liquid or solid state from the atmosphere to Earth.

Recharge—water from rain and snowmelt that runs into aquifers.

Runoff—precipitation that flows overland to surface streams, rivers, or lakes.

Storm drain (or storm sewer) - constructed opening in a road system through which runoff from a surface flows into a lake or stream.

Stormwater—water from rain or snowmelt.

Surface water—water above the surface of the land, including lakes, rivers, streams, ponds, floodwater, and runoff.

Topographic map—a map that uses contour lines and symbols to represent the manmade and natural features of the mapped area.

Toxic substance—poisonous waste or chemical that can harm living organisms.

Urban—of, relating to, or characteristic of a city.

Watershed—the land area from which surface runoff drains into a stream, lake, reservoir, or other waterbody. Also called a drainage basin.

Science Process Skills Index

Where Provided:	Science Strands and Expectations:
	SPS1– Scientific Inquiry and Critical Thinking Skills (INQ)
Activity 4	S:SPS1:6:1.2 Plan observations based on a given purpose.
Activity 4	S:SPS1:6:1.3 Identify and investigate similarities and differences among observations and sets of observations.
Activity 5	S:SPS1:6:1.8 Ask questions about relationships between and among observations.
	SPS2– Unifying Concepts of Science
Activity 8	S:SPS2:6:2.1 Recognize that thinking about things as systems means looking for how every part relates to others.
Activity 1	S:SPS2:8:2.1 Understand that any system is usually connected to other systems, both internally and externally; thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.
Activity 1	S:SPS2:6:2.3 Estimate or predict the effect that making a change in one part of the system will have on other parts, and on the system as a whole.
	SPS3– Personal, Social, and Technological Perspectives
Activity 4 and 5	S:SPS3:8:1.2 Work collectively within a group toward a common goal.
Activity 3	S:SPS3:6:2.1 Develop, focus and explain questions about the environment and do environmental investigations.
Activity 7	S:SPS3:6:2.4 Explore how humans shape and control the environment while creating knowledge and developing new technologies.
Activity 8	S:SPS3:8:2.4 Synthesize observations and findings into coherent explanations about natural resources and the environment.
Activity 3	S:SPS3:6:3.1 Identify problems/issues that can be addressed by design technology.
Activity 3	S:SPS3:8:3.1 Design a product or solution to a problem.
	SPS4– Science Skills for Information, Communication and Media Literacy
Activity 3	S:SPS4:8:1.1 Use a variety of information access tools to locate, gather, and organize potential sources of scientific information to answer questions.
Activity 4	S:SPS4:8:1.2 Collect real-time observations and data, synthesizing and building upon existing information (e.g., online databases, NOAA, EPA, USGS) to solve problems.
Activity 5	S:SPS4:8:1.3 Use appropriate tools to analyze and synthesize information (e.g., diagrams, flow charts, frequency tables, bar graphs, line graphs, stem-and-leaf plots) to draw conclusions and implications based on investigations of an issue or question.
Activity 2	S:SPS4:8:3.3 Make sketches, graphs, and diagrams to explain ideas and to demonstrate the interconnections between systems.
Activity 1	S:SPS4:8:7.1 Keep a journal of observations and investigations, and periodically evaluate entries to assess progress toward achieving the understanding of key ideas.

Science Process Skills Index (continued)

ESS1– The Earth and Earth materials

Activity 2 S:ESS1:8:7.1 Describe how water flows into and through a watershed, falling on the land, collecting in rivers and lakes, soil, and porous layers of rock, until much of it flows back into the ocean.

LS3– Groups of organisms show evidence of change over time

Activity 8 S:LS3:6:1.1 Provide examples of how all organisms, including humans, impact their environment; and explain how some changes can be detrimental to
Activity 6 other organisms.
S:LS3:6:1.2 Explain how changes in environmental conditions can affect the
Activity 6, 7, 8 survival of individual organisms and the entire species.
S:LS3:8:1.1 Describe the type of impact certain environmental changes, including deforestation, invasive species, increased erosion, and pollution containing toxic substances, could have on local environments.

LS4– Humans are similar to other species in many ways, and yet are unique among Earth's life forms

Activity 4 S:LS4:6:1.3 Provide examples of how humans make judgments about new situations based on memories of past experiences.

Activity 5 S:LS4:8:1.3 Explain how all behavior is affected by both inheritance and experience.

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