This curriculum was developed to meet the Education component of the National Pollution Discharge Elimination System (NPDES) Phase II Storm Water Regulations.
Developed by the Hamilton County Soil and Water Conservation District.
Funding was provided by the Hamilton County Storm Water District.

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www.hcswcd.org

HAMILTON COUNTY
Storm Water District

HAMILTON COUNTY
soil and water
CONSERVATION
DISTRICT

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Acknowledgements

This curriculum would not have been possible if not for the generous donation of activities from local, national and even international sources. These activities were selected based on their high quality content, teacher friendly use and applicability to nonpoint source pollution. Each activity references the original organization in the activity information box with a full reference at the end of the curriculum. Following is a list of all the contributors. The Hamilton County Storm Water District is tremendously grateful for their creativity and generosity.

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Maine Department of Environmental Protection
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Ontario Nature- Federation of Ontario Naturalists
Project Wet
Salt Lake County Storm Water Quality
Texas Commission of Environmental Quality
United States Environmental Protection Agency
United States Geological Survey
Water Resource Center, University of Wisconsin

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Bruce Koehler, Senior Environmental Planner, OKI Regional Council of Governments
Dan Hawblitzel, Meteorologist, National Weather Service, Wilmington

Concept and edit of the curriculum was performed by Gwen Z. Roth and Holly Utrata-Halcomb (HCSWCD). Michelle Balz (HCSWCD) developed the curriculum, gathered and edited activities and compiled background information.

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How to Use this Curriculum

This curriculum is divided into six sections: Watersheds, Nonpoint Source Pollution, Urban, Rural, Effects and Action. Each section is intended to build on the previous section; however, almost all activities can be completed independently of the section and even the curriculum. Within each section there are generally two to four activities for each grade level group. The grade levels have been grouped as kindergarten through second (K-2), third through fifth (3-5), sixth through eighth (6-8) and ninth through twelfth (9-12).

The format of the curriculum is straightforward. At the beginning of each section there are a few pages of background information covering the basis for the activities in this section. The background section introduces vocabulary words and covers basic concepts critical for effectively teaching the activities. Although this part is intended for the teacher's knowledge there are many maps, graphs or images you may want to share with the students. The background sections end with a concise table describing each activity to follow.

Grade Level
Recommended grade levels
Ohio Academic Content Standards
Correlating standards
Subject
Associated academic subjects
Time
Duration of activity from start to finish
Materials
List of materials needed to complete the activity
Setting
Recommended setting for the activity to take place
Terms
Key vocabulary words
Reference
Source of the activity

At the beginning of each activity there is a title box containing the title of the activity and a box on the left that gives you all the information needed to decide if the activity is appropriate for your class. This information box contains the recommended grade levels, correlations to Ohio Academic Content Standards, academic subjects associated with the activity, approximate time the activity will take, materials needed to complete the activity, setting in which the activity should take place, terms covered in the activity and reference to the source of the activity.

The activity itself will be divided into sections starting with a brief *Summary* and the *Objective* of the activity. Next the *Procedure* section will have an *advanced preparation* and *warm up* paragraph if necessary. The steps of the *activity* are numbered preceding the *follow up* questions or discussion. Many activities also include an *Extension* section that suggests further activities and investigations for your students.

If the activity requires the use of any student sheets they will follow directly after the activity. A small copy symbol will appear in the upper right hand corner of pages intended to be copied.

After the six-activity sections there are two curriculum-correlation tables. The first table correlates Ohio Academic Content Standards with each activity in the curriculum. Similarly, the second table correlates school subjects with each activity. Following the tables is a list of resources you will find helpful for further information. Finally, a glossary defines all of the key terms mentioned in the curriculum.

Nonpoint Source Pollution, OEPA NPDES Phase II Storm Water Program and the Hamilton County Storm Water District

This curriculum is part of a countywide effort to raise awareness about nonpoint source (NPS) pollution. Nonpoint source pollution is the pollution from our yards, streets, construction sites and agricultural fields that is picked up by storm water runoff and carried into streams, rivers and groundwater. NPS pollution is now responsible for over half of the poor water quality in the United States. Pesticides, fertilizers, sediment, pet waste, automotive fluids and litter are a few of the common nonpoint source pollutants. Polluted storm water can be unhealthy for humans and wildlife alike. It can lead to fish kills, destruction of wildlife habitat, impaired recreational areas, loss of aesthetic value and contaminated drinking water resources.

Since the enactment of the original Clean Water Act by Congress in 1972, local and state governments have worked with industries and wastewater treatment plants to reduce pollution loads, thus improving the quality of receiving streams. Industries and wastewater treatment plants produce point source pollution or pollution that empties into a stream and can be traced back to a single identifiable source. As these end-of-pipe pollution sources improved, however, it became apparent that other types of pollutants were having significant impact on the quality of waterways. These nonpoint pollution sources include agricultural runoff (e.g., sediment, fertilizers, pesticides), urban runoff, stream channelization, mining, land disposal and construction site runoff. To address NPS pollution, the United States Environmental Protection Agency (USEPA) initiated the National Pollution Discharge Elimination System (NPDES), Phase I and Phase II, storm water programs.

In response to the NPDES Phase II requirements of the Clean Water Act the Hamilton County Commissioners established a Storm Water District to address the Phase II regulations on a countywide basis. To date, forty-three (43) of the forty-nine (49) jurisdictions in Hamilton County have joined the district. The district was established to provide to continuity in water quality regulations as well as for the economic benefits to members.

The Hamilton County Engineer administers the overall management of the Storm Water District. The Hamilton County Soil and Water Conservation District, the Department of Public Works, the Metropolitan Sewer District, and the General Health District conduct various aspects of the Phase II program in partnership with member jurisdictions. Members of the Storm Water District have an opportunity to provide input at monthly Oversight Board meetings.

The Hamilton County Storm Water District has several major functions which correlate with the six minimum controls of the NPDES Phase II regulations:

1. **Public Information & Education**
   Develop brochures, create a web-based library of educational materials on storm water, present information to community groups, adopt or prepare K-12 educational materials and issue press releases.
2. **Public Involvement & Participation**
   Establish hotline and complaint database, form a storm water advisory group, coordinate and finance storm drain labeling and watershed signage and support local watershed groups.
3. **Illicit Discharge Detection**
   Prepare county wide map of storm water outfalls/discharge points, enact illicit discharge ordinance and implement a spill detection and reduction plan, prepare a septic system management plan, perform dry weather screening of storm sewers and train local government employees.
4. **Construction Site Runoff Control**
   Develop and enforce erosion and sediment control ordinances including site plan review and inspection on land disturbance of one acre or greater area, train local government employees and implement Best Management Practices (BMPs) manual.
5. **Post Construction Runoff Control**
   Prepare sensitive areas plan and develop ordinances for riparian corridor protection. Implement, inspect and maintain structural and non-structural BMPs.
6. **Pollution Prevention and Good Housekeeping**
   Assist local governments in the development of a maintenance and chemical handling plan to then serve as a model for private industry.

The Hamilton County Soil and Water Conservation District (HCSWCD) is involved in three of these six controls. Developing this curriculum and presenting educational programs about nonpoint source pollution in schools and to community groups function under the first control "Public Information and Education." Under "Public Involvement and Participation" HCSWCD coordinates storm drain labeling events and watershed signage throughout Hamilton County. The HCSWCD's Earthwork Program serves to reduce construction site runoff in the fourth control by visiting construction sites that fit certain qualifications and recommending erosion control practices.

For more information about the Hamilton County Storm Water District please visit http://www.hamilton-co.org/stormwater/, call (513) 946-4250, or write to:

Hamilton County Storm Water District
County Administration Building, Room 700
138 East Court Street
Cincinnati, Ohio 45202

To report storm water pollution, please call (513) 946-7000

Hamilton County Resources, A Brief Overview

Hamilton County is in the southwestern corner of Ohio, along the Kentucky and Indiana borders. It occupies about 413 square miles, or 265,152 acres. Cincinnati, the county seat, is in the south-central part of the county, along the Ohio River. In 1970 the population of the county was 924,018, making it the second most populous county in the state. In 2005, the population fell to 814,611.

The landscape is characterized by wide terraces and flood plains, steep hillsides along the major rivers and tributary stream valleys and gently rolling glacial till plains. More than ¾ of the county has been converted from agricultural and forestry uses to urban uses. The dominant urban use is residential development. The dominant industries in the area manufacture machine tools, jet engines, automobiles and soap and detergents. Urbanization is increasing, particularly in the areas near the interstate highways and is resulting in pressure for the development of flood plains and steep hillsides, where flooding and landslide are severe hazards. The Hamilton County Earthwork Regulations were implemented in 1990 to safeguard hillside stability and control sediment and erosion.

The remaining agricultural areas are in the valleys of the Great Miami, Whitewater and Little Miami Rivers. The soils in these valleys are fertile; and good yields of corn, soybeans, wheat, hay and garden vegetables are common. Flooding generally does not occur during the normal growing season of those crops.

Climate (Dan Hawblitzel, Meteorologist, National Weather Service, Wilmington)

Hamilton County is cold in winter but quite hot in summer. Winter precipitation, frequently snow, results in a good accumulation of soil moisture by spring which minimizes drought during summer on most soils. There are 99 different soil types in Hamilton County. Normal annual precipitation is adequate for all crops that are adapted to the temperature and length of growing season in the area.

In winter the average temperature is 32.8 degrees F in Cincinnati and the average daily minimum temperature is 24 degrees. The lowest temperature on record, which occurred in Cincinnati on January 18, 1977, is -25 degrees F. In summer the average temperature is 74.2 degrees and the average daily maximum temperature is about 85 degrees. The highest recorded temperature, which occurred in Cincinnati on July 29, 1952, is 101 degrees.

The total annual precipitation is 41.33 inches. Of this, 21 inches, or 50.8 percent, usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 18 inches. The heaviest 1-day rainfall during the period of record was 5.21 inches in Cincinnati on March 9, 1964. Thunderstorms occur about 45 days each year, and most occur in summer.

Average seasonal snowfall is about 23.1 inches. The greatest snow depth at any one time during the period of record was 12 inches in Cincinnati in 1974. On an average

of 15 winter days, at least 1 inch of snow is on the ground. The number of days varies greatly from year to year.

The average relative humidity is midafternoon is about 60 percent. Humidity is higher at night and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible in the summer and 40 percent of the time in the winter. The prevailing wind is from the south-southwest. Average windspeed is highest, 11 miles per hour, in winter.

Occasionally, tornadoes and severe thunderstorms strike the area. These storms usually are local and of short duration. The pattern of damage caused by these storms is variable.

Physiography

Hamilton County lies in the Till Plains section of the Central Lowland physiographic province. This province is characterized by structural and sedimentary basins, domes and arches which came into existence throughout Paleozoic time. Among these features, the Cincinnati geoanticline, or "Cincinnati arch," is structurally significant in southwestern Ohio. Hamilton County is almost at the crest of this arch. The axis of the arch is only several miles east of the metropolitan area. The bedrock underlying the county is shale and fossiliferous limestone of Middle and Late Ordivician age, the oldest in Ohio. It outcrops on steep valley walls and at numerous waterfalls. In other areas it is overlain by glacial deposits that range in thickness to as much as 400 feet.

The county is part of an upland plain rising some 960 feet above sea level. All of the county drains into the Ohio River and its tributaries, mainly the Great Miami River, Little Miami River and the Mill Creek. The Ohio River crosses the area in a valley some 500 feet below the general level of the plain.

The main local physiographic features are gently rolling glacial uplands, steep hillsides along the major streams, extensive glacial river terraces and outwash plains and flood plains. Near the larger streams the land is hilly, made so by numerous tributary stream valleys that vary greatly in length; some are 10 miles or more in length, and some are mere ravines. As a rule, there is little flat upland between these smaller valleys. Back a few miles from the larger streams, the tributary valleys are not so numerous and not so deep and there are broad, rolling uplands such as those at Mt. Healthy and Blue Ash.

Because of the almost horizontal altitude of the underlying bedrock, no local surface feature is outstanding. The most striking feature is the breadth of the Miami and Whitewater River Valleys considering the size of their streams. These valleys are broad, flat bottomed depressions flanked on either side by relatively steep bluffs rising 200 to 500 feet above the general level of the valley floor. The valley floors are low enough to be subject to floods and are covered by a thin veneer of recent alluvium. These broad valleys are the remnants of valleys that existed prior to Pleistocene glaciation and were partly filled with glacial drift. In some places the present stream follows the course of the ancient stream, but at a much higher elevation.

Preglacial drainage

Geological evidence indicates that there were three major preglacial streams in the area. The present primary stream, the Ohio River, headed at Manchester and from the east flowed northward through part of what is now the Little Miami Valley to the vicinity of Red Bank, and thence it flowed generally westward across the Norwood Trough to about Elmwood Place. There it merged with the Licking River, which entered the area

from the south, and together these streams flowed northward through the present basin of the Mill Creek Valley to a junction with the Great Miami River south of Hamilton. From this point, the main stream took a northeasterly course up the Great Miami River Valley, where it joined the Teays, a large preglacial river flowing northwestward across Ohio.

Following glaciation and the blocking of the old channel south of the Norwood Trough by ice and glacial deposits, the Ohio River cut a new course following generally its present alignment. The old abandoned waterway in the Mill Creek Valley became a relatively small stream and reversed its direction southward into the present Ohio River.

Glaciation

Pleistocene glacial invasions preceded and followed by stream erosion provided the county with its rolling, hilly terrain. Water flowing southward from the melting and retreating glaciers carried debris from glacial moraines and filled the ancient valleys and relocated riverbeds. This debris, which we call glacial outwash, consisted of sand, silt, gravel, cobbles and boulders. The retreating glaciers also dropped onto the rock base large deposits of ground-up rock and soil material, which we call glacial till. Stream erosion dissected the unconsolidated glacial deposits, producing gently undulating surfaces and exposing, in places, the alternating layers of gently dipping soft shales and limestones.

At least three continental glaciers-the Kansan, the Illnoian and the Wisconsian-invaded the county. The occurrence of these glaciers is manifested by three tills. The oldest till is probably Kansan in age, and the next oldest is Illinoian. The youngest of the three tills was deposited during the Tazewell or Iowan substage of the Wisconsinan stage.

Mineral resources

Sand and gravel deposits important for the construction industry are the predominant mineral resources extracted currently in the county. Principal deposits are along the Great Miami and Whitewater Rivers, in Mill Creek Valley and along the Little Miami River, particularly east of Newtown. Hamilton County is ranked second in the state for the mining of sand and gravel. Although not presently extracted on a large scale, limestone, clay and molding sand can be produced in limited areas of the county.

Water Supply

The main source of water for Hamilton County and the City of Cincinnati is the Ohio River. Over 100 million gallons is taken daily from the Ohio River by means of a submerged intake crib near the Kentucky shore opposite the suburb of California, serving 88% of Greater Cincinnati Water Works customers. An additional 15 million gallons per day, serving 12% of Greater Cincinnati Water Works customers is pumped from the Miami Valley aquifer by 10 wells averaging 120 feet in depth. These wells, at the Bolton plant in Fairfield, furnish water to the areas of Colerain Township, Forest Park, Pleasant Run, New Burlington and Mt. Healthy.

The Cincinnati Water Works, owned and operated by the City of Cincinnati, serves 23 municipalities and villages and most of the unincorporated area of the county. It also serves part of Butler County and part of Warren County.

The preglacial river valleys, which are filled with glacial drift to a depth of 200 to 400 feet, are an important source of ground water. The glacial drift consists of intermittent layers of sand, gravel, silt and clay. Most of this water-sorted and stratified drift is permeable.

Before pumpage, these aquifers were filled and there were many artesian wells. Heavy pumpage of some of the reservoirs, such as the Norwood Trough and the Mill Creek Basin, has substantially lowered the water table. Cincinnati and industries in the area now secure water from the Miami River Basin in Butler County. There is presently little pumpage in the Lower Miami Valley or in the Whitewater Valley. These areas are potentially significant sources of ground water. They also are potentially important for energy conservation. Heat pumps utilizing the heat contained in ground water are proving to be more reliable and efficient than air-to-air heat pumps.

The aquifers are recharged by precipitation and by floodwaters of streams traversing these glacial deposits. Preservation of the flood plains is therefore a requirement of an adequate ground water supply. In this urbanizing county, however, where the choicest land was developed years ago, pressure to develop flood plains increases every year.

The water supply in bedrock is very small. The dominant rocks in the area are the Ordovician shale and the interbedded limestone. The clay shale is very impermeable. The interbedded limestone is fossiliferous and dense, lacking much pore space for water storage. This formation generally does not supply enough water even for domestic use.

Land use

In 2001, only about 2% of the county's total area of 265,152 acres was used for traditional agriculture. Most of the remaining land is dominated by urban and residential development. A small percent of the county is undeveloped woodland because of the severity of topography. That information was gathered in a survey by the Ohio-Kentucky-Indiana Regional Council of Governments.

The urbanized area extends outward from the core of Cincinnati, along major transportation arteries. The central part of the county, running north to south through the Mill Creek Valley, is entirely urbanized. The pattern of urban development in Hamilton County has been influenced greatly by the major transportation routes as well as sources of water and their flood plains and valley floors were easily developed by early technology. They determined the location of land transportation routes, which affected subsequent urban development.

Transportation

Four interstate roads serve the county. Cincinnati is linked to Cleveland and Louisville via I-71, to Indianapolis and Chicago via I-74, and to Northern Michigan and Southern Florida via I-75. The I-275 circle freeway encompasses the Tri-state metropolitan area.

Commercial air service to Cincinnati (Hamilton County) is provided by Greater Cincinnati, Northern Kentucky International Airport, located in Boone County, Kentucky, some 13 miles from downtown Cincinnati. Seven major airlines provide daily flights between Cincinnati and 140 major cities. Two airports for private craft are located in Hamilton County.

Farming

Most of the farming in Hamilton County is west of the Great Miami River. Some row crops and specialty crops are grown in the Little Miami Valley.

In 2003, Hamilton County had 400 farms and 32,000 acres of farmland. The average farm size was 80 acres. The relative importance of the eight major farm commodities, by percent of cash receipts, was as follows: greenhouse and nursery

products, 58 percent; vegetables, 8 percent; corn, 7 percent, dairy products, 6 percent, soybeans, 6 percent, cattle, 5 percent, other livestock, 3 percent, and fruit, 2 percent (4). Today, Hamilton County ranks third among Ohio counties for total cash receipts from greenhouses and nurseries.

Hamilton County Water Resources, A Brief Overview

Hamilton County is situated in the extreme southwestern corner of the State of Ohio and covers an area of 413 square miles. In 2005, the population of Hamilton County was 814,611 people. Within the County are 49 political jurisdictions, including 21 cities, 16 villages and 12 townships. Forty-four of the political jurisdictions belong to the Hamilton County Storm Water District (for more information see the previous section).

There are four major watersheds within Hamilton County not including the Ohio River Watershed, which encompasses the entire area. The Great Miami, Little Miami, Mill Creek and Whitewater watersheds make up the majority of the county. A Hamilton County Watershed Map is provided in the Resources section at the end of the curriculum. These watersheds, of course, correspond to the major rivers in Hamilton County and Table One summarizes the total length of all the streams and the size of their drainage basins. The Ohio River is 981 miles long and drains 203,940 square miles (see map in *Resources* section at end of curriculum).

	Total Stream Length	*Hamilton County Stream Length*	*Total Drainage Basin*
Great Miami River	170.3 miles	27 miles	5,702 square miles
Whitewater River	90 miles	7.3 miles	1,765 square miles
Little Miami River	105.5 miles	23.9 miles	1,757 square miles
Mill Creek	28.1 miles	20 miles	166 square miles

Table One: Hamilton County Stream Lengths
Source: Gazetteer of Ohio Streams, ODNR Division of Water, Second Edition, August 2001

Although there is no naturally occurring lake in Hamilton County there are three major manmade lakes, which are all part of the Hamilton County Park District. The largest lake by far is Winton Woods Lake covering 188 surface acres followed by Miami Whitewater Lake covering 85 surface acres and Sharon Lake covering 36 surface acres. Hundreds of manmade ponds also exist throughout the county. The majority were built with the assistance of the Hamilton County Soil and Water Conservation District and the Natural Resources Conservation Service.

The majority of Hamilton County residents receive drinking water from the Greater Cincinnati Water Works although there are a few smaller water works

Sharon Woods Lake
Courtesy of Hamilton County Park District

operating in the County. Those residents in the southern and eastern sections of the county, approximately 82% of county residents, derive water from the Ohio River. Those residents in the northwestern region of the county, approximately 18% of county residents, primarily derive drinking water from the groundwater source of the Great Miami Aquifer.

The overall water quality in Hamilton County has improved immensely since the enforcement of the Clean Water Act of 1972, however, according to the Ohio Environmental Protection Agency (OEPA) most water in the county does not meet aquatic life standards. The OEPA uses both biological and chemical criteria to evaluate water quality.

The water resources in Hamilton County are plentiful with many rivers, lakes and aquifers. Some of our resources have suffered very little impact of pollution while others are in need of great attention and clean up. The lessons provided here are one step to educating the citizens of Hamilton County on the importance of preserving and protecting our water resources.

For more information about the water quality of the Great Miami River, the Mill Creek and the Little Miami River, please see the maps in the *Resources* section of this curriculum.

Section One

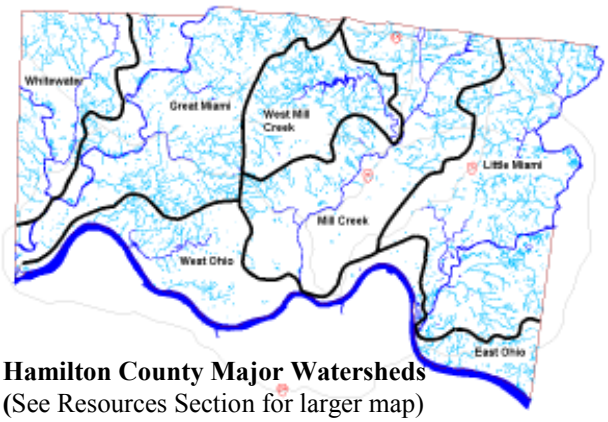
Watersheds

This section will give you and your students the basic concepts needed to appreciate what watersheds are and how they work. Watersheds are one of the fundamental principles behind nonpoint source pollution and essential to understanding how the activities of individuals and communities can affect the environment on a large scale. For older students this section offers the chance to study topographic maps and recognize how development influences a watershed over time.

Waterwhats?

Regardless of where you are in the world everyone lives in a watershed. Water is always trying to flow downhill towards the sea. (Gravity at work!) Pick any body of water (e.g., lake, river, stream, wetland or ocean) and all the land that contributes water to that body is called its *drainage basin* or *watershed*. A **watershed** is an area of land that drains into a body of water. Watersheds are like funnels; they drain an area of land into a common collection site. A low rise, a crest of a hill or a mountain chain separates one watershed from another. Rain or snow that falls on opposite sides of the hill or mountain causes water to flow into two different watersheds. One well-known example of this is the **Continental Divide**, separating the Pacific Ocean Watershed form the Atlantic Ocean Watershed.

Hamilton County residents are all within the Ohio River Watershed, yet they are also in many other, smaller drainage basins. Like nesting dolls, small watersheds are part of larger watersheds, which in turn are part of even larger watersheds. Depending on your location in Hamilton County you could also be in the Great Miami, Little Miami, Whitewater, Mill Creek or Ohio River watershed. Each smaller area of land could drain to a nearby creek or stream and you could be in that watershed as well! Everyone in the Ohio River Watershed is also considered to be within the Mississippi River Watershed and the Atlantic Ocean Watershed.



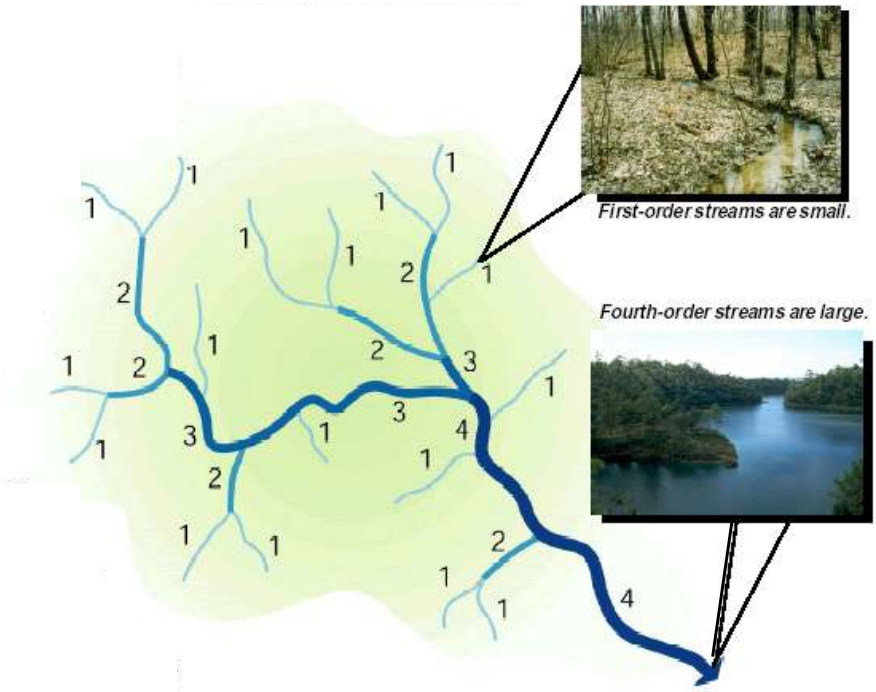
Hamilton County Major Watersheds
(See Resources Section for larger map)

Stream Systems

Hydrologists have devised a system for classifying the position of streams in a watershed. The uppermost channels with no tributaries are designated first-order streams. A second order stream is formed when two first order streams join. Similarly, third-order streams are created when two second-order streams meet. All the streams in the watershed form a network (see picture on next page). To help keep everything organized, the U.S. Geological Survey developed a system to keep track of all the different scales of watersheds. There are four basic sizes of watersheds in their system. The largest are

known as the *major river basins* and include the Rio Grande River Basin in the Southwest and the Ohio River Basin in the Midwest. The smallest watersheds defined in the USGS watershed classification system are called *catalog units*. Generally, the catalog unit size is the most focused on size of watershed. Most catalog units are named after the river that flows through them.

Not all watersheds are the same. Some watersheds are hilly, while others are flat plains. In all cases, precipitation that falls on the watershed flows over land to reach the lowest point, a body of water: a lake, river, wetland, ocean or stream. As water flows over land, it picks up soil, chemicals and other pollutants and carries them to the body of water. This water transportation system is called runoff. Water runoff, whether from urban areas or agricultural fields, is considered to be potential nonpoint source pollution, which will be discussed extensively in the next section.



Streams are ordered according to their position in the watershed. The smallest streams have a "1" and are called "first-order" streams.

Watershed Science

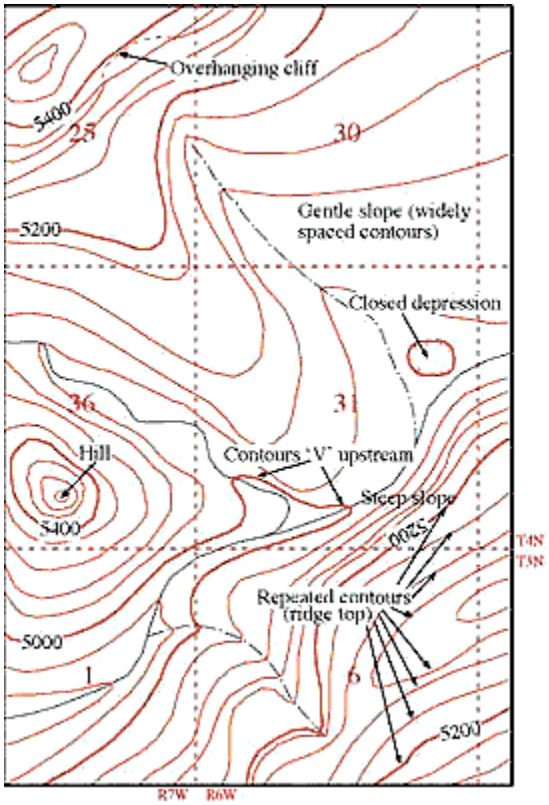
Resource managers and policy makers use maps to monitor land use changes that could contribute to increased amounts of runoff flowing into a body of water. Land use changes can have significant impact on the water resources of a region. Streams, lakes and other bodies of water collect runoff drained from the watershed. After periods of precipitation surface water is also captured by the soil and vegetation, stored in groundwater and plants and then slowly released into the streams, lakes or rivers. Changes in land use can alter the way water is released into these bodies of water.

Resource managers are developing and using Geographic Information Systems (GIS) to generate land use maps. These maps can be compared with historic information to examine changes that have occurred in the watershed. By using this information, land managers can carefully assess land use changes and set development policy accordingly.

Another map that resource managers often use is a **topographic** or **contour map**. Topographic maps depict three-dimensional features, such as mountains and canyons, on a two dimensional surface. This is accomplished with the use of contour lines, which connect points of the same elevation. When contour lines appear very close to one another on a topographic map surface, the map is depicting a steep slope and when the lines are further apart the change in elevation is more gradual. Depending on the scale of the map, contour lines can be drawn at various intervals. For example, a new line could

appear for every 20 foot change in elevation: 600 ft, 620 ft, 640 ft, etc., or a new line could appear for every 100 foot change in elevation: 600 ft, 700 ft, 800 ft, etc.

Topographic maps are very useful for determining watershed boundaries. The examination of a topographic map can explain how steep a slope is and where water would drain from any point on the map. Contour lines form a "V" or "U" shape when there is a stream. Ridges and peaks of hills or mountains are also identifiable by locating the tightest circles of contour lines. Often times the highest points in elevation mark the dividing lines between two watersheds.



Sample Topographic Map

Activities in Section One		
Activity	**Grade Level**	**Description**
How Water Flows: Surface Runoff	K-2	Build a model showing water flows downhill
A Watershed Puzzle	K-2	Create a watershed using puzzle pieces
Watershed Address	K-2, 3-5	Learn about local watersheds
Whatzzzzup-Stream	6-8	Work in groups to build a watershed
Topographic Maps	6-8	Study topographical maps and how a watershed is laid out
Walking In The Watershed	6-8, 9-12	Obtain a real world perspective by walking through a watershed
Color Me A Watershed	9-12	Interpret maps to observe how development can affect a watershed

HOW WATER FLOWS: SURFACE RUNOFF

Grade Level
K-2
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Earth Science, Fine Arts
Time
30 minutes
Materials
- Tin pan
- Sand
- Button
- Measuring cup
- Water
- Food Coloring
- Rain Rain Rivers by Uri Shulevitz (ISBN 0374461953)

Setting
Classroom
Terms
Absorb, Flow, Runoff
Reference
Adapted from the Water Sourcebook Series, K-2, United States Environmental Protection Agency

Summary

Students help build a model to understand that water travels downhill.

Objective

Students will:

1. Observe and orally explain that water flows downhill.
2. Observe and orally explain surface water absorption and runoff.
3. Give an oral or written definition of new terms: absorb, flow, and runoff.

Procedure

Warm Up

Read Rain Rain Rivers by Uri Shulevitz. Discuss with students information in book. Ask them to think of an area they know where there are hills. When it rains where does the water go? Does it all flow downhill or does some absorb into the ground?

Activity

1. Use wet sand to shape a small hill on one end of a pan.
2. Ask students where water will end up if poured on top of the hill. Place a button in that spot.
3. Slowly pour one cup of water (mixed with a few drops of food coloring) from a measuring cup on to the top of the hill.
4. Observe the water flow. Ask students where the water went. Did it all flow down the hill or was some absorbed into the ground?
5. Record class observation.
6. Compare results to their prediction. Discuss what happened.

Follow Up

Have each student use modeling clay to shape a hill. Let children add details such as models of trees, boats, people, etc. Display projects and title them. Have students pour water over the model and discuss runoff and its effects on the model.

Extension

Make rain at the easel! Mix paint and water (¼ water and ¾ paint). Have children dip a brush in the paint and observe the paint running down the paper making different designs. Repeat using various textures of paper or fabrics; discuss differences in paint absorption and design. Display children's artwork.

A WATERSHED PUZZLE

Grades
K-2
Ohio Academic Content Standards
See chart in *Resources* section
Subjects
Earth Science, Geography, Social Studies, Ecology
Time
30 minutes
Materials
- Pruned branches or pipe cleaners
- Copies of the Ohio River Watershed Map (1 per student)
- Plastic baggies (1 per student)
- 17" x 11" construction paper
- Scissors
- Tape or glue
- Crayons or markers (optional)

Setting
Classroom
Terms
Mouth, Source, Watershed
Reference
Adapted from Geography Action! 2001, "A Perfect Little River," National Geographic Society

Summary

Students piece together a puzzle of the Ohio River Watershed.

Objective

Students will:
1. Identify the different parts of a river.
2. Recognize the natural downward flow of a river or stream.
3. Understand basic geography of the Ohio River Watershed.

Procedure

Advance Preparation

Make copies of the Ohio River Watershed, enough for each student (if possible blow up the image on the copier). Cut each sheet into 5 to 7 pieces and keep puzzle together in a plastic baggie. Save one map for demonstration purposes.

Warm Up

Review with students the different parts of a river (source and mouth). To illustrate the concept of a watershed bring in pruned branches from a tree or pipe cleaners shaped like streams. Explain that the main stem is a bigger river with smaller rivers flowing into it and even smaller rivers flowing into them.

Show students the map of the Ohio River Watershed. Explain that the bold, red line is the Ohio River and that there are many other rivers flowing into the Ohio River. Make sure the students understand that not all rivers are on the map.

Explain that all the land that drains into the Ohio River is its watershed. To help illustrate how much area is contained in the watershed, ask students if they have ever been to the Smokey Mountains. Tell them that when rain falls on some parts of the Smokey Mountains it can end up in the Ohio River. Review the important states on the map.

Activity

1. Pass out puzzles, construction paper, glue, and crayons.
2. Have students assemble the watershed using the teacher's copy as a guide.

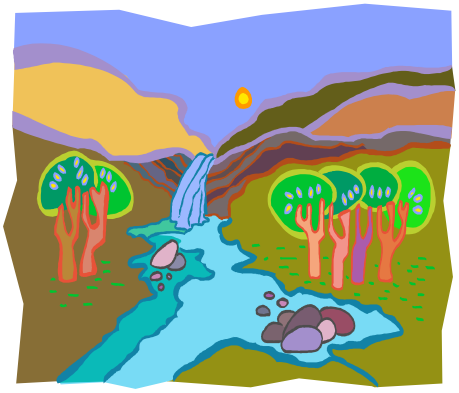
3. When each student is satisfied with the river, tape the pieces together on construction paper.
4. Ask students to trace the Ohio River in one color, and tributaries of the Ohio River in another. Have students outline the Ohio River Watershed (gray area).

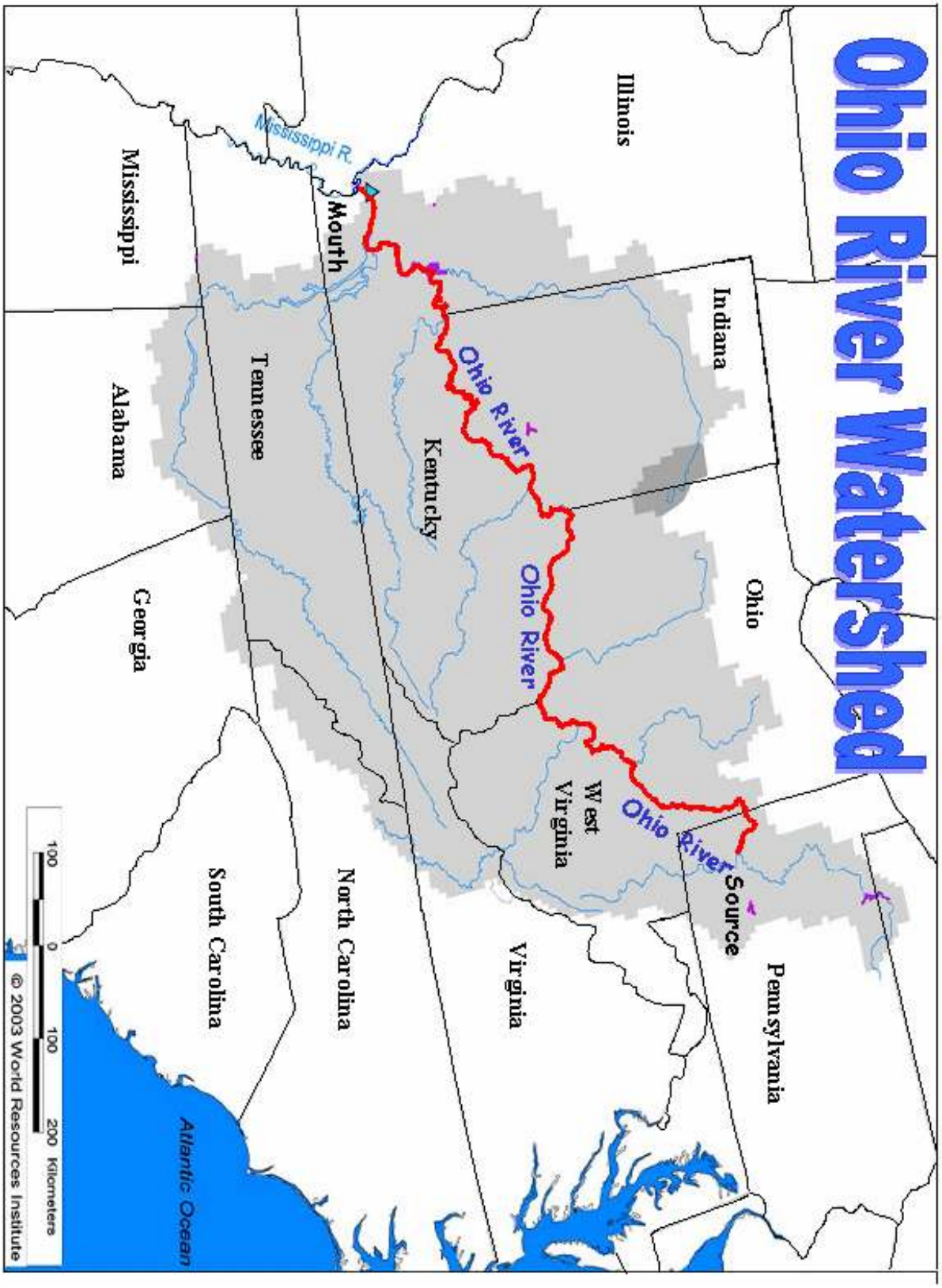
Follow Up

Ask the students what would happen if someone in Pennsylvania dumped pollution in the Ohio River. Where would the pollution go? Would it affect us in Cincinnati? How? (drinking water, recreation, etc.) What if rain picked up pollution off of the school parking lot? Trace with students the steps the water and pollution would take while they follow along on their puzzles (for example, storm drain to Little Miami River to Ohio River to Mississippi River to Gulf of Mexico.

Extension

To emphasis the watershed concept further follow with the watershed address activity.




Ohio River Watershed
Illinois
Indiana
Ohio
Pennsylvania
Source
Ohio River
Ohio River
Ohio River
West Virginia
Virginia
Kentucky
Mouth
Mississippi R.
Mississippi
Tennessee
Alabama
Georgia
North Carolina
South Carolina
Atlantic Ocean
100 0 100 200 Kilometers
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WATERSHED ADDRESS

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Earth Science, Geography
Time
45 minutes
Materials
- Several Hamilton County Maps (free maps are available with the Engineers Office).
- Copy of Hamilton County Watershed Boundaries Map (Resources Section)
- Map of the United States showing major rivers and oceans
- Copy of Watershed Address handout for each student

Extension Materials
- Paper
- Markers
- Maps (above)

Setting
Classroom
Terms
Map, River, Slope, Stream, Tributary, Watershed
Reference
Adapted from the Kids' Activities, Bryant Watershed Project and the Atlas Page

Summary

Students learn what a watershed is and determine the watershed in which they live.

Objective

Students will:
1. Understand that there are many levels of watersheds.
2. Identify and describe the watersheds in which they live.

Procedure

Advance Preparation

Obtain free Hamilton County Maps from the Hamilton County Engineer's Office (visit www.hamilton-co.org/Engineer/Free-Maps.htm or call 513-946-4250) and make copies of maps in the Resources section of this curriculum. The Hamilton County Soil and Water Conservation District can also help you obtain soils maps. It is helpful to have many different maps at different scales for students to study and explore. See also websites listed in "Resources" section.

Warm Up

How does the post office know where to bring your mail? A street address points out exactly in which house, street, city, state, and country a student lives. Students can also have a "watershed address" or a series of creeks, streams, rivers, and oceans that make up the students' watersheds.

Have students cup their hands together and imagine that their hands are a watershed and the space in between their hands is a river. Explain that the watershed is all of the land that drains into a river (or any body of water). If a drop of rain landed on the tip of the student's index finger it would end up in the river.

Explain that a watershed is defined by the direction the land is sloping. Draw a simple mountain on the board and two different rivers on either side. Demonstrate to students that rain or snow falling on one side of the mountain is in one watershed while rain or snow falling on the other side is in another watershed. Explain that even if the land is not on a mountain, like the students' backyards or the school parking lot, it is still gently sloping toward some waterway and is therefore in a watershed.

Activity

1. As a class locate your school on the map and trace all creeks and rivers to the Ohio River.
2. Pass out maps for each student or pair of students covering all of the areas in which the students live.
3. Have students locate their house on the map (or a section of their street).
4. Have them find the closest stream or creek to their house on the map. (Teachers Note: Unless you are using a topographic map you cannot know for sure the house is in this watershed but for this activity a traditional map is adequate.) To look up exactly what watershed you live in go to www.epa.gov/surf/ and click on *Locate Your Watershed*.
5. Have the students follow that stream and record each larger stream or river it flows into until they have reached the ocean. (Tip: Having many small local maps and one large continental map is sufficient.)

Follow Up

Have students explain how they would give directions to a mail carrier who is going to travel upstream from the ocean to their house.

Extension

Students can trace or draw their watershed address, labeling each waterway and using the maps as guides. Have students compare each other's watersheds.

What's My Watershed Address?

Street Address	Watershed Address
Street/Road	Local Stream/Creek
Town/City	Larger Stream/Creek
County	Large Stream/River
State	Major River
Country	Ocean/Gulf

Using the information you've gathered, answer the questions:

1.What is a watershed? _____

_____

2. Do you live in a watershed? _____

3. What is the name of your local watershed? _____

4. What is the Mississippi River Watershed? _____

_____

5. What are the east and west boundaries of the Mississippi River Watershed?

_____

6. Where does the water from your local watershed finally end up?

_____

WHATZZZZUP-STREAM?

Grade Level
6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Earth Science, Geography
Time
60 minutes
Materials
- Bucket
- Blue marker
- Aluminum foil
- Water in a sprinkling can or spray bottle
- Shallow washbasin or dishpan
- Large and small rocks, chunks of wood, and/or boxes
- Wet erase markers

Setting
Classroom
Terms
Runoff, Watershed
Reference
Adapted from the NPS Activity Sheets, United States Environmental Protection Agency

Summary

Students work in groups to build an active model watershed.

Objective

Students will:
1. Explain what a watershed is and name landforms within a watershed.
2. Explain how precipitation falls on a watershed and what path it follows.

Procedure

Warm Up

Review with students what a watershed is and the names of the watersheds in which they live (students could do Watershed Address Activity). Explain that they will have the opportunity to build their own watersheds. Discuss different types of landforms that they could include in their watershed.

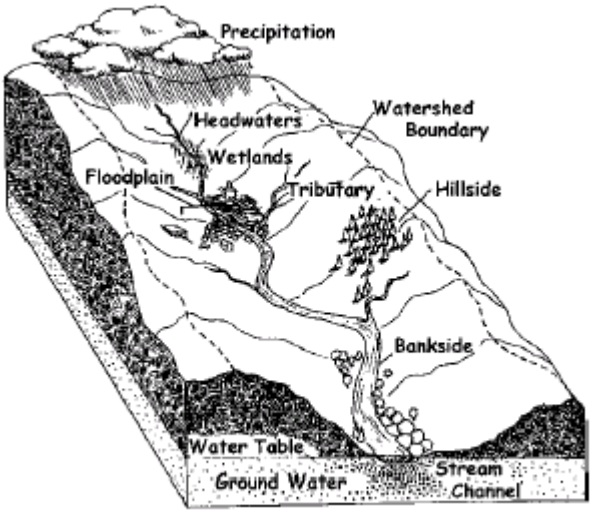
Activity

1. Have students break into groups.
2. In the shallow washbasin have students arrange rocks, wood or boxes higher on one end of the basin than on the other. Have them cover the rocks with aluminum foil, pressing the foil against the rocks to create a miniature landscape within the washbasin. Caution them; be sure the edges of the foil should remain inside the tub. Be careful not to rip holes in the foil.
3. Encourage them to make different folds, routes, ridges and valleys to force the "rainwater" to flow down different paths. Have them use a blue marker to draw the place where they predict the main rivers will flow.
4. Have students use the spray bottle to make it "rain" over the land. Observe what happens when it rains and record observations using the Whatzzzz-up Stream Worksheet.
5. Have students do the simulation again, but this time, before they make it "rain," have them draw potential pollution on the aluminum foil with wet erase markers (i.e. green for fertilizers, brown for oil spills, etc.)

6. Ask students to clean up. Remove the foil from the rocks, remove the rocks from the tub and empty the "rainwater" into a bucket.

Follow Up

Have students share their answers from the worksheet. Compare and contrast the results of the different watersheds.



Whatzzzz-up Stream Worksheet

Hypothesize

Read the questions below and guess what might happen. After you do the experiment, write the answers to the questions below. Were your theories right?

Observations

What happened to the water as it began to rain? _____

_____

What were some of the sources of pollution? _____

_____

How many streams formed? _____

Where did streams form? _____

_____

Where did all the water end up after the rainstorm? _____

Where were the first-order streams located in your watershed? _____

What happened to your main river as other streams joined it? _____

_____

Analysis

How did streams form? _____

What caused the water to flow in a certain direction? _____

_____

If this were a real watershed, where would all the water end up at the conclusion of the experiment? _____

Conclusions

Write a brief paragraph about what happens to water after it enters a watershed on the back of this worksheet.

TOPOGRAPHIC MAPS

Grade Level
6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Geography
Time
45 minutes
Materials
- Topographic map
- Copies of Topographic Map Worksheet

Setting
Classroom
Terms
Contour line, Topographical map
Reference
Adapted from What Do Maps Show?, United States Geological Survey Learning Web

Summary

Students study and learn to use topographic maps while developing an understanding of how a watershed works.

Objective

Students will:
1. Explain what a topographical map is and how it is used.
2. Develop skills in reading a topographic map.

Procedure

Advanced Preparation

To find a topographic map of your school visit http://terraserver.microsoft.com or http://www.topozone.com or http://cagis.hamilton-co.org. These websites allow you to search for topographic maps and aerial photographs of a specific address or area. Print enough maps so each student will be able to clearly study the map. All of the maps do not have to be the same; in fact, you could print enough to cover an entire neighborhood or each student's home addresses if you choose. Make copies of the Topographic Map Worksheet.

Warm Up

Explain to students that a topographical map represents a three-dimensional surface on a flat piece of paper. To demonstrate, crumble a piece or paper and then flatten out enough to create a contoured landscape. Explain that a topographic map will show mountains and valleys with contour lines instead of a three dimensional surface. Contour lines join points of equal elevation. The closer together contour lines appear the steeper the slope.

Activity

1. Have students become acquainted with the topographical map by finding examples of the features in the legend on the map.
2. Ask students to identify familiar locations.
3. Point out landforms such as a cliff, a mountain, a hill, a river or a meadow on the map. If any of these landforms do not appear on the map, ask students to explain why.

4. Have students complete the student worksheet *How to Read a Topographical Map*.

Follow Up

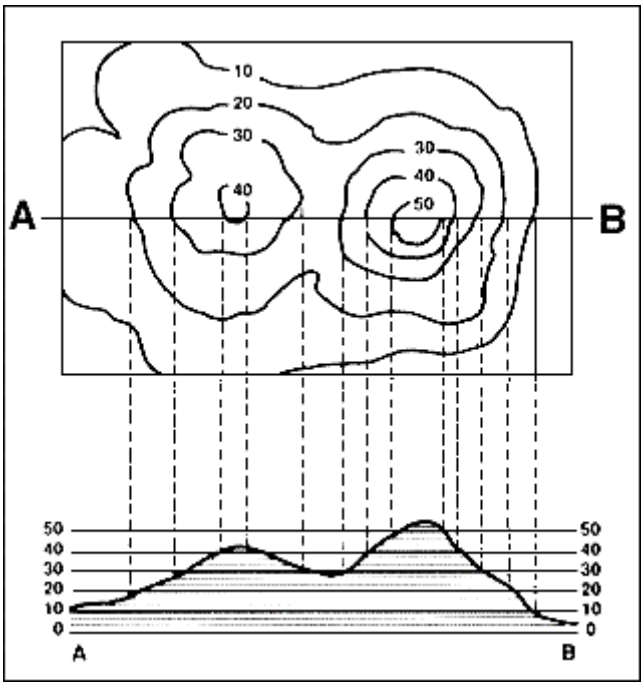
Review the worksheet with students. Have them apply what they learned in the worksheet to the real topographic map. Where is the highest point on the topographic map? Where is the lowest? Which hills are steeper than others? What symbols do they recognize on the maps? Have students find an area that they know, visualize the topography of the area and compare it with what they see on the map. Have students discuss why it is important to have topographic maps. What is the potential use for these maps?

Extension

The Hamilton County Soil and Water Conservation District offers a free topographic map program for presentation in your school. The program requires two class periods and involves several hands-on demonstrations with topographic maps. Call (513) 772-7645 to schedule. Programs are offered on a first come first serve basis.

How to Read a Topographic Map

One special kind of map is called a Topographic Map. It has contour lines to show the shape and elevation of the land. They are sometimes called "level lines" because they show points that are at the same level. Here's how contour lines work:



The top of this drawing is a contour map showing the hills that are illustrated at the bottom.
On this map, the vertical distance between each contour line is 10 feet.

Which is higher, hill A or hill B? _____

Which is steeper, hill A or hill B? _____

How many feet of elevation are there between contour lines? _____

How high is hill A? _____ Hill B? _____

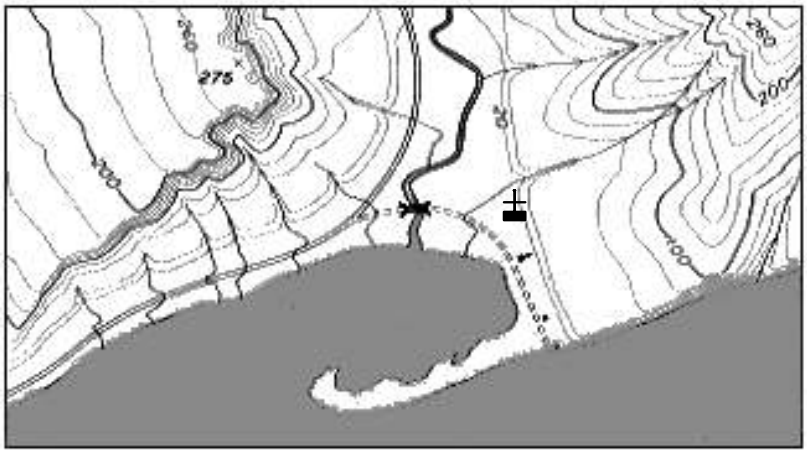
Are the contour lines closer together on hill A or hill B? _____

Look at this picture. It shows a river valley and several nearby hills.

On the illustration, locate the following featurs:

- A church
- A bridge over the river
- An oceanside cliff
- A stream that flows into the main river
- A hill that rises steeply on one side and more smoothly on the other

Here is a topographic map of the same place.



Find the features you located on the illustration on the topographic map.

- Circle the symbol for a church.
- Draw a church symbol on this line. _____
- Put a square around the map symbol for a bridge.
- Draw a bridge symbol here. _____
- Put an X on the oceanside cliff

WALKING IN THE WATERSHED

Grades 6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subjects
Earth Science, Geography, Environmental Science
Time
Part 1: 60-70 minutes
Part 2: homework
Part 3: 2-3 periods for research, 1 period for presentations
Materials
- Outdoor clothing
- Clipboards
- Pen or pencil
- Stream Walk Survey, 1 copy/3-4 students
- Watershed Walk Survey, 1 per student
- Map of the school area
- Pushpins
- Camera (optional)
- Materials for presentation

Setting
Outdoors and classroom
Terms
Nonpoint source pollution, Storm drain, Watershed
Reference
Adapted from the Salt Lake County Storm Water Quality Education Lesson and Activity Plans Salt Lake County, Utah, Public Works Department Engineering Division

SALT LAKE COUNTY

Summary

The outdoor stream and watershed walks will help give students a real-world perspective on how a watershed functions and how it may be impacted by land use and human actions.

Objective

Students will:
1. Survey a section of stream to identify land uses and pollution sources.
2. Survey sections of the watershed surrounding the school and their neighborhood.
3. Record and report observations and findings.
4. Assess pollution sources and issues in the community.
5. Research an observed pollution source, its effects, solutions and/or alternatives, costs and laws.
6. Present research to the class.

Procedure

Advanced Preparation

Prior to the Stream Walk survey, walk the area to be surveyed to note any dangerous sections and the location of private property. Obtain maps of the area from Hamilton County Engineers or by using TerraServer (see Resources sections). The day before the walk remind students to wear appropriate clothing and shoes for the day of the survey.

Warm Up

Review with students the concepts of watershed, nonpoint source pollution and various land uses. Explain to students that they will be going on a stream walk and have them list the nonpoint sources of pollution they think they will see. Share with students the maps of the area.

Activity

Part 1 – Stream Walk Survey

1. Discuss the purpose of the surveys with the students. Divide them into teams of 3-4, distribute the *Stream Walk Survey* form and choose a team scribe to record the group observations. Mark a section of 100 yards for each group on a community map. Discuss

the survey and ask students what kinds of observations they should make and record during their walk. If any camera equipment will be used, go over procedures and appropriate use with the students. Remind students of low-impact behavior such as staying on the path, not littering and not picking flowers. Tell students of the time limit or signal for when they should return to the classroom.

2. Once outside, students should walk along the stream noting the land uses on their survey forms; such as farms, construction sites, car washes, shopping malls and green spaces. Unique characteristics about each land use should also be recorded, such as oil running off parking lots into the waterway, discharge pipes from sewage treatment plants or signs of litter. In addition to land uses, general stream characteristics should be observed; such as eroding stream banks, lack of streamside vegetation channelized areas or dammed areas.
3. When students return from the stream walk, chart and discuss their findings.
   - What land uses did you see on the walk?
   - Are there areas with little or no sign of human impact?
   - Did you see any signs of wildlife?
   - Did you notice anything unexpected?
   - Make a list of pollution problems and rank them from most to least polluting. How do they impact you and me? How does the pollution impact other living things?
   - Could you identify the source of each problem? If not, why?
   - How might these pollution problems be prevented?
   - Are there areas that may be impacted by future growth or development such as new shopping malls, golf course and large parking lots?

Part Two- Watershed Walk Survey

1. Distribute the "Watershed Walk Survey" to each student. Encourage students to conduct the survey with a fellow student or with a parent, relative or friend. Discuss the survey and ask students what kinds of observations they should make and record during their walk. If any camera equipment will be used, go over procedures and appropriate use with the students.
2. As homework, students should complete the survey by investigating the area around their home and also by walking through their neighborhood; students should record land uses; such as gas stations, construction sites, shopping malls and green space. Unique characteristics about each land use also should be recorded; such as oil running off parking lots into the storm drain, excess fertilizer on sidewalks and other evident pollution.
3. When the students have finished the watershed walk, discuss their findings. Compare and contrast the findings to the Stream Walk Survey. Add new data to the chart.
   - What land uses did you see on your walk?
   - Are there areas with little or no sign of human impact?
   - Did you see any signs of wildlife?
   - Did you notice anything unexpected?
   - List additional pollution problems and rank them from most to least polluting. How do they impact you and me? Does the pollution impact other living things?
   - Could you locate the source of each problem? If not, why?
   - Could the pollution impact the quality of the water in the stream? How?
   - How might these pollution problems be prevented?

- Are there areas that may be impacted by future growth or development such as new shopping malls, golf course and large parking lots?

Part Three: A Closer Look

1. Each student or group of students should pick one storm water pollution source from the surveys to research in more detail. Research should include the following:
   - Hypothesize the reasons for the pollution?
   - Has technology influenced water quality? Positively or negatively?
   - Whom the negative effects of the pollution might impact?
   - Identify faulty reasoning, misinterpretation or statement that go beyond fact or evidence.
   - What is the scale of the problem (e.g., local, regional, national)?
   - What laws, if any, address the problem?
   - What could be done to solve the problem? Are there alternatives? For each alternative, what are the strengths and weaknesses? How have other communities solved the problem? What could you do to address the problem?
   - What will it cost to solve the problem?
2. After the research is complete, have students develop class presentations, including photos or short videos, if possible. Discuss the positive and negative consequences of each proposed solution. What are local community groups doing to address it? How might the students address the problem?

Follow Up

Ask students to list potential pollution sources around their homes and behaviors they could assume to reduce or prevent pollution.

Have students imagine that they were responsible for the management of the section of the water body that they surveyed. Have them develop a management plan that would protect the quality of the water.

Extension

Encourage students to make presentations to other classes, at a school-wide assembly, community meeting or to a local citizens group.

Have students map the route of pollution from a source such as a cornfield to the nearest stream or river.

Stream Walk Survey

Describe the stream

1. Does the stream flow in a straight line or does it curve? _____

2. Is the stream channel natural or changed by people? _____

3. What is on the bottom of the stream? _____

4a. What color is the water? _____

b. Can you see any pollution problems that might change the stream's color? (Remember, color isn't always a sign of pollution.) _____

5. Do you see trash in the stream? Describe the kinds of trash you see. _____
_____

6. Do you smell any unusual smells like oil, sewage or rotten eggs? Why would it smell unusual?
_____

Describe the Land Uses

1. Describe the land uses along the stream.
Mark what you see:

__roads	__houses	__apartments	__schools
__farms	__shopping malls	__golf courses	__trash dumps
__discharge pipes	__storm water drains	__sewer manholes	
__parkland	__vacant lots	__other_____	

2. Do you see any pipes along the stream bank that might discharge water into the stream? _____

Where do you think the pipes come from? _____

What do the pipes discharge into the stream? _____

Is there water coming from the pipes? If so, what color is the water? _____

Describe the wildlife

1. Do you see any signs of animals (animal tracks, beaver dams, bird nests and droppings)? _____

Describe what you see? _____

2. Can you see fish in the stream? _____ Do you know what kinds of fish live in your stream? _____

3. Describe the animals, birds and other wildlife you see on your walk? _____

4. How does the wildlife depend on the stream for survival? _____

Sketch the Stream on the back of this sheet.
Sketch your survey section of the stream. Make sure to include streets and other landmarks, land uses along the stream, wildlife, types of vegetation, pollution sources and other findings.

Watershed Walk Survey

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

1. Look around you. Is most of the land area open space or is it developed (e.g., buildings, streets)?
_____

2. What is the open land used for: parks, green space, lawn, golf course, vacant lots or farming?
_____

3. What is the main vegetation on the open land? Grass? Shrubs and weeds? Gardens? Farm crops?
_____

4. Do you see a lot of greenery such as trees, grass or shrubs? _____

5. Do you see a lot of roads or land surfaces covered by concrete or asphalt? _____

6. What is the developed land used for? Schools? Gas Stations? Office buildings? Stores? Parking lots? Sidewalks? Streets? _____

7. Where does the rain go when it falls? Are there many areas where rainwater can soak into the soil or other permeable surfaces or does most of it run on paved and built surfaces? _____

_____

8. Do you see storm water drains? _____Where does water go after it flows into the storm drains?
_____

9. Are there many rooftops? _____ Are the rooftops flat or sloped? _____

Where does water flow from rooftops? _____

Where does the water go after it flows through gutters and downspouts? _____
_____

10. Do you see round metal covers in the street and sidewalk? _____ These metal covers are called manhole covers and they provide openings for people to climb in and make repairs. What do the metal covers say on top: sewer, water, telephone, electric utility or other? _____

11. Do you see any small tributary streams or creeks? _____
Where do they flow? _____

12. Do you see trash in the streets? _____

What happens to the trash when it rains? _____

13. Do you see areas that are irrigated? _____ People watering lawns and gardens or sprinkler?
_____

COLOR ME A WATERSHED

Grades 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Math, Social Studies
Time
Preparation time:
Option 1: 10 minutes
Option 2: 10 minutes
Option 3: 10 minutes
Activity time:
Option 1: 40 minutes
Option 2: 50 minutes
Option 3: 40 minutes
Materials
- Copies of *Maps A, B, and C*
- Colored pencils
- Calculator
- Copies of the chart *Area of Land Coverage*
- Copies of the chart *Volume of Rain and Volume of Runoff*
- Maps and photographs of community, past and present (see Resources for maps) (optional)

Setting
Classroom
Terms
Discharge, Runoff, Watershed
Reference
Adapted from Project WET Curriculum and Activity Guide, *Copyright International Project WET*

Summary

Through interpretation of maps, students observe how development can affect a watershed.

Objective

Students will:

1. Recognize that population growth and settlement cause changes in land use.
2. Analyze how land use variations in a watershed can affect the runoff of water.

Procedure

Warm Up

What did the land and water around cities like Cincinnati, Los Angeles, Portland, Minneapolis, Houston, Chicago, New Orleans, Miami or Washington D.C., look like 100 or 50 years ago? How has growth changed each region? Ask students to imagine their community 100 years ago. They may want to refer to old photographs or news stories. Was the school in existence? What happened when water fell on the ground then, compared to now? If a body of water were near the school, would its appearance and condition have been altered over the years? Tell students that maps can teach us about the past and possibly answer questions such as these.

Activity

1. Provide students with copies of *Maps A*, *B* and *C*. Explain that they represent aerial views of a watershed taken at different times. To simplify map interpretation, the borders of the watershed coincide with the edges of the grid. In addition, the outlines of various land areas (e.g., wetlands, forests) align with the grid lines.
2. Following are three options for interpreting changes in the watershed presented on the maps. The first option may be more appropriate for younger students, but can help all students complete Options 2 and 3. Students should be able to multiply and calculate percentages to complete the second and third options.

Option 1

1. Tell students to look at *Maps A*, *B* and *C*. Explain that they represent changes in this land over a 100-year period. Have students look at the key for each map. Instruct them to designate each area with a different color (e.g., color all forests green). They should use the same color scheme for all maps.
2. When the students finish coloring, have them compare the sizes of different areas on each map and among maps. Ask them to compare plant cover and land use practices in each of these periods. They may note changes in croplands, forests, grasslands, wetlands, urban land uses, etc.
3. Discuss one or more of the following questions:
    - What happens to the amount of forested land as you go from *Map A* to *Map C*?
    - Which map has the most land devoted to human settlements?
    - Where are most of the human settlements located?
    - What effect might these settlements have on the watershed?
    - Would you have handled development differently?

Option 2

1. Have the students determine the land area of each of the maps. Each unit in the grid represents 1 square kilometer; there are 360 square kilometers (or 360,000,000 m^2) on each map.
2. For each map, have students determine the area occupied by each type of land coverage (e.g., forest, wetland and farmland). Responses can be guesses or exact calculations. For example, for *Map A,* 17 of the grid units are occupied by wetlands. By dividing 17 by the total number of units (360), students should calculate that 4.7% of the land area is wetlands. The amount of land allotted to wetlands, forests, etc. will change for each map, but the amount of stream coverage (111 squares or 30.8%) will remain constant. Students should record their answers in the *Area of Land Coverage* chart.

Note: Most watershed calculations employ standard measurements: inches and cubic feet per second (cfs). However, to facilitate students' computations, metric measurements are used here.

3. Tell students that the watershed has received 5 cm (0.05 m) or rain. (Although rain does not normally fall evenly over a large area, assume that 5cm of rain fell evenly over the entire watershed.) By converting both the rainfall and the land area to meters, students can calculate the amount of water (m^3) that fell of the land. 18,000,000 m^3 of rain fell on the watershed (0.05 m x 360,000,000 m^2 = 18,000,000m^3). Of this 18,000,000 m^3 of rain, 5,550,000 m^3 landed on the stream (11,000,000 m^2 x 0.05 m = 5,550,000 m^3). This might seem like a large quantity of water, but if 5cm of rain did fall evenly on a watershed of this size, the stream would receive this volume of water. (NOTE: 100 cm = 1m; 1,000,000 m^2 = 1 km^2.)
4. Ask students to estimate the amount of water that would be drained from the land into the stream. Tell students that for the watershed represented by *Map A*, 2,767,500 m^3 of rain was runoff (i.e., the water flowed into the stream and did not soak into the ground, did not evaporate and was not used by plants or animals). (Runoff volumes are provided in the Answer Key below. In Option 3, students can calculate runoff for each land area.)
5. Discuss changes in land coverage represented in *Maps A* through *C*. Ask students if they think the amount of runoff would increase or decrease.

6. Tell students that when 12,450,000 m^3 of rain fell on the land represented by *Map A*, 2,767,500 m^3 was runoff. For *Map B,* 3,612,500 m^3 was runoff. For the *Map C*, 4,797,500 m^3 was runoff. Discuss the following questions in addition to those listed in Option 1.
    - Which absorbs more water, concrete or forest (or wetlands or grasslands)?
    - Which map represents the watershed that is able to capture and store the most water?
    - What problems could arise if water runs quickly over surface material, rather than moving slowly or soaking in?
    - How might the water quality of the stream be affects by changes in the watershed?

Option 3

Have students determine how the figures in Option 2 were obtained. In the chart, *Volume of Rain and Volume of Runoff*, each land area has been assigned a proportion of the water that is not absorbed or that runs off its surface. Using the information from this chart and from the Area of Land coverage, have students calculate the amount of water each land area does not absorb. For example, for the forested land in *Map A*, 189 km^2 x 1,000,000 m^2/km^2 = 189,000,000m^2 of land. Multiply this by the amount of rainfall (189,000,000 m^2 x 0.05 m + 9,450,000 m^3). Since 20% of the rainfall was runoff; 1,890,000 m^3 of water drained into the stream from the forested land (9,450,000 m^3 x .20).

Note: The figures for percent runoff are based on hypothetical data. To determine how much water is absorbed by surface material, one needs to know soil type and texture, slope, vegetation, intensity of rainfall, etc. In addition, many farms and urban areas practice water conservation measures that help retain water and prevent it from streaming over the surface. The information in the chart is intended only for practice and comparisons.

Follow Up

Based on the three maps, have students summarize how changes in the land affected the watershed.

Have students discuss how changes in the land affect the quantity and quality of runoff in a watershed. Identify land use practices in the community and how they may affect water discharge in the watershed. Take students on a walking tour and note areas that contribute to or reduce storm runoff. For example, parking lots, paved roads and sidewalks promote runoff; parks, wetlands and trees capture water. What would cause increases in runoff? Decreases?

Students could attend a public meeting in which land use for their community is being discussed.

If students were to draw a fourth map of the same area 100 years in the future, how would it appear? Have students plan a city that contributes positively to a watershed. They should contact city planners or conduct library research to support their projects.

Extension

Have students explore changes in their own community. Sources of historical and current maps include the Natural Resource Conservation Service, the Bureau of Land Management, the U.S.D.A. Forest Service, the U.S. Geological Survey or a local public works department. Sometimes libraries contain historical, hand-drawn maps from the 1700s to the 1900s. Resource people in these agencies or the community will also have information and perspectives about past, present and future water use.

Students may want to conduct a more accurate analysis of the degree to which different surface areas are permeable to water. Contact conservation agencies or Extension agents in your community to learn how different soil types affect runoff.

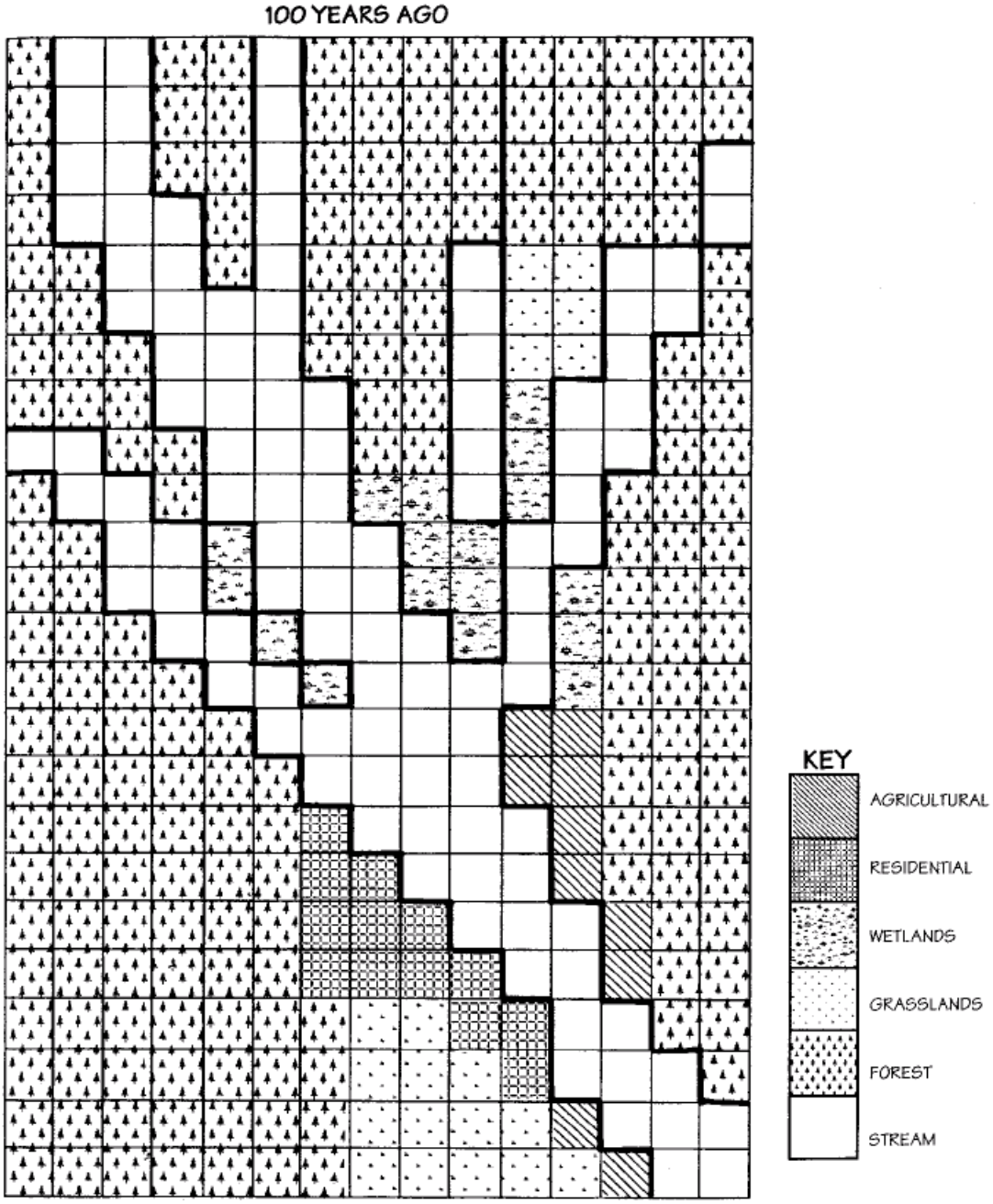
Several books for young people powerfully describe and illustrate the effects of human development on land areas. Students may want to compare the changes indicated by maps to changes portrayed in *Window*, by Jeannie Baker, (ISBN: 0688089186) or other sources.

Students can use computer technology to increase their understanding of geographical features, such as Geographic Information Systems (GIS). Contact Charlie Fitzpatrick, ESRI K-12 Education and Libraries, 3460 Washington Drive, Suite 101, St. Paul, MN 55122 (612) 454-0600, ext. 26). Or email cfitzpatrick@esri.com for information about how to order and use ARCVIEW, a computer program that enables learners to investigate GIS files.

Answer Key: Volume of Rain and Volume of Runoff

	Map A 100 years ago		**Map B** 50 years ago		**Map C** Present	
Land coverage and % runoff	**Volume m^3**	**Runoff m^3**	**Volume m^3**	**Runoff m^3**	**Volume m^3**	**Runoff m^3**
Forest 20% runoff	(9.45×10^6) 9,450,000	(1.89×10^6) 1,890,000	(8.1×10^6) 8,100,000	(1.62×10^6) 1,620,000	(5.55 x 106) 5,550,000	(1.11 x 106) 1,110,000
Grasslands 10% runoff	(1.11×10^6) 1,110,000	(1.0×10^6) (1.0 x 105) 100,000	(7.0×10^5) 700,000	(7.0×10^4) 70,000	(3.0×10^5) 300,000	(3.0×10^4) 30,000
Wetland 5% runoff	(8.5×10^5) 850,000	(4.25×10^5) 42,500	(6.5×10^5) 650,000	(3.25×10^4) 32,500	(2.5×10^5) 250,000	(1.25×10^4) 12,500
Residential 90% runoff	(6.5×10^5) 650,000	(5.85×10^5) 585,000	(1.65×10^6) 1,650,000	(1.485×10^6) 1,485,000	(2.9×10^6) 2,900,000	(2.61×10^6) 2,610,000
Agriculture 30% runoff	(5.0×10^5) 500,000	(1.5×10^5) 150,000	(1.35×10^6) 1,350,000	(4.05×10^5) 405,000	(3.45×10^6) 3,450,000	(1.035×10^6) 1,035,000
Total Runoff		2,767,500		3,102,500		4,797,500
Total runoff plus stream discharge (5,550,000 m3)		(8.32×10^6) 8,317,500		(8.652×10^6) 8,652,500		(1.0347×10^7) 10,347,500

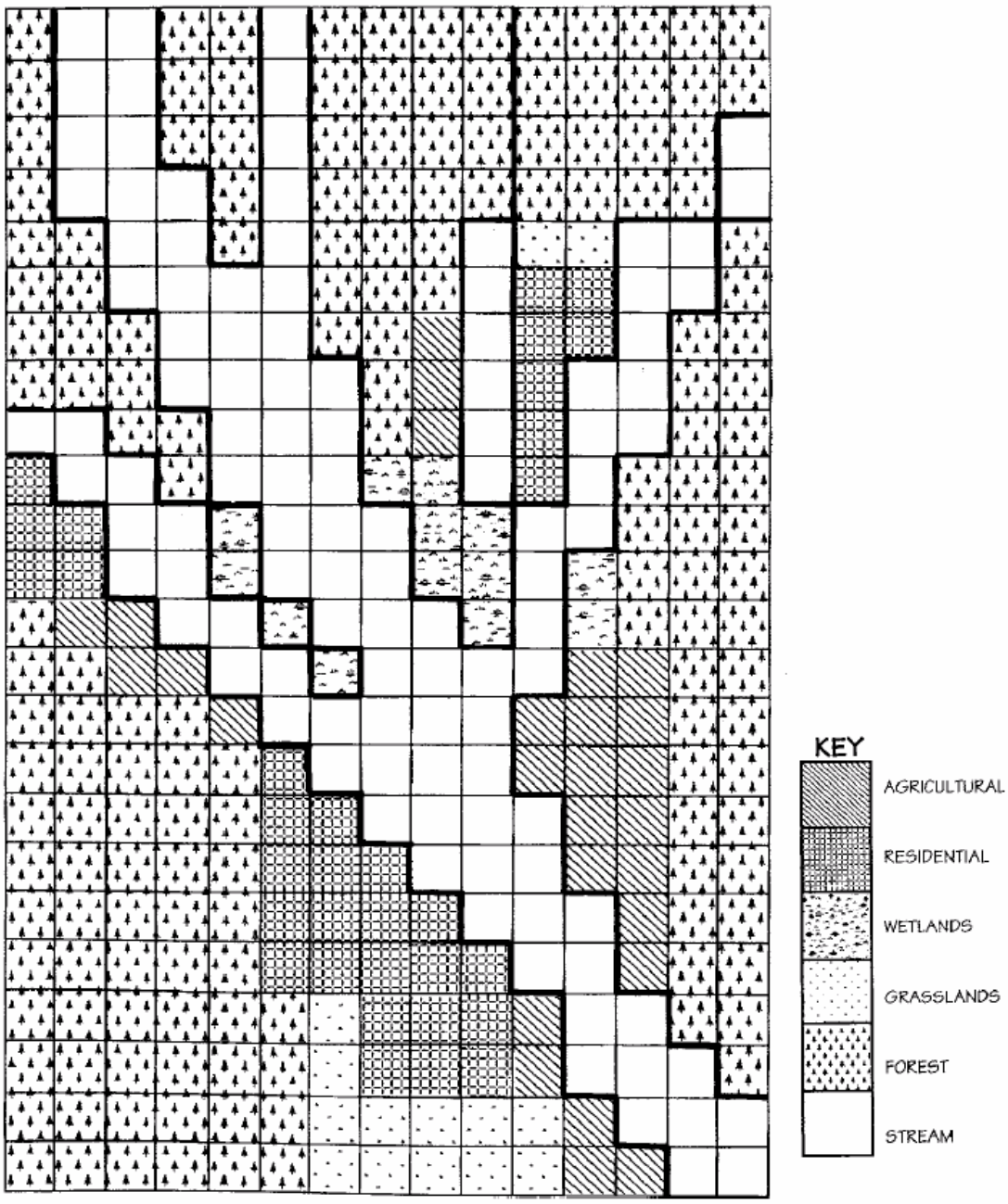
Map A



The Watercourse and Council for Environmental Education (CFE)

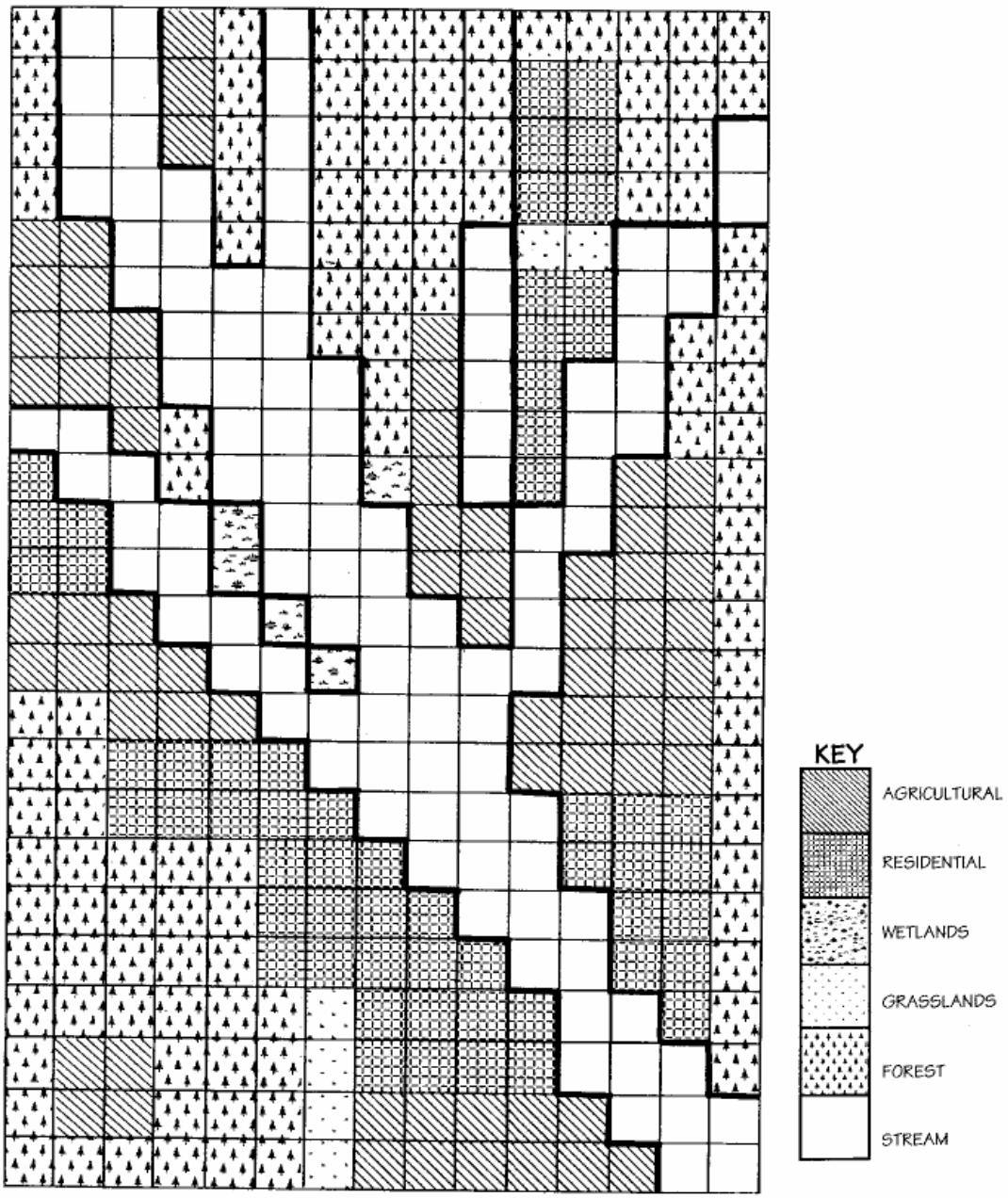
Map B

50 YEARS AGO



Map C

PRESENT



Name _____ Date _____

Chart for Option 2 AREA OF LAND COVERAGE

	MAP A 100 years ago		MAP B 50 years ago		MAP C Present	
Land coverage	km^2	%	km^2	%	km^2	%
Forest						
Grassland						
Wetland						
Residential						
Agriculture						
Stream						

Chart for Option 3 VOLUME OF RAIN AND VOLUME OF RUNOFF

	MAP A 100 years ago		MAP B 50 years ago		MAP C Present	
Land coverage and % runoff	volume m^3	runoff m^3	volume m^3	runoff m^3	volume m^3	runoff m^3
Forest 20% runoff						
Grassland 10% runoff						
Wetland 5% runoff						
Residential 90% runoff						
Agriculture 30% runoff						
Total runoff						
Total runoff plus stream discharge (5,550,000m^3)						

Section Two

Nonpoint Source Pollution

This section builds on the watershed concept and clearly defines nonpoint source pollution, as well as some of the land uses that contribute to the problem. Students have the chance to identify specific "sources" of nonpoint source pollution, evaluate current issues surrounding storm water and engage in a mock trial.

When most of us think of pollution, images of billowing smokestacks or industrial pipes dumping waste into a stream come to mind. While these images are more "traditional" pollutants, this curriculum focuses on a type that everyone can help prevent because we are all the "source" of the pollution.

Finding the Source

Everyday activities such as washing the car, fertilizing the lawn, driving to work and taking the dog for a walk contribute contaminants to the watershed. When it rains or when water comes from another source, such as car washing or the watering of crops and lawns, pollutants spread throughout the watershed are picked up with the water. This polluted water flows into our waterways, either directly or through a storm drain collection system that (for much of Hamilton County) dumps directly into streams and rivers without being treated. **Nonpoint Source (NPS) Pollution** is water pollution that cannot be traced to any specific point or location. The term nonpoint source pollution is used to distinguish this type of pollution from point source pollution, which comes from specific sources such as sewage treatment plants or industrial facilities.

No matter where you live, the water quality in rivers and streams is determined by what happens in the watershed. In urban areas, hard surfaces such as sidewalks, rooftops and roadways prevent water from soaking into the ground. As a result the runoff which can be contaminated with road salt, heavy metals, oil and antifreeze, flows into storm drains that dump directly into streams and rivers. In rural areas, water runoff carries a wide variety of materials, some of which provide nutrients and some of which are toxic. Common materials in agricultural runoff include fertilizers and pesticides from fields, bare soil from tilled areas and manure from livestock that often runs from the pasture or feedlot directly into waterways. These kinds of pollutants do not have a single source that you can point to, so they are called nonpoint source pollution. This section will first present activities that give an overview of NPS pollution and the various contributors while the next two sections focus on three land uses critical to Hamilton County: Agricultural areas, Developing areas and Urban areas.

Point versus Nonpoint

In order to fully define nonpoint source pollution one must compare it to its counterpart: **point source pollution**. Point sources, also referred to as "pipe" sources, are usually deposited directly from a source into a waterway through a pipe. Point sources, such as sewage treatment and industrial waste, are easier to track and monitor and therefore easier to regulate. Nonpoint sources can originate from anywhere and are almost impossible to trace back to the specific source. For example, if sediment were found in a stream it would be difficult to say exactly where upstream the soil is eroding. On the other hand, if a specific chemical were found in the water, one could trace it back to an industry that may have pumped that chemical into the stream as a waste product.

Given that NPS pollution is so difficult to trace back, it is more difficult to regulate. In the past 25 years the United States has made tremendous advances to clean up the aquatic environment by controlling point source pollution from industries and sewage treatment plants. Unfortunately, we did not do enough to control pollution from nonpoint sources. The United States Environmental Protection Agency has estimated that nonpoint source pollution remains the nation's largest source of water quality problems. It's the main reason that approximately 40 percent of national rivers, lakes and estuaries surveyed are not clean enough to meet basic uses such as fishing or swimming. The best way to decrease NPS pollution is through public awareness, education and individual action.

Dissolving Pollution

The fundamental properties of water explain how nonpoint source pollution occurs at the most basic level. There are many substances that will blend or **dissolve** into water, which is why we use water to clean just about everything. A **solution** forms when one substance dissolves into another substance. When a substance dissolves, it breaks down into molecules, which mix with the molecules of the other substance. For example, road salt will mix with runoff and form a solution. There are other materials that are picked up with the runoff, such as oil or sand, which will not dissolve in water. A mixture in which particles of a substance are scattered in another substance but not dissolved is called a **suspension**. Some suspended pollution can settle out onto the bottom of a creek or stream while other pollution, dissolved and suspended, can travel all the way from Ohio to the Gulf of Mexico.

The Storm Water Issue

Storm water pollution, like other environmental issues, is very complex. It involves a variety of interest groups and several often-opposing viewpoints. Common factors in a given environmental issue might include resource commodity, agency management policies, land-use planning policy, landownership, weather and climate, local economies, personal behavior and recent national environmental policy. Any effect and any related action of this issue may be local, regional, statewide, national or international.

Like many other issues today, environmental issues rarely have absolute right and wrong sides and usually they are more than two-sided. Any environmental action decision will be a selection of one of several possible alternatives and will reflect trade-offs and compromises in the values of the groups involved. These decisions have both short and long-range effects and implications: economically, socially, politically and environmentally. Discovering ways to analyze environmental issues promotes better understanding and smoother decision-making.

Activities in Section Two		
Activity	**Grade Level**	**Description**
Mudpuppy Pond	K-2	Follow an interactive story and learn the many different sources of pollution possible in an animal's habitat
What's the Point: Point VS. Nonpoint	K-2	Learn the difference between point and nonpoint sources of pollution
Now You See It, Now You Don't	K-2	Explore substances that dissolve and do not dissolve in water
Knowing Nonpoint	3-5	Assume the roles of community members to discover their nonpoint source pollution contribution
Water Pollution Detectives	3-5	Identify different contributors to pollution through guided imagery
Use Your Head, Protect Your Watershed	3-5, 6-8, 9-12	Describe and identify land use activities within a watershed
You Be The Judge	6-8, 9-12	Act out a trial involving various sources of nonpoint source pollution
Analyzing Storm Water Issues	6-8, 9-12	Analyze the issues surrounding storm water and gain insight on challenges involved in developing solutions
Name That Source	6-8, 9-12	Differentiate between point and nonpoint source pollution using flash cards

MUDPUPPY POND

Grade Level
K-2
Ohio Academic Content Standards
See chart in *Resources*
Subject
Environmental Science, Ecology, Language Arts, Fine Arts
Time
1-hour preparation
50 minutes
Materials
- 12" x 22" poster board
- Glue
- Plastic frog
- 1-gallon jar
- Tbsp cold tap water
- 36"x24" cardboard box
- 1 33-gallon trash bag
- Sand and Soil
- Aluminum foil
- 2-4 index cards
- Popsicle sticks
- 7 small paper cups
- Small rocks or gravel
- Brown sugar
- Pancake syrup
- Punched paper dots
- Detergent
- Warm tap water
- Green and yellow food coloring
- Wood ashes

Setting
Classroom
Terms
Habitat, Pollution, Runoff, Urban storm water runoff, Watershed
Reference
Adapted from the Water Sourcebook Series K-2, U.S. Environmental Protection Agency

Summary

Students follow an interactive story and learn the many different sources of pollution possible in an animal's habitat.

Objective

Students will:

1. Describe, orally or in writing, the amount and distribution of water on the Earth in fresh water and salt water.
2. Identify, orally or in writing, causes of water pollution.
3. Describe and evaluate, orally or in writing, the effects of different kinds of land use on wetland habitats.
4. Give an oral or written definition of new terms: habitat, lake, pollution, pond, river, runoff, urban storm water runoff, and watershed.

Procedure

Advance Preparation

To set up Verde Frog's habitat, cut sides of cardboard box leaving a depth of 8 inches. Slit the heavy-duty garbage bag down one side and across the bottom. Line the cardboard box with the plastic bag. Place about 4 to 5 inches of sand in box forming a watershed area, river, creek, and pond. Line the waterways with aluminum foil to hold water in these areas. Place a plastic frog in pond.

Number the baby food jars 1-9 (Note: there is no Jar #6 in the story). Label and fill jars as follows:

Jar #	Fill With	Label
1	Soil	Soil
2	¼ cup water, yellow food coloring	Animal Waste
3	¼ cup brown sugar	Fertilizers & Pesticides
4	¼ cup molasses or syrup	Oil
5	Paper punched dots	Trash
7	½ warm water and squirt of detergent	Factory Waste
8	¼ cup ashes	Ashes
9	Small rocks and vinegar	Rocks

Set out green food coloring label it "Toxic Waste". Make a big book from suggested pages in activity. Make student copies of Verde (Spanish for green) Frog student activity page.

Warm Up

If all of the Earth's water fit in a gallon jug, available fresh water would equal just over a tablespoon. About 97 percent of the planet's water is salt water; another two percent is locked in icecaps and glaciers. Vast reserves of fresh water underlie the Earth's surface, but much of it is too deep to tap economically. Help students understand the notion by modeling the gallon jug of water and a tablespoon of water.

Tell students that water pollution has become one of the most serious environmental problems facing the United States, as well as other countries around the world. Industry, government, cities and towns have spent billions of dollars on research and treatment plants to try to reduce water pollution. This activity will help students realize how water is polluted and the effects of pollution on animals.

Activity

1. Ask students to identify pollution and ways in which water becomes polluted. Use a semantic map or word web to organize the students' ideas.
2. Make word labels - watershed, pond, creek, frog habitat - using index cards and popsicle sticks. Ponds and freshwater wetlands are known as standing water habitats. Many species of animals live in these areas of freshwater. Habitats are areas where animals find food, water and shelter necessary for their daily living and reproduction. Ponds and wetlands are some of the best places for frogs and amphibians to live. Place labels at appropriate places in the box of sand.
3. Invite the students to see what happened to Verde Frog's habitat as pollution begins to invade Mudpuppy Pond. Pass out the activity jars, food coloring, and the Verde Frog student activity page.
4. Read the big book story, "The Disappearance of Mudpuppy Pond" - a story about the destruction of Verde Frog's habitat at Mudpuppy Pond. Pause after each page for students to add "pollution" to the frog's habitat. Every student should write down a different describing word each time they are asked the question, "How does Verde Frog feel?"
5. After the "pollution" has been added to the habitat, discuss the appearance of the frog and his habitat. Record the describing words on a master list.

Follow Up

Go back to the semantic map organizer and with a different color marker, identify more ways water can be polluted.

Verde Frog

Sing to the tune of "Froggie Went a-Courtin".

Froggie was a floatin' in Mudpuppy Pond, uh-huh, uh-huh.
Froggie was a floatin' in Mudpuppy Pond, uh-huh, uh-huh.
His long sticky tongue helped him catch his prey;
Slurping his worm and a croakin' all day, un-huh, uh-huh.
Pollution threatened to end his life, uh-huh, uh-huh.
Pollution threatened to end his life, uh-huh, uh-huh.
Contaminatin' all his food;
And destroyin' his home, oh how rude! Uh-huh, uh-huh.
Soon Froggie wasn't feeling very well, uh-huh, uh-huh.
Soon Froggie wasn't feeling very well, uh-huh, uh-huh.
Eroded soil filled his pond;
He lost his home since the water's gone, uh-huh, uh-huh.
Be careful not to pollute the water, uh-huh, uh-huh.
Be careful not to pollute the water, uh-huh, uh-huh
Help our world and dispose your waste;
Put it in its proper place, uh-huh, uh-huh.

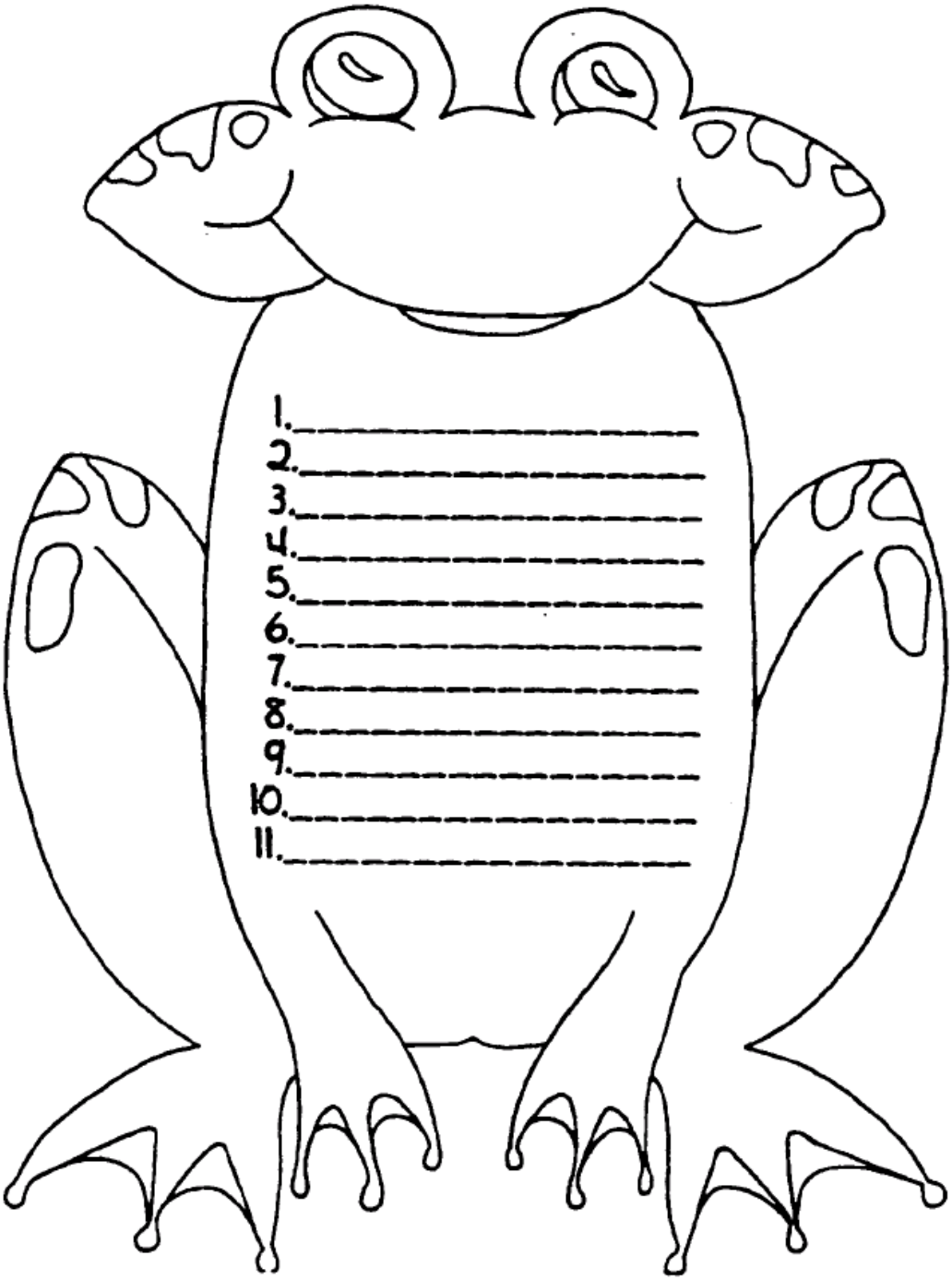
Follow-up this activity with “What’s the Point? Point versus Nonpoint.”

Extension

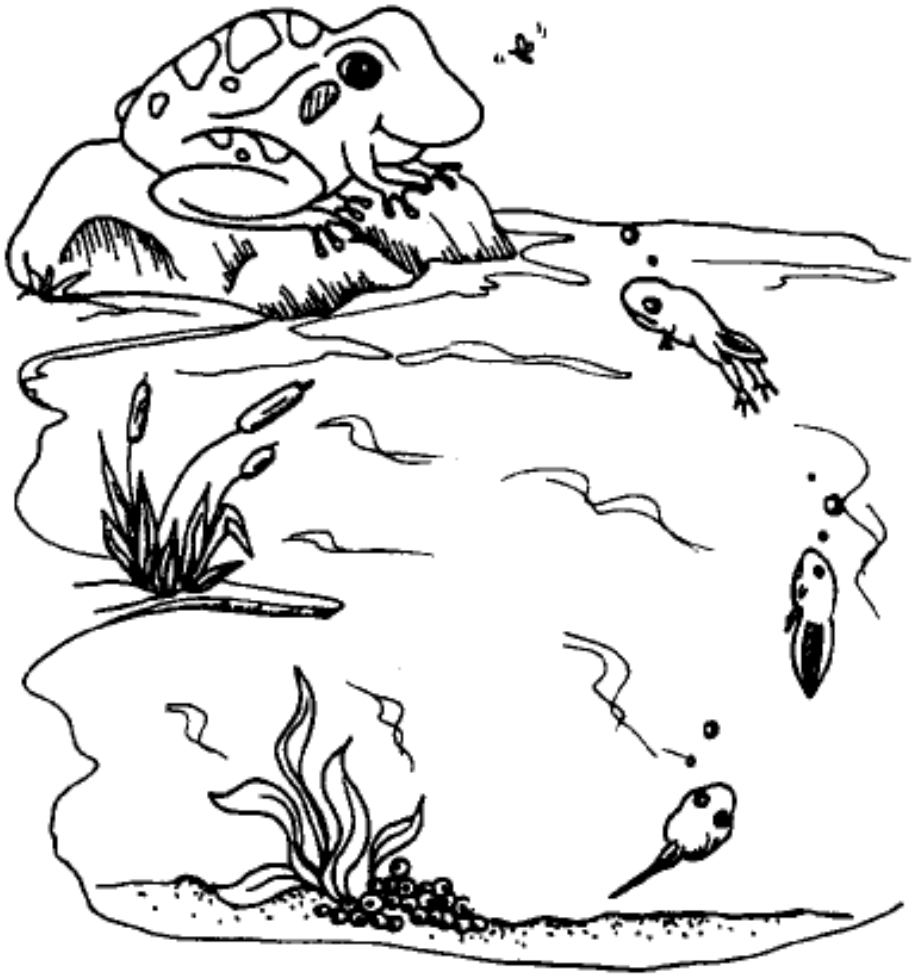
Divide the class into as many as 11 groups. Write a class comic strip about Verde Frog’s predicament. Assign a different pollution activity to each group. As groups place their pages on the wall, have students sequence the stages of polluting Mudpuppy Pond.

After the discussion, have the students form a circle (symbolic of the water cycle), and sing the song about Verde Frog.

HOW IS VERDE FROG?

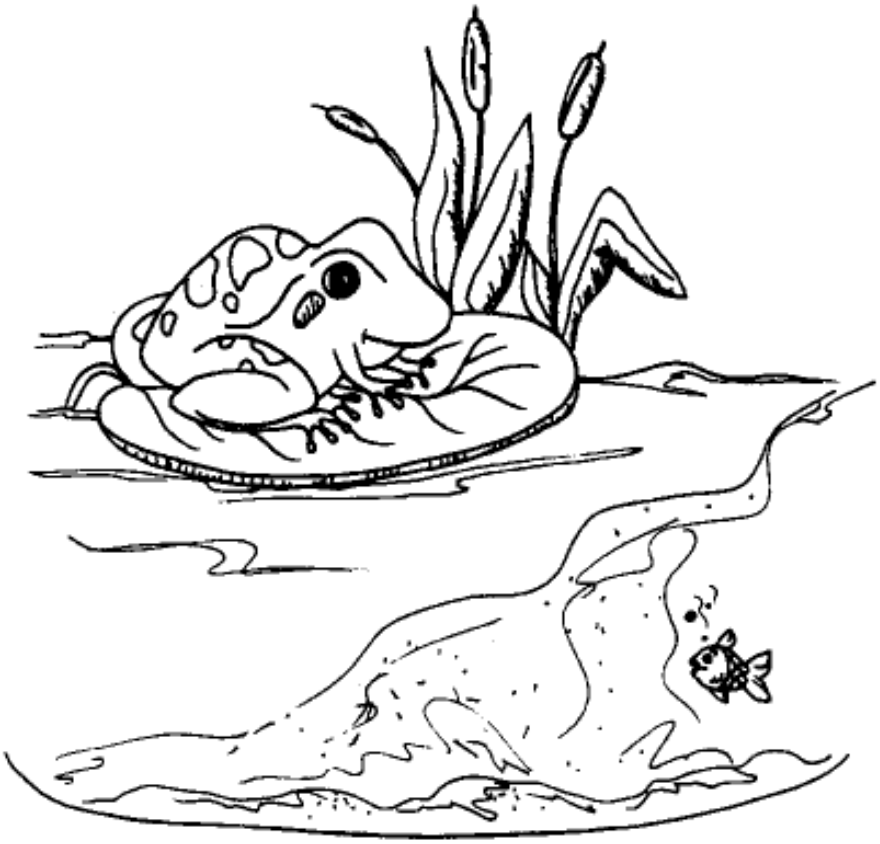


Directions: Write down a different describing word each time you are asked a question, "How does Verde Frog feel?



In the spring, Verde Frog began his life at Mudpuppy Pond. Like all amphibians, he went through several changes or metamorphoses before he became a frog. The unpolluted waters of Mudpuppy Pond helped him grow from an egg, to a tadpole, and finally to an adult frog. Verde loved to hop and swim in Mudpuppy Pond. Slurping bugs and worms with his long sticky tongue was the best part of the day. Life was good. Until . . .

1



People became careless. They did not think about all the species of animals that lived in Mudpuppy Pond and the creek upstream from it. Water, the most abundant liquid on the earth, provides a variety of valuable habitats or homes for wildlife. Verde's habitat began to change.

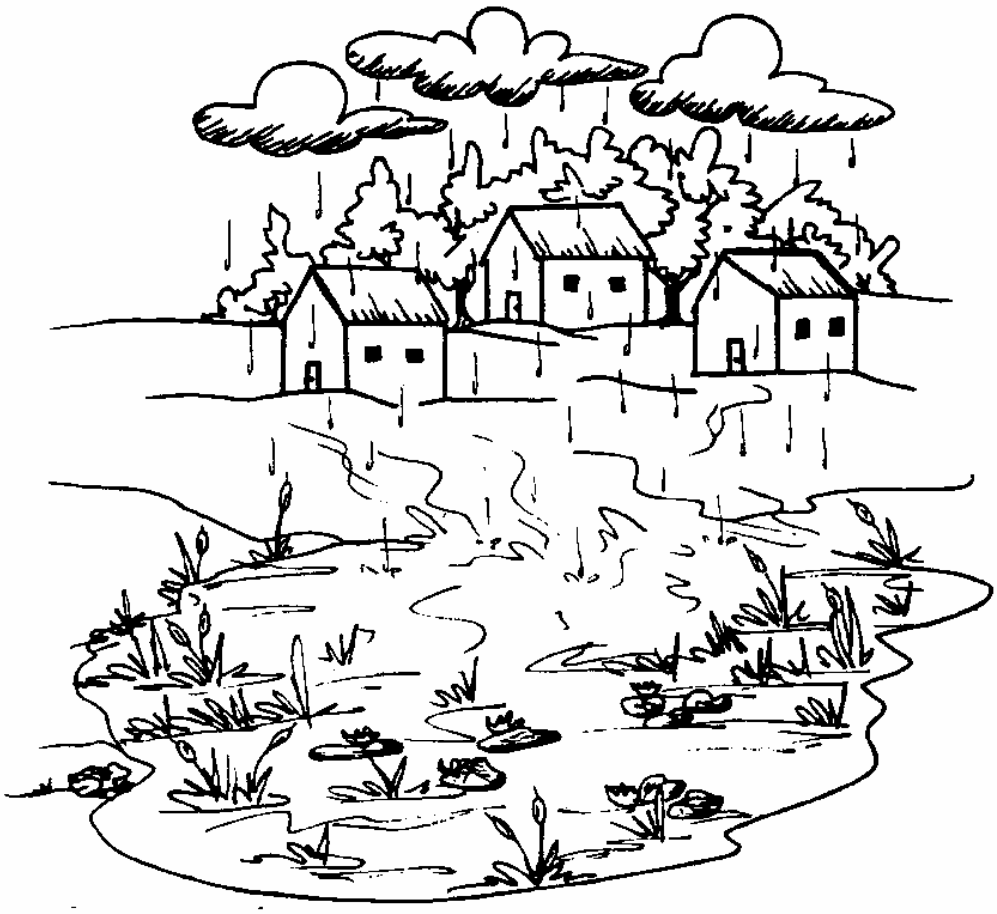
2

Mr. Farmer freshly plowed his field near the creek. It begins to rain and some soil erodes into the creek near Mudpuppy Pond. Large amounts of sediment are beginning to fill in the creek and pond. (Pour contents of jar 1 into the creek near Mudpuppy Pond.) How does Verde frog feel?

3

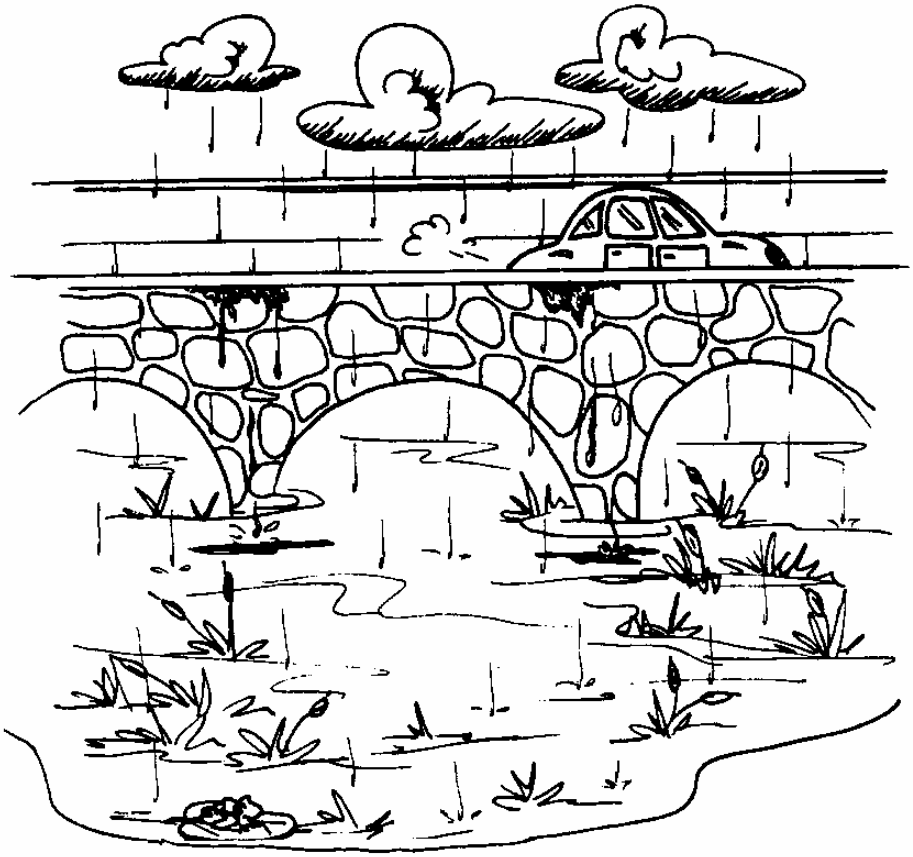
The cows are grazing on the green grass next to the creek. Sometimes they wade out into the creek to get a drink of water or to cool off on a hot summer day. The animal waste washes into the pond. (Pour the contents of jar 2 into Mudpuppy Pond.) How does Verde Frog feel?

4



Many houses are built near the pond. Fertilizer and pesticides used on the lawns and gardens wash into the pond after a heavy thunderstorm. The fertilizer makes the plants in the pond grow very fast and thick. Mudpuppy Pond can't support all those plants. They begin to die and are starting to rot. Their decomposition (rotting) is using up some of the oxygen Verde's food sources need to live. (Pour contents of jar 3 into Mudpuppy Pond.) How does Verde Frog feel?

5

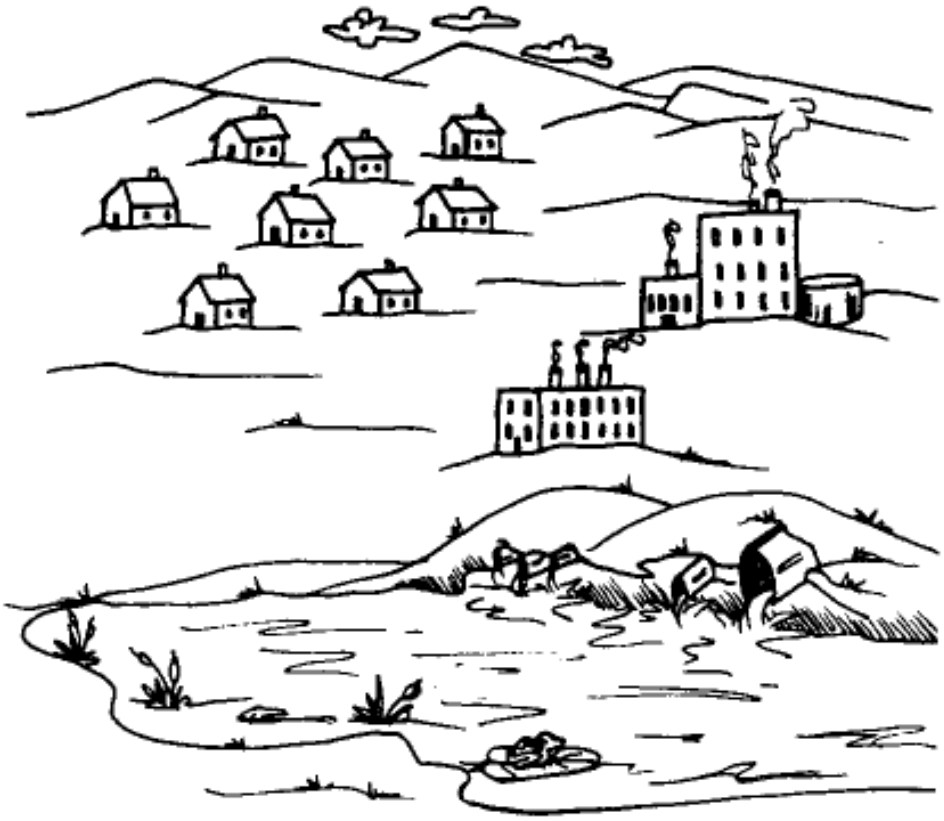


A beautiful park was built on the other side of the creek near Mudpuppy Pond. A bridge was built over the creek so people could travel back and forth. Some cars traveling across the bridge are leaking oil. The rain is washing the oil into the creek. (Pour contents of jar 4 into the creek.) How does Verde Frog feel?

6

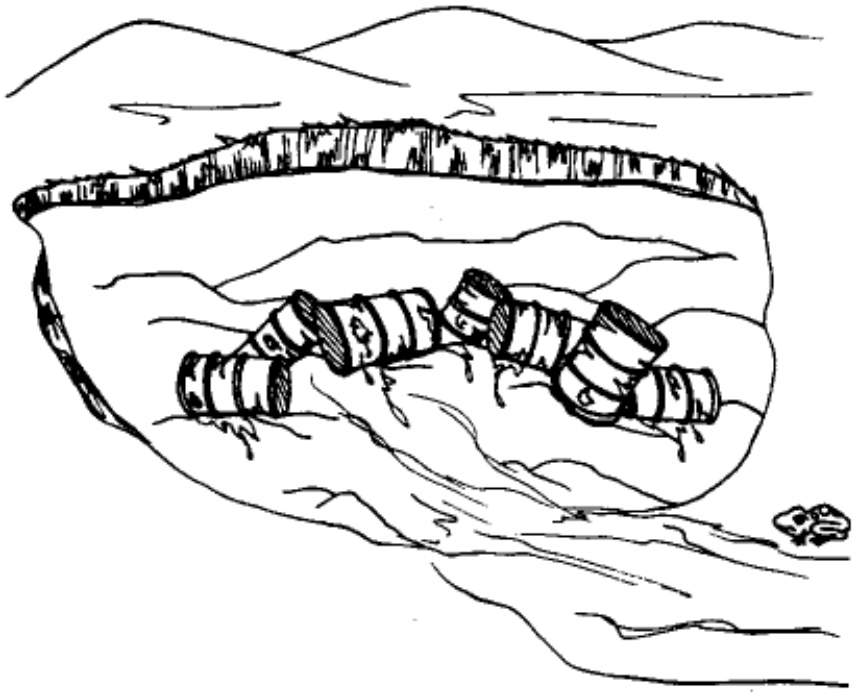
People visit the park often. They play games and picnic near the water. Some people don't throw their trash into the garbage cans provided by the Parks and Recreation Department. The wind is blowing paper into the creek and pond. (Pour the contents of jar 5 into the pond and creek.) How does Verde Frog feel?

7



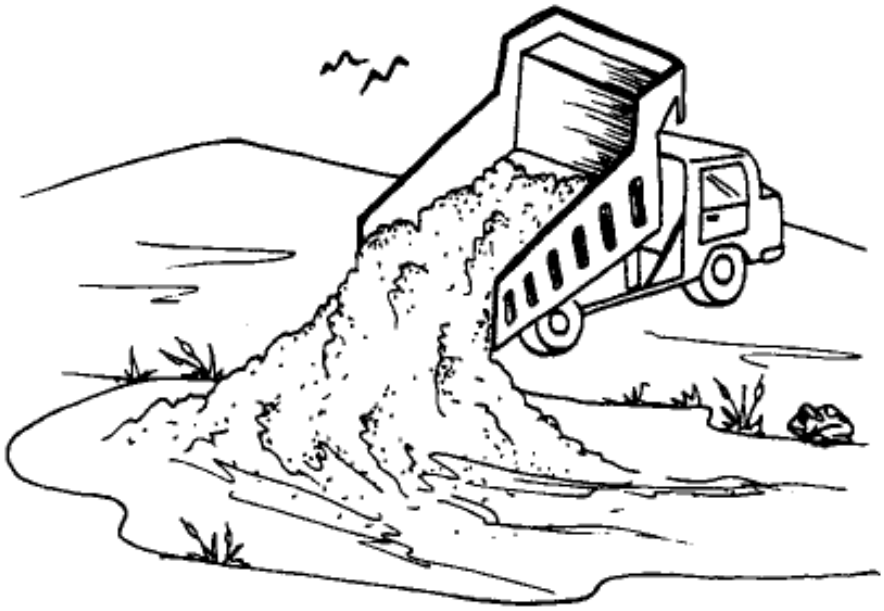
The town began to grow and several factories were built near the creek upstream from Mudpuppy Pond. Although laws limit the amount of pollution the factories are allowed to dump into the water, the factory owners don't always obey the laws. (Pour contents of jar 7 into Mudpuppy Pond.) How does Verde Frog feel?

8



A hazardous waste landfill was built to store dangerous materials. The town's people knew how important it was to prevent them from getting into surface water and groundwater. Over time, the barrels become rusty and toxic chemicals start leaking onto the ground. The rain washes these chemicals into Mudpuppy Pond. (Squirt one drop of green food coloring into Mudpuppy Pond for every barrel that is leaking.) How does Verde Frog feel?

9



The growing town needed more electricity than the neighboring town's power plant could supply. The town built a coal-burning power plant close to Mudpuppy Pond. The pollution laws and rules aren't as strict as they should be, so the plant dumps the ashes left from burning coal into the pond. The ashes have a lot of metals in them. Mercury is one of those metals that is harmful to the wildlife living at Mudpuppy Pond. (Pour contents of jar 8 into Mudpuppy Pond.) How does Verde Frog feel?

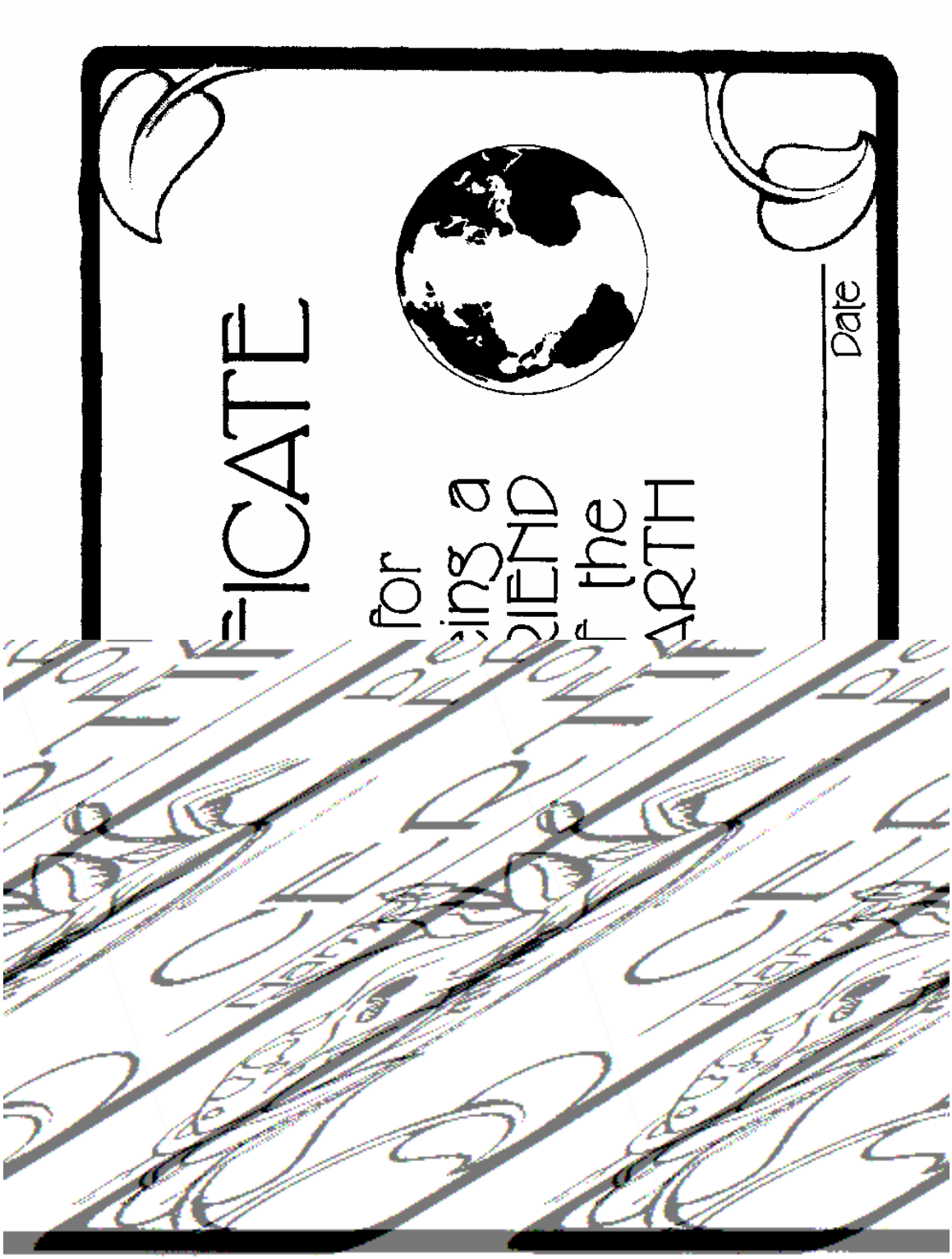
10

Local residents discovered a mineral on a hill near Mudpuppy Pond. Mining is started to remove the mineral. The owners dump the rocks removed from the hill near the pond. As the rock pile grows, some of them fall into the pond. The rocks are filling in the place where the creek runs into Mudpuppy Pond. Fresh water cannot flow in. Soon, the water becomes smelly. (Pour contents of jar 9 into the creek where it runs into the pond.) How does Verde Frog feel?

11

Mudpuppy Pond has changed. People forgot that every living thing has a purpose and exists so that other living things can continue to live. The pollution in the lake has upset the balance in Verde's environment. How can we help Mudpuppy Pond become healthy again?

12



WHAT'S THE POINT: POINT VS. NONPOINT

Grade Level
K-2
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Language Arts, Math
Time
1-2 class periods
Materials
- Verde Frog's habitat from Mudpuppy Pond
- Construction paper (red, blue, yellow, green, brown)
- Bucket, basket or box
- Mudpuppy Pond big book
- Student activity page
- Assortment of recycled materials (fabric scraps, wooden skewers, Popsicle sticks, plastic lids, wood pieces)
- 11 sheets of 11" x 14" chart paper

Setting
Classroom
Terms
Bacterial water pollution, Conserve, Erosion, Fertilizer, Nonpoint source pollution, Nutrient pollution, Point source pollution, Sewage, Thermal pollution, Toxic pollution
Reference
Adapted from the Water Sourcebook Series K-2, U.S. Environmental Protection Agency

Summary

The Mudpuppy Pond Story is used again to establish the difference between point and nonpoint source pollution.

Objectives

Students will:

1. Define, orally or in writing, point and nonpoint source water pollution.
2. Identify, orally or in writing, types of point and nonpoint source pollution.
3. Discuss and evaluate, orally or in writing, lifestyle changes to minimize the damaging effects on habitats.
4. Identify, orally or in writing, ways to prevent water pollution.
5. Give an oral or written definition of the new terms: bacterial water pollution, conserve, erosion, fertilizer, nonpoint source pollution, point source pollution, sewage and thermal pollution.

Procedure

Advance Preparation

Cut two inch squares from red, blue, yellow, green and brown construction paper. Use enough red, yellow and blue squares for all of the students but two. Add one green and one brown. Students will each receive one square of colored construction paper.

Copy the Mudpuppy Pond story and the student activity page. Cut 11 sheets of 11" x 14" chart paper into water drop shapes. Glue a page from Mudpuppy Pond story on back. Gather an assortment of recycled materials for students to use to problem solve ways to prevent pollution from entering waterways. Gather water pollution reference books from library or see the Resources section for ideas and Internet downloads.

Warm Up

Ask the students, "What is pollution?" Tell students there are two types of water pollution, point source and nonpoint source, in the story Mudpuppy Pond. Write the words on the board.

To help students understand these two types, do this pollution simulation activity. Pass out one construction paper square to each student. (There will only be one square of green and one square of

brown passed out). The squares represent different types of pollution. Tell the students to write the color of their "pollution" square on a piece of scratch paper. Then the students will place the "pollution" squares into a bucket (the pond). Mix the squares, then have all the students with red squares come up and pick out the exact pollution square they put into the bucket. Since all the red squares look alike, it is impossible to find the exact square. Have all red students sit together with pollution squares in the middle. Do this activity with all the colors until all "pollution" squares have been passed out. Tell students that it is easy to point to the brown and green "pollution" squares. They are called point sources. Point source pollution can be traced to a certain pipe or culvert. Nonpoint source pollution comes from specific areas or the red group, blue group, and yellow group, but it cannot be assigned or pointed to one person or source. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground carrying pollutants with it. This type of pollution is hard to control because it comes from many different places with people and animals contributing to the problem. We all contribute to the problem without realizing it.

Activity

1. Prior to reading the Mudpuppy Pond story again to the class pass out the student Point/ Nonpoint Source activity page. Pause after reading each page for students to write a naming word that tells who polluted the waterway, recording it under the heading they believe is correct.
2. After reading the story, discuss the various sources of pollution.
3. Record the source under the correct heading on chart paper and discuss.

Teacher's Answer Sheet and Solution Suggestions			
Page	**Pollution**	**Point or Nonpoint**	**Solution**
3	Erosion/ Sediment	Nonpoint	No-till farming, Planting a buffer
4	Animal Waste	Nonpoint	Build a fence to keep animals out
5	Fertilizers/ Pesticides	Nonpoint	Plant a buffer, Use less chemicals
6	Leaking Oil	Nonpoint	Fix car
7	Litter	Nonpoint	Recycle or throw away garbage
8	Factory	Point	Hire more inspectors, Make laws
9	Toxic Waste	Nonpoint	Use a liner in landfill
10	Ashes	Point	Make laws for proper disposal
11	Mining	Nonpoint	Make laws for proper disposal

Follow-Up

Tell students each individual can play an important part in stopping pollution by changing certain everyday habits or by using the land responsibly. Brainstorm ways to prevent pollution from entering waterways. Help students come up with solutions on their own by asking questions like, "What could we do to stop litter from going into the pond?" or "What could we do to stop pet waste from going into the pond?"

Place the students in 11 cooperative groups. Pass out chart paper. Have each group read its part of the story. Then, turn the sheet over and semantically map ways to keep pollution from getting into the water. The group may use reference books or brochures that have been placed in the classroom reference center.

Display each group's web on a bulletin board.

After gathering information, each group will use recycled supplies to correct problems in simulated Mudpuppy Pond community. For example, they could use fabric pieces to prevent erosion or create garbage cans to prevent litter.

Extension

Make a chart with the three headings “Problems, Causes, Solutions,” placed where everyone can see it. Write and illustrate an environmental leaflet that addresses the causes and solutions to point source and nonpoint source pollution.

What's the Point: Point vs. Nonpoint Student Activity Page

Point Source Pollution

Nonpoint Source Pollution

NOW YOU SEE IT, NOW YOU DON'T

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Physical Science
Time
60 minutes
Materials
- Cafeteria trays
- Styrofoam egg carton or test tubes
- Water
- Craft sticks, one/child
- Plastic spoons, one/tray
- Newspaper
- Dry materials: salt, hot chocolate mix, sand, fine gravel, corn meal, flour, seeds
- Cooking oil
- Jar with lid
- Kool-Aid
- Sugar
- Spoon
- Pitcher
- Measuring cup
- Cup for each child
- Copies of handout

Extension Materials
- Clear jar
- Oil
- Food Coloring

Setting
Classroom
Terms
Dissolve, Liquid, Solution, Suspension
Reference
Adapted from the Water Sourcebook Series K-2, U.S. Environmental Protection Agency

Summary

Using various materials, students recognize substances that dissolve and substances that do not dissolve in water.

Objective

Students will:
1. Give an oral or written definition of dissolve, liquid, and solution.
2. List, orally or by writing, substances that dissolve in water.
3. Explain how water can carry pollutants.
4. Classify, orally or by writing, substances into categories "will dissolve" and "will not dissolve" in water.

Procedure

Advance Preparation

Put newspaper on trays (1 tray per group of 4) and place one egg carton on each tray. Fill one row of sections with water (3/4 full). Opposite each section of water, put a dry material. Use as many different dry materials as number of sections of water. Older students could measure their own materials to practice measuring skills. Place four craft sticks and one plastic spoon on each tray.

Warm Up

Have the entire class watch as a pitcher of Kool-Aid is being made. Name the ingredients as they are added. Give each child a cup of Kool-Aid. Ask the children questions such as: Where is the sugar? Where is the powdered Kool-Aid? Can you feel them? Can you see them? Is it still there? Can you taste them? Listen to answers and give correct responses as needed. Be sure that students understand that they should not drink other scientific experiments and they will not be drinking any of the other solutions mixed in the activity.

The Kool-Aid is an example of a "solution." Explain the concept "dissolve" to the students defining "liquid" in the process. Tell the students that they are going to add different materials to water to test if they do or do not dissolve. Explain that pollution sometimes dissolves in water and water carries the dissolved pollution to the stream.

Activity

1. Divide students into groups of four.
2. Pass out trays and one student worksheet.
3. Have each group predict if the material will dissolve. Write “yes” or “no” on the worksheet.
4. Tell students to put a spoonful of salt in one section of their container. Stir it with the craft stick. Ask questions such as: “Can you see the salt?” “Can you feel it?” “Where is it?” On the worksheet under “Did it dissolve?” write “yes” or “no.”
5. Have the students try all of the other dry ingredients.
6. Discuss the results and explain that you cannot always tell what is in water by looking at it. Clear water can have salt and sugar just as clear water in a stream can have pollution in it.

Follow Up

Let the containers set for 30 minutes. Recheck and discuss the results. Point out that pollution in a stream may act similarly and not remain dissolved in the water forever.

For grades 3-5 follow activity with Knowing Nonpoint to make the pollution connection while the activity is still fresh.

Extension

As a class fill a clear jar half-full of water and add some oil and food coloring. Put the lid on tight and shake the container of water and oil. Discuss the fact that the food coloring will dissolve but the oil will not. Let the container set for a while. Recheck and discuss the results.

Now You See It, Now You Don't
Student Worksheet

Directions: For each material, predict if it will dissolve in water or not. Then test each material. Add one spoon of material to one section of water and stir.

Material	Will it dissolve?	Did it dissolve?	What happened after 30 minutes?
1. Salt			
2. Fine Gravel			
3. Corn Meal			
4. Hot Chocolate Mix			
5. Sand			
6. Flour			
7.			
8.			

KNOWING NONPOINT

Grade Level
3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Social Studies
Time
1 to 2 class periods
Materials
- Broom
- Recycled paper (3 per students)
- Role cards (1 per student)

Extension Materials
- Aluminum Foil
- Food Coloring
- Salt and Pepper
- Water spray bottle

Setting
Classroom
Terms
Nonpoint source pollution, Point source pollution
Reference
Adapted from the International Office for Water and Science Education, Utah State University

Summary

Students assume the role of various community members and discover the many ways everyone contributes to nonpoint source pollution.

Objective

Students will:
1. Define nonpoint source pollution and explain the difference between point and nonpoint sources.
2. Explain the ways that each community member contributed to NPS pollution.
3. Suggest ways each community member can help prevent nonpoint source pollution.

Procedure

Warm Up

Write the terms nonpoint source pollution and point source pollution on the board. Ask students what they think the terms mean. Accept all answers, but do not define the terms. Indicate that the activity they are going to do next will demonstrate nonpoint source pollution.

Activity

1. Distribute role cards (one per student).
2. Discuss how the different groups represented on the cards can pollute the water.
3. Distribute three sheets of recycled paper to each student. Have each student identify two or three different pollutants that could come from the activity described on their role card. Write one pollutant on each of the two or three papers. Then tell them to wad up each paper and throw it on the floor.

Example: If a student were given a paper that says, "You live in an urban development" the student might write on the three separate pieces of paper:

1. *Oil from my car dumped on the ground.*
2. *Spilled paint cleaned up and put in trash.*
3. *Grass clippings washed down the storm drain.*

4. Assign a person to be the "rain person," who uses a broom to

sweep the paper into a pile, simulating rain water flowing into a lake.

5. Place the following headings on the chalkboard: Agriculture, Mining/Logging, Urban (business/home), Waste Disposal and Construction. Unfold each paper and list each pollutant under the appropriate heading.
6. Once the list is completed on the board, discuss the results with the class. For example, was the oil from just one car harmful? Was the oil from all the cars harmful? Even though each student only dropped three pieces of paper, look how much it added up.
7. Have students suggest ways each community member could help prevent nonpoint source pollution.

Follow Up

Discuss your community's water supply. Where does it come from? How might it become contaminated?

Teacher's Note: Here is a list of the role cards and some examples you can use to guide the students.

Farmer (crops): Pesticides, Fertilizers, Soil erosion
Farmer (livestock): Bacteria from manure, Nutrients from manure, Soil erosion
Driver: Leaking oil, Leaking antifreeze, Phosphate from car wash soap
Airport: Spilled fuel, Deicing fluid for plains, Leaking oil
Grocery Store Owner: Salt from parking lot, Leaking oil from cars, Leaking antifreeze
Zoo: Leaking oil from cars, Salt from paths, Manure from animals
Home Mechanic: Spilled oil when changing, Dumped extra paint, Excess cleaners
Gas Station Owner: Spilled fuel, Leaking underground tank, salt from parking lot
Homemaker: Bleach and CLR on outside of home, fertilizers, pesticides
Principal: Salt in parking lot, Excess paint dumped in drain, Pesticides
City Streets: Salt, Oil, Antifreeze
Logging Company: Soil erosion, Oil from trucks, Fuel from chainsaw
Miner: Acid drainage, Soil erosion, Minerals or metals
Landfill: Toxic leaking, Bacteria, Nutrients from decomposing items
Lawn: Fertilizers, Pesticides, Fuel from mower
New Roads: Soil erosion, chemicals from tar, automotive fluids
Contractor: Soil erosion, arsenic from treated lumber, automotive fluids

Extension

Create an aluminum foil watershed. Form the foil into mountains, valleys, and rivers. Sprinkle pepper and drop some red, blue and green food coloring on different parts of the watershed. Use a spray bottle to make it rain and collect the run off. What does it look like? Where did the pollution come from? What can be done to clean it up? What could have been done before it rained?

Knowing Nonpoint Student Role Cards

You are a farmer who grows wheat and corn.	You are a farmer who grows apples and grapes.	You are a rancher who raises sheep.
You are a farmer who raises pigs.	You drive five miles to work everyday.	You are in charge of an airport.
You are a farmer who raises cattle.	You operate a large grocery store.	You operate a zoo.
You like to work on your car at home.	You own a gas station with large underground tanks.	You are a homemaker who likes to keep your house clean.
You are a principal of a large school.	You are in charge of your city streets	You own a large logging company.
You produce coal from your mine.	You produce copper from your mine.	You are in charge of a landfill.
You have a large lawn.	You are in charge of building new roads in your town.	You are a major contractor in your community.

WATER POLLUTION DETECTIVES

Grade Level
3-5, 6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Social Studies, Language Arts
Time
2-3 class periods
Materials
- Can you "Detect" Potential Water Pollution Problems? Handout
- Copies of Guided Imagery for all students
- Magazines, photographs, slides, or other pictures of water pollution (optional)

Setting
Classroom
Terms
Algal bloom, Contaminate, Erosion, Forestry, Mining, Nonpoint source pollution, Pesticide, Phosphate, Point source pollution, Water pollution
Reference
Adapted from Environmental Resource Guide, "Water Pollution Detectives", grades 6-8, 1992, with permission from the Air and Waste Management Association, Pittsburgh, PA 15222.

Summary

Students use guided imagery to identify different contributors to nonpoint source pollution.

Objectives

Students will:

1. Define water pollution and describe the difference between point and nonpoint.
2. Describe the main sources of water pollution- urban, agriculture, mining, and forestry and list examples of each.
3. Identify ways to minimize nonpoint source pollution.
4. Read descriptive passage for cause and effect.

Procedure

Warm Up

Introduce the terms water pollution and point and nonpoint source pollution. Pass out student handout "Can You 'Detect' Potential Water Pollution Problems?" While looking at the illustration, have the students distinguish point from nonpoint and explain why. Read the brief history of the Clean Water Act in the Storm Water District Background (page iv-v).

Explain to the students that in this activity they will be traveling back in time to the 1960's to explore some of the bad environmental practices we had in the past and how they have changed today. Tell the students that this lesson will introduce them to four major sources of water pollutants - urban, agriculture, mining and forestry. Note that urban includes cities, residential areas, malls, industries and roadways.

Activity

1. Pass out copies of the guided imagery.
2. Read the guided imagery to the class or have students take turns reading out loud.
3. After each passage, ask the students to identify and write down the source of the pollution and explain why. If you would like, show students an image of the pollution after each passage.

Guided Imagery

Introduction: We are going to travel back to 1960. Imagine the following:

1. It's raining during rush-hour traffic in an industrial park where several factories are changing shifts. Smoke is billowing from the smokestack at the factories and from some automobile and truck exhaust pipes. Visibility is limited due to the smog and drivers are being very cautious of the wet roads.
   What is the pollution source?

2. Rain is also falling on parking lots at shopping malls and on the highways. The waters flow into a nearby stream. After the rain stops, some boys playing in the water downstream notice that there is a light film of oil on the water.
   What is the pollution source?

3. Farther downstream the boys notice a house being built and the stream is muddy.
   What is the pollutant source?

4. This same stream then flows by a cornfield that has been crop-dusted to kill corn earworm. The farmer's grandchildren who are fishing in the stream the next day notice that there are several dead fish in the water that were not there the day before.
   What is the pollution source?

5. The farmer's grandchildren decide to continue on downstream to find another fishing spot. The stream continues to flow by another farmer's land where there are dairy cows. Some cows are grazing in the pasture and others are drinking out of the stream. The children notice that the water is very muddy.
   What is the pollution source?

6. The children continue hiking on downstream and pass a cornfield. They remember how hot they were last month when they helped their grandfather fertilize the field to get it ready to plant. They remember how wonderful it was when it rained the next day. At last the children came upon a spot where they usually catch many fish. They found algae and weeds that were not there during the first part of the summer. The children wonder why there were so many algae and weeds growing in the stream now.
   What is the pollution source?

7. Meanwhile, back in the city, employees of the wastewater treatment plant notice an increase in bacteria when conducting their routine water tests on the 3:00 pm-11:00 pm shift. The employees remember that the heavy rains earlier in the day washed a lot of mud and litter down gutters and curbs and caused the storm sewers to overflow.
   What is the pollution source?

8. During the next week, employees of the wastewater treatment plant notice the creek turns green and smells. The employees couldn't understand this, so they look at maps to determine if any creeks flowing into the river might be the source of the new pollution. They notice that a creek a couple of miles upstream flows by the new golf course that had just opened and they call the golf course office to find out if they had fertilized their grass. They had, in fact, fertilized it right before a heavy rain.
   What is the pollution source?

9. The drinking water treatment plant employees do a metal analysis and find that there is an unacceptable amount of lead in the water. They look at their map for possible areas where metal might be entering the creek. The employees notice an abandoned area by a creek, which flows into the river that is the source of the city's drinking water. Officials go to check the area and find half-filled paint cans among garbage that had been illegally dumped.
   What is the pollution source?

10. Months later, drinking water treatment plant employees notice test results that indicate that the water is too acidic. Remembering that a coal mine is located near one of the streams that flow into the river they use for drinking water, they send someone over to check the situation. The coalmine had been abandoned.
    What was the source of pollution?

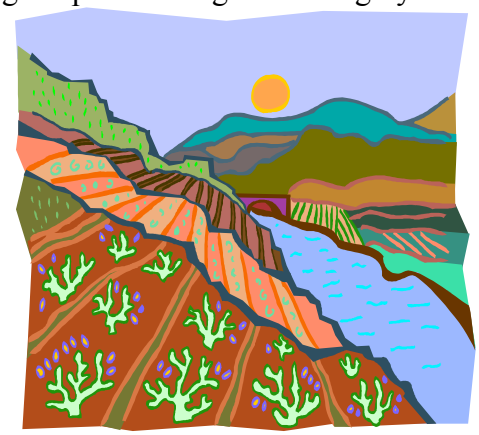
11. For several months, the wastewater treatment plant had an increase in the amount of sediment in the water, so they sent someone to check this out. They find that a "fly-by-night" logging company had clear-cut the forests near the creek that is used for drinking water.
    What was the pollution source?

Answers to Guided Imagery Pollution Sources:

1. URBAN- Gases from fossil fuel burning power plants, industrial smokestacks, cars, and trucks cause air pollution and acid rain.
2. URBAN- Oil and other deposits from automobiles were on the parking lot and highway pavement and as rainwater flowed over the parking lot and highway it became polluted.
3. URBAN- Erosion from bare land exposed during construction.
4. AGRICULTURE- The pesticide drifted into the stream when the field was being crop-dusted and killed the fish.
5. AGRICULTURE- Dairy cows are trampling down the stream bank and are also depositing animal wastes into the water. "Trampling" results in loss of vegetation and increased erosion. Animal wastes can pollute the water with bacteria and nutrients. This is making the water muddy.
6. AGRICULTURE- The fertilizer runoff (excessive nutrients) from the cornfield caused the algal bloom and excess aquatic weed growth.
7. URBAN- Heavy rains cause pet wastes, soil and litter to wash from paved and other hard surfaces into streams. Both pet waste and litter can contribute bacteria to the stream. Also if storm sewers are combined with sewers for domestic and commercial wastes, untreated waste may also be released to surface waters following heavy rains.
8. URBAN- the fertilizer washed into the creek that eventually flowed into the river that was used by the water treatment plant. The fertilizer added nutrients, which caused an algal bloom.
9. URBAN- The old paint contains lead and the rain-washed the lead into the creek that flowed into the river used by the drinking water treatment plant.
10. MINING- The runoff from the spoil piles of leftover rocks flowing into the creek was acidic. Spoil piles contain sulfur and other compounds which turn into acids when they combine with water.
11. FORESTRY- When the forests are clear-cut and the bare soil is not protected, soil erosion increases. Therefore, there is more soil or sediment flowing into streams. More sediment makes the water muddy.

Follow Up

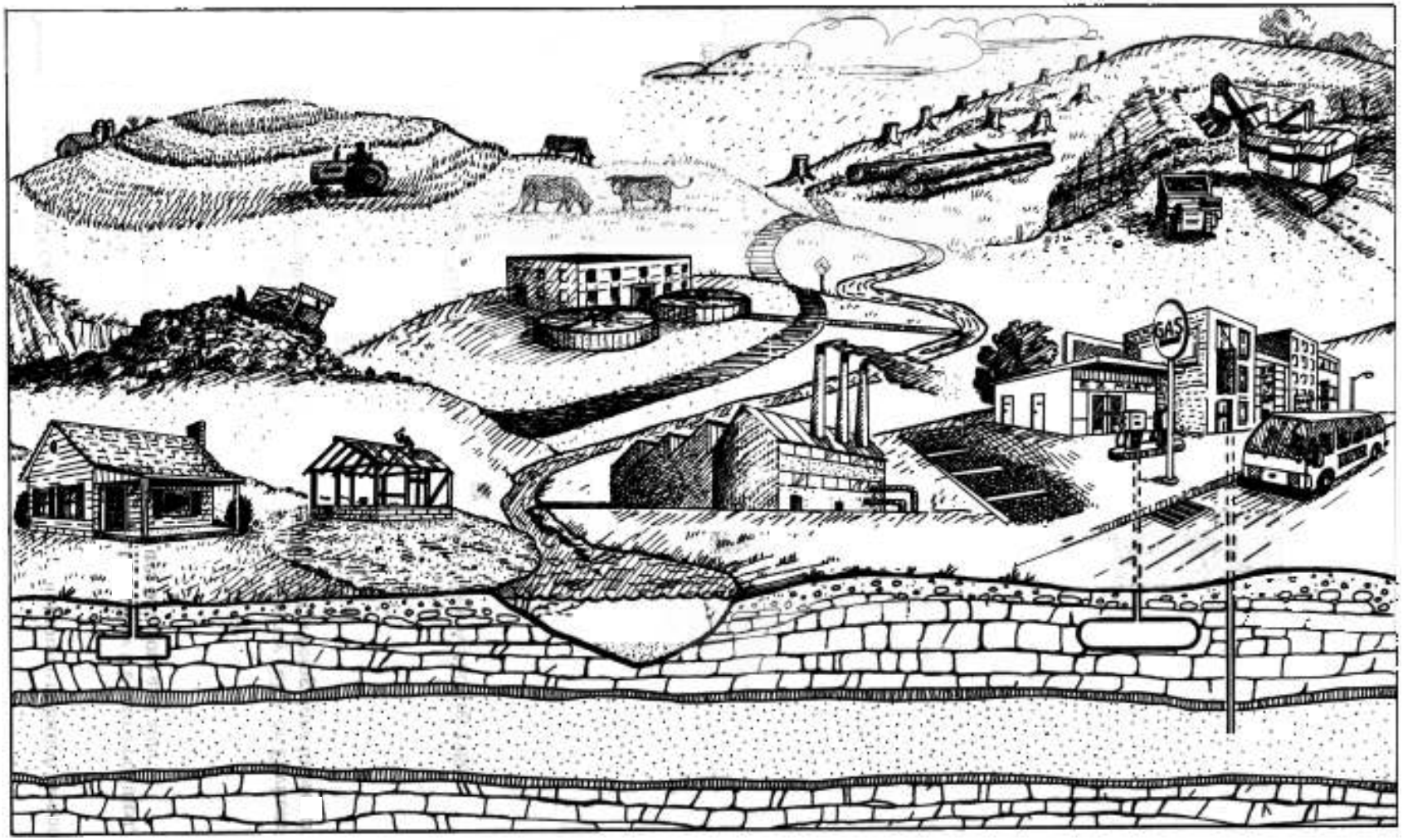
Divide the class into 11 small groups and have them research what people have done since 1960 to prevent the type of pollution described in their assigned part of the guided imagery. An Internet search or the EPA website would be helpful. Have each group rewrite their guided imagery using their research and share them with the class. After each story have the students explain what is different and how it prevents pollution. Guide younger students through the research by selecting books and other materials.



Extension

Have students research and write a plan detailing what they can do personally to reduce pollution in their home, school and community, (e.g., ride bike to school instead of having parents drive them).

CAN YOU "DETECT" POTENTIAL WATER POLLUTION PROBLEMS?



USE YOUR HEAD, PROTECT YOUR WATERSHED!

Grade Level
3-5, 6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Math, Social Studies
Time
50 minutes
Materials
- Candy (e.g., Skittles ®, M+Ms ®)
- Plastic sandwich bags (1 bag per student or group)
- Graph paper
- Colored pencils (optional)
- Paper towels

Setting
Classroom
Terms
Ammonia, Bacteria, Fertilizers, Hazardous, Nitrate, Pesticides, Phosphate, Sediment, Water quality
Reference
Utah Nonpoint Source Pollution Activities for Grades 1-12, Dr. Kitt Farrell-Poe, Extension Environmental Engineer, Utah State University

Summary

Students describe and identify land use activities within a simulated watershed by analyzing its water quality and creating a graph.

Objective

Students will:
1. Describe and identify land use activities within a watershed.
2. Create a graph from numbers.
3. Explain how different watersheds contain different pollutants.
4. Associate pollution problems with land use activities.

Procedure

Advance Preparation

Decide if students will work individually, in pairs or in groups. Each "unit" of students will have one bag. Divide candy amongst the bags. There should be about 30 pieces of candy per bag. Each baggie represents a water sample from a different watershed. Have students wash their hands so they can eat the candy after the activity.
(Teacher's Note: You could use pieces of colored paper if you did not wish to use candy in class).

Suggested Color Ratio
Agriculture- Brown=15, Red=8, Green=7
Ranch- Brown=15, Yellow=15
Urban Development- Brown=30
Forestry- Brown=15, Red=15
Human Waste Disposal- Yellow=15, Green=15
Surface Mining- Brown=10, Purple=10, Green=10
Residential- Orange=8, Blue=8, Red=8, Green=6

Suggested Color Assignment
Sediment=Brown, Pesticides=Red, Oil=Blue, Metals=Purple, Fertilizers/Excess Nutrients=Green, Animal/Human Waste=Yellow, Antifreeze=Orange

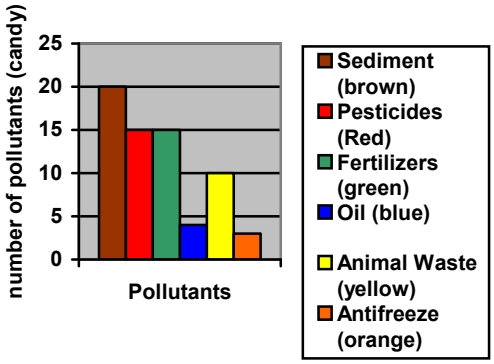
Warm Up

Use the table on the next page to initiate a discussion about the pollution that can come from different land use activities. Review nonpoint source pollution and the meaning of any terms with which students are unfamiliar. Review the key parts to making a bar graph.

Activity

1. As a class assign a pollutant (or group of pollutants) to each color of candy or use the suggested assignments.
2. Distribute graph paper to each student (or group). Have the students draw a bar graph of the pollutants in their watershed. Label the x-axis with the names of the candy colors or pollutants and the y-axis with numbers.
3. Give each group a baggie with candy and a paper towel on which to put the candy.
4. The students should separate and count the number of each color and graph them on the graph paper. Colored pencils can be used to fill in the bars. For younger students, have them make a bar graph by lining their candies up in vertical columns. Have the students infer what land use activities are occurring in their watershed.

Pollutants in Watershed



Follow Up

Discuss how each watershed is different and why some watersheds might contain an abundance of one certain type of pollutant. Almost all forms of pollutants can be found (even in small amounts) in each watershed. Can they classify their watershed (e.g., agricultural, industrial, urban, forest)?

Extension

Ask students to perform computer research on hazardous materials like paint and antifreeze. They could research where the product comes from, how it could contaminate storm water, what the effects are and how it could be properly disposed.

Have students construct a collage or poster within different watersheds (i.e. Little Miami, Mill Creek).

Land Use	Activities	Problems
Agriculture	Tillage, cultivation, pest control, fertilization, animal waste mgmt.	Sediment, nitrate, ammonia, phosphate, pesticides, bacteria
Urban Development	Land clearing, excavation and grading	Sediment
Forestry	Timber harvesting, road construction, fire control, weed control	Sediment, pesticides
Human Waste Disposal	Septic systems	Bacteria, nitrate, phosphate
Surface Mining	Excavation, extraction	Sediment, heavy metals, acid drainage, nutrients
Residential	Automobile maintenance, lawn and garden care, painting	Oil, gas, antifreeze, nutrients, pesticides, paints

WATERSHED WATER ANALYSIS	
Color of Candy	***Type of Contaminant***
Red	
Orange	
Yellow	
Green	
Brown	
Blue	
Purple	

YOU BE THE JUDGE

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Fine Arts, Environmental Science
Time
2 class periods
Materials
- "You be the Judge" script
- Slides or pictures representing various activities mentioned

Setting
Classroom
Terms
Algae, Fertilizer, Nonpoint source pollution, Pesticide, Phosphate, Sediment
Reference
Adapted from Maine Department of Environmental Protection Lesson Plans, David Courtemanch
Bureau of Land and Water Quality and from a script used at the 1997 Children's Groundwater Festival by the Lower and Upper Elkhorn Natural Resource Districts, Nebraska

Summary

Students act out a trial to better understand various sources of nonpoint source pollution.

Objective

Students will:
1. List various sources of pollution and the associated pollutant.
2. Explain possible solutions to nonpoint source pollution.
3. Improve public speaking skills.

Procedure

Advanced Preparation

The script mentions showing slides occasionally to give students a realistic view of the polluting activities. Slides, magazine clippings or pictures could be used or substitute the slides for pictures the students draw themselves. Here is a list of the pictures the script requests:

- Animals in a creek or stream
- Pesticides being applied
- Manure being spread
- Eroding ditch
- Sediment, oil and litter polluted water
- Area near river where trees are cut down
- Earth moving machinery
- Area with large amount of trees cut away
- Graded soil

Warm Up

Review the concepts discussed in the trial such as types of fish that live in the Ohio River and sediment pollution.

Choose students to play the roles of the defendants, prosecutor, defense attorney(s) and bailiff. The remainder of the students can be the jury. The teacher or a student can play the role of the judge. If students know ahead of time, they can bring costumes in for their respective characters the day of the activity.

Activity

1. Pass out scripts to all the students who have lines to read.
2. Set up the classroom so there is a section for the jury, a chair for the judge and desks for both prosecuting and defense attorney(s).
3. Read the script.

Follow Up

Ask whether these are truly crimes that someone could be brought to trial for (no). All these practices and problems are actually instances where a person has made a poor decision that could result in water pollution. In each instance, there are better alternatives that could be used to achieve the same results without affecting water quality. Discuss what a few of these alternatives might be.

YOU BE THE JUDGE SCRIPT

BAILIFF All rise. Water Court is now in session. The Honorable Judge I. R. Fair presiding.

JUDGE Be seated. Bailiff, please call the first case.

BAILIFF People versus the Citizens of Hamilton County, Ohio. The charge is the pollution of the County's waterways.

JUDGE The prosecution and defense may now select the jury.

(Prosecutor and defense attorneys now ask questions of the jury to determine if they are fit to hear this trial.)

PROSECUTOR

What is the name of the tiny, one-cell green plants that live in lake water? (*Green algae*)

What element is important to control algae pollution in our lakes? (*Phosphorus*)

Name three sources of phosphorus pollution. (*Fertilizers, Manure, Detergent*)

DEFENSE

Why is oxygen important in our water? (*Necessary for aquatic wildlife to breath*)

Name three fish that live in the Ohio River. (*Catfish, Gar, Perch*)

Name three uses of our lakes that require good water quality. (*Drinking, Swimming, Fishing*)

PROSECUTOR AND DEFENSE Your Honor we find this jury to be knowledgeable about water quality and are therefore fit to try this case.

JUDGE Prosecution may now proceed with the opening statements.

PROSECUTOR Your Honor, I am Will Convictum, prosecuting attorney for the people of Hamilton County, Ohio. I would now like to show the court that certain citizens of Cincinnati and the surrounding areas are polluting the waters of Hamilton County. With the help of the county's Soil and Water Conservation District I have assembled some slides that document what is going on in this town. (Slides)

Thank you your Honor.

DEFENSE Your Honor, My name is Gedoff Easy, defense attorney for the people of Hamilton County. All of the law-abiding citizens to whom the Prosecutor is referring have done nothing more than live their everyday lives and I will show that these citizens are not responsible for the polluted waters of Hamilton County.

BAILIFF Defendants, please stand and raise your right hand. Do you swear to tell the truth, the whole truth and nothing but the truth.

DEFENDANTS I do.

JUDGE Thank you, prosecutor, you may call your first witness.

PROSECUTOR I call the defendant Mr. Herb E. Side, local farmer. Mr. Side, as prosecuting attorney I would like to ask you a few questions about your farm to determine if you are guilty or innocent of polluting the waters of Hamilton County, Ohio.

Do you allow your animals to walk in and drink from Taylor Creek, which flows to the Great Miami River? (Slide) (Defendants always answer in the affirmative to each question)

Do you apply quantities of pesticides to your crops, even before a rainstorm? (Slide)

Do you spread manure on your fields in the winter when it can runoff into nearby waters? (Slide)

I have no further questions of Mr. Side, your Honor.

JUDGE Does the defense wish to ask any questions of the defendant.

DEFENSE Mr. Side, I would like you to answer a few questions that may show your innocence.

Mr. Side, isn't your farm one of the most prosperous and beautiful in all of Hamilton County? (Defendant always answers questions in the affirmative)

Mr. Side, don't you let the children in town come and pet your animals because they are so tame and you keep your barnyard so clean?

Mr. Side, don't people from all over town come to your farm to buy your produce because there is never a bug or a worm on your fruit and vegetables?

Thank you, I have no further questions, your Honor.

PROSECUTOR For my next witness I call the defendant Ms./ Mr. B.G. Homoner. Ms. Homoner, I would like to ask you a few questions about your home on the Little Miami River.

Isn't it true, Ms. Homoner, that your driveway has an eroding ditch that causes a mud flow to the Little Miami River every time it rains? (Slide)

Doesn't the water from your roof and your driveway flow directly into the Little Miami River carrying with it all the dirt, oil and litter that has accumulated on these surfaces since the last rain storm? (Slide)

Haven't you cut down all the trees along this section of the Little Miami River to make a lawn and don't you apply excessive amounts of fertilizer and pesticides to that lawn to keep it green? (Slide)

I have no further questions, your honor.

JUDGE Does the defense wish to ask any questions of the defendant?

DEFENSE Ms. Homoner, allow me to ask a few questions that may prove your innocence.

Don't you have one of the greenest lawns in Hamilton County with hardly a blade of crabgrass?

Would you agree that your house is one of the nicest ones on the Little Miami River and that you pay a lot of taxes to live there?

Don't you have a nice road and large driveway so you can invite your many friends over to enjoy the river?

Thank you, your Honor.

PROSECUTOR For my last witness, I would like to call the defendant Mr./Ms. Gotta Bulldoze, local building contractor. I would like to ask you about the kind of construction work that you do around Hamilton County, Ohio.

Isn't it true that you have a lot of large machinery that can dig up large amounts of earth and even change the flow of small streams? (Slide)

Isn't it true that you often cut down large areas of trees, and leave areas of land without vegetation even though it erodes in a heavy downpour? (Slide)

And don't you grade the earth so that storm water runs off quickly to the nearest stream or lake? (Slide)

Thank you, your honor. The prosecution rests its case.

JUDGE Does the defense wish to ask any questions of the defendant.

DEFENSE Mr./Ms. Bulldoze, I think I can clear up any misunderstanding about your work if you will answer a few questions.

Aren't you one of the most successful contractors in the area because you get your work done fast and cheap?

Don't you like to keep a large area of earth cleared so you can drive your bulldozer and dump trucks at top speed to get your work done?

Aren't you proud of your ability to drain the land so that your workers and machines never have to get muddy?

Thank you, your Honor; the defense rests its case.

JUDGE Members of the jury. How do you find each of the defendants, guilty or not guilty? (Read each defendant's name (Herb E. Side; Ms./Mr. B.G. Homoner, Ms./ Mr. Gotta Bulldoze) and have the jury vote on his or her guilt or innocence.)

JUDGE Do any of the defendants wish to make a statement before sentencing?

(Read the defendant's name: Herb E. Side; Ms./ Mr. B.G. Homoner, Ms./ Mr. Gotta Bulldoze) Instead of sentencing you to jail time or a fine I sentence you to community service.

(Pick one of the following)

1. If you live near a river, plant a buffer to protect water quality (explain what buffers are and why they are important).
2. Inspect your home for leaking fuel tanks, pesticide and paint containers (do this only with the help of parents!).
3. Wash your family's car on the grass, not in the driveway.
4. Ask your parents to try one box of phosphorus free detergent.
5. Identify eroding areas around your schoolyard.
6. Use a plastic bag to pick up and dispose of your pet's waste.
7. Visit your town's recycling center and recycle something.

JUDGE I hope each of the defendants have learned something today. I'd like to thank the jury for your time and help. Court is adjourned. (Bang Gavel)

ANALYZING STORM WATER ISSUES

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources*
Subject
Environmental Science, Language Arts, Social Studies
Time
3 class periods
Materials
- Copies of Activity Sheets 1 and 2
- Current information sources such as newspapers, magazines, state and federal agency reports, and videos.
- Butcher paper or Poster Board
- Markers and pens
- Tape
- Camera and Film (optional)
- Other materials for presentations

Setting
Classroom
Terms
Environmental Issue, Environmental Problem, Storm Water
Reference
Adapted from the Salt Lake County Storm Water Quality Education Lesson and Activity Plans Salt Lake County, Utah, Public Works Department Engineering Division

SALT LAKE COUNTY

Summary

Through the process of analyzing environmental issues, students learn about the many participants and perspectives involved and gain insight on the challenges to developing solutions.

Objective

Students will:
1. Identify, collect and analyze data about a storm water issue.
2. Identify and list individuals and/or groups who might be interested in or affected by a storm water issue.
3. Identify factors contributing to an issue.
4. Generate possible courses of action to solve problems and evaluate the advantages and disadvantages of these actions.
5. Select a proposed solution, recommendation or course of action, determine its feasibility and plan its implementation.
6. Prepare a presentation to forward their group's plan.

Procedure

Advanced Preparation

Make copies of the activity sheets, one per student. A few weeks in advance, have students begin collecting resource materials such as newspaper and magazine articles, brochures, links to websites and other resources regarding local water quality issues. The teacher can collect resources as well. "After the Storm video available free from USEPA. See resources section for ordering details.

Activity

Part 1 – Issue Analysis

1. Begin by asking students to distinguish the differences between an environmental problem and an environmental issue. Write the definitions of each so that it is visible for all. Discuss the other components of issue analysis, allowing the students to help define each component.
2. Working in small groups, have students read an article or watch a video regarding a local water quality issue. See the Resources section for information on obtaining such a video. The groups should then briefly discuss the article or video and summarize the

situation. Emphasize to students to look at the issue from both sides.

3. Distribute Activity Sheet 1 and have students complete it based on the information gathered in the article or video.
4. When students have completed Activity 1, discuss their findings. What is the main issue they are exploring? Who are some of the key players? What type of impact will this issue have locally, regionally or nationally? What types of additional information would be helpful? (If time permits, allow students to research additional information.) Review students' suggested solutions.

Part 2 – Alternatives and Action Planning

Components of Issue Analysis

Problem: A condition in which the status of someone or something is at risk.
Issue: A problem or its solution about which differing beliefs and values exist.
Players: The individuals, groups, or organizations having a role or interest in the issue.
Position: The point of view held by a player concerning the issue.
Solutions: The various strategies available to resolve the issue.
Consequences: The short and long-term by-products of one of the proposed solutions

5. Again in their small groups, students should examine the proposed solutions from Step 6, Activity Sheet #1. Ask the students to brainstorm consequences (both positive and negative) to each alternative.
6. Distribute copies of Activity Sheet #2. Each group should develop a plan of action for one of their alternatives, keeping the consequences they brainstormed in mind.
7. Have students create a recommendation statement and a presentation for the class, using posters, photos and other materials. Make sure students include how they would evaluate their course of action. *We recommend* (this action about the issue) *because* (of these facts) (and these opinions from our group). *The following steps would be necessary to implement our recommendation…*
8. Discuss the process with students. What were some of the challenges? Are you surprised by some of the alternatives presented? Did some seem silly at first and now seem more plausible? Could you suggest changes or improvements to any? How could we use this process to resolve other issues?

Follow Up

Have students write several paragraphs from the prospective of one of the issue's players. Then compare and contrast it with their perspectives about the issue.

Extension

Have students role-play the issue in the context of a public hearing, TV debate, radio show or panel discussion.

Analyzing Storm Water Issues
Student Activity Sheet #1

1. Article/Video name, date of publication and publication/organization name.

2. Description of the Issue:
    a. What is happening?

    b. Where is it happening?

    c. Who is affected and how?

    d. What are the impacts of the issue?

3. Rank the impact of the Issue (none, moderate or heavy) locally, regionally and nationally.

4. List some of the Players and their Positions on the Issue. Why might they take this particular perspective?

5. List the major factors you feel are affecting the problem.

6. List at least three possible courses of action to bring about an improvement or solution to the issue.

Analyzing Storm Water Issues

Student Activity Sheet #2

1. Suggested course of action (from Step 7, Activity Sheet #1).

2. List 2 positive and 2 negative consequences to selected course of action.

3. Identify individuals, groups and agencies that can help implement this course of action.

4. Implementation steps (what must be done, what order, when?)

5. How would you evaluate the effectiveness of your actions?

NAME THAT SOURCE

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Social Studies
Time
2-3 class periods
Materials
- Newspapers and magazines
- Scissors
- Colored felt markers or colored pencils
- 3" x 5" index cards
- Glue stick
- 2 buzzers or bells
- Camera and film (optional)

Extension Materials
- 2 equal sized poster boards
- Glue
- Cards from above

Setting
Classroom
Terms
Bacteria, Nonpoint source pollution, Nutrients, Particulate matter, Point source pollution, Sediment, Toxic
Reference
Adapted from Environmental Resource Guide, "Name That Source", grades 6-8, 1992, with permission from the Air and Waste Management Association, Pittsburgh, PA 15222.

Summary

Students use flash cards to identify sources and types of pollution and differentiate between point and nonpoint source pollution.

Objective

Students will:

1. Identify the source of the pollutant using flash cards to depict sources. More advanced students will identify the type (urban, forestry, agriculture or mining) in addition to distinguishing whether the source in nonpoint or point.
2. Identify the type of pollutant (sediment, nutrients, bacteria or toxics).

Procedure

Advanced Preparation

Have students make flash cards by cutting out pictures from old magazines and newspapers of potential sources of point and nonpoint source pollution. Include construction, automobiles, farms, factories, gardens and landfills. If pictures are not available, have students make sketches or take photographs around the community.

Use a spray adhesive or glue sticks to attach pictures and sketches to the 5" x 7" index cards. On the back of each card, write *a*. point or nonpoint, *b*. the source and *c*. the type. For example, a power plant discharge pipe would be *a*. point, *b*. urban *and c*. toxics.

Additional facts might also be added such as power plants may cause acid rain. Laminate the cards for future use.

Warm Up

Explain or review the following:

- Water pollution comes from point and nonpoint sources.
- Water pollution that can be traced to a single source, such as a discharge pipe from an industrial facility, is called a point source.
- Nonpoint source pollution enters water from many diffuse sources and is often difficult to control.
- Most nonpoint source pollution originates from four major land-use sources: urban, forestry, agriculture or mining.

- Nonpoint source pollutants include sediment, bacteria, nutrients and toxics.
- Nonpoint source pollutants such as bacteria, nutrients and toxics may bind or attach to sediment particles and be transported with sediment.

Activity

1. Divide the class into two equal teams and have the teams form two lines. The first person in each line will have one bell or buzzer. The teacher will flash the cards up one at a time so the students can see the card. The first team to buzz or ring gets to answer. Each team gets two points for every correct answer and loses one point for each wrong answer. To answer correctly students should give the three words (a, b, c) on the back of the card. If the answer is wrong the other team is given a chance to answer. Then, these two people move to the end of the line and let the next two have the buzzer or bell.
2. After each card discuss the answer, especially if one or both of the teams answer incorrectly. Use a piece of poster paper taped to the wall or the chalkboard to keep score. Continue until all the cards are used up.

Follow Up

Create a new game called "Name the Solution" which focuses on solutions to nonpoint source pollution problems. Students can work in groups to come up with solutions.

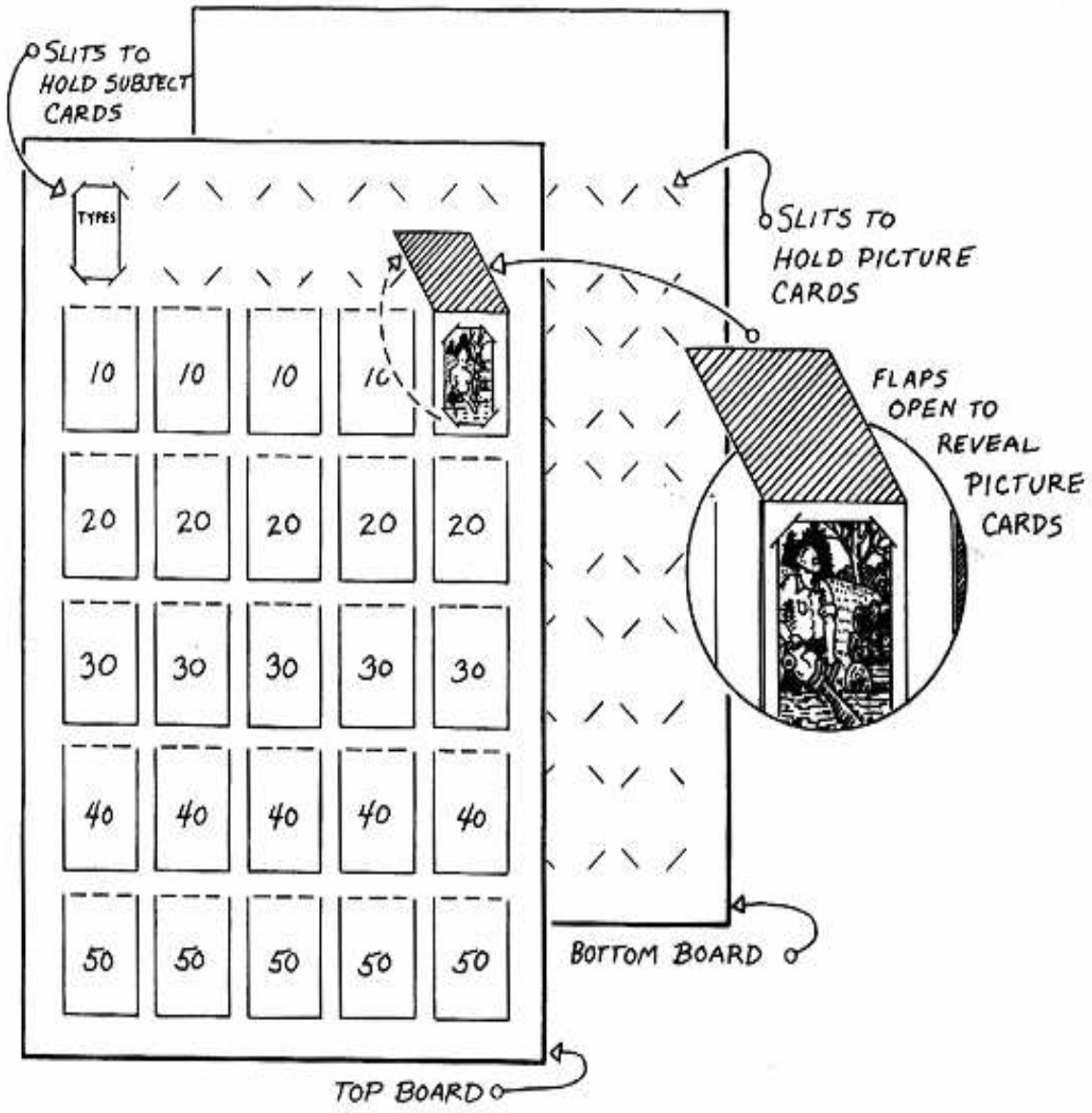
Extension

Use the same cards to create a "Jeopardy-type" game board. Create the game board by taking two equal size poster boards and preparing them as follows:

a. Make slits and cut out flaps on the top board and attach the top to the bottom with glue.
b. Then make the slits as shown on the bottom board. (You may want to laminate both sheets first and then cut them out to make a more durable game board.)
c. Make subject cards on 3" x 5" cards and attach to the top of the columns.
d. Then make or adapt your picture cards to relate to the subject cards. You may want to use some pictures for several categories in future games. To do this, label the answers Game A, B, C, etc. You may want to laminate the cards and use peel-off labels or overhead marking pens to put new answers on the back.

The game follows a "Jeopardy-like" format. Have the students form two or three lines. Then role a dice or flip a coin to see who chooses the first category. Open the flap to expose the card. The first person to ring the buzzer gets to respond. Like "Jeopardy," the person must respond with a question. For example, if the category were "Types" and the picture showed muddy water running off a soybean field, the response would be "What is sediment?" If the same picture were under the "Source" category, the response would be "What is row-cropping?" You may have some with more than one acceptable answer. For example, using the same picture under "Effects," the response might be "What will kill or harm aquatic life?" or "What will make water unsuitable for drinking or swimming?"

To score the game, give the first person/team with the correct answer the point value on the flap. Deduct the value from their score for wrong answers. Play the game until all flaps are opened up. You may want to add new cards and categories and repeat the game if you have time or play it later as a review.


SLITS TO HOLD SUBJECT CARDS
TYPES
SLITS TO HOLD PICTURE CARDS
FLAPS OPEN TO REVEAL PICTURE CARDS
10 10 10 10
20 20 20 20 20
30 30 30 30 30
40 40 40 40 40
50 50 50 50 50
BOTTOM BOARD
TOP BOARD

Section Three

Urban

This section explores nonpoint source pollution further with a focus on pollution sources found in an urban area. Activities in Section Three give students a clear understanding of what a storm drain collection system is and it's role in nonpoint source pollution. Students participate in simulations and build models of storm drain systems. There is also a focus on specific actions that contribute to nonpoint source pollution such as car washing and boating. Students will learn the difference between impervious and pervious surfaces and design an urban area with storm water in mind.

Curriculum Note

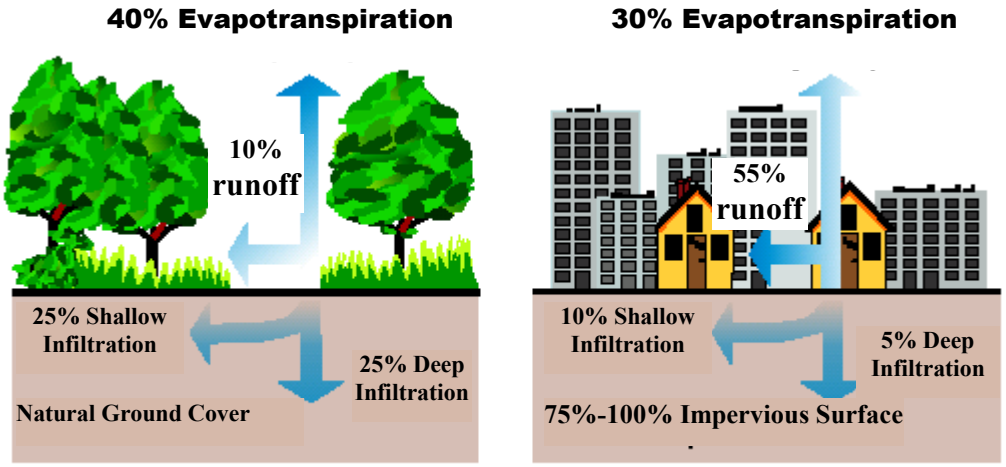
While urban and agriculture are divided into two sections in this curriculum it is important to keep in mind that the divide can never be complete. Many of the pollution causing activities discussed in this section also pertain to suburban areas that do not have a majority cover of pavement. Likewise an urban area can have erosion and contribute pesticides and fertilizers to the waterways just as agriculture. Especially in Hamilton County our developing rural areas and our urban areas blend, as does their pollution. We are all in the watershed together and therefore all share an equal responsibility in keeping it clean.

Land Use

Four main land uses contribute the majority of the urban nonpoint source pollution: urban, agriculture, mining and forestry. Due to the land uses in Hamilton County, this curriculum focuses on urban and agriculture. Urban land use is particularly pertinent to Hamilton County considering nearly 176,000 acres of the total 264,203 acres are urban (OKI data layer on land use). An **urban area** is defined as an area with a majority of land covered with impervious surfaces, such as pavement, buildings or houses. The City of Cincinnati and many of the older urban areas in Hamilton County fall under this category.

Urban Streams

Streams and rivers in an urban area are usually very different from streams and rivers in a forest or other natural area. Urban streams tend to carry more water at a faster speed after a storm than those in less developed areas. The reason for this involves what happens to rain after it hits the earth's surface. In forests, meadows and other natural areas, about half the water that falls to earth



Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.

soaks into or **infiltrates** the soil. Most of what remains on the ground and in the grass, tree leaves and other plants is returned to the atmosphere by **evapotranspiration**, a combination of evaporation and transpiration (loss of water vapor by plants). Only a small portion of rainfall (about 10 percent) travels across the land as runoff and drains into a stream, lake or pond. However, the situation in urban areas is very different. When people move into an area, they build houses, buildings, streets and parking lots. In urban and suburban areas, buildings and pavement cover much of the land surface, which do not allow rain and snowmelt to soak into the ground. Instead, most developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. Scientists use percent imperviousness to describe how much of a given area is covered by hard surfaces. Many cities have areas that are 75 to 95 percent **impervious**. This means that most of the rain that falls will not infiltrate into the soil and instead will flow off streets and parking lots. The U.S. Environmental Protection Agency estimates that a typical city block generates over 5 times more runoff than a woodland area of the same size. If all this extra water is diverted directly into a stream channel, changes will occur. These changes will be discussed in the Effects Section (Section 5) later in the curriculum.

Storm Drains

In urban areas the majority of the rainfall cannot soak into the ground and has to flow into a **storm drain**. What's the difference between a storm drain and a sewer? Storm drains collect water from outside our homes and businesses. This runoff is carried untreated directly to streams and rivers. Sanitary sewers collect water from inside homes and businesses and carry it to a treatment plant, where the water is cleaned before it reaches streams and rivers. There are areas of Hamilton County that have combined sewers where sewage and rainwater merge and both are treated. These are primarily the older parts of the County, such as downtown Cincinnati or Cheviot. The primary problem with combined sewers is during a hard rain and the capacity of the treatment plant is overtaxed the sewers overflow and outlet into streams. Combined sewer overflows are point source pollution. The public works departments of most communities in Hamilton County can tell you if your community has combined or separate sewers.

Storm water in a city is usually collected in storm sewers and transported to a stream in large pipes. This photo shows water exiting a pipe into a stream.

Urban Sources

Urban runoff contains pollutants from throughout the watershed that are the result of everyday life. Activities such as fixing, driving and washing the car, boating and other water recreation, using fertilizers and pesticides around the home and walking the dog can all lead to nonpoint source pollution.

In order to keep automobiles or other motorized equipment working they must be maintained. Oil, gasoline, brake fluid, degreasers and antifreeze are necessary products in automobile maintenance. All of these products, however, contain chemicals that can harm

aquatic life if they flow into a stream or river. One gallon of used oil can ruin up to 2 million gallons of drinking water (EPA Office of Wetland, Oceans and Watersheds). If these products accidentally spill on the ground, storm water runoff will pick them up and carry them to the nearest stream. Some chemicals are acutely toxic and can cause immediate harm or death to insects, fish and other animals within 96 hours (for example, antifreeze, which is toxic to pets, has a sweet taste that cats and dogs love). Others are chronically toxic and cause harm over time.

Most people would never think they are polluting by washing their car in the driveway but it can be a problem. Many cleaning products contain phosphates and chemicals that can be harmful to fish and other aquatic life. Although there may be no rain in sight, using a hose to wash off suds creates a stream of wastewater that can travel down a driveway, into the street and down a storm drain. It takes 25 gallons of water for a 5-minute shower and 35 gallons to fill a normal bathtub. In comparison, the average person washing a car uses more than 500 gallons of water! All that water washes the soapsuds down the street's storm drain and into the waterways.

Another common pollutant in an urban area is fertilizer. Many people will apply fertilizers in excess on their lawns thinking the more fertilizer they use, the greener the grass. Too much fertilizer applied at the wrong time can be very harmful to grass. It can weaken the grass making it more susceptible to disease, weeds and poor root growth and can make your lawn less able to withstand periods of heavy rain or dry weather. The same rains that pick up oil, gas and other hazardous chemicals also pick up excess fertilizer from your lawn and carry it to a lake or stream. Instead of making grass grow in the front yard, this fertilizer can make algae and weeds grow in streams and lakes.

Litter and pet waste are not only unsightly when left on the ground but can be potential pollutants. Litter washes away with storm water and can harm aquatic wildlife. Pet feces contain a large number of bacteria, viruses and parasites that can contaminate streams and rivers. In addition, pet waste contains nitrogen and phosphorus, two elements that fertilize algae and other aquatic plants and make them grow out of control. The more feces pets leave behind, the more bacteria, nitrogen and phosphorus is left behind for rainwater runoff to pick up. In a densely populated watershed in Arlington, Virginia (Four Mile Run), scientists estimate that dogs deposit more than 5,000 pounds of feces each day.

Pet waste can become a serious pollutant.

Many people use pesticides around their home and yard to remove insects, weeds and other pests with which they do not want to share a home. However, using harsh pesticides can be harmful for people and the environment alike. A recent study conducted by the United States Geological Survey (USGS) in southwestern Ohio showed that insecticides, such as diazinon, commonly used by homeowners were frequently detected in urban streams. Sometimes these pesticides were at or above drinking water standards or guidelines for protecting aquatic life. In the same study scientists also discovered that insecticide concentrations increased in 29 small stream basins as the amount of urban land increased. Those pesticides lying on the ground can also be picked up with storm water runoff and make their way to the stream.

With the Ohio River and so many other rivers close by, Hamilton County has ample opportunities for boating and other water recreation. Many water sports use motorized equipment, which require the same types of products used to maintain automobile engines. These motorized vehicles have the potential to leak pollutants directly into the water. The telltale sign of oil and gas pollution is a rainbow sheen on the water's surface.

Planning for the Future

Considering all of the potential pollutants and the increase of runoff in urban areas, designing and planning a city that protects water quality is important and challenging. **Urban planners** decide how to place buildings to best use the land around them and map the overall development of communities, counties and regions. The community land is divided by planners into residential, commercial or industrial development. They plan for the future by forecasting the area's growth and creating the right balance of work and housing zones. Planners also decide when to build and repair roads, electric lines, schools, hospitals and other parts of a community's infrastructure.

Urban planners play an important role when considering the county's water needs including the measures implemented to protect and maintain clean sources of water. The need to improve storm water quality and to prevent further pollution has become more and more pressing. As knowledge of the causes and consequences of storm water pollution increase, planners must redesign and implement solutions within the existing city structure. Settling ponds, wetlands and other natural filtration systems are built in order to improve the quality of urban runoff. Planners are often challenged with implementing these techniques within the existing cityscape, long after roads, buildings and homes are already in place.

Activities in Section Three

Activity	Grade Level	Description
A Family Boat Ride	K-2	Follow a story explaining why garbage should not be thrown into the river
Amazing Water	K-2, 3-5	Move through a maze of "drainage pipes" a drop of storm water
Storm Drain Dumping	3-5, 6-8	Construct a model to visualize pollutants entering a storm drain system
The Superior Car Wash	6-8	Develop a water conserving strategy for a car wash through math interpretation
Bon Voyage to Bad Boating Habits	6-8	Create a boating commercial about responsible boating practices
School Yard Permeability	6-8	Examine the school yard for permeable and impermeable surfaces
Designing a Community With Storm Water in Mind	6-8, 9-12	Design an ideal community while protecting storm water quality
No Place to Run To	6-8, 9-12	Model how impermeable surfaces contribute to NPS pollution

A FAMILY BOAT RIDE

Grade Level
K-2
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Language Arts, Fine Arts
Time
30 minutes
Materials
- The "A Family Boat Ride" Story Booklet
- 1 garbage can
- 1 recycling bin
- A variety of garbage items (including some aluminum cans and paper, as well as other types of garbage)

Setting
Classroom
Terms
Litter, Recycle
Reference
Adapted from the Water Sourcebook Series, K-2, United States Environmental Protection Agency

Summary

Students follow a story explaining why garbage should not be thrown in the river.

Objective

Students will:
1. Sort items according to "garbage" or "recycle."
2. Identify, orally or in writing, at least two items that should not be placed in rivers, streams, lakes, or oceans.

Procedure

Advance Preparation

Make copies of "A Family Boat Ride" for each student and teacher. Staple pages together so that each person has the complete story.

Gather at least as many items of garbage as you have students. For a list of what is recyclable in your community visit www.hcdoes.org, or call the Hamilton County Recycling Hotline at (513) 946-7741.

Warm up

Ask students if they have ever seen litter outside? Where have they seen it? Tell them they will read a story about littering and learn what they should do with garbage instead of littering. Discuss with students what items are recyclable and which items are thrown away.

Garbage Song
Tune, "Mary Had A Little Lamb"
Garbage should not go in water,
Go in water,
Go in water.
Garbage should not go in water,
It should go in here.

Activity
1. Read "A Family Boat Ride" to the class.
2. Pass out the individual booklets.
3. Read the story again, allowing them to follow along.
4. Have students draw illustrations in their booklets.

Follow-Up

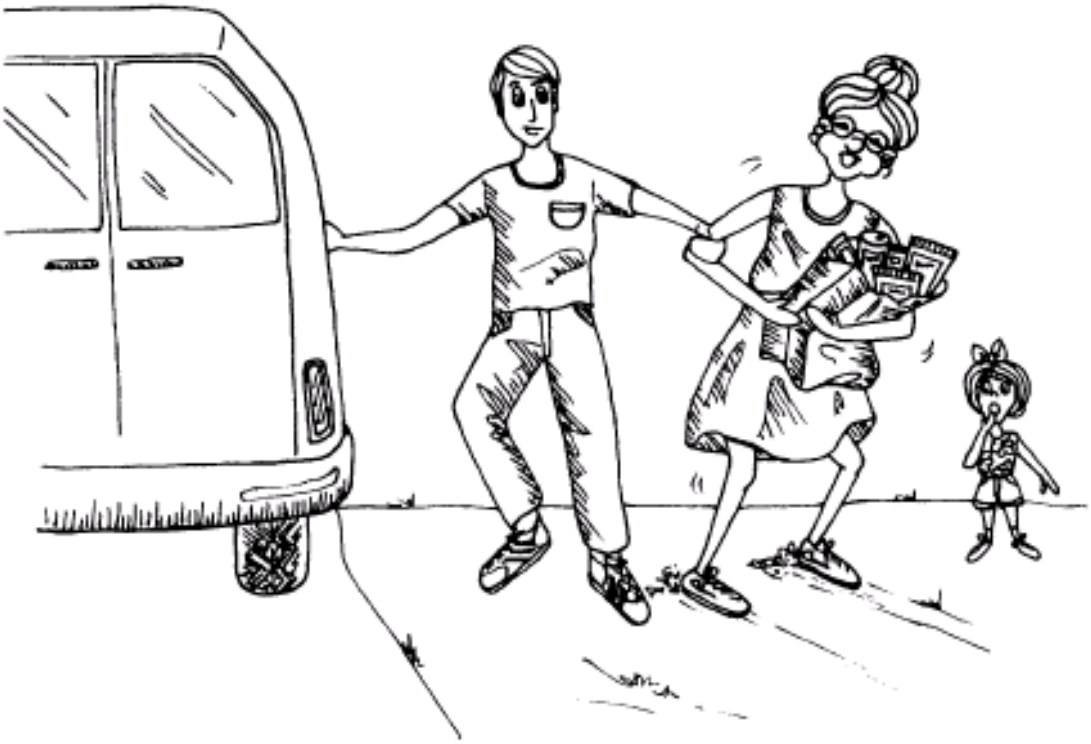
Place the container of garbage items (collected earlier), the garbage can and the recycling bin in front of the class. Let a student select a piece of garbage. The class should sing the Garbage Song together as each student places the piece of garbage in the correct container. Each student should give reasons for putting in either the recycling bin or the garbage. Let each student have a turn. Discuss the impact of polluted water on recreational water activities.

Extension

Discuss with students the impact litter can have on aquatic life. Find pictures of the effects and share them with the children. Have students design a sign that could be posted in a marina educating boaters about the effects of throwing garbage overboard. The signs could be laminated and posted at a marina with their permission.

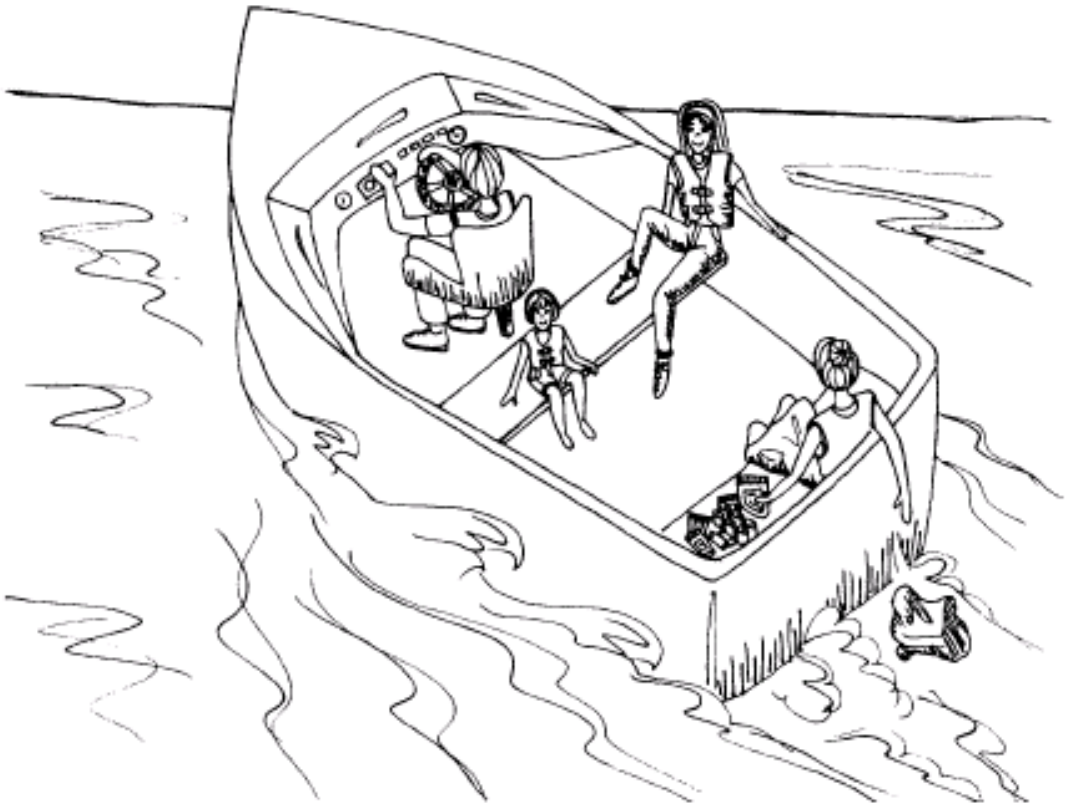
-|-

One day my family went for a boat ride. My aunt Sue said she wouldn't go but she did.



-2-

When we got into the boat Dad told us not to throw garbage into the water. Aunt Sue said she wouldn't but she did.



-3-

Aunt Sue threw candy wrappers into the water.

-4-

Aunt Sue threw cans in the water.

-5-

Aunt Sue threw plastic bags in the water.

-6-

Dad told Aunt Sue to stop polluting. He explained that we must take care of our water by helping to keep it clean.

-7-

Aunt Sue said she wouldn't throw garbage in the water again but she did.

-8-

Dad stopped the boat. Aunt Sue said she wouldn't get out. BUT SHE DID!

A-MAZE-ING WATER

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Health
Time
45 minutes
Materials
- Can or bottle labeled "chemicals" or "oil"
- Chalk or chairs
- Pieces of self-sticking paper, flour, or other materials to represent pollutants found in urban runoff

Setting
Classroom, School Yard, or Gymnasium
Terms
Contaminants, Nonpoint source pollution, Runoff, Storm drain, Urban Area
Reference
Adapted from Project WET Curriculum and Activity Guide, *Copyright International Project WET*

Summary

Students become a drop of water and move through a maze of "drainage pipes" to learn how actions in the home and yard affect water quality.

Objective

Students will:
1. Describe urban forms of pollution.
2. Provide reasons why people should monitor what they put on their lawns or in the streets.
3. Identify ways to treat urban runoff.

Procedure

Warm Up

Show students a can or bottle labeled "chemicals" or "oil." Tell the students you need to dispose of the chemicals and plan to dump them in the street in front of the school. Ask students if they think this is a good idea. Have students describe what they think will happen to the waste material. Read the first paragraph in the scenario and ask the students what they think might happen to the runoff.

Activity

1. Discuss how water is used to clean things, such as the surface of a table after a spill. Relate how rainwater washes the outdoors. Explain that as it flows over plants, soil, and sidewalks, it picks up and carries away soil and other materials. Inform students that cities use water to clean waste from city streets and sidewalks. Often the water goes down storm drains, collects in pipes, and flows to a river or a treatment plant. (If a media center or water play table is available, younger students can use pieces of tubing and plastic pipe to create a mini-water transport system. They can explore how pipes help water travel over distances by pouring water into one end of a tube and watching it run out in a different direction.)
2. Draw a simple but large maze on the school blacktop (see example at end of exercise) or arrange chairs in the classroom to form a maze. The maze represents underground pipes that collect and transport surface water that has flowed down storm drains.

Have students walk quickly through the maze. Inform them they are water flowing through the drainage pipes to the river or treatment plant.

3. Discuss locations of water that run into the storm sewer system (streets, lawns, parking lots, etc). What might this water carry? (Oil from cars, pet waste, fertilizers, litter.)
4. To simulate surface water transporting pollutants into drainage pipes, have several students position themselves along edges of the maze. They represent storm drains and the contaminated water flowing through them. They should hold pieces of self-sticking paper to symbolize the pollutants. When other students walk quickly through the maze, the students representing storm drains stick pieces of paper onto the clothing of the runners to represent contaminated water mixing with water (that may or may not be clean) flowing through the system. Allow students to take turns playing different roles.
5. After several trips through the maze discuss what happens to this dirty water. What if it flows into the river? What if it flows to a wastewater treatment plant? Have students summarize why they should not litter.
6. To represent a treatment system, have two students stand at the maze exit. Similar to the game London Bridge, the two-treatment students "trap" each passing "water" student and remove as many pollutants as possible in three seconds before he or she goes into the river. Repeat with each student. What happens as the "water" students back up? How do the students' feel about the quality of the water passing into the river?

Scenario

Imagine the parking lot of a large shopping center. Each year thousands of cars park in the lot, each depositing a small amount of engine oil and grit (loosened road materials). A gentle rain begins to wash the lot. At the lot's lowest point, water containing oil and gas begins to flow into the storm drain. A few blocks away, an urban river flows, filled with floating debris, sediment, and multi-colored water from another street, then another and another. The flow now nearly fills a ditch constructed to channel urban runoff. From a distance the storm water in the drainage system appears dark colored. Perhaps the road salt used to melt ice on roads and sidewalks has mixed in. How about the paint a neighbor pours into the gutter? The pet waste near the sidewalk? Whoosh, more water moves by! What next? What about the nearby stream and the people using water downstream for their drinking supply?

You follow the water to a large pond that the city constructed to catch storm water. The water in the pond is now moving slowly to the cattails and other wetland vegetation, and its color has started to change. Where is the debris and sediment? And what about other waste materials? A woman from the city health department tests the water as it enters a small stream. She concludes that the water is cleaner than the river it is about to enter.

Follow Up

Discuss the problems associated with untreated urban runoff entering rivers or other bodies of water. Have students identify or research ways contaminated water affects aquatic life and drinking water supplies.

Introduce students to the many actions people can take to limit contaminants entering urban runoff. These include properly disposing of pet waste and litter, and discarding chemicals and oils according to manufacturer's directions. Inform students that many cities have developed systems to treat runoff. Refer to the scenario and read the second paragraph.

Have students contact their local wastewater treatment plant or public works department to determine whether their street runoff enters the treatment plant or if it flows directly into the river or filters into ground water systems.

Students may want to participate in a storm drain labeling event. The Hamilton County Soil and Water Conservation District (HCSWCD) will come to your classroom and give a presentation on nonpoint source pollution and then provide all the supplies to label the storm drains in a nearby community. The labels caution people not to dump waste into the storm drains. Students will place door hangers on all of the homes in the community illustrating how and why they should monitor what flows down streets and into storm drains. The labels attached to the storm drains are watershed specific and will last for years to act as both a pollution deterrent to the community and a reminder to the students of their commitment to the environment. Call the HCSWCD to set up an event at (513) 772-7645.

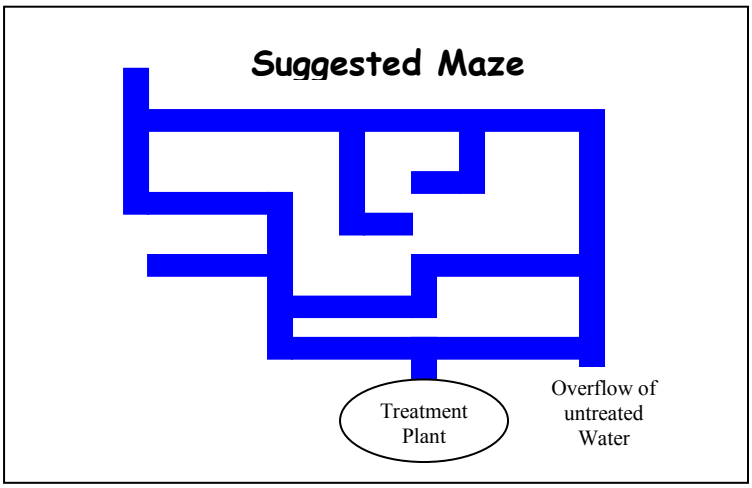
Extension

Students can research alternatives to house and lawn chemicals and cleaning agents. Contact the local recycling center, the wastewater treatment facility, or a local environmental group for details. Invite a representative from the local water treatment plant to enrich the activity. Visit a local gas station and have the manager explain what happens to oil after cars are serviced.

Read a book to the students that explains in more detail how a water treatment plant works. Some examples: Cole, Joanna. 1986. *The Magic School Bus at the Waterworks*. New York, N.Y.: Scholastic, Inc. (ISBN: 0590403605).

Macauley, David. 1983. *Underground*. Houghton Mifflin/Walter Lorraine Books. (ISBN: 0395340659).

Macauley, David. 1998. *The New Way Things Work*, revised ed. Houghton Mifflin/Walter Lorraine Books. (ISBN: 0395938473).



STORM DRAIN DUMPING

Grade Level
3-5, 6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Language Arts
Time
Preparation 50 minutes (requires overnight drying)
50 minutes
Materials
- Wax paper
- Salt
- Tape
- Food coloring
- Clay
- Oil
- Water
- Other materials to represent pollutants
- Sugar
- Eyedropper

Setting
Classroom
Terms
Pollution, Runoff, Storm drain
Reference
Adapted from Teaching Environmental Science Lesson Plans, Texas Commission of Environmental Quality and R. Debra Lopez

Summary

Students construct a model of a storm drain system to visualize the pollutants that enter the system and their path.

Objective

Students will:
1. Develop an awareness of what happens to water contaminated through neighborhood runoff.
2. Make observations.
3. Hypothesize path and changes.

Procedure

Advance Preparation

Maze construction can be done by the students in groups or by the teacher depending on time. Cover a piece of cardboard with wax paper and form a maze out of clay. The maze needs a starting point and 2 exits. One exit leads to the treatment plant and the other into a stream. Label each exit. Place drops of food coloring, salt water mixed with pepper and oil on different locations throughout the maze. Allow one day for water to evaporate and the clay to dry.

Warm Up

Review storm drain information with students (can be found on pages 85-87). This activity is based on a location with only combined sewers. Begin by discussing how students would feel if everything that was dumped in the storm drain went into a glass as they turned on the water tap. Review the vocabulary words.

Activity

1. Students should make a list of those things that enter a storm drain inadvertently or on purpose.
2. If the students were not involved in construction of the maze explain what each drop in the maze represents.
3. Have students form a hypothesis of how the drop will travel.
4. Tilt the maze, add a drop of water at the starting point and let it drop slowly to an exit. Tilt the maze back and forth to guide the drop through the maze. It will pick up contaminants as it goes

through the maze.

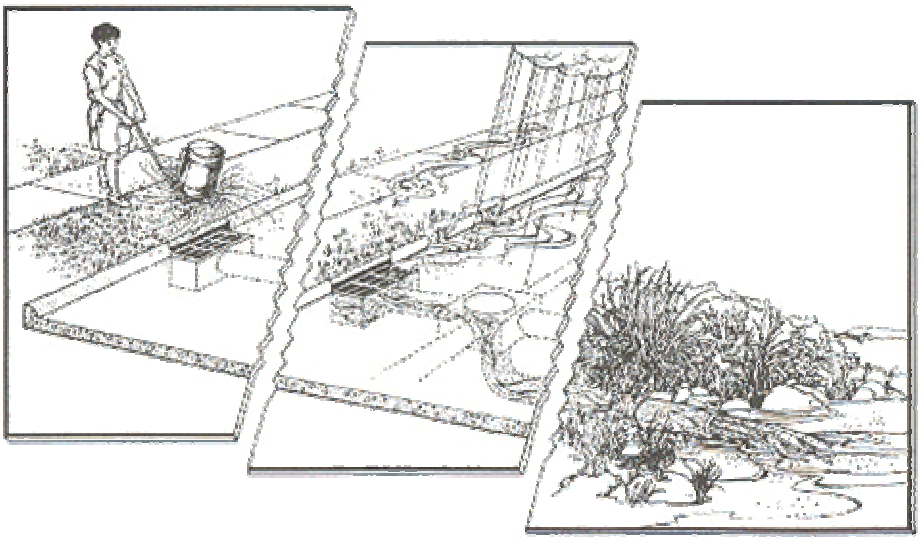
5. Students should be able to observe and describe what the drop looks like and feels like when it exits.
6. If the drop went to the treatment plant, the drop is replaced with a clean drop of water into a cup labeled stream. If it ended in the overflow (untreated) exit, the polluted drop is added directly to the stream cup.

Follow Up

Summarize observations. Have students put observations and conclusions into a descriptive paragraph. Discuss the problems associated with untreated urban runoff entering bodies of water. Discuss how some of these pollutants can be kept out of the water.

Extension

Have the students identify and research ways contaminated water affects aquatic life and drinking water supplies.



THE SUPERIOR CAR WASH

Grade Level
6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Math
Time
50 minutes
Materials
- 1 copy of "The Superior Car Wash" for each student

Setting
Classroom
Terms
Conservation, Dilution, Phosphates
Reference
Adapted from the NPS Activity Sheets, United States Environmental Protection Agency

Summary

Students use math interpretation to develop a water-conserving strategy for a car wash.

Objective

Students will:

1. Compare different car washing methods and decide which cleans better with the least amount of water.
2. Explain how dilution works in cleaning.

Procedure

Warm Up

Review with students that most soap used to wash cars contains phosphates that are harmful to aquatic wildlife. Explain how phosphates are harmful and how they affect algal growth. When the soaps are washed away with the rinse water they become nonpoint source pollution.

Activity

1. Tell students to imagine that they have a weird bucket that holds as much as they want, but no matter how hard they try, they can never empty the last ounce when drained. In the weird bucket, there will always be one undrainable ounce of some sort of gunk they want to rinse away.
2. Tell the students they will compare washing a car using two different methods. The first is with several small repeated washes.
3. Have students do the calculations in Part One of the student sheet.
4. Now tell the students they will try the car wash with one big wash. Have the students complete Part Two.

Follow Up

Ask the students to compare the two methods. Which method took more water? Which method is better? Could this exercise be applied to the real world? Ask students what other activities in their everyday life use soap or detergent that contain phosphates and what they can do to reduce the amount of phosphate pollution.

Extension

Follow this activity with the “Phosphates in Your Water” activity in the Effects Section

The Superior Car Wash

Imagine that you have a weird bucket that holds as much as you want, but no matter how hard you try, you can never empty the last ounce when drained. In the weird bucket, there will always be 1 undrainable ounce of some sort of gunk you want to rinse away.

Part One

Start out with 1 ounce of gunk in your bucket. Draw it!

Do the math!
Mix in 1 ounce of water. You now have a 2-ounce mixture of gunk and water. Drain away half of the mixture. How much total mixture is left? How much of that is water? How much of it is gunk?

Repeat. Pour in 1 ounce of water so that you have a 2-ounce mixture. Drain away half of the mixture. How much gunk do you have now?

Repeat again. After three dilutions, how much gunk is left?

The Superior Car Wash (cont.)

Part Two

Suppose you want to get down to 1/8 ounce of gunk by adding water just once to your weird bucket. How much water will you need to add?

Making a Superior Car Wash—Thinking It Through

How many total ounces of water did the one-big-wash method take?

How many ounces of water did the small-repeated-washes method take?

Which method is better? Explain your answer.

Putting it all together

When you wash your car, soap attaches to the dirt and loosens the hold the dirt has on the car. This makes it easier for water to rinse away the dirt. If you were to closely examine the water left on your car after rinsing it, you would find a thin layer of water containing dirt with soap attached to it. Think of the dirt with soap attached as the gunk talked about in the questions above. If you rinse your car with just enough water to cover the surface of the car, it acts like diluting the gunk with water as you did in the examples above. Each time you add water and drain the mixture, you are left with a smaller amount of soapy dirt gunk still in the mixture than you had before. If this mixture works the same way as the mixture in the weird bucket, which method would use less water - one big rinse or several small rinses? Think about this the next time you wash your car. You can use less water if you use several small rinses instead of one large one.

The Superior Car Wash- Answers

Part One

Start out with 1 ounce of gunk in your bucket. Draw it!

Do the math!
Mix in 1 ounce of water. You now have a 2-ounce mixture of gunk and water. Drain away half of the mixture. How much total mixture is left? How much of that is water? How much of it is gunk?

1-ounce total mixture
.5 ounce water + .5 ounce gunk (or ½ water + ½ gunk)

Repeat. Pour in an ounce of water so that you have a 2-ounce mixture. Drain away half of the mixture. How much gunk do you have now?

.75 ounce water + .25 ounce gunk (or ¾ water + ¼ gunk)

Repeat again. After three dilutions, how much gunk is left?

.875 ounce water + 0.125 gunk (or 7/8 water + 1/8 gunk)

Part Two

Suppose you want to get down to 1/8 ounce of gunk by adding water just once to your weird bucket. How much water will you need to add?

8 ounces

Making a Superior Car Wash—Thinking It Through

How many total ounces of water did the one-big-wash method take?

8 ounces

How many ounces of water did the small-repeated-washes method take?

3 ounce

Which method is better? Explain your answer.

Answers will vary but the small-repeated-washes method cleans the car with less water.

BON VOYAGE TO BAD BOATING HABITS

Grade Level
6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Fine Arts, Language Arts, Social Studies
Time
1 class period to prepare
2 -3 class period to perform
Materials
- Boating information
- Props for commercials (optional)
- Video Camera (optional)

Setting
Classroom
Terms
Environmentally responsible
Reference
Adapted from the NPS Activity Sheets, United States Environmental Protection Agency

Summary

Students create a boating commercial to better understand environmentally responsible boating practices.

Objective

Students will:
1. Identify common boating-related threats to waterways.
2. List common problems created in waterways by boaters.
3. Explain environmentally friendly boating practices.
4. Understand the impact of poor boating practiced on the health of fish.

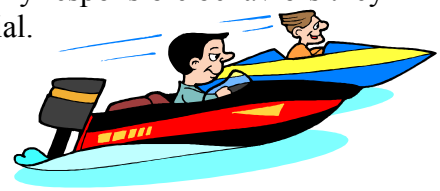
Procedure

Warm Up

Gather informative materials about boating practices, the effects they have on waterways and better practices boaters could use. This research could be done before class by the teacher if short on time or by the students as a research project. The Environmental Protection Agency's website is an excellent source of information (http://www.epa.gov/owow/nps/nps_edu/index.html or http://www.epa.gov/owow/nps/facts/point9.htm).

Activity

1. Tell the students they are natural resources specialists at a local environmental agency. One of their jobs is to spread the word about environmentally responsible boating behaviors. With a production team (groups of 3-4) they will create a television commercial that encourages boaters to behave in environmentally responsible ways.
2. Have students list environmentally responsible behaviors they want to include in the commercial.
3. In groups students should discuss the setup of the commercial. How can they get the information out in a way that it is both interesting and informative? What setting are they going to use in the commercial? Who will the spokespeople be? (TV news people, boating enthusiasts, environmental agency



personnel or possibly a mascot they create to speak for their cause).

4. Each group will also need to plan the media campaign. Where will they show this video so that it will be most effective? At whom is the commercial aimed? What age group of people would be the best target?
5. Next students should write a script for the commercial. The script will include the behaviors listed in step 2 and should be written so the targeted audience will find the message interesting and understandable.
6. Depending on the resources available students can either act out the commercial in front of class or actually film the commercial with a video camera and show the commercial in class. Use props, costumes and interesting settings to make your commercial appealing.

Follow Up

Discuss with students the effectiveness of commercials similar to their own that they may see on television. To support their conclusions, give examples of other effective or ineffective commercials designed to change people's behaviors (e.g., Smokey Bear, anti-drug commercials, anti-smoking commercials, etc.) Are there more effective ways to get boaters to be friendlier to the environment?

SCHOOL YARD PERMEABILITY

Grade Level
6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Math, Language Arts, Fine Arts, Earth Science
Time
2 class periods
Materials
- Large pieces of butcher paper
- Glue
- Tape or glue
- Marking pens
- Copies of Low Impact Development Sheets
- Graph paper (optional)
- Ruler (optional)
- Calculator (optional)

Setting
Classroom, School Grounds
Terms
Impermeable, Impervious, Infiltrate, Low-impact development, Permeable
Reference
Adapted from the NPS Activity Sheets, "Streams in the City," United States Environmental Protection Agency

Summary

Students examine the schoolyard and local development sites for drainage systems and impervious and pervious surfaces. After researching methods of low-impact development, they redesign the area with those methods in mind.

Objective

Student's will:
1. Differentiate between permeable and impermeable surfaces.
2. Describe low-impact development methods.

Procedure

Warm Up

Explain to students the difference between permeable and impermeable surfaces. Ask what would happen to a cup of water if you poured it on grass? What would happen if you poured water on the sidewalk? Explain how impermeable surfaces affect stream flow. Also explain low impact development.

Activity

1. Have students draw a birds-eye-view sketch of the school grounds. This can be done by memory, by taking a walk around the school grounds or by using aerial photographs of the school grounds (found at http://www.terraserver.com).
2. In the sketch, students should label areas: impervious, somewhat impervious or permeable.
3. Have students list all the areas where permeable surfaces would allow infiltration. List all the surfaces that would allow little or no infiltration.
4. Compare the amount of area that would allow infiltration with the areas that would allow little or no infiltration. If the amounts are about equal, the schoolyard is about 50 percent permeable. What is the percent permeability of your schoolyard? Depending on time students can guess the percentage or improve the accuracy of the estimate by taking measurements of each of the different areas included in the sketch of the schoolyard. Redraw the picture of the schoolyard to include the measurement. Use graph paper to help create a more accurate drawing. Is the percent permeability of the

schoolyard estimate different when based on the new drawing?

Follow Up

Review with students again how impermeable surfaces can affect stream flow. Ask the students what could be changed in the schoolyard to improve permeability or how they would design a new school on the existing school property. Pass out copies of the Low-Impact Development Practices. Have students sketch the school grounds again but this time use some low-impact development practices to redesign the schoolyard. Label all the low-impact development practices used to help infiltrate runoff from impervious surfaces around your school.

Extension

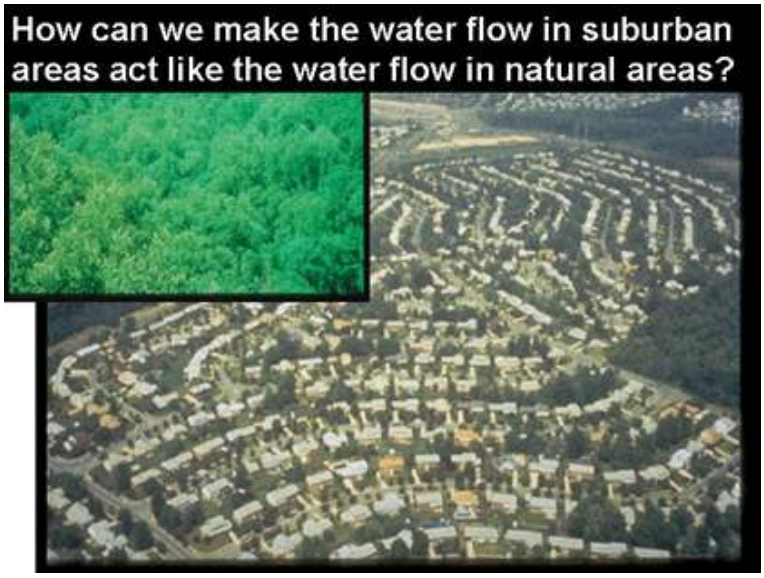
Have students look at the areas around streets in their neighborhood. Are there strips of open spaces or areas that are not directly used as roadway, bike path or walking pavement/trail? What is the land cover of these surfaces?

Students should draw a cross section of their street. Encourage them to include the diameter of cul-de-sac, the width of their street, the width of sidewalks and parking areas. Make sure the drawing is to scale.

Next have students draw a cross section of their street in which they implement some of the practices that will increase the infiltration, detention and retention of water that comes down in a storm. Also, students should think about ways to delay the conveyance time (the time it takes for rainwater to enter streams) and try to incorporate those.

Low-Impact Development

Engineers are trying to come up with ways to make the water flow in urban and suburban areas act like the water flow in natural areas. To do this, they have come up with practices that help improve the interception and infiltration of water. Low-impact development is the phrase used to describe urban and suburban development that uses these



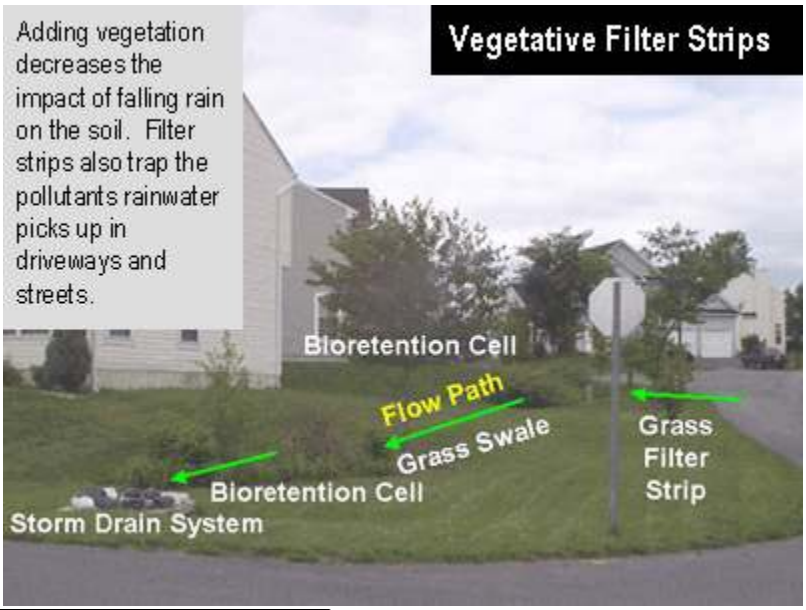
Examples of Low-Impact Development Practices

A bioretention filter consists of a grass buffer strip, a sand bed, a ponding area, an organic layer or mulch layer, planting soil and plants such as leafy shrubs. These filters look like beds of shrubbery and can be placed as islands on parking lots. They use soils and woody and leafy plants to remove pollutants from storm water runoff. Runoff from large paved surfaces like parking lots passes first over or through a sand bed, which slows the speed of the flowing water. It also distributes the water evenly along the length of the ponding area. The ponding

area is made of soil, but it slopes into the center. Water gradually infiltrates the bioretention area, evaporates and is taken up by the plants.

Natural drainage courses can be maintained by using grass-lined channels as much as possible instead of concrete canals, pipes and gutters.

Vegetative Filter Strips



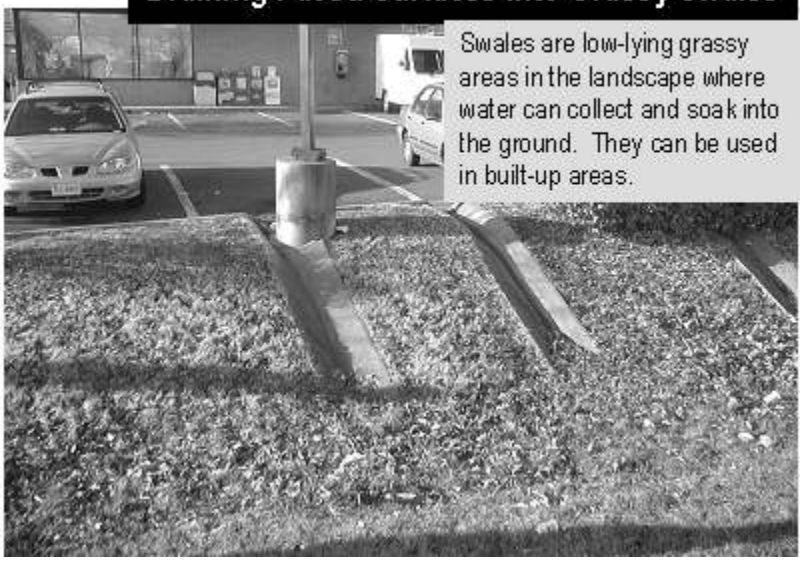
Adding vegetation decreases the impact of falling rain on the soil. Filter strips also trap the pollutants rainwater picks up in driveways and streets.

Maintaining Natural Vegetation Around Construction Sites

Maintaining natural tree cover and revegetating areas wherever possible helps to increase interception and infiltration.

Minimizing large cleared, flattened, and sloped areas prevents fast runoff.

Draining Paved Surfaces into Grassy Swales



Swales are low-lying grassy areas in the landscape where water can collect and soak into the ground. They can be used in built-up areas.

DESIGNING A COMMUNITY WITH STORM WATER IN MIND

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Math, Social Studies, Language Arts, Fine Arts
Time
2 class periods
Materials
- Large pieces of butcher paper
- Colored construction paper
- Ruler
- Glue
- Tape
- Marking pens

Setting
Classroom
Terms
Community, Storm water, Urban planner
Reference
Adapted from the Salt Lake County Storm Water Quality Education Lesson and Activity Plans Salt Lake County, Utah, Public Works Department Engineering Division

Summary

In this activity, students will design an ideal community that meets the needs of its members, while also protecting storm water quality.

Objective

Students will:

1. Create a map of an "ideal" community that includes all the services and resources people need to live there.
2. Identify and include in the community designs that protect and enhance the quality of storm water runoff.
3. Present to the class the components of their design and justification for their placement and use.

Procedure

Warm Up

Ask students, "What is a community?" Have the students consider what places or services they and their families use in their everyday lives. How do those services enrich their life? Are there any services the students could not live without?

Activity

1. Have pairs of students list five places or services that are in or should be in their community. Examples might include roads, schools, hospitals, electric plants, parks, libraries, police/fire services or movie theaters. As students share their ideas, list the examples on an overhead transparency or blackboard.
2. Look over the list and ask students whether anything that people in the community need to live there is missing. Help class members think of services or resources by asking questions such as the following:
   - How do people acquire the food they need?
   - Where do they live?
   - How do they move around?
3. Add new ideas to the list, so that the final list includes places to live, work, learn and play, along with public services, public utilities and cultural resources.
4. Ask students to brainstorm ways that these services/resources might contribute to storm water pollution? Could we design a

community differently so that pollution was prevented or minimized? What design components of things would be necessary? Chart the students' responses.

5. Explain to the students that they will have the opportunity to be community planners and to design a community that meets the needs of its residents (refer to the brainstormed list from #2) while protecting and enhancing storm water quality.
6. Divide the students into groups of three students. Allow students two class periods to plan and map their communities.

Potential sources of pollution	*Prevention designs*	*Design components*

Follow Up

When students have completed their maps, ask groups to share them with the rest of the class and to describe the features of their design. Use these questions to lead a discussion about the maps and planning process:

- How did your group decide what features to include and where to place them?
- Give an example of how your group resolved a disagreement.
- What would it be like to live in each of the communities? What would it be like for a young child? For a storeowner? For an animal?
- How are the planned communities the same as the community you live in? How are they different?
- What did you learn from this activity?

Extension

Have students research communities that are working to protect water quality. The Internet offers many examples across the globe (see Resources section).

Invite a representative from an urban planning office or firm to visit your class. Students can ask the planner about the process in which land-use decisions are made, about the community's goals for the future or about changes the community anticipates making as it grows.

Interview residents who have lived in the community for more than 25 years. Ask them how the community (particularly regarding water resources) has changed and whether they think the changes were for the better.

Have students write about a "day in the life" of their storm water community, including an explanation of its design and how the design protects and maintains storm water quality.

Can you identify the activities that contribute to pollution in your watershed?

NO PLACE TO RUN TO

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Social Studies
Time
2 class periods
Materials
- Cardboard boxes or clear tubs (1 per group)
- Garbage bags
- Plastic hose (1'/group)
- Duct tape
- Styrofoam pieces
- Sponges
- Food coloring
- Vegetable oil (optional)
- Eyedroppers
- Small plastic jars (6 per group)
- Large jar (1 per group)
- Scissors
- Hacksaw
- Watering can
- Water
- Paper towels
- Pictures of different parking lots and urban areas (optional)

Setting
Classroom
Terms
Impermeable, Nonpoint source pollution, Permeable
Reference
Adapted from Environmental Resource Guide, "No Place To Run To", grades 6-8, 1992, with permission from the Air and Waste Management Association, Pittsburgh, PA

Summary

Students construct an urban model to understand how impermeable surfaces contribute to nonpoint source pollution.

Objective

Students will:
1. Develop a model that demonstrates how impermeable areas collect a number of pollutants that can runoff into nearby lakes and streams.
2. Cite examples of urban water pollution sources by observing the model.
3. Suggest ways to reduce runoff in urban areas by redesigning and testing their models.

Procedure

Advance Preparation

Prepare the following mixtures in small plastic jars as follows:

A. ¼ cup oil + 3 drops yellow food coloring + 3 drops green food coloring – label "oil or gasoline"
B. ½ cup water + 3 drops red food coloring – label "pesticides"
C. ½ cup water + 3 drops green food coloring – label "fertilizers"
D. ½ cup water + 1 teaspoon oil + 5 drops yellow food coloring – label "pet wastes and rotting litter"
E. ½ cup water + 5 drops blue food coloring – label "toxic chemicals" or "household hazardous waste"

Store jars in a cool place to prevent molding. If you wish to use the model again do not include the oil in the mixtures. Prepare an example model for students to use as a guide.

Warm Up

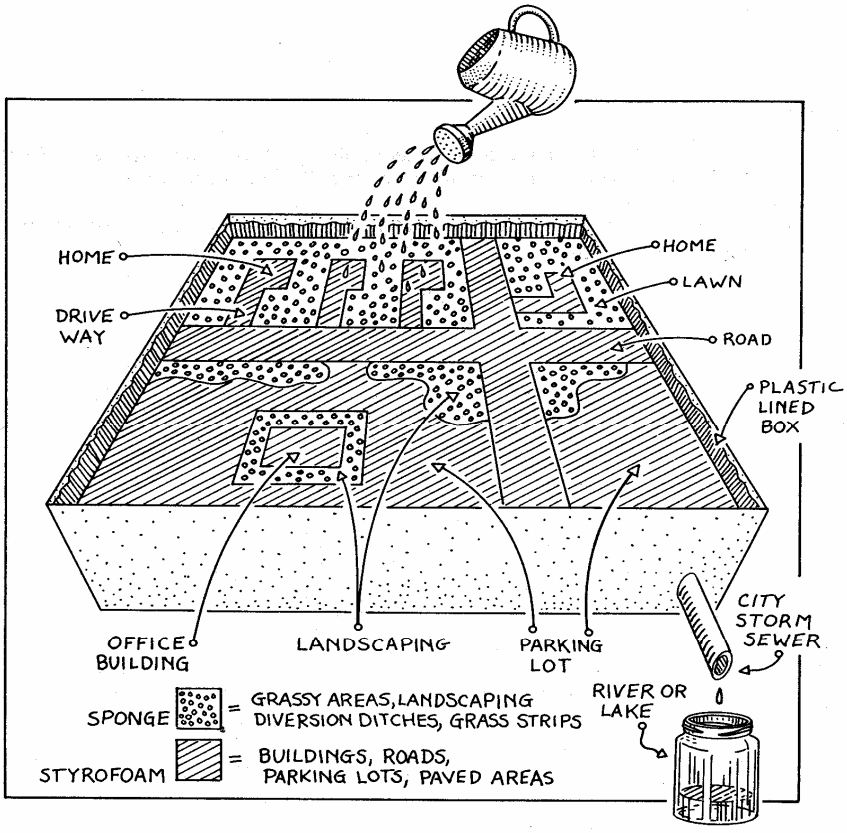
Define terms together as a class. Explain that rainwater running off roofs, lawns, streets, industrial sites and other impermeable areas washes a number of pollutants into rivers and streams. Tell the students that hard-surfaces, like parking lots, provide no place for rain to slowly filter down through the soil. Pollutants transported in urban storm sewer systems include nutrients, bacteria, litter, soil, toxic chemicals and organic materials.

Activity

1. Divide the class into groups of three or four and give each group a box or tub. Have them line the box with a garbage bag (not necessary if using clear tub). Then poke a hole through the plastic and the end of the box. Attach a hose to serve as a drain. Put the hose through both the box and the bag holes. Make sure the hose fits tightly. Use duct tape to seal the hose. The hose will represent a city storm sewer. Tell them that the water flowing through the hose will travel straight into a nearby stream.
2. Have the students design their own urban environment on a piece of paper first. Tell them they are going to use Styrofoam blocks and sponges to create this environment. The Styrofoam will represent buildings and parking lots. The sponges will represent grassy areas, landscape plantings, diversion ditches or grass filter strips.
3. When they have completed the design, have them cut out and arrange the pieces in their boxes. (NOTE: Suggest to the students that they minimize cutting in their designs because it takes a lot of work to cut the design out and minimizes cracks between Styrofoam).
4. When the students finish designing their urban areas, have them wet the sponges and wring them out. This lessens the amount of rainwater that will be needed. Then have the students use eyedroppers to deposit pollutants onto their environments. Use the pollutants prepared in the Advanced Preparation section. The pollutants should be placed where they would occur normally.
5. Place a large plastic jar under the hose to catch the drainage and create a heavy rainstorm using a sprinkling-type watering can. Keep raining until pollutants wash off. (NOTE: Use the same amount of "rain" on each model). Watch the water draining out of the storm drain. What does it look like? Did the runoff from different models look different? Why or why not? Explain that now all the pollutants are mixed up so we can't see what they are.

Follow Up

Discuss with them how diversion ditches and grass strips prevent or reduce the amount of contaminants reaching the surface waters. How could the model be designed differently to reduce pollution? What other things could be done to prevent urban pollution? Have the students redesign their models with diversion ditches, grass filter strips and/or holding ponds.



Compare the water collected from the redesigned model to the sample from the original model. Were they successful? Why? What worked and what didn't? Why?

Extension

Invite an urban planner, architect or water quality professional to visit your class and talk about what is being done to reduce urban water pollution in your area. Ask the invited speaker to judge the students original or redesigned models and suggest additional modifications.

Section Four

Rural

While Section Three concentrated on nonpoint source pollution from the urban areas of Hamilton County, Section Four concentrates on the pollution from rural and developing areas of the County. Over 37,000 acres in Hamilton County are traditional agricultural (food, grain and fiber crops). Although Hamilton County is very urban compared with other Ohio counties, in 2001, about 9,500 acres of land in the County were planted with corn and soybeans (Ohio Department of Agriculture, Ohio Agricultural Statistics). Agriculture and the development of rural land into suburbs contribute similar types of nonpoint source pollution including sediment, fertilizers and pesticides. In Section Four students will learn many facets of sedimentation and runoff that could result from agriculture and development. Students also explore the use of fertilizers and pesticides and even attempt to solve problems associated with raising cattle.

Don't Settle for Sediment

The most abundant pollutant in the United States' waterways by volume is sediment. **Sediment** is soil carried into rivers and streams through the mass movement of soil from all forms of erosion. Every time it rains, millions of tons of soil eroded from land washes into lakes, ponds, streams and rivers. This sediment fills in lake bottoms, river channels and reservoirs; transports many different chemicals and turns water muddy brown. Thus, excessive amounts of sediments can damage aquatic ecosystems.

Poorly managed construction on Hamilton County sites can result in erosion.

Erosion can occur in rural and urban areas or wherever soil is not adequately protected. In urban and suburban areas construction sites are especially vulnerable to erosion. Large areas of soil are dug up and often allowed to remain bare for long periods. In rural areas, agricultural fields and logging operations can be susceptible to erosion unless preventative measures are taken. Studies in the Great Lakes Basin indicate that more than two million tons of sediment reach Lakes Erie and Michigan annually and that 37 percent of this is from sheet erosion off agricultural land (McEwen and Stephenson, p. 264). The World Resources Institute estimates the world's rivers deliver about 22 billion tons of sediment to the oceans each year (World Resources Institute, p. 53).

Erosion and sedimentation are natural processes and their environmental impacts are not always negative. Sediment carried into water by natural erosion actually helps to maintain the fertility of an aquatic ecosystem because it contains nutrients necessary for aquatic organisms. Among the richest and most productive environments on the planet are the Nile and Mississippi River Deltas, which are formed from the deposition of fertile sediments from upstream. Erosion is a natural and important geological process, but if too much vegetation is removed from riparian areas, agricultural lands or urban construction sites, water carrying soil, organic matter and pollutants can

cause accelerated sedimentation in streams and harm aquatic life. When excess sediment sinks to the bottom of a body of water, it can damage or destroy spawning grounds for fish, smother fish eggs, smother macroinvertebrates and prevent light from reaching aquatic plants that live on the bottom, which may deplete oxygen levels in the water. Additionally, sediments often carry chemicals that may accumulate on the bottom of rivers, lakes and bays where they can harm aquatic ecosystems.

Animal Waste is No Small Matter

Cattle grazing and the location of feedlots close to streams are considered major sources of erosion and lowered water quality. Livestock and other farm animals can cause erosion with their hooves or feet by walking on the slopes or the same paths repeatedly. However, the main nonpoint source pollution concern with livestock is manure. Animal waste is no small pollutant in the United States. Consider that in 1999 beef and dairy cows, hogs and poultry together produced nearly *one billion tons* of waste! This waste can mix with storm water runoff or be deposited directly into rivers and streams through poorly managed livestock farms.

In some cases, farmers use animal waste as fertilizer. Even though it's natural, if used incorrectly (e.g., applying too close to waterways, applying at too high a rate, applying before a rain storm or applying on frozen ground) it can cause severe damage to water resources. Unfortunately erasing these forms of pollution entirely is almost impossible. However, there are steps farmers and ranchers can take to reduce the amount of pollution that comes from farms and ranches. For starters, they can reduce the amount of soil erosion and sedimentation considerably by using soil conservation practices (discussed in the Action Section).

U.S. Animal Waste in 1999

- Beef cows – 624 billion pounds
- Dairy cows – 409 billion pounds
- Hogs – 242 billion pounds
- Poultry – 146 billion pounds

Pesticides and Fertilizers

Chemicals in pesticides and fertilizers are a third cause of nonpoint source pollution. Pesticides are used to kill pests such as crop-eating insects and to control the growth of weeds and fungi. Fertilizers are used to improve soil fertility and to help grow more productive crops.

Fencing off natural streams from cattle will reduce sedimentation and nutrient pollution.

Unfortunately, chemicals used to kill bugs and weeds can also damage other things. The chemicals can kill fish and other wildlife, poison food sources and destroy habitat.

On agricultural fields fertilizers are applied to maximize crop production and economic return. When erosion occurs, phosphorus and nitrogen fertilizers are carried to waterways. Phosphorus is generally not soluble in water. However, phosphate ions will cling to soil particles. The input of excess phosphorus into lakes results in the rapid growth of aquatic organisms (particularly algal growth). This increased growth increases

turbidity and reduces sunlight penetration. The reduction of sunlight limits biological activity at deeper levels and can lead to eutrophication (see Effects Section for a detailed description).

Each year, about three billion pounds (1,362,000 metric tons) of pesticides are used in the United States. Pesticides are beneficial because they can improve crop yields significantly by controlling weeds, insects and plant disease. Farmers are by far the largest users of pesticides, although homeowners do over-apply pesticides more often than farmers. Because pesticides are designed to kill living organisms, they can cause serious health and environmental problems if not used properly. Some pesticides can stay in the environment for long periods of time and may travel from the soil into groundwater and surface waters. Through the U.S. Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) the U.S. EPA is responsible for controlling the risks of pesticides through a registration process. This registration only ensures that when a pesticide is properly used, it poses no unreasonable health or environmental risks. It is up to the person applying the pesticide to make sure it is used properly. However, the best way to limit nonpoint source pollution from pesticides is to reduce their use and consider safer alternatives such as biological controls and resistant plant species.

Pesticides enter water in two ways. Those that are soluble in water find their way through the environment by being carried to nearby waters in surface runoff or by leaching into groundwater systems. Secondly, both soluble and insoluble pesticides may attach to soil particles and be carried to watercourses with eroded soil.

Septic Tanks

Septic tanks are used to collect, treat and disperse wastewater generated by homes and businesses. They are required in areas that are not served by public sewers. A septic tank is a large watertight, covered receptacle designed and constructed to receive wastewater from a building. The tank provides primary treatment where heavy solids in the wastewater sink to the bottom of the tank and lighter solids, such as greases, separate from the liquid and form a scum layer on the top. **Anaerobic** bacteria break down the solids into carbon dioxide, methane and water. The scum layer and heavy solids remain in the tank. This undigested residue must be periodically pumped out and taken to a wastewater treatment plant. The “clear layer,” located between the scum and sludge layers, contains the liquid discharged from the septic tank. This liquid is mostly water which contains dissolved materials that flow out of the tank and into a piping network called a drain field. Here, perforated pipes surrounded by gravel slowly release the wastewater into the soil where **aerobic** bacteria in the soil finish the treatment process. Soil bacteria continue to destroy the remaining organic material in the effluent.

To avoid contamination, houses with both septic tanks and a private well typically must not have their water well within 100 feet of the septic system and well’s casing must be sealed. This is intended to prevent the well water from being contaminated with pathogenic microorganisms or other harmful substances from the septic system. People with dwellings along lakes and rivers who have septic systems for their wastewater treatment and dispersal must locate the absorption fields and pipelines no closer to the stream or lake than 50 feet; thus providing adequate filtration to remove microorganisms and nutrients. If the ground is too wet or if the soil is too sandy, this

distance may not be adequate; microorganisms and nutrients may filter through to the lake or stream. No onsite treatment system should be installed in any area having one percent or greater chance of flooding. Because this would contaminate lake or river waters, beaches in both public and private recreational areas should be closely monitored. Prior to septic tank installation, soil samples are taken to determine how well the absorption field will work and how quickly wastewater will move through it.

Activities in Section Four		
Activity	**Grade Level**	**Description**
Settling In- Sedimentation	K-2	Experiment with sedimentation and how soil acts in water
What Is A Septic Tank?	3-5	Learn what a septic tank is using an interactive model.
Rain Water Runoff	K-2, 3-5	Explore runoff, erosion, and sediment through experimentation
Sediments and Suspension	3-5	Measure the amount of sediment in a natural water sample
Improving Old MacDonald's Farm	6-8	Calculate how much fertilizer Old MacDonald's crops need, explore keeping costs down and preventing nutrient runoff
Mooving Those Cows	6-8	Design a method for transporting cows across a stream while preventing manure runoff
What's Your Decision?	6-8	Use role cards to better understand the various points of view involved in an environmental issue
Do Septic Tanks Do the Job?	6-8, 9-12	Take samples from waterways near septic systems to understand how they can pollute the waterways
Pesky Pesticides	9-12	Interview a farmer to understand pesticide use and alternatives

SETTLING IN - SEDIMENTATION

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Physical Science, Environmental Science, Language Arts
Time
1 hour
Materials
- 2-3 baby food jars for each student
- Sand
- Water
- Recording sheet
- Soil (use any soil that has silt or clay size particles)
- Tablespoons
- Stopwatch
- Pebbles (optional)
- Pictures of Ohio River (optional)

Setting
Classroom
Terms
Sediment
Reference
Adapted from the Water Sourcebook Series, K-2, United States Environmental Protection Agency

Summary

Students perform an experiment to better understand sedimentation and how soil acts in water.

Objective

Students will:
1. Mix sand with water and record or tell what they observed with sedimentation or settling.
2. Predict, record, or tell the effect of shaking on the particles.
3. Give an oral or written definition of the new term: sediment.

Procedure

Advance Preparation

Fill the baby food jars about 2/3 full of water, and place one jar on each student's desk. They will use the same jar for the sand and the silty soil.

Warm Up

Ask students if they have ever seen the Ohio River look brown. You can show them pictures of the Ohio River to emphasize the color. Explain that they are going to do an activity that shows why the Ohio River turns brown. On the recording sheet, have students draw a picture of what the jar of water will look like after a spoon of sand is added to it and a picture of what the jar will look like when a spoon of silty soil is added to it. Ask the students which will settle faster.

Activity

1. Have students add 1 tablespoon of sand to the water in their jars and then draw a picture of their observations.
2. Have students draw a picture of what they think the sand and water will look like after they shake their jars.
3. Tell students to shake their jars. After 30 seconds, tell the students to stop. Start the stopwatch. Have them draw what they see.
4. Ask students to guess how long it will take for the sand to settle.
5. Have each student raise his/her hand when all of the sand has settled. Write the settling times on the board.

6. Repeat the process with the silty soil. Students can add the silty soil to the jar with the sand.

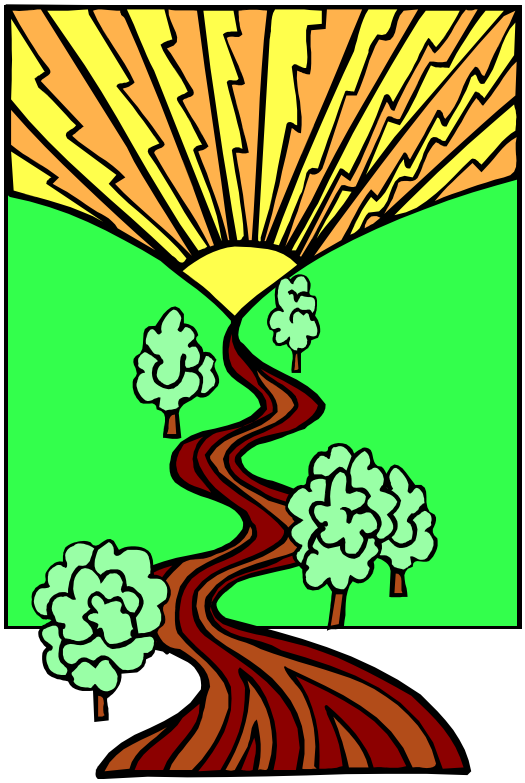
Follow-up

Working in pairs, have students write or discuss their ideas about why one kind of material settled more quickly than the other. Point out that what occurred in the jar is similar to what happens in a natural body of water. The shaking is similar to the rivers or streams flowing and moving particles from place to place. A faster river can carry sediment farther and is able to carry larger sediment like sand. Once the river slows down particles settle out at the bottom called sediment.

Ask students where sediment comes from. Explain that when rain washes over the land it picks up pieces of soil and brings the soil to streams. If you wish to go into more detail about erosion and the effects of sedimentation follow this activity with the *Rain Water Runoff* activity.

Extension

Plan a field trip to visit both the Ohio River and a smaller river or stream. Compare color, speed and sizes of the rivers. Show students a map of the Ohio River watershed. Discuss how big of an area drains into the Ohio River and how sediment is deposited into the river. The Hamilton County Soil and Water Conservation District may be able to help you plan this trip.



Sediment Experiment

prediction

What I think the jar will look like with soil added.

1. Jar with Sand.

Time to Settle _____

2. Jar with Silt and Sand

Time to Settle _____

Which took longer to settle?

WHAT IS A SEPTIC TANK?

Grade Level
3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Math
Time
1 hour
Materials
- 1 plastic or aluminum container
- (6-8 inches deep)
- Potting soil
- Gravel
- 1/2 gallon paper milk carton, labeled "House"
- 1-quart paper milk carton, labeled "Septic Tank"
- Plastic straws
- Clay
- Chart paper
- Cup for water
- Black line master for "How a Septic Tank Works"
- Tack or small nail

Setting
Classroom
Terms
Drain field, Effluent, Septic tank, Sludge, Wastewater
Reference
Adapted from the Water Sourcebook Series, K-2, United States Environmental Protection Agency

Summary

Using an interactive model, students will learn what a septic tank is and how it works.

Objective

Students will:

1. Identify, orally or in writing, the septic tank as a method of wastewater treatment.
2. Tell or write how a septic tank works.
3. Name, orally or in writing, the basic parts of a septic tank.
4. Give an oral or written definition of the new terms: drain field, effluent, sludge and septic tank.

Procedure

Advance Preparation

Find a picture of a septic tank. Construct a septic tank model. (See diagram.) *Teaching Note: Children in grades three to five could construct this model as part of the lesson. As they construct the model have them write out a paragraph about each part and what will happen to the waste in each section. The teacher should still construct an example model before class.

Fill an aluminum roasting pan or a large plastic storage container 1/2 full of potting soil.

To build the house, place a 1/2-gallon milk carton, cut to a height of approximately six inches, at one end of the container. Make a hole two inches from the base of the carton and insert a drinking straw. Seal the connection with clay or tape to prevent leakage.

To build the septic tank, cut a quart-sized milk carton to a height of three inches. On two opposite sides of the carton make a hole 2 inches from the base of the carton. Connect one hole to the straw that is attached to the house.

Make field lines as follows:

1. Punch a large hole in one straw.
2. Insert another straw horizontally through the hole and seal each end with clay.
3. Punch a large hole near the end of this straw. Insert a straw in each hole. Seal the open ends with clay.

4. Using a tack or small nail, punch holes in each straw to allow drainage.
5. Connect the field lines to the septic tank by inserting the middle straw into the hole in the quart carton.
6. Test the system by pouring water into the house and checking for leaks as the water moves through the system. Use clay and or tape to seal any leaks.
7. Put a fine layer of gravel over the soil in the end of the container that represents the drain field.
8. Place the model in the container.

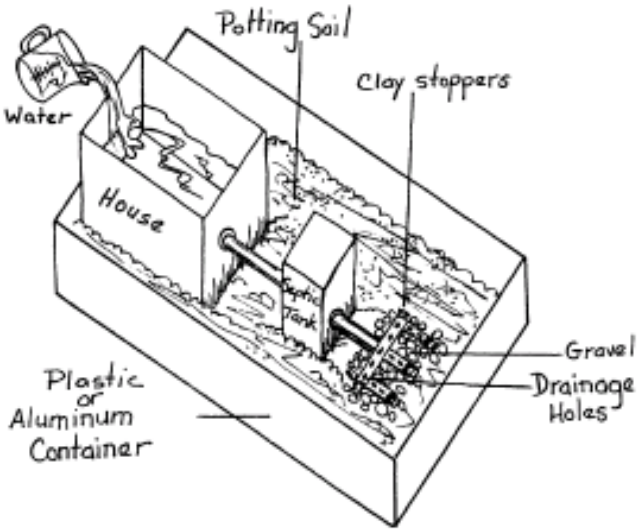
Warm Up

Ask students, what they think wastewater is. Have them identify places wastewater can be found at school. Make a list on chart paper. Show students some drainpipes in school (under sinks). Explain that wastewater must be treated to make it safe before it is discharged into the environment.

Show the students a picture of a septic tank. Ask students, what do you think this is? What is it used for? Explain that it is a septic tank used to treat wastewater.

Tell students they are going to learn how a septic tank works.

Model Diagram



Activity

1. Display the septic tank model and give the students time to examine the model.
2. Explain each part of the model.
3. House - Wastewater leaves through a pipe that is connected to the septic tank.
4. Septic Tank - Explain how solids (sludge) sink to the bottom and that liquids will flow into the field lines. Point out that this process is similar to sedimentation in streams and rivers if you have already completed a sedimentation activity. Explain that there are bacteria living in the tank that help break down the waste. Bacteria cannot break down everything though, so septic tanks have to be pumped every once in while to remove the sludge.
5. Field Lines - Field lines are placed on a bed of gravel. The wastewater seeps out of the holes in the field lines and passes through the gravel into the soil. Bacteria in the soil also help destroy harmful organic material.
6. Demonstrate how the septic tank works by pouring water into the house and letting students observe as the water moves through the system. Explain that this model does not show the solids that are carried by the wastewater and that the process takes much longer in a real septic tank system.

Follow Up

Give the students a copy of the black line master, "How a Septic Tank Works." Have the students label the parts of the septic tank system. Use blue and brown crayons to color the path of wastewater movement into the septic tank. Use the brown crayon to illustrate sludge that settles in the septic tank. Use the blue crayon to show the wastewater flowing though the rest of the system. Divide students into pairs. Ask each student to use the black line master to tell his/her partner what happens to wastewater in a septic tank system.

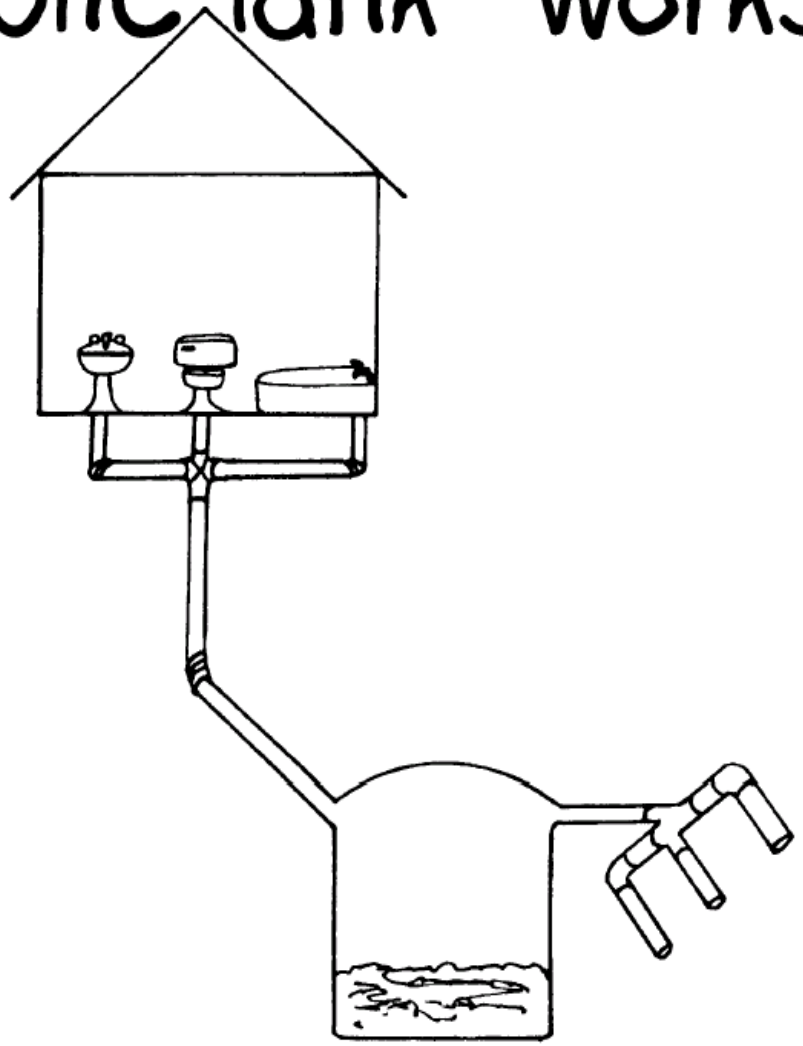
Extension

If possible, visit a site where a septic tank is being installed. Contact the Hamilton County General Health District for possible sites.

Ask each student to find out if his/her house has a septic tank for treating wastewater. Graph the results of the survey.

Discuss with students what would happen if the septic tank leaked. How might this affect nearby streams, lakes and groundwater?

How A Septic Tank Works



1. Label the following;
   drainage pipes
   sludge
   septic tank
   field lines
2. Color the flow of waste water blue. Color the sludge brown.

RAIN WATER RUNOFF

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Earth Science, Geography, Language Arts, Math
Time
2 class periods
Materials
- *Rain, Rain Rivers* by Uri Schulevitz (ISBN: 0374461953)

Each group of 3 students will need:
- 3 1.89-liter (half-gallon) milk cartons
- Outdoor source of soil
- 2-liter bottle
- Metric ruler
- Plastic bucket (5 gallon ice cream bucket)
- Water supply
- Paper towels or cloth hand towel
- Newspaper
- 3 large baby food jars
- Masking tape

Setting
Classroom or outside
Terms
Erosion, Runoff, Sediment, Slope, Uncontaminated
Reference
Adapted from the Water Sourcebook Series, K-2, United States Environmental Protection Agency

Summary

Students conduct an experiment to better understand runoff, erosion and sediment.

Objective

Students will:
1. Describe, orally or in writing, the effects of rainwater runoff.
2. Conduct an experiment on soil erosion and give an oral or written description of the results.
3. Compare and discuss, orally or in writing, the effect of sloping and erosion on soil samples.
4. Give an oral or written definition of the new terms: erosion, sediment, slope, and runoff.

Procedure

Advance Preparation

Collect a plastic gallon bag of soil for each group. Do not use potting soil. Use scissors to cut out the side panel of a milk carton under the spout, leaving the spout intact.

Fill a 2-liter bottle with water. Divide the bottle into thirds by drawing a band around the bottle with a permanent marker and collect supplies on a cardboard tray (box from a case of soft drink cans works great) or tub.

Reproduce one copy of student activity pages for each student.

Warm Up

Read *Rain, Rain Rivers* **ISBN:** 0374461953 by Uri Schulevitz to students.

Explain what erosion is and that rain is important to animal and plant life. Explain to the students that uncontaminated means that the runoff has no pollutants. Runoff waters are necessary to renew many wetlands and other habitats. However, erosion due to fast moving water can be harmful to our environment. Pollution such as insecticides, automobile fluids caked on parking lots and lead from paints and exhausts are washed by runoff into surface waters, streams, rivers, lakes and oceans. Look back through the book for examples of erosion. Silently hold up pictures again and have students write

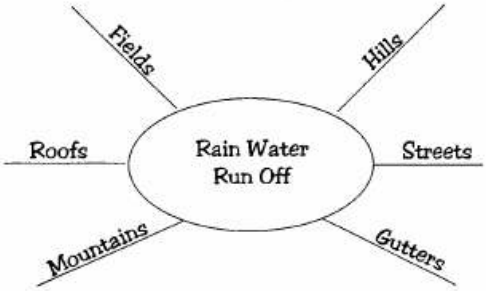
different types of erosion in the book on a group semantic map (a graphic organizer). Discuss the different types observed and what each type of erosion could be washing away.

Define sediment, slope and run-off. Discuss how each term is related to erosion.

The warm up could be done in one class period and the activity the next or depending on time the activity could be completed the following day.

Activity

1. Ask students to describe what happens when water moves over soil. How does the slope of the land affect the washing away of loose soil? (What does slope mean?)
2. Group students into pairs and have them cover the work area with newspaper.
3. Hand out the data sheet "Rain Water Runoff." Show students the tray of materials and describe the procedure.
4. Hand out the trays to each group of students. Also hand students three strips of masking tape. Place one on each of the empty baby food jars. Label them one, two and three. Guide students through the experiment.
5. Lay the milk carton on its side, with the cut out panel facing up. Then fill the carton half-full with the soil. (Use no more than 1/3 of soil in bag.) Pat the soil to smooth the surface. Place the spout side of the milk carton on the edge of a desk. Place jar #1 in the bucket. A student will hold the jar under the spout and over the bucket during the experiment.



6. Ask students to observe the water in the 2-liter bottle and record their description on the record sheet. To simulate rainfall, have one student pour 1/3 of the water from the bottle over soil while another student is catching water from the spout in baby food jar #1 held over the plastic bucket. The goal is to provide a constant flow of water over a flat surface. When the jar is full, observe the color of water. Are there any soil particles in water? Set the jar aside and record observations.
7. Now repeat steps 5 and 6 with another milk carton and a fresh soil sample, but raise the end of the carton to 3 cm. Have students problem solve what to use from the classroom to raise the slope. Hold jar #2 over the bucket and under spout. Be sure to use the same amount of water as in the first trial. Observe the difference in the flow of the water. When the jar is full, observe the color and amount of soil particles. Set the jar aside and record observations.
8. Repeat procedure for a third time, raising the carton to a height of 5 cm. Hold jar #3 over the bucket and under spout. When the jar is full observe the color of the water and amount of soil particles. Set jar #3 aside and record observations.
9. Allow each jar at least ten minutes for soil particles to settle. Ask students to observe jars. (Remind students to not move the jars when measuring). Then measure and record the height of soil in the bottoms of the jars. Tell students that when soil particles settle from water it is called sediment. Have students write a definition for erosion and sediment at the bottom of the record

sheet. When the slope of the carton was increased, what happened to the amount of soil particles?

10. To clean up, collect cardboard trays and supplies. Have students take milk cartons outside and dump the soil in flowerbeds around school. Collect milk cartons in garbage bag and rinse, dry, and store for use again. Use the overflow water in the buckets to water plants around the school.

Follow-Up

Have the students demonstrate their knowledge of soil erosion by performing the following tasks.

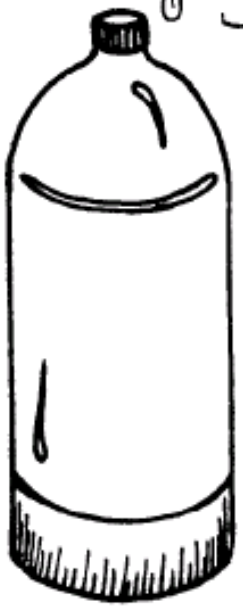
- Explain how water gets muddy. (The runoff of rainwater over soil.)
- Define sediment. (Tiny bits of rocks, soil, and other materials carried into water.)
- Define erosion. (The removal or wearing away of soil or rock by water.)
- Explain how erosion can be both harmful and helpful? (Erosion can be harmful when it removes soil from the land or destroys property along a riverbank. It can also be harmful when the runoff picks up harmful pollutants and deposits them in our surface water. It can be helpful when the soil is dropped somewhere else, building up new land.)
- Have students complete "What Causes Erosion?" activity page.

Extension

Conduct a tour around the schoolyard looking for signs of erosion. In an urban setting, look for such things as cracked and pitted sidewalks, rounded pebbles used for decorative stone, and rivulets carved in dirt by water flowing along street gutters or down slopes on the schoolyard. Construct a chart with the names of areas of erosion. Brainstorm possible solutions.

Write a letter to the principal explaining what you have been studying, along with the area noted on your tour and possible solutions. Ask permission to enlist help from parents and community to correct problem areas. Set up a work session with students and parents to follow through with solutions designed by the class.

RAIN WATER RUNOFF



scientist name _____

1. Describe water in bottle.

color	solid particles

2. Hypothesis:
After the rain shower I think the water will

_____

Experiment_____

3.

JAR 1	JAR 2	JAR 3
		

Observe jar and record your data.

color_____

soil pieces

_____ cm	_____ cm	_____ cm

4. erosion-_____

5. sediment-_____

What Causes Erosion

List the things in this picture that could cause erosion:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Name: _____ Date: _____

SEDIMENTS AND SUSPENSION

Grade Level
3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Earth Science
Time
1 hour for collection
24 hours for settling
40 minutes for activity
Materials
- Two or more clear jars with lids
- Several clear cups or jars
- Rulers
- Filter or strainer
- Bucket or sink
- Microscope

Setting
Creek side for collecting, classroom for remainder
Terms
Clay, Sand, Sediment, Sedimentation, Silt, Turbidity
Reference
Adapted from Stevens Creek Connections, Environmental Volunteers and Water Ecology Topics, Janet Hougardy and Linda Wagner

Summary

Students observe sediments from a local creek and measure the amount of sediment in a natural water sample to explore the process of sedimentation.

Objective

Students will:
1. Discover how flowing water can carry particles in suspension.
2. Observe how and why sediments settle out.
3. Understand that sediments come from erosion.

Procedure

Advanced Preparation

Collect several jars of murky water from a lake or stream to take back to the classroom (enough for each group of four students to have one jar). Also collect half of a jar of sediment from the edge of the creek bed for each group of four students.

Warm Up

Explain to students where each jar came from. Define sediment and sedimentation (or settling). The turbidity of a creek or stream keeps sediments suspended in the water just like when you shake the jar. As the water slows down some of the sediments settle to the bottom causing sedimentation.

Explain to students that sediments can be different sizes depending on what type of soil they are. Sand is large and heavy while clay is small and light. Silt falls in the middle. Ask students which type of sediment they think will settle out first and why?

Jar showing settlement of sediments

Activity
1. Have students set the jars of murky water on a shelf or windowsill undisturbed for 24 hours to allow them to settle out.
2. Fill the jar that has the creek side sediment

in it nearly to the top with tap water, put the lid on and shake it, remove the lid and set it on the sill to settle out over night with the other collected water samples.

3. The next day, let students measure the layer of sediment in the collected water samples.
4. Gently filter the water from the jar and discard.
5. Have students observe the remaining sediments under the microscope. Students can use student sheets to keep notes about the amount of sediment, type of sediment and the clarity of the water after the settling.
6. Observe the sediment in the jar that was collected from the creek side. Students will make observations and measurements as noted for the water samples. This will allow them to get an understanding of sedimentation and turbidity.

Follow Up

Ask students the following questions:

- Where do sediments in the creek water come from?
- When is most sediment likely to enter the stream?
- Which materials settled out first?
- Which materials are likely to be carried the farthest in the creek?
- What will happen to the sediments that are carried down the Ohio River?

Extension

Collect a half jar of schoolyard soil and do as above, comparing school soil composition to creek side soil. What are the percentages of rock, gravel, sand and clay?

Sediments and Suspension

Day One

Hypothesis:

1. Which type of sediment will settle to the bottom first: sand, silt, or clay? Label the layers of the jar with the order you think the sediment will settle.

2. Explain why you made these predictions.

Day Two

Water Sample

3. How many layers of sediment do you observe in the jar?

4. Have all the sediments settled? How can you tell? (Hint: How clear is the water?)

5. List the measurements and include a brief description of each layer. Include a drawing of the jar in the space provided.

	Number	Thickness	Describe
Layer			
Layer			
Layer			

Creek Sample

6. How many layers of sediment do you observe in the jar?

7. Have all the sediments settled? How can you tell? (Hint: How clear is the water?)

8. List the measurements and include a brief description of each layer. Include a drawing of the jar in the space provided.

	Number	Thickness	Describe
Layer			
Layer			
Layer			

Under the Microscope

9. Observe sediments under the microscope. Compare sediments from different layers. Describe what you see.

   Top Layer

   Type of sediment (Sand, Silt or Clay)

   Describe what you see

   Middle Layer

   Type of sediment (Sand, Silt or Clay)

   Describe what you see

   Bottom Layer

   Type of sediment (Sand, Silt or Clay)

   Describe what you see

IMPROVING OLD MACDONALD'S FARM

Grade Level
6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Math, Language Arts
Time
2 class periods
Materials
- Copies of student sheet
- Calculators (optional)

Setting
Classroom
Terms
Fertilizer, Nitrogen, Phosphorus
Reference
Adapted from the NPS Activity Sheets, United States Environmental Protection Agency

Summary

In this exercise, students progress through a series of calculations to determine how much fertilizer Old MacDonald's crops need and explore surrounding issues such as keeping costs down and preventing nutrient runoff into nearby lakes and streams.

Objective

Students will:

1. Work through calculations to determine how much fertilizer is needed to meet a plant's nutrient requirements.
2. Draw conclusions about the most cost-effective and environmentally sound farming practices.

Procedure

Advanced Preparation

This activity can be altered to have a science or math focus. If calculators are used the focus is less on the calculations and more on the message of the activity. Activity time will be shortened with the use of calculators and can be shortened further by providing students with the completed chart on the teacher's answer sheet.

Warm Up

Introduce the terms fertilizer, nitrogen and phosphorus. Explain briefly to the students how fertilizers are a part of nonpoint source pollution.

Activity

1. Pass out student sheets and discuss with students Old MacDonald's dilemma. Review units if necessary.
2. Fill out chart after the dilemma.
3. Have students perform calculations in Part I.
4. Discuss with students their answers in Part I to ensure all of the answers are correct.
5. Have students fill out Option 1 of Part II.
6. Tell with students that there is another option for the farmer and ask if they can hypothesize that option.
7. Have students fill out Option II.

8. Ask students to compare the two options and finish the student sheet calculations.

Follow Up

Have students write a paragraph justifying their decision.

Explain to students that manure also contains other nutrients such as manganese, calcium, sulfur, boron and iron that plants need to survive. If Old MacDonald applies manure only to his pastureland (as was the case for nitrogen based application), he might still have to purchase and apply these additional nutrients to satisfy crop needs. Manure application will also increase the health of the soil because manure contains organic matter that is used as food by worms and other organisms in the soil. The result is a healthier soil that grows healthier crops while reducing the environmental damage of excess nutrient runoff into lakes and streams.

Extension

Contact the Hamilton County Soil and Water Conservation District to purchase a soil quality testing kit for $12.00. You can use the kit to sample the soil around your schoolyard for similar nutrients.

Improving Old MacDonald's Farm

Dilemma

Old MacDonald has a small farm. The cows graze in a 15-acre pasture, and he grows corn to feed his chickens, pigs and cows in a 35-acre field. Altogether, Old MacDonald's animals produce about 170 tons of manure every year! That manure contains 1,200 pounds of nitrogen and 800 pounds of phosphorus.

Old MacDonald knows that manure is an unbalanced fertilizer for corn because it has too much phosphorus and not enough nitrogen. Corn plants use 5 to 20 times as much nitrogen as phosphorus, and there is less than twice as much nitrogen than phosphorus in manure. Farmers usually apply manure to fulfill the nitrogen requirements for crops. Because crops do not use up the phosphorus in the manure, the result is an over application of phosphorus. This phosphorus then builds up in the soil until a rainstorm washes it into nearby streams or rivers, where it can cause water quality problems and threaten aquatic life.

Solving the Problem

Old MacDonald wants to fertilize his pasture and cornfields with the manure that his cows, chickens and pigs produce. After all, it's free, and he doesn't have to haul it from somewhere else! And commercial fertilizer is expensive - nitrogen costs 15¢ per pound and phosphorus costs 50¢ per pound. However, his choice is not easy. Either he spreads enough manure so that the crops get enough nitrogen (leaving large amounts of leftover phosphorus that could run off into streams and lakes) or he spreads only enough manure so that the crops get the right amount of phosphorus (but not enough nitrogen).

After testing the soil, Old MacDonald is able to determine that the pasture requires 80 lb/acre of nitrogen and 5 lb/acre of phosphorus for the best growth. He also discovers that his corn crop needs 125 lb/acre of nitrogen and 25 lb/acre of phosphorus for the best growth. Fill in the table below with information from the preceding paragraphs.

	Number	Units
Pasture size		
Corn field size		
Manure produced		
Nitrogen in manure		
Phosphorus in manure		
Cost for extra nitrogen		
Cost for extra phosphorus		
Nitrogen needed to fertilize pasture		
Phosphorus needed to fertilize pasture		
Nitrogen needed to fertilize corn		
Phosphorus needed to fertilize corn		

Doing the Calculations . . .

Part I.
Find the amounts of nitrogen and phosphorus required on the farm:

1. How much nitrogen does Old MacDonald need to fertilize his farm?
_____Acres pasture x _____lb nitrogen per acre = _____lb
_____Acres cropland x _____lb nitrogen per acre = + _____lb
lb = nitrogen requirement

Remember your order of operations. Multiplication is done before addition.

2. Now compare the amount of nitrogen required on the farm to the amount of nitrogen in the manure. Is there enough nitrogen in the manure to fertilize both the pasture and corn?

3. How much more nitrogen does he need?

4. How much phosphorus does Old MacDonald need to fertilize his farm?
_____Acres pasture x _____lb phosphorus per acre = _____lb
_____Acres cropland x_____ lb phosphorus per acre = + _____lb
lb = phosphorus requirement

5. Now compare the amount of phosphorus required on the farm to the amount of phosphorus in the manure. Is there enough phosphorus in the manure to fertilize both the pasture and corn?

6. How much more phosphorus does Old MacDonald need?

Part II.
Option 1: Fertilize with enough manure to meet nitrogen needs

From the calculations in Part I, we discovered that the pasture needs 1,200 pounds of nitrogen. This is exactly the amount of nitrogen contained in the manure produced on Old MacDonald's farm. So, let's assume that Old MacDonald uses all the manure to fertilize his pasture. This will completely satisfy the pasture's need for nitrogen and phosphorus.

However, he still needs to fertilize his corn crop. Because Old MacDonald used all the manure produced on his farm to fertilize his pasture, he must buy commercial fertilizer for his corn. He needs to buy both nitrogen and phosphorus.

7. How many pounds of nitrogen would Old MacDonald need to buy? *Hint: Look at your calculations in #1.*

8. How much would Old MacDonald have to pay to buy enough commercial nitrogen?

9. How many pounds of phosphorus would Old MacDonald have to buy? *Hint: Look at your calculations in #3.*

10. How much would Old MacDonald have to pay to buy enough commercial phosphorus?

11. How much would Old MacDonald spend in all on commercial fertilizer for Option 1?

Option II. Fertilize with enough manure to meet phosphorus needs
Old MacDonald does not have to use all the manure from his farm to fertilize his pasture. From the calculations in *Part I*, we found that if Old MacDonald puts some of the manure on the pasture and some on the corn field according to the amount of phosphorus each field needs, he will need to buy only 10 pounds of phosphorus. However, he will then have to put nitrogen on both his pasture and his cornfield. Will this method of distributing fertilizer be worth it? Let's find out.

12. After spreading manure according to the phosphorus needs of each field, how many pounds of phosphorus would Old MacDonald need to buy?

13. Find the total price that Old MacDonald would have to pay for commercial phosphorus.

14. How many pounds of nitrogen would Old MacDonald have to buy? *Hint: Subtract the total amount of nitrogen Old MacDonald needs from the amount of nitrogen in the manure that he spread.*

15. Find the total price that Old MacDonald would have to pay for commercial nitrogen.

16. How much would Old MacDonald spend in all on commercial fertilizer for Option 2?

Making the Right Decision

17. Which is cheaper for Old MacDonald, Option 1 or Option 2?

18. How much would Old MacDonald save if he used the cheaper method?

19. Which method of fertilization would lead to less excess phosphorus accumulation in the soil? (Remember that excess phosphorus in the soil is washed away by rainwater and leads to pollution in nearby waterways.)

Old MacDonald's Farm

Verse 1
Old MacDonald had a farm . . . E-I-E-I-O
And on this farm he had 900 chickens . . . E-I-E-I-O
With a cluck-cluck here and a cluck-cluck there,
Here a cluck,
There a cluck,
Everywhere a cluck-cluck
Old MacDonald had a farm. . . E-I-E-I-O
Verse 2: And on this farm he had 10 pigs
Verse 3: And on this farm he had 12 cows

Answer Sheet- Old MacDonald's Farm

	Number	Units
Pasture size	***15***	***Acre***
Corn field size	***35***	***Acre***
Manure produced	***170***	***Tons***
Nitrogen in manure	***1200***	***Pounds***
Phosphorus in manure	***800***	***Pounds***
Cost for extra nitrogen	***15***	***Cents***
Cost for extra phosphorus	***50***	***Cents***
Nitrogen needed to fertilize pasture	***80***	***Pounds/ Acre***
Phosphorus needed to fertilize pasture	***5***	***Pounds/ Acre***
Nitrogen needed to fertilize corn	***125***	***Pounds/ Acre***
Phosphorus needed to fertilize corn	***25***	***Pounds/ Acre***

Part I.

1. __***15***__Acres pasture x __***80***__lb nitrogen per acre = _***1200***_lb
   __***35***__Acres cropland x _***125***__lb nitrogen per acre = + _***4375***_lb
   5575 lb = nitrogen requirement

2. ***No***
3. ***4375 pounds***
4. __***15***__Acres pasture x __***5***___lb phosphorus per acre = __***75***__lb
   __***35***__Acres cropland x__***25***__ lb phosphorus per acre = + ***87***__lb
   950 lb = phosphorus requirement

5. ***No***
6. ***150 pounds***

Part II.

Option 1: Fertilize with enough manure to meet nitrogen needs

7. ***4375 pounds***
8. ***$656.25***
9. ***150 pounds***
10. **$75**
11. ***$731.25***

Option II. Fertilize with enough manure to meet phosphorus needs

12. ***10 pounds***
13. ***$5.00***
14. ***4375 pounds***
15. ***$656.25***
16. ***$661.25***
17. ***Option 2***
18. ***$70.00***
19. ***Option 2***

MOOVING THOSE COWS

Grade Level
3-5, 6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Language Arts
Time
1 hour
Materials
- Copies of Mooving Those Cows worksheet and Solutions

Setting
Classroom
Terms
Nonpoint source pollution
Reference
Adapted from the NPS Activity Sheets, United States Environmental Protection Agency

Summary

Students design a method for transporting cows across a stream and providing the cows with water while preventing manure runoff.

Objective

Students will:

1. Better understand the various dilemmas farmers face with cows around a stream.
2. Develop and evaluate some of the solutions to these dilemmas.

Procedure

Warm Up

Discuss with students how manure can contribute to nonpoint source pollution. Also mention how manure can be beneficial to us when used as a fertilizer.

Activity

1. Explain the dilemma to the students and pass out the student sheets.
2. Allow the students a few minutes to design solutions on their own. Students can draw the plan on the sheet and explain in writing if necessary.
3. Ask students to read the information sheet and discuss some of the conservation measures that are currently being taken to prevent manure from becoming a nonpoint source pollutant.
4. Allow students to adjust their plans accordingly.

Follow Up

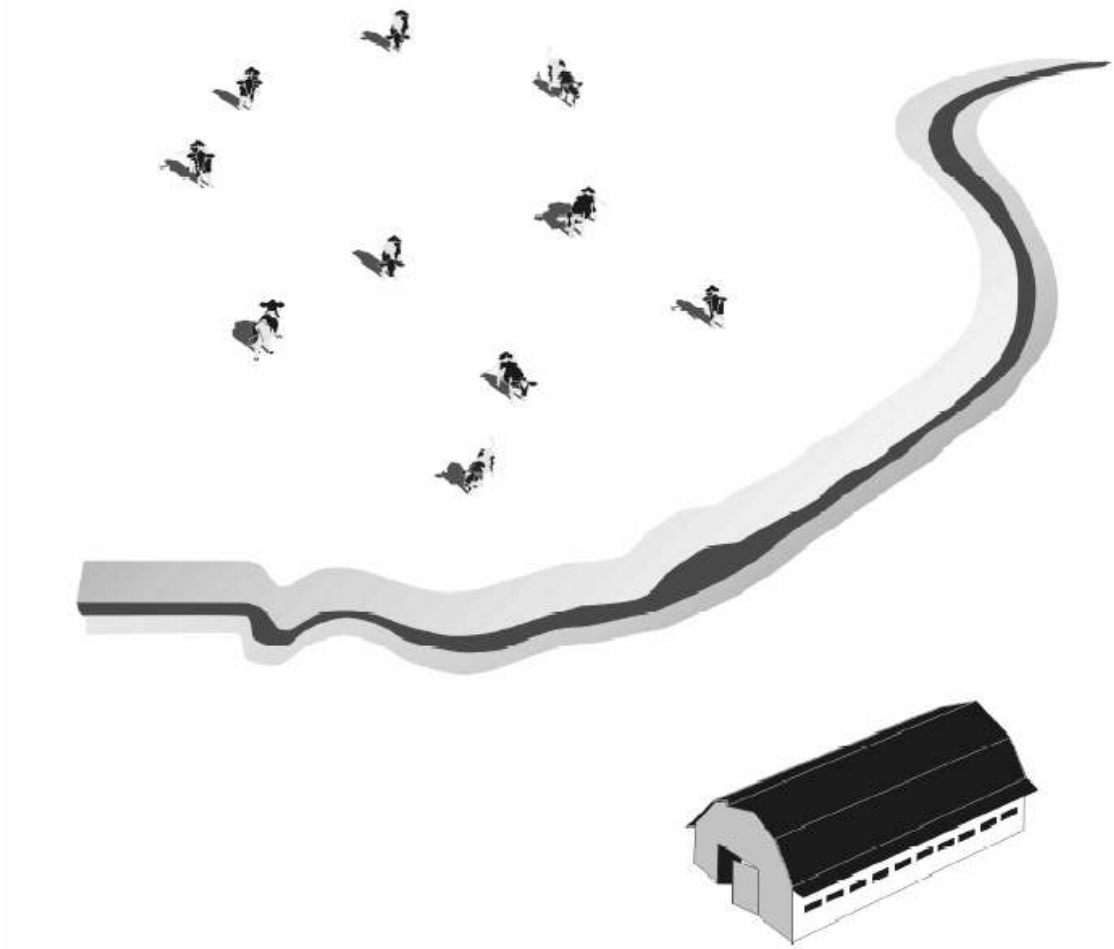
Have students present their drawing and plans to the rest of the class.

Extension

Visit a local farm to observe the conservation practices they use with livestock. There are several excellent educational farms in the area (see Resources section for list).

Mooving Those Cows

Old MacDonald has a second dilemma. A small stream runs between the cow pasture and the barn, as shown in the picture below. Your job is to draw a plan that will allow the cows to roam between the barn and the pasture and will also provide water for the herd. Label any devices that you use and their purpose. When you are finished with your drawing, write a paragraph about the benefits and drawbacks of your design.



Things to think about

- How would you get your cows water but keep them out of the stream?
- What problems can you cause for the stream if you let the cows drink directly from it?
- How else can you get water from the stream to the cows?
- How will the cows get across the stream to their barn?
- What streamside practices would you use to make sure water quality, the physical stream structure, and the fish and organisms living in the stream are protected?

Mooving Those Cows Solutions

For years, farmers have been working on new ways to keep cows out of nearby streams. They have come up with a number of practices that help reduce the damage cows can do to a stream. You can use some of these practices to help Old MacDonald with his cows, or you can come up with some practices of your own.

- A watering trough is a place where cows can drink away from the stream. Use a water pump to get water out of the stream and into the trough.
- Wherever cows gather together in a large group, they dig up the ground with their hooves. Rainfall washes the loose dirt down the stream as sediment. Use a heavy use pad (geotextile fabric and crushed stone) in places where cows are expected to gather to keep this from happening.
- Put up a wire fence to prevent cows from getting into the stream or breaking up mud along streamside areas with their hooves.

Wire fences keep cows from walking on stream banks and digging them up with their hooves.

- Plant grasses or bushes to protect the stream from mud and sediment washing into it off the banks.
- Remember that cows leave manure wherever they stand around for a long time. If rain falls on these high-use areas, it will wash manure down into the stream. Plant grasses, shrubs, and trees along the stream bank to capture and filter some of that runoff.
- Catch water from high use areas in a settling pond. This practice allows bacteria and pollutants from the manure to settle out of the water before it runs into the stream.
- Ever heard of a cow path? Cows typically find a path and stick to it. They will find their way back to the barn from the stream. But they might crowd around trying to get back into their pens! Create an outdoor holding area/exercise area outside the barn door that is fenced off.
- You can expect cows to leave manure in the exercise area. A water ditch can divert water to wash manure out of this area. Then the water should be directed into a settling pond before flowing back into the stream.

Planting vegetation along stream banks can help filter out nutrients and bacteria from rainwater that runs off cow pastures.

- Create a bridge over the stream so that cows will be able to cross over the stream without trudging in it or leaving manure in it.
- Wire fences (above) keep cows from walking on stream banks. Planting vegetation (left) along stream banks can help filter out nutrients and bacteria from rainwater that runs off cow pastures.

WHAT'S YOUR DECISION?

Grade Level
6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Social Studies, Language Arts
Time
45-60 minutes
Materials
- Copies of dilemma and point of view cards
- Props and costumes (optional)

Setting
Classroom
Terms
Nonpoint source pollution
Reference
Adapted from Big Sioux Water Festival, East Dakota Development District and the Local Watershed Studies, Elementary School Curricula

Summary

Students use role cards to better understand the various points of view involved in an environmental issue.

Objective

Students will:
1. Consider an environmental issue from different points of view.
2. Consider everyone involved in an environmental issue and their different perspectives and identify the strengths and weaknesses of different action steps.
3. Develop justification for their decision.

Procedure

Warm Up

Explain to students that many times there is not a right or wrong answer to an environmental question and that people have different motivations determining their views of an environmental issue.

Activity

1. Divide students into groups of nine and hand out the, "What's Your Decision" dilemma to each student.
2. Tell the students in each group that this dilemma will involve each of them. The focus of the dilemma will be on the character that draws the, "Environmental Agency Employee".
3. Have students carefully read the, "What's Your Decision" dilemma.
4. Ask each student in the group to draw one, "Point of View" character card.
5. Instruct the groups to share their dilemmas with each other and their initial decision. After everyone has had a turn, explain to the group that their first decision may not be their final decision. Each should not feel an undue responsibility to defend their first choice. As the discussion continues, they may believe they've made a choice that needs to be reconsidered and possibly changed.
6. Have each member make a final decision on the action that they will take to solve the problem. Stress to each student that there is no right answer.

Follow Up

Have each group summarize their discussion. Allow students to write a justification and share their final decision and justification for that decision.

- How many students changed their decision? How and why?
- How difficult or easy was this task? Why?
- What conclusions can you draw?

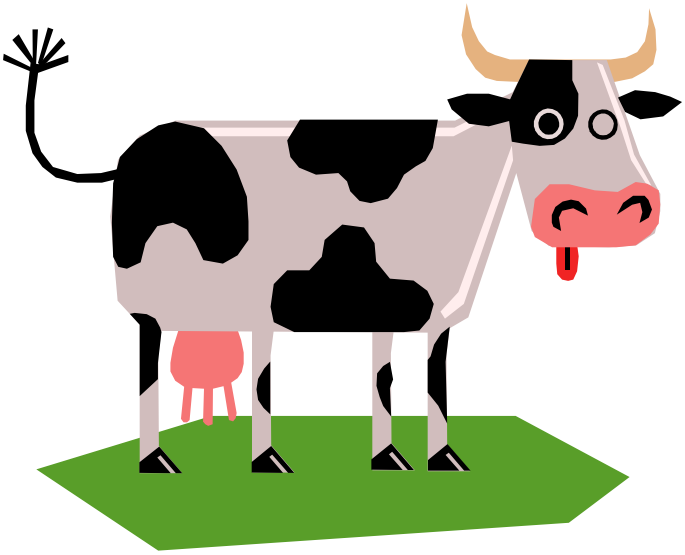
Extension

Research nonpoint source pollution concerns in Hamilton County. As a class, prioritize each concern, based on the detriment to the county community. Choose the top priority and design a flyer or brochure that provides information and educational assistance to the group most affected by the pollution. Distribute throughout the community.

What's Your Decision Dilemma?

A regional environmental agency employee has been traveling in the county area looking for potential sources of nonpoint source pollution. During his/her travels, it is discovered that about 25 head of cattle are grazing in and near a creek, which feeds Clear Lake. Clear Lake is a 100-acre lake surrounded by many year-round residents. The creek runs through about 60 of the 180-acre Branson farm. This farm has been in the Branson family for four generations and has never been more than a marginal operation. The Branson family and the environmental agency employee's family have been close friends for as long as anyone can remember.

The grazing practices are against current environmental guidelines. The environmental agency employee must report all occurrences of improper grazing practices. Such reports of similar practices in the past have resulted in court orders to halt grazing within 100 yards of a stream. If such action is taken in this case, the Branson's will probably have to give up farming and sell the land for some other use.



Point of View Environmental Agency Employee Dilemma: Should you initiate action to halt this nonpoint source pollution entering Clear Lake?	**Point of View** Mr. Branson Dilemma: What is your responsibility to your family and the community if you continue to graze your cattle by the creek?	**Point of View** Head of the local Sierra Club Dilemma: Should you follow the dictums of the Sierra Club and proclaim an environmental hazard, even though Mr. Branson is your brother and you grew up on the farm?
Point of View One of the Branson children about to inherit the farm Dilemma: What is your responsibility to the community and your family if you continue the grazing practices?	**Point of View** A lake property owner adjacent to the creek outlet Dilemma: How will the continuance of their grazing practices affect your feelings about your neighbors and good friends, the Branson's?	**Point of View** Environmental Agency Employee's Father Dilemma: Should you side with your son/daughter or your close personal family friend Mr. Branson?
Point of View A city dweller who drinks the water from Clear Lake Dilemma: Should you pressure the Environmental Agency to stop the grazing practices, thus causing the sale of the farm?	**Point of View** A realtor who wants to buy the Branson farm for development purposes Dilemma: Should you pursue the purchase of the farm, knowing the possible controversy with the Branson's family, neighbors and friends and more importantly, problems with the Environmental Agency?	**Point of View** The neighbor farmer who lives upstream from the Branson's Dilemma: should you side with the Branson's knowing that your cattle also graze close to the creek?

DO SEPTIC TANKS DO THE JOB?

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Biology, Ecology
Time
3 days
Materials
- Copies of Background information
- Copies of all student sheets
- Fecal Coliform Testing Kit (available from Carolina Biological)
- Water samples in bottles
- Plastic, sterile, disposable petri dishes
- Disposable gloves
- Alcohol for clean up
- Microscope
- Slides and slide covers

Setting
Classroom, Waterway near a septic tank
Terms
Absorption field (drain field), Fecal coliform bacteria, Percolation, Percometer, Septic system, Septic tank
Reference
Adapted from the Water Sourcebook Series, 6-8, United States Environmental Protection Agency

Summary

Students take samples from waterways near septic systems and conduct an experiment to better understand how a septic system can pollute the waterways.

Objective

Students will:

1. Investigate a septic tank system and tell the functions of its two major components.
2. Explain how inefficient septic systems can cause contamination of surface waters located nearby.
3. Culture bacteria and practice sterile techniques in the lab.

Procedure

Advance Preparation

Order a Fecal Coliform Testing Kit.

Find sources of water (streams or lakes) that are close to homes using septic tank systems. For help locating an area using septic tanks contact the Hamilton County General Health District.

Have the students collect bottles of water from the designated areas. Make certain to practice safety procedures (e.g. gloves, goggles). Be certain that the water is collected in clean bottles and that it is then stored in the refrigerator until used as the possible source of bacteria-containing water. They should also collect some water close to the stream bank and upstream from the possible contamination. This will let them know if the lake or stream already had a fecal coliform population independent of the suspected source.

Be certain that the students know the sterile procedures to be used when culturing bacteria.

Warm Up

Explain to the students that beaches may be closed if fecal coliform bacteria in sufficient numbers are found there. A high fecal coliform count indicates that human and/or animal wastes have contaminated the water. However, there is no reliable means to determine the exact source of fecal coliform bacteria. It is safer, cheaper and more effective to prevent the bacteria from reaching a high level in the stream or lake than to treat the polluted water.

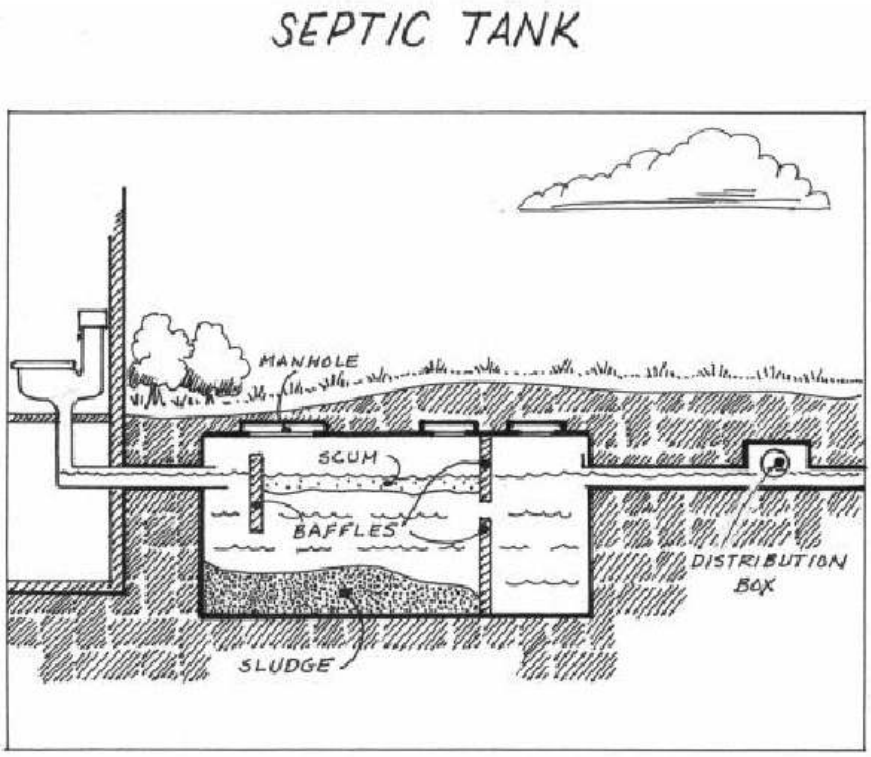
Explain to the students that whenever bacteria are cultured, there are sterile procedures that must be followed. Work surfaces should always be washed down with a diluted bleach solution. Hands should always be washed before and after working with the bacteria and gloves should be worn during testing. A minimum amount of movement should be permitted in the room to help keep the work area sterile (i.e., not stir up dust). Petri dishes should be opened only when the agar or gel is to be poured and when the gel is swabbed with the water from the lake or stream. The top of the petri dish should never be placed facedown on the counter. To learn how to grow the indicator fecal coliform bacteria, follow the instructions in the kit.

Activity

1. Explain to the students that inadequate septic tank systems along a stream or lake shoreline can contaminate the water with bacteria.
2. Ask for volunteers to bring in bottles of water from designated areas to be tested for fecal coliform bacteria.
3. Inoculate the gels with the water from the designated areas. Label samples by locations.
4. Incubate the cultures for the specified time; then look for fecal coliform growth on the gels.
5. Determine if the fecal coliform count reaches the action level. For swimming there should be no more than 200 fecal coliform/100 ml of water.

Follow Up

If the fecal coliform level is not within the safety range call the Hamilton County General Health District at (513) 946-7800. Have the students label a diagram of a septic system and explain the functions of the two parts of the system. Tell them to write the functions under the labeled picture.



Extension

If any students have a septic system, have them bring in water samples from any wells or streams nearby (if applicable) for fecal coliform testing.

BACKGROUND INFORMATION

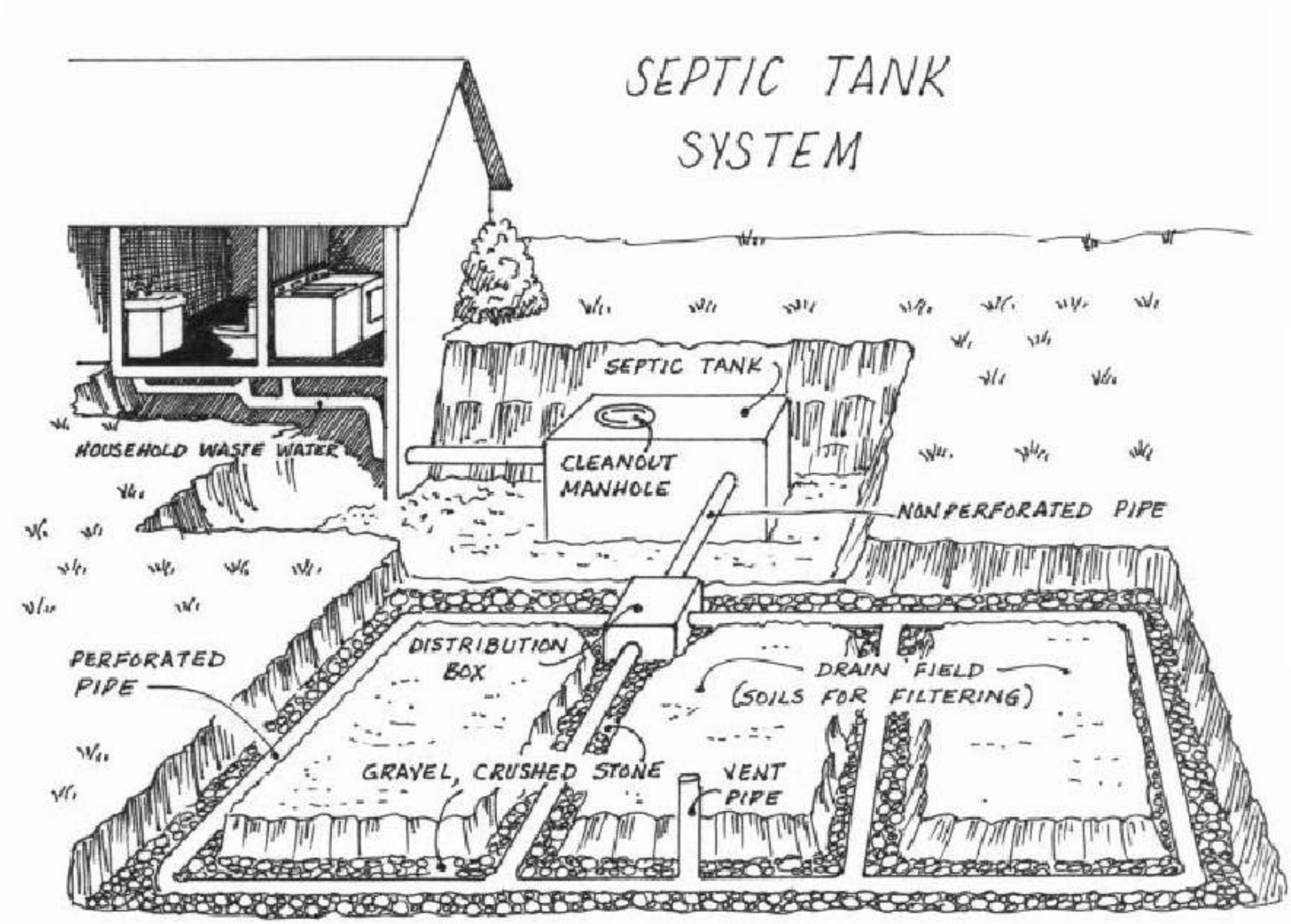
Almost 30 percent of the U.S. population disposes their sewage and wastewater through an on-site disposal system. Some 85 percent of the on-site disposal systems are septic tanks.

Septic tanks are used to collect, treat and disperse wastewater generated by homes and businesses. They are required in areas that are not served by public sewers. A septic tank is a large watertight, covered receptacle designed and constructed to receive wastewater from a building. The tank provides primary treatment where heavy solids in the wastewater sink to the bottom of the tank and lighter solids, such as greases, separate from the liquid and form a scum layer on the top. **Anaerobic** bacteria break down the solids into carbon dioxide, methane and water. The scum layer and heavy solids remain in the tank. This undigested residue must be periodically pumped out and taken to a wastewater treatment plant. The "clear layer," located between the scum and sludge layers, contains the liquid discharged from the septic tank. This liquid is mostly water which contains dissolved materials that flow out of the tank and into a piping network called a drain field. Here, perforated pipes surrounded by gravel slowly release the wastewater into the soil where **aerobic** bacteria in the soil finish the treatment process. Soil bacteria continue to destroy the remaining organic material in the effluent.

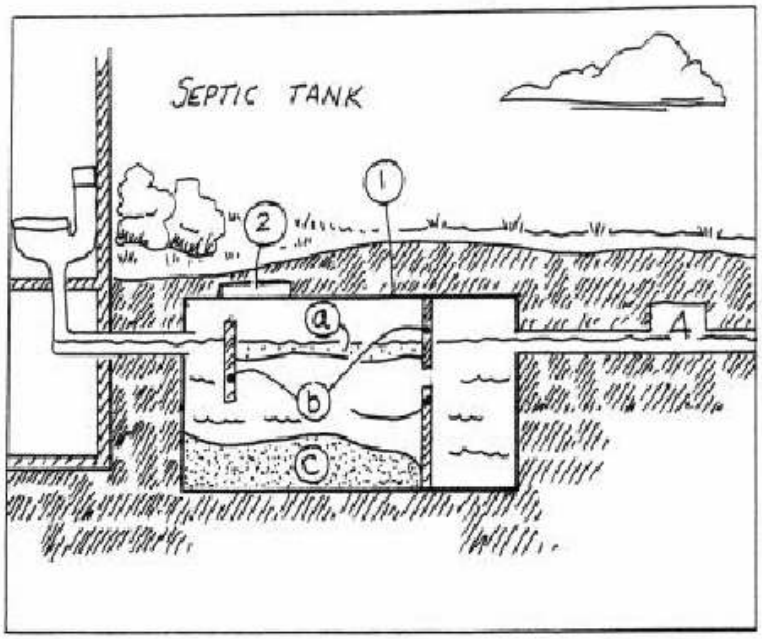
To avoid contamination, houses with both septic tanks and a private well typically must not have their water well within 100 feet of the septic system and well's casing must be sealed. This is intended to prevent the well water from being contaminated with pathogenic microorganisms or other harmful substances from the septic system. People with dwellings along lakes and rivers who have septic systems for their wastewater treatment and dispersal must locate the absorption fields and pipelines no closer to the stream or lake than 50 feet; thus providing adequate filtration to remove microorganisms and nutrients. If the ground is too wet or if the soil is too sandy, this distance may not be adequate; microorganisms and nutrients may filter through to the lake or stream. No onsite treatment system should be installed in any area having one percent or greater chance of flooding. Because this would contaminate lake or river waters, beaches in both public and private recreational areas should be closely monitored. Prior to septic tank installation, soil samples are taken to determine how well the absorption field will work and how quickly wastewater will move through it.

Terms

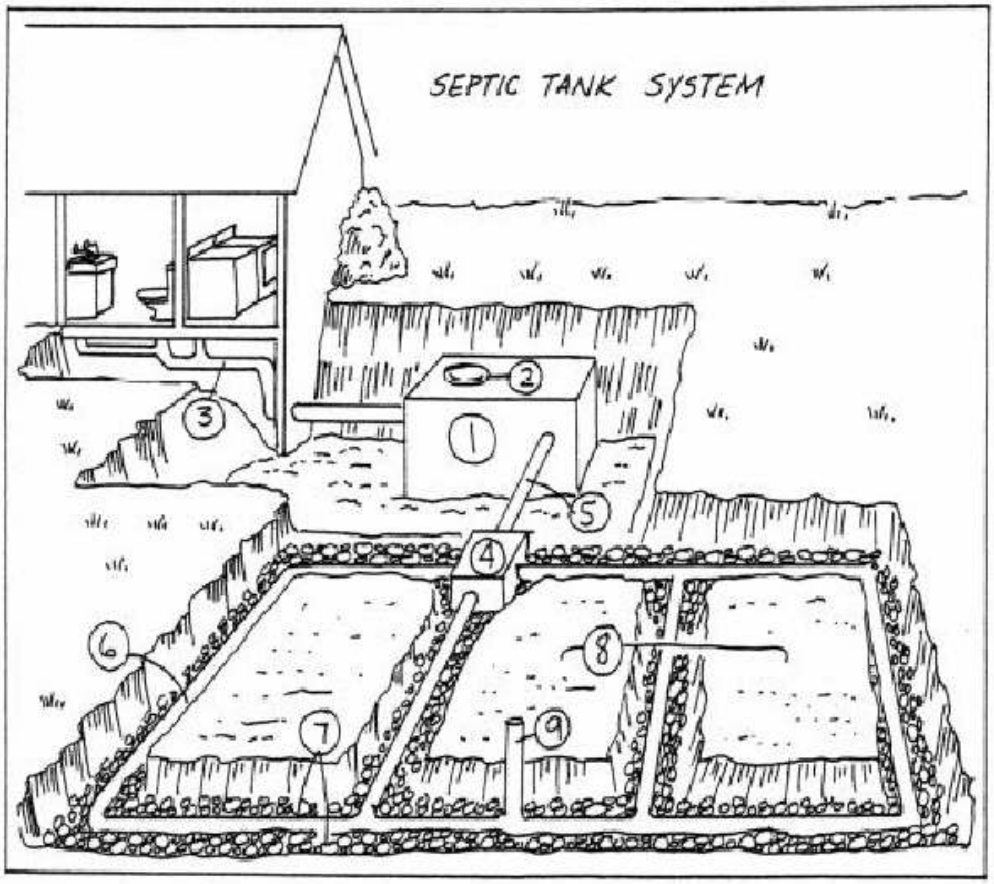
Absorption field (drain field): area where effluent from a septic tank is discharged.
Fecal coliform bacteria: a type of coliform bacteria found in the intestines of humans and warm-blooded animals that aids in the digestion process and is used as an indicator of fecal contamination and/or possible presence of pathogens.
Percolation: the downward movement through the subsurface soil layers to groundwater.
Percometer: an instrument to measure the rate of percolation.
Septic system: on-site equipment or system to treat wastewater, consisting of a septic tank and an absorption field.
Septic tank: a tank, commonly buried, to which all of the wastewaters from the home should flow and in which, primary digestion of the organic matter occurs by anaerobic bacteria; the main part of a septic system where scum and solids accumulate.


SEPTIC TANK
SYSTEM
SEPTIC TANK
CLEANOUT
MANHOLE
HOUSEHOLD WASTE WATER
NONPERFORATED PIPE
DISTRIBUTION
BOX
PERFORATED
PIPE
DRAIN FIELD
(SOILS FOR FILTERING)
GRAVEL, CRUSHED STONE
VENT
PIPE

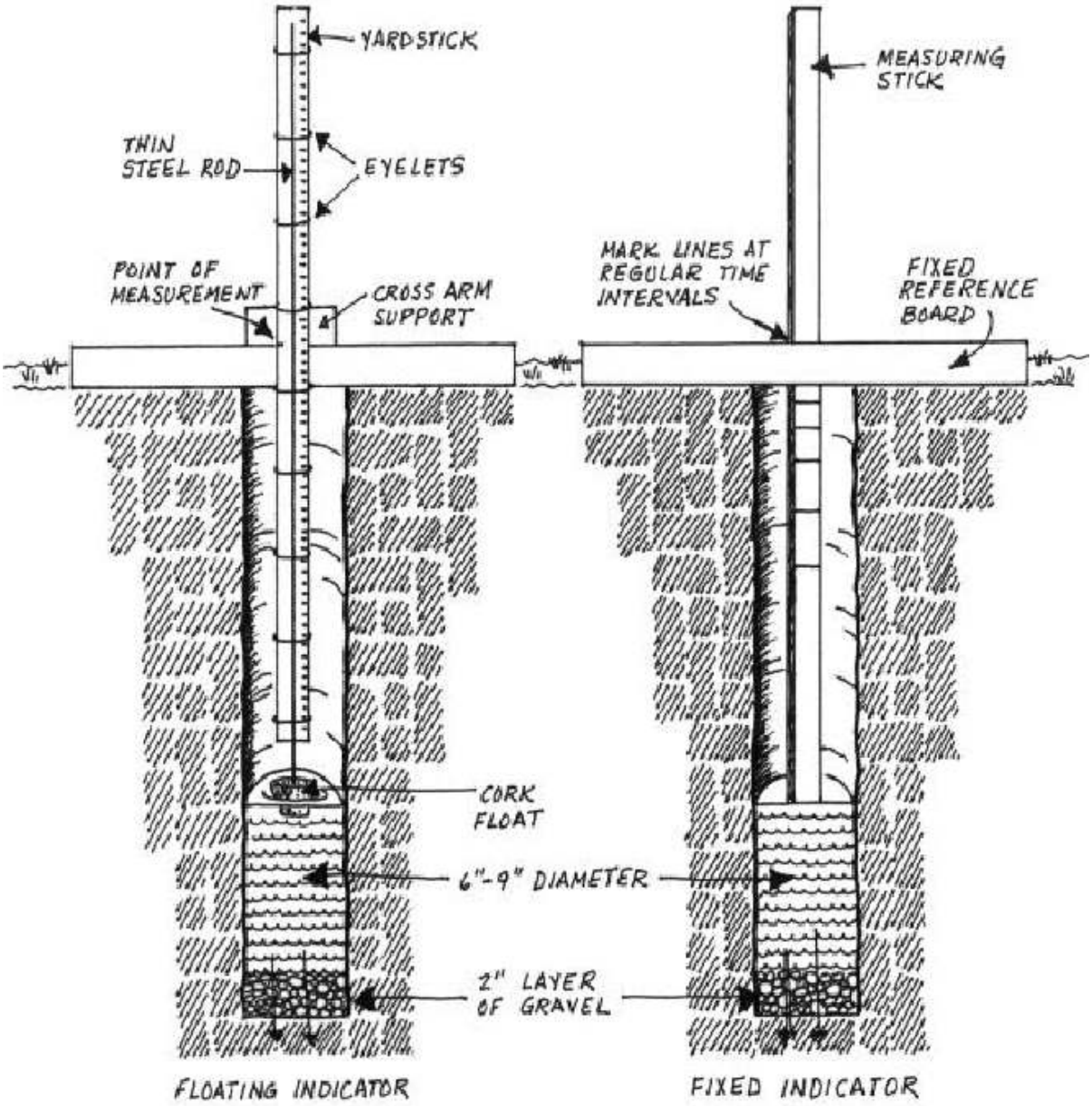
Septic Tank Parts Identification



1. _____
   a. _____
   b. _____
   c. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____

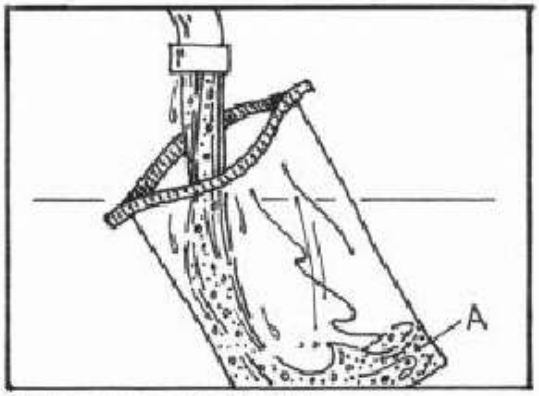


PERCOMETERS

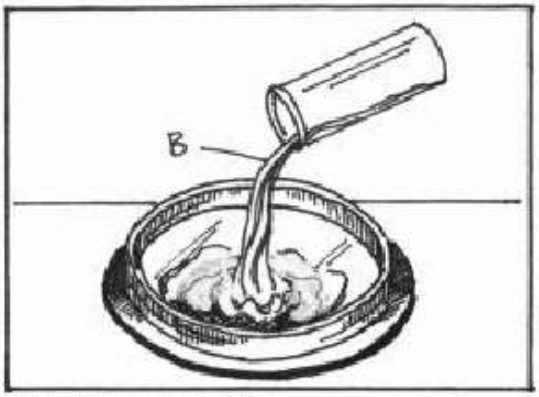


PREPARE HOLE AND PERCOMETER. FILL HOLE WITH WATER. MEASURE TO DETERMINE RATE AT WHICH WATER PERCOLATES OUT OF THE HOLE AS IT SEEPS THROUGH SOILS.

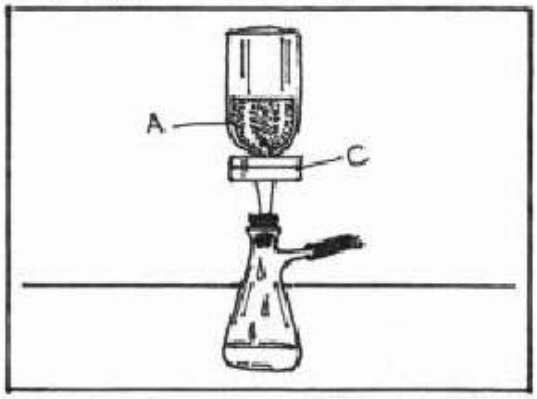
MEMBRANE FILTRATION TEST FOR BACTERIAL CONTAMINATION OF WATER



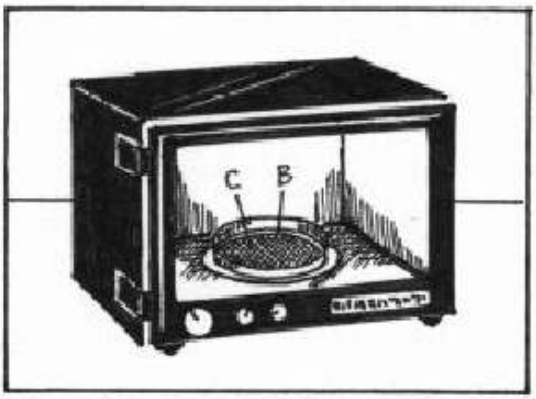
COLLECT SAMPLE (A).
DILUTE, IF NECESSARY, WITH WATER.



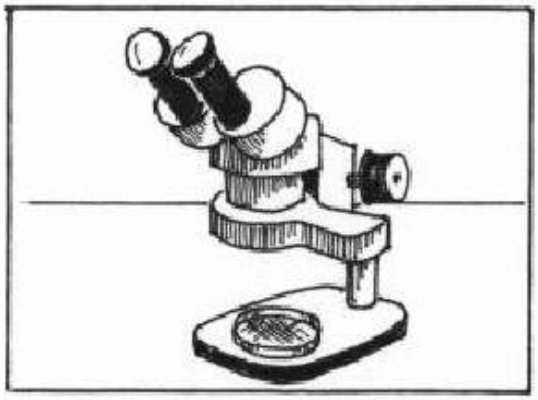
MIX MEDIUM (B).
ADD MEDIUM TO PETRI DISH.



VACUUM- FILTER SAMPLE (A) THROUGH MEMBRANE FILTER (C). RINSE FILTER.

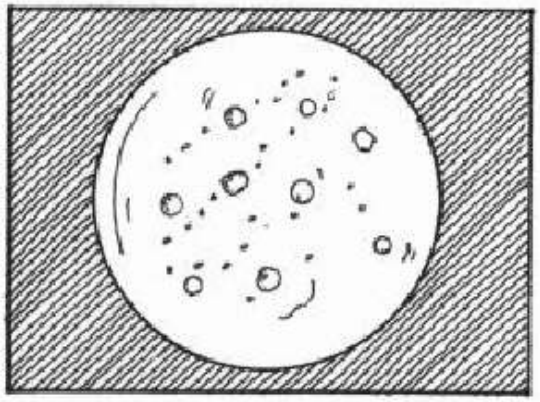


INCUBATE FILTER (C) ON MEDIUM (B) IN PETRI DISH AS INSTRUCTED.



COUNT TYPICAL COLONIES AT 10-15X MAGNIFICATION.

(OR)



CONFIRM COLONIES AND REPORT THE RESULTS.

PESKY PESTICIDES

Grade Level
9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Language Arts, Social Studies
Time
2-3 class periods
Materials
- Pencil
- Paper
- Poster board
- Scissors
- Glue
- Farmer/Gardener Interview Questions
- Household Pesticides Handout
- Examples of pesticides (optional)

Setting
Classroom and Farm (for interview)
Terms
Hazardous, Nonpoint source pollution, Toxic
Reference
Adapted from Environmental Resource Guide, "Pesky Pesticides", grades 6-8, 1992, with permission from the Air and Waste Management Association, Pittsburgh, PA 15222.

Summary

Students gain an understanding of pesticide use and alternatives by interviewing a farmer or gardener and conducting research.

Objective

Students will:
1. List and describe the purpose of common pesticides used by farmers and gardeners.
2. Interview farmers and gardeners to gather data on how common pesticides are used in their communities.
3. List the negative effects of conventional pesticides.
4. List examples of safe pesticide alternatives for home use.

Procedure

Advanced Preparation

Gather a collection of materials that students can look through regarding pesticides. Farming magazines, chemical pamphlets and advertisements, cooperative extension publications, EPA publications and fact sheets can be found from local farm co-ops. Additionally, consider the *Safe Pesticide Alternatives for Homeowners* handout for the students to use.

Warm Up

Explain that water pollution is any contamination of water that lessens its value to humans and nature. Understanding nonpoint sources of pollution means looking at a wide range of human activities and land management practices.

Define pesticides as herbicides, insecticides, fungicides and rodenticides. Tell the students that pesticides are used on agricultural lands, urban lawns and gardens, forests and in lakes and ponds for aquatic weed control. If available, show students examples of pesticides. Explain that surface water can be contaminated by drift from pesticide spraying and by runoff from pesticide treated areas.

Activity

1. Have each student contact at least one farmer or homeowner and interview them by asking the questions on the farmer interview sheet (contact HCSWCD or see Resources section for help finding a farmer).
2. After obtaining the information listed, the student should compile the information into a chart. On the chart, identify the chemical,

what it is used for, who uses it (farmer, gardener or other), how it is applied and what precautions are taken.

3. Assign a group of three or four students to investigate each chemical. Have them find out what the chemical is usually used for, who typically uses it, if it require a license, how long it persists in the environment and if it is approved by the USEPA.
4. If possible, obtain a copy of the instructions and warning labels for each. If warning labels and instructions are not available, go to a farmers' co-op, garden center, or your local cooperative extension agency and copy down the information. Your county extension agent would also be a good resource person. He/she can supply materials or leaflets about pesticides.
5. Have the groups make posters showing information they gathered.
6. When the posters are done, tape them up around the room. Also tape up the chart.
   - Are the people you interviewed using the pesticides correctly?
   - How dangerous are the chemicals being used?
   - What do farmers and anyone else who uses pesticides do with the empty containers?

Follow Up

Explain to the students that rain or irrigation of crops would wash some of these chemicals into the soil and then into the groundwater, streams and lakes. What impacts might pesticide use have on fish and wildlife? Can the farmer make a living without these chemicals? Why or why not?

Invite a person from your local farm co-op or a local farmer to come speak to your class.

Go over the handout included and discuss safe alternatives to pesticides for home use. Discuss how they could reduce their use of pesticides. Can a gardener be successful without chemicals? What are some of the alternatives to pesticides? How could people reduce the chance of pesticides washing into the environment?

Extension

Have the students use information from interviews and other research materials to write an article or local news story.

Organic farming is a method of farming without any chemicals. Have the students research organic farming. Grow a small garden at the school and use organic gardening methods. Divide the garden into two plots and compare organic gardening to conventional gardening. Why might organically grown vegetables cost more? Is it worth it?

Have the students research and write a paper on environmental laws regulating pesticides. For instance, in the U.S., the Environmental Protection Agency regulates pesticides under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). In Canada pesticides are regulated under the Pest Control Products Act. In both countries, permits to buy, handle and use pesticides is regulated by the state (U.S.) or provinces (Canada).

Farmer/ Gardener
Interview Questions

1. What crops do you grow?

2. How many acres or square feet of crops do you have?

3. Do you use any chemicals or pesticides? What are they?

4. What is the purpose of each chemical?

5. How is each chemical applied?

6. How do you determine how much pesticide to use?

7. What precautions do you take when applying pesticides? (For example, checking weather forecasts for rain and wind predictions or timing application so it breaks down before harvest time, following label directions as to proper concentration, application, handling of product and disposal of containers.)

SAFE PESTICIDE ALTERNATIVES FOR HOMEOWNERS

1. **Ants**
   - Vinegar: Wash counter tops, cabinets and floors with equal parts vinegar and water to deter ant infestations.
   - Flour and Borax: Mix 1-cup (1/4 liter) flour and 2 cups (1/2 liter) borax in a quart (liter) jar. Sprinkle the contents around the house foundation. Keep borax out of the reach of children and pets.
   - Bone meal and Powdered Charcoal or Lemon: Set up barriers where ants are entering. They will generally not cross lines of bone meal or powdered charcoal. If you can find a hole where ants are entering the house squeeze the juice of a lemon in the hole or crack. Then slice up the lemon and put the peeling all around the entrance.
   - Pennyroyal, Spearmint, Southernwood and Tansy: Growing these plants around the border of your home will deter ants and the aphids they carry.
2. **Fleas**
   - Vacuum: Vacuum, remove the vacuum bag, seal it and dispose of it immediately outside your home.
   - Vinegar: A ratio of 1-teaspoon (5 cc) vinegar to 1-quart (1 liter) water per 40 pounds (18 kg) of pet weight in their drinking water helps to keep your pets free of fleas and ticks.
   - Fennel, Rosemary, Red Cedar Shavings, Sassafras, Eucalyptus, or Pennyroyal: Spread leaves or shavings of these plants under and around the pet's bed.
3. **Flies**
   - Prevention: Keep kitchen garbage tightly closed. Sprinkle dry soap or borax into garbage cans after they have been washed and allowed to dry; it acts as a repellant.
   - Orange: Scratch the skin of an orange and leave it out: The citrus acts as a repellant.
   - Cloves: Hang clusters of cloves to repel flies.
   - Mint or Basil: Mint planted around the home repels flies. A pot of basil set on the windowsill or table helps to repel flies. Keep the basil well-watered from the bottom so that it produces a stronger scent. Dried ground leaves left in small bowls or hung in muslin bags are also effective.
   - Fly Swatters, Fly Traps, or Fly Paper: Use according to label directions.
   - Sugar and Corn Syrup: Make your own flypaper by boiling sugar, corn syrup, and water together. Place mixture onto brown paper and hang or set out.
   - Egg, Molasses, and Black Pepper: Beat the yolk of an egg with a tablespoon (15 cc) each of molasses and finely ground black pepper. Set it out in shallow plates.
4. **Garden Pests**
   - Cultural Controls: Nutrition, resistant varieties, interplanting, timed planting, crop rotation, mulch, trap crops and cultivation.
   - Mechanical Controls: Handpicking, physical barriers, traps.
   - Biological Controls: Frogs, spiders, ladybugs, praying mantises, other predatory and parasitic insects and microbes.
   - Chemical: natural sprays and dusts.

5. **Mice**
   - Mashed Potato Powder or Buds: Place instant mashed potato powder or buds in strategic places with a dish of water close by. After eating the powder or buds mice will need water. This causes fatal bloating.
   - Mouse Traps: Use according to label directions.

6. **Moles**
   - Castor Oil and Liquid detergent: Whip together 1-tablespoon (15 cc) castor oil and 2 tablespoons (30 cc) liquid detergent in a blender until the mixture is like shaving cream. Add 6 tablespoons (90 cc) water and whip again. (Caution: Keep this mixture out of the reach of children and pets.) Take a garden sprinkling can and fill with warm water. Add 2 tablespoons (130 cc) of the oil mixture and stir. Sprinkle immediately over the areas of the greatest mole infestation. For best results, apply after a rain or thorough watering. If moles are drawn to your lawn because of the grubs feeding in the soil, you may be able to rid yourself of both pests by spreading milky spore disease to kill the grubs.

7. **Mosquitoes**
   - Prevention: Eliminate pools of stagnant water. Avoid wearing perfume, bright colors, flowery prints and bright jewelry as these items attract mosquitoes.
   - Biological control: Put up purple martin birdhouses.
   - Citronella: Burn citronella candles to repel insects.
   - Tansy or Basil: Plant tansy or basil around the patio and house to repel mosquitoes.

8. **Moths**
   - Prevention: Store items in a clean condition; moth larvae especially like areas soiled with food stains.
   - Rosemary, Mint, Thyme, Cloves and Ginseng (optional): Chicago area weavers and spinners use 1/2-pound (.23) kg rosemary, 1/2-pound (.23 kg) mint, 1/4-pound (.12 kg) thyme, 1/4-pound (.12 kg) ginseng (optional), and 2 tablespoons (10 cc) cloves. Mix and put in cheesecloth bags and place in closets or drawers.
   - Dried Lavender or Rosemary and Mint: Make sachets of dried lavender or equal portions of rosemary and mint. Place in closets, drawers or closed containers to mothproof garments.
   - Rosemary, Sage, Mint, Dried Lemon Peel and Cinnamon: Mix handfuls of the first three ingredients. Add a little lemon peel and a pinch of cinnamon. Place in muslin bags.
   - Molasses, Vinegar and Yellow Container: To trap moths, mix 1 part molasses with 2 parts vinegar and place in yellow container to attract moths. Clean regularly.
   - Clothes Dryer: Kill moth eggs by running garment through a warm dryer.

9. **Roaches**
   - Prevention: Close off all gaps around pipes and electric lines where they enter the house by using cement or screening. Caulk small cracks along baseboards, walls, cupboards and around pipes, sinks and other fixtures. Seal food tightly Rinse off dishes that are left overnight. Do not leave pet food out over night.

- Hedge Apples (Osage Orange): Cut hedge apples in half' and place several in basement, in or around cabinets or under the house to repel roaches.
- Flour, Cocoa Powder and Borax: Mix together 2 tablespoons (30 cc) flour, 4 tablespoons (60 cc) borax and 1-tablespoon (15 cc) cocoa. Set the mixture out in dishes. (Caution: Borax is toxic if eaten. Keep out of reach of children and pets.)
- Borax and Flour: Mix 1/2-cup (1/8 liter) borax and 1/4-cup (1/16 liter) flour and fill a glass jar. Punch holes in jar lid. Sprinkle along baseboards and doorsills. (Caution: Borax is toxic if eaten. This recipe may not be for you if there are young children or pets in the house.)
- Oatmeal, Flour and Plaster of Paris: Mix equal parts and set in dishes. (Caution: Keep out of reach of children and pets.)
- Baking Soda and Powdered Sugar: Mix equal parts and spread around infested area.

10. **Slugs and Snails**

- Natural Predators: Garter snakes, grass snakes, ground beetles, box turtles, salamanders, ducks and larvae of lightning bugs all feed on snails.
- Clay Pots: Place overturned clay flowerpots near the shady side of a plant. Rest one edge on a small twig or make sure that the ground is irregular enough for the slugs and snails to crawl under the rim. They will collect there during the warmest part of the day. Remove slugs and snails regularly and drop in a bucket of soapy water.
- Beer: Set out saucers or jars full of stale beer, placed below ground level near the garden. The fermented liquid draws them and they drown.
- Sand, Lime or Ashes: Snails avoid protective borders of sand, lime, or ashes.
- Tin Can: Protect young plants by encircling them with a tin can with both ends removed. Push the bottom end of the can into the soil.

Section Five

Effects

Now that the primary nonpoint source pollutants have been identified and explained, it is important to investigate the various effects that nonpoint source pollutants can have on the environment. In this section students will conduct experiments to explore the effects of oil, erosion and nutrients on the environment and participate in a stream ecosystem simulation. Older students will have the chance to sample a real stream to determine its health. The effects of biomagnification in the food chain and eutrophication of waterways will also be examined.

Erosion

The largest source of nonpoint source pollution by volume, erosion, has been discussed in detail in this curriculum. Erosion is a natural process and has positive effects such as the shaping of canyons and mountain ranges. However, when human actions like clearing trees or groundcover combine with various degrees of topography and excessive rainfall, accelerated erosion occurs and waterways become choked with sediments. In the waterways, the sediments both nourish and cause problems for the plants and animals living in the aquatic environments. Increased erosion or reduced shade resulting from streamside deforestation can cause changes in the temperature of water. Cooler water is capable of holding a larger amount of **dissolved oxygen** (DO) that is oxygen suspended in the water. Soil particles when suspended in water absorb heat. As temperature rises, water holds less oxygen and this can make it difficult for fish and other aquatic organisms to breathe.

Streams in areas with more impervious surfaces tend to have above normal amounts of sediment settle on the channel bottom when the flow slows down. Part of this material comes from eroding stream banks. A large percentage, however, is carried by runoff water washing the pavement and land clean. When runoff reaches the stream it drops its load of sediment on the bottom of the channel. This can decrease the light available to aquatic plants making the entire food chain suffer.

Eutrophication

Nonpoint source pollutants can also affect the natural aging of a lake. The population of **aerobic** (oxygen-dependant) life in a pond, lake, or stream depends in part on the amount of dissolved nutrients in the water. Too little or too much of any single nutrient can limit or prevent growth of a population of plants or animals, even if the other factors within the ecosystem are at or near their most desirable range. Nutrients like phosphates and nitrates stimulate plant growth and are limiting factors in the growth of plant life. In other words, they naturally occur in limited amounts that help govern the growth of different organisms and keep ecosystems in balance. Water low in nutrients is called **oligotrophic**, while water high in nutrients is call **eutrophic**.

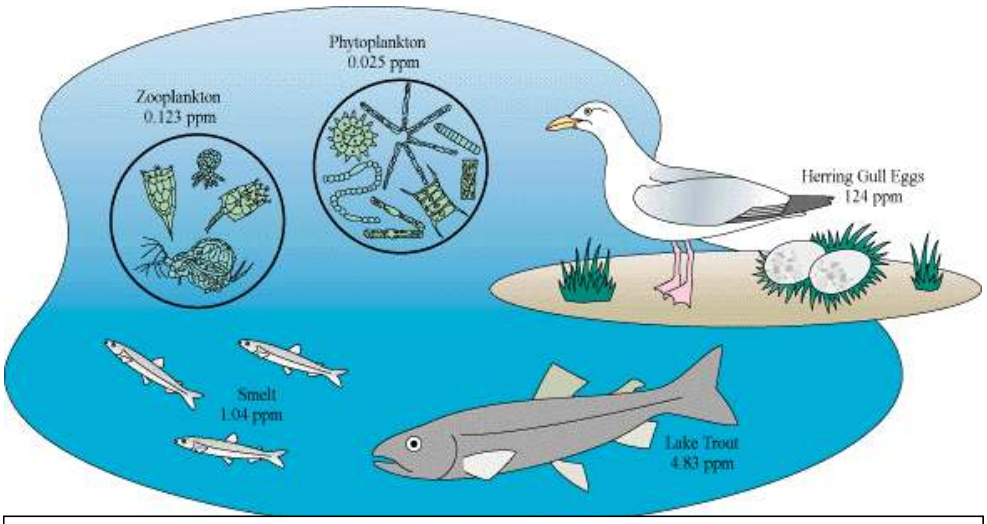
Phosphorous is usually the least naturally available or limiting nutrient in freshwater ecosystems followed by nitrogen. In salt-water ecosystems, nitrogen is the limiting nutrient. Eutrophication is a natural and gradual process of nutrient enrichment in waterways. The

nutrients encourage plant growth and eventually lakes and other water bodies accumulate decaying plant materials and begin to shrink in size, often becoming a bog or marsh. Eutrophication typically happens slowly over millions of years. When the process is accelerated by the addition of excess phosphates and nitrates into a waterway, some plant species can experience explosive growth, literally out-competing other life forms. One such example is the rapid growth of blue-green or other algae. This is called an **algal bloom**. Algal blooms can produce thick surface mats, turn water green, stain boats and cause skin rash on swimmers. They may also be toxic to animals that drink the water. When the excess nutrients are used up, the algae die. The breakdown or decaying of the dead algae uses oxygen, which reduces the amount available for use by aquatic animals. This can cause fish kills and further degrade the water quality.

Human activities can greatly increase the rate at which eutrophication happens. Nonpoint sources of nutrient enrichment include yard fertilizers, livestock wastes, pet feces, failing septic tanks and eroded soil. Phosphate detergents can enter waterways through storm drains from improperly treated wastewater as well as from the use of soaps and cleaners on sidewalks, garage floors and driveways. When it rains, storm water runoff carries soil and nutrients into water bodies. (Phosphates usually travel into water bodies attached to soil. Nitrate fertilizers are water-soluble; they can dissolve directly in water and do not always travel to water bodies attached to soil particles.)

Biomagnification

Another effect is **biomagnification**, the increase in concentration of pollutants as they move up the food chain. The most common nonpoint source pollutants involved in this process are insecticides. When insecticides enter aquatic ecosystems, they can bio-magnify. Both living and dead organic matter can absorb insecticides that accumulate in bottom sediments. This matter is a food source for aquatic plants, animals and other microscopic organisms. Stream invertebrates like water boatmen or dragonfly nymphs eat these organisms and in turn are eaten by predacious animals like diving beetles or fish. Fish with sub-lethal pesticides in their tissues exhibit a variety of abnormal behavior and pathological conditions as well as failures in



Some chemicals such as PCBs bioaccumulate. This diagram shows the degree of concentration in each level of a Great Lakes aquatic food chain for PCBs (in parts per million, ppm). The highest levels are reached in the eggs of fish-eating birds such as herring gulls.

reproduction. Stream dwellers eventually become food sources for bobcat, raccoons, heron and other visitors. At this top end of the food chain, the pesticide is more concentrated and it may affect the health and reproductive capabilities of these species.

Many pesticides being used today will break down into less toxic organic compounds within nine to twenty weeks of their application. Organic pesticides that are highly soluble in water generally have short durations in the environment. However, the inorganic compounds containing such elements as mercury and arsenic, or persistent chemical compounds, can remain for a long time in the environment. In a recent USGS survey scientists found that PCBs (polychlorinated biphenyls) and DDT, both pesticides banned or restricted in the U.S. since the 1970's, continue to persist in fish tissue in streams in southwestern Ohio. Many of the pesticides detected were in concentrations at or near the maximum concentrations found nationwide.

Pesticides that persist in the environment can have detrimental effects on the food chain. For example, DDT, a pesticide now banned in the U.S., washed into water bodies and was absorbed into single-cell organisms that were eaten by aquatic insects and fish. Predatory fish ate these fish, which were, in turn, eaten by eagles. Female eagles contaminated with DDT laid eggs with thinner shells, which were crushed when sat upon. This and other factors reduced eagle populations to the point where they were listed as an endangered species. Exposure to certain pesticides may also cause illnesses in humans such as cancer or birth defects.

Environmental Indicators

Different animals and plants have varying levels of tolerance to pollution. For this reason many species can be used as indicators of ambient environmental conditions (much like the canary in the coalmine). In some cases, species can indicate the biological effects of pollutants more accurately than predictions based on chemical analyses. For example, the larvae of mayflies, caddisflies, stoneflies and true flies have been used to identify point sources of environmental hazards in streams and other wetlands. Earthworms, which pass large amounts of soil through their digestive tracts, are excellent indicators of ground pollution. Bees, whose body hairs electrostatically attract dust particles and collect pollutants linked with their food, water, and even air, have become an early warning system at nuclear power plants, weapons factories, testing laboratories and solid waste dumps. Mussels, oysters and fish are collected regularly as part of a National Status and Trends Program established by the National Oceanic and Atmospheric Administration (NOAA) along the USA coastline.

The diversity and abundance of different species of macroinvertebrate is used locally to determine water quality. Macroinvertebrates are organisms that lack an internal skeleton and are large enough to be seen with the naked eye. They are an integral part of wetland and stream ecosystems. Examples of macroinvertebrates include mayflies, stoneflies, dragonflies, rat-tailed maggots, scuds, snails and leeches. These organisms may spend all or part of their lives in water; usually their immature phases (larvae and nymphs) are spent entirely in water. Larvae are usually very different in appearance from the adult versions of the insects. For example, "maggot" is the term used for the larva of some flies. Nymphs generally resemble adults, but have no developed wings and are usually smaller.

A variety of environmental stressors can impact macroinvertebrate populations. Urban and agricultural runoff can produce conditions that some macroinvertebrates cannot tolerate.

Sewage and fertilizers added to streams induce the growth of algae and bacteria that consume oxygen and make it unavailable for macroinvertebrates. Sedimentation destroys habitats by smothering the rocky areas of the stream where macroinvertebrates live. The removal of trees along the banks of a river and/or alteration of stream velocity can alter normal water temperature patterns in the stream. Some organisms depend on certain temperature patterns to regulate changes in their life cycles.

Some macroinvertebrates, such as the mayfly and stonefly nymphs and caddisfly larvae, are sensitive (intolerant) to changes in stream conditions brought about by pollutants. Some of these organisms leave to find more favorable habitats, but others die or are unable to reproduce.

Stonefly larvae, a macroinvertebrate

Other macroinvertebrates (e.g., rat-tailed maggots and midge larvae) may thrive in polluted conditions and are called tolerant organisms. A third category, called facultative organisms, includes invertebrates such as dragonfly and damselfly nymphs that prefer good stream quality but can survive polluted conditions.

Water quality researchers often sample macroinvertebrate populations to monitor changes in stream conditions over time and to assess the cumulative effects of environmental stressors. Environmental degradation will likely decrease the diversity of a community by eliminating intolerant organisms and increasing the number of tolerant organisms. If the environmental stress is severe enough, species of intolerant macroinvertebrates may disappear altogether. For example, if a sample of macroinvertebrates in a stream consists of rat-tailed maggots, snails and dragonfly nymphs, the water-quality conditions of that stream are probably poor (i.e., low oxygen level, increased sediment, contaminants). If, on the other hand, the sample contains a diversity of organisms, including intolerant species, the stream conditions are likely good. Baseline data is essential, however, because some healthy streams may contain only a few macroinvertebrate species. A variety of food sources, adequate oxygen levels and temperatures conducive to growth all characterize a healthy stream.

Caddisfly larvae, a macroinvertebrate

Activities in Section Five		
Activity Name	**Grade Level**	**Description**
Oily Water	K-2	Explore how oil affects the aquatic environment
The Run-Off Race	K-2, 3-5	Observe the effect of removing ground cover from a slope
The Temperature's Rising	3-5	Examine how sediment effects water temperature
Macroinvertebrate Mayhem	3-5, 6-8	Learn how pollution affects aquatic macroinvertebrate populations
Phosphates In Your Water	3-5, 6-8	Conduct an experiment to understand how fertilizer affects water quality
Where Does Pollution Go?	3-5, 6-8	Experiment with vegetables, water, and food dye to observe the uptake of pollutants into plant tissues
The Great Debate	6-8, 9-12	Study the impacts of excessive soil erosion on the people, the economy, and the environment
Fed Up	9-12	Explore eutrophication and nutrients
Biodiversity = Water Quality	9-12	Evaluate the effects of pollution on the stream ecosystem and assess the health of the stream

OILY WATER

Grade Level
K-2
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Physical Science, Life Science
Time
1-hour preparation
50 minutes activity
Materials
- Newspaper
- Cake pans (or another container)
- Vegetable cooking oil
- Water
- Cotton balls
- Feathers
- Craft sticks
- Dish soap
- Paper towel
- Pictures of oil spills and clean ups

Setting
Classroom
Terms
Nonpoint source pollution
Reference
Adapted from Teaching Environmental Science Lesson Plans, Texas Commission of Environmental Quality and R. Debra Lopez

Summary

Students understand how pollutants affect our bodies of water by experimenting with a model.

Objective

Students will:
1. Have hands-on knowledge of the effects of oil on water.
2. Understand that organisms and the environment come in contact with polluted water.

Procedure

Warm Up

Brainstorm ways we use water. Explain that oil is something that can pollute our water. Ask students if they have ever seen a puddle with rainbow colors. Explain that what they see is oil-polluted water. Show the students pictures of oil spills and the effects of oil pollution on birds. Good pictures can be found at www.saveaduck.com

Activity
1. Lay newspaper down to cover desk or table surface.
2. Fill cake pans half full of water. This activity can be done individually, in small groups, or as a whole class.
3. Have students guess what will happen when you put oil on the water.
4. Pour approximately one cup of oil on top of the water.
5. Let students feel the oil-water mixture, and describe what they feel. Do the oil and water mix? Dip feather into mixture, observe.
6. Have students try to remove the oil from the water using cotton balls, craft sticks, paper towels, and dish soap. Is it easy or hard? Which item worked the best?

Follow Up

Explain to students that oil can enter waterways through an oil spill or in the form of nonpoint source pollution from leaky cars and oil poured down a storm drain. Discuss the possible effects on birds from oily water. Discuss possible effects on other wildlife species, on humans, and on the environment.

Extension

Visit a local park where water birds can be found. Invite a local ornithologist, wildlife officer, park naturalist, wildlife rehabilitator, or wildlife pathologist to discuss common pollution problems for nearby wildlife. The Cincinnati Zoo could be contacted to bring a bird into the classroom. These professionals may also be able to give information about the impact of improperly disposed of toxins on local wildlife populations.

THE RUN-OFF RACE

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Earth Science
Time
1 to 2 class periods
Materials
- 1-quart jar with lid
- 2 large cans of equal size
- Pebbles, sand, soil, crushed leaves, etc.
- Piece of artificial turf (doormat)
- 2 flat sheets of wood similar in size to the doormat
- 2 shallow aluminum paint pans
- Supports to hold the wooden sheets at a slope
- 2 one-quart containers

Setting
Classroom
Terms
Compacted, Erosion, Filtration, Ground cover, Particulate Matter, Precipitation, Runoff, Sediment, Silt
Reference
Adapted from Stevens Creek Connections, Environmental Volunteers

Summary

A demonstration of how ground cover on a hillside can decrease erosion.

Objective

Students will:
1. Understand the role of ground cover in controlling erosion.
2. Understand why erosion can be harmful to aquatic wildlife.

Procedure

Advance Preparation

Before class begins, prepare the demonstration models as shown in the diagram below. The models should have about a 45-degree slope.

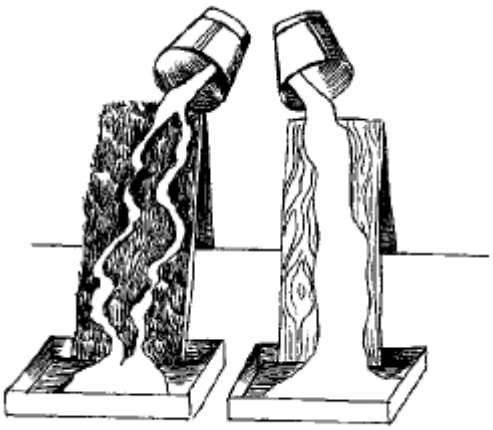
Prepare two large cans mixed with equal amounts of small pebbles, sand, soil, and crushed leaves and have someone spread the mix from one can evenly on the demonstration surfaces. Be sure that the dirt is completely worked into the doormat.

Warm Up

Ask students to list a variety of plants that act as ground cover to soil. What are some reasons ground covers would be removed? What would happen to the soil if the ground cover were removed?

Activity

1. Take a quart jar and fill it half full with the same mixture used on the demonstration surfaces (pebbles, sand, soil, and crushed leaves). Top off the jar with water and secure the lid. Have a student shake the jar until the contents are thoroughly mixed. Set the jar on a table in front of the class.



Runoff Demonstration Model

2. As the children watch the sediments in the jar settle, explain that muddy water can be harmful to wildlife. Ask the children to think of reasons why this might be so (e.g. clogging fishes' gills, impairing vision, blocking sunlight that plants need.)
3. Observe how the particles are settling in the jar (usually in layers with the largest particles settling first, and the finest particles remaining in suspension for quite some time). Let the jar sit undisturbed overnight and observe how much of the finer particulate matter settles out.
4. Describe how plants on a hillside can slow the flow of water by simply being in the way. The ground cover breaks the force of the water so the water carries less soil away. Using the models to demonstrate, explain that the model with the doormat represents a grassy hillside filled with plants. The model that is bare, except for the debris on the surface, represents a bare compacted hillside, such as one that bikes and hikers have used. Ask students to imagine rain falling on each hillside and eventually ending up in the creek or reservoir, represented by the paint pans beneath the model.
5. Provide 2-quart jars of water, and have volunteers pour water slowly and simultaneously onto the "hillsides" near the top edge. Notice which hillside produces the fastest flow of water. Notice which hillside has less soil washed out into the paint pan. Which hillside has cleaner water flowing into the "reservoir" below?

Follow Up

Ask the students the following questions:

- How does killing or removing all of the plants on a hillside affect the flow of water down the hillside?
- Why would people want to remove plants from a hillside?
- What might be some other effects of this activity?
- Which of the models used in the demonstration would be most likely to produce a landslide?
- Which of the reservoirs (paint pans) would be best for swimming?
- How do you think that plants prevent erosion?
- Find pictures of erosion that was caused by human activities. How could these activities have been altered to prevent the damage? See resource section for a sample of pictures.

Extension

Have students think of other ground covers that could help prevent erosion and using the already constructed model experiment with the different covers. Mulch, rocks, sticks, and straw are just a few materials that could be used in the experiments.

Have students mimic raindrops by measuring "splash erosion" on each slope:

1. Stand measuring stick on end.
2. Pour water, drop fashion, near stick.
3. Measure how high on the stick the muddy drops splash.

THE TEMPERATURE'S RISING

Grade Level
3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Physical Science, Math, Social Studies
Time
1-2 class periods (Note: Requires temperature readings every 30 minutes)
Materials
- Baby food jars or any small jars with lids (4 per group)
- Thermometers (digital preferred)
- Green construction paper
- Tape
- Markers
- Scissors
- Water
- Soil (preferably clay type; available at art supply stores carrying ceramic supplies)
- Grow light (optional)

Setting
Classroom
Terms
Erosion, Sediment
Reference
Adapted from Environmental Resource Guide, "The Temperature's Rising", grades 6-8, 1992, with permission from the Air and Waste Management Association

Summary

Students conduct an experiment to explain how sediment affects water temperature.

Objective

Students will:
1. Define water pollution.
2. Describe the relationship between sediment loads and heat retention in dirty and clean water.
3. Explain the effects water pollution has on plant and animal life.

Procedure

Warm Up

Explain that water pollution is any contamination of water that reduces its usefulness to humans and nature. Also explain that suspended sediment can increase water temperatures because cloudy water absorbs more solar radiation. Warmer water holds less oxygen and if oxygen levels are too low, this can make breathing difficult for aquatic organisms like fish.

Tell students that in this experiment they are going to see what happens to a stream when trees and other vegetation are removed immediately adjacent to its banks. The first jar (Jar 1) will be a control and the other three will compare the effects of different situations. Jar 2 will look at the effect of simply removing the trees. Jar 3 will examine the effects of only erosion. Jar 4 will look at the combined effects of tree removal and erosion.

Activity

1. Divide the class into groups of three or four. Have each group collect four jars.
2. Have students cut out green construction paper and cover the sides of two of the jars by wrapping the paper around them and securing the paper on with tape.
3. Fill one covered jar and one uncovered jar with plain water. Label the covered Jar 1: Shaded Mountain Stream. Label the uncovered Jar 2: Trees Removed.
4. Next put water in the two remaining jars, add one-tablespoon dry

powdered soil, attach the jar lid, and shake vigorously. Label the covered jar with soil Jar 3: Erosion in Mountain Stream. Label the uncovered jar with soil Jar 4: Clear-Cut Stream. Remove the lids from the jars.

5. Have the students measure the water temperature in each jar using a digital thermometer. (Most digital thermometers should detect temperature changes to the tenth of a degree.)
6. Record information on "The Temperature's Rising" chart.
7. Have the students place all the jars in a sunny location for 30 minutes. If sunny windows are not available, use a grow light. Have the students predict what is going to happen in each jar.
8. After 30 minutes, have the students measure and record the water temperature of each jar again. Repeat this procedure at 60 and 90 minutes. (Note: Depending on time constraints, the teacher may need to do the 60 and 90-minute readings.)

Follow Up

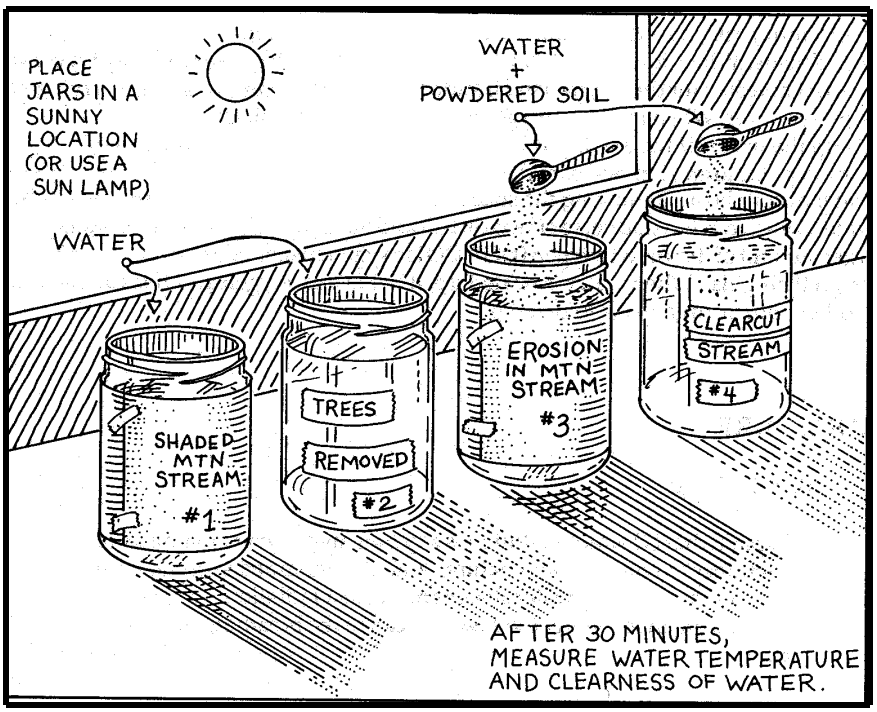
Was there a change in temperature after 30 minutes? 60 minutes? 90 minutes? Have the students describe what happened. What effect does removing trees (shade) from the stream have? What effect does erosion have? What effect does clear cutting have? What impacts do you think this will have on the animals and plants in the stream? What could we do to prevent this?

Extension

Have the students measure the temperature of water in various locations such as mountain streams, farm ponds, urban streams or puddles in the school parking lot. Put this information in a chart; include the air temperature that day, land use where the temperature reading was taken, water clarity and whether or not the site is sunny or shady. Ask the students why the temperatures vary.

Have the students find out what temperature ranges various fish can tolerate. They could write reports on the entire life cycle of fish. How do changes in habitat affect fish behavior, reproduction, growth and survival? How could poor practices affect fish habitat, spawning, and growth?

Contact the local Agriculture Extension Service or colleges and see if they have films, videos, slides, printed materials and case studies on nonpoint source pollution problems in the area.



The Temperature's Rising

Jar #	Initial reading			Reading #1			Reading #2			Reading #3		
	Time	Temp	Clearness	Time	Temp	Clearness	Time	Temp	Clearness	Time	Temp	Clearness
1												
2												
3												
4												

1. Describe what happened.

2. What effect does removing trees (shade) from the stream have?

3. What effect does erosion have on the stream?

4. What effect does clear cutting have on the stream?

5. What impacts do you think the actions in question 2-4 will have on the animals and plants in the stream?

6. What could we do to prevent these things from happening?

MACROINVERTEBRATE MAYHEM

Grade Level
3-5, 6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Ecology, Environmental Science, Math, Language Arts
Time
Preparation time:
Part I: 20 minutes
Part II: 50 minutes
Activity time:
Part I: 50 minutes
Part II: 50 minutes
Materials
- Samples of macroinvertebrate organisms (optional)
- Resources (texts, field guides, encyclopedia)
- Identification labels for Macroinvertebrate groups, one per student
- Pillowcases or burlap bags
- Chart paper or a chalkboard

Setting
Large playing field (50'x 50')
Terms
Biodiversity, Macroinvertebrate
Reference
Adapted from Project WET Curriculum and Activity Guide, *Copyright International Project WET*

Summary

Students participate in a simulation that demonstrates the effects of environmental stressors on macroinvertebrate populations.

Objective

Students will:
1. Illustrate how tolerance to water quality condition varies among macroinvertebrate organisms.
2. Explain how population diversity provides insight into the health of an ecosystem.

Procedure

Advance Preparation

Divide the number of students by seven and make that number of copies of each macroinvertebrate identification label.

One side of each label should have a picture of one of the seven macroinvertebrates. The other side of each label (except those for midge larvae and rat-tailed maggots) should have a picture of either the midge larva or rat-tailed maggot.

For durability, the cards may be laminated. Use clothespins or paper clips to attach labels to students' clothing.

Warm Up

Review the conditions that are necessary for a healthy ecosystem. Ask students to describe what could happen to an ecosystem if these conditions were altered or eliminated. What clues would students look for to determine if an ecosystem was healthy or not?

Remind students that a stream is a type of ecosystem. Ask them how they would assess the health of a stream. Students may suggest conducting a visual survey of the surrounding area and answering the following questions: What land use practices are visible in the area? How might these practices affect the stream? Are the banks of the stream covered with vegetation or are they eroded? What color is the water? What is living in the stream?

Identify several environmental stressors (e.g., urban and agricultural runoff, sedimentation, introduction of alien species) and discuss how they can affect the health of a stream. Review the many types of plants and animals, including insects, which live in streams. How might environmental stressors affect these organisms? Would all organisms be impacted in the same way? Why or why not?

Activity

Part I

1. Introduce the practice of sampling macroinvertebrate populations to monitor stream quality. Show students pictures or samples of macroinvertebrates used to monitor stream quality. Pictures can be obtain from the web or from the Soil and Water Conservation District office.
2. Divide the class into seven groups and assign one macroinvertebrate (see *Macroinvertebrate Groups*) to each group. Have group members conduct library research to prepare a report for the class about their organism. The report should include the conditions (e.g., clean water, abundant oxygen supplies, cool water) the organism must have to survive.
3. Have students present their reports to the class and compare each organism's tolerance of different stream conditions.

Macroinvertebrate Groups
Caddisfly larva
Mayfly nymph
Stonefly nymph
Dragonfly nymph
Damselfly nymph
Midge larva
Rat-tailed maggot

Intolerant Macroinvertebrates and Hindrances		
ORGANISM	HINDRANCE	RATIONAL FOR HINDRANCE
Caddisfly	Must place both feet in a bag* and hop across field, stopping to gasp for a breath every five hops	Caddisflies are intolerant of low oxygen levels
Stonefly	Must do a push- up every ten steps	When oxygen levels drop, stoneflies undulate their abdomens to increase the flow of water over their bodies.
Mayfly	Must flap arms and spin in circles when crossing field.	Mayflies often increase oxygen absorption by moving gills.

*CADDISFLY LARVAE BUILD CASES AND ATTACH THEMSELVES TO ROCKS FOR PROTECTION AND STABILIZATION.

Part II

1. Tell students they are going to participate in a simulation that demonstrates changes in a stream resulting from the introduction of an environmental stressor, such as a pollutant. Show students the playing field and indicate the boundaries.
2. Have one student volunteer to be an environmental stressor (e.g., sedimentation, sewage or fertilizer). Discuss the ways that a stream can become polluted and how this can alter stream conditions. Within a large classroom or playing field, more students will need to be stressors.

3. Divide the rest of the class into seven groups. Each group represents one type of macroinvertebrate species listed in *Macroinvertebrate Groups*. Record the number of members in each group, using a table similar to *A Sample of Data From Macroinvertebrate Mayhem*.
   NOTE: Try to have at least four students in each group. For smaller classes, reduce the number of groups. For example, eliminate the stonefly nymph and the damselfly nymph groups.

A Sample of Data From Macroinvertebrate Mayhem:

ORGANISM	TOLERANCE	NUMBERS (AT START AND AFTER EACH ROUND)			
		START	ROUND ONE	ROUND TWO	ROUND THREE
Caddisfly larva	Intolerant	5	2	2	2
Mayfly nymph	Intolerant	5	4	1	0
Stonefly nymph	Intolerant	4	4	4	2
Dragonfly nymph	Facultative	5	5	4	4
Damselfly nymph	Facultative	4	4	4	3
Midge Larva	Tolerant	4	6	7	9
Rat-tailed maggot	Tolerant	4	6	9	11
TOTAL	31	31	31	31	31

4. Distribute appropriate identification labels to all group members. The picture of each group's macroinvertebrate should face outward when labels are attached.
5. Inform students that some macroinvertebrates have hindrances to crossing the field. (*See Intolerant Macroinvertebrates and Hindrances*.)
6. Assemble the macroinvertebrate groups at one end of the playing field and the environmental stressor(s) at midfield. When a round starts, macroinvertebrates will move toward the opposite end of the field and the stressor will try to tag them. To "survive," the macroinvertebrates must reach the opposite end of the field without being tagged by the environmental stressor. The environmental stressor can try to tag any of the macroinvertebrates, but will find it easier to catch those with hindered movements.
7. Begin the first round of the game. Tagged macroinvertebrates must go to the sideline and flip their identification labels to display the most tolerant species (i.e., rat-tailed maggot or midge larva). Tagged players who are already in a tolerant species group do not flip their labels.
8. The round ends when all of the macroinvertebrates have either been tagged or have reached the opposite end of the playing field. Record the new number of members in each species.
9. Complete two more rounds, with all tagged players rejoining the macroinvertebrates who successfully survived the previous round. Record the number of members in each species of macroinvertebrates at the conclusion of each round. Because some players will have flipped their identification labels, there will be a larger number of tolerant species in each successive round.

Follow Up

The game is completed after three rounds. Discuss the outcome with students. Emphasize the changes in the distribution of organisms among groups. Have students compare population sizes of groups at the beginning and end of the game and provide reasons for the changes. Review why some organisms are more tolerant of poor environmental conditions than other organisms. Have students compare the stream environment at the beginning of the game to the environment at the end. What can be done to prevent pollutants from entering stream?

Have students investigate a nearby stream. What types of macroinvertebrates live there? How would students describe the diversity of organisms? Do students' findings provide insight into the quality of the stream? What other observations can students make to determine stream quality? They may want to report their findings to local watershed managers or water quality inspectors. Contact the Izaak Walton League of America or the Hamilton County Soil and Water Conservation District for information on investigating a stream and how to collect and identify macroinvertebrates in a stream.

Extension

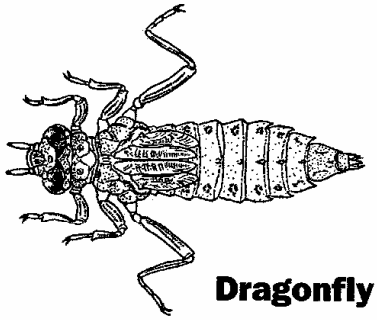
Supplement the students' macroinvertebrate survey of a stream with chemical tests and analyses.

Have students design their own caddisfly case.

Have students study aspects of biodiversity by adding another round to the game. For example, add a fourth round in which all organisms are caddisflies. This round will demonstrate how a few intolerant species or a single species can be quickly eliminated.

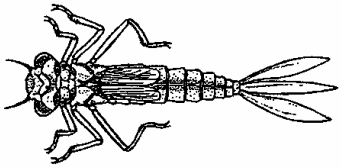
PROJECT WET
Water Education for Teachers

Identification Labels

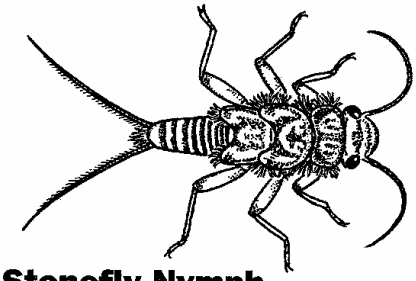


Dragonfly Nymph

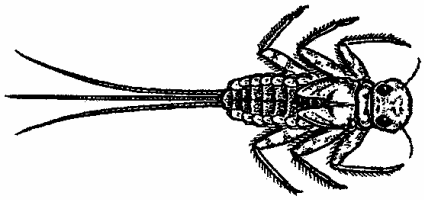
Caddisfly Larva



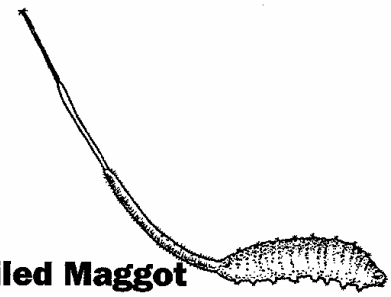
Damselfly Nymph



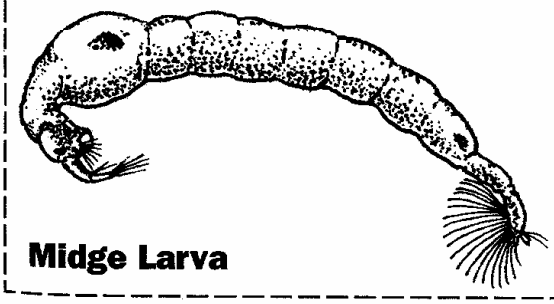
Stonefly Nymph



Mayfly Nymph



Rat-tailed Maggot



Midge Larva

Environmental Stressor

ILLUSTRATION OF MACROINVERTEBRATES USED WITH PERMISSION OF THE ARTIST, TAMARA SAYRE.

Macroinvertebrate Mayhem
Project WET Curriculum and Activity Guide

PHOSPHATES IN YOUR WATER

Grade Level
3-5, 6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Life Science, Environmental Science, Math
Time
45 minutes for the first day
15 minutes on day 7
30 minutes on day 14
Materials
- Access to a nearby pond or stream
- Dissolved oxygen test kit (available through Carolina Biological)
- 10 jars
- Trowel
- Water, plants (some with roots), and mud from a pond
- Detergent containing phosphates
- Fertilizer in powder form
- Measuring spoons

Setting
Classroom, Pond (optional)
Terms
Fertilizer, Dissolved oxygen, Phosphates
Reference
Adapted from the NPS Activity Sheets, United States Environmental Protection Agency

Summary

Students conduct an experiment to look at how fertilizer runoff affects waterways.

Objective

Students will:
1. Examine the effects of detergents and fertilizers on aquatic life.
2. Test for dissolved oxygen in water samples.
3. Determine the relationship between pollutants and dissolved oxygen in water.
4. Collect and interpret data.

Procedure

Advanced Preparation

With permission, collect water, plants (some with roots) and mud from a nearby pond. Students enjoy collection if time is available.

Warm Up

Begin by explaining to students what fertilizers used for and that some are made of chemicals called phosphates. Explain that detergents also sometimes contain phosphates. Show students examples of fertilizers and detergents. Where are some places that fertilizers are used? How do fertilizers end up in waterways? How do phosphates end up in the waterways? Could they have an effect on the organisms in the water?

Activity

1. Label jars 1 through 10. Cover the bottom of each jar with mud and plants (roots and all). Fill each jar with pond water.
2. Place the appropriate amount of fertilizer or detergent in each jar using the amounts listed in the following chart. Stir carefully (i.e., not disturb mud) to ensure that the fertilizer and detergent are dissolved and evenly mixed.
3. Following test kit directions, measure the amount of dissolved oxygen in the pond water.
4. Put all the jars in a sunny location.

5. Have students hypothesize which solution will grow the healthiest plants.
6. Make observations daily for two weeks. This can be done on the back of the dissolved oxygen observation sheet.
7. Measure the amount of dissolved oxygen, according to the kit directions, on day 7 and day 14 of the experiment.
8. Discuss observations.
9. Have students write a conclusion to the experiment.

Follow Up

Ask students the following questions:

- At the end of the experiment, which jar had the most vigorously growing plants? The least?
- Which jar had the least dissolved oxygen? The most?
- What would happen in a stream that has an excess of phosphates, warm temperatures, and good sunlight?
- Why are certain levels of phosphates in the water important?

Have students look around their homes and school and list possible sources of phosphates that might be entering local streams.

Extension

Have students research whether or not Ohio has a phosphate detergent ban (it does). Historical research on the ban and the national role Procter & Gamble played is also interesting and ties the importance of a local company to a national dilemma. Also ask students to research how many other political jurisdictions in the United States have phosphate bans.

Jars	Treatments	Dissolved Oxygen Day 1	Dissolved Oxygen Day 7	Dissolved Oxygen Day 14
1.	CONTROL			
2.	CONTROL			
3.	1/8 tsp detergent			
4.	1/4 tsp detergent			
5.	3/8 tsp detergent			
6.	1 tsp detergent			
7.	1/8 tsp fertilizer			
8.	1/4 tsp fertilizer			
9.	3/8 tsp fertilizer			
10.	1 tsp fertilizer			

Note: tsp = teaspoon

WHERE DOES POLLUTION GO?

Grade Level
3-5, 6-8
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Life Science, Environmental Science
Time
2 class periods
Materials
- Paring knife
- Cups, jars, or beakers, 3-4 per group
- Vegetables such as celery, cauliflower, squash, radish, asparagus, broccoli (3-4 types per group)
- Food coloring
- Water
- Paper and pencil to record observations

Setting
Classroom and in community
Terms
Absorption, Capillary action, Food chain, Runoff, Water pollution
Reference
Adapted from the Salt Lake County Storm Water Quality Education Lesson and Activity Plans Salt Lake County, Utah, Public Works Department Engineering Division

Summary

Students conduct an experiment using vegetables, water, and food dye to observe the uptake of pollutants into plant tissues.

Objective

Students will:
1. Observe how plants absorb nutrients and toxic substances from water.
2. Discuss the impacts of water pollution on the food chain.

Procedure

Advanced Preparation

Slice the vegetables just before class, keeping them as fresh as possible. Cut the vegetables to expose the insides in several different ways: whole, in sticks, sliced in thin layers, etc. Some of the vegetables, like celery, need to be sliced at the bottom to expose the internal parts to the food coloring.

Warm Up

Tell the students that they will be conducting an experiment to mimic how pollution can make its way through the food chain. Ask students to list some plants and animals that might be affected by water pollution (e.g. frogs, fish, water lilies). Could water pollution affect people? How? Explain that plants use transport tubes to transport water and nutrients between their roots and leaves.

Activity

1. Have students close their eyes. Read the following:

The sky is filled with gray clouds. Thunder and lightening fill the air. Rain is pouring out of the sky. You can see puddles forming on the side of the street. The street gutter is filled with a small river. You think about putting a stick in this small river, but when you come close to the water, you notice that the river already has a small stick in it. In fact, there are many sticks floating with the water. And grass clippings, leaves and here comes a wrapper from a candy bar. You look closer and see patches of rainbow colored water. Why would the water have those strange patches? “Is it because of oil?” You follow the small river until you see where it disappears into a drain. You

watch as the sticks, grass clippings, leaves, candy bar wrapper and oily water go down the drain. "I wonder where that water goes?"

2. Ask the students where they think the water in the above story goes. Explain that from the drain, the water goes into pipes underneath our streets. The pipes carry the storm water to the nearest stream or river.
3. Tell the students that they will be observing what can happen to vegetation as a result of pollution in our streams and rivers. The vegetables represent different plants found along a stream or river, while the water in the cups represents the river water.
4. Have each group retrieve a sample of each type of vegetable. Fill one cup per vegetable sample with about two inches of water.
5. Have students add several drops of food coloring to the water. Explain that the food coloring represents storm water polluted with antifreeze, oil, soil, pesticides, leaves and pet waste.
6. Have students place their vegetable samples into the cups overnight. Overtime, the colored water will travel via capillary action through the plant, showing how plants can absorb pollutants with the water they "drink." The colored water may or may not be visible on the outside of the vegetable. Cut off 1-inch pieces of the vegetables for the students to study closely and record observations.

Follow Up

Review students' observations. Discuss what happens to pollutants when absorb by plants.

- How do plants help purify water? (Pull pollution out of water and either store or use in processes)
- Where does water go after uptake into the plant? (Lost in transpiration)
- Why is the water in the cups still colored? (The vegetables, like plants, do not absorb all of the pollution)
- What happens to pollution that is left in the water? (Taken in by other plants and animals, or humans)
- How might wildlife be affected by water pollution? (By eating plants that have absorbed pollution or drinking polluted water)
- Is there a limit to how much polluted water a plant can take in? (Yes, represented by water still colored).
- Can we use plants to clean up all of our polluted water? (No, prevention of water pollution at the source is the most effective method)

Explain to students that sometimes ditches or storm water management ponds are built to filter polluted runoff and excess rainwater. These ponds are often planted with vegetation to aid in the filtering. As the runoff and rainwater rest before flowing on, many of the pollutants, especially soil particles, settle to the bottom and the cleaner water drains off from the top. Also point out that not all pollutants have color. Water may appear clear and still contain pollutants.

Extension

Is there a storm water management pond near the school? Visit the pond on a dry day and again just after a heavy rain or snow. Is there a difference in the appearance of the water in the pond and/or the water washing into the pond? From where is the water flowing? Where is it going? Water may be able to be seen leaving the pond – is it cleaner? How does the water leaving the pond compare to the water coming into the pond?

Where Does Pollution Go?

Word Bank

1. Water Pollution

2. Absorption

3. Filtering

4. Food Chain

5. Runoff

Warm Up Questions

1. List some plants and animals that might be affected by water pollution.

2. Explain two ways that water pollution can affect people.

Observations

Test Item	Day 1	Day 2

Follow Up Questions

1. What did the food coloring in our experiment represent?

2. Explain how plants help purify water.

3. Where does water go after uptake into the plant?

4. At the end of the experiment, why was the water in the cup still colored? Is there a limit to how much polluted water a plant can take in? Explain.

5. Explain what will happen to pollution that is still in the water.

6. Explain two ways that wildlife might be affected by water pollution.

7. Can we use plants to help clean up all of our polluted water?

THE GREAT DEBATE

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Fine Arts, Language Arts
Time
20 minutes to assign character
60 minutes for the debate
Materials
- Copy of *Lake Simcoe: A Case Study* per student
- Role cards and nametags
- Flip chart/chalkboard

Setting
Indoors
Terms
Eutrophication, Perspective, Phosphorus
Reference
Adapted from Don't Treat Soil Like Dirt, Federation of Ontario Naturalists,

Summary

Students assume roles of various characters involved in a debate about soil erosion and eutrophication.

Objective

Students will:

1. Identify impacts (social, environmental and economic) of soil erosion in the Lake Simcoe region.
2. Compare the wide range of perspectives from which citizens of a community view conservation efforts.
3. Compare natural eutrophication to human induced eutrophication.
4. Develop public speaking skills

Procedure

Advanced Preparation

Have students read the *Lake Simcoe: A Case Study* and their characters' descriptions. Give students this information two or three days before the debate. Answer questions to help students understand their characters, but discussion of the case should be saved for the debate itself.

As moderator the teacher should enforce time limits for presentations. The pressure of a limited presentation time is very realistic in most hearings.

Prior to beginning the debate, draw straws for the order of opening statements and record these on the flip chart or chalkboard.

Encourage students to dress up and develop their characters. For the day of the debate, transform the classroom into a community hall setting. Place chairs in groups facing the front of the room where a table is placed for the teacher. After the debate, arrange the chairs into one large circle for discussion.

Warm Up

Have students share their own experiences with eutrophication of a Cincinnati lake or fishing pond.

Activity

1. Two to three days prior to the debate, divide students into groups

of two or three. Assign a character role to each group. All or some of the twelve role cards provided may be used. The student's responsibility will be to portray their assigned roles using the information on the role card in the case study and any other information they can gather.

2. Have students read the Case Study aloud in class and discuss the issues involved.
3. On the day of the debate, the following format is suggested:
    a) Introduction, welcome and explanation of procedure by moderator;
    b) Two-minute opening statements by each group including introducing themselves and explaining their case;
    c) Five minutes to formulate a question to be directed at one other group;
    d) Question period: one question from each group, one-minute answer, one-minute rebuttal from each group;
    e) Two-minute closing statements from each group;
    f) Moderator wrap-up including statement that no one has won the debate, thank-you and discussion. Have students drop their roles.

Follow Up

Lead a discussion using the following questions to help direct the follow up:

- How did you feel in your role-playing?
- Did you have difficulty in portraying your character? Why or why not?
- Where could you find additional information to help represent your role?
- How did you feel during the question period following your presentation? Why were some questions easy to answer and others difficult or impossible?
- Was this debate realistic? Why or why not?
- Did your opinion change during the debate after hearing other persons' opinions?
- What did you learn about the complexity of land-use issues and their problems and solutions?
- What further steps could the class take to help solve or be involved in a land-use issue in your area?

If students have not mentioned these, discuss the eight impacts of soil erosion in the Lake Simcoe Region include:

1. Eutrophication of the lake
2. Decrease in oxygen content in deep water
3. Algae blooms
4. Egg-laying fish such as lake trout and whitefish no longer reproduce in the lake
5. Commercial fishing closed
6. Recreational fishing limits are decreased (2 lake trout and 2 whitefish per day)
7. Farmers lose money (estimate of $704 per farmer)
8. Decrease in recreational value of the lake

Extension

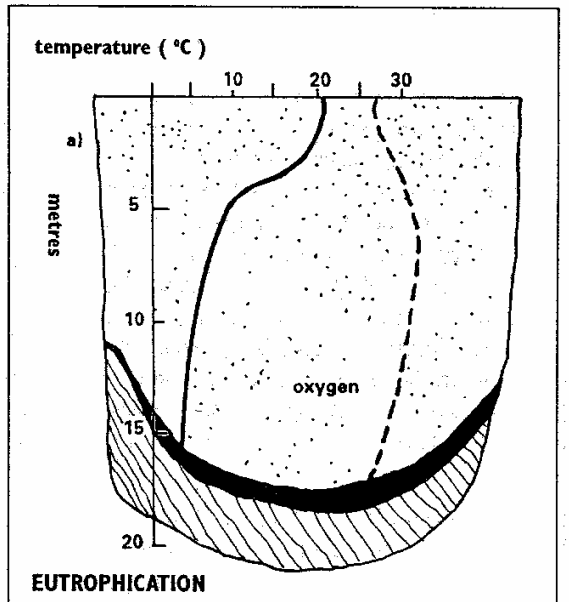
Issues such as this are complex because of the social, environmental and economic factors that come into play. As a homework assignment, have students write out a list of eight impacts of soil degradation in the Lake Simcoe Region and suggest how they would solve the problems that exist. Collect assignments and summarize results.

LAKE SIMCOE: Case Study

Conservation tillage is a combination of practices used by farmers to control soil erosion and other forms of soil degradation. It maintains at least a 30% cover on the soil surface as a protection against water and wind erosion.

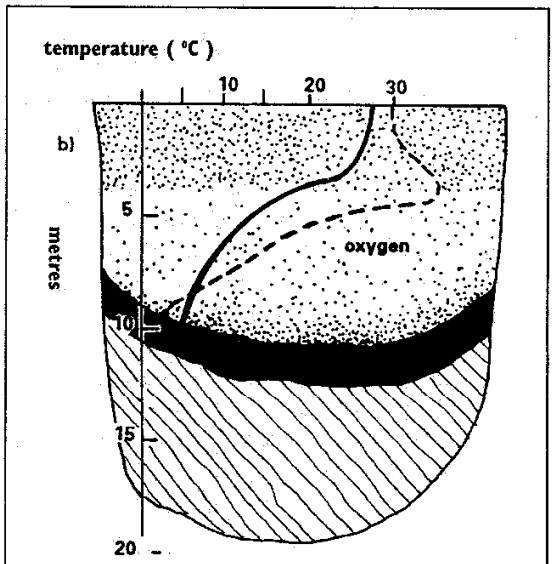
The Holland Marsh is a major fruit and vegetable growing area in Ontario (approximately 6,000 acres). The soils of the Holland Marsh are organic in nature (decomposed plant and animal matter), and heavy applications of fertilizer are applied annually.

Lake Simcoe is located between Lake Ontario and Georgian Bay. It is southern



EUTROPHICATION

A lake in its early stages of maturity has relatively cool water in the upper layer. The deep water is well oxygenated. The organic matter that drifts to the bottom falls through a relatively large volume of water.



A lake that receives excess nutrient input soon becomes eutrophic. The nutrients cause the rapid growth of aquatic organisms like plankton and algae. A large amount of organic matter drifts to the bottom and decomposes, using up valuable oxygen. The water is then no longer able to support life forms that require higher oxygen content.

Ontario's largest inland lake; it is within an hour's drive of about 50% of Ontario's population and is heavily used year-round for recreation. The main attraction of Lake Simcoe has been recreational fishing, as the lake naturally supports both cold-water and warm-water fish species. Every year more than 115,000 people fish in Lake Simcoe. There are also over 12,000 cottages and year-round residences on the lake.

Up until the 1960's, Lake Simcoe's cold-water fish included lake trout and lake whitefish. Warm-water species included yellow perch, bass, walleye and northern pike. Now lake trout and whitefish do not reproduce naturally. The annual fish-stocking program operated by the Ontario Ministry of Natural Resources (OMNR) maintains their populations.

Stocking of lake trout began in 1970 and whitefish in 1982. Fish stocking rates as of 1995 are 100,000 lake trout and 140,000 whitefish per year.

In 1977 the OMNR reduced catch limits to two lake trout and two whitefish per day on Lake Simcoe.

Because fishing is a major component of the very important tourism industry in the area, full restrictions for whitefish and lake trout could not be imposed. Activities like fishing generate approximately $147 million in economic benefits each year for the Lake Simcoe region.

Although Lake Simcoe will probably never see commercial fishing again as it did prior to 1940, it is expected that the stocking of the two coldwater fish species will allow recreational fishing to continue.

What has happened since the 1960's to upset the biology of Lake Simcoe?

The problem is eutrophication. Eutrophication is a natural process that every lake experiences. However, Lake Simcoe's problem has been induced by human activity and is referred to as cultural eutrophication.

Excess nutrient levels in a lake cause cultural eutrophication. High inputs of phosphorus in particular, cause rapid and accelerated growth of algae and plants. As the organisms die, they sink to the bottom of the lake where they decompose and use vast quantities of oxygen from the deeper waters. Deep-dwelling, coldwater fish species such as lake trout and whitefish cannot survive as oxygen supplies decrease. Lake Simcoe's state of eutrophication is considered to be a severe case of water pollution.

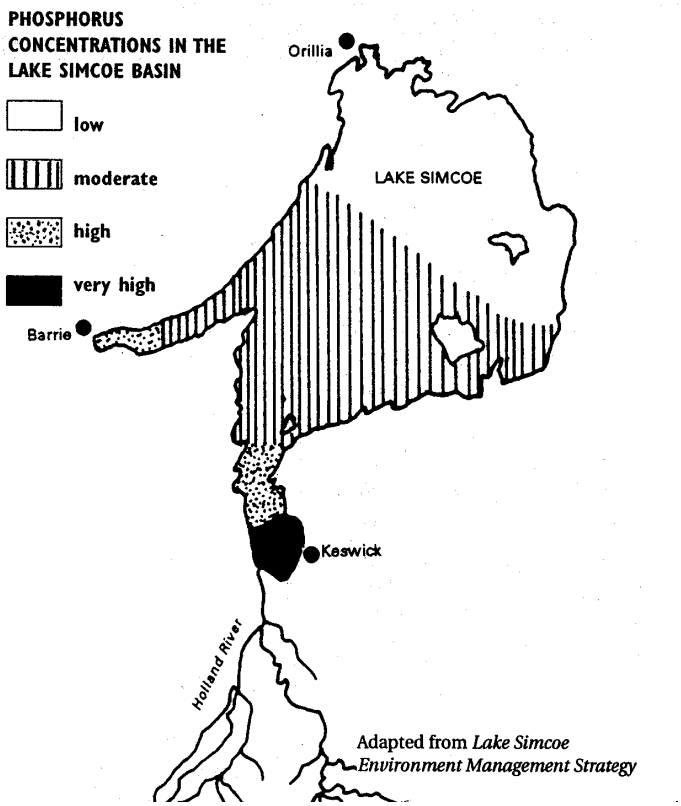
Altogether, an estimated 82 tons of phosphorus are dumped into Lake Simcoe each year. The pollution is primarily from rural and agricultural sources and can be broken down as follows: 64% (53 tons) from rural and agricultural sources; 16% (13 tons) from sewage effluent from urban centers; 16% (13 tons) from the air through dust and rain; and 4% (3 tons) from the septic tanks of approximately 12,000 cottages along the edges of the lake.

Of the 64% from rural and agricultural sources, half - or about 26 tons - come directly from the vegetable farms of the Holland Marsh. The Holland River drains the vegetable farms of the Holland Marsh and flows into Cook Bay at the southern end of the lake (see map).

The main sources of agricultural phosphorus are chemical fertilizers and, to a lesser extent, cattle manure. The phosphorus attaches directly to soil particles and is carried into the lake by water erosion of soil.

The cost of soil erosion is not felt only in the lake. It is estimated that erosion costs the average-sized farm in the basin $704 annually in lost productivity.

With some 4,000 farms within



Adapted from *Lake Simcoe Environment Management Strategy*

the Lake Simcoe watershed, erosion is estimated to cost farmers over $3 million annually (Crabtree, p.1).

An increase awareness of conservation tillage and farming modifications, such as reducing the use of chemical fertilizers, controlling soil erosion and better management of livestock manure, has helped decrease phosphorus loading. However, only a widespread implementation of such practices could significantly decrease the contribution from agriculture.

To help decrease phosphorus loadings from sewage, there has been a diversion from Aurora and Newmarket to the Duffin Creek Water Pollution Control Plant on Lake Ontario.

The cost of this sewage diversion was $23 million. However, it will decrease the phosphorus input by approximately 6.9 tons per year. The upgrading of existing sewage treatment plants in Barrie and Orillia was estimated to further reduce the phosphorus loadings by 5 tons annually (Crabtree, P.2). The addition of new facilities at Keswick and Innisfil should help to noticeably decrease additional phosphorus inputs from sewage.

It is expected that, with reduced phosphorous loadings, eutrophication can be reversed and fish restocking will no longer be required. However, this can only happen with considerable co-operation by all residents and visitors alike, or Lake Simcoe will continue to prematurely age and decline in productivity.

Since 1990, phosphorous loadings have declined but there have yet to be significant improvements in water quality.

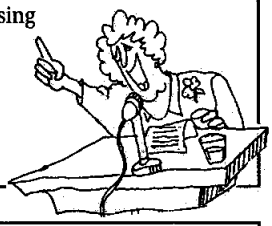
Bill or Brenda Richardson

You are president of the local naturalists' club and a long time, year-round resident in the area. The club consists of 130 active members who have been concerned about the eutrophication of Lake Simcoe for quite some time. As an active club member, you have written letters to local and provincial government officials about the need to clean up Lake Simcoe by controlling phosphorus inputs. You would like to see a new area sewage treatment plant built, even though the diverting of sewage to other plants has helped. The club is in favour of stocking the lake, but hopes to see the lake return to normal so that stocking is unnecessary.

John or Judy Adamson

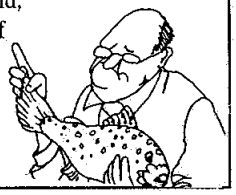
You are a re-elected councillor in the county. You have lived in this area for 22 years and see the need to update services because of the popularity of the area with tourists and cottagers. You campaigned on this issue, and one of your campaign promises was the building of a sewage treatment plant to help control pollution in Lake Simcoe. You realize that providing new services will cost money, but you justify this with the fact that the area is keeping pace with other communities in terms of developing services and may even surpass them by realizing the necessity of a sewage treatment plant to help protect the environment.

You also favour a new proposed cottage development because it will attract more people to the area and help the economy by increasing the tax-base, for example.



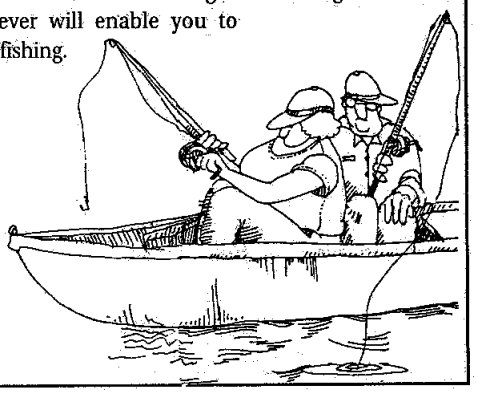
Fred or Frieda Martin

You are a biologist who has worked on the Lake Simcoe study for 15 years. You have seen the decline in the health of the lake. You are pleased with the success of the fish-stocking program, but you see it as a cover-up of the larger problem of eutrophication. You want more public education to help people understand phosphorus pollution and the changes they need to make to help improve the quality of the environment. The sooner the sewage treatment plant can be built and all the cottages hooked up to sewers, the better. Also, you want to see some kind of government assistance to encourage farmers to change their farming techniques, to decrease their dependence on phosphorus and other chemical fertilizers, to use more soil conservation techniques that will control erosion and, therefore, reduce the input of phosphorus into Lake Simcoe.



Ron or Rhonda Carter

You are a sport fishing enthusiast who enjoys fishing at Lake Simcoe year-round. You are glad they are stocking the lake with fish because the fishing now is better than it was 10 years ago. Because you are not a resident of the area, you are not aware of all the problems related to the eutrophication of Lake Simcoe or how or why the phosphorus input should be decreased. You just enjoy the opportunity to fish and are in favour of continuing the stocking of fish or whatever will enable you to keep fishing.

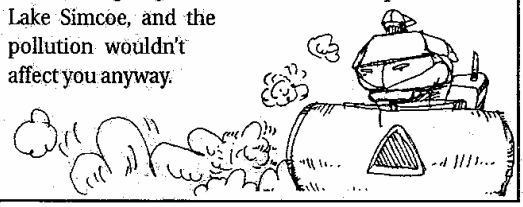


Neil or Nancy Purdy

You are a developer who has purchased a large tract of land on the northeast shore of Lake Simcoe. You have plans to build a cottage community over the next five years. You want to develop the area, sell the properties and then move on to another project. However, your proposal has encountered an obstacle. There is pressure to build a sewage treatment plant and hook all new cottages up to sewers. The county government wants you to wait until the plant is built. This delay will cost you about $500000.

Tim or Tina Green

You are a middle-aged vegetable farmer whose farm backs onto the Holland River. You inherited the farm from your parents and one of your children will continue to farm the land after you retire. You do not practise any methods of conservation farming because you are making money farming it the way you always have. Farming with fertilizers and pesticides has increased your crop yields steadily over the years and has resulted in higher profits. So, why change your practices now? You wish people with these conservation and pollution viewpoints would mind their own business and leave you alone to farm the way you do, make a living and then retire. You don't believe that any erosion coming off your land is contributing very much, if at all, to eutrophication of Lake Simcoe, and the pollution wouldn't affect you anyway.

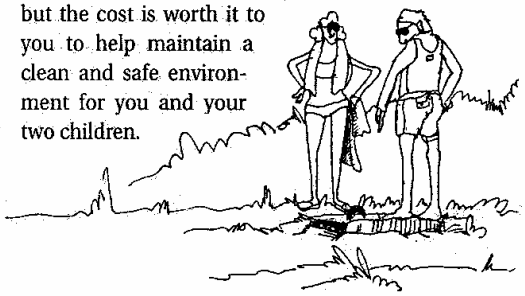


Harry or Helen Shepherd

You are a middle-aged farmer whose farm is located close to Lake Simcoe. The farm was passed onto you by your parents and you plan to pass it onto your children when you retire. Your father was an open-minded farmer, as you are. You understand what the land means to your livelihood and that of your children; therefore, you do not abuse it. As a result, you practise conservation tillage, apply fertilizers and pesticides correctly and at the correct rates, and limit erosion by maintaining buffer zones. You would like more of the area's farmers attending the information sessions on conservation farming; however, you feel you are doing the best you can.

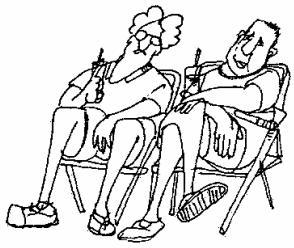
Paul or Paula McDonald

You are a 33-year-old cottager. The cottage was willed to you and your spouse by your in-laws. You are very conscious of pollution and the effects of contaminants on the environment. You would like to see a new sewage treatment plant built and all the cottages hooked up to sewers, replacing the septic tanks. You realize this could take a couple of years and will cost extra money on your taxes, but the cost is worth it to you to help maintain a clean and safe environment for you and your two children.



Dennis or Denise Rogers

You are a retired cottage owner on the lake. You and your family have been getting away from the hectic pace of the city to the Lake Simcoe area ever since you were a child. You enjoy the quiet of the area and don't miss the amenities of the city one bit. After all, the cottage is in the country. Because of this, you do not see a need for sewage treatment facilities. Your septic tank works fine most of the time. So, what is all the concern about a little natural phosphorus going into the lake? You believe the cottagers contribute little to the problem. It's the farmers that are really to blame.



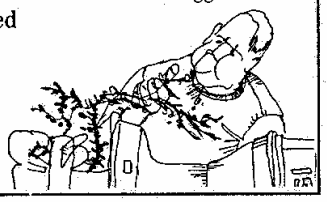
Vince or Valerie Douglas

You are the father or mother of a family with three young children. You enjoy getting out of the city on weekends during the summer and spending time at the lake. Your children like swimming and picnicking. However, the lake is not the same as you remember it being when your parents brought you as a child. There are a lot more "weeds" in the water, and the water doesn't seem as clean. You're upset that people can't keep the lake clean enough for safe and pleasant swimming.

Carl or Carla Fisher

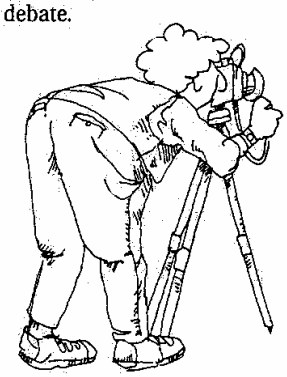
You are a marina owner and the spokesperson for the Marina Owners Association (M.O.A.) of Lake Simcoe. Being the spokesperson of M.O.A. is a challenge at times because the 35 members who own marinas in the area often do not all agree. However, there is an overwhelming consensus that the eutrophication of Lake Simcoe has resulted in a decrease in business. Boat owners have commented that the lake is not as attractive as it used to be and that excessive aquatic plant growth gets tangled in motors, causing frustration and. occasionally, the need for repairs.

Your association feels the excessive plant growth should be "weeded out" regularly all summer. You have even volunteered to help supervise workers to do this. However, the whole issue is so bogged down in government "red tape" that the association is getting tired of waiting.



Doug or Donna Porter

You are a newspaper reporter from the *Lake Simcoe Topic* in Newmarket. You are not presenting any bias but are trying to represent what is happening at the debate. You go around taking pictures and notes of what goes on at the debate.



FED UP

Grade Level
9-12
Ohio Academic Content Standards
See chart in *Resources*
Subject
Environmental Science, Physical Science
Time
1-hour preparation
10 min observation-30 days
1-hour conclusion
Materials
- Granulated fertilizer
- Pond water
- 3 1-quart jars/ group
- Safety goggles
- Several 1 tsp. spoons
- Hand lenses
- Student Data Sheets
- Masking tape or labels
- Water-resistant pens
- Paper towels
- Dissolved oxygen kit
- Sun lamp or grow light
- Camera and film

Setting
Classroom
Terms
Eutrophication, Control, Dissolved Oxygen, Nitrate, Nonpoint, Nutrient, Oligotrophic, Phosphate
Reference
Adapted from the Salt Lake County Storm Water Quality Education Lesson and Activity Plans Salt Lake County, Utah, Public Works Department Engineering Division

Summary

Through a controlled experiment, students will compare the effects of varying nutrient levels on water and discuss the process of eutrophication in aquatic environments.

Objective

Students will:

1. Perform a controlled experiment examining the changes in pond water due to phosphate and nitrate enrichment over a 30-day period.
2. Define eutrophication and explain how excessive nutrients affect water quality.
3. Explain the role of phosphorus and nitrogen compounds in the eutrophication of water systems.
4. Identify nonpoint sources of nutrient enrichment.

Procedure

Advanced Preparation

Purchase granulated fertilizer of equal nitrate and phosphate concentration at a garden supply store. A few days prior to the experiment, obtain several gallons of pond or stream water (depending on the class size) and store in a cool place until ready for use. Make copies (1 per student) of the *Student Data Sheets*.

Warm Up

Begin by asking the students what they know about fertilizers. Where are they used? Why? Do they occur naturally or are they manufactured? What are they made from? List students' responses and help fill any gaps in their information.

Discuss eutrophication. Where might the nutrients come from? Explain that eutrophication happens naturally, but can also be accelerated by human activity, such as the improper use of fertilizers. How might fertilizers or another outside source of nutrients, arrive in the water? What impact, if any, does fertilizer have on water quality? On fish and other wildlife?

Activity

1. Explain that students will have the opportunity to observe the various effects of nutrient enrichment on water quality by conducting a controlled experiment. Emphasize the need for careful observation and record keeping, as well as safety.
2. Divide students into groups of three or four and give each student a data sheet and safety goggles. Give each team three clean 1-quart jars. Have students label each with masking tape or labels. Number the jars from 1 to 3 with a marking pen. Container #1 will be the control.
3. Fill each jar 2/3 full with pond or stream water. To jar #2, have each group add 1 teaspoon of fertilizer. To jar #3, add 2 teaspoons of fertilizer. Have students perform dissolved oxygen (DO) tests on all 3 jars (Note: at this point all three readings should be similar). Students should record their findings on the data sheet.
4. Secure a piece of paper towel over each container and place them in a sunny location so that each container receives the same amount of light. Use a sun lamp or grow lamp if sunlight is unavailable.
5. Predict what you think will happen in each jar.
6. Use the data sheet provided to record daily observations (for thirty days) for all three containers. Data collected should include observations on color, clarity and odor of the water. Photos can be taken to record changes as well.
7. On day thirty, have students make regular observations. In addition, students should perform DO tests on all three samples and record their findings.

Follow Up

When the experiment is completed have the students answer the following questions based upon their observations:

- What changes did you observe?
- How long did it take before changes in the control and in each test jar were observed?
- After five days, how did the contents of the jars compare?
- After ten days, how did the jars compare?
- How did the DO tests compare from day 1 to day 30? Between samples?
- Did they follow your predictions?
- How might you explain these observations?
- Is there a correlation between DO and algal growth?
- How might this affect aquatic animal life? Plant life?
- What can or should be done to control nonpoint sources of phosphate and nitrate compounds in runoff?
- What can you do?

Extension

Have the students identify the type(s) of algae that grew using algae identification charts, microscopes and commercially prepared algal slides.

Perform a larger-scale study on the effects of nutrient enrichment using plastic wading pools as artificial ponds. Add different amounts of nitrate and phosphate fertilizers, phosphate detergents, grass cuttings, etc. Be sure to leave one pond as a control. Have students answer the

above questions. Have students compare what goes on in these “ponds” to what happens in local water bodies.

Have students obtain water samples from a variety of water systems. Take samples from waters that appear to be eutrophic and at least one from water that appears to be oligotrophic or from areas you suspect may be impacted despite their appearance. Label each sample with time, date and location. Record sampling locations on a map or sketch and describe each sampling site. Survey the area and note possible nonpoint sources of pollution. Test each sample for nitrate and phosphate levels using commercial kits. Compare the results of the test to your observations from each sampling site.

Student Data Sheet

Name _____ Date _____

Water Sample Date collected_____ Location collected_____

Hypothesis

Results

Conclusions

Dissolved Oxygen Test			
Day	SAMPLE NUMBER		
	#1	#2	#3
1			
30			

Daily Observations			
Date	SAMPLE NUMBER		
	#1	#2	#3

BIODIVERSITY = WATER QUALITY

Grade Level
9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Life Science, Environmental Science, Ecology
Time
2 hours field trip + travel time
Materials
- Each team will need:
- Measuring tape
- A white enamel pan
- Calculator (optional)
- Notebook and pencil
- Kick seine, screen, or net
- Student sheets
- If samples are to be preserved, containers with 70% alcohol (ethyl or isopropyl) solution are needed

Setting
Stream
Terms
Ecosystem, Facultative, Pollution intolerant, Macroinvertebrate, Pollution tolerant
Reference
Adapted from the Water Sourcebook Series, 9-12, United States Environmental Protection Agency

Summary

On a field trip to a stream, students assess the health of a stream.

Objective

Students will:
1. Learn how to collect macroinvertebrate samples.
2. Define and identify pollution tolerant, pollution intolerant and facultative macroinvertebrates.
3. Classify macroinvertebrates by tolerance level.
4. Determine the degree of pollution in a stream by using indicator organisms and a pollution tolerance index.

Procedure

Warm Up

Before the field trip, review safety procedures for collecting samples and working around water. Also review with students, animal handling procedures. Hand out Student Sheets and have students study the taxonomic (taxa) groups. Show slides or pictures of the macroinvertebrates if available. Divide students into teams. Obtain permission slips if necessary.

Activity

1. Have each team choose a one-meter square area representative of the riffle or shallow area being sampled.
2. Use a kick seine, screen or net to collect macroinvertebrate samples.
3. Approach the sample sites from downstream to avoid disturbing the organisms at the sampling location.
4. Take three samples to be sure representative samples are collected. Samples may also be taken from some other microhabitats at the site, such as rocks in slow moving water near banks because different organisms may be found there.
5. Place samples in white pans for identification. Macroinvertebrates can be released after identification. To preserve a few for classroom use place in 70% alcohol solution.
6. Record on Student Sheet the presences of each type of organism collected and classify it by its level of tolerance. (Use the Student Sheet: Macroinvertebrate Picture Key.) Estimate the number of

each organism type and record on Student Sheet.

7. Calculate the stream index by multiplying the number of types of organisms in each tolerance level by the index value for that level and add the resulting three numbers. DO NOT use the number of individuals.

Pollution Tolerance of Macroinvertebrates		
Group 1- Pollution Intolerant (Index Value =3)	Group 2- Wide Range of Tolerance (Index Value =2)	Group 3- Very Tolerant (Index Value =1)
1. Stonefly Nymph 2. Caddisfly Larva 3. Water Penny 4. Riffle Beetle 5. Mayfly Nymph 6. Dobsonfly Larva 7. Gilled Snail	8. Crayfish 9. Sowbug 10. Scud 11. Alderfly larva 12. Fishfly larva 13. Damselfly Nymph 14. Watersnipe Fly larva 15. Crane Fly larva 16. Beetle larva 17. Dragonfly larva 18. Clam	19. Aquatic worm 20. Midge Fly larva 21. Blackfly larva 22. Leech 23. Pouch Snail 24. Other Snails
Cumulative Index Values	23 and above = Excellent Water Quality 17 -22 = Good Water Quality 11 -16 = Fair Water Quality 10 or less = Poor Water Quality	

Follow Up

Have each group graph the results of this activity with a bar graph using the total index number for each group. When this is completed, the groups will meet together to compare graphs. Make generalizations about their results. Record results for the class and produce a composite graph.

Have the class answer these questions.

- What is the quality of this stream?
- What are some possible reasons for the quality of this stream?
- When examples of organisms that are sensitive to pollution are present, what might this indicate to you?

Extension

Test the stream for physical and chemical water quality parameters. Compare results.

Have a professional consultant in the environmental field address the class about water quality.

Perform a literature search to find articles about biodiversity and water quality. Share articles.

Collect samples from a site that is known to be polluted by runoff and compare the results to the study site for this activity.

Biodiversity = Water Quality Student Sheet

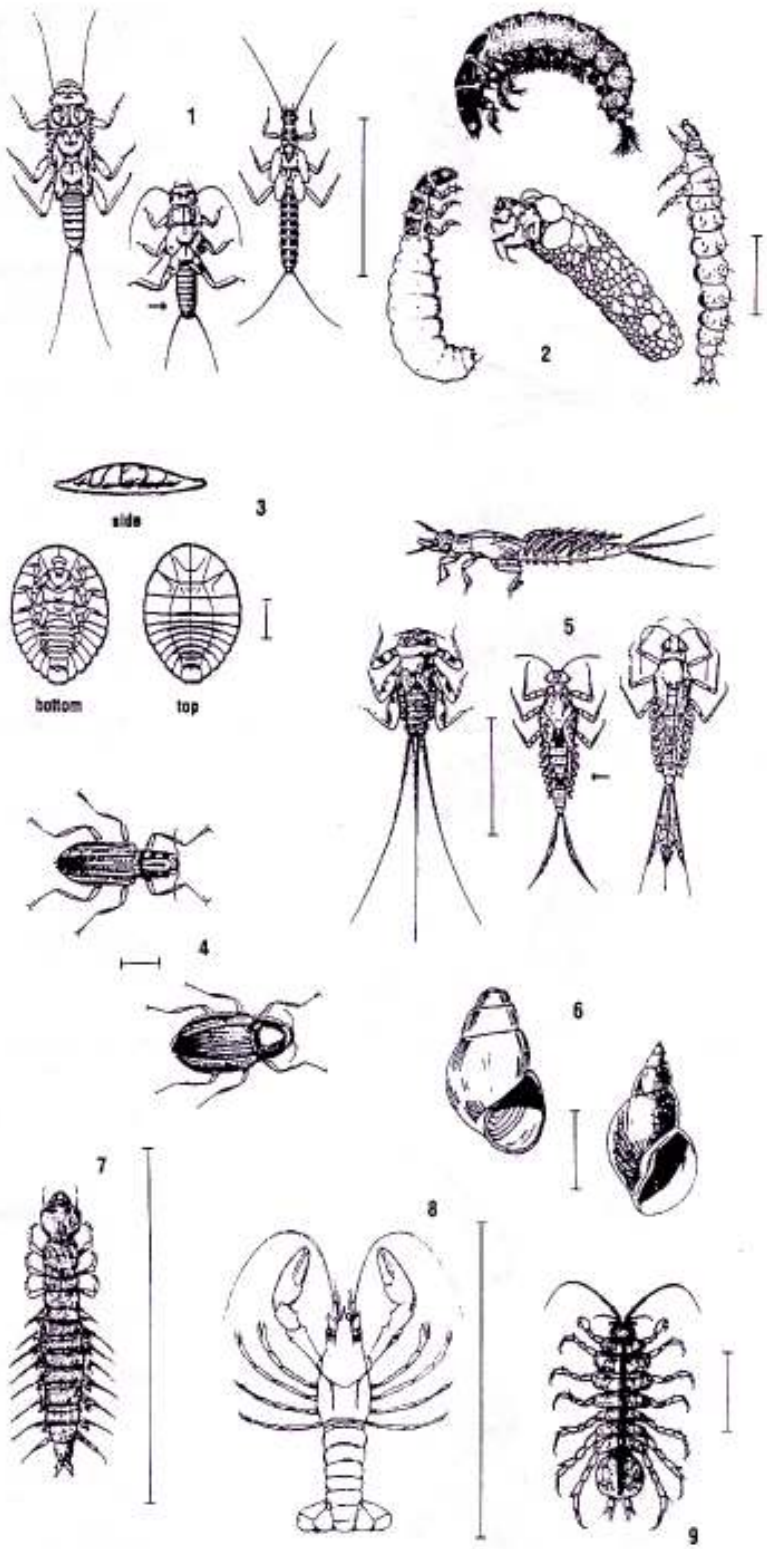
TEAM MEMBERS _____

Data Record
#_____
Test Site (riffle)

1. Quantity and types of organisms present in Group 1 on key.

2. Quantity and types of organisms present in Group 2 on key.

3. Quantity and types of organisms present in Group 3 on key.



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

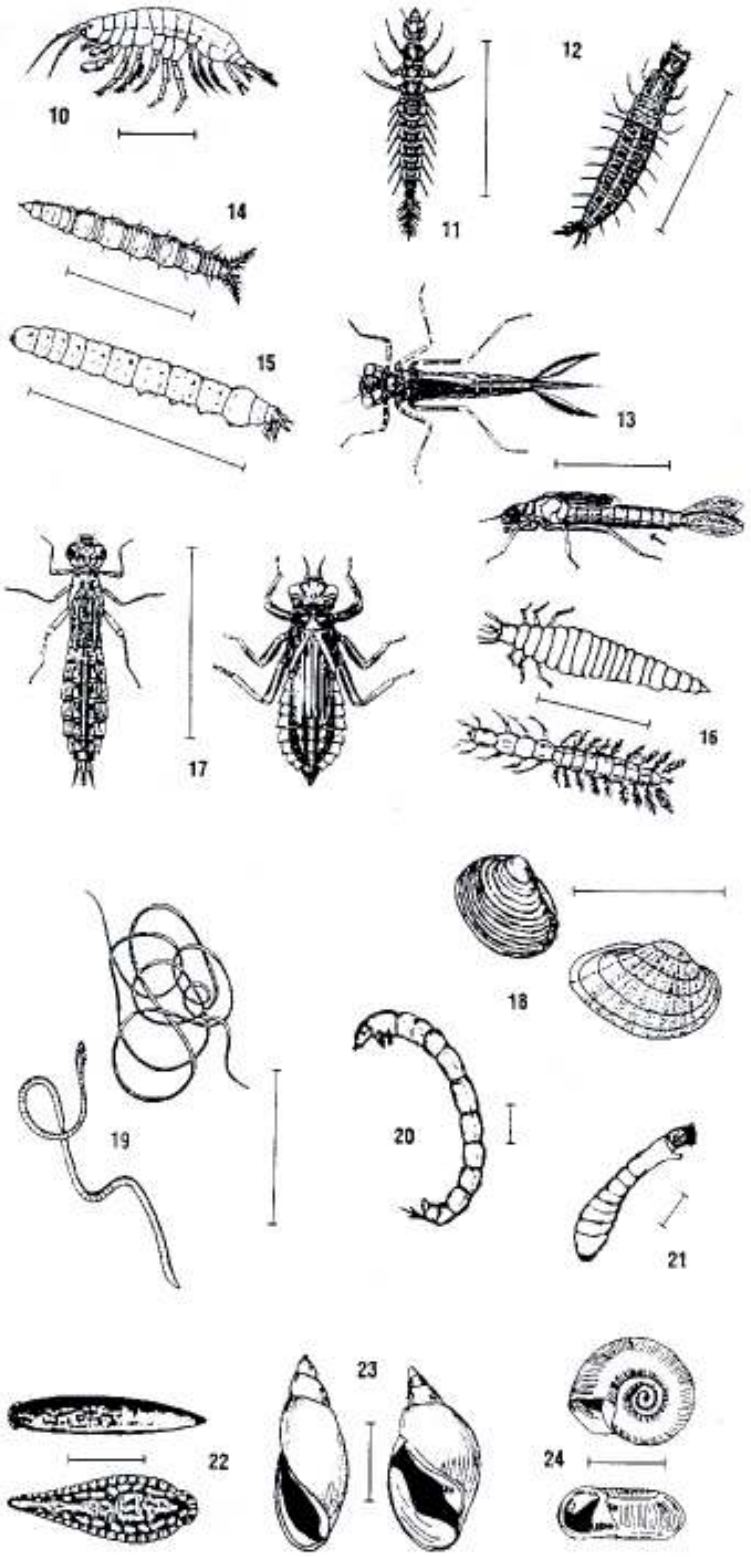
Somewhat pollution tolerant organisms can be in good or fair quality water.

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.

Action

The final section in this curriculum focuses on solutions to the nonpoint source pollution problem. Many of these actions every person, even students, can engage in to reduce pollution. An overview of other solutions is also included. The activities in this section direct students to act out a play and obtain a better understanding of the difference between clean and dirty water. Students will also experiment with planning and educating a community, explore erosion control methods and study clean water laws.

Community Action

Nonpoint source pollution is a community problem caused by the collective actions of the members of the community. For this reason the solution to nonpoint source pollution is to educate the community regarding the causes, effects and solutions to the problem. Students can play a role by taking actions to prevent pollution and educating community members. Organizing a clean-up to remove litter is one classic solution to involve and empower students. Students can educate the community by making posters, bumper stickers or flyers with a NPS pollution message. Writing class letters to government officials is another way for them become involved.

Students can directly increase awareness of nonpoint source pollution by organizing a storm drain labeling event. The Hamilton County Storm Water District funds **storm drain labeling** events and will provide storm drain labels, flyers and all materials necessary to attach the labels to the drain. Students learn about NPS pollution and then move around the community gluing labels to storm drains and placing informational door hangers on nearby homes. The labels promote the message "No Dumping, ____ River Watershed" (e.g., Mill Creek Watershed or Great Miami Watershed). Since labels last many years, students will have a reminder of their effort and the importance of community action towards nonpoint source pollution. For more information regarding storm drain labeling, call the Hamilton County Soil and Water Conservation District at (513) 772-7645.

Individual Action

There are many other actions students can take in their everyday lives to improve water quality. Many people understand that putting garbage in its place is very important so that litter does not wash down the storm drain or into a creek or stream. However, a lot of litter is unintentional so it is important to secure garbage can lids tightly and to organize recycling bins so that nothing blows away. Picking up pet waste from your dog is also an important step to ensure that harmful bacteria do not wash away with the runoff. Pet waste should be thrown away with the garbage or flushed down the toilet where it goes to the wastewater treatment plant.

Some people still dispose of chemicals, yard waste or soap from washing the car down the storm drain. Nothing but rainwater should flow down the storm drain. **Household hazardous waste**, such as paint or motor oil, should be disposed of properly. Use household hazardous products only when necessary and use only the amount needed. When it comes to household

hazardous chemicals, more is not better. For assistance disposing of these items the Hamilton County Solid Waste Management District has a free Household Hazardous Waste Hotline, (513) 946-7777, or you can visit their website for the information (www.hcdoes.org).

Students can help with composting yard waste to prevent it from flowing into a waterway. Using compost to fertilize flowerbeds and gardens as well as planting native grasses that do not have high fertilizer requirements are great ways to reduce the amount of fertilizers used. Before fertilizing, soils should be tested to learn exactly what nutrients the lawn needs. Apply fertilizer only when it is needed, during the right season and in proper amounts. Fertilizer should not be left on driveways and sidewalks where it can be washed away by runoff from the next storm. Do not fertilize if a heavy storm is predicted.

As discussed in the Urban pollution section, washing cars can add to nonpoint source pollution. Students can use a bucket instead of a hose to save water and limit flow. If water is conserved while washing the car, fewer suds will flow into the waterways and keep phosphates and other chemicals out of streams and lakes. Biodegradable soaps are less detrimental to the stream ecosystem. If the car is parked on gravel or a lawn, wastewater does not flow away but penetrates into the ground. If it is parked away from direct sunlight the evaporation will be slowed and water spots will not form.

While boating there are several important actions that people can take to limit nonpoint source pollution. As on land, never litter by throwing trash overboard. Use funnels and extreme care when fueling and maintaining a motor while on the water and never top-off a tank. Also use oil-absorbing pads in the bilge and dispose of them properly when they are dirty.

Construction and Mining Solutions

There are other solutions to nonpoint source pollution in which students do not take a direct role but benefit from the protection of the waterways. One such area involves erosion control on construction or gravel mining sites. In Hamilton County when an area greater than one acre is being cleared, the developer must file for a National Pollution Discharge Elimination System permit and an earthworks permit to address hillside slope stability issues. There are two basic approaches in controlling erosion. One is **sediment control**, which is a temporary and involves sediment basins and traps, compost filter berms, temporary seeding and silt fences to capture sediment on a site. These controls can significantly reduce soil from leaving the site generally by 30%-85% depending on topography, soil types and length of time exposed. Sediment control is designed for a 10 to 25 year storm maximum so very severe weather will likely result in erosion from the construction site. The following describes four commonly used sediment control methods:

- A **sediment basin** is a temporary settling pond that releases runoff at a controlled rate. It is designed to slowly release runoff, detaining it long enough to allow most of the sediment to settle. The entire structure is removed when construction is complete and the drainage area is stabilized.
- A **compost filter berm or blanket** involves applying compost to a construction site usually with a blower truck. A compost berm is a long mound of compost that acts like a fence to reduce the speed of water flowing on a slope, thereby reducing the speed of soil particles. A compost blanket is applied evenly on a slope to prevent soil from rolling and gaining

momentum. These methods are both all natural, amend native soil to assist in revegetation, and do not need to be removed after construction.

- **Temporary seeding** provides erosion control on areas in between construction operations. Grasses that are quick growing are seeded and usually mulched to provide prompt, temporary soil stabilization. It effectively minimizes the area of a construction-site prone to erosion and should be used everywhere the sequence of construction operations allows vegetation to be established.
- A **silt fence** is a sediment trapping practice utilizing a **geotextile** fence, topography and vegetation to cause sediment deposition. A silt fence follows the contour of the land, reducing the ability of runoff to transport sediment by ponding and dissipating small rills of concentrated flow into uniform sheet flow. The bottom of the fence is trenched into the ground to a depth of 4-8 inches. If muddy sediment deposits reach half the height of the fence, they should be cleaned out. Silt fencing must be removed after construction.

Permanent construction site erosion control is the second approach. The most obvious permanent approach is to leave as much of the original vegetation as possible on the construction site. Also **phasing** the clearing process by only clearing sections of the site at a time is very effective. When construction is complete on a site, **permanent seeding** should be used to permanently stabilize soil, prevent sediment pollution, reduce runoff by promoting infiltration, and provide storm water benefits offered by dense vegetation. Permanent seeding involves seedbed preparation, seeding, and the establishment of perennial vegetation.

Planning and Zoning

Another area of NPS pollution prevention is planning and zoning. New urbanization projects, such as housing developments or shopping malls, should include storage ponds built in a corner as part of the landscaping or behind the main construction. Water that runs off parking lots and paved areas can be stored in retention ponds. These ponds will capture and hold the first half-inch of precipitation reducing the amount of water that streams need to carry after a rain and preventing excessive sedimentation and stream bank erosion.

Engineers in low-impact developments are trying to make the water flow in urban areas behave like the water flow in natural areas. To do this, they have come up with practices that help improve the interception and infiltration of water. For example, a **bioretention filter** consists of a grass buffer strip, a sand bed, a ponding area, an organic layer or mulch layer, topsoil and plants such as leafy shrubs. These filters look like beds of shrubbery and can be placed as islands on parking lots. Woody and leafy plants and soils remove pollutants from storm water runoff. Runoff from large paved surfaces such as parking lots passes first over or through a sand bed, which slows the speed of the flowing water. It also distributes the water evenly along the length of the ponding area. The ponding area is made of soil, but it slopes into the center. Water gradually infiltrates the bioretention area, slowly percolates to a drainage pipe, evaporates or is taken up by plants.

Natural drainage courses can be maintained by using grass-lined channels as much as possible instead of concrete canals, pipes and gutters. Replacing impervious surfaces like sidewalks and driveways with permeable areas allows more water to infiltrate into the ground. Adding vegetation decreases the impact of falling rain on the soil. Swales are low-lying grassy areas in the landscape where water can collect and soak into the ground. They can be used in built-up areas.

For all drainage courses or streams, the vegetation along the banks, or the riparian corridor, should be preserved. The roots serve to hold the stream bank intact and filter

contaminants that might otherwise flow directly into the stream channel. A tree canopy also provides shade for the stream, thereby preventing excessive algae growth. Algae thrive in areas that receive high amounts of sunlight and its decomposition reduces oxygen in the stream system that was once available to aquatic life.

In order to control and prevent nonpoint source pollution, we must be careful how we use the land. Certain kinds of land can be used for certain purposes, but are not suitable for other purposes. For example, landfills should not be built on sandy soil or next to bodies of water; development and agriculture on steep slopes should be minimized and good cropland and wildlife habitat should not be developed. Making wise land use decisions can reduce nonpoint source pollution.

Pesticide Alternatives

There are also natural ways to deal with another NPS pollutant: pesticide. Some aquatic plants and animals can detoxify pesticides. Aquatic microorganisms and bacteria are probably the most important in this regard. Pesticides are broken down into their basic elements and these harmless substances are then available for circulation in the ecosystem. These organisms may be tools we use to help detoxify the environment in the future. Similarly, farmers can limit the damage of pesticides, herbicides and fungicides. By doing some research into the soil makeup, the climate conditions and the pest history of their farms, farmers can choose the most effective and most environmentally friendly methods to control pests. Many farmers use a method of pest control called **integrated pest management** (IPM). IPM uses a combination of pest resistant crops, pesticides and natural predators, such as ladybugs and prying mantises, to reduce the use of pesticides. In addition, certain chemicals work well with certain crops. Matching **pesticides**, **herbicides** and **fungicides** to all of these specific elements of agriculture means that farmers will lower the amount of the chemicals they use. And, of course, less use results in less contamination of water sources and a monetary savings for the farmer.

Laws, Laws and More Laws

Another solution to NPS pollution lies in lawmaking. Several laws have been passed that attempt to protect waterways from nonpoint source pollution. The Federal Water Pollution Control Act (Clean Water Act), passed in 1972 with major amendments in 1977, 1981 and 1987, provides the basis for water quality standards today. The Clean Water Act was originally created in response to public demands that the government do something to clean up and protect the nation's waterways. To address nonpoint sources of pollution, the United States Environmental Protection Agency (USEPA) initiated the National Pollution Discharge Elimination System (NPDES) Phase I and Phase II storm water programs (for more information see the beginning of the curriculum). In 1994, approximately 63 percent of the nation’s surveyed waters fully supported their water quality designated uses. This number has steadily increased over the years due to the efforts of state and federal regulators, local governments, industries, citizens and environmental organizations.

Activities in Section Six		
Activity	**Grade Level**	**Description**
The Little Gold Fish	K-2	Act out a water pollution play about the importance of community involvement
Is Our Water Clean?	K-2, 3-5	Recognize the difference between clean and polluted water and the difficulty in cleaning polluted water
Planning For The Future	K-2, 3-5	Create a land use plan for the future focusing on nonpoint source pollution
Getting to the Root of the Matter	K-2, 3-5	Examine roots and consider their importance in preventing erosion
Going Undercover to Stop Erosion	3-5	Explain the importance of maintaining an organic cover over soil
A Pollution Prevention Message	3-5, 6-8, 9-12	Develop a storm water education plan and educate the community about storm water
Creative Erosion Control	6-8, 9-12	Learn solutions to construction site and stream bank erosion
Uncle Sam Says "Keep It Clean!"	6-8, 9-12	Explore the Clean Water Act through vocabulary, reading articles and a writing assignment
Best Management Practices and Pollution Prevention	6-8, 9-12	Go on a field trip to learn some of the best management practices surrounding storm water

THE LITTLE GOLD FISH

Grade Level
K-2
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Fine Arts, Social Studies
Time
1-2 hours
Materials
- Paper and markers for props
- Costumes

Setting
Classroom
Terms
Conserve, Litter, Pollution, Recycle, Water pollution
Reference
Adapted from the Water Sourcebook Series, K-2, United States Environmental Protection Agency

Summary

Students act out a play about water pollution and learn some things they can do to help keep waterways clean.

Objective

Students will:

1. Act out a play about water pollution.
2. Make props and costumes in small groups.
3. Create and act out their own version of a play incorporating their solution to the problem of pollution.
4. Give an oral or written definition of water pollution.

Procedure

Advance Preparation

Prepare a space to perform the play. Select small groups to perform the play together. Read the play.

Warm Up

Read the story, The Little Gold Fish, adapted from the classic children's story, "The Little Red Hen," and discuss the lesson to be learned by the animals and what lesson we can learn from the story. If your students are not familiar with the story, "The Little Red Hen," read it first. Then, discuss how the two stories are alike and different. Guide the discussion to help the students understand the story and relate it to their own lives. Call attention to the events in the story, how lazy friends might act, how the little gold fish might feel doing all the tasks by herself with her children, and how the friends might feel when they are left out in the end. Pose questions about the different actions, having children exaggerate body parts to show the action.

Talk about how litter might affect beavers, snakes, fish and other wildlife. Ask students if it easier to clean up a messy room by themselves or with the help of the whole class? Emphasis the importance of cooperation.

Activity

1. Narrate the story as a small group of children act it out using student-made props and costumes (guiding the activity as the children dictate the action).
2. Divide students into small groups for the different characters in the story. If there are extra children, have them make up characters or roles. The groups will make up their own version of the play along with their own costumes and props. And of course, what the children invent is always right. After the students have had sufficient time to invent their play, have them act it out for the other groups. Compare the different ways the groups performed the play.
3. Students may want to polish their plays to perform later for parents or the school. This may be over a couple of days. Emphasize to the students how these plays deliver a message about water pollution.

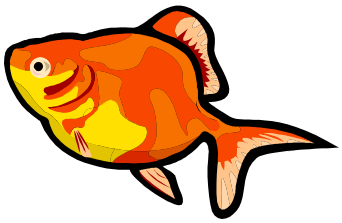
Follow Up

Have the students make up a different version of the play with all the characters helping the little gold fish to clean up the pond, recycle the trash, write the rules and make the posters and bumper stickers. Ask the students to decide how the play might end if everyone cooperated.

Make bumper stickers with a "keep our waterways clean" type message.

Extension

Organize a litter clean up on school grounds. Have students think of ways they could gain the cooperation of other classrooms to help.



The Little Gold Fish

By Donna Morgan

Adapted from the classic children's story, "The Little Red Hen"

Once there were four friends - a beaver, a snake, a duck and a little gold fish. The little gold fish had three baby fish. One day the little gold fish and her three baby fish were swimming in a shallow pond, and she found some aluminum cans, foam cups and plastic soda pop rings. She went to her three friends and asked, "Who will help me pick up the trash to make our pond beautiful?"

"Not I," groaned the beaver.
"Not I," hissed the snake.
"Not I," quacked the duck.

"Then my children and I will pick up the trash from the bottom of the pond," said the little gold fish. And they did.

Then the little gold fish asked her three friends, "Who will help me recycle all this trash to conserve our beautiful pond?"

"Not I," groaned the beaver.
"Not I," hissed the snake.
"Not I," quacked the duck.

"Then my children and I will recycle the trash," said the little gold fish. And they did.

By and by the little gold fish asked her three friends, "Who will help me write rules about littering in our pond and help to stop the pollution?"

"Not I," groaned the beaver.
"Not I," hissed the snake"
"Not I," quacked the duck.

"Then my children and I will write the rules about littering our pond," said the little gold fish. And they did.

Next the little gold fish asked her friends, "Who will help me make posters and bumper stickers to let the people know about pollution in our pond?"

"Not I," groaned the beaver.
"Not I," hissed the snake.
"Not I," quacked the duck.

"Then my children and I will make posters and bumper stickers to let the people know not to pollute our pond," said the little gold fish. And they did.
Then the little gold fish called to her friends, "Who will swim and play in the beautiful pond?"

"I will," groaned the beaver.
"I will," hissed the snake.
"I will," quacked the duck.

"Oh, no," said the little gold fish. "My children and I will swim in the pond by ourselves." And they did.

IS OUR WATER CLEAN?

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Physical Science
Time
45 minutes
Materials
- 2 glass jars
- Wire strainer
- Tap water
- Coffee filter
- Polluted water
- *The Magic School Bus at the Waterworks* by Joanna Cole (ISBN: 0590403605)
- Funnel

Setting
Classroom
Terms
Water pollution
Reference
Adapted from Teaching Environmental Science Lesson Plans, Texas Commission of Environmental Quality and Sue Weiss, Pflugerville

Summary

To help students recognize the difference between clean and dirty water and gain an understanding about the water we use.

Objective

Students will:
1. Identify qualities of clean water
2. Develop an awareness of people in the community who keep our water clean.
3. Identify water as a non-renewable resource.

Procedure

Advance Preparation

Obtain a jar of obviously dirty water. This can be retrieved from a nearby pond or prepared by adding dirt, crushed leaves, etc. to tap water.

Warm Up

Review the water cycle. See picture in "Resources" section. Show the students a jar filled with tap water and a jar filled with dirty water. Ask students to compare the two jars of water. How are they similar and how are they different? You might want to use a magnifying glass to look carefully at the two jars. Take suggestions as to how we could make the dirty water cleaner.

Activity

1. Introduce the various straining devices one at a time. For example, what would happen if we poured the water through the funnel? What could we take out of the water? Pour the dirty water through the funnel and observe.
2. Make a chart of results. Continue to progress using the strainer and the coffee filter.
3. Fill in the chart. Allow students to conclude that the coffee filter will be the best tool to clean the water.
4. Explain that they are cleaning things that you see from the water. Just because water looks clean does not mean that it is. You have to also clean it of things you cannot see. Pollutants that people put into the water can be very difficult to remove. Explain to students

that it would be easier to not pollute in the first place than try to remove pollution from the water.

5. Introduce *The Magic School Bus at the Waterworks* by Joanna Cole. Explain that the Waterworks is a place where people are trained to clean the water for us. Read the book to the class. (In order to simplify, leave out the water facts on the edges of the pages.) Return to pages 20 through 29 to explain the process more clearly with the use of the pictures. Talk about the workers that do different jobs at the Waterworks.

Extension

Use the steps of water treatment to write a sequence story. The teacher provides the words and the students draw a picture. Develop an opposite concept of clean and dirty. Make a list of other things that can be clean or dirty (e.g., clothes, face, room, dishes).

Go on an outdoor scavenger hunt to collect objects that might make our water dirty. Caution students to only pick up items that are on the list. Assign quantities for items to find using numbers. For example: five broken leaves or three tiny rocks.

Invite a speaker from the local water utility company to speak and answer questions about our water.

PLANNING FOR THE FUTURE

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Fine Arts, Social Studies
Time
2-3 class periods
Materials
(For each student)
- Community Landmarks handout
- Scissors
- Construction paper
- Glue
- Soil survey of the County, available from the Hamilton County Soil and Water Conservation District (optional)
- Pictures of a community (optional)

Setting
Classroom
Terms
Community, Conservation, Landmarks, Land use plan
Reference
Adapted from On the Trail of Nonpoint Source Pollution, Hamilton County Soil and Water Conservation District

Summary

Through creating a land use plan, students consider all of the economic and environmental needs of a community.

Objective

Students will:
1. Learn to balance a variety of economic needs with environmental concerns.
2. Create a land use plan for a model community.

Procedure

Warm Up

Explain to the students that they are going to have a chance to plan their own community. Show pictures of a community or describe the different parts of a community to the students. List on the board the different needs of people. (For example, we need a place to get water, to take our trash, to live, to go to school, etc.)

Discuss the necessity of balancing different needs when deciding what to include in their plans. Introduce the terms "conservation," or to save, and "use" and explain the importance of each. Ask students how nature benefits them and why it is important to conserve natural areas.

Activity

1. Pass out materials to each student, including the "Community Landmarks" handout and, if appropriate, a soil survey of your area.
2. Have the students begin by designing a base map, including such features as a lake, a river, a marsh, wildlife habitat, slopes, prime agricultural land, and forest. They can draw these areas on a large piece of construction paper or they can cut out the different features and glue them onto a large piece of paper. This is the land on which they will develop their community. Have students consider which resources are renewable and which resources are nonrenewable when planning their community.
3. Have students cut out the landmarks on the handout. Define any of the landmarks with which the students are unfamiliar.
4. Tell students to decide which landmarks to include in their

community. Before gluing them onto the base map have students complete a rough draft on a scrap piece of paper.

5. Students should glue the landmarks down on the base map where they belong. (For example, if students choose to use the public marina, it should be glued next to the river.) Tell students to consider how closely they place certain items together. (For example, the landfill should not be placed too closely to homes.) Explain to students that they do not need to use all of the landmarks and they can create new ones.
6. Remind students of the plants and animals that live in the habitats they are building on. Encourage them to consider what areas to set aside for conservation and how much space those plants and animals need.

Teaching note: An alternative to Step 4 is to list all of the possible landmarks on the board. Allow students to design their own out of construction paper, label them, and attach them to their maps.

Follow Up

When students have completed their community plans, discuss why they made the decisions they did. This can be done in individual conversations with the students or in small groups. Older children may wish to present their land use plans to the whole class. In your discussions, ask such questions as:

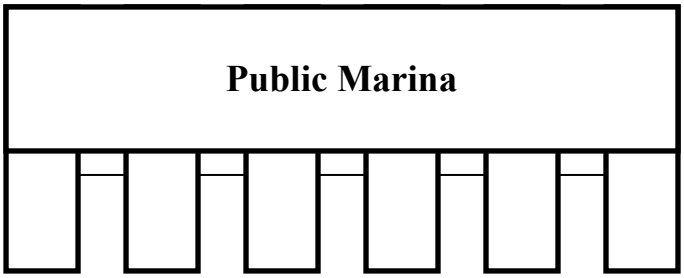
- What are some of the most important features of your community?
- What will happen to wetlands or other natural areas under your plan?
- Have you included any conservation in your plan? Why or why not?
- Where will the people live?
- Where will they work?
- Where will they play?
- What will happen if more people move to your community?

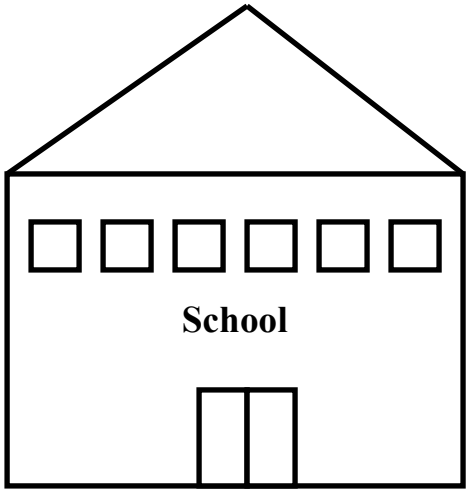
In a concluding discussion, help the class understand that planning a community requires taking into account the present and future needs of many different people as well as of the environment. For younger students explain that by sharing the land with all of the plants and animals we can all have a place to live.

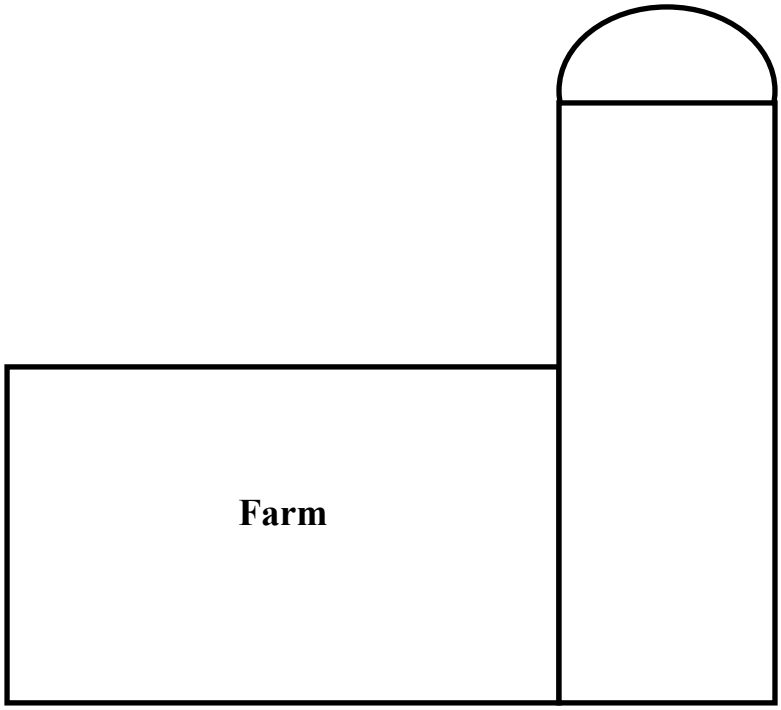
Extension

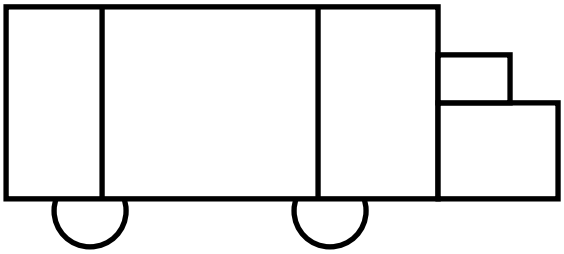
Have the students examine the community in which they live. If they were community planners, what types of things would they change in their community? What would they add and what would they remove? Encourage students to use their imaginations and to consider the needs of people other than themselves. Possible changes could include more natural spaces, a recycling center or a new housing development. Students might also suggest tearing down dilapidated buildings or making parkland out of empty lots.

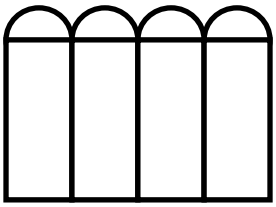
Community Landmarks



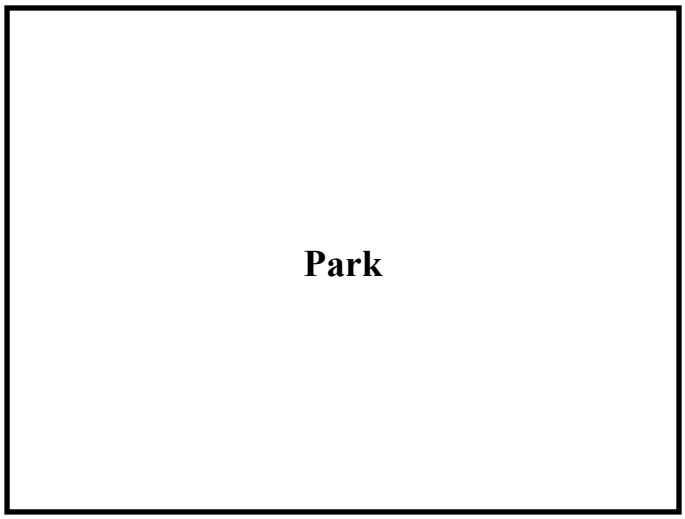


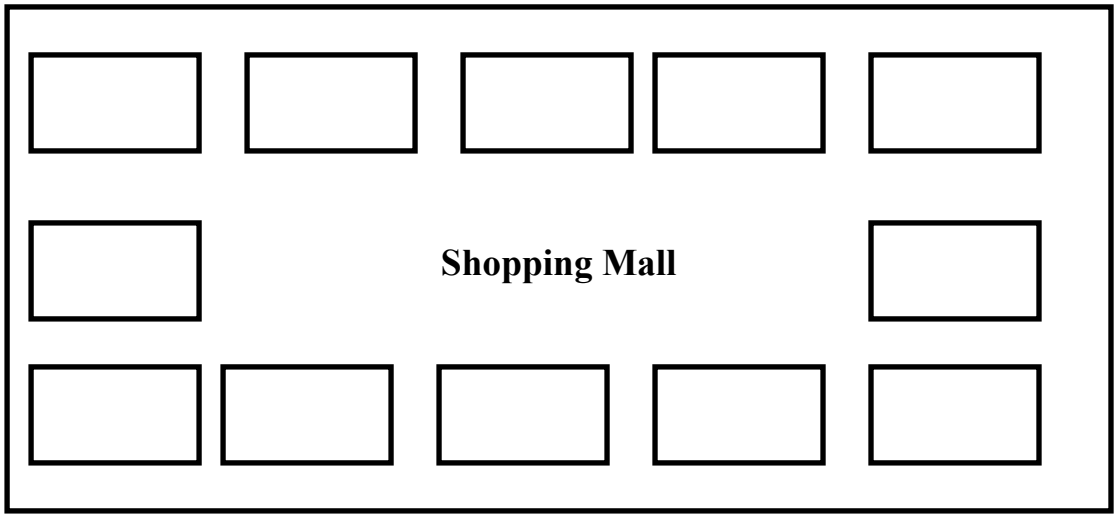


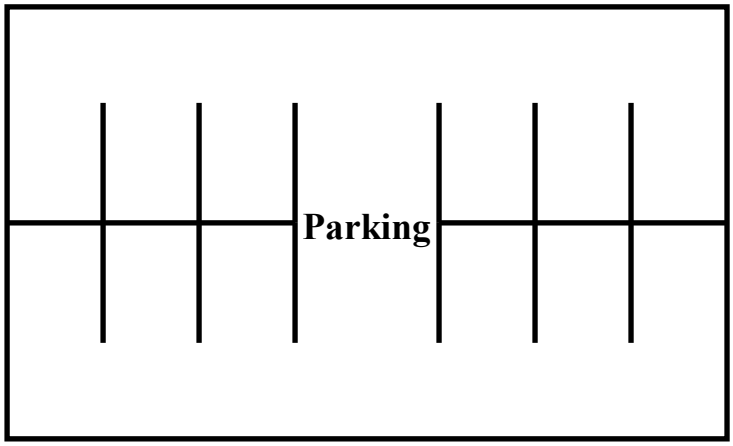


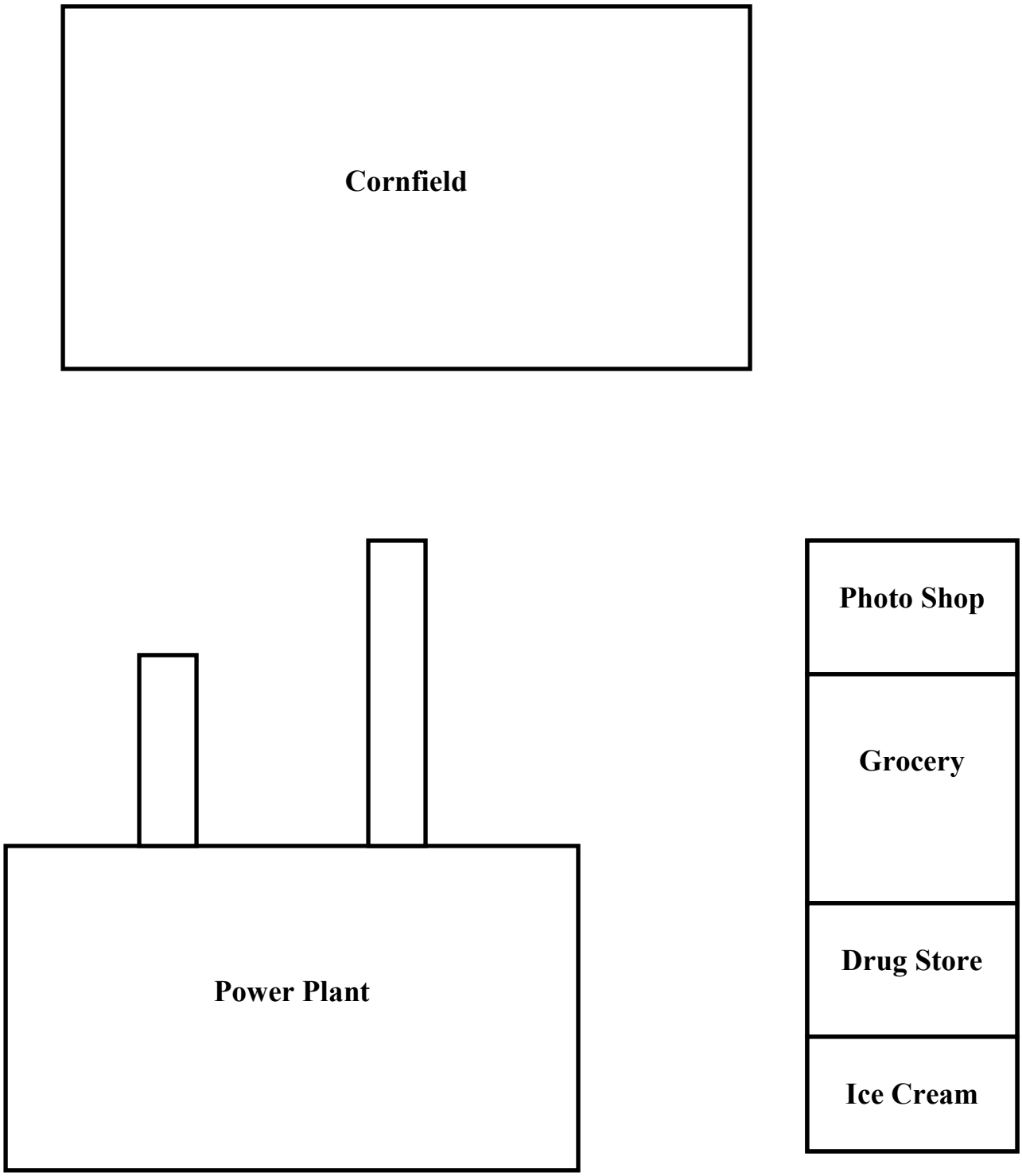


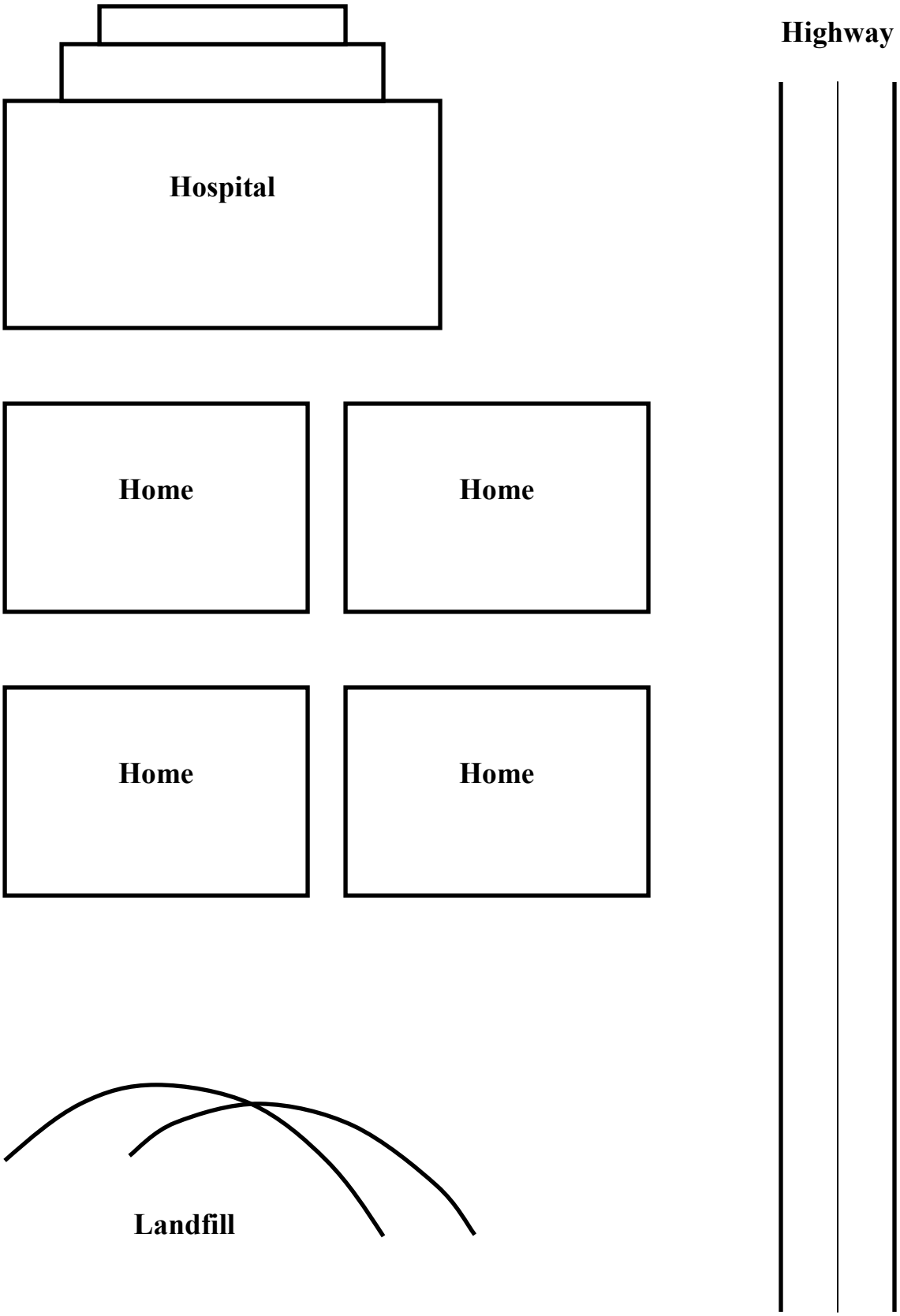
Recycling Center








Cornfield
Power Plant
Photo Shop
Grocery
Drug Store
Ice Cream



GETTING TO THE ROOT OF THE MATTER

Grade Level
K-2, 3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Life Science, Environmental Science
Time
30 minutes
Materials
- Spade
- Several plastic bags
- Root-filled soil

Setting
Classroom or Schoolyard
Terms
Erosion, Organic Matter, Soil
Reference
Adapted from On the Trail of Nonpoint Source Pollution, Hamilton County Soil and Water Conservation District and Minnesota's Ag-Stravaganza, Minnesota Association of Soil and Water Conservation Districts

Summary

Students examine roots and consider their importance in preventing erosion.

Objective

Students will identify how roots can help prevent erosion.

Procedure

Advanced Preparation

Locate an area easily accessible to the school that has root-filled soil. This could be any area where plants are growing, such as a grassy lawn. If you do not wish to bring the students outside you could bring a clump of root-filled soil into the classroom.

Warm Up

Ask students how the soil helps plants. Do most plants need the soil to survive? Then ask the students if the soil receives anything in return from the plants. Do the plants give anything to the soil? What would happen to the soil if the plants were not present? Discuss the concept of erosion with the students and how roots help to prevent erosion. The Run-Off Race is a good accompaniment to this activity.

Activity

1. Either take the students outside to turn over a spade full of root-filled soil or bring some root-filled soil into the classroom
2. Using a plastic bag to catch the soil, examine the root structures to see how they hold the soil. Shake the clump. Does the soil shake easily from the roots? (This will vary with the kind of soil). Students will discover that the black soil filled with organic matter clings to the roots. Explain to students that roots hold soil in place so it is more difficult for wind and water to erode it away.
3. If possible, examine legume roots like alfalfa, clover, soybeans, beans, or peas. (You may want to grow some of these in your classroom). Note the nodules on the roots. These roots contain bacteria that take nitrogen from the air and convert it to fertilizer for the plant.

Follow Up

Have the students write a poem or short story from the point of

view of a root. “I am a root of _____.” Include at least three things you do as a root. (Example: I like to hide in the soil. I grow in all directions. I like water. I like to wrap myself around the soil.)

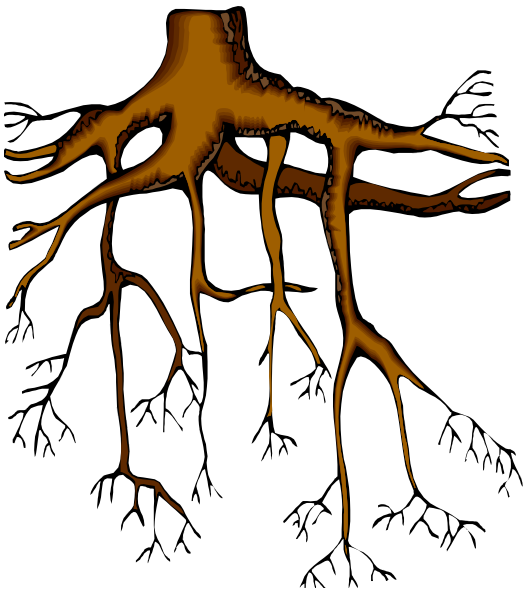
Have students contemplate how the removal of trees and vegetation for development affects soil and water quality.

Extension

Grow plants with fibrous roots, such as grass, in the same soil as a plant with taproots (roots that have main and secondary branching). Once roots take hold compare which roots hold more soil. The plants could also be grown in different types of soil, for example, clay, sand or humus, to compare how well the roots can hold the different types of soil.

Place lima beans in a plastic baggie with a wet napkin. Students can journal the progress of the roots as they grow.

Integrate lesson into a social studies unit about the Great Plains and the Central Plains. Talk about how the plains differ. Explain to the students that the plains regions were often passed over during the expansion until the steel plow was invented to cut through the tough mat of roots.



GOING UNDERCOVER TO STOP EROSION

Grade Level
3-5
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Environmental Science, Life Science
Time
30 minutes
Grow grass 2-3 weeks before activity
Materials
- 3 shoeboxes
- Enough plastic, tin, or tarpaper to line each box
- 3 pieces of thin tin or aluminum
- 3 wide-mouth containers
- 3 flower sprinklers
- 3 sticks of wood (measuring about 1 inch thick)
- Soil
- Grass seed
- Mulch

Setting
Classroom
Terms
Erosion, Ground cover, Organic cover, Soil, Water pollution
Reference
Adapted from On the Trail of Nonpoint Source Pollution, Hamilton County Soil and Water Conservation District and Teaching Soil and Water Conservation: A Classroom and Field Guide. U.S.D.A., Soil Conservation Service

Summary

Students compare the runoff of protected and unprotected soils.

Objective

Students will explain the importance of maintaining an organic cover over soil.

Procedure

Advanced Preparation

Begin preparation two to three weeks before conducting activity. Cut a wide V-shaped notch 1 to 1.5 inches deep in one end of each box. Fit a piece of tin or aluminum in each notch to act as a spout to direct water out of the box in a narrow stream. Line each of the boxes with plastic, tin or tarpaper to make it watertight.

Two to three weeks before conducting this activity fill one of the boxes with soil and plant grass seed.

Warm Up

Ask students to list all of the plants that grow in soil. Are there any activities that people do that would cause the plants to be removed? What would happen to the soil during a rainstorm without those plants?

Activity

1. Fill one of the empty boxes with just soil.
2. Fill the other empty box with soil and cover the soil with mulch. The third box should now be covered with grass grown on the same kind of soil.
3. Set the boxes on a table so that the spouts extend over the edge.
4. Place the sticks under the back ends of the boxes to make them slope down toward the spouts.
5. Put the empty containers just beneath the spouts.
6. Ask for three volunteers. Tell your students that the volunteers are going to pour water on the boxes. Have students predict what will happen.
7. Fill the sprinklers with water.
8. Have the volunteers hold the sprinklers the same height (about one

foot) from the boxes and pour the water on the boxes at the same time. Have them pour steadily and at the same rate for all of the boxes. The water will rush off the bare soil into the jar, taking soil with it. The flow will stop soon, but the jar will contain muddy water. The water that flows from the mulched soil and the sod will be reasonably clear. It will take longer for the flow to stop and it will continue longer. Also, not as much water will reach the jar. The amount of water already present in the soil samples will affect the results somewhat. If the soils are waterlogged the activity will not be successful. The samples do not need to be completely dry.

Note: You can get different results by pouring from different heights.

Follow Up

Have your students record the results on a piece of paper with "detective's log" written on the top.

Extension

Repeat the demonstration several times, changing the slopes of the boxes each time. Have the students predict what will happen, as well as, graph and record the results.

Grow different plants in the boxes in addition to grass. Note which plants best prevent erosion.

Cover all three boxes with different amounts of mulch. Note which amount prevents erosion best.

A POLLUTION PREVENTION MESSAGE

Grade Level
3-5, 6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Language Arts, Environmental Science, Social Studies
Time
Variable for each student
2-3 class periods
Materials
Variable for each student
Setting
Classroom and in community
Terms
Storm water
Reference
Adapted from the Salt Lake County Storm Water Quality Education Lesson and Activity Plans Salt Lake County, Utah, Public Works Department Engineering Division

Summary

After studying storm water pollution, students can educate their community about storm water issues by developing a storm water education plan. This is an excellent culminating activity for the end of a pollution unit.

Objective

Students will:

1. Develop a community storm water education plan.
2. Implement the plan to encourage others to be more aware of storm water pollution and its prevention.

Procedure

Warm Up

Review the sources of storm water pollution with students. Specifically, ask students to list ways in which individuals contribute to the pollution of runoff at their homes, schools, and businesses. The list might include littering, improperly dumping automotive fluids and other hazardous wastes, not picking up pet waste, allowing cars to leak fluids, over-fertilizing lawns, over use of insecticide and failing to remove leaves and grass clippings from sidewalks and gutters.

Discuss how technology and progress aggravate or improve storm water quality i.e. impervious surface, recycling and better product development.

Activity

1. Divide students into groups of 4 to 6.
2. Ask students to brainstorm ways of educating others about storm water pollution. Challenge them to develop a community education plan to inform the local community about storm water issues and pollution prevention. Methods might include: posters, flyers, door hangers, web pages, plays, songs, public service announcements on TV or radio, storm drain labeling, newsletters or community presentations.
3. Discuss and identify the following elements with the students, either as a whole class or in groups:
    - Target audience/area - who are they trying to inform? For

younger students use the school as the community. Older students can focus on the immediate neighborhood then the community.

- Methods - what method(s) will the group use to reach the target audience (e.g. flyers, web page)?
- Materials (and budget, if appropriate) - what is needed to carry out the project? From where will the materials be obtained? Often times a local business, organization or government agency will provide some of the materials needed for student projects.
- Message - what is the main message being conveyed?
- Timeline - establish deadlines and a timeline for the projects.
- Evaluation - how will the success of the project be measured? How will they know if their audience received the message?

4. Before presenting their projects, students should have the teacher, other students or a local water quality specialist check the factual accuracy of their materials. If students will be working off school grounds, they should obtain permission to do so from parents and the school administration.

Follow Up

When students have completed their projects, discuss them as a class. Have students share their plans with the class. What went well? What could be improved? What might they do differently? Did anything unexpected happen? If they were to give advice to someone planning a storm water education project, what would it be?

Extension

Have students host a storm water pollution prevention fair. Gather community organizations, agencies and individuals to display information regarding pollution prevention programs, projects and information for the school and local community.

Students can design and conduct a Storm Water Survey for members of the school or the larger community to determine what people know about storm water pollution. Using the data gathered from the survey may help students design their pollution prevention message. Students can do a post project survey to assess impact.

CREATIVE EROSION CONTROL

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources*
Subject
Environmental Science, Social Studies
Time
3 class periods
Materials
- Samples of current erosion control materials – straw bales, silt fence, gravel, and erosion control fabric – can be obtained from a construction site or building supply company.
- Copies of Student Sheets
- Large sheets of paper and pencils for drawing erosion control plans
- Toy cars, trees, houses, etc. for erosion control models (optional)
- Grass seed and other vegetation materials for model (optional)

Setting
Community and classroom
Terms
Erosion
Reference
Adapted from the Salt Lake County Storm Water Quality Education Lesson and Activity Plans Salt Lake County, Utah, Public Works Department Engineering Division

Summary

Students identify erosion issues and learn about solutions to construction site and stream bank erosion by creating their own erosion control designs.

Objective

Students will:
1. Understand why erosion control methods are important.
2. Identify and investigate existing erosion control methods.
3. Create and test an experimental erosion control method.

Procedure

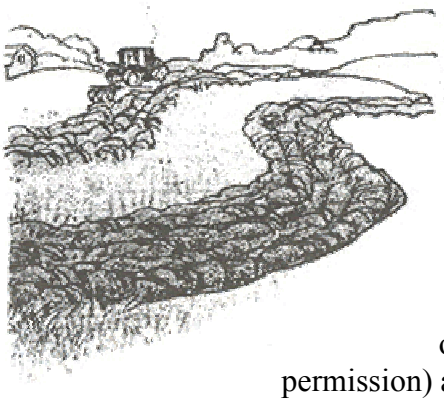
Advance Preparation
Prior to the erosion walk with students, familiarize yourself with sites containing signs of erosion, either on the school grounds or in the neighborhood.

Warm Up
Review with students that in construction many times ground cover has to be removed leaving the soil exposed. Ask students why this could lead to a problem. Review effects of erosion with students.

Activity
1. Begin by taking students on an erosion walk either on the school grounds or in the surrounding areas. Have students try to identify 3-4 examples of erosion and, if possible, locations where erosion control methods are being implemented and erosion control materials are being used. Discuss the following: What are the signs of erosion? Where and why is it important to control and prevent erosion? How might further erosion be prevented or controlled? Are there places where erosion should not or cannot be controlled? If possible, have the students compare and contrast a site where erosion is obvious with one in which it is not. Try to return to the sites when it's raining or right after the rain. What differences and similarities do they notice?
2. Now that students have identified a problem have them research community issues regarding soil erosion, prevention and policies.

Some of the following methods may be helpful in gathering information:

- Contact the Hamilton County Soil and Water Conservation District for information on erosion and sediment control and hillside stability regulations and strategies used in stream bank and other soil stabilization.
- Contact ORSANCO or the County Engineering Division to learn about past and present methods for controlling stream bank erosion along the Ohio River.



- Students can contact a local building inspection or zoning office to ask someone to speak to the group or do a phone interview about control methods and construction ordinances.
- Invite builders (maybe a student's parent or relative) to talk about erosion control from their perspective.
- Tour a construction site. Obtain permission to visit a construction site to see erosion control methods in action. Make an appointment with a builder or contractor for the tour. Compare other construction sites (stay off the property if you do not have permission) and their methods of erosion control. Which ones seem to be working? Which ones do not? Why?
- Contact the county extension office and other water quality specialists (e.g. university professor) to learn more about locally recommended erosion control techniques.

3. Have students make an experimental erosion control plan. Using the information they have gathered, as well as their observations and creativity, have students apply creative ideas for erosion control. The two planning flow charts for soil stabilization and the sample erosion control plan on the following pages will be helpful. When thinking about the plan, consider the following questions:
   - How effective are current methods such as straw bale fences, silt fences or sediment basins?
   - What would be the best way to control erosion during winter or spring melt?
   - What would be the best way to control erosion on very steep slopes?
   - What is the lowest cost erosion control method?
   - Which erosion control method requires the least maintenance?

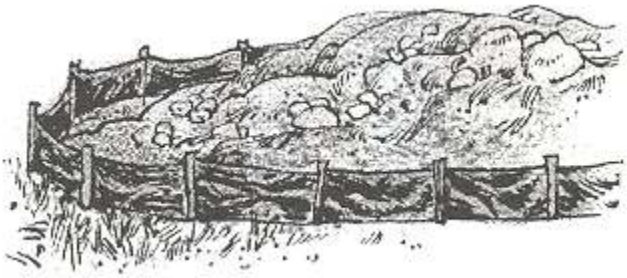
Follow Up

Using a model, an unplanted garden, a site on school property or one where students have obtained permission, students should implement their erosion control plan. Students should record their observations and note any necessary changes in their design.

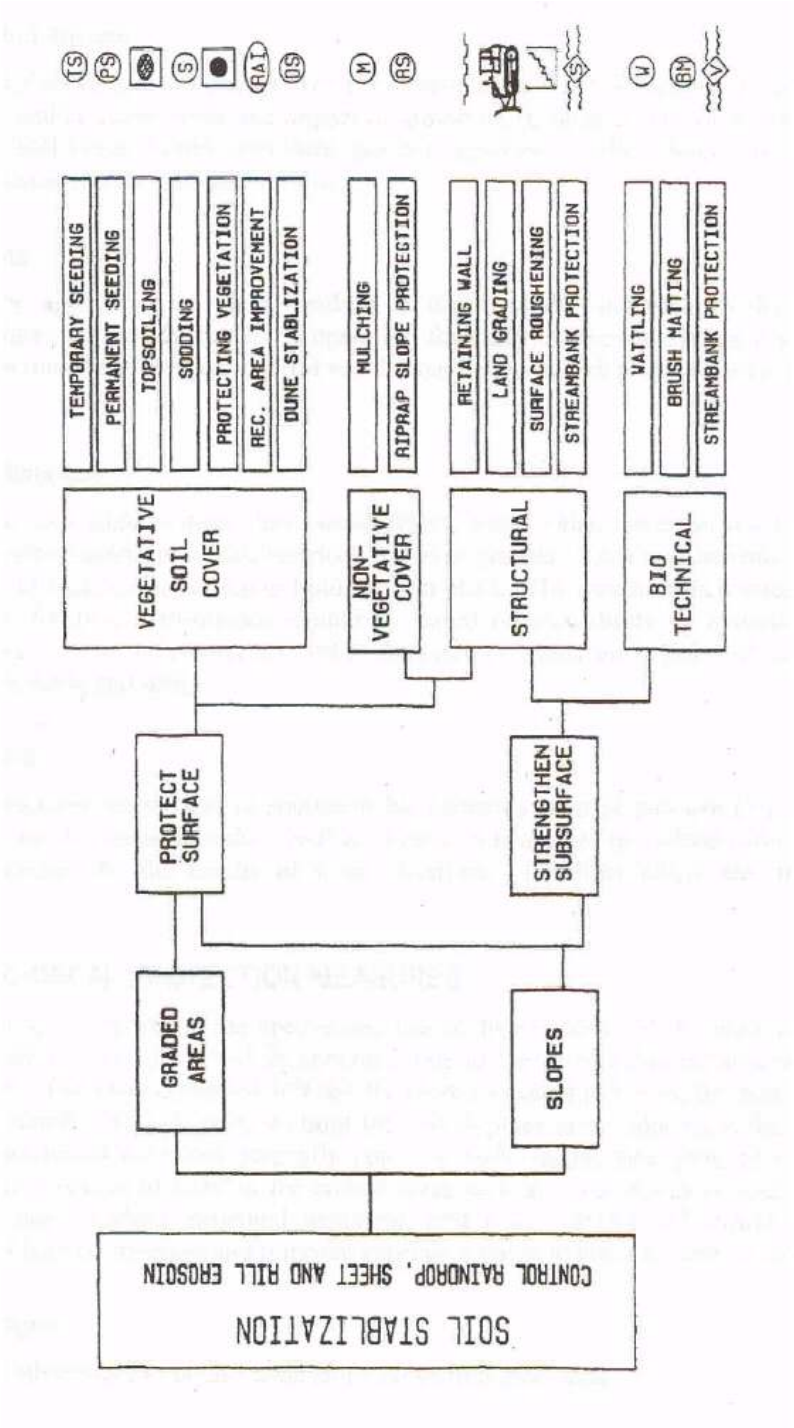
Students can share their findings with the class, comparing methods and the costs and benefits of each method.

Extension

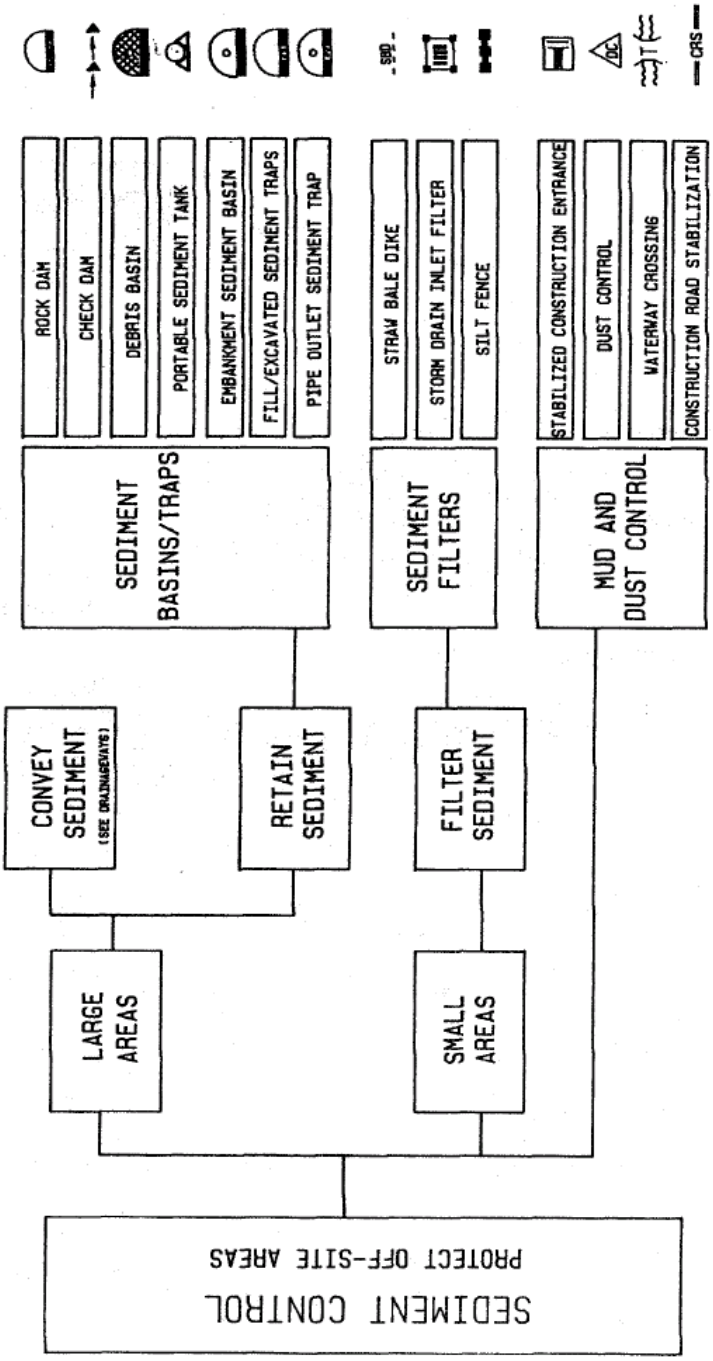
Have students investigate the area around their homes for possible sites of water quality degradation due to erosion. Challenge students to devise an erosion control method and then test the method.

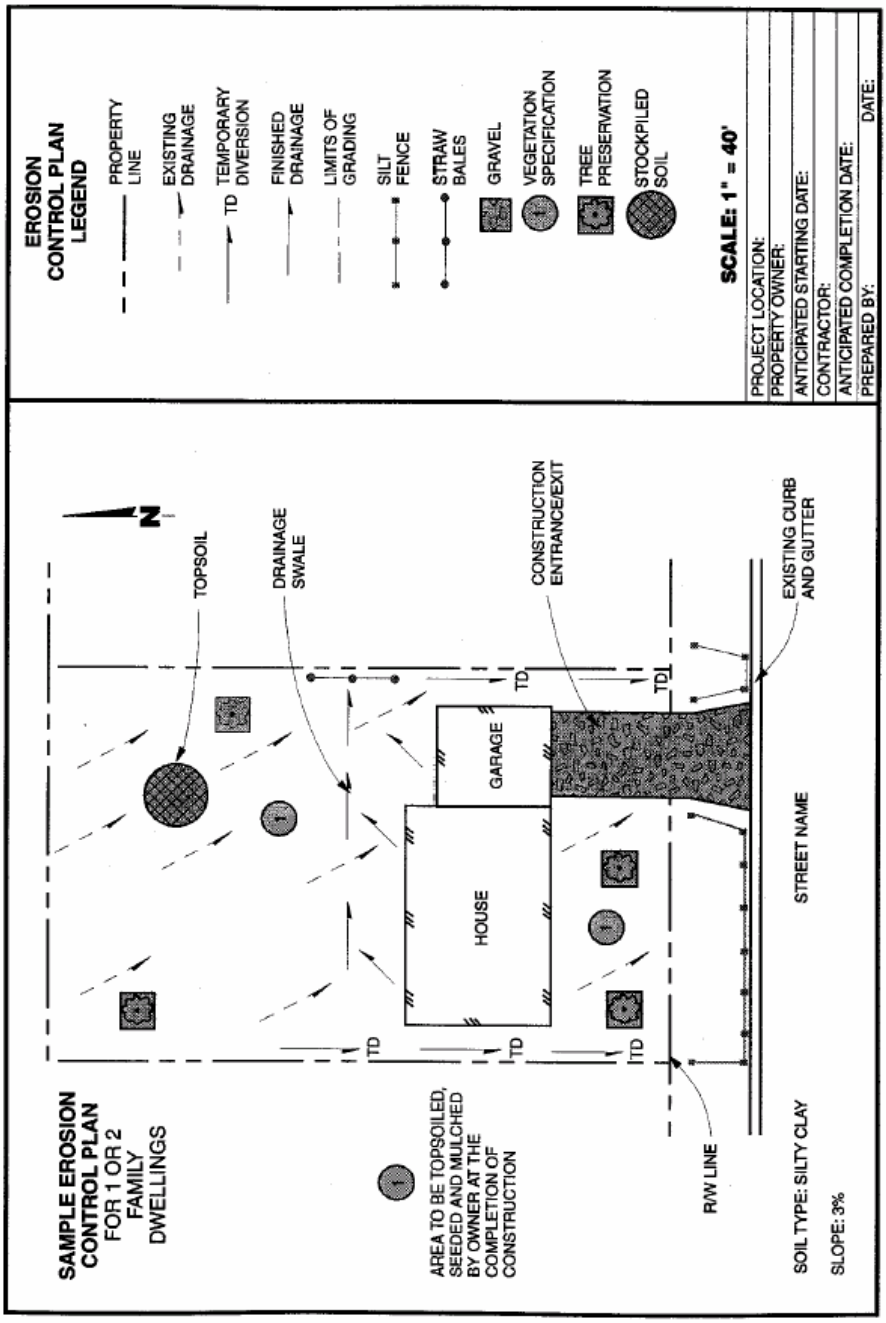


Planning Flow Chart- Soil Stabilization



Planning Flow Chart- Sediment Control




SAMPLE EROSION CONTROL PLAN
FOR 1 OR 2 FAMILY DWELLINGS
AREA TO BE TOPSOILED, SEEDED AND MULCHED BY OWNER AT THE COMPLETION OF CONSTRUCTION
TOPSOIL
DRAINAGE SWALE
TD
HOUSE
GARAGE
CONSTRUCTION ENTRANCE/EXIT
R/W LINE
EXISTING CURB AND GUTTER
STREET NAME
SOIL TYPE: SILTY CLAY
SLOPE: 3%
N
EROSION CONTROL PLAN LEGEND
PROPERTY LINE
EXISTING DRAINAGE
TEMPORARY DIVERSION
FINISHED DRAINAGE
LIMITS OF GRADING
SILT FENCE
STRAW BALES
GRAVEL
VEGETATION SPECIFICATION
TREE PRESERVATION
STOCKPILED SOIL
SCALE: 1" = 40'
PROJECT LOCATION:
PROPERTY OWNER:
ANTICIPATED STARTING DATE:
CONTRACTOR:
ANTICIPATED COMPLETION DATE:
PREPARED BY:
DATE:

UNCLE SAM SAYS, "KEEP IT CLEAN!"

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Social Studies (Economics, Government, Political Science), Language Arts
Time
2 class periods
Materials
- Student Sheets

Setting
Community, classroom and library
Terms
Biodegradable, Inference, Nonpoint source pollution (NPS), Point source pollution, Poison water quality criteria, Toxic chemical, Wastewater treatment plant
Reference
Adapted from the Water Sourcebook Series, United States Environmental Protection Agency

Summary

The Clean Water Act is explored through vocabulary, reading articles, and a writing assignment.

Objective

Students will:
1. Describe the Clean Water Act.
2. Give an overview of the Clean Water Act.
3. Gain exposure of reading legal documents.

Procedure

Advance Preparation

Write the terms on the board before the beginning of class. Have students enter the words and definitions into class journals.

Warm Up

Use the vocabulary words as introduction. Ask students if they know of any law that protects water in the United States. Tell them they will be reading and completing assignments about the Clean Water Act.

Activity

1. Allow time for independent reading of *America's Clean Water Act*.
2. Discuss the article according to the 5 W's of a newspaper article: Who, What, When, Where and Why.
3. Ask for students' opinions about federal laws controlling water pollution.
4. As a homework assignment, ask students to select one of the following activities:
   - Write a letter to the editor of your local newspaper in which you cite an obvious infraction of some requirement of the *Clean Water Act* as you understand the Act.
   - Draw a political cartoon in which you stress one of the principles of the *Clean Water Act*.
   - Write a conversation between two people who have owned lakefront property for several years. In the dialogue, one is concerned about federal regulations of lake water and the

other is supportive of federal regulations.

- Work with one other student to create a skit involving a federal compliance officer and a person who has violated one requirement of the *Clean Water Act*. Have the officer explain the violation; have the other person disagree and then accept responsibility for the violation and agree to "clean up his/her act." As each skit is presented to the class, a copy of the *America's Clean Water Foundation Personal Proclamation* may be presented to students (year may be changed from 1992 to the present).

5. Students can use additional articles to aid in their research and understanding of the Clean Water Act.
6. Have each student write a question concerning the *Clean Water Act*. Compile the best questions into a quiz for students.

Follow Up

Have students write a paper on where the act was applied, why it was applied, and what was the outcome. Students could conduct research on a situation where the Clean Water Act was enforced.

Extension

Have students present activities to entire class on assigned day. Assignments may be further developed according to student interests and response.

Have students solve Cryptoquote and Word Find. (See Student Sheets.)

America's Clean Water Act

In response to citizens' demands that the government do something to clean up and protect our water resources, Congress passed the Federal Water Pollution Control Act amendments of 1972, known as the Clean Water Act. Its message was simple- there shall be no unlawful discharge of pollution to U. S. waters. The goals of the law called for water to be clean enough for swimming, fishing, and other recreational uses.

In the first decade after the Clean Water Act was passed, when the nation's population grew by 11 percent and water use by industry and recreation increased, significant progress was made. It is estimated that:

- 47,000 stream miles improved in quality. That's a distance of about twice around the world.
- 390,000 acres of lakes (an area twice the size of New York City) improved in quality.
- 142 million people received secondary or more advanced levels of sewage treatment - a 67 percent increase.

Congress revised and expanded the Clean Water Act in 1977, 1981 and 1987. Today the Clean Water Act addresses:

- Point-source pollution (direct pollution from pipes or other conveyances)
- Nonpoint-source pollution (diffuse pollution from sources such as urban, rural, and agricultural runoff)
- Marine ecology, including oceans, estuaries, and wetlands
- Toxic pollutant controls
- Groundwater protection.

America's water quality continues to improve. Federal, state and local laws have been strengthened; and public and private institutions have invested many billions of dollars to restore the physical, chemical and biological quality of water.

While advances in technology have helped clean up our waters, societal demands continually increase pollution. To ensure clean water for us and for future generations, we must strengthen our clean water programs and provide the necessary funds to protect our precious water resources.

WATER QUALITY LEGISLATION

Laws involving water quality date back as far as 1914. The first Federal law dealing exclusively with water quality was the Water Pollution Control Act, passed in 1948. Under this law, the states retained primary responsibility for water quality standards and maintenance. The Federal government supplied money primarily for research. There were no water quality standards established and the law provided only weak punishments for offenders. During the 1960's, amendments provided for water quality standards for interstate waterways, Federally approved state standards and increased funding for research. However, as water pollution increased in many areas of the country, public concern resulted in passage of two more very important environmental laws.

The National Environmental Policy Act of 1969 (NEPA) required federal agencies to consider the environmental impacts of their actions. All federal agencies must prepare environmental impact statements to assess the impacts of major federal actions, such as large building or industrial projects. Because of NEPA, federal undertakings have been conducted in a manner to ensure protection of all natural resources, including water.

The Federal Water Pollution Control Act (Clean Water Act), which was passed in 1972 and amended in 1977, 1981, and 1987, provides the basis for water quality standards today. The Clean Water Act allowed the Federal government to assume a lead role in cleaning up the nation's waterways. National goals for pollution elimination were set, and the National Pollutant Discharge Elimination System (NPDES) was established. The NPDES permitting system made pollution discharge without a permit illegal. Generators of pollution to surface waters (sources) must apply for NPDES permits, which are issued by EPA or EPA - approved state agencies. The limits on what the generators may release vary from small amounts (for suspended biodegradable organic material and solids) to none allowed (for some toxics). The stringency of the requirement is greatest for the most dangerous water pollutants. The public is invited to participate in the permit issuance process through public notice of proposed permits and opportunity to comment or request a public hearing.

The Clean Water Act also established four national policies for water quality:

1. Prohibit the discharge of toxic pollutants in toxic amounts
2. Assist publicly owned treatment works with Federal grants and loans
3. Support area-wide waste treatment planning at Federal expense
4. Create a major research and development program for treatment technology.

In 1994, 63 percent of surveyed surface waters met water quality standards. In 1973, only 36 percent of streams were of high enough quality to meet standards. Future amendments to the Clean Water Act are likely to make ecosystem protection as important as providing potable water for human use. Amendments are also likely to establish water quality standards for lakes and to focus more specifically on preventing storm water nonpoint source pollution.

Other federal laws that deal with water quality are the Safe Drinking Water Act and Amendments of 1986 and 1996, the Toxic Substances Control Act of 1976, the Resource Conservation and Recovery Act of 1976, the Surface Mining Control and Reclamation Act of 1977, and the Rivers and Harbors Act of 1899.

Water:

The Source of Life

America's Clean Water Foundation ©1992

President George Bush, the United States Congress and 35 Governors have proclaimed 1992 as the Year of Clean Water and October as Clean Water Month to commemorate the Twentieth Anniversary of the passage of the Clean Water Act.

In 1972 Congress passed the Federal Water Pollution Amendments (Public Law 92-500) (The Clean Water Act). The Clean Water Act was designed to respond to public demands that the government do something to clean up and protect our nation's waterways. The Act stated that there shall be no unlawful discharge of pollution to U.S. waters. The goals called for waters to be "fishable" and swimmable" by 1983 and the elimination of pollution discharges to navigable waters by 1985.

With the passage of time, the public attention to these goals has waned, even though Americans consistently cite clean water as among their highest priorities. In an effort to rekindle support for the mission of the Clean Water Act, America's Clean Water foundation was created to coordinate the Twentieth Anniversary of the Clean Water Act. The goals of this nonprofit foundation are to:

1. Increase public awareness.
2. Educate our nation's youth.
3. Promote personal stewardship.
4. Generate national support for protecting our precious water resources.

To accomplish these goals, the foundation has enlisted the support and involvement of a host of public and political figures, known throughout the world as active supporters of environmental protection. For example, Senator Edmund Muskie, Senator Howard Baker, and Representative William Harsha (the original authors of the Clean Water Act) jointly chair the Foundation's Board of Governors. The Board is comprised of such leaders as President Jimmy Carter, 16 members of Congress, 5 state governors, and a host of prominent environmental leaders. Some 70 national organizations serve on America's Clean Water Foundation Steering Committee and a Celebrity Advisory Council assists the Foundation with public outreach.

For ideas on how you can get involved and help us make a difference, call or write:
America's Clean Water Foundation Roberta Haley Savage, President, 750 First Street NE, Suite 1030, Washington D.C. 20002
202-898-0908 www.acwf.org

This booklet was adapted from the 1992 The Year of Clean Water Calendar. A special thanks to Kathryn Sevebeck, George Wills, and T. W. Johnson of the Virginia Water Research Center, and to Charles Evans of America's Clean Water Foundation for their dedication to citizen awareness of clean water.

Backyard mechanics that change their own oil generate over 324 million gallons of used oil and dispose of more than 90 percent of it improperly.

Nearly 1.3 billion gallons of used oil are produced each year, but recyclers reprocess only about 770 million gallons.

Since 1950 fertilizer use has increased from 20 million tons annually to 50 million tons. Nearly 1.1 billion pounds of pesticides are applied each year in the United States.

The average household generates 20 pounds of hazardous waste each year from household cleaners and chemicals.

An estimated 60 percent of the 23 million septic systems in the United States are not operating properly.

About 10 percent of the 1.4 million underground storage tanks for gasoline and other hazardous substances are leaking.

KEEPING IT CLEAN

President George Bush and the Congress have proclaimed October as Clean Water Month. During the month there will be many opportunities to participate in activities that will broaden your understanding of today's critical water quality issues.

- Organize a stream cleanup program and monitor the stream on a regular basis for evidence of pollution incidents. Report the results to your state water control agency.
- Participate in comprehensive plan development and zoning for your city or county and take a position on how your community can best protest its water.
- Encourage civic associations and other community groups to get involved in programs and efforts to maintain clean water.
- Tell your elected representatives about your concern for the quality of life and the need for protection of our natural environment for drinking water, wildlife habitat, and human activities.
- Become a steward of our natural resources.

America's Clean Water Foundation
Personal Proclamation

WHEREAS: clean water is a natural resource of tremendous value and importance to every American citizen;

WHEREAS: there is resounding public support for protecting and enhancing the quality of this Nation's rivers, lakes, wetlands, coastal waters and groundwater;

WHEREAS: maintaining and improving water quality is essential to protect public health, to protect fisheries and wildlife, and to assure abundant opportunities for public recreation;

WHEREAS: substantial progress has been made to improve water quality since the passage of the Clean Water Act in 1972 due to the concerted efforts by Federal, State and Local governments, the private sector and the American public;

WHEREAS: further development of water pollution control programs, advancement of water pollution control research, technology and education are necessary and desirable;

WHEREAS: 1992 is the 20th anniversary of the enactment into law of the Clean Water Act;

NOW THEREFORE, be it resolved that I, the undersigned, do hereby proclaim, in support of America's Clean Water Foundation to make the calendar year 1992 my personal YEAR OF CLEAN WATER, and be it further resolved that I will do all I can to assure the integrity of our vital water resources for my generation and for the generations to follow.

_____
Signatory of Proclamation

_____
Roberta Haley Savage

ONE HUNDRED FIRST CONGRESS OF THE UNITED STATES OF AMERICA

AT THE SECOND SESSION

Begun and held at the City of Washington on Tuesday, the twenty-third day of January one thousand nine hundred and ninety

JOINT RESOLUTION

To establish calendar year 1992 as the "Year of Clean Water".

Where as, clean water is a natural resource of tremendous value and importance to the Nation;
Where as, thee is resounding public support for protection and enhancing the quality of the Nation' rivers, streams, wetlands, and marine waters;
Where as, maintaining and improving water quality is essential to protect public health, to protect fisheries and wildlife, and to assure abundant opportunities for public recreation;
Where as, it is a national responsibility to provide clean water as a legacy for future generations;
Where as, substantial progress has been made in protecting and enhancing water quality since passage of the
1972 Federal Water Pollution Control Act (Clean Water Act) due to concerted efforts by Federal, State, and local governments, the private sector, and the public;
Where as, serious water pollution problems persist throughout the Nation and significant challenges lie ahead in the effort to protect water resources from point and nonpoint sources of conventional and toxic pollution;
Where as, further development of water pollution control programs and advancement of water pollution control research, technology, and education are necessary and desirable; and
Where as, October of 1992 is the 20th anniversary of the enactment into law of the Clean Water Act:
Now, therefore, be it

Resolved by the Senate and House of Representatives of the United States of America in congress assembled, That, the Congress of the United States hereby designates calendar year 1992 as the "Year of
Clean Water" and the month of October 1992 as "Clean Water Month": in celebration of the Nation's accomplishments under the Clean Water Act, and the firm commitment of the Nation to the goals of that Act.

APPROVED
October 12, 1990

Speaker of the House of Representatives

President of the Senate

Uncle Sam Says, "Keep it Clean!"

Cryptoquote: Here's how it works: One letter stands for another letter. Single letters, punctuation, and the length and formation of the words are all hints. E is the most frequently used letter. Have fun!

M H M L O T V M L M T P Q M L N B P Q V N G R X A

C M P S Q O; E M M J N Q Z Y M P G, J Y M P B M !

O X S L S G Z Y M B P U

WORD FIND

CLEAN WATER
POLLUTION
QUALITY
STANDARD
PRES BUSH
CONGRESS
WATERWAYS
TOXIC
POINT
NONPOINT
POISON
CULVERT
CRITERIA
INTERSTATE
ENVIRONMENT
ILLEGAL
ECOSYSTEM
SEWAGE
RUNOFF

P	S	E	W	A	G	E	H	U	N
E	O	H	U	N	T	S	V	T	R
N	I	L	L	E	G	A	L	N	U
V	N	I	L	Q	L	L	E	I	N
I	T	A	L	U	S	A	C	O	O
R	E	B	A	A	T	M	I	P	F
O	R	A	G	L	A	I	X	N	F
N	S	P	O	I	N	T	O	O	E
M	T	O	O	T	D	R	T	N	G
E	A	I	S	Y	A	E	C	T	P
N	T	S	Y	S	R	H	R	R	R
T	E	O	A	E	D	P	I	E	E
S	H	N	W	E	R	D	T	V	S
S	M	A	R	R	I	A	E	L	B
E	L	Y	E	N	W	E	R	U	U
R	J	A	T	N	E	G	I	C	S
G	N	E	A	S	P	A	A	U	H
N	S	E	W	A	A	W	N	M	A
O	L	R	W	A	T	E	R	G	A
C	M	E	T	S	Y	S	O	C	E

Uncle Sam Says, "Keep it Clean!"

Teacher Sheet

Solution to Cryptoquote: Everywhere water is a thing of beauty; keep it clean, please! - Your Uncle Sam

CLEAN WATER ACT

WORD FIND
CLEAN WATER
POLLUTION
QUALITY
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P	S	E	W	A	G	E	H	U	N
E	O	H	U	N	T	S	V	T	R
N	I	L	L	E	G	A	L	N	U
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R	E	B	A	A	T	M	I	P	F
O	R	A	G	L	A	I	X	N	F
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M	T	O	O	T	D	R	T	N	G
E	A	I	S	Y	A	E	C	T	P
N	T	S	Y	S	R	H	R	R	R
T	E	O	A	E	D	P	I	E	E
S	H	N	W	E	R	D	T	V	S
S	M	A	R	R	I	A	E	L	B
E	L	Y	E	N	W	E	R	U	U
R	J	A	T	N	E	G	I	C	S
G	N	E	A	S	P	A	A	U	H
N	S	E	W	A	A	W	N	M	A
O	L	R	W	A	T	E	R	G	A
C	M	E	T	S	Y	S	O	C	E

BEST MANAGEMENT PRACTICES AND POLLUTION PREVENTION

Grade Level
6-8, 9-12
Ohio Academic Content Standards
See chart in *Resources* section
Subject
Physical Science, Earth Science, Ecology
Time
3-4 class periods
Materials
- Bus to travel to the school bus maintenance shop
- Copies of background information for each student
- Field trip permission slips (if applicable)

Setting
Community, classroom and library
Terms
Best management practices (BMPs), Pollutant (water), Pollution prevention, Runoff, Storm water
Reference
Adapted from the Water Sourcebook Series, K-2, United States Environmental Protection Agency

Summary

Students go on a field trip to explore some of the best management practices related storm water.

Objective

Students will:

1. Define storm water runoff.
2. Identify types of pollutants found in storm water.
3. Investigate how to prevent the pollution of storm water at the school bus maintenance shop.
4. Develop a Best Management Practices (BMP) plan for the maintenance shop.

Procedure

Advance Preparation

Reserve a school bus for the field trip. Contact the school bus maintenance shop to set up a field trip to learn about the BMP plan for the shop. If the shop does not have a plan, secure cooperation for the students to develop a plan.

Copy Background Information and Student Sheets for each student. Go over terms and define.

Warm Up

Hand out Background Information and Student Sheets. Student Sheets show important steps that can be taken in the community (Municipal Program) or by industries (Industrial Program) to prevent storm water pollution. Student Sheets also depict common contributors to storm water pollution.

Discuss best management practices. Lead a discussion on how storm water can increase pollution in water bodies. Review the 5 major phases involved in developing a BMP plan (see first Student Sheet). Ask students why it would be important to name a pollution prevention coordinator or team. (Answers: point of contact in an emergency and clearly defines the BMP plan as a part of the coordinator/team job)

Explain that many sources of pollutants exist at automotive repair facilities. Some examples are these:

- Fuel

- Engine oil and other lubricants
- Antifreeze
- Refrigerants
- Batteries
- Wash water from the washing of the interior and exterior of buses and other equipment.
- Steam cleaning fluid from the cleaning of engines and other equipment

Explain to students that when it rains at the shop and these types of pollutants come into contact with the rainwater, the runoff can become polluted. Ask students about other sources of pollution that might exist at an automobile (bus) repair facility.

Activity

1. Take a field trip to school bus maintenance shop.
2. At the shop, ask the following questions:
    - Is fueling conducted on site? If so, are the fuel tanks above ground or below ground? If they are above ground, do they have secondary containment?
    - Where are used batteries kept?
    - How is used oil managed?
    - Is maintenance conducted on-site?
    - How are used tires managed?
    - If oil, fuel, antifreeze or other fluids are spilled or leaked, how are they cleaned up? (Examples: oil dry, kitty litter, sawdust)
    - What types of activities are occurring on-site that might lead to water discharges not from storm water? (Examples: washing of buses and the steam cleaning of engines)
3. After identifying pollution sources, ask students to describe methods that can be used to prevent the pollution of storm water runoff at the shop.
4. For homework, have students think about BMPs to use in developing a class BMP plan for the shop.
5. On the following day, divide students into work groups to develop a BMP plan for the shop. Have students share their ideas. Combine the work into a class BMP plan.
6. Present the class BMP plan to school bus maintenance shop.

Follow Up

Visit the maintenance shop in a month. Give the shop manager a copy of the BMP plan in advance to evaluate and suggest revisions and/or additional improvements to the BMP plan.

Extension

Develop other BMP plans for your school (chemistry class chemical disposal, erosion control on school grounds or art class paint disposal).

Have a speaker come from the Hamilton County Storm Water District to explain the county's BMP plans for storm water management.

Five major phases involved in developing a BMP plan for storm water runoff

1) **Planning & Organization**
   a) Name a pollution prevention team.
   b) Review other BMP plans and build on other plans available such as a Spill Prevention Control and Countermeasures (SPCC) plan. The SPCC plan is a plan to help keep petroleum-related products from being discharged into the water. You should be able to get a copy of this at the bus maintenance facility.

2) **Assessment**
   a) Develop a site map.
   b) Inventory and describe exposed materials.
   c) List significant spills and leaks.
   d) Test for non-storm water discharges.
   e) Evaluate monitoring data.
   f) Summarize pollutant sources and risks.

3) **BMP Identification Phase**
   a) Baseline BMPs.
      - Good Housekeeping
      - Preventive Maintenance
      - Visual Inspections
      - Spill Prevention and Response
      - Sediment and Erosion Prevention
      - Traditional Storm Water Management Practices (storm water detention ponds, collection of storm water)
      - Other appropriate BMPs
      - Employee Training
   b) Select activity and site-specific BMPs.

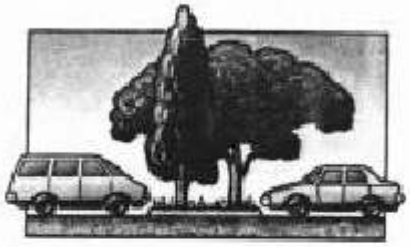
4) **Implementation Phase**
   a) Implement BMPs.
   b) Train employees.

5) **Evaluation Monitoring**
   a) Conduct annual site inspection/BMP evaluation.
   b) Conduct record keeping and reporting.
   c) Review and revise plan.

MUNICIPAL PROGRAM

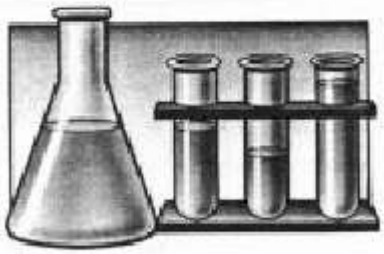
Prevent the release into the storm sewer system of hazardous substances such as used oil or household or yard chemicals.

Make sure new commercial and residential developments include storm water management controls, such as reducing areas of paved surfaces to allow storm water to seep into the ground and planting a 25' buffer of trees and shrubs along stream banks.



Promote practices such as street sweeping, limiting use of road salt, picking up litter and disposing of leaves and yard wastes quickly.

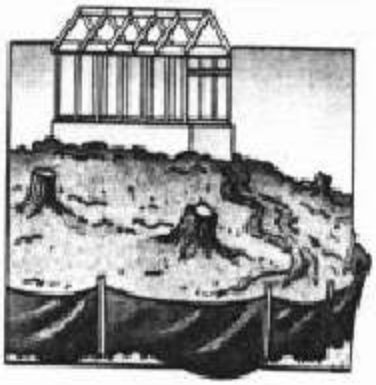
Collect samples of storm water from industrial sites to see whether pollutants are being released. If so, identify the type and quantity of pollutants being released.



Design and institute flood control projects in a way that does not impair water quality.

MUNICIPAL PROGRAM

Test soil fertility so fertilizers can be properly calibrated to meet the plants needs. Prevent runoff of excess pesticides, fertilizers and herbicides by using them properly and efficiently. (Commercial, institutional and residential landscapes can be designed to prevent pollution, conserve water and look beautiful at the same time.)

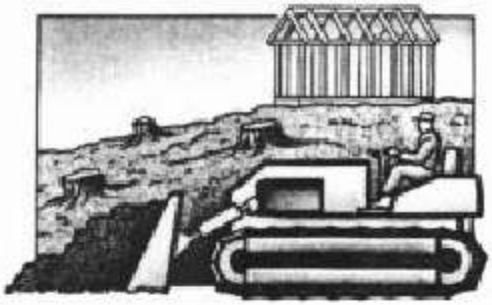


Make sure that construction sites control the amount of soil that is washed off by rain into waterways.

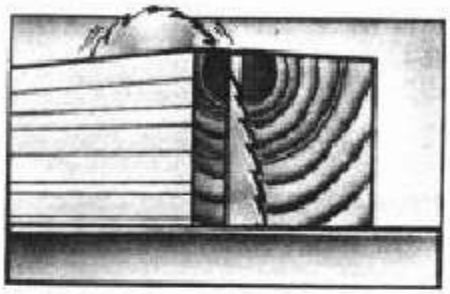
Promote citizen participation and public group activity to increase awareness and education at all levels. Encourage local collection pick-up days and recycling of household hazardous waste materials to prevent their disposal into storm water drains. Call the Hamilton County Environmental Services for collection dates and locations.

INDUSTRIAL PROGRAM

Owners of construction sites that disturb 1 or more acres must develop a plan before beginning construction. The plan must limit that area of disturbed soil and provide controls - like sediment basins and mulch berms - to keep sediment from running off.

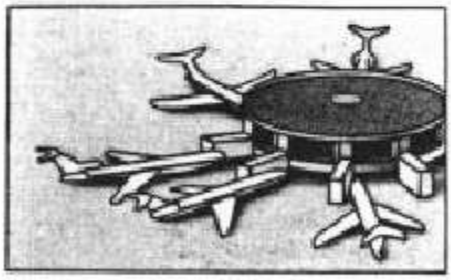


Operators of saw mills can reduce pollution by storing their materials and processing their products indoors; and removing any by-products from outdoor areas before these products come in contact with storm water runoff.

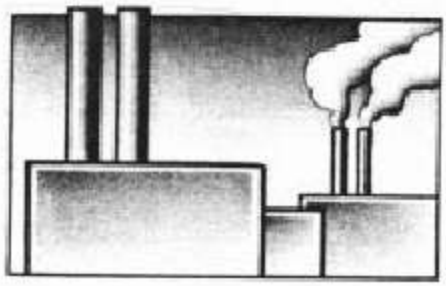


Operators of landfills should keep the storm water runoff from flowing over the pollutants and carrying them off the landfill sites.

Airport employees can reduce storm water runoff pollution by using deicing chemicals only in designated collection areas and by cleaning oil and grease spills from pavement immediately.



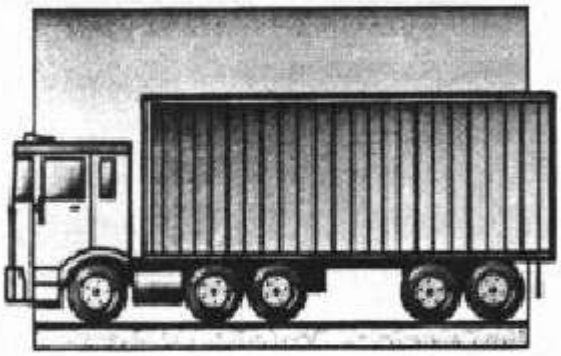
Chemical plant operators should develop spill prevention plans and use types of containers that do not rust or leak, eliminating exposure of materials to storm water runoff.



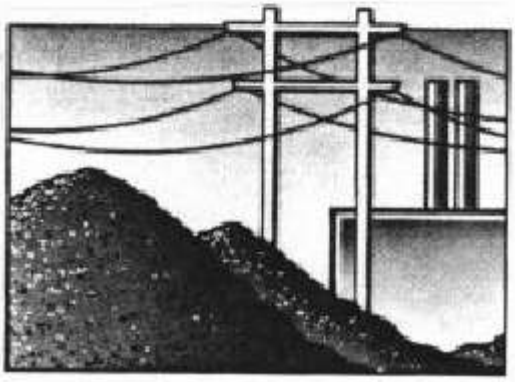
INDUSTRIAL PROGRAM

Owners of automobile junkyards should drain fluids from junked cars and properly dispose of hazardous chemicals and batteries.

Operators of trucking terminals should develop good housekeeping practices that clean up leaks and spills of oil and grease from the path of storm water runoff.

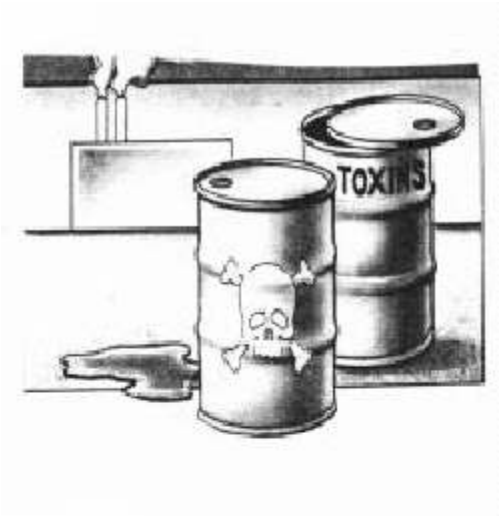


Power plant operators often store piles of coal and other fuels that have toxic components. Runoff from coal piles must be treated; other substances should be stored away from any possible contact with storm water runoff.

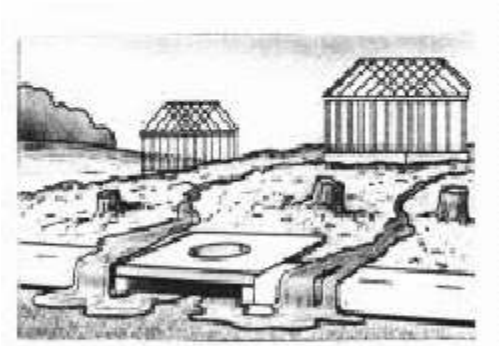


COMMON CONTRIBUTORS TO STORM WATER POLLUTION

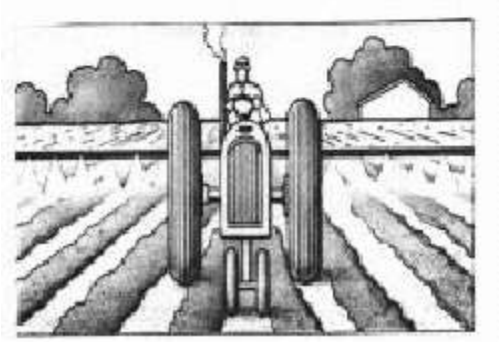
Industry - At industrial sites, chemicals spills that contain toxic substances, smoke stacks that spew emissions and uncovered or unprotected outdoor storage or waste areas can contribute pollutants to storm water runoff.



Construction - Waste from chemicals and materials used in construction can wash into our waterways during wet weather. Soil that erodes from construction sites can contribute to environmental degradation as well.



Agriculture - Fertilizers, herbicides and insecticides used in crop production can be toxic to aquatic life and can contribute to over enrichment of the water, causing excess algae growth and oxygen depletion. Although storm water runoff from agriculture areas is not regulated under the EPA storm water-permitting program, it is a nonpoint source of storm water pollution addressed by other EPA and USDA programs.

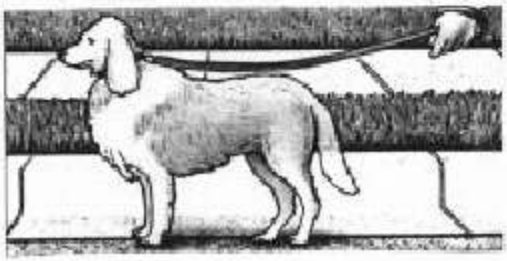


COMMON CONTRIBUTORS TO STORM WATER POLLUTION

Household - Chemicals used to grow and maintain beautiful lawns and gardens, if not used properly, can run off into the storm drains when it rains or when we water our lawns and gardens

Household - vehicles drip fluids (oil, grease, gasoline, antifreeze, brake fluids, etc.) onto paved areas where storm water runoff carries them through our storm drains and into our waterways.

Household - Pet wastes left on the ground get carried away by storm water, contributing harmful bacteria, parasites and viruses to our waterways.



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Resources

County Specific Information
For information about local soil and water resources, to view historic aerial photos, floodplain, wetland, topographic or soil maps, to schedule a free classroom presentation or to report erosion on or near active construction sites, please call the Hamilton County Soil and Water Conservation District at 513-772-SOIL (7645) or visit www.hcswcd.org.

Educational farms in the area include: Hamilton County Park District's Parky's Farm in Winton Woods (www.hamiltoncountyparks.org; 513-521-7275), Greenacres Farm in Indian Hill (www.green-acres.org; 513-891-4227), Gorman Heritage Farm in Evendale (gormanheritagefarm.org; 513-563-6663) Cincinnati Nature Center's Long Branch Farm in Goshen (www.cincynature.org; 513-831-1711), and Sunrock Farm in Northern Kentucky (www.sunrockfarm.org; 859-781-5502).

For local agricultural statistics and information, contact the Hamilton County Farm Bureau at 513-831-5870 or visit www. ofbf.org.

Free Hamilton County Maps from the Hamilton County Engineers' Office. Visit www.hamilton-co.org/Engineer/Free_Maps.htm or call 513-946-4250.

If you have questions about recycling, please call the Hamilton County Environmental Services, Solid Waste Management District's recycling hotline at 513-946-7777 or visit www.hcdoes.org

Local Water Related Information
For more information about the Hamilton County Storm Water District and the current members, please visit www.hamilton-co.org/stormwater or call 513-946-4254. To report storm water pollution, please call the Storm Water District hotline at 513-946-7000.

The Greater Cincinnati Water Works website has maps showing drinking water resources throughout the county as well as a teacher resource center filled with educational publications. Visit http://www.cincinnati-oh.gov/water/pages/-3026-/ for more information or call 513-591-7700.

For information about waste water local treatment issues visit Metropolitan Sewer District's website at www.msdgc.org or call 513-352-4900. You can also schedule a tour of the wastewater treatment plant by calling 513-557-7119.

Little Miami Inc. has a website with information about the Little Miami River, www.littlemiami.com or call 513-965-9344. For more information on the Little Miami River visit the Little Miami River Partnership's website at www.littlemiamiriver.org or call 513-695-2542.

The Miami Conservancy District's website, www.miamiconservancy.org, has information on the Great Miami River Watershed or call 937-223-1271. For more information on the Great Miami River visit the Friends of the Great Miami website at www.fogm.org or call 513-769-4924.

For more information on the Mill Creek visit the Mill Creek Watershed Council's website at www.millcreekwatershed.org or call 513-563-8800. The Mill Creek Restoration Project is also a great resource for information about the Mill Creek. Visit their website, www.millcreekrestoration.org or call 513-731-8400.

The Ohio River Valley Water Sanitation Commission (ORSANCO) has information about the Ohio River. Visit their website, www.orsanco.org or call 513-231-7719.

The Southwest Ohio Storm Water Coalition is a collaboration of local storm water districts. Visit their website, www.saveohiowater.org.

The Izaak Walton League of America - Cincinnati Chapter heads the local Save Our Streams (SOS) program to certify citizens to monitor local stream based on macroinvertebrates. For more information please call 513-683-7233 or visit http://tinpan.fortunecity.com/wellerville/702/

Established in 1967, The Hamilton to New Baltimore Groundwater Consortium consists of six public and industrial groundwater producers/users in southwest Ohio. Collectively, the Consortium produces over 61 million gallons per day (MGD) for approximately 314,000 residents in southern Butler and northern Hamilton counties as well as a variety of industries and other water users. For more information, please call 513-868-5993 or visit http://www.gwconsortium.org/.

Helpful Organizations and Websites

Bryant Watershed Project, www.watersheds.org, Macroinvertebrate Lunch- a movie about macroinvertebrates and nonpoint source pollution accompanied with lesson plans.

Creek Connection, Allegheny College, Creek Geek Knowledge - Jeopardy like game about water pollution, http://creekconnections.allegheny.edu/JeopardyWP/indexWP.html
US Environmental Protection Agency Polluted Runoff Page, http://www.epa.gov/owow/nps. This website offers publications, information, activities, and a kids' page. Another great US EPA website for water quality activities is http://www.epa.gov/safewater/kids/wsb.

The Maine Department of Environmental Protection has great lesson plans and links to other water quality related web sites, http://www.maine.gov/dep/blwq/teacher.htm.

The Ohio Department of Natural Resources has a Guide to Ohio Streams available online at http://www.ohiodnr.com/streams/. The guide is filled with great information about

water quality in Ohio, pollution threats, habitats, ecology and laws. Excellent streams and watershed maps are also included.

Utah State University offers education activities on their website, http://extension.usu.edu/files/natrpubs/wqnonpo.pdf, in the Utah Nonpoint Source Pollution Education Activities. The 10 activities are for grades 1st through 12th.

ChalkWaves is a partnership of 240 school districts, Missouri, Kansas and Illinois public broadcasters and educational service centers. They offer services that assist teachers in meeting learning objectives and engaging students in meaningful learning experiences. Their website www.chalkwaves.org has many lesson plans in a variety of subjects.

Acorn Naturalists specializes in the development and distribution of science and environmental education resources. Visit their website www.acornnaturalists.com to purchase science and education supplies and use their resources.

The TerraServer-USA Web site (http://terraserver.microsoft.com) is one of the world's largest online databases, providing free public access to a vast data store of maps and aerial photographs of the United States. TerraServer is designed to work with commonly available computer systems and Web browsers over slow speed communications links. You can easily navigate the enormous amount of information in TerraServer by selecting a location on a map or entering a place name. The Microsoft Corporation operates TerraServer as a research project for developing advanced database technology. Maps and images are supplied through a partnership with the U.S. Geological Survey.

Make a crossword puzzle online (www.varietygames.com/cw/)

Books and Videos

"After the Storm" is a half-hour movie made by the United States Environmental Protection Agency and the Weather Channel. To request a VHS copy from US EPA at no charge go to http://www.epa.gov/weatherchannel/video.html or call the National Center for Environmental Publications (NCEP) at 513-489-8190 or 800-490-9198 (EPA document number: EPA 840-V-04-001).

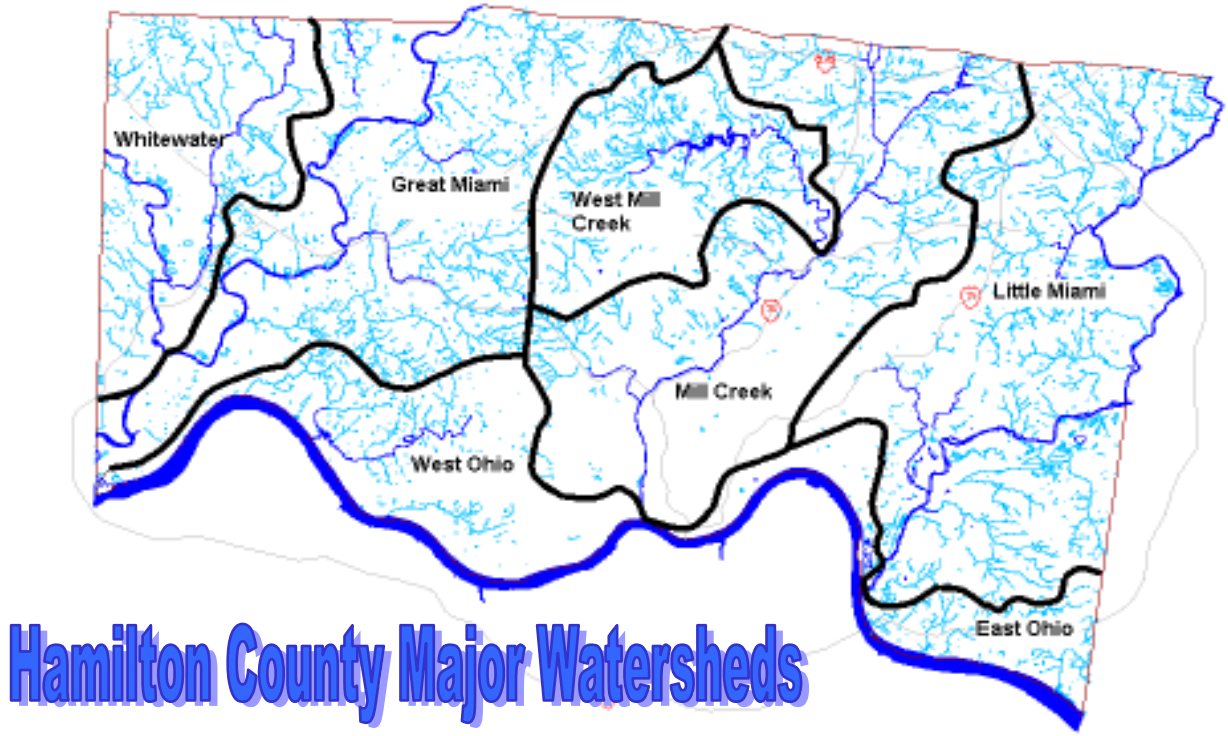
Dobson, Clive and Gregory Gilpen Beck. 1999. *Watersheds A Practical Handbook for Healthy Water*. Firefly Books Ltd. (ISBN: 1552093301).

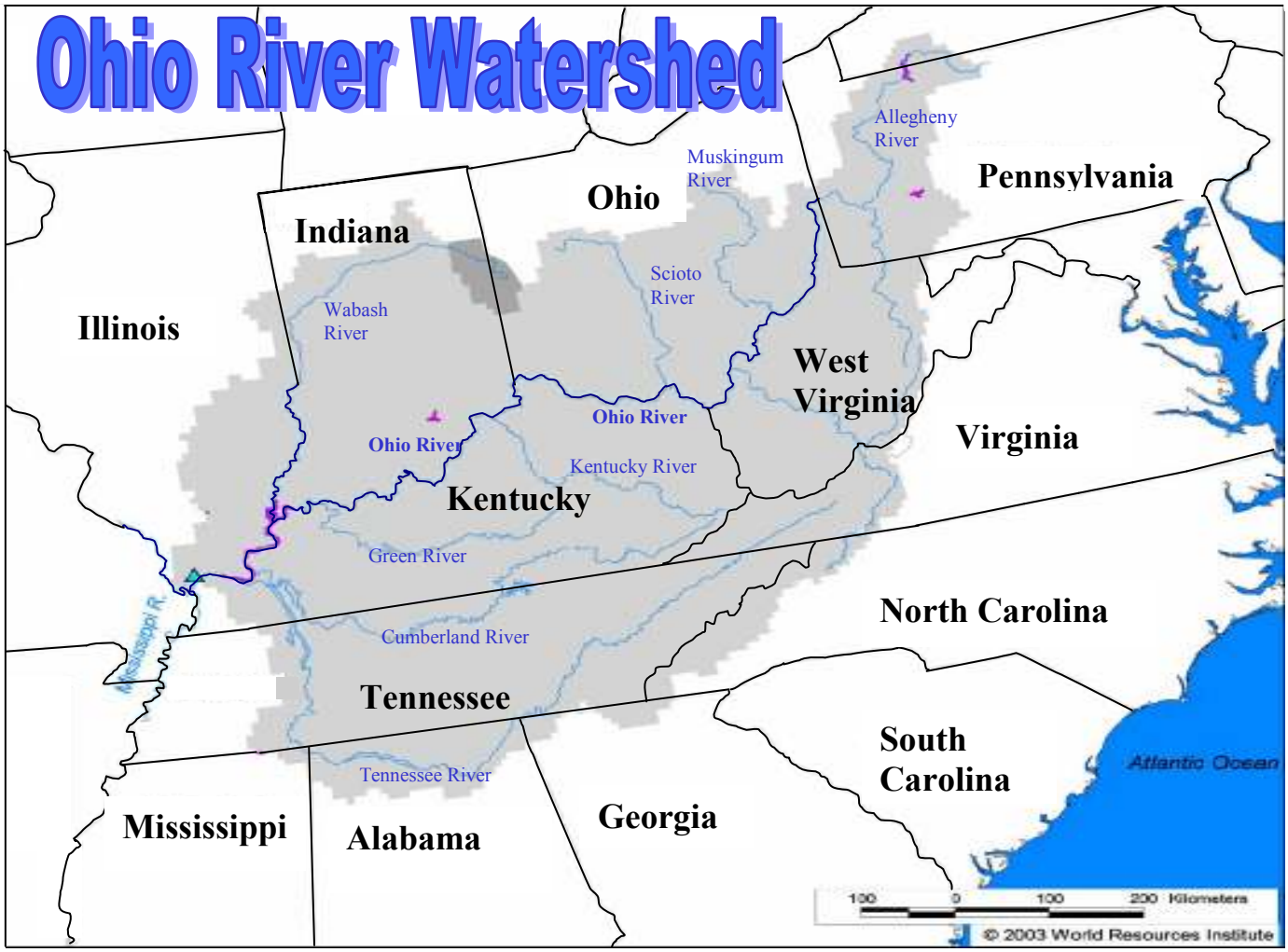
Cole, Joanna. 1986. *The Magic School Bus at the Waterworks*. New York, N.Y.: Scholastic, Inc. (ISBN: 0590403605)

Baker, Jeannie. 1991. *Window*. Greenwillow. (ISBN: 0688089186).

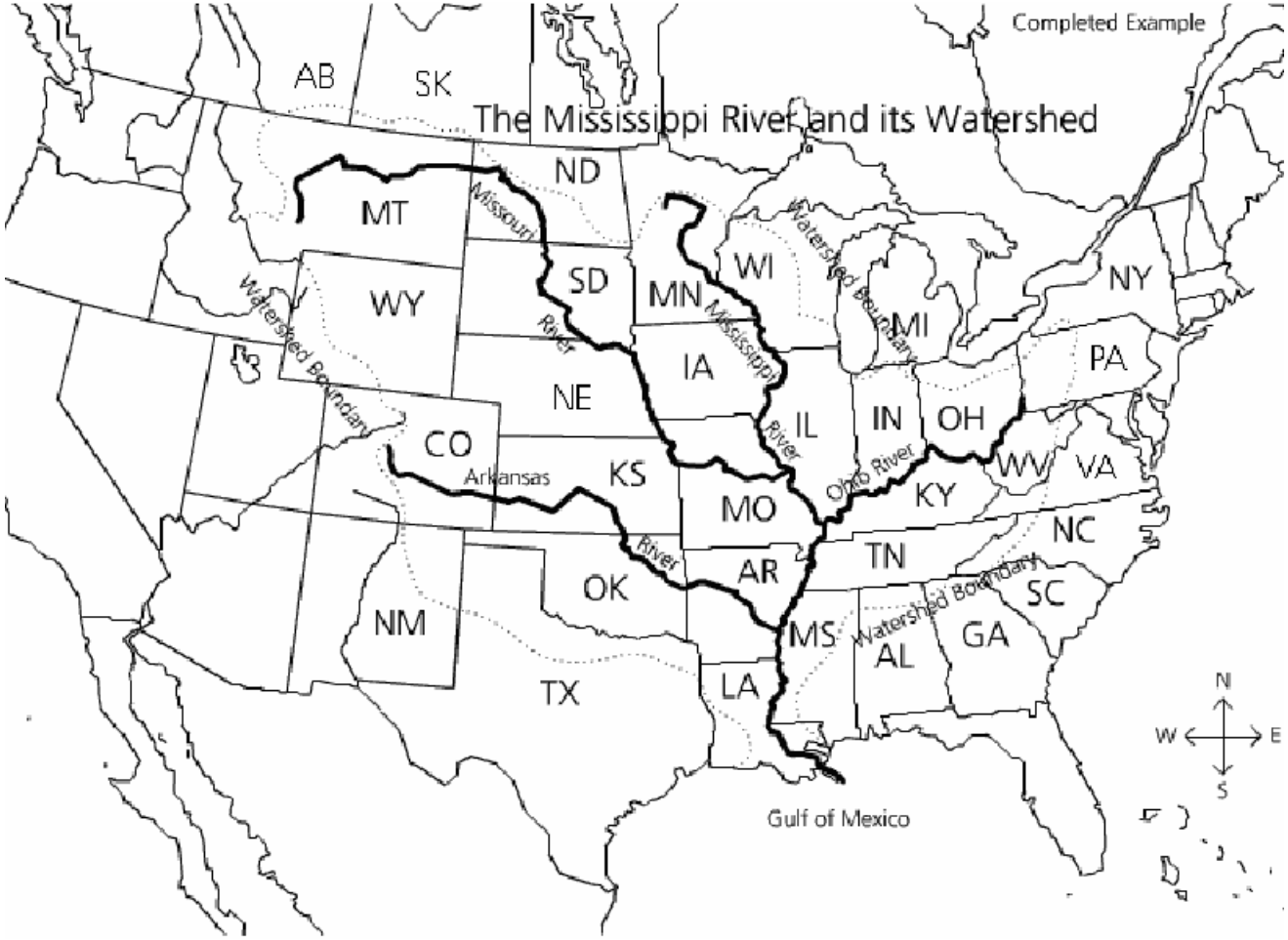
Shulevitz, Uri. 1988. *Rain Rain Rivers.* Farrar, Straus, and Giroux. (ISBN: 0374461953)


The Water Cycle
Condensation
Evaporation
Water storage in the atmosphere
Transpiration
Water storage in oceans
Surface runoff
Streamflow
Freshwater storage
Water storage in ice and snow
Precipitation
Snowmelt runoff to streams
Spring
Infiltration
Ground-water discharge
Ground-water storage
U.S. Department of the Interior
U.S. Geological Survey
USGS

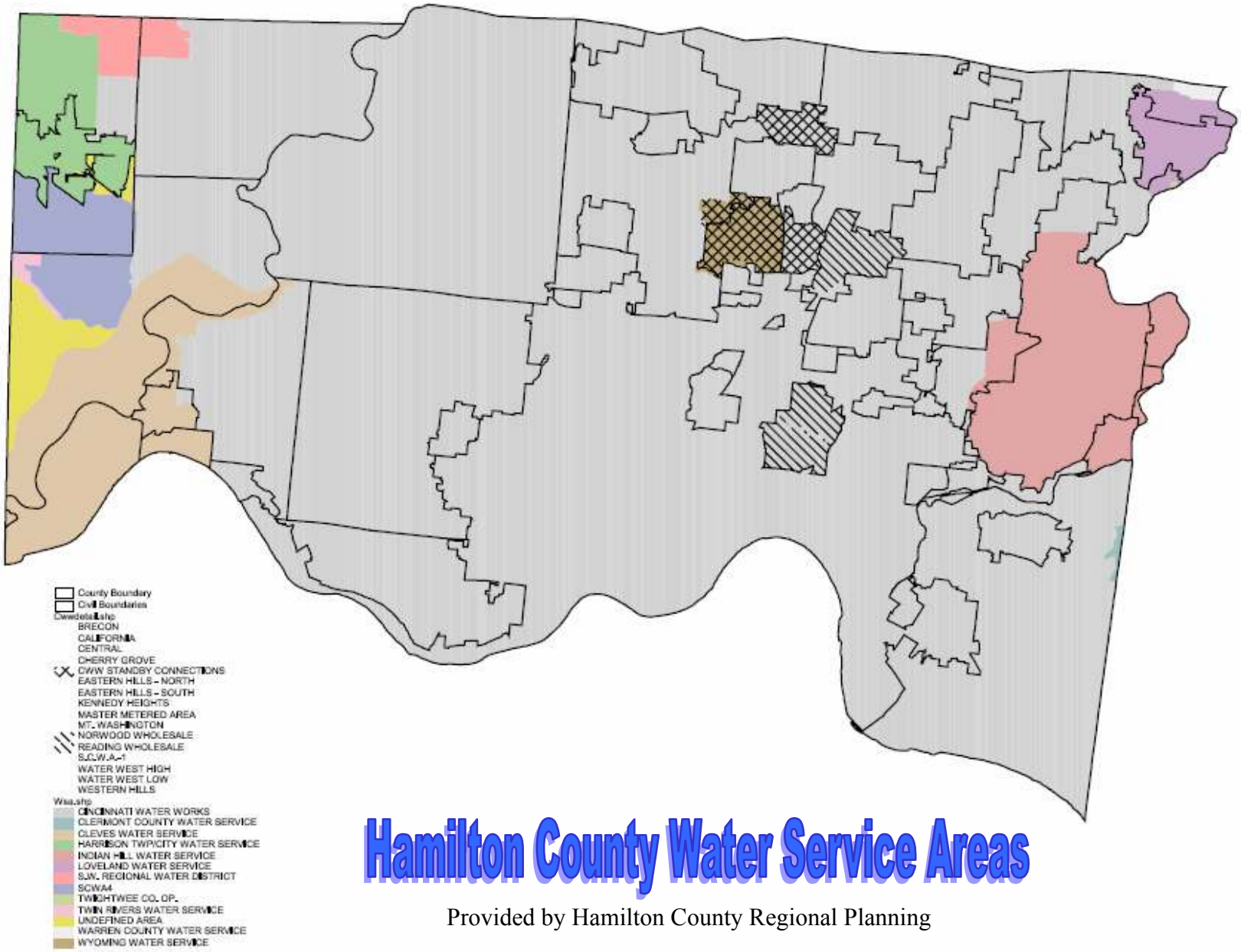

Whitewater
Great Miami
West Mill Creek
Little Miami
Mill Creek
West Ohio
East Ohio
Hamilton County Major Watersheds


Ohio River Watershed
Allegheny River
Muskingum River
Pennsylvania
Ohio
Indiana
Scioto River
Wabash River
Illinois
West Virginia
Ohio River
Ohio River
Virginia
Kentucky River
Kentucky
Green River
North Carolina
Mississippi R.
Cumberland River
Tennessee
South Carolina
Atlantic Ocean
Tennessee River
Mississippi
Alabama
Georgia
100 0 100 200 Kilometers
© 2003 World Resources Institute

Mississippi River Watershed



Map from National Park Service, United States Department of the Interior,
Mississippi National River and Recreation Area



Hamilton County Water Service Areas

Provided by Hamilton County Regional Planning

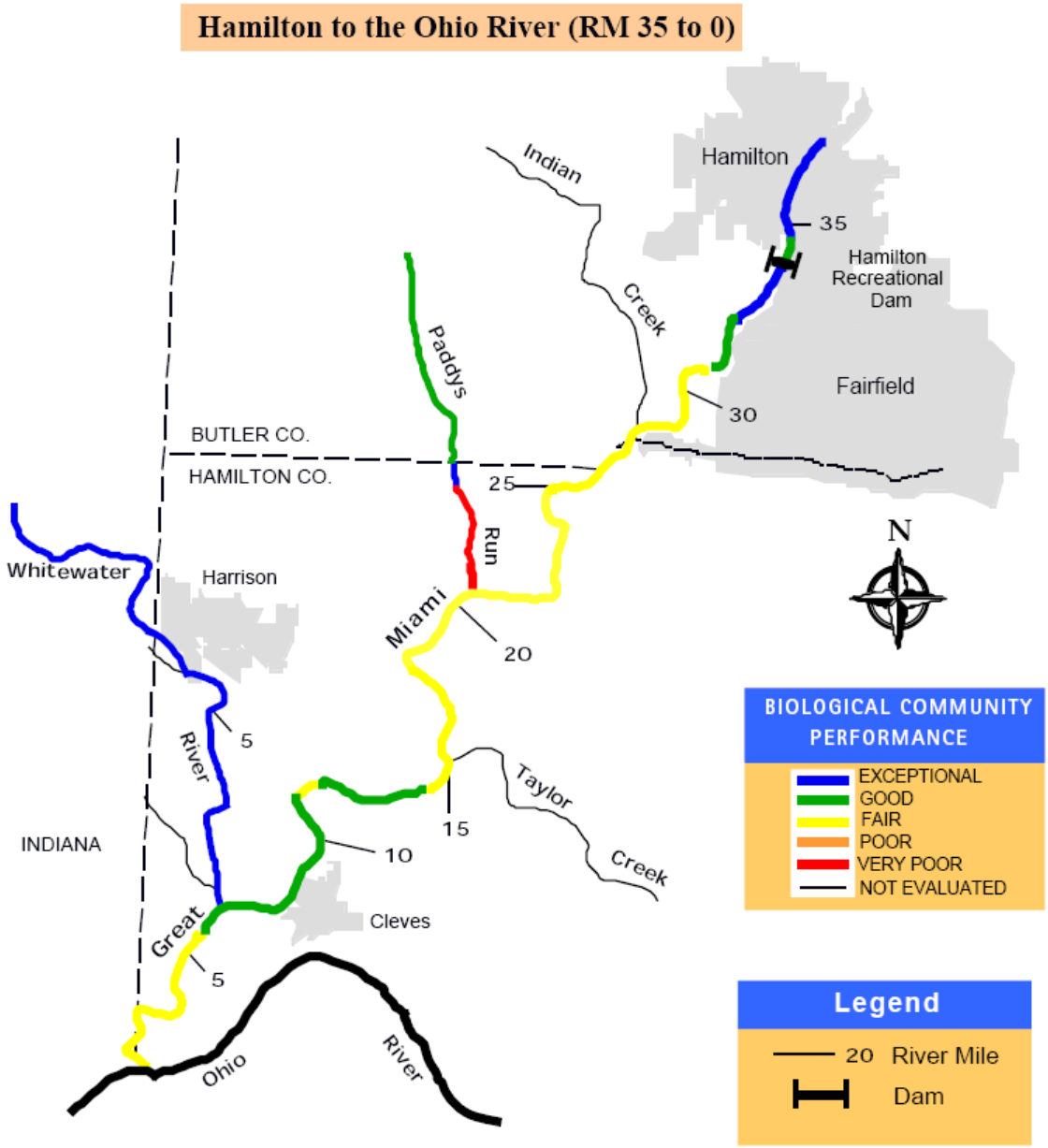
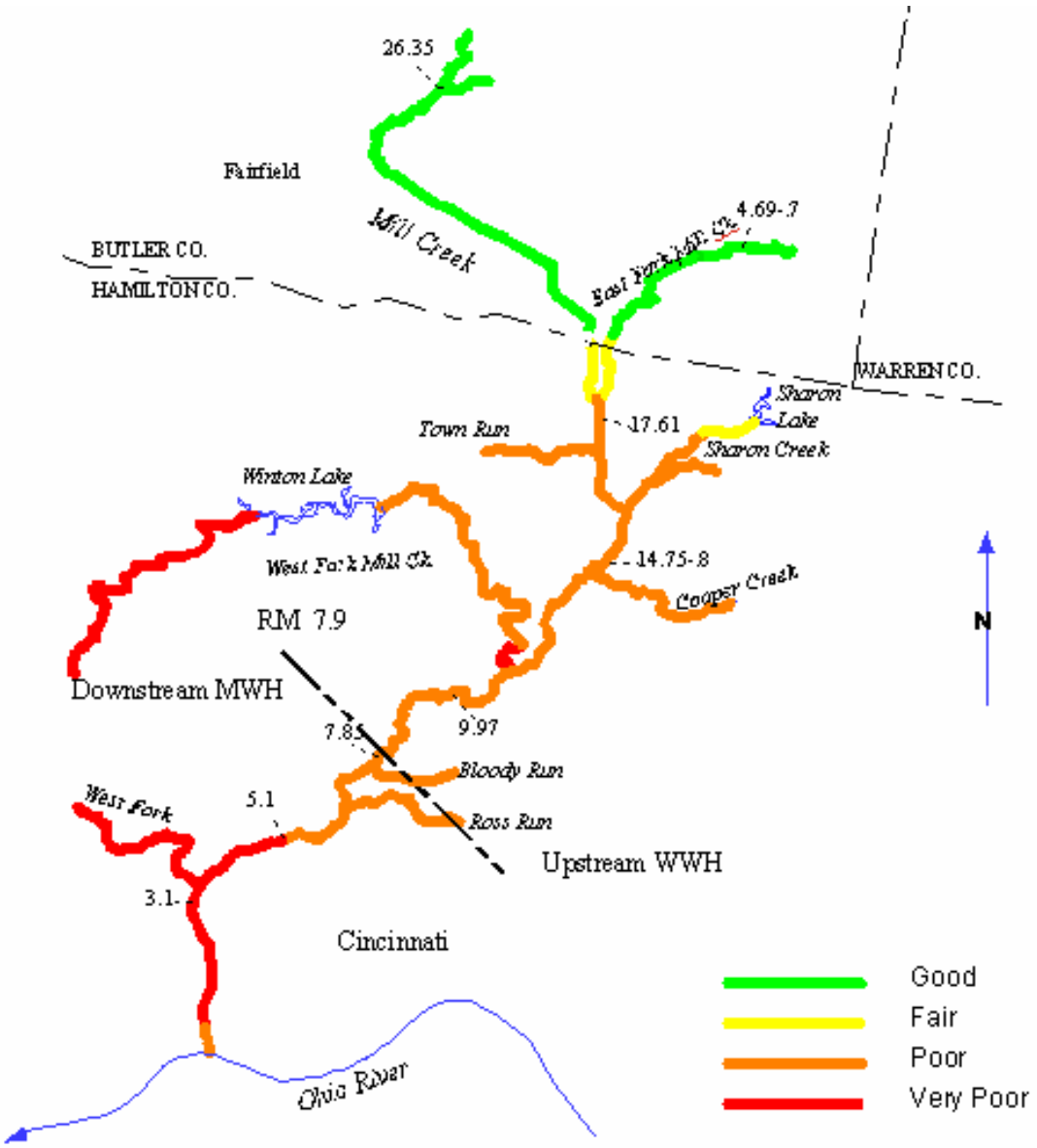


Figure 1c. Map showing the principal streams and narrative biological attainment within the lower third of the 1995 Great Miami River study area.

Great Miami River Water Quality



Mill Creek Narrative Biological Attainment

Mill Creek Water Quality

Little Miami River Water Quality

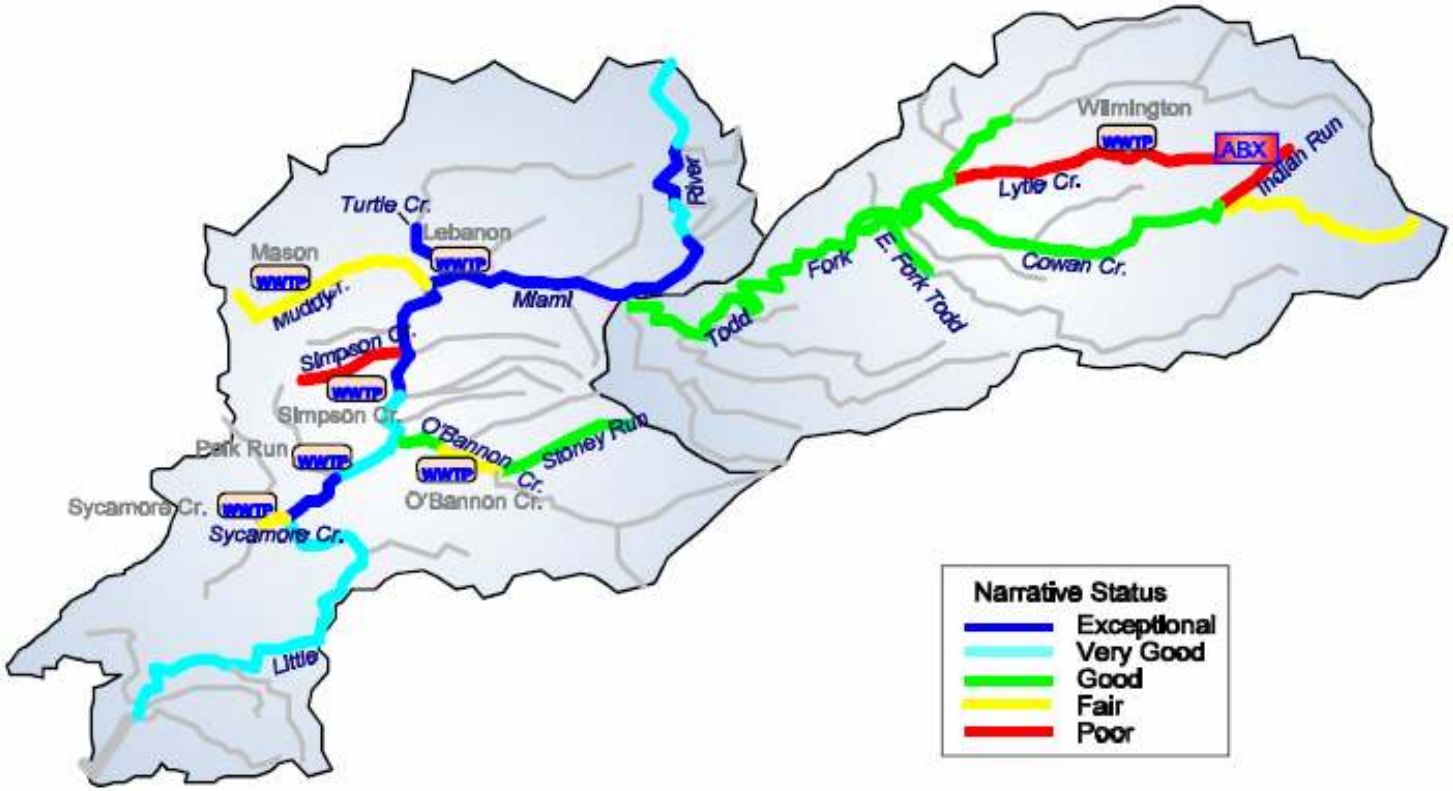


Figure 4. Narrative status of stream segments sampled in the lower Little Miami River basin based on the condition biological communities sampled during 1998.


OCT 18 2004

Picture of erosion in Hamilton County.

Picture of erosion in Hamilton County.

Picture of erosion in Hamilton County.

Picture of erosion in Hamilton County.

Grade Correlator

Activity	K-2	3-5	6-8	9-12
A-Maze-Ing Water (p. 99)	♦	♦		
Analyzing Stormwater Issues (p. 77)			♦	♦
Best Management Practices and Pollution Prevention (p. 251)			♦	♦
Biodiversity = Water Quality (p. 207)				♦
Bon Voyage to Bad Boating Habits (p. 109)			♦	
Color Me a Watershed (p. 24)				♦
Creative Erosion Control (p. 236)			♦	♦
Designing a Community with Stormwater in Mind (p. 115)			♦	♦
Do Septic Tanks Do the Job? (p. 155)			♦	♦
A Family Boat Ride (p. 89)	♦			
Fed Up (p. 202)				♦
Getting to the Root of the Matter (p. 230)	♦	♦		
Going Undercover to Stop Erosion (p. 232)		♦		
Great Debate, The (p. 194)			♦	♦
How Water Flows: Surface Runoff (p. 4)	♦			
Improving Old MacDonald's Farm (p. 141)			♦	
Is Our Water Clean? (p. 222)	♦	♦		
Knowing Nonpoint (p. 60)		♦		
Little Goldfish, The (p. 218)	♦			
Macroinvertebrate Mayhem (p. 181)		♦	♦	
Mooving Those Cows (p. 148)		♦	♦	
Mudpuppy Pond (p. 36)	♦			
Name that Source (p. 81)			♦	♦
No Place to Run To (p. 117)			♦	♦
Now you See it, Now you Don't (p. 57)	♦	♦		
Oily Water (p. 174)	♦			
Pesky Pesticides (p. 162)				♦
Phosphates in Your Water (p. 186)		♦	♦	
Planning For the Future (p. 224)	♦	♦		
Pollution Prevention Message, A (p. 234)		♦	♦	♦
Rain Water Runoff (p. 132)	♦	♦		
Runoff Race, The (p. 176)	♦	♦		
School Yard Permeability (p. 111)			♦	
Sediments and Suspension (p. 137)		♦		

Activity	K-2	3-5	6-8	9-12
Settling In- Sedimentation (p. 125)	♦	♦		
Storm Drain Dumping (p. 102)		♦	♦	
Superior Car Wash, The (p. 104)			♦	
Temperature's Rising, The (p. 178)		♦		
Topographic Maps (p. 15)			♦	
Uncle Sam Says "Keep It Clean" (p. 241)			♦	♦
Use Your Head, Protect Your Watershed! (p. 68)		♦	♦	♦
Walking in the Watershed (p. 19)			♦	♦
Water Pollution Detectives (p. 63)		♦	♦	
Watershed Address (p. 9)	♦	♦		
Watershed Puzzle, A (p. 6)	♦			
What is a Septic Tank? (p. 128)		♦		
What's the Point: Point vs. Nonpoint (p. 53)	♦			
What's Your Decision? (p. 151)			♦	
Whatzzzzup-Stream (p. 12)			♦	
Where Does Pollution Go? (p. 189)		♦	♦	
You be the Judge (p. 71)			♦	♦

Subject Correlator

						Science				
Activity	**Lang. Arts**	**Fine Arts**	**Math**	**Social Studies**	**Geo-graphy**	**Environ ment**	**Ecology**	**Earth**	**Life**	**Physical**
A-Maze-Ing Water						♦				
Analyzing Stormwater Issues	♦			♦		♦				
Best Management Practices and Pollution Prevention							♦	♦		♦
Biodiversity = Water Quality						♦	♦		♦	
Bon Voyage to Bad Boating Habits	♦	♦		♦						
Color me a Watershed			♦	♦		♦				
Creative Erosion Control				♦		♦				
Designing a Community with Stormwater in Mind	♦	♦	♦	♦		♦				
Do Septic Tanks Do the Job?							♦		♦	
A Family Boat Ride	♦	♦								
Fed Up						♦				♦
Getting to the Root of the Matter						♦			♦	
Going Undercover to Stop Erosion						♦			♦	
Great Debate, The	♦	♦				♦				
How Water Flows: Surface Runoff		♦						♦		
Improving Old MacDonald's Farm	♦		♦			♦				
Is Our Water Clean?										♦
Knowing Nonpoint				♦		♦				
Little Goldfish, The		♦		♦						
Macroinvertebrate Mayhem	♦		♦			♦	♦			
Mooving Those Cows	♦					♦				
Mudpuppy Pond	♦	♦				♦	♦			
Name that Source				♦		♦				
No Place to Run To				♦		♦				
Now you See it, Now you Don't										♦

						Science				
Activity	**Lang. Arts**	**Fine Arts**	**Math**	**Social Studies**	**Geo-graphy**	**Environ ment**	**Ecology**	**Earth**	**Life**	**Physical**
Oily Water									♦	♦
Pesky Pesticides	♦			♦		♦				
Phosphates in Your Water			♦			♦			♦	
Planning For the Future		♦		♦		♦				
Pollution Prevention Message, A	♦			♦		♦				
Rain Water Runoff	♦		♦		♦			♦		
Runoff Race, The								♦		
School Yard Permeability			♦			♦		♦		
Sediments and Suspension								♦		
Settling In - Sedimentation	♦					♦				♦
Storm Drain Dumping	♦					♦				
Superior Car Wash, The			♦			♦				
Temperature's Rising, The			♦	♦		♦				♦
Topographic Maps					♦					
Uncle Sam Says "Keep It Clean"	♦			♦						
Use Your Head, Protect Your Watershed!			♦	♦		♦				
Walking in the Watershed					♦	♦		♦		
Water Pollution Detectives	♦			♦		♦				
Watershed Address					♦			♦		
Watershed Puzzle, A				♦	♦		♦	♦		
What is a Septic Tank			♦			♦				
What's the Point: Point vs. Nonpoint	♦		♦			♦				
What's Your Decision?	♦			♦						
Whatzzzzup-Stream					♦	♦				
Where Does Pollution Go?						♦			♦	
You be the Judge		♦				♦				

Kindergarten
Science Standard Correlator

Activity	ESS K.2	LS K.2	LS K.6	PS K.1	PS K.3	PS K.4	PS K.5	ST K.1	ST K.2	SI K.1	SI K.2	SI K.5	SI K.7	SI K.9
A-Maze-Ing Water										♦	♦			
A Family Boat Ride									♦	♦		♦		
Getting to the Root of the Matter	♦		♦											
How Water Flows: Surface Runoff						♦						♦		♦
Is Our Water Clean?					♦					♦		♦	♦	
Little Goldfish, The		♦										♦		♦
Mudpuppy Pond		♦	♦					♦		♦				♦
Now you See it, Now you Don't								♦		♦	♦			
Oily Water													♦	
Planning For the Future				♦						♦	♦	♦		♦
Rain Water Runoff										♦		♦	♦	
Runoff Race, The	♦						♦							
Settling In - Sedimentation												♦	♦	
Watershed Address												♦	♦	
Watershed Puzzle, A										♦	♦	♦		
What's the Point: Point vs. Nonpoint		♦								♦	♦	♦		

Earth and Space Science (ESS)
K.2 Explore that animals and plants cause changes to their surroundings.

Life Sciences (LS)
K.2 Discover that stories (e.g., cartoons, movies, comics) sometimes give plants and animals characteristics they really do not have (e.g., talking flowers).
K.6 Investigate the habits of many different kinds of local plants and animals and some of the ways in which animals depend on plants and each other in our community.

Physical Sciences (PS)
K.1 Demonstrate that objects are made of parts (e.g., toys, chairs).
K.3 Describe and sort objects by one ore more properties (e.g., size, color and shape)
K.4 Explore that things can be made to move in many different ways such as straight, zigzag, up and down, round and round, back and forth or fast and slow.
K.5 Investigate ways to change how something is moving (e.g., push, pull).

Science and Technology (ST)
K.1 Explore that objects can be sorted as "natural" or "man-made."
K.2 Explore that some materials can be used over and over again (e.g., plastic or glass containers, cardboard boxes and tubes).

Scientific Inquiry (SI)
K.1 Ask "what if" questions.
K.2 Explore and pursue student generated "what-if" questions.
K.5 Draw pictures that correctly portray features of the item being described.
K.7 Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers and other appropriate tools).
K.9 Make pictographs and use them to describe observations and draw conclusions.

First Grade
Science Standard Correlator

Activity	ESS 1.1	ESS 1.2	ESS 1.3	LS 1.1	LS 1.4	PS 1.3	PS 1.6	ST 1.3	SI 1.1	SI 1.2	SI 1.4	SI 1.5	SI 1.6	SI 1.8	SI 1.9
A-Maze-Ing Water									♦						
A Family Boat Ride		♦						♦	♦					♦	
Getting to the Root of the Matter			♦	♦										♦	
How Water Flows: Surface Runoff									♦	♦				♦	
Is Our Water Clean?									♦				♦	♦	
Little Goldfish, The								♦			♦			♦	
Mudpuppy Pond	♦		♦	♦	♦				♦					♦	
Now you See it, Now you Don't						♦			♦	♦	♦			♦	
Oily Water									♦		♦		♦		
Planning For the Future			♦	♦					♦						
Rain Water Runoff							♦		♦		♦		♦	♦	
Runoff Race, The							♦		♦			♦	♦		
Settling In - Sedimentation									♦			♦	♦	♦	
Watershed Address													♦		♦
Watershed Puzzle, A									♦	♦					
What's the Point: Point vs. Nonpoint	♦		♦	♦					♦	♦	♦			♦	

Earth and Space Science (ESS)

1.1 Identify that resources are things that we get from the living (e.g., forests) and nonliving (e.g., minerals, water) environment and that resources are necessary to meet the needs and wants of a population.

1.2 Explain that the supply of many resources is limited but the supply can be extended through careful use, decreased use, reusing and/or recycling.

1.3 Explain that all organisms cause changes in the environment where they live; the changes can be very noticeable or slightly noticeable, fast or slow (e.g., spread of grass cover slowing soil erosion, tree roots slowly breaking sidewalks).

Life Sciences (LS)

1.1 Explore that organisms, including people, have basic needs which include air, water, food, living space and shelter.

1.4 Investigate that animals eat plants and/or other animals for food and may also use plants or other animals for shelter and nesting.

Physical Sciences (PS)

1.3 Explore and observe that things can be done to materials to change their properties

(e.g., heating, freezing, mixing, cutting, wetting, dissolving, bending and exposing to light).

1.6 Investigate a variety of ways to make things move and what causes them to change speed, direction and/or stop.

Science and Technology (ST)

1.3 Identify some materials that can be saved for community recycling projects (e.g., newspapers, glass and aluminum).

Scientific Inquiry (SI)

1.1 Ask "what happens when" questions.

1.2 Explore and pursue student-generated "what happens when" questions.

1.4 Work in a small group to complete an investigation and then share findings with others.

1.5 Create individual conclusions about group findings.

1.6 Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers, timers and simple balances and other appropriate tools).

1.8 Use oral, written and pictorial representation to communicate work.

1.9 Describe things as accurately as possible and compare with the observations of others.

Second Grade
Science Standard Correlator

Activity	LS 2.1	LS 2.3	ST 2.1	ST 2.3	ST 2.4	SI 2.1	SI 2.2	SI 2.3	SI 2.5	SI 2.7
A-Maze-Ing Water						♦	♦			
A Family Boat Ride						♦	♦			
Getting to the Root of the Matter	♦									
How Water Flows: Surface Runoff						♦				
Is Our Water Clean?						♦				♦
Little Goldfish, The						♦				
Mudpuppy Pond	♦	♦	♦			♦				
Now you See it, Now you Don't							♦		♦	
Oily Water						♦		♦		♦
Planning For the Future	♦		♦	♦	♦	♦				
Rain Water Runoff							♦			♦
Runoff Race, The						♦				♦
Settling In - Sedimentation							♦			♦
Watershed Address										♦
Watershed Puzzle, A						♦	♦	♦		
What's the Point: Point vs. Nonpoint	♦	♦		♦		♦				

Life Sciences (LS)
2.1 Explain that animals, including people, need air, water, food, living space and shelter; plants need air, water, nutrients (e.g., minerals), living space and light to survive.
2.3 Explain why organisms can survive only in environments that meet their needs (e.g., organisms that once lived on Earth have disappeared for different reasons such as natural forces or human-caused effects).

Science and Technology (ST)
2.1 Explain that developing and using technology involves benefits and risks.
2.3 Predict how building or trying something new might affect other people and the environment.
2.4 Communicate orally, pictorially, or in written form the design process used to make something.

Scientific Inquiry (SI)
2.1 Ask "how can I/we" questions.
2.2 Ask "how do you know" questions (not "why" questions) in appropriate situations

and attempt to give reasonable answers when others ask questions.

2.3 Explore and pursue student-generated "how" questions.

2.5 Use evidence to develop explanations of scientific investigations. (What do you think? How do you know?)

2.7 Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers, non-breakable thermometers, timers, rulers, balances and calculators and other appropriate tools).

Third Grade
Science Standard Correlator

Activity	ESS 3.3	ESS 3.4	ESS 3.5	ESS 3.6	LS 3.6	ST 3.2	ST 3.3	ST 3.4
A-Maze-Ing Water								
Getting to the Root of the Matter	♦	♦	♦	♦		♦	♦	♦
Going Undercover to Stop Erosion				♦		♦		♦
Is Our Water Clean?								
Knowing Nonpoint					♦	♦	♦	♦
Macroinvertebrate Mayhem					♦	♦	♦	
Mooving Those Cows								♦
Now you See it, Now you Don't	♦							
Phosphates in Your Water						♦		♦
Planning For the Future								♦
Pollution Prevention Message, A						♦	♦	♦
Rain Water Runoff		♦						
Runoff Race, The				♦	♦			♦
Sediments and Suspension		♦	♦	♦				
Settling In - Sedimentation				♦				♦
Storm Drain Dumping								
Temperature's Rising, The					♦		♦	
Use Your Head, Protect Your Watershed!						♦	♦	
Water Pollution Detectives					♦	♦	♦	♦
Watershed Address								
What is a Septic Tank						♦	♦	♦
Where Does Pollution Go?								♦

Third Grade (cont.)
Science Standard Correlator

Activity	SI 3.3	SI 3.5	SI 3.6	SWK 3.2	SWK 3.3	SWK 3.4
A-Maze-Ing Water						
Getting to the Root of the Matter		♦		♦		
Going Undercover to Stop Erosion		♦		♦		
Is Our Water Clean?	♦	♦	♦		♦	♦
Knowing Nonpoint	♦	♦	♦			
Macroinvertebrate Mayhem	♦	♦	♦	♦		
Mooving Those Cows					♦	
Now you See it, Now you Don't	♦	♦	♦			
Phosphates in Your Water	♦	♦	♦	♦		
Planning For the Future						
Pollution Prevention Message, A		♦	♦			
Rain Water Runoff	♦	♦	♦	♦		
Runoff Race, The		♦				
Sediments and Suspension	♦	♦	♦			
Settling In - Sedimentation	♦	♦	♦	♦		
Storm Drain Dumping						
Temperature's Rising, The	♦	♦	♦	♦		
Use Your Head, Protect Your Watershed!	♦		♦	♦		
Water Pollution Detectives			♦		♦	♦
Watershed Address						
What is a Septic Tank						
Where Does Pollution Go?	♦	♦	♦	♦	♦	

Earth and Space Science (ESS)

3.3 Describe that smaller rocks come from the breakdown of larger rocks through the actions of plants and weather.

3.4 Observe and describe the composition of soil (e.g., small pieces of rock and decomposed pieces of plants and animals, and products of plants and animals).

3.5 Investigate the properties of soil (e.g., color, texture, capacity to retain water, ability to support plant growth).

3.6 Investigate that soils are often found in layers and can be different from place to place.

Life Sciences (LS)

3.6 Describe how changes in an organism's habitat are sometimes beneficial and sometimes harmful.

Science and Technology (ST)

3.2 Describe ways that using technology can have helpful and/or harmful results.

3.3 Investigate ways that the results of technology may affect the individual, family and community.

3.4 Use a simple design process to solve a problem (e.g., identify a problem, identify possible solutions and design a solution).

Scientific Inquiry (SI)

3.3 Read and interpret simple tables and graphs produced by self/others.

3.5 Record and organize observations (e.g., journals, charts and tables).

3.6 Communicate scientific findings to others through a variety of methods (e.g., pictures, written, oral and recorded observations).

Scientific Ways of Knowing (SWK)

3.2 Keep records of investigations and observations and do not change the records that are different from someone else's work.

3.3 Explore through stories how men and women have contributed to the development of science.

3.4 Identify various careers in science.

Fourth Grade
Science Standard Correlator

Activity	ESS 4.1	ESS 4.2	ESS 4.3	ESS 4.8	ESS 4.10	LS 4.1	LS 4.2	LS 4.5	PS 4.2	PS 4.4	ST 4.1	ST 4.3
A-Maze-Ing Water												
Getting to the Root of the Matter					♦	♦	♦	♦			♦	
Going Undercover to Stop Erosion	♦										♦	
Is Our Water Clean?		♦	♦								♦	♦
Knowing Nonpoint								♦			♦	
Macroinvertebrate Mayhem								♦				
Mooving Those Cows					♦						♦	♦
Now you See it, Now you Don't										♦		♦
Phosphates in Your Water						♦	♦		♦			
Planning For the Future												♦
Pollution Prevention Message, A								♦			♦	♦
Rain Water Runoff				♦	♦							
Runoff Race, The					♦			♦				
Sediments and Suspension					♦							
Settling In - Sedimentation				♦	♦							
Storm Drain Dumping												
Temperature's Rising, The				♦	♦				♦			
Use Your Head, Protect Your Watershed!												
Water Pollution Detectives								♦			♦	
Watershed Address												
What is a Septic Tank											♦	
Where Does Pollution Go?						♦	♦	♦				♦

Fourth Grade (cont.)
Science Standard Correlator

Activity	SI 4.2	SI 4.3	SWK 4.1	SWK 4.2	SWK 4.3	SWK 4.4
A-Maze-Ing Water						
Getting to the Root of the Matter			♦	♦	♦	
Going Undercover to Stop Erosion	♦		♦	♦	♦	♦
Is Our Water Clean?		♦		♦	♦	
Knowing Nonpoint	♦			♦	♦	
Macroinvertebrate Mayhem	♦			♦	♦	
Mooving Those Cows	♦					
Now you See it, Now you Don't		♦	♦	♦	♦	
Phosphates in Your Water		♦		♦	♦	♦
Planning For the Future				♦		
Pollution Prevention Message, A				♦	♦	
Rain Water Runoff	♦	♦		♦	♦	♦
Runoff Race, The		♦		♦		
Sediments and Suspension		♦		♦		
Settling In - Sedimentation		♦	♦	♦	♦	♦
Storm Drain Dumping						
Temperature's Rising, The		♦		♦	♦	♦
Use Your Head, Protect Your Watershed!				♦		
Water Pollution Detectives	♦		♦		♦	♦
Watershed Address	♦				♦	
What is a Septic Tank		♦				
Where Does Pollution Go?		♦		♦	♦	♦

Earth and Space Science (ESS)

4.1 Explain that air surrounds us, takes up space, moves around us as wind, and may be measured using barometric pressure.

4.2 Identify how water exists in the air in different forms (e.g., in clouds, fog, rain, snow and hail).

4.3 Investigate how water changes from one state to another (e.g., freezing, melting, condensation and evaporation).

4.8 Describe how wind, water and ice shape and reshape Earth's land surface by eroding rock and soil in some areas and depositing them in other areas producing characteristic landforms (e.g., dunes, deltas and glacial moraines).

4.10 Describe evidence of changes on Earth's surface in terms of slow processes (e.g., erosion, weathering, mountain building and deposition) and rapid processes (e.g. volcanic eruptions, earthquakes and landslides).

Life Sciences (LS)

4.1 Compare the life cycles of different plants including germination, maturity, reproduction and death.

4.2 Relate plant structures to their specific functions (e.g., growth, survival and reproduction).

4.5 Describe how organisms interact with one another in various ways (e.g., many plants depend on animals for carrying pollen or dispersing seeds).

Physical Sciences (PS)

4.2 Identify characteristics of a simple chemical change. When a new material is made by combining two or more materials, it has chemical properties that are different from the original materials (e.g., burning paper, vinegar and baking soda).

4.4 Explain that matter has different states (e.g., solid, liquid and gas) and that each state has distinct physical properties.

Science and Technology (ST)

4.1 Explain how technology from different areas (e.g., transportation, communication, nutrition, healthcare, agriculture, entertainment and manufacturing) has improved human lives.

4.3 Describe, illustrate and evaluate the design process used to solve a problem.

Scientific Inquiry (SI)

4.2 Analyze a series of events and/or simple daily or seasonal cycles, describe the patterns and infer the next likely occurrence.

4.3 Develop, design and conduct safe, simple investigations or experiments to answer questions.

Scientific Ways of Knowing (SWK)

4.1 Differentiate fact from opinion and explain that scientists do not rely on claims or conclusions unless they are backed by observations that can be confirmed.

4.2 Record the results and data from an investigation and make a reasonable explanation.

4.3 Explain discrepancies in an investigation using evidence to support findings.

4.4 Explain why keeping records of observations and investigations is important.

Fifth Grade
Science Standard Correlator

Activity	ESS 5.5	ESS 5.6	LS 5.1	LS 5.2	LS 5.3	LS 5.4	LS 5.5	LS 5.6	PS 5.2	ST 5.1	ST 5.3
A-Maze-Ing Water	♦	♦								♦	
Getting to the Root of the Matter		♦					♦			♦	
Going Undercover to Stop Erosion		♦								♦	
Is Our Water Clean?	♦							♦		♦	
Knowing Nonpoint	♦	♦				♦	♦	♦		♦	♦
Macroinvertebrate Mayhem		♦			♦	♦	♦	♦		♦	♦
Mooving Those Cows				♦			♦	♦		♦	
Now you See it, Now you Don't											
Phosphates in Your Water						♦	♦			♦	♦
Planning For the Future	♦	♦						♦		♦	♦
Pollution Prevention Message, A								♦		♦	♦
Rain Water Runoff										♦	
Runoff Race, The		♦				♦					
Sediments and Suspension		♦									
Settling In - Sedimentation		♦				♦				♦	
Storm Drain Dumping										♦	
Temperature's Rising, The		♦				♦	♦	♦	♦	♦	
Use Your Head, Protect Your Watershed!						♦	♦			♦	♦
Water Pollution Detectives	♦	♦		♦		♦	♦	♦		♦	♦
Watershed Address										♦	
What is a Septic Tank						♦	♦			♦	♦
Where Does Pollution Go?		♦	♦	♦	♦	♦	♦	♦		♦	

Fifth Grade (cont.)
Science Standard Correlator

Activity	SI 5.2	SI 5.3	SI 5.5	SI 5.6	SWK 5.1	SWK 5.4	SWK 5.5
A-Maze-Ing Water							
Getting to the Root of the Matter	♦	♦			♦		♦
Going Undercover to Stop Erosion	♦	♦			♦		♦
Is Our Water Clean?		♦					
Knowing Nonpoint		♦	♦		♦	♦	
Macroinvertebrate Mayhem		♦		♦			♦
Mooving Those Cows							
Now you See it, Now you Don't	♦	♦		♦	♦	♦	
Phosphates in Your Water							♦
Planning For the Future							
Pollution Prevention Message, A		♦					
Rain Water Runoff	♦	♦		♦	♦	♦	♦
Runoff Race, The		♦					
Sediments and Suspension		♦		♦	♦		
Settling In - Sedimentation	♦	♦			♦	♦	♦
Storm Drain Dumping							
Temperature's Rising, The		♦			♦		♦
Use Your Head, Protect Your Watershed!				♦	♦		
Water Pollution Detectives	♦	♦	♦		♦	♦	♦
Watershed Address						♦	
What is a Septic Tank			♦		♦		
Where Does Pollution Go?	♦	♦			♦		♦

Earth and Space Science (ESS)

5.5 Explain how the supply of many non-renewable resources is limited and can be extended through reducing, reusing and recycling but cannot be extended indefinitely.

5.6 Investigate ways Earth's renewable resources (e.g., fresh water, air, wildlife and trees) can be maintained.

Life Sciences (LS)

5.1 Describe the role of producers in the transfer of energy entering ecosystems as sunlight to chemical energy through photosynthesis.

5.2 Explain how almost all kinds of animals' food can be traced back to plants.

5.3 Trace the organization of simple food chains and food webs (e.g., producers, herbivores, carnivores, omnivores and decomposers).
5.4 Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different types of organisms.
5.5 Support how an organism's patterns of behavior are related to the nature of that organism's ecosystem, including the kinds and numbers of other organisms present, the availability of food and resources, and the changing physical characteristics of the ecosystem.
5.6 Analyze how all organisms, including humans, cause changes in their ecosystems and how these changes can be beneficial, neutral or detrimental (e.g., beaver ponds, earthworm burrows, grasshoppers eating plants, people planting and cutting trees and people introducing a new species).

Physical Sciences (PS)
5.2 Trace how thermal energy can transfer from one object to another by conduction.

Science and Technology (ST)
5.1 Investigate positive and negative impacts of human activity and technology on the environment.
5.3 Explain how the solution to one problem may create other problems.

Scientific Inquiry (SI)
5.2 Evaluate observations and measurements made by other people and identify reasons for any discrepancies.
5.3 Use evidence and observations to explain and communicate the results of investigations.
5.5 Identify potential hazards and/or precautions involved in an investigation.
5.6 Explain why results of an experiment are sometimes different (e.g., because of unexpected differences in what is being investigated, unrealized differences in the methods used or in the circumstances in which the investigation was carried out, and because of errors in observations).

Scientific Ways of Knowing (SWK)
5.1 Summarize how conclusions and ideas change as new knowledge is gained.
5.4 Identify how scientists use different kinds of ongoing investigations depending on the questions they are trying to answer (e.g., observations of things or events in nature, data collection and controlled experiments).
5.5 Keep records of investigations and observations that are understandable weeks or months later.

Sixth Grade
Science Standard Correlator

Activity	LS 6.1	LS 6.3	PS 6.2	PS 6.3	PS 6.4	PS 6.8	ST 6.1	ST 6.2	ST 6.3	ST 6.5
Analyzing Stormwater Issues				♦			♦	♦	♦	
Best Management Practices and Pollution Prevention					♦		♦	♦		♦
Bon Voyage to Bad Boating Habits							♦	♦		♦
Creative Erosion Control					♦		♦	♦		♦
Designing a Community with Stormwater in Mind							♦	♦		♦
Do Septic Tanks Do the Job?	♦	♦	♦		♦		♦	♦		
Great Debate, The							♦	♦		
Improving Old MacDonald's Farm					♦		♦	♦		♦
Macroinvertebrate Mayhem					♦		♦	♦		♦
Mooving Those Cows					♦			♦		♦
Name that Source					♦		♦	♦		♦
No Place to Run To							♦	♦		♦
Phosphates in Your Water	♦	♦	♦		♦		♦	♦		♦
Pollution Prevention Message, A					♦		♦	♦		♦
School Yard Permeability							♦	♦		♦
Storm Drain Dumping					♦		♦	♦		♦
Superior Car Wash, The								♦		
Topographic Maps										
Uncle Sam Says "Keep It Clean"							♦	♦		♦
Use Your Head, Protect Your Watershed!							♦	♦		
Walking in the Watershed			♦				♦	♦		♦
Water Pollution Detectives			♦		♦	♦	♦	♦		♦
What's Your Decision?								♦		
Whatzzzzup-Stream										
Where Does Pollution Go?	♦	♦			♦			♦		
You be the Judge					♦		♦	♦		♦

Sixth Grade (cont.)
Science Standard Correlator

Activity	SI 6.2	SI 6.3	SWK 6.1	SWK 6.2	SWK 6.3	SWK 6.4
Analyzing Stormwater Issues					♦	♦
Best Management Practices and Pollution Prevention		♦		♦		
Bon Voyage to Bad Boating Habits						
Creative Erosion Control				♦		
Designing a Community with Stormwater in Mind					♦	♦
Do Septic Tanks Do the Job?	♦	♦		♦	♦	♦
Great Debate, The					♦	♦
Improving Old MacDonald's Farm			♦	♦	♦	♦
Macroinvertebrate Mayhem	♦			♦		
Mooving Those Cows			♦		♦	♦
Name that Source					♦	♦
No Place to Run To					♦	♦
Phosphates in Your Water	♦	♦	♦	♦	♦	♦
Pollution Prevention Message, A				♦	♦	♦
School Yard Permeability	♦	♦			♦	♦
Storm Drain Dumping					♦	♦
Superior Car Wash, The					♦	♦
Topographic Maps				♦		
Uncle Sam Says "Keep It Clean"				♦		
Use Your Head, Protect Your Watershed!					♦	♦
Walking in the Watershed			♦	♦		
Water Pollution Detectives					♦	♦
What's Your Decision?					♦	♦
Whatzzzzup-Stream		♦	♦		♦	♦
Where Does Pollution Go?	♦	♦	♦	♦	♦	♦
You be the Judge						

Life Sciences (LS)
6.1 Explain that many of the basic functions of organisms are carried out by or within cells and are similar in all organisms.
6.3 Identify how plant cells differ from animal cells (e.g., cell wall and chloroplasts).

Physical Sciences (PS)
6.2 Describe that in a chemical change new substances are formed with different properties than the original substance (e.g., rusting, burning).
6.3 Describe that in a physical change (e.g., state, shape and size) the chemical properties of a substance remain unchanged.
6.4 Describe that chemical and physical changes occur all around us (e.g., in the human body, cooking and industry).
6.8 Describe how renewable and nonrenewable energy resources can be managed (e.g., fossil fuels, trees and water).

Science and Technology (ST)
6.1 Explain how technology influences the quality of life.
6.2 Explain how decisions about the use of products and systems can result in desirable or undesirable consequences (e.g., social and environmental).
6.3 Describe how automation (e.g., robots) has changed manufacturing including manual labor being replaced by highly-skilled jobs.
6.5 Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

Scientific Inquiry (SI)
6.2 Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations.
6.3 Distinguish between observation and inference.

Scientific Ways of Knowing (SWK)
6.1 Identify that hypotheses are valuable even when they are not supported.
6.2 Describe why it is important to keep clear, thorough and accurate records
6.3 Identify ways scientific thinking is helpful in a variety of everyday settings.
6.4 Describe how the pursuit of scientific knowledge is beneficial for any career and for daily life.

Seventh Grade
Science Standard Correlator

Activity	ESS 7.1	ESS 7.2	ESS 7.3	ESS 7.4	LS 7.2	LS 7.3	LS 7.4	LS 7.5	LS 7.6	LS 7.8	PS 7.1
Analyzing Stormwater Issues				♦		♦		♦	♦		
Best Management Practices and Pollution Prevention				♦		♦		♦	♦		
Bon Voyage to Bad Boating Habits		♦		♦		♦		♦			
Creative Erosion Control				♦		♦		♦	♦		
Designing a Community with Stormwater in Mind		♦		♦		♦	♦	♦			
Do Septic Tanks Do the Job?		♦		♦		♦	♦	♦		♦	
Great Debate, The	♦	♦		♦		♦	♦	♦	♦		
Improving Old MacDonald's Farm	♦	♦		♦		♦	♦	♦			♦
Macroinvertebrate Mayhem					♦	♦		♦	♦		
Mooving Those Cows		♦		♦		♦					
Name that Source				♦		♦	♦	♦			
No Place to Run To		♦	♦	♦		♦	♦	♦	♦		
Phosphates in Your Water	♦	♦		♦		♦	♦	♦	♦		
Pollution Prevention Message, A		♦		♦		♦	♦	♦	♦		
School Yard Permeability		♦	♦			♦	♦	♦	♦		
Storm Drain Dumping		♦		♦		♦	♦				
Superior Car Wash, The		♦		♦		♦					
Topographic Maps											
Uncle Sam Says "Keep It Clean"				♦		♦					
Use Your Head, Protect Your Watershed!				♦		♦	♦	♦			
Walking in the Watershed				♦		♦		♦	♦		
Water Pollution Detectives				♦		♦		♦			
What's Your Decision?		♦		♦		♦					
Whatzzzzup-Stream				♦					♦		
Where Does Pollution Go?	♦	♦	♦	♦		♦	♦	♦	♦		
You be the Judge				♦		♦			♦		

Seventh Grade (cont.)
Science Standard Correlator

Activity	ST 7.1	ST 7.2	ST 7.3	SI 7.2	SI 7.4	SI 7.5	SI 7.6	SI 7.7	SWK 7.1	SWK 7.2
Analyzing Stormwater Issues	♦	♦	♦	♦		♦	♦	♦		
Best Management Practices and Pollution Prevention	♦	♦	♦			♦				
Bon Voyage to Bad Boating Habits	♦		♦					♦		
Creative Erosion Control	♦	♦	♦	♦						
Designing a Community with Stormwater in Mind	♦	♦	♦	♦		♦				
Do Septic Tanks Do the Job?	♦	♦	♦	♦	♦			♦	♦	♦
Great Debate, The	♦	♦	♦	♦		♦	♦			
Improving Old MacDonald's Farm		♦	♦			♦		♦		
Macroinvertebrate Mayhem	♦	♦	♦		♦			♦		
Mooving Those Cows	♦		♦	♦		♦	♦			
Name that Source	♦	♦	♦	♦						
No Place to Run To	♦	♦	♦	♦						
Phosphates in Your Water	♦	♦	♦	♦	♦		♦	♦	♦	♦
Pollution Prevention Message, A	♦	♦	♦	♦			♦			
School Yard Permeability	♦	♦	♦		♦			♦		
Storm Drain Dumping	♦	♦	♦	♦					♦	♦
Superior Car Wash, The	♦									
Topographic Maps								♦		
Uncle Sam Says "Keep It Clean"	♦	♦	♦	♦						
Use Your Head, Protect Your Watershed!		♦	♦					♦		
Walking in the Watershed	♦	♦	♦	♦		♦	♦	♦		
Water Pollution Detectives	♦	♦	♦							
What's Your Decision?				♦			♦			
Whatzzzzup-Stream										
Where Does Pollution Go?	♦			♦	♦			♦	♦	♦
You be the Judge	♦	♦	♦							

Earth and Space Science (ESS)

7.1 Explain the biogeochemical cycles which move materials between the lithosphere (land), hydrosphere (water) and atmosphere (air).

7.2 Explain that Earth's capacity to absorb and recycle materials naturally (e.g., smoke, smog and sewage) can change the environmental quality depending on the length

of time involved (e.g. global warming).

7.3 Describe the water cycle and explain the transfer of energy between the atmosphere and hydrosphere.

7.4 Analyze data on the availability of fresh water that is essential for life and for most industrial and agricultural processes. Describe how rivers, lakes and groundwater can be depleted or polluted becoming less hospitable to life and even becoming unavailable or unsuitable for life.

Life Sciences (LS)

7.2 Investigate how organisms or populations may interact with one another through symbiotic relationships and how some species have become so adapted to each other that neither could survive without the other (e.g., predator-prey, parasitism, mutualism and commensalism).

7.3 Explain how the number of organisms an ecosystem can support depends on adequate biotic (living) resources (e.g., plants, animals) and abiotic (non-living) resources (e.g., light, water and soil).

7.4 Investigate how overpopulation impacts an ecosystem.

7.5 Explain that some environmental changes occur slowly while others occur rapidly (e.g., forest and pond succession, fires and decomposition).

7.6 Summarize the ways that natural occurrences and human activity affect the transfer of energy in Earth's ecosystems (e.g., fire, hurricanes, roads and oil spills).

7.8 Investigate the great diversity among organisms.

Physical Sciences (PS)

7.1 Investigate how matter can change forms but the total amount of matter remains constant.

Science and Technology (ST)

7.1 Explain how needs, attitudes and values influence the direction of technological development in various cultures.

7.2 Describe how decisions to develop and use technologies often put environmental and economic concerns in direct competition with each other.

7.3 Recognize that science can only answer some questions and technology can only solve some human problems.

Scientific Inquiry (SI)

7.2 Identify simple independent and dependent variables.

7.4 Choose the appropriate tools and instruments and use relevant safety procedures to complete scientific investigations.

7.5 Analyze alternative scientific explanations and predictions and recognize that there may be more than one good way to interpret a given set of data.

7.6 Identify faulty reasoning and statements that go beyond the evidence or misinterpret the evidence.

7.7 Use graphs, tables and charts to study physical phenomena and infer mathematical relationships between variables (e.g., speed and density).

Scientific Ways of Knowing (SWK)

7.1 Show that the reproducibility of results is essential to reduce bias in scientific investigations.

7.2 Describe how repetition of an experiment may reduce bias.

Eighth Grade
Science Standard Correlator

Activity	ST 8.2	ST 8.3	ST 8.4	SI 8.1	SI 8.2	SI 8.3	SI 8.4	SWK 8.1	SWK 8.2
Analyzing Stormwater Issues	♦		♦						
Best Management Practices and Pollution Prevention	♦	♦				♦		♦	♦
Bon Voyage to Bad Boating Habits									
Creative Erosion Control	♦		♦						
Designing a Community with Stormwater in Mind	♦		♦						
Do Septic Tanks Do the Job?	♦		♦	♦	♦	♦	♦	♦	♦
Great Debate, The	♦								
Improving Old MacDonald's Farm	♦		♦			♦	♦	♦	♦
Macroinvertebrate Mayhem	♦						♦		♦
Mooving Those Cows	♦		♦	♦					
Name that Source	♦		♦						
No Place to Run To	♦		♦			♦			
Phosphates in Your Water			♦	♦	♦	♦	♦	♦	♦
Pollution Prevention Message, A	♦		♦			♦			
School Yard Permeability				♦		♦	♦	♦	♦
Storm Drain Dumping	♦		♦					♦	
Superior Car Wash, The			♦			♦	♦		♦
Topographic Maps	♦								♦
Uncle Sam Says "Keep It Clean"									
Use Your Head, Protect Your Watershed!	♦								
Walking in the Watershed	♦		♦			♦			♦
Water Pollution Detectives	♦		♦						
What's Your Decision?	♦								
Whatzzzzup-Stream	♦		♦			♦		♦	♦
Where Does Pollution Go?				♦		♦		♦	♦
You be the Judge	♦		♦						

Science and Technology (ST)

8.2 Examine how choices regarding the use of technology are influenced by constraints caused by various unavoidable factors (e.g., geographic location, limited resources, social, political and economic considerations).

8.3 Design and build a product or create a solution to a problem given more than two

constraints (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

8.4 Evaluate the overall effectiveness of a product design or solution.

Scientific Inquiry (SI)

8.1 Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations.

8.2 Describe the concepts of sample size and control and explain how these affect scientific investigations.

8.3 Read, construct and interpret data in various forms produced by self and others in both written and oral form (e.g., tables, charts, maps, graphs, diagrams and symbols).

8.4 Apply appropriate math skills to interpret quantitative data (e.g., mean, median and mode).

Scientific Ways of Knowing (SWK)

8.1 Identify the difference between description (e.g., observation and summary) and explanation (e.g., inference, prediction, significance and importance).

8.2 Explain why it is important to examine data objectively and not let bias affect observations.

Ninth Grade
Science Standard Correlator

Activity	ST 9.1	ST 9.2	ST 9.3	SI 9.1	SI 9.2	SI 9.3	SI 9.4	SI 9.5	SI 9.6	SWK 9.2	SWK 9.3
Analyzing Stormwater Issues	♦	♦									
Best Management Practices & Pollution Prevention		♦	♦					♦			
Biodiversity = Water Quality				♦	♦	♦		♦	♦	♦	♦
Color me a Watershed						♦	♦	♦	♦		♦
Creative Erosion Control		♦	♦		♦	♦		♦	♦	♦	♦
Designing a Community with Stormwater in Mind		♦	♦			♦		♦			
Do Septic Tanks Do the Job?											
Fed Up					♦	♦	♦	♦	♦	♦	♦
Great Debate, The	♦	♦		♦		♦		♦			
Name that Source											
No Place to Run To			♦			♦					
Pesky Pesticides	♦				♦						
Pollution Prevention Message, A		♦						♦			
Uncle Sam Says "Keep It Clean"											
Walking in the Watershed	♦			♦	♦			♦	♦		
You be the Judge											

Science and Technology (ST)
9.1 Describe means of comparing the benefits with the risks of technology and how science can inform public policy.
9.2 Identify a problem or need, propose designs and choose among alternative solutions for the problem.
9.3 Explain why a design should be continually assessed and the ideas of the design should be tested, adapted and refined.

Scientific Inquiry (SI)
9.1 Distinguish between observations and inferences given a scientific situation.
9.2 Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g., OSHA, Material Safety Data Sheets [MSDS], eyewash, goggles and ventilation).
9.3 Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts.
9.4 Decide what degree of precision based on the data is adequate and round off the results of calculator operations to the proper number of significant figures to reasonably reflect those of the inputs.

9.5 Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology.
9.6 Draw logical conclusions based on scientific knowledge and evidence from investigations.

Scientific Ways of Knowing (SWK)
9.2 Illustrate that the methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigations.
9.3 Demonstrate that reliable scientific evidence improves the ability of scientists to offer accurate predictions.

Tenth Grade
Science Standard Correlator

Activity	ESS 10.5	ESS 10.6	LS 10.10	LS 10.12	LS 10.15	LS 10.16	LS 10.18	LS 10.19	ST 10.2	ST 10.3
Analyzing Stormwater Issues	♦	♦					♦	♦		
Best Management Practices & Pollution Prevention	♦							♦		♦
Biodiversity = Water Quality	♦	♦		♦	♦	♦				
Color me a Watershed	♦						♦	♦		
Creative Erosion Control	♦						♦	♦		♦
Designing a Community with Stormwater in Mind	♦						♦	♦		♦
Do Septic Tanks Do the Job?										
Fed Up	♦	♦	♦		♦		♦	♦		
Great Debate, The	♦	♦			♦		♦	♦		
Name that Source	♦						♦			
No Place to Run To	♦						♦	♦		
Pesky Pesticides	♦	♦					♦	♦	♦	
Pollution Prevention Message, A	♦						♦	♦		
Uncle Sam Says “Keep It Clean”								♦		
Walking in the Watershed	♦				♦		♦	♦		
You be the Judge	♦	♦					♦			

Tenth Grade (cont.)
Science Standard Correlator

Activity	SI 10.1	SI 10.2	SI 10.3	SI 10.4	SI 10.5	SWK 10.2
Analyzing Stormwater Issues						
Best Management Practices & Pollution Prevention						
Biodiversity = Water Quality	♦	♦	♦	♦	♦	♦
Color me a Watershed		♦		♦	♦	
Creative Erosion Control	♦	♦	♦	♦		
Designing a Community with Stormwater in Mind		♦				
Do Septic Tanks Do the Job?						
Fed Up	♦	♦	♦	♦		
Great Debate, The		♦				♦
Name that Source						
No Place to Run To						
Pesky Pesticides	♦					
Pollution Prevention Message, A		♦				
Uncle Sam Says "Keep It Clean"						
Walking in the Watershed	♦	♦		♦		
You be the Judge						

Earth and Space Sciences (ESS)

10.5 Explain how the acquisition and use of resources, urban growth and waste disposal can accelerate natural change and impact the quality of life.

10.6 Describe ways that human activity can alter biogeochemical cycles (e.g., carbon and nitrogen cycles) as well as food webs and energy pyramids (e.g., pest control, legume rotation crops vs. chemical fertilizers).

Life Sciences (LS)

10.10 Describe how cells and organisms acquire and release energy (photosynthesis, chemosynthesis, cellular respiration and fermentation).

10.12 Describe that biological classification represents how organisms are related with species being the most fundamental unit of the classification system. Relate how biologists arrange organisms into a hierarchy of groups and subgroups based on similarities and differences that reflect their evolutionary relationships.

10.15 Explain how living things interact with biotic and abiotic components of the environment (e.g., predation, competition, natural disasters and weather).

10.16 Relate how distribution and abundance of organisms and populations in ecosystems

are limited by the ability of the ecosystem to recycle materials and the availability of matter, space and energy.

10.18 Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying capacity.

10.19 Illustrate how uses of resources at local, state, regional, national, and global levels have affected the quality of life (e.g., energy production and sustainable vs. nonsustainable agriculture).

Science and Technology (ST)

10.2 Describe examples of scientific advances and emerging technologies and how they may impact society.

10.3 Explain that when evaluating a design for a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced and disposed of in addition to who will sell, operate and take care of it. Explain how the costs associated with these considerations may introduce additional constraints on the design.

Scientific Inquiry (SI)

10.1 Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g. OSHA, MSDS, eyewash, goggles and ventilation).

10.2 Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology.

10.3 Use mathematical models to predict and analyze natural phenomena.

10.4 Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.

10.5 Explain how new scientific data can cause any existing scientific explanation to be supported, revised or rejected.

Scientific Ways of Knowing (SWK)

10.2 Describe that scientists may disagree about explanations of phenomena, about interpretation of data or about the value of rival theories, but they do agree that questioning, response to criticism and open communication are integral to the process of science.

Eleventh Grade
Science Standard Correlator

Activity	ESS 11.11	ESS 11.12	ESS 11.13	ESS 11.14	LS 11.5	LS 11.6	LS 11.7	LS 11.8	LS 11.9	LS 11.11
Analyzing Stormwater Issues	♦		♦	♦					♦	♦
Best Management Practices & Pollution Prevention	♦		♦	♦					♦	♦
Biodiversity = Water Quality			♦		♦	♦	♦			♦
Color me a Watershed			♦		♦				♦	♦
Creative Erosion Control	♦		♦						♦	♦
Designing a Community with Stormwater in Mind	♦		♦						♦	♦
Do Septic Tanks Do the Job?										
Fed Up	♦		♦				♦	♦		♦
Great Debate, The	♦	♦	♦	♦	♦					
Name that Source	♦		♦						♦	♦
No Place to Run To	♦		♦						♦	
Pesky Pesticides	♦		♦		♦				♦	♦
Pollution Prevention Message, A	♦		♦						♦	♦
Uncle Sam Says “Keep It Clean”			♦	♦						♦
Walking in the Watershed	♦	♦	♦		♦				♦	♦
You be the Judge			♦							♦

Eleventh Grade (cont.)
Science Standard Correlator

Activity	ST 11.2	ST 11.3	ST 11.4	ST 11.5	SI 11.1	SI 11.2	SI 11.3	SI 11.4	SI 11.5
Analyzing Stormwater Issues									
Best Management Practices & Pollution Prevention									
Biodiversity = Water Quality					♦	♦	♦	♦	♦
Color me a Watershed						♦			♦
Creative Erosion Control		♦			♦		♦		♦
Designing a Community with Stormwater in Mind	♦								
Do Septic Tanks Do the Job?									
Fed Up					♦		♦	♦	♦
Great Debate, The	♦	♦			♦				
Name that Source									
No Place to Run To					♦		♦		♦
Pesky Pesticides	♦								
Pollution Prevention Message, A									
Uncle Sam Says "Keep It Clean"			♦						
Walking in the Watershed	♦		♦	♦					♦
You be the Judge	♦								

Eleventh Grade (cont.)
Science Standard Correlator

Activity	SWK 11.1	SWK 11.2	SWK 11.5	SWK 11.8	SWK 11.9	SWK 11.10
Analyzing Stormwater Issues					♦	♦
Best Management Practices & Pollution Prevention				♦		♦
Biodiversity = Water Quality	♦	♦				
Color me a Watershed	♦					
Creative Erosion Control		♦		♦		
Designing a Community with Stormwater in Mind						♦
Do Septic Tanks Do the Job?						
Fed Up	♦	♦				
Great Debate, The			♦		♦	♦
Name that Source						
No Place to Run To	♦				♦	
Pesky Pesticides				♦	♦	♦
Pollution Prevention Message, A			♦			♦
Uncle Sam Says "Keep It Clean"			♦			
Walking in the Watershed		♦	♦		♦	♦
You be the Judge						

Earth and Space Sciences (ESS)
11.11 Analyze how materials from human societies (e.g., radioactive waste and air pollution) affect both physical and chemical cycles of Earth.
11.12 Explain ways in which humans have had a major effect on other species (e.g., the influence of humans on other organisms occurs through land use, which decreases space available to other species and pollution, which changes the chemical composition of air, soil and water).
11.13 Explain how human behavior affects the basic processes of natural ecosystems and the quality of the atmosphere, hydrosphere and lithosphere.
11.14 Conclude that Earth has finite resources and explain that humans deplete some resources faster than they can be renewed.

Life Sciences (LS)
11.5 Investigate the impact on the structure and stability of ecosystems due to changes in their biotic and abiotic components as a result of human activity.

11.6 Predict some possible impacts on an ecosystem with the introduction of a non-native species.

11.7 Show how populations can increase through linear or exponential growth with corresponding effects on resource use and environmental pollution.
11.8 Recognize that populations can reach or temporarily exceed the carrying capacity of a given environment. Show that the limitation is not just the availability of space but the number of organisms in relation to resources and the capacity of earth systems to support life.
11.9 Give examples of how human activity can accelerate rates of natural change and can have unforeseen consequences.
11.11 Investigate issues of environmental quality at local, regional, national and global levels such as population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economics, politics and different ways humans view the earth.

Science and Technology (ST)
11.2 Predict how decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment and/or humans.
11.3 Explore and explain any given technology that may have a different value for different groups of people and at different points in time (e.g., new varieties of farm plants and animals have been engineered by manipulating their genetic instructions to reproduce new characteristics).
11.4 Explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges.
11.5 Investigate that all fuels (e.g., fossil, solar and nuclear) have advantages and disadvantages; therefore society must consider the trade-offs among them (e.g., economic costs and environmental impact).

Scientific Inquiry (SI)
11.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
11.2 Evaluate assumptions that have been used in reaching scientific conclusions.
11.3 Design and carry out scientific inquiry (investigation), communicate and critique results through peer review.
11.4 Explain why the methods of an investigation are based on the questions being asked.
11.5 Summarize data and construct a reasonable argument based on those data and other known information.

Scientific Ways of Knowing (SWK)
11.1 Analyze a set of data to derive a hypothesis and apply that hypothesis to a similar phenomenon (e.g., biome data).
11.2 Apply scientific inquiry to evaluate results of scientific investigations, observations, theoretical models and the explanations proposed by other scientists.

11.5 Recognize that bias affects outcomes. People tend to ignore evidence that challenges their beliefs but accept evidence that supports their beliefs. Scientist attempt to avoid bias in their work.
11.8 Explain that the decision to develop a new technology is influenced by societal opinions and demands and by cost benefit considerations.
11.9 Explain how natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society as well as cause risks.
11.10 Describe costs and trade-offs of various hazards - ranging from those with minor risk to a few people, to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.

Twelfth Grade
Science Standard Correlator

Activity	LS 12.8	ST 12.4	SI 12.1	SI 12.2	SI 12.3	SI 12.4	SI 12.5	SWK 12.1	SWK 12.2	SWK 12.4	SWK 12.8
Analyzing Stormwater Issues											
Best Management Practices & Pollution Prevention											♦
Biodiversity = Water Quality			♦		♦		♦		♦	♦	
Color me a Watershed	♦						♦			♦	
Creative Erosion Control			♦	♦	♦		♦		♦		
Designing a Community with Stormwater in Mind											
Do Septic Tanks Do the Job?											
Fed Up			♦	♦	♦	♦	♦		♦	♦	
Great Debate, The		♦						♦			♦
Name that Source											
No Place to Run To			♦				♦			♦	
Pesky Pesticides					♦						
Pollution Prevention Message, A											
Uncle Sam Says "Keep It Clean"		♦						♦			
Walking in the Watershed	♦	♦			♦		♦	♦			
You be the Judge											♦

Life Sciences (LS)
12.8 Based on the structure and stability of ecosystems and their nonliving components, predict the biotic and abiotic changes in such systems when disturbed (e.g. introduction of non-native species, climatic change, etc.).

Science and Technology (ST)
12.4 Explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges.

Scientific Inquiry (SI)
12.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
12.2 Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).

12.3 Research and apply appropriate safety precautions when designing and/or conducting scientific investigations (e.g., OSHA, MSDS, eyewash, goggles and ventilation).
12.4 Create and clarify the method, procedures, controls and variables in complex scientific investigations.
12.5 Use appropriate summary statistics to analyze and describe data.

Scientific Ways of Knowing (SWK)
12.1 Give examples that show how science is a social endeavor in which scientists share their knowledge with the expectation that it will be challenged continuously by the scientific community and others.
12.2 Evaluate scientific investigations by reviewing current scientific knowledge and the experimental procedures used, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence and suggesting alternative explanations for the same observations.
12.4 Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator-prey relationships and properties of semiconductors).
12.8 Recognize that individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them.

Glossary

Absorb: To take something in through pores or interstices.
Absorption Field (Drain Field): Area where effluent from a septic tank is discharged.
Aerobic: An oxygen-dependant organism.
Agriculture: The science and business of cultivating soil, producing crops, and raising livestock; farming.
Algae: Simple rootless plants that grow in bodies of water in relative proportion to the amount of nutrients available.
Algal Bloom: A condition which occurs when excessive nutrient levels and other physical and chemical conditions facilitate rapid growth of algae. Algal blooms may cause changes in water color. The decay of the algal bloom may reduce dissolved oxygen levels in the water killing some aquatic organisms.
Ammonia: A colorless, pungent gas (NH_3) extensively used to manufacture fertilizers and a wide variety of nitrogen-containing organic and inorganic chemicals.
Anaerobic: An organism, such as a bacterium, that can live in the absence of atmospheric oxygen.
Bacteria: A single-celled or non-cellular spherical or spiral or rod-shaped organisms lacking chlorophyll that reproduce by fission; important as pathogens and for biochemical properties.
Bacterial Water Pollution: The introduction of unwanted bacteria into a body of water.
Best Management Practices (BMPs): Techniques that are determined to be currently effective, practical means of preventing or reducing pollutants from point or nonpoint sources, in order to protect water quality. BMPs include, but are not limited to: structural and nonstructural controls, operation and maintenance procedures and other practices. Usually BMPs are applied as a system of practices rather than as a single practice.
Biodegradable: Capable of being decomposed (broken down) by natural biological processes.
Biodiversity: The number of different varieties of life forms in a given area, or an index derived from this number.
Biomagnification: The increase in concentration of pollutants as it moves up the food chain.
Bioretention Filter: A water quality and water quantity control practice that incorporates plants, microbes and soils to aid in the removal of pollutants from storm water runoff.
Buffer Zones: An area of vegetation that lessens the impact of rainwater runoff, usually found between a developed area and a stream or river.
Capillary Action: A phenomenon associated with surface tension and resulting in the elevation or depression of liquids in capillaries.
Catalog Units: The smallest watersheds defined in the USGS watershed classification system.
Clay: A sedimentary material with grains smaller than 0.002 millimeters in diameter.
Community: A group of people living in the same locality and under the same government or the district or locality in which such a group lives.
Compacted: Closely and firmly united or packed together; dense.
Compost Filter Berm (or Blanket): Sediment trapping device using compost or mulch piled in a triangular-shaped dike (2 width: 1 height ratio). They are designed to trap

sediment by allowing water to pond behind the berm to settle out sediment and filtering water that passes through the berm.
Concentration: The amount of a specified substance in a unit amount of another substance.
Conservation: The wise use of natural resources to avoid wasting naturally occurring resources or using them up completely.
Conserve: To protect something from becoming overused or lost all together.
Contaminant: A substance that makes something impure or polluted.
Continental Divide: A series of mountain ridges extending from Alaska to Mexico that forms the watersheds of North America. Most of it runs along peaks of the Rocky Mountains and is often called the *Great Divide* in the United States.
Contour Line: A line on a map that joins points of equal elevation.
Contour Map: A map that shows the elevation of landforms using contour lines.
Control (experimental): A standard of comparison for checking or verifying the results of an experiment.
Deforestation: To cut down and clear away the trees or forests from an area.
Dilution: The reduction in the strength of a liquid by mixing it with an appropriate amount of water.
Discharge: To relieve or unload of contents as in to discharge from a pipe.
Dissolve: To make a solution of a substance by mixing with a liquid.
Dissolved Oxygen (DO): Oxygen that is suspended in water.
Drain Field: see Absorption Field.
Drainage Basin: An area drained by a river system.
Ecosystem: An ecological community together with its environment, functioning as a unit.
Effluent: Treated wastewater, flowing from a lagoon, tank, treatment process or treatment plant released into the environment.
Environment: The combination of external physical conditions that affect and influence the growth, development, and survival of organisms.
Environmental Issue: A problem or its solution about the environment in which differing beliefs and values exist.
Environmental Problem: An environmental condition in which the status of someone or something is at risk.
Environmentally Responsible: To act in such a way as to save natural resources while still performing everyday tasks. (i.e., using recycled or recyclable building materials, fuel efficient vehicles or sustainable materials.)
Erosion: The wearing away of Earth's surface by running water, wind, ice or other geological agents.
Eutrophic: Water high in nutrients.
Eutrophication: Having water rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.
Evapotranspiration: The combination of water that is transpired by plants as a part of their metabolic processes and evaporated.
Evaporation: To change from a liquid into a vapor or gas.

Facultative Organism: Organism that prefers good stream quality but can survive polluted conditions.
Fecal Coliform Bacteria: A type of coliform bacteria found in the intestines of humans and warm-blooded animals that aids in the digestion process. It is used as an indicator of fecal contamination and/or possible presence of pathogens.
Fertilizer: Natural and synthetic materials including manure, nitrogen, phosphorus and treated sewage sludge that are worked into the soil to provide nutrients and increase the fertility.
Filtration: The process of removing impurities from a substance.
First-Order Stream: The smallest streams in a watershed with no tributaries.
Flow: To move or progress freely as if in a stream.
Food Chain: An arrangement of the organisms in an ecological community according to the order of predation in which each uses the next as a food source.
Forestry: The science and art of cultivating, maintaining and developing forests or the management of a forestland.
Fungicide: Any substance used to kill fungus.
Geographic Information System (GIS): A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface.
Geotextile: A woven or non-woven, water permeable fabric generally made of synthetics such as polypropylene, used to capture sediment before it leaves a construction site.
Ground Cover: Any plant or material used to protect loose exposed soil.
Ground Water: Water beneath the earth's surface, often between saturated soil and rock that supplies wells and springs.
Habitat: The place or type of site where an organism naturally or normally lives and grows.
Hazardous: A material with the potential to cause harm.
Herbicide: Any substance used to kill plants.
Household Hazardous Waste: Any product found in the home or garage that can be hazardous to the environment if not disposed of correctly. Examples of household hazardous waste include cleaning solutions, pesticides, pool chemicals, motor oil, antifreeze or used batteries.
Hydrologist: A person who studies the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.
Impermeable: Not easily penetrated. The property of a material or soil that does not allow, or allows with great difficulty, the movement or passage of water.
Impervious Surface: A surface incapable of being penetrated.
Indicator Organism: An organism whose presence or absence typically indicates or provides information on the certain conditions within its environment.
Insecticide: Any substance used to kill insects.
Inference (Infer): The act or process of deriving logical conclusions from premises known or assumed to be true.
Infiltrate: To permeate a substance by passing through its interstices or pores.
Integrated Pest Management (IPM): An ecologically based pest-control strategy that relies on natural mortality factors, such as natural enemies, weather, cultural control methods and carefully applied doses of pesticides to extinguish pests.

Intolerant Organism: An organism sensitive to changes in stream conditions brought about by pollutants.
Land Use Plan: A plan outlining how a particular area of land will be used.
Landslide: The downward sliding of a relatively dry mass of earth and rock.
Landmarks: A prominent identifying feature of a landscape.
Lake: A standing body of water that undergoes thermal stratification and turnover by mixing.
Litter: Rubbish carelessly dropped or left about (especially in public places).
Liquid: A free flowing substance that borrows the shape of its container.
Low-Impact Development: Urban and suburban development that uses practices designed to reduce the negative impact new construction has on the environment.
Macroinvertebrate: Organism that lacks an internal skeleton and is large enough to be seen with the naked eye.
Map: A representation, usually on a plane surface, of a region of the earth or heavens.
Marina: A boat basin that has docks, moorings, supplies, and other facilities for small boats.
Mining: The process of excavating the earth and extracting a valuable substance.
Mixture: Two or more substances mixed together in such a way that each remains unchanged (sand and sugar form a mixture).
Mouth (River): A natural opening, as the part of a stream or river that empties into a larger body of water or the entrance to a harbor, canyon, valley or cave.
Nonpoint Source Pollution: Pollution that cannot be traced to single point because it comes from many individual places or over a widespread area.
Nitrogen (Nitrate): A nonmetallic element that constitutes nearly four-fifths of the air by volume, occurring as a colorless, odorless, almost inert diatomic gas (N_2) in various minerals and in all proteins and used in a wide variety of important manufactures, including ammonia, nitric acid, TNT and fertilizers. Atomic number 7; atomic weight 14.0067; melting point -209.86°C; boiling point -195.8°C; valence 3, 5.
Nutrient: A source of nourishment or a substance a living organism needs to survive.
Nutrient Pollution: A nourishing contamination that causes unwanted plant growth.
Oligotrophic: Water low in nutrients.
Organic Cover: A protective shield of living material over top of otherwise bare soil.
Organic Matter: Relating to living matter.
Particulate Matter: Very minute or small pieces of a substance.
Percolation: The downward movement of water through the subsurface soil layers to groundwater.
Percometer: An instrument to measure the rate of percolation.
Permanent Seeding: The establishment of a dense perennial turf vegetation or groundcover.
Permeable: Capable of transmitting water or air (porous).
Perspective: A mental view or outlook.
Pesticide: Any substance used to kill an organism considered to be a pest. Pesticides include but are not limited to insecticides, fungicides and herbicides.
Phasing: To carry out construction systematically in stages usually in order to mitigate disruption of the normal functioning of the building site while construction work is in progress.

Phosphorus (Phosphate): A highly reactive, poisonous, nonmetallic element occurring naturally in phosphates. An essential constituent of protoplasm, it is used in safety matches, pyrotechnics, incendiary shells and fertilizers and to protect metal surfaces from corrosion. Atomic number 15; atomic weight 30.9738; melting point (white) 44.1°C; boiling point 280°C; specific gravity (white) 1.82; valence 3, 5.
Point Source Pollution: Pollution that can be traced to a single point source, such as a pipe or culvert.
Pollution: An unwanted change in air, water or soil (usually through the introduction of pollutants or contaminants) that can affect the health and survival of humans and other organisms.
Pollution Prevention: Preventing the creation of pollutants or reducing the amount created at the source of generation, as well as protecting natural resources through conservation or increased efficiency in the use of energy, water or other materials.
Pollution Tolerant: Being able to withstand a particular amount of pollution. Different organisms have different levels of pollution tolerance.
Pollution Intolerant: Being unable to withstand a small amount of pollution in the environment.
Pond: A still body of water smaller than a lake where mixing of nutrients and water occurs primarily through the action of wind.
Precipitation: Any form of water, such as rain, snow, sleet, or hail that falls to the earth's surface.
Recycle: To extract and reuse useful substances found in waste.
Riffle: Fast moving area in a stream. Usually small waves or rocks break the surface. The slope of a streambed is steeper in riffles than it is in open pools, where the water surface tends to be smoother.
Riparian Corridor: Vegetation along the banks of a stream or river.
River: A large body of flowing water that receives water from other streams and/or rivers.
Rodenticide: Any substance used to kill rodents.
Runoff: Water (originating as precipitation) that flows across surfaces rather than soaking in eventually entering a water body. Runoff may pick up and carry a variety of pollutants.
Sand: A sedimentary material, finer than a granule and coarser than silt, with grains between 0.06 and 2.0 millimeters in diameter.
Second-Order Stream: A stream formed when two first order streams meet.
Sediment: Solid fragments of inorganic or organic materials that come from the weathering of rock and are carried and deposited by wind, water or ice.
Sediment Basin: A man-made basin or intentional ponding area designed to hold storm water for a period of time to allow sediment and other suspended material to settle. The water eventually flows out of the basin to downstream waterways, evaporates into the atmosphere or infiltrates the ground.
Sediment Control: Using BMPs to prevent sediment from leaving area i.e. construction sites
Sedimentation: The accumulation of geological or organic material deposited by air, water or ice.
Septic System: On-site equipment or system to treat wastewater, consisting of a septic tank and an absorption field.

Septic Tank: A tank, commonly buried, to which all of the wastewaters from the home should flow and in which, primary digestion of the organic matter occurs by anaerobic bacteria.
Sewage: Waste and wastewater produced by residential, commercial and light industrial establishment; typically discharged into sewers and sometimes into septic tanks.
Silt: A type of soil consisting of very fine particles intermediate in size between sand and clay.
Silt Fence: A temporary barrier used to intercept sediment-laden runoff from small areas
Slope: An inclined line, surface, plane, position or direction.
Sludge: Solid material that isn't broken down by bacterial digestion which settles to the bottom of septic tanks or wastewater treatment plants. It must be pumped out and disposed of in landfills, application to land or by incineration.
Soil: The layer of minerals and organic matter, in thickness from centimeters to a meter or more, on the land surface. Its main components are rock and mineral matter, organic matter, water and air. Soils differ in the ratio of these components. Air, trapped in spaces between the various particles and water, trapped in spaces and on the surface of particles, can comprise up to half of the soil by volume.
Source (River): The place where a river begins.
Solution: When one matter dissolves into another. More difficult to separate than a mixture.
Storm Drain: Any inlet to an underground sewer system designed to transport storm water.
Storm Drain Labeling: The act of gluing labels that state, "Dump No Waste Drains to _____ Watershed," onto storm drains to educate residents not to dump waste products into storm drains. For more information, contact the Hamilton County Soil and Water Conservation District.
Storm Water: Precipitation from rain or snow, usually in large quantities, that drains to a sewer system or natural water body.
Stream: A flow of water in a channel or bed, as a brook, rivulet or small river.
Surface Water: Any water found above ground such as lakes, rivers or ponds.
Suspension: A system in which particles are dispersed throughout a less dense liquid or gas from which they are easily filtered but not easily settled because of system viscosity or molecular interactions.
Temporary Seeding: Provides erosion control on areas in between construction operations. Grasses that are quick growing are seeded and usually mulched to provide prompt, temporary soil stabilization.
Thermal Pollution: Varying temperatures above or below the normal condition (e.g., a power plant turbine heated water).
Third-Order Stream: A stream formed when two-second order streams merge.
Tolerant Organisms: Organisms that thrive in polluted conditions.
Topographic Maps: A map that shows the elevation of landforms using contour lines.
Toxic Pollution: Pollution capable of causing injury or death.
Transect: To divide by cutting transversely.
Transpiration: The act or process of transpiring, especially through the stomata of plant tissue or the pores of the skin.

Tributary: A stream that flows into a larger stream or other body of water.
Turbidity: Having sediment or foreign particles stirred up or suspended; muddy.
Uncontaminated: Free from admixture with noxious elements; clean.
Urban Area: An area that is highly populated, such as a city or town.
Urban Planner: An individual who plans and designs the future uses and activities of a city.
Urban Storm Water Runoff: Road salt, soil, lawn and garden chemicals and pet wastes travel via streets and storm drains to nearby rivers, lakes and ponds.
Water Pollution: Degradation of a body of water by a substance or condition to such a degree that the water fails to meet specified standards or cannot be used for a specific purpose.
Water Quality Criteria: Levels of water quality needed to support a designated use for a body of water, usually expressed as concentration values for specific chemicals.
Water Quality: A measure of the usefulness of water, both to humans and as an aquatic environment.
Wastewater: Water that has been used for domestic or industrial purposes.
Wastewater Treatment Plant: A facility that receives wastewater (and sometimes runoff) from domestic and/or industrial sources, and by a combination of physical, chemical, and biological processes reduces (treats) the wastewater to less harmful byproducts.
Watershed: An area of land from which all the water drains to the same location such as a stream, pond, lake, river, wetland or estuary. It can be large, like the Mississippi River drainage basin, or very small, such as the 40 acres that drain to a farm pond. Large watersheds are often called basins and contain many smaller watersheds.
Wetland: A lowland area, such as a marsh or swamp, which is saturated with moisture, especially when regarded as the natural habitat of wildlife.