Unit 1

Water Resources

Overview of Unit 1

Water Resources

Introduction

In this unit, students confront the very real problem of the pollution of our lakes, rivers, streams, and groundwater. This pollution occurs because water resources are often commonly owned and, therefore, tend to be overused by businesses and individuals. Students also will confront the difficult question, "How clean do we want our waterways to be?" It may be possible to clean water resources to an almost perfect, pristine state – but would this be worth the cost, especially in terms of job losses and slowing economic growth? To analyze this situation, students will use the concept of marginalism discussed on page 13.

Learning Objectives

After completing this unit, students will:

1. Understand basic facts about water resources.
2. Explain the economic reasons why water pollution occurs and identify policies to correct it.
3. Explain how a policy mandating zero pollution would affect society.
4. Understand that public policy decisions involve trade-offs.

Unit Outline

I. Facts About Water Resources

II. Water Resources Vocabulary

III. Teaching Activities and Key Concepts to Emphasize

IV. Specific Teaching Activities
   1. The Water Cycle
   2. The White Glove Test
   3. Get the Iron Out
   4. Conserving Water at Home
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   6. Further Investigations
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   8. EEE Actions: You Can Make a Difference!
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V. Answers to Selected Teaching Activities

Facts About Water Resources

Introduction

Water is perhaps our most important natural resource. Without water, life on earth as we know it would cease. During the past several decades, there has been a growing concern in the United States about the proper management of our vital water resources. Water pollution has been a major problem, and recently certain regions have experienced water shortages. Water resource management will continue to be an important public policy issue. Wise public policy requires citizens and decision makers who are knowledgeable about our water resources and who understand basic economic principles.

Basic Information

WATER, WATER, EVERYWHERE: Water is certainly a remarkable substance. In addition to being necessary for life itself, water transports people, goods, and waste; defines political boundaries; cools industrial equipment; irrigates crops; provides electricity and recreation; plays a major role in determining the weather; and is the "universal solvent." Given water's importance, it is fortunate that it is so abundant. Indeed, four-fifths of the world's surface is covered with water - about 340,000,000 cubic miles! However, little of this water is usable since 97 percent is salty ocean water. Another two percent is stored in glaciers and ice caps. In fact, only 0.8 percent of all the earth's water is fresh water that is immediately available for human use. This amount is basically a fixed supply and is all that we have, given current technology.

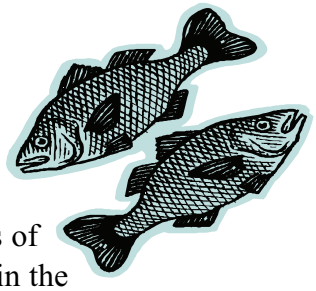
FRESH WATER SOURCES: The fresh water that is available for human use exists primarily as surface water or ground water. **Surface water** is water that we can see. There are five basic categories of surface water: rivers and streams, lakes, oceans, estuaries, and wetlands.

- **Rivers and streams** often begin as fresh springs in mountain areas. The springs turn into streams and then into rivers. Some rivers, such as the Mississippi, start from ground water sources. Springs are the natural discharge of ground water to the surface.
- **Lakes** are bodies of water surrounded by a larger land mass. Lakes change as they age, primarily by accumulating sediment from surrounding land areas.
- **Oceans** are large bodies of salt water that cover 66 percent of the earth’s surface.
- **Estuaries** form where rivers meet oceans. Estuaries are valuable because they are places where many aquatic species live and breed.
- **Wetlands** are low-lying areas that are periodically covered with shallow water. Wetlands are natural filters that preserve and protect ground water quality, help control flooding, and are a breeding ground for many species of wildlife.

Ground water is stored underground. Its importance is illustrated by its volume — over 30 times greater than the volume of rivers, streams, and lakes. Many people believe ground water exists in underground caves. In fact, most ground water is contained in **aquifers**, porous

underground areas containing sand or loosely packed granular materials. The size of the material determines the storage capacity of the aquifer (**porosity**) and its ability to transmit ground water (**permeability**). Ground water flow can vary from several feet a day to only inches per year. Aquifers may be near the surface or deep underground. They may be shallow formations or may be thousands of feet thick. About one fourth of all the fresh water used in the United States (one half of the drinking water) comes from underground sources. Nearly 60 percent of Indiana's population uses ground water for drinking water.

WATER CYCLE: The amount of water available for human use is being replenished constantly through the **water cycle**. Water evaporates into the atmosphere in the form of water vapor. Only pure water evaporates — solids, impurities, and salts remain behind. Eventually, the water vapor cools and falls as fresh water, usually as rain or snow. Most water falls into the oceans. The water that falls on land surfaces either flows into streams and rivers, eventually reaching the oceans, or seeps into the ground and replenishes the groundwater supply. Ground water and surface water interact in the water cycle, as ground water partially recharges rivers, streams, lakes, and oceans. The water cycle is a never-ending process that continually renews the fresh water of the earth.



WATER DISTRIBUTION: One of the unique and challenging features about fresh water availability is its uneven distribution. In some countries and in some regions of the United States, there is an abundant per capita water supply. In other areas, water is much more scarce. And yet, human habitation doesn't always correlate with fresh water availability. For example, there is abundant water in the sparsely populated rainforests of South America, but much less water in certain heavily populated regions in the western United States. These arid regions have continuous or periodic water shortages.

Water Management Problems

There are two fundamental problems in the area of water resource management: 1. the issue of **pollution** (quality) and 2. the issue of **availability** (quantity).

WATER POLLUTION: Water pollution is a complex and interesting subject. In general, people want clean water and have strong opinions about water quality. In the 1960s, people became very concerned about the deteriorating quality of water in the United States. Since that time, water quality has improved throughout much of the country. However, water pollution is still a real problem and is the focus of much public concern.

Pollution: What is it? It is important to distinguish between “waste” and “pollution.” In nature, all living creatures generate waste. It is best to think of **pollution** as meaning "too much." Too much of anything, including waste products, even if it is **biodegradable**, is not good for the environment. For example, in 1776 the biodegradable waste dumped into the rivers from small farms was not a problem. The same could not be said today. There are more people, and the sheer quantity of such waste would cause a major pollution problem.

Pollution from Nature: Water can be polluted by nature as well as by humans. The most common surface water pollution comes from erosion. Soil particles that enter surface water

block sunlight and impair photosynthesis, a process plants depend on to survive. Volcanic eruptions and forest fires cause thermal pollution of surface waters. In some areas, high levels of dissolved salts, irons, calcium, or magnesium may make water unsuitable for drinking or other domestic and farming purposes.

Pollution from Humans: Any time water is used in production or consumption, its quality changes to some degree. If this change is significant, the water becomes "polluted." Primary sources of pollutants are households, industry, agriculture, municipal landfills, and certain government activities.

Types of Water Pollution: There are various basic types of water pollution:

- **Biodegradable Wastes:** Biodegradable wastes, such as sewage and food waste, can harm water supplies because they provide food for oxygen-consuming bacteria. These wastes also contain disease-causing bacteria, viruses, and parasitic worms.
- **Plant Nutrients:** Fertilizers enter waterways primarily from agricultural runoff, causing excessive growth of algae and other water plants. The decomposition of dead plants by bacteria reduces oxygen content and kills certain aquatic populations.
- **Chemical Wastes:** Many different kinds of organic and inorganic chemicals enter our water supplies in a variety of ways. Examples include various toxic wastes, leakage from underground tanks, and pesticides.
- **Heat:** Many large industries use water to cool their machinery. When this heated water is discharged into waterways, it raises overall water temperatures. This reduces dissolved oxygen content and harms certain fish and crustacean populations.
- **Sediments:** Poor soil conservation practices often allow large levels of **silt** to enter waterways. An excessive amount of silt clouds water, limiting the sunlight necessary for photosynthesis by algae and other water plants. When the silt settles to the bottom as sediment, it covers the spawning areas of fish and shellfish.
- **Radioactive Materials:** Despite very stiff regulations about radioactive waste disposal, radioactive materials sometimes enter our waterways, primarily through uranium mining, fallout from nuclear testing, and accidental releases.

Point and Nonpoint Source Pollution: The various types of water pollution can be categorized into two major groups: point source pollution and nonpoint source pollution. **Point source** pollution enters water resources at a particular site, such as waste water discharged from a pipe or a leak in an underground gasoline storage tank. **Nonpoint source** pollution comes from discharges from large land areas. Examples include runoff from croplands, construction areas, parking lots, and urban areas. The distinction requires different public policy approaches to find effective solutions.

WATER AVAILABILITY: In certain arid areas with rapidly growing populations, water availability is a serious problem. In arid regions that rely heavily on agriculture, such as California, the problem is even more acute because of the huge amount of water needed for irrigation. Local and state governments are developing public policies to deal with this problem, which is difficult because of the conflicting interests of groups competing for the right to use the scarce water resources.

Dealing with Water Pollution

Nobody wants polluted water resources. People want their water resources to be clean and safe. But if water quality is so important, why has water pollution been such a problem? Why are solutions to water pollution sometimes so controversial?

WHO OWNS THE WATER? Water can be found throughout the United States; in fact, we have over 250,000 rivers! You have already learned what an important and scarce resource water is to humans. So who owns the water?

In the settlement of America, the government did not play a large role in **property rights**; rather, it was up to settlers to claim their property. Since water was a significant factor in development of towns, the first settlements were usually located near bodies of water. This accounts for the curved shapes of states in the humid East and along the coasts where there are many rivers. The property rights regime associated with this type of settlement is called **riparian rights**, which give the right to use the water to the owner of the land adjacent to the body of water. This method of allocation made sense because those that owned land near the water had easy access. However, the population of the United States has increased since the time of settlement and this form of water allocation no longer acceptable.

Since a riparian right tied the rights of water to the land, the rights could not be separately transferred to people that needed water, but not the land. The **prior-appropriation doctrine** was developed to solve this problem of water transferability by giving the right of the water to the first person to use the resource, regardless of land ownership. This allowed private companies to construct irrigation systems, which helped agriculture and mining flourish in the arid Western states, whose rectangular boundaries are not water-based.

Currently, both state and federal governments play a large role in the allocation of water. In the 1860s, states began to claim ownership of bodies of water, which gave people a **usufruct right**, the right to use water rather than to own the water. This public ownership allowed the government to control the rates charged by companies for irrigation. When it became necessary for water to be transferred across state boundaries, the federal government became involved in water rights to promote fairness and efficiency in regional development and economic growth.

Since 1900, the federal government has built almost 700 dams to provide water and power to the West. Much of the water used by localities and for development is subsidized by the federal government. For example, 81 percent of the cost of supplying irrigation water and 64 percent of municipal water costs are paid by the federal government.

THE PROBLEM OF SPILLOVER EFFECTS: The major economic reason why water pollution is a problem is that most water resources are commonly owned, and are, therefore, overused. For example, a company located on a river has an economic incentive to use the river (or the air) for waste disposal because there is no immediate cost for doing so. This probably would not be a problem if only one company put waste in the river; but if many companies use the river for waste disposal, water quality deteriorates rapidly.

The harmful effects of the pollution of commonly owned resources are called **spillover costs**, or **external costs**. These harmful effects are imposed on other people, forcing these "innocent bystanders" to bear some of the costs of production. For example, instead of incurring the production costs of treating waste water properly, a company can shift these costs to others in the form of polluted water. This is the rationale for government getting involved in pollution control. Through regulation, taxation, or other means, the government attempts to force *internalization* of the negative external effects of pollution. (For a more complete discussion of spillover effects see page 10.)

THE PROBLEM OF SCARCITY: At first glance, improving water quality seems simple enough — the government should implement various regulatory policies that keep people from polluting. Unfortunately, the solution is not that straightforward. Water is required in all production and consumption activities; and any time water is used, its quality is affected to some degree. The only way to guard our water resources completely from pollution would be to stop using them altogether — hardly a feasible solution! The real issue to consider in public policy decisions is how clean we want our water to be. Perfection isn't possible.

At the heart of this issue is the problem of **scarcity**. It takes scarce productive resources (natural, human, and capital) to ensure a safe and clean water supply. These same productive resources can also be used for a variety of other valuable purposes. A community that devotes productive resources to water quality must give up the opportunity of using these resources for other things, such as better roads, schools, and police protection.

HOW CLEAN IS CLEAN? How does a community or society determine how many productive resources to devote to water quality or to any other energy or environmental problem? The economic concept of marginalism helps to answer this question. (See page 13 for a more complete discussion of marginalism.) The basic idea of “optimality” is that, after some point, it is not wise to devote additional productive resources to water quality since the additional costs of continuing to improve water quality become greater than the additional benefits. After some point, it is better to devote scarce productive resources to other valuable purposes. Marginal analysis includes careful consideration of monetary estimates of the costs and benefits of policy options. This can be difficult, especially assigning monetary values to things such as the recreational and aesthetic value of clean water. For different people, these values will vary. Despite the difficulties, marginal analysis gives policymakers their best tool in analyzing energy and environmental issues.

HOW MUCH IS DANGEROUS? Scientists have made great strides in their ability to detect minute levels of possibly dangerous chemicals in our water supplies. For example, in the 1950s, scientists could detect chemicals in water at the part per million (ppm) level. By 1975, this had dropped to parts per trillion (ppt), and recently scientists have found some chemicals at the part per quadrillion (ppq) level! However, these technological advances can complicate public policy decisions. While we now can detect chemicals previously not thought to be in our water supplies, we lack scientific data confirming how these minute quantities affect human health and the environment.

For example, ground water sometimes contains minute quantities of pesticides that leak into the ground. These quantities are usually detected at levels of parts per billion (ppb), a level equivalent to one ounce of chemical dissolved in one billion ounces of water. (One ppb is approximately equal to dissolving one sixth of an aspirin tablet in 16,000 gallons of water, approximately the amount of liquid held in a large train tank car.) Is water containing minute quantities of these chemicals unsafe? In many cases, we simply don't know. However, this illustrates the importance of dosage levels when defining pollution. For example, substances such as chlorine and fluoride are considered toxic at rather modest levels, yet we *add* them to our water supplies to kill harmful microorganisms and reduce tooth decay.

HOW SAFE IS OUR WATER? Since the 1970s, water quality has improved significantly in the United States, thanks in part to federal legislation, such as the Clean Water Act of 1972 and the Safe Drinking Water Act (SDWA) of 1974. These acts charge the Environmental Protection Agency (EPA) with monitoring overall water quality. The SDWA established national water standards called maximum containment levels, or MCLs, for any pollutants that "may" have negative effects on human health. Public water supplies must monitor and comply with these standards. Individuals with private water supplies are responsible for monitoring the quality of their own water. The Clean Water Act and other acts required the EPA to establish national effluent standards and to monitor the amounts of contaminants entering our waterways.

Since 1999, states have been required to develop and implement standards of quality for all of their waters. These values, known as the Water Quality Standards, represent the maximum allowable levels of various contaminants that may exist in the water without causing serious human health problems. To comply with the Clean Water Act, states are required to assess the quality of all bodies of water regarding these standards. If the actual concentration of any particular contaminant exceeds the standard in a given water body, the water body is deemed to be impaired with respect to that pollutant. The state is required to develop and implement specific plans for attaining Total Maximum Daily Loads, commonly known as TMDLs, for all impaired water bodies. These are calculations of the maximum amount of specific pollutants that a particular body of water can receive in one day and still remain within the standard.

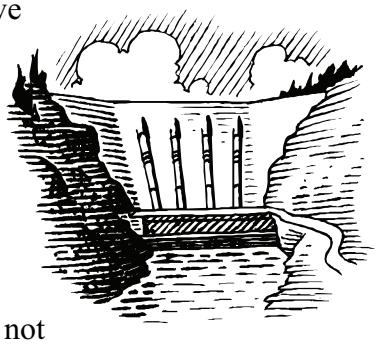
Experts agree that many water supplies in the United States are generally safe for their intended purposes. However, this issue will remain a source of controversy since some level of contamination is inevitable, and individuals will disagree on the effects of minute quantities of contaminants that now can be detected.

Dealing with Water Availability

TWO GENERAL APPROACHES: There are various regions in the western United States that have too little water. This is due largely to low and variable precipitation, high runoff evaporation rates, depletion of ground water supplies because of intensive irrigation, and increased demand from a growing population. There are two basic approaches to dealing with water availability problems: 1. increase **supply** and/or 2. reduce **demand**.

INCREASING SUPPLY: There are various ways to increase water supplies. One of the primary ways is to build dams and reservoirs. These collect water and store it for dry periods, provide flood control, and are a source of energy for electric generation. However, dams and reservoirs are costly to build and they must also be kept free from silt, which can disrupt a river's ecological balance.

Water diversion projects transfer water from one watershed to another, but they are expensive and may have harmful environmental impacts. Another alternative is to rely more heavily on ground water sources. This also can be a problem because excessive usage leads to aquifer depletion. Less feasible alternatives include cloud seeding, and desalination (which is quite expensive).



REDUCING DEMAND: There are two primary ways to reduce water usage. The first is to conserve water by promoting better **water efficiency**. Water efficiency measures how much water it takes to do a certain task. Because water has been generally plentiful and inexpensive in the United States, water efficiency has not been a major concern. Industry, agriculture, and households have tended to use large amounts of water. There has been an emphasis recently to improve water efficiency in all areas. Many industries now recycle waste water for reuse and use new manufacturing techniques to conserve water. In agriculture, new irrigation techniques reduce evaporation and seepage. Many households now have water-saving fixtures and devices that significantly reduce water usage.

The second basic way to reduce water usage is through **full-cost pricing**. Because of government subsidies and pricing policies, the price of water is often kept artificially low and does not reflect the true relative scarcity of water. For example, residential water meters frequently use “decreasing block” pricing, which charges a lower rate for successive units (volume discounts for each hundred gallons per week), rather than “increasing block” pricing, where citizens pay more as they use more water. Low prices encourage consumption and reduce water efficiency. In some regions, consumers are not even metered for their water usage. The obvious economic solution is to establish a true market price for water. Politically, however, this can be difficult. Consumers, especially western farmers, depend heavily on supplies of cheap water. Water pricing and the parallel issue of water rights will remain important and controversial issues.

Summary

Is there really a water crisis in the United States, as some news stories indicate? In general, experts agree that there is no immediate crisis in water quality or availability. For the most part, water supplies in the United States are adequate and the quality is suitable for desired purposes. However, average national statistics mask real local and regional problems. Most experts believe that the water management policies of the federal government, which previously focused on national standards, are shifting to accommodate these local and regional needs. As one report stated:

> Because water management problems and concerns are increasingly localized and complex, the focus of policy decision making is now shifting to non-Federal levels. Where nationally consistent policies were appropriate to water quality or resource management in the past, today's problems require more finely tuned responses.... These may take the form of supplementing national policies with flexibility to address local considerations or even of defining what is "national" in terms of diverse regional or local solutions to a particular water management problem.[1]

One thing is certain — water management issues will figure prominently in public policy decisions in the years ahead.

1. "An Overview of the Nation's Water," *World Eagle*, (March 1992), p. 33.

Water Resources Vocabulary

Aquifer	Porous underground layers of sand or other granular materials that hold ground water
Biodegradable	Capable of being broken down into simpler substances by the action of living organisms such as bacteria
Effluent	Wastewater that is discharged into waterways (may be treated or untreated)
Environmental Protection Agency (EPA)	Federal governmental agency responsible for making and enforcing environmental regulations
Estuaries	Surface water areas where rivers meet oceans
Ground Water	Water located in aquifers beneath the earth's surface
Marginal Benefit of Pollution Control	The benefit of eliminating an additional amount of pollution
Maximum Containment Levels (MCLs)	Legally-enforceable water pollution standards for certain chemicals set by the EPA under the Safe Drinking Water Act (SDWA)
Natural Pollution	Pollution caused by forces of nature
Nonpoint Source Pollution	Pollution that does not enter surface water at any one place
Percolation	The action of surface water gradually seeping underground
Point Source Pollution	Pollution that enters surface water from one particular source, such as wastewater from a pipe
Sediment	Small soil particles that settle on the bottom of waterways
Sludge	The residue that remains after treating wastewater
Spillover Costs (External Costs)	When harmful effects of pollution are imposed on individuals not directly involved in the buying and selling decisions that caused the pollution
Surface Water	All the water that one can see, including oceans, rivers and streams, lakes, estuaries, and wetlands

Thermal Pollution	When the temperature of surface water is raised to harmful levels by the addition of warmer water
Trade-off	Giving up some of one thing in order to get some of another
Transpiration	The giving off of moisture through skin pores or leaves
Wastewater	Water discharged by users into surface water; may be treated or untreated
Water Cycle	The movement of water in our environment as it goes from liquid to vapor, and back to liquid again
Water Efficiency	Measure of how much water it takes to do a certain task
Water Pollution	Harmful and unwanted effects on waterways caused by contaminants and wastes
Wetlands	Areas periodically covered with shallow water, such as swamps, marshes, and bogs

Teaching Instructions

Overview

The specific teaching activities in this unit do not necessarily have to be done in order. However, it may be best to do the Case Study toward the end of the unit when students have mastered much of the basic information.

Some of the basic information to teach your students is found in the Facts About Water Resources section. Other information is available from a variety of sources. Encourage your students to research this information on their own. The Further Investigations sections suggest a variety of research activities.

Some of the key economic concepts your students should learn are described below in the Important Concepts to Emphasize section. The Key Questions to Ask Students section will also be helpful.

Important Concepts to Emphasize

1. **Pollution and Spillover Costs —** Wastewater discharges impose spillover costs (external costs) on "innocent bystanders." The spillover costs of water pollution, like air pollution, especially arise when no one *owns* particular water resources. Since there is no cost for people or businesses to use these commonly owned water resources, they become overused and polluted. Government intervenes to correct this problem, usually with regulation and/or taxation. The government tries to "internalize" the external costs so that the producers and consumers who benefit from polluting the water resources bear the costs.

2. **The Problem of Growth —** In the Case Study, the cause of the pollution problem was the cumulative effect of the growing number of factories. The individual firms were complying with existing environmental standards, but as overall production increased, the lake was unable to assimilate the increasing discharges.

3. **Growth Versus Protecting the Environment —** These two community goals frequently come into conflict, as they do in the Case Study. Emphasize that protecting the environment will hurt economic growth to some degree. There is no free lunch; it is costly to implement environmental regulations. Usually, any solution involves trade-offs. Communities accept moderate amounts of pollution so that economic growth is not hampered too severely.

4. **Marginal Analysis —** "How clean *should* our waterways be?" This question is at the heart of the issue of water pollution. Some strict environmentalists (like Dr. Johnson in the Case Study) will tolerate little or no pollution. For others, larger amounts of pollution are quite tolerable, especially if it means jobs for the community. Economists argue that it makes sense to clean up water resources to the point where the additional (marginal) benefits of the purer water equal the additional (marginal) costs. Beyond that point further clean-up is unwise, since scarce productive resources could best be used elsewhere. See the more completed discussion of marginal analysis in the Introduction (page 13).

5. **Making Growth and Environmental Protection More Compatible —** The goals of growth and environmental protection are increasingly being viewed as more compatible. A new idea is the selling of pollution rights. By allowing less efficient firms to purchase pollution "rights" from more efficient firms better able to meet pollution standards, the aggregate amount of pollution can be controlled at socially acceptable levels.

Teaching Suggestions

Do the following activities with your students:

ACTIVITY 1: THE WATER CYCLE. Make sure your students follow all the directions carefully. You may wish to have students write a paragraph describing the water cycle and the places where pollution enters the cycle.

ACTIVITY 2: THE WHITE GLOVE TEST – HOW CLEAN IS CLEAN? In this activity, students learn to use marginal analysis in deciding how clean the environment should be. Essentially the same teaching activity ("How Much Is Enough?") also appears on page 145 of this booklet, where the activity has been modified to apply specifically to the issue of global warming.

ACTIVITY 3: GET THE IRON OUT! Even though this is a hypothetical scenario, it is a realistic one. Some states are considering regulations that would require reductions in iron concentrations in local water supplies.

ACTIVITY 4: CONSERVING WATER AT HOME. Your students will relate well to the issue of shower length! Discuss their answers in class. You may want students to work in groups and present their conclusions to the class.

ACTIVITY 5: CONSERVING WATER OUT WEST. The economic concepts of **shortage**, **price**, and **demand** are presented in this activity. It is important to emphasize that increasing the price of a natural resource is an effective and efficient way to get *consumers* to conserve. A higher price is also the most efficient way to get *producers* to search for new supplies of a natural resource.

ACTIVITY 6: FURTHER INVESTIGATIONS. Encourage students to do their own research. If time permits, let students share information they have learned with their classmates.

ACTIVITY 7: DEBATING THE ISSUES. Students can debate orally or present their views as a written assignment.

ACTIVITY 8: EEE ACTIONS: YOU CAN MAKE A DIFFERENCE! Encourage students to implement some of the suggested activities.

ACTIVITY 9: CASE STUDY: THE CASE OF THE POLLUTED LAKE. Make sure your students understand the Five-Step, Decision-Making Model. (See Introduction, page 17.) You can do this case study as a large or small group activity. Students should use the Decision Worksheet (page 51) and the Decision Grid (page 52) to help them. Discuss the different group decisions.

Another way to complete this activity is to have individual students or small groups of students make presentations supporting the various viewpoints in the case study. Let the rest of the class be the city council and decide what to do.

Key Questions To Ask Students

1. What is water pollution? *(It is best to think of pollution as meaning "too much." All water is "polluted" in that it contains trace elements of various kinds of substances. Water becomes polluted when the quantity of these substances makes water unusable for its desired purpose.)*

2. What is the primary economic reason for water pollution? *(Pollution occurs because no one usually owns water resources. Businesses and individuals can use these resources without paying for them, causing them to become overused and polluted.)*

3. How do governments deal with water pollution? *(They impose regulations and pollution taxes, give subsidies to firms to clean up water resources, create market incentives to encourage firms to control pollution.)*

4. Why is a proposal to entirely eliminate water pollution unreasonable? *(In the first place, it is impossible to eliminate all traces of pollution in water. All water is "polluted" to some degree. More importantly, the additional cost of eliminating increasingly smaller amounts of pollution eventually outweighs the additional benefits of doing so. At some point, we must accept a certain level of pollution.)*

5. In the case study, is Marty and Sam's idea to impose regulations and have employees and owners accept lower wages and profits fair? *(It is fair to the extent that it conforms to this basic principle – the producers and the consumers who cause and benefit from the pollution should bear the costs. It is a reasonable suggestion since consumers would pay a higher price for goods produced by polluting firms, which would receive lower profits and their workers would earn lower wages while still keeping their jobs.)*

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