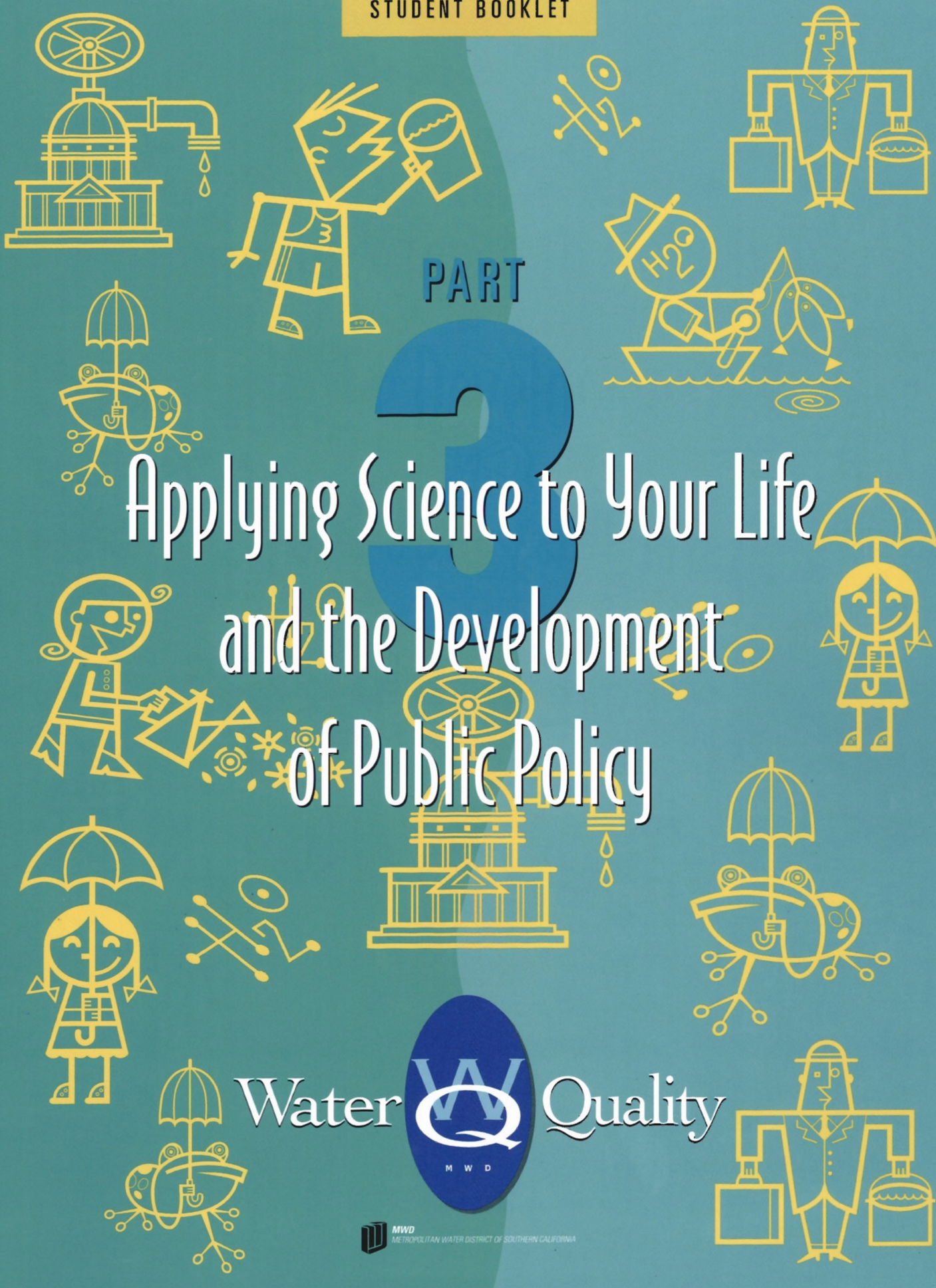
STUDENT BOOKLET



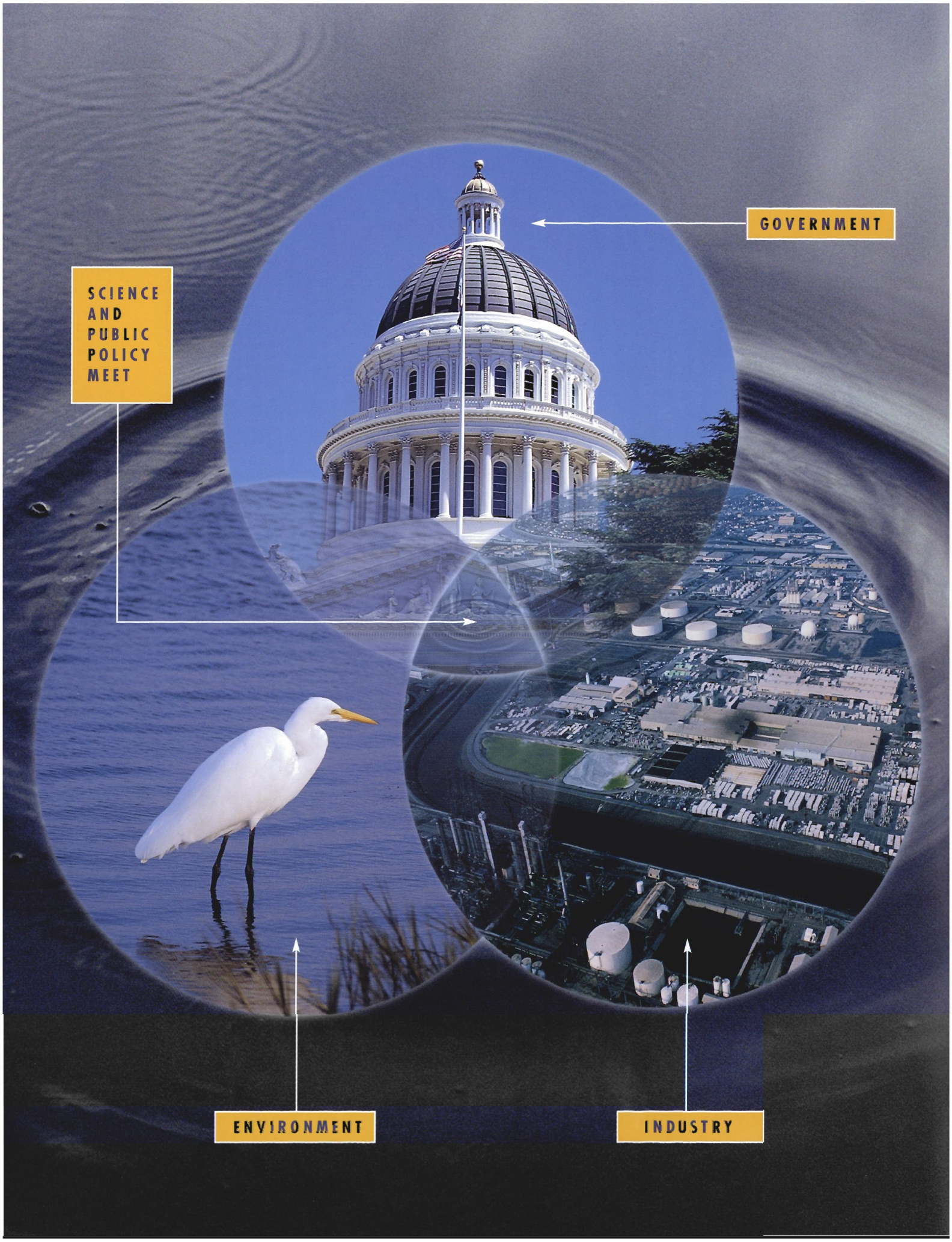
PART 3

Applying Science to Your Life and the Development of Public Policy

Water Quality

MWD

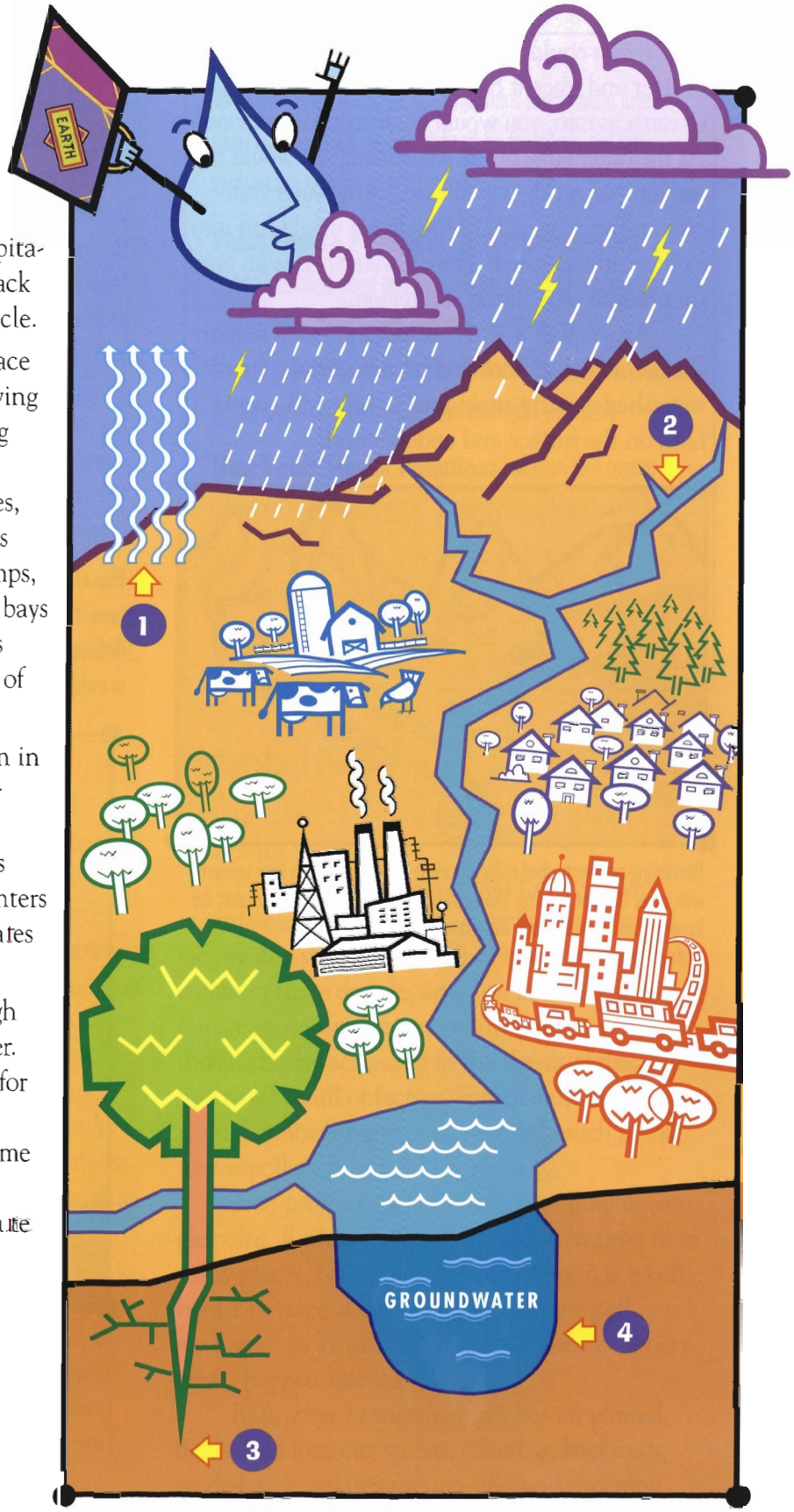
MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA


GOVERNMENT
SCIENCE AND PUBLIC POLICY MEET
ENVIRONMENT
INDUSTRY

Watersheds and the Environment

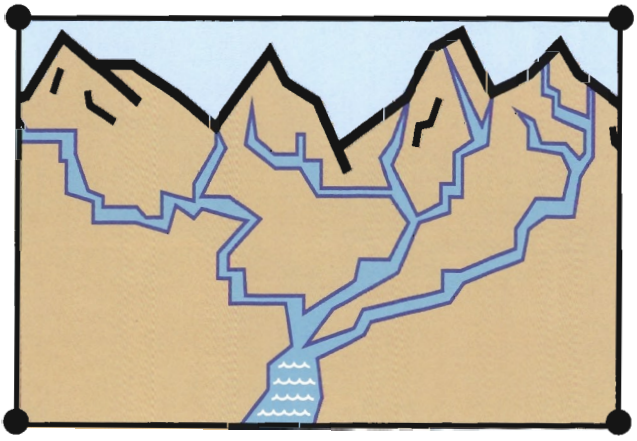
When a drop of rain falls on land, it can take one of four paths:

1. It can evaporate back into the atmosphere. In arid regions, as much as 80 percent of the precipitation takes this short-cut route back to the beginning of the water cycle.
2. It can run across the earth's surface until it meets up with other flowing water. This runoff can flow along curbs, streets, sidewalks, playgrounds, parking lots, golf courses, fields, forests and deserts. It flows into creeks, streams, rivers, swamps, wetlands, marshes, ponds, lakes, bays and oceans. This surface water is vitally important to the survival of every living creature.
3. It can soak into soil and be taken in by the roots of plants. The water taken in by plants nourishes the plants with its dissolved minerals and nutrients. Then the water enters the leaves. From there it evaporates and returns to the atmosphere.
4. It can seep, or "percolate," through soil where it becomes groundwater. Some groundwater can be stored for centuries in aquifers, which are underground pockets of water. Some of the groundwater will seep out through springs and follow the route of #2.



If you could take every drop of water in a lake or river and trace it back to the spot where it fell to earth as rain, you would be defining a *watershed.* At the outer edge of the watershed, you would be standing on a ridge or "divide." Any water that falls on the other side of the divide would run into a different watershed. Thus, a watershed is an area that "drains" the runoff of a region.

As you will discover in the following sections, the natural conditions and human activity in a watershed directly affect the quality of the water both on the surface and underground.

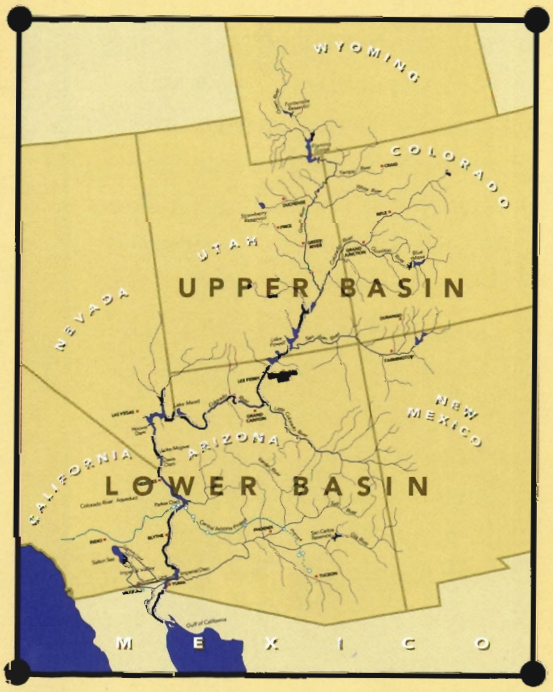


Rain falling on a watershed collects in rivers or streams, which then connect with larger rivers or streams. The small flows represent small watersheds; the large river represents a large watershed.

THINK ABOUT THIS: JOHN WESLEY POWELL AND BOUNDARIES

Before the political boundaries for many states were drawn, explorer John Wesley Powell made a recommendation that fell on deaf ears. He reasoned that the lack of water in the arid West would cause tension. So he suggested that state boundaries be drawn around watersheds rather than along lines of latitude/longitude or along rivers. (If a river defines a political boundary, the two political entities share the watershed.) He thought that if one political body governed the whole watershed, it could distribute the water more fairly and take care of the water resources more wisely.

The ridges above the rivers define major watersheds (see the map below). What "states" would be defined by these natural boundaries? How many would there be?



Water Quality and Watersheds

The conditions that affect water quality in a watershed are both natural and human-made.

Natural Conditions

Areas covered with trees, shrubs and grasses soak up water. Then the spongy soil under the vegetation releases it gradually. The runoff is slow and steady throughout the seasons.

Bare or rocky landscapes, or those that have hard-packed soils such as clay, allow water to run off more quickly. These bare and hard surfaces often cause flash floods. The rapid runoff causes erosion and carries sediment into streams and rivers. This sediment makes the water cloudy or turbid. In addition, such landscapes create a "feast or famine" condition. Floods follow heavy rainfall, but the streams run low, or even dry up, in between rains.

Human-Made Conditions

Human activities can interact with natural processes in many ways. For example, cutting down a forest on a hillside changes conditions downstream. Runoff flows faster, carries more sediment after rains and is less constant between rains. Plants and animals may need the water the way it once was: a clear, cool stream with a constant flow of fresh water. They may have trouble adjusting to the increased muddiness of the water. The eroded hillside will also cause more extreme cycles of high and low flow. The plants and animals may need the more steady flow that drains off a forested hillside.

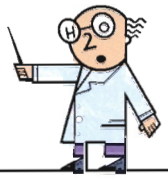
What happens if we cover a meadow with a parking lot? Pavement is "impermeable," so water cannot seep through it. The storm runoff will be more severe. In addition, it will carry substances such as motor oil, grease, gasoline, rubber, metal and paint. These substances create a serious and complex human problem: pollution.

DEFINITIONS

Watershed: A land region that drains precipitation into a lake, river or ocean, usually defined by the ridges and lowlands in the area.

Point Source Pollution: Pollution that comes from a clearly identified point and that can be traced to a particular pipe or ditch. Point source pollution usually enters the water in large quantities and is usually produced by an industry or by disasters, such as a train crash that spills chemicals.

Non-Point Source Pollution: Pollution that cannot be traced to a single source, but that comes from low quantities of pollutants scattered over a watershed, such as pollution that comes from automobiles, roadways and farms.



Watershed Pollution

Pollution has two forms: point source and non-point source.

Point source pollution comes from a single identifiable place, such as a pipe flowing out of a factory or a sewage drain. This sort of pollution was common three decades ago. You could see raw sewage spewing from an outflow pipe or a river turning colors according to the dye used that day in a nearby mill or factory. Fortunately, environmental controls have greatly reduced such point source pollution in the U.S. today.

Non-point source pollution comes from no single point. Rather, it comes in small quantities from many places. Non-point source pollution is much harder to trace and prevent because the polluters are harder to identify. Non-point source pollution might happen like this:

Rainwater or snowmelt washes off plowed fields, feed lots, city streets, suburban backyards, eroded areas at construction sites and shopping

mall parking lots. The runoff picks up sediment, nutrients (fertilizers), contaminants and toxins (herbicides and pesticides), and bacteria and viruses (from stormwater drains, septic systems, livestock pens, wildlife and boats). Some of these pollutants and microorganisms seep through the soil into the groundwater; some wash into rivers, lakes, wetlands and coastal waters. As a rule, one person's pollution doesn't cause too much damage, but the pollution from many people accumulates into a major pollution problem.

REGULATING POLLUTION: AN OVERVIEW

In the early 1970s, the Clean Water Act set the goals of keeping our drinking water safe and restoring natural streams, rivers and lakes to a "swimmable and fishable" level of health.

To do so, the Environmental Protection Agency (EPA) took on the obvious culprits: point source polluters. The EPA regulated industries and required a "permit" to release any harmful substances. This permitting process encouraged industries to "pretreat" their waste, keeping most of the pollutants out of the waste stream entirely. Many industries changed their processes so they used fewer toxic chemicals, an approach called "source reduction."

By 1985, the regulation of point source pollution had been successful. People could swim and fish in some waters that were once swirling with toxins and sewage. Fish had returned to lakes and rivers that were once declared "dead." And our drinking water met higher standards than ever.

Still, one-third of our lakes, rivers and harbors fall below standard and are neither fishable nor swimmable. Heavy metals, oils, pesticides, insecticides, sewage and fertilizers still seep into the water. Who is to blame for this pollution? How much tighter must we regulate polluters?

You may think that some industries are still polluting the water and that we need to regulate these industries more strictly. But the EPA studies show that most of the water pollution is not from industry. Instead, it comes from non-point sources: each and every one of us!

To further improve water quality, the EPA started requiring storm runoff permits for cities greater than 100,000. Cities must reduce runoff or treat it before it enters the watershed. In addition, many cities are trying to limit pollution through source reduction – by educating the public about each person's contributions to water pollution. They hope that an educated public will be a responsible public.

WHO ARE THE POLLUTERS OF OUR WATER?

Forty eight percent of households think water pollution is created by industry, but the EPA estimates that more than 90 percent of industries meet federal regulations. Non-point source pollution is now the leading cause of water pollution. The largest contributors to non-point source pollution are:

1. Agriculture and farms account for 72 percent of polluted rivers and 56 percent of polluted lakes. Farm runoff includes pesticides, herbicides, insecticides, fertilizers, animal waste, soil erosion and salts from over-irrigation.

2. Urban and residential pollution includes:
   - oil from motor vehicles;
   - sediment from eroded roadsides and construction sites;
   - organic wastes from improperly maintained septic tanks;
   - salts from road deicing;
   - household and garden products; and
   - fertilizers and pesticides from lawns and golf courses.

3. Ordinary people contribute daily to non-point source pollution:
   - 25 million households use fertilizer, but only 54 percent follow the directions carefully. Most do not know that fertilizer can harm the watershed.
   - 70-80 million households use septic systems, but 50 percent of these homeowners do not know they must maintain their septic system regularly to protect water quality. Poorly maintained septic tanks put 8 billion gallons of waste water into soil and groundwater nationwide.
   - Waste water from private residences is more toxic than waste water from industries. Household waste water contains medicine, cleaning agents, oil, paint and copper (from pipes), etc. Recently renovated houses have the most toxic waste of all.
   - Runoff from streets and parking lots contains lead (from batteries), zinc (from galvanized steel in car bodies), and cadmium (from steel-belted radial tires).
   - Countless people pour used motor oil on the ground or down a storm drain instead of recycling it. A gallon of used motor oil can ruin one million gallons of fresh water. This oil contains heavy metals and organic compounds that can be detected in the water for years and can enter the food chain.[1]

[1]This information was extracted from three publications: "Riverways," a publication of the Riverways Program of the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement, p.3; "Water, Taking a New Track on Non-Point Source Pollution," published by Metropolitan Water District, pp.11-12; and "Texas Protecting the Trinity River," a pamphlet published by the North Central Texas Council of Government's Department of Environmental Resources.

THINK ABOUT THIS: HOW DO THESE CONDITIONS AFFECT WATER QUALITY IN A WATERSHED?

Natural Conditions

- Quantity of rainfall (flooding, erosion, drought)
- Climate (temperature, pattern and type of precipitation)
- Type of soil and vegetation
- Underlying geology (whether rock layers are deep or shallow, permeable or impermeable)
- Topography (hilly, flat)
- Animal populations

Human-Made Conditions

- Development (agricultural, residential, urban, industrial)
- Travel and transportation (roads, bridges)
- Flood control (dams, levees)
- Recreation (swimming, boating, fishing)
- Water resource development (reservoirs, pumping water from lakes, rivers and aquifers)

Building, Polluting and Testing a Watershed

INTRODUCTION

In this activity, you will build a model watershed, observe the flow of water and pollution within it, and try to clean it.

MATERIALS

PART 1: Building a Watershed and Exploring Runoff Patterns

Plastic pan or basin, such as a 10" x 14" plastic food storage container
Crumpled sheets of newspaper
Sheet of thin plastic (such as plastic wrap) to cover the newspaper
Spray bottle full of clean water

PART 2: Experimenting with Different Surface Covers

Small pieces of sponge
Paper towels and tissues

PART 3: Polluting and Testing a Watershed

Food coloring in a dropper bottle
Colored drink powder
A selection of "pollutants" such as food dye in a dropper bottle, colored drink powder, vinegar, cooking oil and dried herbs (to represent organic material)

Getting started

What happens to rainwater as it flows across hills, wetlands, forests, parking lots, golf courses, city streets and backyards?

PART 1: Building a Watershed and Exploring Runoff Patterns

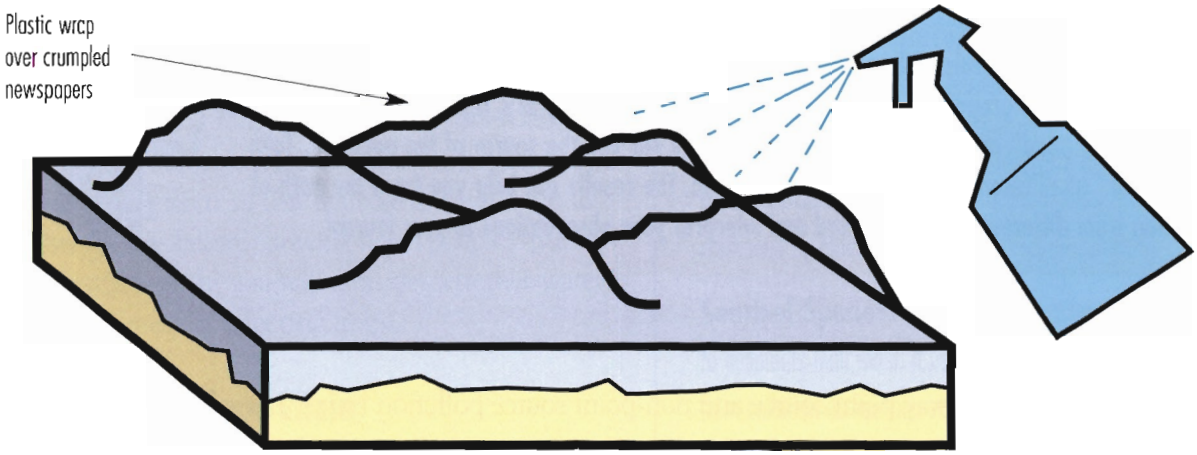
① Crumple up five or six sheets of newspaper and place them in the bottom of the plastic container so they make the shape of hills and valleys.

② Cover the newspaper and line the sides of the plastic container with plastic wrap. Do this step carefully so the newspaper will stay as dry as possible.

③ Fill the spray bottle with water and spray it on the watershed model, creating a model rainstorm.

④ Observe the path of the water as it flows through the watershed. How does it collect in "streams," "ponds" and "marshes?"

⑤ On a piece of paper, draw and/or describe the path of the water in the container, naming the sub-watersheds within the larger watershed.



PART 2: Experimenting with Different Surfaces

NOTE: If you think of your plastic as bedrock, you can add coverings that model soils, trees and plants, changing the behavior of your watershed.

① Think of ways to use the material provided or other easy-to-find materials to make different types of "surface coverage" in the watershed. You may put different surface materials on different parts of the same watershed or make several models with different "landscapes."

② Experiment with the runoff patterns over different surfaces. Does the type of surface change the places the water collects? Does it change the speed of the runoff? Does it change the volume of water that watersheds can absorb?

BECOMING A CIVIL ENGINEER

If the people living in your watershed needed a reliable water supply, where might you want to build a reservoir? Try creating that reservoir by building a dam out of any materials you choose. What qualities within a watershed would make it suitable for a dam and reservoir?

PART 3: Polluting and Testing the Watershed

① Add a drop of food coloring – representing point source pollution – to a single location within the watershed. Add a drop of a different color to another location, and a third drop to a third location.

② Sprinkle tiny bits of colored drink powder at different locations to represent non-point source pollution.

③ Use the spray bottle to create a model rainstorm over the watershed.

④ Observe and describe the paths of the two types of water pollution in the watershed.

⑤ Can you tell the source of the pollution in the streams? The ponds?

⑥ Record your observations in your journal.

TRY THIS: FINDING A SOURCE OF POLLUTION

Food dyes become brownish when they mix, so you can't tell their "source." However, food dyes have different properties, so they spread differently as they dry. Dip a piece of paper towel in a polluted "pond" and let it dry. What you see can tell you the source of the pollution. Take a "dip test" at different locations in the watershed. The results can help you trace the path of pollution from different sources. Record and interpret your observations in your journal.

Talk it over

① Compare the way point source and non-point source pollution travel in a watershed.

② Do you think pollutants are harder to test and treat when they are all mixed up?

③ Might you be able to clean up the pollution in your watershed?

④ In your journal, list all of the contaminants you might find in a typical watershed. Next, list the sources of that contamination. Write a one-page paper answering the question, "Who polluted the water?"

Go further

① Your teacher will provide you with different types of soil: clay, sand and silt.

② Predict and test the speed with which water will move through a watershed containing these different types of soil.

③ If the soil or water contain pollutants, how does the type of soil affect the speed of pollutants moving through the watershed?

Pollutants in the Environment

When pollutants enter a watershed, they may have far-reaching and long-lasting effects. They may damage an ecosystem immediately or in years to come. The effects of this damage may show up in other species before showing up in people. In this application study, you will consider whether water pollution may be affecting frogs.

Toxins in the Food Chain

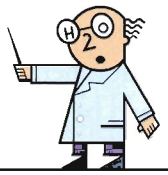
The "food chain" is the process by which the food energy and chemicals in one species are passed on to the species that eat it. Plankton and insects are at the bottom of the food chain, so all higher forms of life depend on them to some degree.

DEFINITIONS

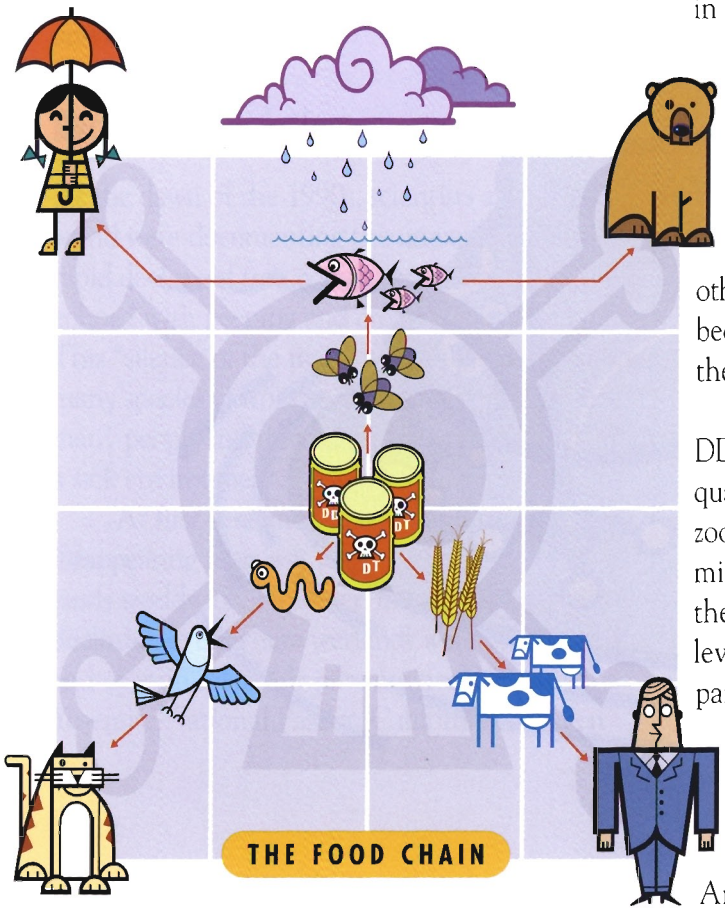
Accumulation/Bioaccumulation: The increasing concentrations of either food energy or pollution in the higher stages of the food chain.

Food Chain: The process of smaller organisms being consumed by other organisms.

Sentinel Species: A species that is more sensitive to pollutants than most. It becomes sick from pollution earlier than others, thus warning others of potential future danger.



If the water is polluted, that pollution starts to move through the food chain. The concentration of toxic chemicals and metals in more complex animals starts to increase.



The Insecticide DDT

The insecticide DDT (dichloro-diphenyl-trichloroethane) was introduced in 1944 to help farmers whose crops were destroyed by locusts and other pests. Most people assumed that DDT would become diluted in the environment and only kill the targeted pests.

Instead, the food chain began to process the DDT. The zooplankton absorbed the DDT in tiny quantities as low as parts per trillion. But as the zooplankton were eaten by the minnows, the minnows by the fish, and the fish by the eagles, the concentration of DDT increased – from levels in the parts per trillion to levels in the parts per million. At that level, the DDT disrupted the formation of calcium in the eggs of eagles, causing the eggs to crush under the bird's own weight. DDT in the food web contributed to the near extinction of America's national symbol, the bald eagle.[1]

[1] Alice Outwater, A Natural History of Water, "Nature's Hydrologists," pp. 150-152. Her source for the concentration of DDT in the food chain was: G. Tyler Miller, Living in the Environment: An Introduction to Environmental Science, 7th ed. (Belmont, Calif.: Wadsworth, 1992).

The Mystery of the Deformed Frogs

Imagine if a school that once teemed with laughing, shouting children were suddenly silent, with no more children living in the neighborhood.

Imagine if another school still had a few children, but 60 percent of them had extra legs, missing legs or other deformities.

The community would be pretty upset! People might want to know if something in the environment were causing these problems. They would be even more concerned if they learned that the same problems were being reported in schools around the world. Some might ask if something were wrong with the worldwide environment.

A Global Warning by a Sentinel Species?

While those problems are not affecting children, they are affecting frogs. And scientists feel that, in a way, frogs are our children, because they are part of our food web and share our environment. If something terrible is happening to them, perhaps we too will soon be in danger.

At one time, coal miners carried canaries with them as carbon monoxide "alarms." Canaries die at low concentrations of carbon monoxide, but the miners still had time to escape. Canaries were "sentinels" or guards. A dying canary was a life-saving warning signal to miners. Are frogs a sentinel species for the rest of our ecosystem, like a canary in a coal mine?

The Sensitive Frog

Just as canaries are more sensitive to carbon monoxide than humans, frogs are more sensitive to water and air pollution. What harms them in low concentrations may eventually harm us as the concentrations climb higher.

Because they are amphibians, frogs spend their lives both in water and on land. Their eggs have no protective shell or membrane, and their skin has no protective fur or scales. Their skin is also porous, allowing frogs to breathe through it. As a result, eggs and tadpoles are vulnerable to pollutants in the water, and full-grown frogs can absorb pollutants in the water, mud, soil and air through their skin. In addition, the increased radiation that reaches earth because of the thinning of the upper ozone layer may damage frogs, tadpoles and eggs.

Declining Populations

At the dawn of the 1990s, scientists around the world were documenting the unexplained and rapid decline of frog populations. Ponds that once echoed with peeping and croaking remained quiet. This "silence of the frogs" was happening to so many species of frogs and in so many places that many people interpreted it as a "wake-up call" from a sick environment.

At first it seemed that a major cause of the disappearing frogs was the disappearance of wetlands worldwide. However, frog populations were declining even where wetlands were still healthy, and even in relatively pure environments such as Yosemite National Park in California. Between 1915 and 1992, seven species of frogs declined in Yosemite, and three have disappeared entirely. Two amphibians that are now rare were once common there: the Yosemite Toad and the Mountain Yellow Legged Frog. Some scientists suspect they might be victims of air pollution such as ozone, dust, smoke, sulfates and nitrates.

One study at a Canadian National Park (Point Pelee, on the northern shore of Lake Erie) linked the decline of frog populations to contamination by pesticides. The investigated area had lost no major wetlands, but it had been sprayed by DDT until 1967. Twenty-five years later, scientists could still measure a byproduct of DDT called DDE in the amphibians there. They took measurements of DDE in frogs at five sites: one that had been exposed to DDT until the 1960s and four others that had not been exposed. Here is what they found:

Concentration of DDE in Frogs in Point Pelee National Park, Canada

	Concentration of DDE in the fat of Green Frogs
Exposed Site (Point Pelee)	5,000 ppm
Unexposed Site 1 (Hillman Marsh)	300 ppm
Unexposed Site 2 (Holiday Beach)	6 ppm
Unexposed Site 3 (Long Point Provincial Park)	250 ppm
Unexposed Site 4 (Rondeau Provincial Park)	100 ppm

Interestingly, only five species of amphibians remain at Point Pelee because several became extinct in the 1970s. In contrast, unexposed sites 3 and 4 have ten and twelve amphibian species respectively.

Review Questions

Use your journal to respond to these questions:

1. What is a sentinel species?
2. What are four reasons why frogs may be extremely vulnerable to pollutants and other environmental changes?

The Plot Thickens

In August 1995, a middle school class in Minnesota was on a field trip when they began catching frogs near a pond and uncovered the first clue of a deepening mystery.

One student showed the teacher a frog with a missing leg. There was no sign of injury, so the teacher assumed it had been born with a defect. Then another student found a frog with a withered leg. Of the 22 frogs collected that morning, 11 had deformed legs. "I think the kids got kind of scared," the teacher said. "They started asking me about the cancer rate in the area."

Soon, a local wildlife biologist and then the Minnesota Pollution Control Agency were on the case. Reports came in from all over the state that deformed frogs were turning up everywhere. By September 1996, the Environmental Protection Agency gathered scientists together to help trace the cause of similar deformities reported nationwide.

So far, scientists are baffled by the sudden and widespread appearance of these deformed frogs. They are also puzzled by the extreme nature of the deformities: missing legs, extra legs, legs that stick out of the body at odd places, legs webbed together with extra skin, legs fused to the body, legs that split in two halfway down. Some frogs had missing eyes. One frog had an eye in its throat. Another had nine legs. In 1995, most of the deformed frogs had extra legs. In 1996, most had missing legs. Habitats with deformed frogs range from the Midwest to Vermont and the Sierra Nevada. In some habitats, 90 percent of the frogs are deformed.

Is It Genetic?

Frogs, like any species, have some naturally occurring inherited genetic defects. But the rate of these defects is normally pretty low. In addition, inherited defects are confined to one species and are not shared by many species.

Some scientists think that the eggs or young tadpoles could be genetically damaged by water pollution or by the increased radiation that results from the thinning ozone layer.

Other Explanations

Other scientists wonder if the parasites that normally live under the skin of frogs have undergone a change that makes them more harmful. Since the population of parasites is controlled by water temperature, unusual warmth may cause them to behave differently. They may also be affected by pollution.

The search for clues to the mystery of the frogs has only just begun. Until recently, no studies have been done on the effect of pollutants on frogs. Scientists are gathering samples of the mud, sand and water to study, but they do not really know what they are looking for.

Review Questions

Use your journal to respond to the questions that follow. For some questions, you can find answers by carefully reading the previous material. Other questions have no right or wrong answers; you must consider the facts that you know and your personal value system in light of so many unanswered questions.

1. In your own words, explain why scientists are concerned about finding large numbers of deformed frogs.
2. Do you personally care what happens to the frogs? Why or why not?
3. What are some reasons why scientists do not think the deformities are caused by inherited genetic defects (as opposed to genetic defects caused by environmental damage)?
4. What are three possible explanations for the deformities?
5. Do we humans have the ability to control or correct each of those possibilities?
6. It may be years before scientists understand what is happening to the frogs. Do you think we should wait until we have more scientific evidence to take action to prevent further damage? Or should we take action now based on what we can assume is the cause of the damage?
7. How much money (in general terms) do you think society should spend to protect the frogs? Is the amount of money you think we should spend dependent on how certain we are about the scientific explanation for the deformities? Who should decide? The government? Industry? Communities? Scientists?
8. As a sentinel species, what might deformed frogs be telling us? How does their plight affect us?

YOU CAN GET INVOLVED

There are many ways you and your school can get involved in studying the mystery of the frogs. The first step of any scientific investigation is to gather data about habitats with both healthy and unhealthy frog populations.

- Hamline University in St. Paul, Minnesota has a school-based monitoring and networking program called "Thousand Friends of Frogs" for students across the country. They welcome your participation. Contact them at (612) 641-2812 or (800) 888-2182. http://cgee.hamline.edu/frogs/
- The Minnesota Pollution Control Agency maintains a website with extensive current information about the frogs. Contact them at (612) 296-6300. http://www.pca.state.mn.us/hot/frog-bg.html
- The United States Geological Survey (USGS) maintains several web pages related to the deformed frogs. One is the North American Amphibian Monitoring Program: http://www.im.nbs.gov/amphibs.html Another is the North American Reporting Center for Amphibian Malformations: http://www.npwrc.usgs.gov/narcam/

Conduct your own computer Internet search for deformed frogs and update your research every week or two. Use search engines to look for the key word "deformed frog." Data and debate will probably be pouring in on this troubling topic for years to come.

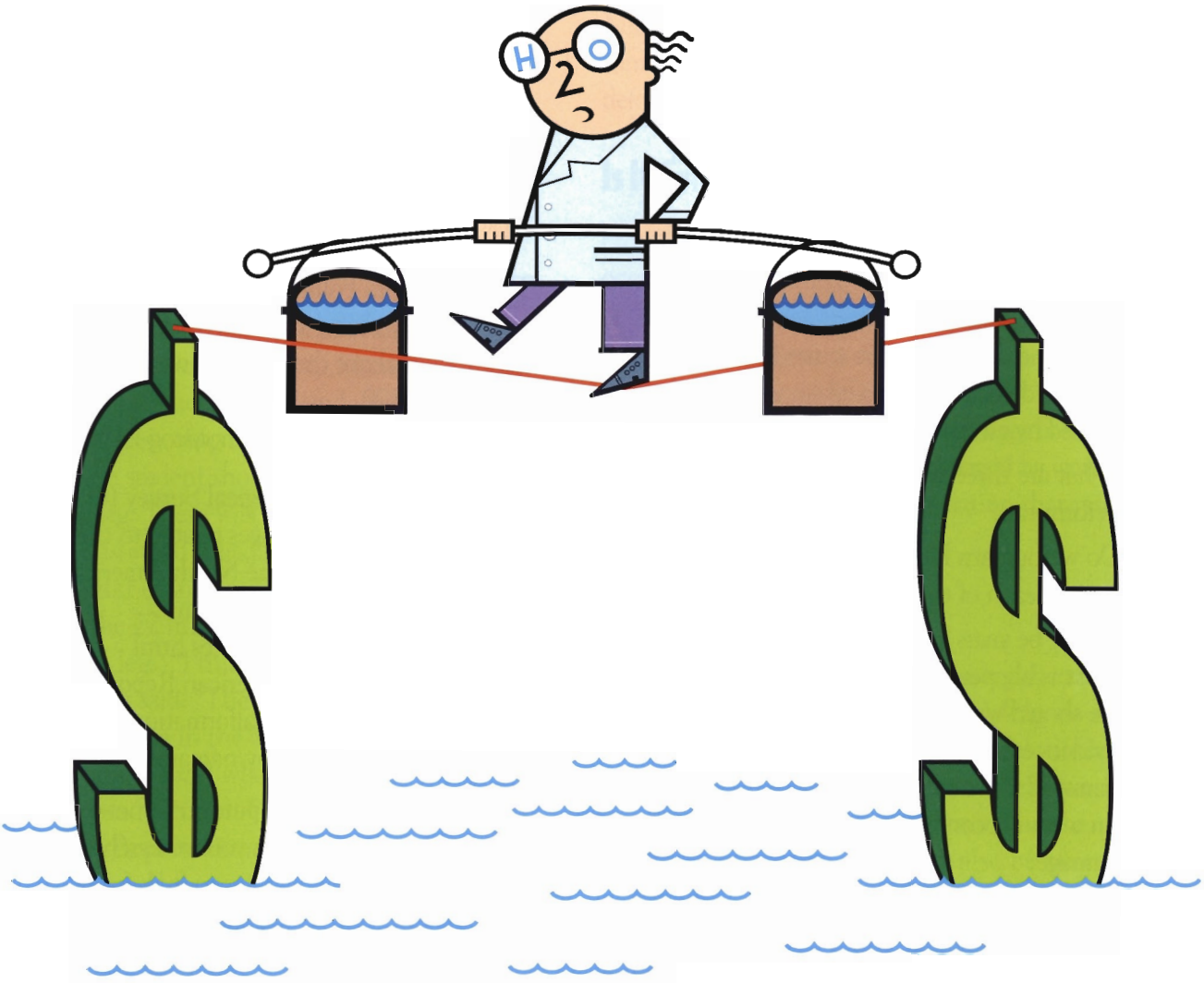
INVESTIGATE

Are there any frogs or toads living near your home or school? If so, is it possible to study them? Are any of them deformed?

Protecting the Public Health

The science of water quality can tell us a lot about bodies of water. Science, however, does not make decisions – people do. Science provides information; people interpret it. Science helps determine what substances present risks and the severity of those risks; people decide whether or not those risks are acceptable. Science can teach us about the sources and dangers of pollution; people choose whether or not to pollute.

The following three studies and related investigations will help you explore these complicated issues.



Setting Safety Levels

Regulating Pollution to Protect Public Health

Regulations are laws that govern the way society handles areas of public concern, such as transportation safety, air quality, land use, food and consumer products. In the case of water quality, regulations define "safe" drinking water, and they tell us what chemicals can and cannot be in our water.

The Role of Science in Regulation

The science behind the regulation of water quality is very complex. It requires laboratory experiments, statistics, mathematical modeling and more. Discussions about regulations involve such terms as epidemiologic studies, carcinogens, exposure levels, mortality rate, probability, risk assessment, cost-benefit analyses and so on.

The Politics of Regulation: Two Approaches

The politics of regulation is as complex as the science, especially when it comes to *carcinogens*, which are cancer-causing substances. Some people think regulations should ban any substance that causes cancer in laboratory animals. Others argue that we can never eliminate all of the risks in our environment, and that it is not helpful to spend time and money chasing tiny, theoretical risks. There are many positions in between these two, and scientists line up on all sides of the issues. However, there are two basic approaches to regulation: *zero-tolerance* and the *threshold theory*.

The zero-tolerance approach requires no exposure to risk. The threshold theory permits some exposure as long as it is theoretically not enough to hurt us. To understand this difference, pretend that a toothpick represents a suspected carcinogen that causes harm when it touches the skin hard enough to be felt. Does the mere touch cause the harm? Or must the skin be touched at a particular level of pressure to be harmful? If so, what is that level of pressure? If it is not the same for all people, where should the safety level be set?

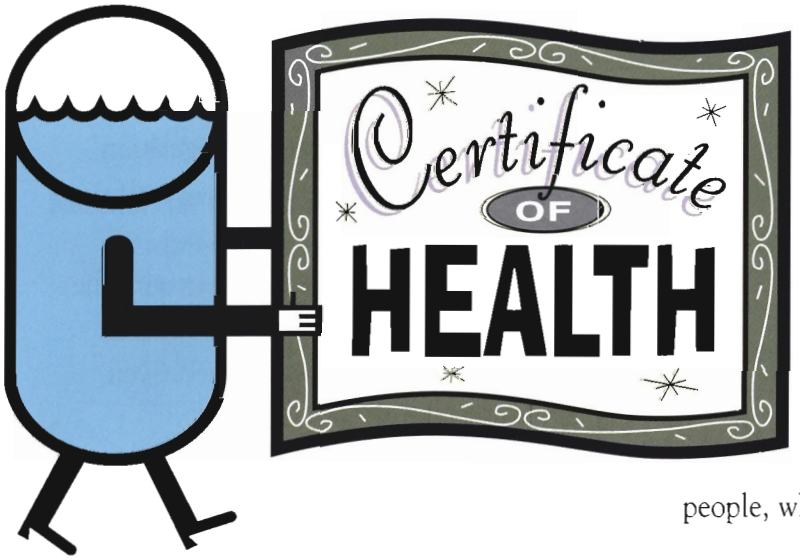
DEFINITIONS

Carcinogen: A substance that causes cancer.

Regulations: Laws that regulate the amount of a substance that can be released into the environment or to which humans can be exposed.

Threshold Theory: The theory that a carcinogen does not cause cancer until the level of exposure passes a certain safe level.

Zero-tolerance: An approach to regulation based on the premise that there is no safe level of exposure to any carcinogen.



APPROACH	THEORY	REGULATION
Zero-Tolerance	Any risk of cancer is unacceptable.	Drinking water must contain no carcinogens at all. All amounts must be regulated.
Threshold Theory	Carcinogens must be present above certain level to cause cancer in people.	Drinking water should not contain carcinogens above the threshold level. Amounts below the threshold are not harmful.

Zero-Tolerance: No Safe Exposure Level

The zero-tolerance approach assumes that there is no safe exposure level for a carcinogen. Using our toothpick analogy, if laboratory experiments show that twenty touches by toothpicks cause cancer in animals, then one touch of a toothpick is not safe for human beings.

This approach became part of the Environmental Protection Agency's method for regulating potentially harmful substances. Today, many people object to this approach, because it focuses too much on tiny, potential risks and not enough on large, everyday risks. They also criticize the science behind zero tolerance, arguing that just because large amounts of a substance cause cancer, that does not mean tiny amounts do.

This issue becomes more confounding as our ability to detect tiny levels of substances improves with new technologies. When the zero-tolerance approach was adopted by the EPA in the early 1970s, scientists could detect most substances diluted in water at the level of one part per hundred-thousand (1:100,000). Today, we can detect many substances at quantities of even smaller than one part per trillion (1:1,000,000,000,000). Given these tiny detection levels, it is increasingly difficult and costly to meet the zero-tolerance standard.

The Threshold Theory: Just Noticeable Difference

Critics of the zero-tolerance approach proposed a different approach to regulation. The threshold theory holds that a substance does not cause harm until the exposure exceeds a certain level or threshold. The substance does not need to be regulated, unless people will be exposed to levels above the threshold of harm.

As you can imagine, there are critics of the threshold theory as well. Some claim it is an effort by industry to ease up on regulations that protect the general public. Some worry that it is impossible to tell where the threshold level is, since we can't do laboratory experiments on humans.

In addition, different people have different thresholds. For example, babies, elderly people and those with weakened immune systems have less tolerance than healthy adults. Other critics claim there may be thresholds for some substances, but for chemicals and heavy metals that accumulate in the food chain, no threshold can be considered safe.

Review Questions

Write your responses to these questions in your journal.

1. In your own words, what are three reasons for regulating water quality?
2. What is the zero-tolerance approach to regulation?
3. What is the threshold theory of regulation?
4. What are some of the possible flaws with the zero-tolerance approach?
5. What are some of the possible flaws with the threshold theory?
6. In your journal, explain which theory you agree with and why.

The "Just Noticeable Difference" Threshold

INTRODUCTION

For this activity, pretend that toothpicks are suspected carcinogens. However, not just any toothpick causes cancer. The sensation of a single point of a toothpick is harmless, while the sensation of two points can cause cancer.

If you touch someone with two points but the points are so close together that the person only feels one point, there is no danger of getting cancer. However, if the two points are far enough apart that the person feels two distinct points, the exposure level has passed the threshold of safety and poses a cancer threat.

Getting started

How can you determine how far apart the two toothpicks must be before a person feels two distinct points? That distance will be the "threshold" for the sensation of two toothpicks. Once you know this threshold, what regulations should you develop to protect the public from feeling two toothpick points?

Make a prediction

Record your ideas about the following points in your journal:

① How far apart do two toothpicks need to be before you can feel two distinct tips?

② Will the distance be the same for different test sites, which represent different segments of the population?

③ Do some parts of our skin have more touch sensitivity than others? Explain your answer.

④ Are males and females equally sensitive to the touch of toothpicks?

Figure it out

Work in groups. Using the card you make, test and record your results.

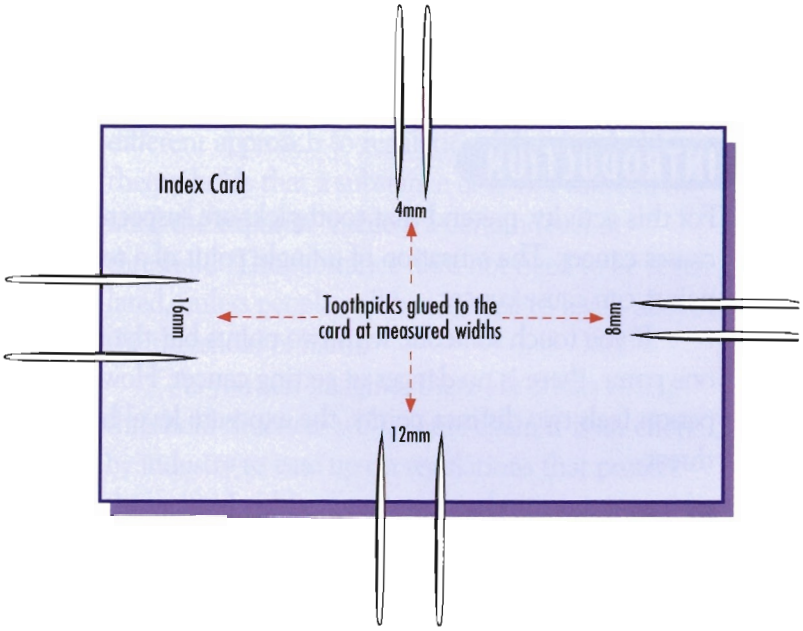
Your team will include:

- Subject (blindfolded or with eyes closed)
- Tester
- Recorder

Materials for Making Test Cards

white glue or rubber cement
metric ruler
flat toothpicks broken in half
index card
blindfold

① Make your test equipment by taping toothpicks to index cards on the marked lines. Both toothpicks in a pair should extend the same distance from the card. Be sure the round, blunt end is pointing out rather than the sharp end.



② You will use this equipment to test whether your blindfolded subject can tell if there are one or two points and to find the "threshold" for feeling two points.

③ The tester and recorder need to develop a pattern for random testing, occasionally mixing a single toothpick with the toothpick pairs, as well as mixing different widths. Record the results from each touch on a chart.

④ Test these areas: Cheek Lip Forearm Back of hand

⑤ Blindfold the subject.

⑥ Touch the toothpicks to your partner using gentle touches. Harder pressure makes the points easier to distinguish. (The pressure activates deeper pressure receptors instead of the touch receptors just under the skin.)

⑦ The subject will tell whether she/he feels the sensation of one toothpick or two. Record your results in your journals. If you wish, change roles until each member of the team has been tested and the results recorded.

⑧ Combine all test data on a master chart. More data will help you see patterns.

What does it mean?

① Using the data from your own group, rank the test points in order from most sensitive to least sensitive. The more sensitive parts have the lowest threshold (shortest distance). Record the rank and the threshold in your journal.

② How do your thresholds compare with those of the other research teams in the class?

③ What do the class data tell you about the sensitivity of the different test points?

④ What do the data tell you about the sensitivities of different people?

⑤ How did the test results compare with your predictions (hypotheses)?

Go further 1: Graph the Results

① Graph the class results and establish a threshold for each of the test points.

② What is the lowest threshold (shortest distance) in the class for each test point? What is the highest threshold (longest distance)?

Talk it over

① If the point at which you feel two points of the toothpick at a certain test point represents the threshold of danger (the point at which people will probably get cancer), where would you set the threshold of acceptability?

② Would you try to protect the most sensitive groups, even if it meant making unpleasant or costly regulations for the least sensitive?

Go further 2: You Are the Chief of the Regulatory Agency

As chief of the regulatory agency, you must establish the best possible regulatory standard for society. Suppose that the cost of making a threshold stricter is $1 billion for the first increment (4 millimeters in your test), $10 billion for the second increment, $100 billion for the third increment, etc.

At the largest distance between points, 10,000 people may get cancer and die each year. With each incremental tightening of the threshold, you will save ten times more lives. For example, by decreasing the threshold 4 mm, maybe only 1,000 people may get cancer and die; by decreasing it another 4 mm, maybe only 100 people may get sick and die, and so on.

Each increase in spending for preventing cancer takes public money away from other services, such as preventive medicine, education and food programs for needy children.... But it saves somes lives. Where do you propose setting the threshold?

Talk it over

① What do you feel is an acceptable level?

② What does the class feel is acceptable?

Record in your journal the threshold level at which you will set your limit for an entire person (taking into account all of the test sites), and write a brief statement about why you set it there.

Regardless of where you set your limits, you can be sure that some people will be dissatisfied.

In some cases, you will have made the threshold so weak that some people will get cancer and die. Likewise, if you make the threshold too tight, it will cost some families so much money to implement that they may not be able to eat a healthful diet. Do you want to change your decision or leave it the same?

ASSIGNMENT 1:

Write a letter to the local paper responding to criticism that your policies will be responsible for cancers in the community that could be prevented if you had made the regulation stricter.

ASSIGNMENT 2:

Write a letter to the local paper responding to criticism that your regulations are so costly that they are taking food out of the mouths of poor children in the community.

Epidemiology and the *Cryptosporidium* Mystery

Background

When a person gets sick, a doctor can diagnose and treat that person based on medical observations. But what if a large number of people in one geographic area came down with a similar disease? Such an outbreak is called an "epidemic." The scientists and physicians who try to understand epidemics and the spread of disease are called "epidemiologists."

Epidemiology is the study of the occurrences and causes of diseases in human populations. People use this knowledge to prevent and control health problems. Epidemiologists look at populations to see if there is a statistical relationship between exposure to a condition and the occurrence of a disease. For instance, they might study if there is a relationship between a microorganism in the water and an outbreak of *cholera*. Epidemiologists may notice clusters or groupings of diseases at a given time or place, or among a certain group of people. For instance, they may notice that many people who attended a ten-day convention became ill, that several people who live near a contaminated well develop cancer, or that there is a lot of lung cancer among smokers.

DEFINITIONS

Background Rate: The rate at which a disease normally occurs in the general population.

Epidemiology: The study of the occurrence and causes of disease, and the application of this knowledge to prevent and control health problems.

To explain these "clusters," epidemiologists study the people who get the disease and the people who don't. They study behaviors, diet, activities, homes, air, water and more. Common threads provide clues about the possible causes of a disease and the ways it is transmitted.

To find out whether an epidemic has actually occurred, epidemiologists must first figure out the background rate of the disease for the general population. That is, the number of people who would get the disease under any circumstance. For a substance or situation to be considered risky, epidemiologists must show that it increases the disease rate above normal.

A *Cryptosporidium* oocyst

Mystery Spore OUTBREAK!

In 1993, Milwaukee made headlines with a widespread outbreak of a disease called "cryptosporidiosis." It is caused by the microorganism *Cryptosporidium*. About 400,000 people contracted the disease, and 100 of them died. Almost all of the fatalities had AIDS. After months of study, scientists blamed the outbreak on an increase in the turbidity of Milwaukee's drinking water source.

Until recently, water scientists considered turbidity a concern of "aesthetics" and taste, but not health. In other words, high turbidity might make the water look, smell or taste funny, but it was not considered unhealthy.

After Milwaukee and several similar outbreaks, scientists realized that turbid water could provide a hiding place for microorganisms, some of which were not killed by disinfection.

The news that turbidity should now be considered an indicator of contamination did not disturb the water managers in Las Vegas. The water in the Southern Nevada Water System (SNWS) had low turbidity. The water was drawn from Lake Mead. After entering the lake, a drop of water could spend years before being withdrawn. During that time, most of the solid particles settled, leaving the water crystal clear.

Furthermore, a common source of *Cryptosporidium* contamination in water is runoff from cattle, but there were no cattle ranches around Lake Mead. In addition to low turbidity and low exposure to sources of *Cryptosporidium*, SNWS's water treatment system worked properly, with no breakdowns or deficiencies. The agency met or exceeded all water quality regulations. Even though federal law did not require it, SNWS tested their raw and treated water monthly for *Cryptosporidium*, and the results always came back negative.

Then one day in March 1994, the local health department called the water department. During the previous three months, the number of cases of cryptosporidiosis among HIV-infected people had jumped almost 500 percent! HIV means Human Immunodeficiency Virus; it is the virus that causes AIDS, Acquired ImmunoDeficiency Syndrome. People with advanced HIV infection and AIDS are very susceptible to cryptosporidiosis. The water department looked at the data:

Cryptosporidiosis Among the HIV-Infected Community in Las Vegas

Months	Number of Identified Cases of Cryptosporidiosis
June 28 - December 31, 1993	9
January - March 19, 1994	49

The water department was stunned about what happened. They agreed to test the distribution system and water supply for the geographic areas in which these 49 cases occurred. This area spanned four water distribution areas, so it was widespread and not confined to one small part of the water system. The water department knew that the drinking water supply is the most common source for such a widespread outbreak of cryptosporidiosis. They tested the water at the treatment plant and here is what they found:

Results of Las Vegas Water Tests in March 1994

Turbidity	0.15 ntu (Nephelometric Turbidity Unit)
Cryptosporidium oocysts	none

The accepted standard for turbidity is up to a level of .5 ntu.

Then they looked back through their records but found no problems with their treatment plant during the past three months. The turbidity level had stayed around 0.15 ntu, far below federal requirements.

WHAT DO YOU THINK?
Complete Epidemiology Worksheet 1. To answer these questions, reread the preceeding sections, looking for information on the rate of cryptosporidiosis infection, the reasons for or against suspecting the water supply as the source of infection, and other ways that cryptosporidiosis can be spread.

SNWS asked the National Centers for Disease Control (CDC) in Atlanta to help investigate the cause of the outbreak. The CDC wanted to find anything shared by the victims and not shared by the rest of the people. They also wanted to know if the outbreak was limited to the HIV-infected community, or if it also affected the general population. To find out, they used methods practiced by epidemiologists:

- They interviewed all the people affected by cryptosporidiosis in the HIV-infected community.
- They interviewed a "control" set of HIV-infected people who were not affected by cryptosporidiosis but lived in the same area.
- They interviewed another 200 people in the community-at-large who reported having had diarrhea and stomach cramps during the same period of time.
- They plotted where the people lived, worked, visited and traveled during the period when they might have been infected by *Cryptosporidium*.

WHAT WOULD YOU WANT TO KNOW?
Complete Epidemiology Worksheet 2. You will have to put yourself in the shoes of a CDC investigator to piece together what you know about how cryptosporidiosis infects populations in general so you can trace its source in this population.

Results of the CDC Investigation

Here is what the CDC found by interviewing the people who had developed cryptosporidiosis and a "control" group that did not develop the disease:

By April 1994, 78 people were infected with cryptosporidiosis.

- The cases were not geographically clustered in one particular area of the water distribution system.
- Of the 78 people who were infected with cryptosporidiosis, 65 were adults and 13 were children.
- 61 of these 65 adults were HIV-infected, and most had AIDS.
- 2 of the children with cryptosporidiosis were HIV infected and 11 were not.
- 90 percent of the people who contracted cryptosporidiosis drank tap water during the period of infection; the rest drank bottled water or filtered water.
- There were no common patterns among the victims for:
  - recreational water exposure
  - behavior of household members
  - animal exposure
  - restaurant or food supply use
- Of the 200 people interviewed from the community-at-large who reported having diarrhea during this time, 91 percent had symptoms beginning in February, and 80.5 percent used tap water.

During the CDC investigation, something even more baffling than the sudden outbreak of the disease happened. The outbreak suddenly stopped!

By August 1994, the number of cases of cryptosporidiosis dropped back to about three per month. The quality of the raw water, the treated water, and the water in the distribution system showed no change.

WHAT DO YOU CONCLUDE?
In writing your responses to Epidemiology Worksheet 3, reread the section above looking for possible causes that were shared by the people who had confirmed cases of crytosporidiosis and those who reported diarrhea during the same time. After completing this Worksheet, you will be ready to prepare the report below.

Write Your Report

Prepare a report that states the conclusions of the CDC's investigation. This report should state:

1. What data was obtained.
2. What the CDC thinks is responsible for the outbreak.
3. What the CDC's conclusion indicates about the state of water treatment in Las Vegas.
4. What actions the Southern Nevada Water System should take to safeguard the people of Las Vegas from a repeated outbreak of *Cryptosporidium*.

Source Protection and Body Contact

Source Protection: It is better to prevent pollution than to treat it

Modern water teatment can do wonders with poor quality water. It can take the salt out of saltwater. It can take microbe-infested water and disinfect it. It can filter turbid water to make it clear, and it can soften hard water. It can remove harmful nutrients and filter out organic debris. It can remove many harmful chemicals. However, there are three important reasons why it is important to protect water at its source.

First, treatment processes all cost money. Treating polluted water may make it too expensive for the average consumer, or take money away from other public health and safety programs.

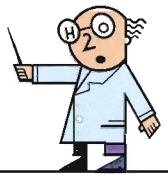
Second, no treatment is completely successful. If a disinfection process were 99.9 percent effective, thousands of microorganisms are still swarming through the pipes. Suppose there were one million microorganisms in the water. If the disinfection is 99.9 percent effective, how many organisms would still survive? For most people under most conditions, that number will be too small to cause harm. But some people could become ill. Third, many water treatment processes have negative side-effects, such as the potentially harmful byproducts of chlorination known as "disinfection by-products" or "DBPs." It makes sense to keep the bacteria and organic compounds out of the water in the first place, because doing so reduces the need for disinfectants.

DEFINITIONS

Body Contact: Exposure of a person's body to a water supply, such as swimming in a water supply reservoir.

Pathogen Loading: The quantity of disease-causing microorganisms that enter the water through body contact or other sources of contamination.

Source Protection: The prevention of pollution in a watershed, thus reducing the need for expensive treatment to remove contaminants.



The effort to keep pathogenic microorganisms and organic compounds out of the water supply is called *source protection*. Source protection has become a major effort that unites different cities, counties, states and nations that share the same watershed. It can also be a problem when different interests conflict.

Body Contact

One area where interests can conflict is "body contact" or swimming in water. People love to swim and water ski in rivers and lakes. But a water agency must ensure that the quality of the drinking water meets federal and state drinking water standards. Meeting these standards often means "trading off" people's right to swim in a public body of water with their right to clean drinking water. In many ways protecting the right to clean water means "no body contact" in drinking water supplies. Here's why:

Body contact always increases the *pathogen loading*, which is the amount of disease-causing microorganisms in the water. Swimming introduces fecal matter that includes bacteria, viruses and parasites. Increasing the number of these microorganisms requires stronger disinfection, which produces more disinfection by-products.

The Science of Body Contact

To determine how many pathogens body contact adds to the water supply, scientists developed a mathematical model. This model helped them determine the risk posed by body contact.

Scientists developed the model based on the number of "recreators" or people swimming and the pathogen load of each swimmer, which means how much fecal matter washes off an average person when swimming. Scientists measured this amount at about 0.14 grams per average adult after 20 minutes of exposure. After 20 minutes, no more washed off.

In the following Investigation, you will try to determine whether or not to allow swimming in your local water supply. While the activity sets up a fictitious town, the problems are real and the situation occurs in towns across the country.

Body Contact Town Meeting

Situation

The town of Clearwater draws its drinking water from the Central Reservoir. The reservoir is surrounded by a beautiful forest and has lovely natural sand beaches. The town maintains walking and bike paths through the forest, and anglers arrive early in the morning to catch trout. Swimming, however, has never been allowed at the reservoir.

For years, residents of Clearwater have wanted to open the Central Reservoir to swimming. The newly elected members of the Town Council ran on the promise to make swimming at "Central Park" a reality, and they have set aside money in the town's budget for lifeguards, a bath house, ropes and docks.

Problem

The Clearwater Water Works opposes the effort to open the reservoir to swimming. They fear swimming will increase the pathogens in their source water. A vote by the citizens of the town, however, can override their position.

Town Meeting

The town of Clearwater will decide whether or not to allow swimming at the Central Reservoir by a majority vote of the people attending the meeting.

Your teacher will divide your class into different interest groups, and each group will participate in a town meeting. The purpose of the town meeting will be to hear arguments about whether or not swimming should be allowed at the reservoir. Use the Body Contact Group Worksheet to help you prepare for your group's presentation at the town meeting.

Following the meeting, the class will vote on whether to accept or reject the proposal to open the reservoir for swimming. Use the Body Contact Individual Worksheet to help you sort out your own convictions.

The People Attending the Town Meeting and the Roles They Play

1. Moderator
   - ▲ introduces the proposal
   - ▲ calls on speakers
   - ▲ recognizes speakers from the floor
   - ▲ maintains order and decorum in the meeting
   - ▲ calls for votes
2. Chair of the Town Council
   - ▲ argues that the citizens of Clearwater deserve a place to swim
3. Manager of the Clearwater Water Works
   - ▲ argues that his agency cannot allow activities that add pathogens to the water
4. Town's Public Health Officer
   - ▲ provides figures about the estimated number of people who will swim each day (about 850: 250 adults and 600 children), and the quantity of the pathogens they will add to the water. This person asserts that one of two things will happen: 1) treatment costs will rise or 2) the frequency of certain illnesses will increase, but he/she does not estimate by how much.
   - ▲ recommends whether or not body contact should be allowed

Individuals and Groups to Speak at the Public Meeting and Their Positions

1 Town Council

▲ The citizens of Clearwater deserve a place to swim, and we are there to serve them.

2 The Clearwater Water Works

▲ We exist to serve the people by providing clean drinking water, and we cannot allow activities that add pathogens to the water.

3 Public Health Officer

▲ Based on the estimated number of people who will swim each day (250 adults and 600 children), you infer that the number of related illnesses will rise and/or the cost of water treatment will rise.

▲ Pose a question to the community: "If someone gets sick as a result of allowing body contact, who is responsible?"

4 Residents Group A

▲ Why shouldn't we be able to enjoy this recreational resource? Swimming should be available to all residents, not just those who can afford country club fees!

5 Residents Group B

▲ Why should we put our health at risk? By increasing pathogens, we have to increase disinfectants, and that just presents another risk. People who can afford to drink bottled water will be the only ones who can afford to stay healthy.

6 Residents Group C

▲ Why doesn't the town invest in building a public swimming pool instead of allowing swimming in the reservoir? Building a pool may cost more in construction and maintenance, but it will help to protect our drinking water supply.

7 AIDS Support Group

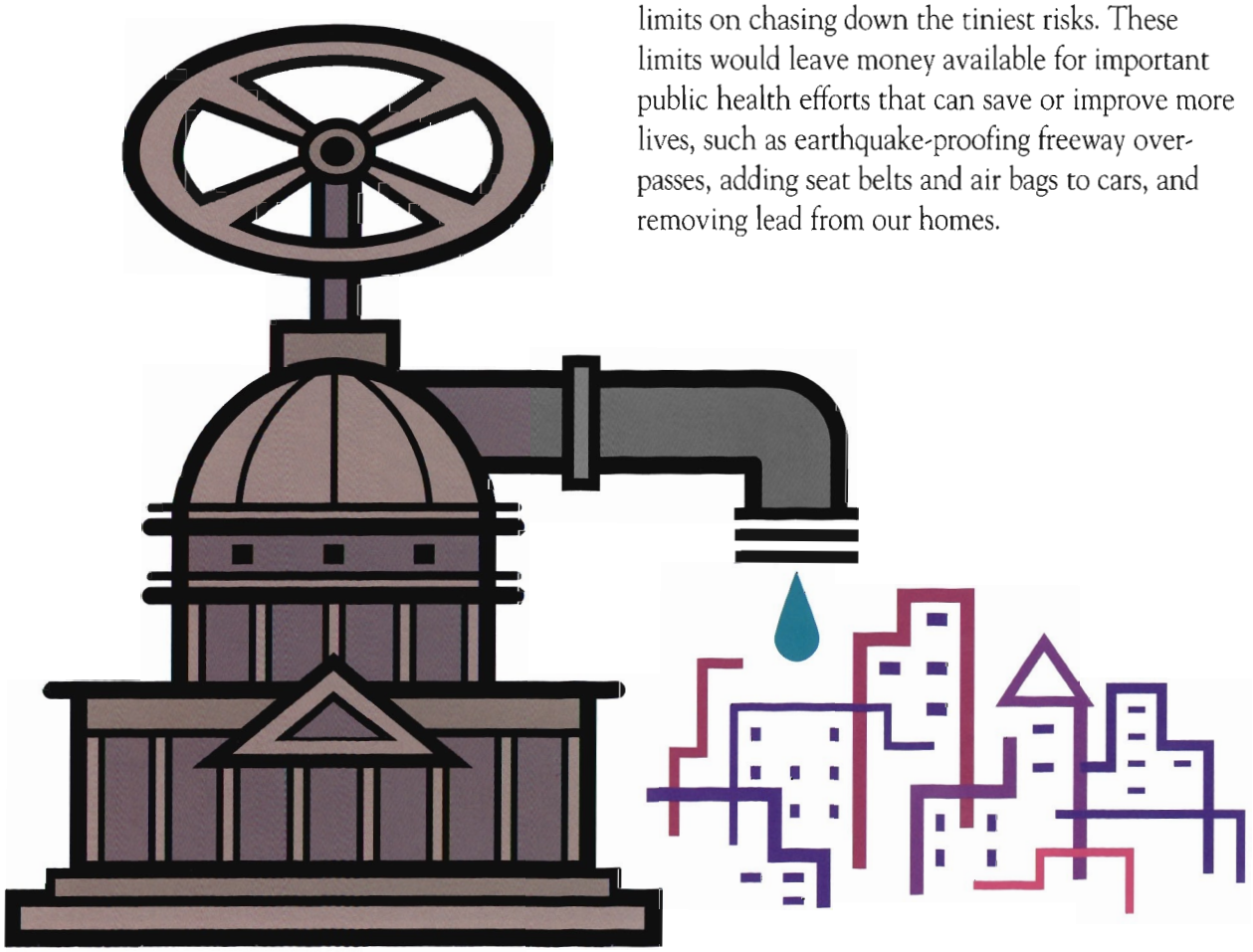
▲ Water containing only a tiny amount of *Cryptosporidium* can be fatal to people with HIV. The community must work to protect every member of the community, and one way to do that is to ensure the safety of the public drinking water supply.

Water Quality and Rights

The U.S. Constitution does not give us a right to high quality drinking water. It does not guarantee us freedom from disease- and cancer-causing pollutants. It does, however, hold the government responsible for the "general welfare." Over time, that responsibility has come to include protecting the public's health.

With that responsibility came the power to outlaw certain harmful or dangerous conditions. Today, it is hard to imagine a time when there were no controls over harmful substances that could enter our water supply. Most people would be outraged if their drinking water smelled of sewage or was laced with the harsh industrial chemicals. Yet before the regulation of drinking water quality, these conditions occurred frequently.

Keeping harmful substances out of our drinking water is generally expensive. Some people feel there should not be a limit to the amount of money society spends to prevent a single death, since each life is priceless. Others believe that since we have limited resources, society must set limits on chasing down the tiniest risks. These limits would leave money available for important public health efforts that can save or improve more lives, such as earthquake-proofing freeway overpasses, adding seat belts and air bags to cars, and removing lead from our homes.



A Public Policy to Protect People From *Cryptosporidium*

In the following investigation, you will grapple with some of the most difficult questions we face as a nation. How much should we pay for clean water? How clean is clean enough? Is it the public's responsibility to protect the weakest in our society… even if protecting them costs so much that it hurts others?

You will use the tiny parasite *Cryptosporidium* to address these issues. If you are not familiar with this microorganism, read Fact Sheet 8 and Protecting the Public Health Application Study 2, both of which are part of this water quality program.

F.E. Weymouth Filtration Plant, La Verne, California

A Public Meeting on Cost Versus *Crypto*

Your teacher will divide you into groups representing different interest groups in society. Your group must define its goals and purposes, and then decide whether you support the expenditures required to make your water system safe for all members of your community. You will make a persuasive statement at a public meeting, and then write a newspaper editorial expressing your view.

The Groups and Their Purposes

A The Water Department: Your job is to provide the public with the safest water possible at the most reasonable rates. You must justify your rates to the public, and you must comply with all federal water quality regulations. Your community expects high-quality, affordable drinking water.

B The AIDS Support Group: Your role is to help people who are infected with HIV or who have AIDS get the best health care available and to educate them about how to maintain a healthy and active lifestyle. In the past few years, medical breakthroughs have been restoring patients to health who might have died only a few years earlier. It is tragic that these same people are now at risk of dying from a preventable disease like cryptosporidiosis.

C The League of Concerned Scientists: Your role is to educate people about the risks they face and to show them how to put these risks in perspective. For instance, you tell people who are concerned about the small chance of getting cancer from barely detectable amounts of contaminants in the drinking water that there is a much higher risk of getting cancer from coffee, tea, soda, chocolate, sugar substitutes, tobacco and many other common substances. You don't like the idea of spending ever-higher amounts of money to remove tiny risks from our environment. You encourage people to attack major, preventable kinds of risks, such as smoking and drunk driving.

D The Urban Poor Coalition: Your role is to ensure that public services go toward programs that help the poor improve their living conditions and job opportunities. You see many poor people struggling to pay for nourishing food and minimum health care. If a poor household's water bill were raised by $100 a year, that increase would further limit the amount they could spend on food and medicine. You question the wisdom of spending a great deal of money to help so few people when it would hurt so many.

The Facts on Costs

- Switching from chlorine disinfection to ozone disinfection will cost the average family of four $300 a year in additional water rates.
- Switching to a membrane filtration system that can filter out *Cryptosporidium parvum* will cost the average family of four $150 a year in additional water rates.
- Neither ozone disinfection nor membrane filtration protect the water from *Cryptosporidium* after it leaves the water treatment plant.
- The community has never had levels of *Cryptosporidium* higher than 50 oocysts per 100 liters of water. This level is probably not enough to make the average person sick, but it can make HIV-infected and AIDS patients sick, sometimes fatally.
- Improved source protection can probably assure that the level of *Cryptosporidium* will never go beyond 50 oocysts per 100 liters, and it will probably reduce the level.

The Mayor's Options

The Mayor is asking your group to recommend one of the following options for action at the town meeting. These options were drawn up and approved by the City Council. You must choose one of these options even if none are perfect; you cannot suggest an alternative option because all options must be approved by the Council.

- **A** Invest in both ozone disinfection and membrane filtration immediately.
- **B** Invest in just ozone disinfection immediately.
- **C** Invest in just membrane filtration immediately.
- **D** Keep the existing water treatment system as is.
- **E** Keep the existing water treatment system as is for now, but plan to build an ozone disinfection system and/or a membrane filtration system as soon as the existing system goes beyond its useful life.
- **F** Keep the existing water treatment system but protect the water source to guard against the conditions that might encourage *Cryptosporidium*.

Regardless of the outcome of the vote, the water department is committed to three other courses of action:

- ▲ protecting the water supply from contamination;
- ▲ providing public education about how to prevent the spread of disease through proper hygiene; and,
- ▲ developing a communication network with people who are vulnerable to *Cryptosporidium* so they will know when they need to boil or filter their tap water.

Procedure

1. Your teacher will assign you to a group. Review the material above in light of your group's role and responsibility.
2. Before your group meets, think through your own position in private using the *Cryptosporidium* Private Decision Worksheet.
3. When your group meets, share your responses and discuss any differences of opinion. Reach a consensus and answer the following questions in your journal.

   Which option does your group recommend?

   What are the reasons (provide three) why your group recommended this option?

   Which option does your group strongly discourage? Why?
4. Each group can select a spokesperson to make a public statement at the public hearing. Try to make the statement a short, powerful "sound bite" to support your recommendation.
5. After listening to all the group presentations, the class will take a vote by private ballot. Each individual student may vote his or her private opinion; you do not need to vote according to the position of your group.

Follow-Up

Write a 200-word editorial for the *Clearwater News Gazette* that argues your personal position. The purpose of this editorial is to educate and influence voters who will make a decision on a referendum ballot.

MTBE – You're the Reporter

A Better Burning Gasoline for Cleaner Air

You probably already know that much of Southern California has air quality problems. In fact, most people around the U.S. probably identify Los Angeles with smog. In general, the area's air quality problems get more attention than its water quality problems.

Much of this area's air pollution comes from vehicles that burn gasoline. Their exhaust contains carbon monoxide, hydrocarbons and other harmful compounds. Carbon monoxide is unhealthy to breathe, and hydrocarbons form smog. Some of the other compounds are carcinogenic, meaning that they cause cancer.

To reduce this unhealthy exhaust, state and federal laws called for a change in the chemistry of gasoline. The outcome was a product called "reformulated gasoline." This new mix reduces harmful exhaust fumes by helping gasoline burn more completely.

The Road to Cleaner Air...Leads to a Major Groundwater Problem

In the mid-1970s, gasoline companies removed lead from gasoline because it polluted the air. Without lead, though, the gasoline did not burn completely, so the oil companies had to add chemicals to help it. Over the years, regulations have called for more and more chemicals in the gas to help it burn completely and to reduce air pollution.

The oil companies added a chemical to the gasoline called MTBE (methyl tertiary-butyl ether), and it was thought to be highly effective. Scientific studies did not show that it caused cancer in humans, and it has reduced air pollution significantly.

By 1995, the gasoline sold in Southern California contained 11 percent MTBE, so for every 100 gallons of gas sold, 11 gallons of it were MTBE. The EPA estimates, this change:

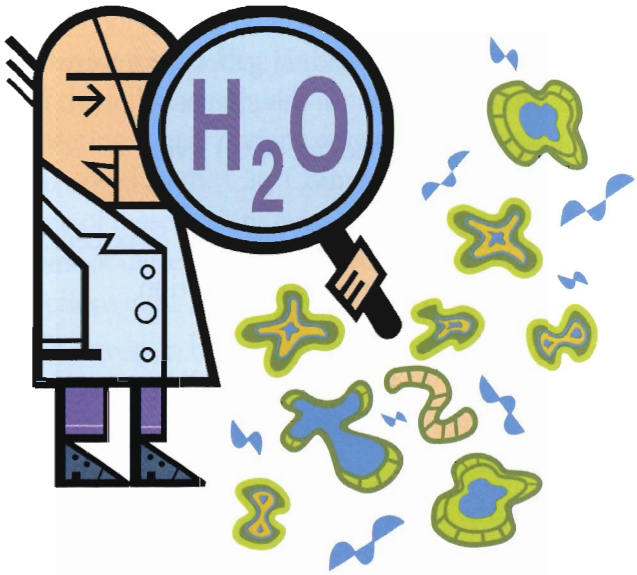
- reduced carbon monoxide (CO) levels by 11 percent.
- reduced sulfur dioxide (SO_2) levels by 80 percent.
- improved ground-level ozone pollution by 18 percent.
- reduced exhaust haze by 50 percent.
- reduced carcinogenic benzene vapors by 60 percent.
- reduced the overall cancer risk by 40 percent.

Using MTBE clearly helped air quality! But the environment is a complex system. As the use of MTBE increased, it started to show up in Southern California's groundwater.

MTBE is highly soluble, so it dissolves easily in both gasoline and water. Once dissolved, it moves with water, but unlike oil it does not stick to soil and rock. Since its movement is not slowed by the rocks and soil, it reaches groundwater quite easily. Once there, it is very hard to remove.

Thus, while MTBE was solving serious air pollution problems, it was creating a new water pollution problem. Scientists are just learning how serious this problem really is.

Most of the MTBE in the groundwater comes from gasoline spills and leaking underground tanks. Nationwide, 22 percent of the nation's 1.2 million underground storage tanks are leaking, so MTBE contamination is continuing to rise. Low levels of MTBE have been detected in test wells around the country. Nationwide, in fact, it is one of the most commonly detected contaminants in water.



Contaminated Wells in Santa Monica

One California city – Santa Monica – is paying heavily for this groundwater contamination. Seven of its underground wells have been closed because of high MTBE levels. Each year, the city pays more than 3 million dollars for replacement water, which is raising consumers' water bills.

No one knows how much it will cost to decontaminate the city's wells, or even if decontamination is possible.

Nobody knows what levels of MTBE might be safe for humans. The EPA has set a "health advisory level" of 20 to 200 parts per billion (ppb). When they were closed, Santa Monica's wells had MTBE levels of 610 ppb.

Researching MTBE

As you can imagine, many people are trying to find a way to address the problems caused by MTBE. Here are some of the questions they are asking:

1. Should we use a different gasoline additive altogether? For example, ethanol, an alcohol derived from corn, also boosts the combustion of gasoline.
2. Should we continue using MTBE and focus on replacing and repairing the leaking tanks and pipes responsible for most of the MTBE contamination?
3. Should we discontinue using MTBE and focus on other ways of reducing automobile emissions?

In California, these questions are being hotly debated. In fact, California Governor Gray Davis issued an executive order to phase out MTBE gradually by the end of 2002, and he requested a waiver of EPA regulations requiring the use of reformulated gasoline. This action will not end the debate over how the state–and the nation–will protect both air and water quality.

In this investigation, you will be a newspaper reporter trying to sort out this debate for the public. First, you must identify the "stakeholders" in the debate – those people and groups who have a personal interest in the outcome. Then, you will write an article that presents a balanced overview of several different positions. Before you begin, hold a brainstorming session with your "managing editor" (your classmates!) to establish a few strategies and editorial policies.

Brainstorm as a Class:

1. Who do you think might be stakeholders in the MTBE issue? Why?

   List as many organizations and companies as you can on MTBE Worksheet 1. You will use this list as a starting point for your investigation. Next to each stakeholder, indicate why they might care about the issue and how you think they might answer these two questions:

   - **A** What are the public health issues at stake? How critical are they?
   - **B** If we continue using additives in the gasoline, does it matter if we use a petroleum product (MTBE) or an agricultural product (ethanol made from corn)?

2. What sources will you use to learn about these stakeholders and their positions? Record your ideas on the first part of MTBE Worksheet 2. Add to this list as you continue your investigation.
3. As you carry out your research, keep in mind that many articles and reports can be one-sided. What questions should you ask yourself as you read? How can you tell if the article or report is balanced or biased? Record your guidelines for reading on the second part of MTBE Worksheet 2.

Begin your investigation

Take a week or two to research the positions of different stakeholders from as many different sources as possible. Look for current articles as well as older ones in the library and on the Internet.

Collect a "file" (it could be note cards) on the different stakeholders, their positions and their reasons for holding these positions. Make notes on how they respond to critics, and how they counter the arguments of other stakeholders. Look back at your responses on MTBE Worksheet 1 about your predictions about their interests and perspectives. Modify your responses as necessary.

Prepare a report summarizing what you have learned about the different stakeholders. You may present this report as a newspaper article or a taped news report for radio or TV. Make the report as objective as possible, giving equal time to at least three major stakeholders. Without giving your own opinion, present the positions of each of these three stakeholders. How will the positions of these stakeholders affect such concerns as air pollution, water pollution, public health, the state's economy and the nation's economy?


Water Quality
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