

The Solid Waste Management Resource Guide for Massachusetts Schools

1996 Edition



William F. Weld, Governor
Commonwealth of Massachusetts

Trudy Coxe, Secretary
Executive Office of Environmental Affairs

David B. Struhs, Commissioner
Department of Environmental Protection

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Lt. Governor

DAVID B. STRUHS
Commissioner

October, 1996

Dear Massachusetts Educator:

The Department of Environmental Protection is pleased to present the revised *Solid Waste Management Resource Guide for Massachusetts Schools, 1996 Edition*. This guide, first produced in 1990, has been invaluable in fostering an awareness and knowledge of solid waste among the students of the Commonwealth.

Massachusetts has set ambitious goals for waste reduction and recycling, to be achieved by the end of this decade. At the same time, the Commonwealth has also created new educational standards for both educators and students. These goals reflect the growing recognition that it is our responsibility to maintain a healthy environment for future generations as well as to provide the citizenry of Massachusetts with the skills and knowledge necessary to make decisions regarding environmental protection.

If we are to reach these goals, we must continue to invest in the education of the youngest members of our society, our children. We must continue to educate and inform the students of today about the environmental issues they will face in the future. This resource guide will assist educators in teaching students about the source reduction and solid waste management issues they face today and will confront tomorrow.

The Executive Office of Environmental Affairs and the Department of Environmental Protection are committed to increasing recycling education resources available to educators. We are confident that the Revised 1996 Solid Waste Management Resource Guide will continue to be a valuable tool in imparting awareness of solid waste management issues.

Sincerely,

A handwritten signature in cursive script, reading "David B. Struhs".

David B. Struhs
Commissioner
Department of Environmental Protection

**Waste Management, Inc.**

A WMX Technologies Company Phone 617.246.4210
580 Edgewater Drive
Wakefield, MA 01880-6292

Dear Educator,

At Waste Management, Inc., we are dedicated to increasing recycling awareness and education throughout Massachusetts. We are honored to join the Massachusetts Department of Environmental Protection and the Massachusetts Audubon Society in sponsoring the *Solid Waste Management Resource Guide: 1996 Edition* for the schools in our state.

All of us at Waste Management, Inc., hope the guide will be a valuable tool in expanding statewide education initiatives. This public/private partnership allows us to teach today's youth the importance of protecting our natural resources.

Our company provides recycling services to cities, towns, and businesses throughout the commonwealth. Educating the next generation of leaders today on the importance of waste reduction and reuse is an important step in both increasing and maintaining recycling efforts statewide.

At a time when environmental issues are a concern to everyone, the 1996 *Solid Waste Management Resource Guide* serves as an effective tool to educate students of all ages. This curriculum teaches sound environmental practices through hands-on activities and projects. As a company dedicated to protecting and enhancing the environment, we are pleased to have a role in supporting this program.

We look forward to being a community partner for this worthwhile project.

Sincerely,

Jay Rooney
Northeast Group President
Waste Management, Inc.

Using the Resource Guide

Building public awareness is a critical step toward ensuring that our solid waste is managed in environmentally responsible ways in the future. Teachers have a golden opportunity to reach our children and to help them understand the nature of waste, why it needs to be dealt with, and how it can be managed. The material in this guide is meant to provide teachers with supporting material and specific activities to use in teaching about solid waste issues and the individual's role in affecting them.

This Resource Guide was developed for grades K–12. It reflects the Commonwealth's forward-looking legislation and DEP's Solid Waste Master Plan 1995 update. The goals behind preparation of this material were to:

Help students understand solid waste and resource management issues.

Make students understand that their attitudes and actions affect these issues.

Present the state's four-step integrated approach to solid waste management: reduce, recycle, incinerate, and landfill.

The material in this guide is divided into four sections: an overview of the materials that comprise the waste and recycling streams; a brief history of solid waste management in Massachusetts; profiles of the four disposal strategies being implemented by DEP; and appendices. Activities following each of the first three sections are divided into two age groups, K–6 and 7–12. We encourage you to browse through the activities for both age groups for ideas.

The activities are designed to increase the students' knowledge and awareness of solid waste issues, to enhance their skills through interdisciplinary studies, and to encourage active participation in understanding and addressing solid waste issues. You may wish to create solid waste units or use individual activities to supplement your regular curriculum.

The guide's updated appendices contain sources used in the development of this project, as well as an extensive list of organizations, publications, audio-visual materials, and other instructional tools that provide supporting information on solid waste issues.

This guide is not intended to function as a curriculum by itself. Rather, it should be viewed as a treasure chest of ideas and background information for you to use creatively and freely. Please feel free to photocopy materials from the guide and share them with your colleagues. Additional copies may be obtained by contacting the DEP at (617) 338-2255 from area code 617 and outside Massachusetts, and at 1-800-462-0444 from area codes 413 and 508.

Overview of Revisions to the 1996 Resource Guide

Dear Educator,

The original scope of the Resource Guide revisions was to update facts and figures only. The project revisions expanded to reflect the significant changes in the Commonwealth's *Solid Waste Master Plan: 1995 Update*. The layout of the guide is essentially the same as that of the 1990 edition, with some sections expanded. The major sources for the updated information were the *Massachusetts Solid Waste Master Plan: 1995 Update*, and the U.S. Environmental Protection Agency's *Characterization of Municipal Solid Waste in the United States*, 1992 and 1994 editions. The Commonwealth has made significant strides toward the goals set out in its original 1990 Master Plan. The information in the guide reflects the state's progress. Changes in the guide include:

1. Revision of the appendices:

All resources listed were verified by mail and phone.

The *Further Readings* Appendix was removed due to the outdated publications listed.

The *Entertainer* Appendix is now Appendix D, *Performers*, and has been significantly expanded.

The *Audio-Visual* and *Curricula* Appendices have been expanded and separated according to the following topics: composting, recycling, and household hazardous waste.

There are two new appendices: Appendix C-7, Resource Guides, and Appendix C-8, Multi-Media Tools for Teaching About Waste Management.

Appendix B-4, *Industry*, has been expanded significantly. Many of the materials are free; however, they are meant to represent the viewpoint of the industry providing them. This should be kept in mind when using the materials.

2. Revision of the guide's background materials:

The "Household Hazardous Waste" section of "Problem Waste Facts" has been significantly expanded in the areas of hazardous product identification, safe management, and reduction.

The "Problem Waste Facts" section was expanded to include an extensive section on batteries.

"Trash Facts" was changed to "Recycling Facts" where appropriate to reflect that recyclables in the waste stream are, in fact, valuable resources.

The "Natural Resources" section was moved to the front of the guide to reflect the concept that waste is a resource.

A discussion of aseptic packaging (e.g., drink boxes, juice boxes) has been added

3. Revision of the activities:

Facts and figures in activities have been updated. No new activities were added.

The “School Recycling” section was removed. Instead, DEP has sponsored the development of a separate publication, *Manual for Implementing a School Recycling Program*. This manual is available from DEP’s Division of Solid Waste Management.

The 1996 edition of the Resource Guide serves as a foundation for teaching about solid and hazardous waste, conservation of natural resources, and pollution prevention. There are a multitude of good, solid waste curricula, audio-visual materials, and instructional resources available to supplement the activities offered here. Check the appendices for an extensive listing of these resources. The effort invested in the guide’s revisions is dedicated to the empowerment of the community to make informed, responsible environmental decisions.

Sincerely,

Lynn Rose

Program Director

Franklin County Solid Waste Management District

SECTION I: WHAT IS WASTE?

Solid Waste Composition

Is trash really waste?

Waste is often composed of products for which we no longer have a use. These products are made up of natural resources that can often be used repeatedly before being disposed of. Old products can be broken down, reprocessed, and used to replace virgin materials in the manufacturing process. Thus, waste can be a valuable resource. For our society to truly recapture the natural resources that are discarded as trash, we need to re-evaluate what we mean by “waste.”

What is the definition of solid waste?

While it can be called garbage, trash, or refuse, solid waste takes many forms and comes from many sources. The Commonwealth of Massachusetts uses these definitions for¹ waste:²

- **Total Solid Waste:** Unwanted or discarded material that requires disposal of some type. It can come in a solid, liquid, or contained gaseous form. This material comes from household, commercial, industrial, agricultural, mining, or municipal activities. Solid waste does not include materials such as hazardous waste or sewage.
- **Municipal Solid Waste (MSW):** The portion (about 73 percent) of the total solid waste stream that comes from residences, businesses, municipalities, and institutions (schools, hospitals, nursing homes, etc.). MSW does not include solid waste from manufacturing, mining, or agricultural operations.

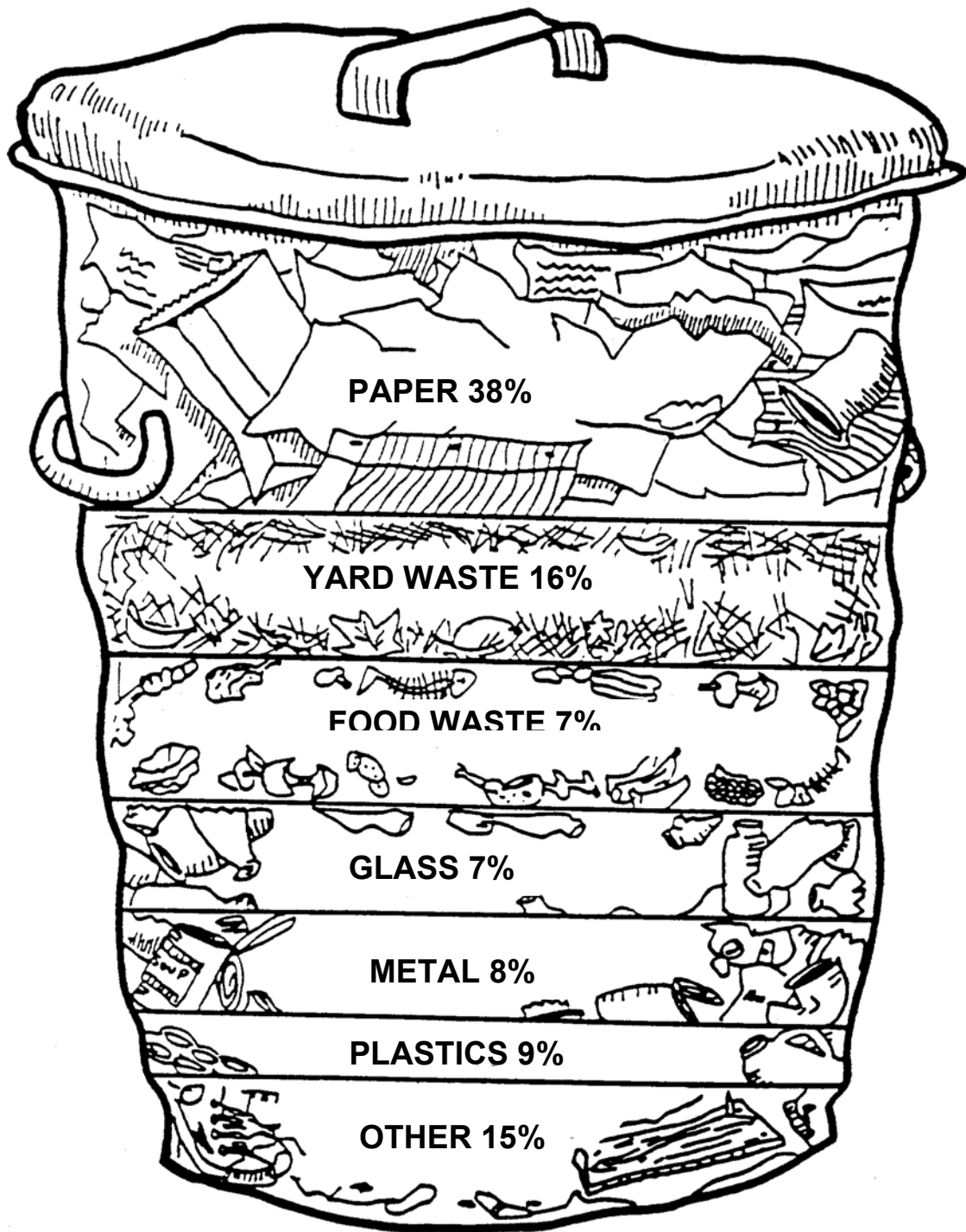
In 1994, Massachusetts generated approximately 10 million tons of solid waste, of which more than 7 million tons were MSW. Solid waste (including recyclable and compostable material) from residences accounted for 41 percent of all MSW, while commercial waste (business and institutional wastes) accounted for the remaining 59 percent of the MSW.³ The remaining 3 million tons of solid waste were composed primarily of industrial wastes, biosolids (sludge) from wastewater and industrial processes, and construction and demolition debris. Figure 1-1 shows the composition of a typical American community’s municipal solid waste stream by percentage of material.

How much solid waste do we generate?

- Americans generate enough waste every year to fill a convoy of 10-ton garbage trucks 145,000 miles long, which would circle the equator six times.⁴
- Americans throw away enough aluminum to rebuild the American air fleet 71 times, enough steel to reconstruct Manhattan, and enough paper and wood to heat 5 million homes for 200 years.
- National figures show that Americans generated over 207 million tons of solid waste in 1993, more than three-quarters of a ton per person.⁵ This amount equals approximately 4.4 pounds per person per day.

Where is solid waste generated?

Waste is generated at every step of a product's lifecycle, including mining, processing, manufacturing, packaging, use, and disposal. Thus, our purchase of consumer products creates waste that we don't see or deal with directly. Our consumer habits directly affect the amount of industrial and agricultural waste generated in this country and abroad.



Source: U.S. EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*

Figure 1-1. Components of municipal solid waste in the United States, by weight

Natural Resource Facts

What are natural resources?

Natural resources are valuable, naturally-occurring materials on which we and other living organisms depend. Some examples of natural resources include air, water, soil, rock, minerals, plants, wildlife, metals, and fossil fuels. They can be mined from the ground, harvested from forests and fields, or removed from the atmosphere. Every product we use and produce is derived from one or more natural resources. As a result, our continued existence is directly related to the abundance, availability, and quality of these raw materials. It is also dependent on our ability to obtain them. A great deal of time and energy are spent locating raw materials and transforming them into products we need and use.

Although it is sometimes difficult to recognize the source of manufactured or processed items, everything can be traced back to the earth. A fast food hamburger, for example, is made from beef, which comes from a cow. The bun is made from grains which, like the grass that cows feed on, grow in soil and are nourished by minerals, water, and sunlight. The polystyrene container is made from fossil fuels extracted from the earth. In addition, a large quantity of energy, also derived from natural resources, is used to transform the raw materials into the hamburger. Producing just one burger requires many natural resources, often tapping sources worldwide. Because the earth is the ultimate source of everything we need and produce, we must take good care of it.

What are renewable and nonrenewable resources?

Natural resources can be divided into two major categories: renewable and nonrenewable.

Renewable resources are those that are replenishable on a short time scale. Because they are replenished naturally, supplies can be restored and maintained indefinitely, if properly managed. Some examples of renewable resources include trees, plants, wildlife, solar energy, and hydropower. Many useful materials and products such as food, clothing, medicine, paper, and lumber are derived from these resources. After the raw materials are harvested, more can be planted or grown and, over time, restored. For example, if we harvest trees to use in paper production, we can plant new seedlings that will grow to produce more wood.

Renewable resources can be replenished, but excessive and improper use can severely deplete and, ultimately, destroy them. In general, we have the ability to consume resources more quickly than they can regenerate. Sophisticated technology and equipment exacerbate this problem as they enable us to harvest resources at rates that greatly exceed their natural ability to replenish themselves, even with human assistance such as replanting. Harvest and regrowth should be carefully balanced to maintain sustainable supplies of renewable resources.

Nonrenewable resources are those resources that cannot be replenished in the short term. Some examples of nonrenewable resources include precious metals, minerals, and fossil fuels. These raw materials are used as fuel, as well as to produce plastics, synthetics, glass, steel, and other useful items that are now part of our daily lives. Limited supplies of these materials are found on the earth. Running out of raw materials that have become necessities could significantly alter the way we live and have far-reaching environmental ramifications. Like humans, some renewable resources, such as trees, depend on nonrenewable resources, including minerals, soil, water, and air. Consequently, nonrenewable resources must be carefully managed for the sake of all living beings.

How do consumer practices affect the supply of natural resources?

Natural resources are not equally distributed around the world. Thus, countries compete for rights and access to these valuable materials. As the world population and the complexity of most societies increase, the demands and pressures placed on natural resources also increase. In addition, an increase in toxic materials entering the environment and polluting the water, air, and soil greatly threatens the integrity of existing resource reserves.

Excessive human consumption and mismanagement are destroying supplies of both renewable and nonrenewable resources. Varying amounts of resources and energy are required to support different lifestyles. The United States and other industrialized nations require more energy and resources per capita than do most other countries. Only 6 percent of the world's population lives in the United States, yet we consume 33 percent of the world's energy. Much of this energy is used to meet industrial, residential, and transportation demands that are viewed by many as excessive and inefficient. As a result, natural gas and oil are disappearing rapidly. It has been estimated that the earth's fossil fuels will be depleted in the next 30 to 60 years, and that coal supplies will be exhausted by the year 2400. Unfortunately, fossil fuels are nonrenewable resources and no amount of money or power will be able to replenish them. Zinc, lead, copper, and other nonrenewable resources are also expected to be depleted within the next century.

Poor management and excessive consumption of a renewable resource not only threaten that resource, but all those who depend on it as well. For example, trees are being harvested from tropical rain forests much faster than they can possibly grow back. Although trees are considered to be renewable with proper management, most tropical rainforests and North American old growth forests that are clear-cut and burned will probably never return to their original state. Rapid deforestation destroys valuable plant species and eliminates habitat and food sources for many species of wildlife. A reduction in mature forest vegetation also means a decrease in its oxygen-producing capacity and in the amount of organic matter and essential nutrients that are returned to the soil. Less vegetation means fewer roots exist to hold the soil in place, thereby increasing soil erosion and decreasing soil fertility. These are some of the ways that poor resource management can have local as well as global ramifications.

Our convenience-oriented lifestyle not only consumes a great deal of natural resources, but it also wastes them. Many resources are converted to products with very short life spans. For example, oil—which is produced over millions of years—is used to create a plastic container that will warm a hamburger for 30 minutes before it is discarded and sent to a landfill to be buried. This use pattern severely restricts the benefits that can be gained from such a limited and versatile resource as petroleum.

How can we conserve natural resources?

There are several steps we can take to conserve resources and protect the environment. The first step is to become an educated and responsible shopper. We can reduce our resource consumption by purchasing fewer disposable products, especially those made from nonrenewable resources such as petroleum. In addition, purchasing products in reusable and recyclable containers can prevent the resources making up those containers from becoming trash. Instead of using virgin raw materials, recyclables can be used to make new products, often reducing the amount of energy needed and the pollution generated in production.

Reducing, reusing, and recycling decrease the demands on natural resources, as well as the rate at which they are consumed. Fewer resources are used, limited supplies are conserved, and regeneration of renewable resources is given time to occur. In addition, less waste is generated, thereby reducing

the amount of trash that must be landfilled or incinerated. As the amount of trash buried or burned decreases, so does the potential for air and water pollution from the improper disposal of wastes.

Natural resources must be conserved and properly managed to prevent their depletion and contamination, and to ensure that people around the world have access to those materials necessary to maintain a decent standard of living. Choices we make in our personal lives can and do affect the environment. By reducing, reusing, and recycling, we can help conserve the earth's resources and the life they support for many generations to come.

Recycling Facts

Paper

DID YOU KNOW THAT 38 percent (by weight) of all municipal solid waste is made from paper or paperboard? Some paper products that we discard regularly include newspaper, cereal boxes and other paperboard food containers, letters, magazines, tissues, toilet paper, and paper towels. Currently, the United States is the largest producer and consumer of paper and paper products in the world. In 1993, the United States generated 78 million tons of paper and paperboard waste.⁶ Of this total, approximately 66 percent was not recycled or composted.⁷

Where does all this paper come from?

Paper is produced from wood. About 35 percent of the world's annual wood harvest is used to produce paper and this share is expected to grow to 50 percent by the year 2000. It takes approximately 17 trees (roughly 3,700 pounds of wood) to make 1 ton (2,000 pounds) of paper. Fortunately, trees are a renewable resource; however, we are currently harvesting our trees faster than we are replacing them. Without proper management or sufficient natural regeneration, some species of trees (as well as the production of paper and other wood products) could be threatened.

How is paper made?

Paper is made in paper mills, which are usually located near the forests where the trees are harvested. Once the trees are cut down, they are debarked and chipped. These smaller pieces of wood are mixed with chemicals and processed in a large pressure cooker called a *digester*. This process helps to break the wood down into cellulose fibers. These fibers are rinsed to remove chemicals, unwanted wood contaminants, and dirt. The remaining wood-water mixture is called *slurry* and is fed onto screens that catch the fibers. The material on the screens is shaken to intermesh the fibers and drain any excess water. The resulting sheets of paper are passed through a series of rollers where they are pressed and dried. The final rolls of paper are produced by machines at rates as fast as 30 feet per second and can be as wide as 16 feet.

An increasing number of paper mills are using recycled paper as a feed stock to make new paper. Recycled paper contains cellulose fiber that can be reused (alone or combined with new fiber) to make many kinds of paper products including newsprint, stationery, towels, tissues, napkins, insulation, roofing paper, packaging, and paperboard. When it arrives at the paper mill, recycled waste paper is first processed in a pulper. Water is added to turn the paper into a soft, wet material called *pulp*. Chemicals may be added to remove inks and contaminants from the paper fibers. The pulp is sifted through screens (to remove staples, paper clips, etc.) and washed. Clean pulp is mixed with clean water until it becomes a thick, white substance. This is spread into thin layers on a screen, heated, dried, and smoothed on a series of rollers to form sheets of clean finished paper.⁸

As paper recycling programs have become more common, the supply of recycled paper has increased and become more reliable. Many new paper mills that use recycled paper are being located near population centers to be near this new source of raw materials.

How does paper production affect our environment?

In addition to consuming resources, paper production can pollute our environment. Producing 1 ton of paper from trees may create as much as 84 pounds of air pollutants, 36 pounds of water pollutants, and 176 pounds of solid waste. This does not include the negative impacts resulting from the conventional disposal of used paper and paper products.

While the use of recycled paper to make more paper should be encouraged, the recycling process does create its own environmental hazards. The paper de-inking process, in which ink is removed from recycled paper, produces wastes that may contain lead. These wastes require careful management and disposal. As more printing companies switch to soy-based inks, the de-inking process should become less of an environmental concern.

Of major concern in the production of paper, either from trees or recycled paper, is the use of chemicals that produce cancer-causing wastes. Chlorine, which is commonly used to bleach, or whiten, paper fibers, causes the production of dioxin, a known carcinogen. New bleaching methods that reduce or eliminate the use of chlorine are being developed. Paper mills are slowly switching over to using oxygen, carbon dioxide, hydrogen peroxide, and ozone in place of chlorine.

What are the benefits of recycling paper?

Paper has become an integral part of our lives and plays an important role in many sectors of our society. It is a product that adds to our high standard of living and is essential in maintaining quality education, health and safety standards, and cost effective and efficient transportation of goods.

If we recycled half of the paper used in the world today, we would meet almost three-quarters of the demand for new paper and save millions of acres of forest at the same time. When left standing, forests help purify the air, provide essential wildlife habitat, and offer recreational opportunities to humans. Using waste paper instead of trees to manufacture new paper products also reduces water consumption by 60 percent and the generation of environmental pollutants by 70 percent. Recycling a ton of newsprint is equal to saving four 42-gallon barrels of oil! In addition, recycling paper products extends the life of landfills by conserving valuable space. Recycling 1 ton of waste paper saves an average of 3 cubic yards of landfill space.

How can we “close the loop?”

To “close the loop” is to purchase products that contain recycled materials. If demand for recycled-content goods is steady, manufacturers are more likely to invest in the machinery and processes needed to use recycled materials in their products. Manufacturers that are set up to use recycled materials as feedstock provide a steady market for recyclables that are collected by community recycling programs.

A Recycling Success Story in Massachusetts

Newspapers are the most commonly recycled household item in Massachusetts. The Commonwealth and the Massachusetts Newspaper Publishers Association signed an agreement in 1989 in which newspaper publishers voluntarily agreed to increase the recycled newsprint content used in Massachusetts newspapers to 13 percent by 1993, 23 percent by 1995, 31 percent by 1997, and 40 percent by 2000. This agreement promised a steady demand for old newspapers, and paper manufacturers became willing to invest millions of dollars in recycling technologies. This legislative initiative brought recycled newspaper supply and demand closer to equilibrium than they had been previously. By 1992, the average recycled content of Massachusetts newspapers had risen from 6.4 percent in 1991 to almost 15 percent.

Sources: Massachusetts DEP, *Master Plan: 1995 Update*; Florida, *4Rs Project*

Glass

DID YOU KNOW THAT 7 percent (by weight) of everything we threw away in 1993 was made from glass?⁹ Some examples of commonly used glass items are jars and bottles which contain food, beverages, toiletries, cleaners, and medicines. Other glass objects in the waste stream include window panes, light bulbs, and mirrors. It is estimated that each person in the United States uses almost 400 bottles and jars each year. Glass is popular because it is versatile, strong, and fairly easy to produce. It can be recycled an unlimited number of times. Refillable glass bottles were originally designed to endure 30 round trips from manufacturer to consumer. Because we often throw them away after using them only once or twice, the raw materials and energy invested in their production are wasted. The Massachusetts Bottle Bill, passed in 1983, has greatly increased the number of bottles recycled in the state, although many glass containers are exempt and are still discarded as garbage.

Where does glass come from?

Glass is produced from minerals. Silica, more commonly known as sand, is the primary ingredient used in its production. Silica is the most common substance in the earth's crust, and although it is a nonrenewable resource, there is quite a large supply of it. It takes 1,330 pounds of sand, 433 pounds of soda ash, 433 pounds of limestone, 151 pounds of feldspar, and 15.2 million BTUs (British Thermal Units) of energy to produce 1 ton of glass. The soda ash (sodium carbonate) lowers the melting point of silica and helps regulate the consistency of the mixture. Limestone (calcium carbonate) is added to stabilize the mixture and keep it from dissolving in water. Different colors of glass are produced by adding small amounts of other substances such as iron, copper, and cobalt. Green glass, for example, is made by adding iron.

How is glass made?

Glass is produced in factories where the raw materials are melted together and transformed into bottles, jars, and other products. There are 90 glass manufacturers in the United States that produce a total of approximately 80 million containers a day. The mixture of silica, soda ash, limestone, and feldspar is called a *batch* of glass. The batch is mechanically fed into large furnaces and heated to temperatures as high as 2,800 °F. When it is completely melted, the material is transferred to a glass forming machine where molten glass is dropped into molds for shaping. Compressed air is then forced into the center of the mold blowing the glass out against its walls, forming the desired shape. This formation process only takes approximately 13 seconds. Finally, the containers are placed on conveyor belts and are slowly passed through cooling tunnels to prevent shattering. Slow cooling, in addition to a protective coating, strengthens the glass and increases its durability. In about 1 hour, the bottles are cool enough to touch and can be labeled, filled and sent to market.

How are glass, energy, and the environment related?

The raw materials used to produce glass are plentiful and fairly accessible, but the process of transforming them into glass requires a lot of energy. It takes about 7,600 BTUs of energy to produce just 1 pound of glass. In addition, the manufacturing of 1 ton of glass can generate as much as 385 pounds of mining waste and 28 pounds of air pollutants.

What are the benefits from reusing and recycling glass?

Reusing glass at home conserves resources and energy. Industries also reuse glass by cleaning and refilling glass containers that are returned for the bottle deposit. The energy savings from this activity, though, are partially offset by the energy expended in the cleaning and transport of the used bottles.

Recycling glass can also save resources and energy and can reduce the amount of waste and pollution generated by glass production. To be fully useful to manufacturers, recycled glass must be separated by color—green, brown and clear. Ceramics and window glass, which have an entirely different composition from container glass, are considered contaminants to recycled container glass.

Recycled glass is crushed into cullet, small pieces less than one-half inch in size. Adding cullet to the batch saves energy because recycled glass has a lower melting point than do the virgin source materials. The temperature of the furnace can be lowered 10 degrees for every 10 percent cullet added. Because a new batch of glass may contain up to 83 percent cullet, using old bottles to make new ones can conserve a significant amount of energy (approximately 6 percent). Using 1 ton of recycled glass will also save 1.2 tons of raw materials and reduce mining wastes and other harmful by-products of glass production. It has been estimated that using 50 percent recycled glass in the manufacturing of new glass can reduce mining wastes by 79 percent, water consumption by 50 percent, and air emissions by 14 percent.

In addition to making new glass containers, recycled glass can also be used in fiberglass manufacturing and as a substitute for aggregate in road building. Finally, recycling glass saves landfill space. Instead of becoming trash and lying in landfills for thousands of years, bottles and jars can be used over and over again, and recycled indefinitely.

Sources: AVR, Teacher's Resource Guide; Bell and Swartz, Oscar's Options; Florida, 4Rs Project

Metal

DID YOU KNOW THAT 8 percent of everything we threw away in 1993 was made from metal?¹⁰ Iron and aluminum are the metals most frequently used in the production of items we use daily, such as food and beverage containers, pie plates, frozen food trays, foil, car and aircraft parts, gutters, pipes, window frames, construction beams, and appliances. The chemical composition and structure of these metals result in products that are strong and durable, even when exposed to the elements. For example, an aluminum can left outside will take 500 years or longer to disintegrate to dust. Unfortunately, the very properties that make metal products so useful and versatile also contribute to problems associated with their disposal.

Where does metal come from?

Metals are elements or mixtures of elements that occur naturally in the earth. Abundance, accessibility, and the processing required to transform these natural substances into a usable form vary with the type of metal.

Aluminum

Aluminum is the third most common element and constitutes 8 percent of the earth's crust. Although it is quite common and can be found dispersed throughout most rocks and clays, it is never found naturally in its metallic state. The greatest concentration of aluminum is found in bauxite ore, which contains large amounts of alumina. Most of the world's bauxite reserves are in the subtropics where heat and water weather away other elements, leaving a high concentration of alumina. The United States imports 85 to 90 percent of its bauxite.

Surface mining of bauxite requires a large energy input and generates solid, waterborne, and hazardous wastes, as well as air pollution. After the bauxite ore is extracted from the ground, it is transported to refineries where the alumina is chemically separated from the ore. The aluminum is then extracted from the alumina through an energy-intensive process called *electrolysis*. Small amounts of other metals or alloys may be added to the aluminum to strengthen it. The melted aluminum is then cast into ingots and sent to manufacturing plants where it is remelted and formed into a variety of items. Aluminum is often used when a strong, durable, yet light-weight, material is needed.

Iron, Steel, and Tin

Iron is also a naturally occurring element. Steel is produced by adding carbon to iron. Different grades of steel are produced by adding various elements to this basic mixture. Tin is another metallic element. "Tin" cans are really steel cans with a thin coating of tin, which prevents the steel from rusting or corroding. Steel is very strong and is the most widely used metal today. The mining and processing of iron is quite costly, and energy intensive.

How can I tell the difference between the types of metals?

You can tell the difference between steel cans and aluminum cans with a magnet. Magnets will attract steel, but not aluminum. Bimetal cans are steel cans with an aluminum top and bottom. A

magnet will attract these cans if pointed at the steel portion, but not if placed near one of the aluminum ends.

What are the benefits of recycling metal products?

Metal products are used extensively throughout the world. We have come to depend on them for transportation of people and goods, for sturdy building materials, and for packaging and storage of food and beverages. It is clear that as population increases and the standard of living rises worldwide, so too will the demand for metal products. Unfortunately, metals are nonrenewable resources and their extraction from the earth is expensive, energy intensive, and detrimental to the environment. Recycling metal and reusing it to make new cars, appliances, and window frames, for example, can offset the monetary and environmental costs of consuming metal products, while continuing to meet the increased demand.

Pure aluminum cans are 100 percent recyclable. Using them to produce new aluminum products can reduce energy consumption and air and water pollution by approximately 95 percent. Recycled aluminum is shredded, remelted and cast into ingots and mixed with virgin aluminum before being shaped. Once produced, aluminum cans may be recycled indefinitely.

Compared with manufacturing steel from virgin materials, recycling steel can reduce energy consumption by 74 percent, air pollution by 86 percent, water use by 40 percent, water pollutants by 76 percent, and mining wastes by 97 percent. For every ton of steel recycled, 2,500 pounds of iron ore, 1,000 pounds of coal, and 40 pounds of limestone are saved. The Steel Recycling Institute reports that each year in the United States, recycled steel saves enough energy to meet the electrical power needs of the city of Los Angeles for 8 years! Recycled steel is generally shredded or compacted, cleaned, and remelted. For each ton of scrap metal used in place of virgin materials, 1.5 tons of iron ore and one-third of a ton of coke/coal are saved.

Most residential recycling of ferrous metals—i.e., iron and steel products—focuses on the recovery of steel cans. Steel cans are composed of roughly 1 percent tin (used as a coating) and 99 percent steel. These cans are most often sent to a de-tinning factory where the chemical separation of tin from steel takes place. The two materials are then marketed to different manufacturers for use in new products. Increasingly, steel cans are being sent directly to steel mills where they are mixed with other raw materials to make new steel.

In addition to reducing pollutants and conserving resources and energy, recycling metal materials saves landfill space. Every pound of metal that you recycle means one less pound of metal for your community to dispose of by landfill or incinerator. Steel is 100 percent recyclable and can endure an infinite number of cycles through the recycling process.

The recycling of metals has increased dramatically in the past two decades. In 1970, only 3 percent of all metals in the United States were recycled. By 1990, 21 percent were being recycled.¹¹

Sources: AVR, Teacher's Resource Guide; Bell and Swartz, Oscar's Options; Florida, 4Rs Project

Plastic

DID YOU KNOW THAT plastics account for approximately 9 percent by weight¹² of everything we threw away in 1993, and represent roughly twice that amount in volume?¹³ Since the end of World War II, plastics have become extremely popular in the United States. Plastics are used to produce many items we rely on daily, including milk and juice jugs, soda bottles, food wraps, garbage bags, and several types of packaging. In addition, plastics have contributed to many scientific breakthroughs and have played a major role in the development of important products such as contact lenses, artificial hearts, more fuel-efficient cars, and portable computers. Plastics are lightweight, durable, waterproof, versatile, relatively inexpensive to produce, and increase the mobility and shelf life of many products. These properties make plastics very desirable to both consumers and manufacturers, and as a result, they have been replacing traditional materials such as glass, aluminum, steel, and paper. Unfortunately, the very properties of strength and low weight that make plastics appealing also create complex problems during their production and disposal.

What is plastic made from?

Plastics are synthetic materials derived from petroleum and natural gas. Petroleum and natural gas also provide energy for residential and commercial needs, production processes, and transportation needs around the world. Availability of these scarce, nonrenewable resources is a critical issue underlying the continued use and disposal of plastics. At current consumption rates, world-wide reserves of accessible petroleum and natural gas are only expected to last for another 30 to 60 years.

How are plastics made?

Plastics consist of carbon combined variously with hydrogen, oxygen, nitrogen, chlorine, or fluorine. They are made by linking together small molecule groups called *monomers* into long-chain molecules called *polymers*. When this chemical rearranging occurs, a plastic resin is formed. While in liquid form, plastics can be molded and cast into many different shapes. Plastic resins are used to produce hundreds of different types of plastic, all of which fall into two basic categories, thermoset and thermoplastic.

Thermoset plastics harden permanently, making them difficult to recycle. Thermoset plastics are used to produce products that require a hard, durable, and permanent plastic such as, furniture, toys, tableware, and computer casings. These items constitute approximately 10 percent of plastics sold in the United States.¹⁴

Thermoplastics will also harden when cooled, but may be remelted and molded into new plastic products. This characteristic makes thermoplastics good candidates for recycling. Thermoplastic resins are commonly used for rigid containers such as soda, dairy, detergent, and cosmetic bottles, and other noncontainer products such as trash bags, toys, rope, utensils, flooring, Styrofoam, upholstery, and pipes. To recycle thermoplastic materials, scrap plastic must be reduced to granules, pellets, or powder, which are then marketed as feedstock to plastics molders.

Many thermoplastic products have a recycling code imprinted on their bottom panel. The code consists of a number, 1 through 7, inside of a recycling symbol (the chasing arrows). The Society for the Plastics Industry (SPI) developed this code so that plastics could be sorted by type at

recycling facilities. Whether these numbered plastics are recyclable in a particular community depends on local collection capabilities and existing markets for recycled plastics.

The thermoplastic resin types most commonly used in the United States and most frequently seen in the waste stream are listed below, next to their SPI code:



Polyethylene Terephthalate (PET) has been used extensively since 1977 for soft drink bottles. It is also used in other packaging materials such as plastic jars, sheeting, and blister packs, as well as for certain appliance and auto parts.



High Density Polyethylene (HDPE) is used for the majority of rigid containers such as milk jugs, laundry detergent jugs, plastic tubs for butter and margarine, containers for ice cream, cosmetics, and medicine, and for heavy-duty trash bags.



Polyvinyl Chloride (PVC) is a versatile plastic because it is tough, yet can be modified by additives to be flexible. PVC is primarily used for durable construction products such as pipes, siding, cables, and gutters. Commonly known as “vinyl,” it also is used extensively for flooring, paneling, siding, luggage, footwear, upholstery, clothing, camping gear, and beach rafts. Roughly 25 percent of the PVC produced is used for disposable packaging.



Low Density Polyethylene (LDPE) is used extensively in packaging materials such as clear wrap, supermarket produce bags, bread bags, dry-cleaning bags, and for coating other containers such as milk and juice cartons.



Polypropylene (PP) is used for durable items including battery cases, furniture, fibers for rope and strapping, cellophane-like food wrappers, and in some of the layers of multi-layered plastic containers.



Polystyrene (PS) is best known in its foamed form, better known by Dow Chemical’s trademark, Styrofoam. It is used for products such as food trays, egg cartons, hot cups, and clamshell containers for take-out foods. Polystyrene is also used to produce plastic cutlery, disposable razors, prescription and vitamin bottles, mini-containers for cream, and packaged cookie trays.



Other includes plastics that are not one of the six previous types. Also in this category are products that consist of multiple plastic resins in layers, blends, or different parts. Mixing resins allows strength, flexibility, and other desired properties to be combined in one product. Squeezable ketchup bottles are an example of a multi-layered plastic container. Although these plastics help to increase product shelf life or protect the flavor and texture of food items, mixing of multiple plastic resins makes them more difficult to recycle.

What are the disadvantages to using plastics?

The production of plastics requires large quantities of crude oil and natural gas, and generates a significant amount of solid waste, as well as air and water pollutants. Each day, millions of plastic products are discarded, and the potential energy embodied in them is wasted. Disposal of plastics can generate air pollution when burned in combustion facilities. For example, burning PVC releases chlorine gas into the atmosphere, which can threaten human health. The burning

process also creates hydrochloric acids that can corrode the inside of combustion chambers, resulting in an increase in atmospheric emissions.

In addition to the problems associated with the production and subsequent disposal of plastic waste, many plastic items are disposed of improperly and end up in oceans, waterways, and along roadways. This plastic litter threatens the health of many species of wildlife and often compromises the natural beauty of these areas. It is estimated that plastic garbage (e.g., six-pack rings, fishing lines and nets, plastic bags, utensils) commonly found in United States waters accounts for the death of thousands of marine mammals per year, including endangered species of turtles and whales.

Plastic products and packaging have become necessities in our convenience-oriented society. In Massachusetts, plastics accounted for approximately 528,000 tons of municipal solid waste in 1992.¹⁵ Plastics do not rust, biodegrade, dissolve, or evaporate when exposed to the elements. Although most plastic products are used only briefly, they will remain in our environment for a very long time and will continue to create serious waste management and pollution concerns.

What are biodegradable and photodegradable plastics?

The litter and marine pollution problems associated with plastics have prompted keen interest in the development of degradable plastics that break down naturally and disappear over time. True biodegradable plastics that can be broken down into organic substances by bacteria and fungi are presently in the experimental stage, and are not yet available for general use.

Recently, several plastic products such as trash bags and disposable diapers have been advertised as being biodegradable. These plastics are oil-based and contain additives such as cornstarch. Bacteria readily feed on the starch in the blend and, although this action breaks up the plastic material into small fragments, these little pieces of the oil-based plastic remain in the environment.

Photodegradable plastics are blended with additives that degrade when exposed to the ultraviolet rays in sunlight. Direct exposure to sunlight for extended periods of time causes these materials to become brittle and the plastics break down into smaller pieces. These fragments of plastic also remain in the environment. Manufacturers are currently producing six-pack yolks from photodegradable plastics and are required to do so by law in over twelve states, including Massachusetts. Other commercial products made with photodegradable plastics include trash bags and agricultural mulches. While these items break down in the sunlight, they will have the longevity of other plastics if buried in landfills, as they will receive no exposure to the sun.

How are plastics recycled?

The ideal type of plastics recycling is a *primary* recycling process that creates a closed-loop system. An example of a primary process is the conversion of an old laundry detergent container into a new detergent container, again and again, indefinitely. There are some factors that limit the use of the primary recycling process for plastics. The cost to transport the high-volume, low-weight plastic containers to a manufacturer that can process the containers into more of the same kind is often prohibitive. There are also U.S. Food and Drug Administration regulations that limit the use of recycled plastic in food grade containers because recycled plastic containers cannot be sufficiently sterilized during the recycling process.

A *secondary* recycling process is one that converts a plastic product into a different product that is also recyclable. While this process does not eliminate the need to use virgin materials to make more of the first product, it does displace some virgin materials in the production of the second product.

A *tertiary* recycling process converts the recyclable plastic into an item that cannot be recycled again. The ideal goal in this process is to take items with short life spans, such as ketchup bottles, and convert them into an item with a long life span, such as plastic lumber.

Although there are more than seven kinds of thermoplastics, only a few types are commonly recycled. The most-recycled plastics are #1, PET, and #2, HDPE. They comprise 90 percent of the plastics used for bottle remanufacturing.¹⁶ Recycling these plastics involves shredding or grinding the containers, washing them, and removing contaminants. They are then melted down and formed into new products.

Manufacturing new plastic goods with recycled plastic feedstock requires less energy than using virgin raw materials for the process. Making containers from recycled PET requires only 12 percent of the energy needed when using virgin materials. Recycling 1 ton of HDPE conserves approximately 76 million BTUs. Recycled PET is commonly used as fiberfill in pillows, jackets, sleeping bags, and automobile seats. Other uses include insulation, shower stalls, floor tiles, automobile bumpers, taillight covers, and power tool housings.¹⁷ Recycled HDPE can be remolded into flower pots, trash cans, automotive mud flaps, kitchen drain boards, beverage bottle crates, and pallets.¹⁸

Polystyrene foam packaging is being recycled in a growing number of programs around the country. Various types of foam packaging waste are collected, flaked, remelted, and pelletized. Recycled polystyrene is mixed with virgin polystyrene to produce coat hangers, flower pots, wall and building insulation, and protective packaging.

The plastics industry has also developed technology and products that do not require the separation of resins for recycling. Mixed-resin plastics are used to make plastic lumber for boat docks, auto curb stops, park benches, horse stalls, picnic tables, railroad ties, marine pilings, piers, and fencing. Research into the separation of mixed plastics and its uses is continuing.

At this time, plastics recycling programs are expensive because of the high-volume/low-weight characteristics of plastic. One ton of plastics takes up six times the space of 1 ton of glass, for example. Crushing and densifying plastic containers reduces their volume, allowing greater shipping and storing efficiencies. These efficiencies can result in a more cost-effective collection program.

Sources: Massachusetts DEQE, Plastics Recycling; U.S. OTA, Facing America's Trash; AVR, Teacher's Resource Guide; Florida, 4Rs Project

Aseptic Packaging and Milk Cartons

DID YOU KNOW THAT approximately 3 billion aseptic drink boxes are sold in the United States each year? Nationally, each household generates approximately 9 pounds of aseptic packaging and milk carton waste per year. Drink boxes have gained popularity because they are sterilized and they allow liquids to be stored without the need for refrigeration or preservatives. They also have a lower packaging-weight-to-product-weight ratio (4 percent) than do other containers, such as glass bottles (35 percent), plastic bottles (16 percent), or aluminum cans (5 percent). This attribute makes aseptic packaging attractive to those paying for product transportation by weight.

What is aseptic packaging made of?

Aseptic packaging consists of three different materials layered together. Paper makes up 70 percent, by weight, of each drink box. Polyethylene (24 percent) and aluminum (6 percent) make up the rest of the box. Each box has six layers of material: two innermost layers of polyethylene, followed by aluminum, polyethylene, paper, and a final layer of polyethylene. This combination of materials makes drink boxes waterproof and durable.

Is aseptic packaging recyclable?

Packaging that contains more than one type of material presents a recycling challenge. Because aseptic packaging is 70 to 80 percent paper, many paper companies use equipment that will separate the paper fiber from the polyethylene and aluminum. This process, called *hydrapulping*, blends the cartons with water in a big vat that acts like a blender. Cut up, empty containers are put in the vat and agitated in the water, which turns them into a soft, mushy pulp. This pulp is sifted and cleaned to separate the paper fiber from the aluminum and polyethylene. The paper fiber is used to make new paper products, such as paper towels, napkins, tissues, and writing paper. The aluminum and polyethylene are currently burned for energy or landfilled.

A new recycling technology that is being developed for aseptic containers is called *mixed plastics recycling*. In this process, the remaining polyethylene and aluminum from the hydrapulping process are combined with other kinds of plastics to form building materials, such as plastic lumber. Though technically possible, the commercial applications for this process are still being developed. In the future, this recycled plastic may be used as a substitute for traditional construction materials, such as wood, to make a variety of products, including highway markers, garden planters, and decking.

Source: Aseptic Packaging Council, *The Truth About Aseptic Packaging*

Problem Waste Facts

Problem wastes are components of the waste stream that need to be managed differently from the way typical components of the residential and commercial waste stream are handled. These “difficult-to-manage” wastes place special demands on the waste management system. Problem wastes include construction and demolition debris, tires, sludge, waste oil, batteries, household hazardous wastes (HHW), and bulky items (furniture and appliances).

Batteries

DID YOU KNOW THAT Americans purchase nearly four billion batteries every year? These batteries power such items as radios, watches, flashlights, toys, laptop computers, cellular phones, and many other household appliances. Batteries play an important role in our daily lives. Increasing concern, however, has developed over the disposal of these batteries due to their heavy metal content.

What is a battery?

Batteries are electrochemical devices that convert chemical energy into electrical energy and provide power for many commonly used items. The basic battery cell consists of a negative electrode (anode), a positive electrode (cathode), and an electrolyte, which is a solution through which an electrical current can travel between the anode and the cathode. There are two types of batteries: primary cells and secondary cells.

Primary Cells (nonrechargeable): A primary cell is not rechargeable and ceases to work when the active chemicals that produce the energy are depleted. They are not designed to be recharged and attempting to do so may cause them to explode. Most common household batteries are primary dry cells. Dry cell refers to the nonliquid electrolyte contained in the battery.

Secondary Cells (rechargeable): Secondary cells, or wet cells, are rechargeable and can be used repeatedly. The chemical reaction that creates the electricity can be reversed, thereby allowing an electrical current to recharge the battery. The electrolyte in the wet cell is in the form of a liquid bath. A common example is a rechargeable household battery that is available with a special charging unit. A car battery is also a secondary cell.

Table 1-1 identifies different types of common household batteries and their chemical components.

Table 1-1. Most Common Types of Household Batteries

Battery Type	Common Sizes	1992 Percent Sales	Chemical Components	Principal Applications
Alkaline	D, C, AA, AAA, N, 9V, button	63%	Manganese dioxide, zinc, potassium hydroxide, cadmium, mercury ^a	Consumer appliances
Zinc-Carbon	D, C, AA, AAA, 9V	20%	Manganese dioxide, zinc, ammonium chloride, lead, cadmium, mercury ^a	Consumer appliances
Silver Oxide	Button	3%	Silver oxide, zinc, potassium hydroxide, mercury ^a	Watches, calculators, hearing aids, some cameras, small electrical devices
Mercuric Oxide	Button, some cylindrical	1%	Mercuric oxide, zinc, potassium hydroxide	Hearing aids, watches, calculators
Zinc-Air	Button	3%	Zinc, potassium hydroxide, mercury ^a	Hearing aids, electronic pagers
Lithium	Button, coin, and larger 3V, 6V, AA	0.2%	Manganese dioxide, lithium, organic solvents	Photographic applications, small electronic devices
Nickel-Cadmium (rechargeable)	D, C, AA, AAA, 9V, battery "packs"	9%	Nickel hydroxide, cadmium, potassium hydroxide	Power tools, computers, cellular phones, video cameras
Sealed Lead-Acid (rechargeable)	Rectangular block, one round cell	0.6%	Lead dioxide, lead, sulfuric acid	Computers, cellular phones, video cameras, garden tools

^aMercury being phased out by several battery manufacturers beginning in 1990.

Source: New York State Department of Environmental Conservation, *Report on Dry Cell Batteries in New York State*

Why are batteries a problem?

Lead-acid automotive batteries, nickel-cadmium rechargeable batteries, and button batteries are undesirable in the waste stream because they contain heavy metals that can harm the environment and threaten human health. Until recently, alkaline or zinc-carbon household batteries also had heavy metals in them. The principal routes of heavy metals from batteries into the environment are:

Incineration of solid waste: When batteries are burned, heavy metals (particularly mercury) can enter the environment through air emissions if the air pollution technology is not designed or operated properly to capture the metals.¹⁹ Air emissions include both fly ash in the smoke and vaporized materials. Proper air pollution control equipment can filter out the fly ash better than it can capture the vapors. Heavy metals concentrate in the bottom ash of the incinerator and can come in contact with humans or the environment during storage, transportation, and disposal of the ash. Lastly, these metals may render the ash hazardous, thereby increasing disposal costs for the material.

MSW composting: When batteries end up in composting operations, heavy metals may become concentrated in the composted soils.

Unlined landfills: When batteries are buried in unlined landfills, leachate (water percolating through the garbage) may carry the heavy metals out of the landfill and into the surrounding groundwater.

Most heavy metals are toxic to people and animals and can cause a variety of serious health disorders. Unlike most organic compounds (those containing carbon), heavy metals do not decay or break down in the environment. Because plants and animals cannot metabolize these substances, they experience a build-up of heavy metals in their tissues. As larger animals eat contaminated smaller animals or plants that have been contaminated, the heavy metals become more and more concentrated and continue to bioaccumulate as they make their way up the food chain. The toxic battery components of major concern are cadmium, lead, and mercury. Batteries have been the largest source of cadmium and mercury in MSW.

Current manufacturing technology has dramatically reduced the mercury content of household batteries. In past years, mercury content was roughly 1 percent of the battery's weight. The major American battery manufacturers are now producing "no-mercury-added" alkaline batteries that present less danger to the environment.²⁰ Between 1990 and 1993, Eveready, Duracell, Panasonic/Kodak, and Rayovac all converted to a no-mercury-added design for their alkaline and zinc-carbon batteries. Government and industry are working to create the ideal battery that has no toxic components, is rechargeable, is recyclable, can be safely handled, and meets high performance standards.

There are also safety concerns related to batteries. Batteries need to be stored properly. Batteries should not be stored in tight containers or poorly ventilated areas in case of hydrogen gas or mercury vapor build-up. Batteries may leak and corrode metals or cause a skin burn on contact. Batteries should be stored in dry, vented containers that are clearly labeled. Such containers could be made of steel with a protective lining or heat resistant plastic or nylon.

Are batteries recyclable?

Metals can be extracted from batteries and recycled, but this technology is very expensive. Most of the research for battery reclamation is being done in Europe and Japan. Comparatively, the United States is doing less research, though programs to recycle button and nickel-cadmium rechargeable batteries have begun in some parts of the country.

Recycling batteries uses large amounts of energy and has very high capital and operating costs. The cost of battery recycling is determined by battery type, concentration of mercury, and the avoided costs of disposal. The cost of recycling could be reduced somewhat if batteries were more easily sorted by type. Sorting difficulties currently add to the cost of collecting the batteries.

Metals from batteries will become an increasingly attractive feedstock for the metals industry as battery manufacturers eliminate mercury from alkaline and zinc-carbon batteries.

How should we handle old batteries?

Because each type of battery poses a different kind of environmental concern, the issue of what to do with a dead battery can be confusing. Listed below are the types of batteries and how to dispose of them in Massachusetts:

Household batteries (alkaline and zinc-carbon): Throw away with the regular household trash. While these batteries do contain some levels of toxic metals, most are low enough in mercury to be safely put into landfills or incinerators. Household batteries are not considered hazardous waste under the federal Resource Conservation and Recovery Act (RCRA) and thus they are not regulated as hazardous waste for collection, storage, and processing.

Button batteries: Should be recycled through a recycling program. Due to their heavy metal content and the fact that they are salvageable at reasonable cost, button battery recycling programs are available throughout the state.

Rechargeable batteries (nickel-cadmium): Federal law prohibits the land disposal of nickel-cadmium batteries. Should be recycled or taken to a hazardous waste collection. Although they are longer-lasting than single-use disposable batteries, the toxic metals they contain pose a significant environmental risk if they are discarded in landfills or incinerators. Remember that many small appliances have rechargeable batteries built in. Remove the battery for recycling or disposal through a household hazardous waste collection program before discarding the appliance.

Automotive batteries (lead-acid): Recycle through a recycling program or bring them to auto garages or retail stores. You can trade your old battery in when you purchase a new one. Since 1992, lead-acid batteries have been restricted from Massachusetts landfills and incinerators. Nationally, nearly 90 percent of lead-acid batteries are recovered for recycling.²¹ These batteries are valued for their lead content, and the battery acid and plastic casing can be reused.

Sources: AVR, Teacher's Resource Guide; Household Batteries; Taylor et al., Recycling in the 1980s; New York DEC, Report on Dry Cell Batteries

Motor Oil

DID YOU KNOW THAT American car owners who change their own oil generate more than 200 million gallons of used motor oil each year? Unaware of the potential dangers associated with adding used oil to the environment, many people discard their waste oil wherever it is most convenient. It is estimated that through this “innocent” dumping, 180 million gallons of waste oil enter the environment each year.²² In other words, do-it-yourself mechanics dump the equivalent of the Exxon Valdez oil spill every 3 weeks!

What is waste oil and why is it dangerous?

Waste oil is motor oil that has been used in cars, trucks, boats, trains, and other engines that need oil to function properly. Waste oil can contaminate water supplies, pose serious health threats, and cause extensive environmental problems. One gallon of used oil can contaminate and foul 1 million gallons of fresh water, which is equivalent to one year’s supply of water for 50 people. One pint of used motor oil can produce an oil slick slightly larger than a football field and will kill floating aquatic organisms and algae that are food sources for fish. As fish eat these contaminated organisms, oil accumulates in their bodies. Oil also prevents the replenishment of dissolved oxygen in the water, further threatening the lives of fish and other aquatic creatures. Since contaminated organisms are eaten by fish, birds, and people, components of the waste oil move up through the food chain and can cause serious health disorders and genetic abnormalities. Human health is threatened if we drink oil-contaminated water, eat fish or animals that have ingested oil, or if our skin is directly exposed to it for long periods of time.

In addition, there are many additives and contaminants present in waste oil that make it toxic. For example, several substances are added to automotive oil to prevent rusting of engine parts and to enhance oil performance. The breakdown of these additives, plus contaminants from engine wear, and the infiltration of gasoline and combustion by-products, creates high levels of heavy metals such as lead, zinc, magnesium, and cadmium, as well as benzene and other potentially harmful substances. If not disposed of properly, these materials can contaminate water supplies, enter the food chain, and cause long-term ecological damage.

How does waste oil enter the environment?

Many consumers pour their used oil on the ground, down the sink, into storm drains, or discard it with the rest of their trash, which is landfilled or incinerated. A number of problems result from these disposal methods. When oil is dumped on the ground or buried, it can leach into groundwater and contaminate drinking water supplies. Oil poured into storm drainage systems meant to carry rainwater is transported directly into streams, lakes, and rivers. In a sanitary sewer system, wastewater proceeds to treatment plants. If waste oil contaminates this water, it can kill the bacteria that help break down sewage and purify the water. Not only does this diminish the effectiveness of the wastewater treatment, but water contaminated with oil is often discharged from these plants into rivers and coastal waters. It has been estimated that sewage treatment plants discharge twice as much oil into coastal waters as do oil tanker accidents—15 million gallons per year versus 7.5 million gallons per year. While it is quite difficult to prevent oil tanker accidents, we can effectively manage our waste oil to ensure that it does not haphazardly enter and pollute our waterways and the environment.

How can recycling waste oil save resources and protect the environment?

Improper disposal of used motor oil not only threatens human health, it also squanders a nonrenewable and scarce resource. Waste oil can be recycled by cleaning or refining it and can be used indefinitely as a lubricant. It only takes 1 gallon of used oil to produce 2-1/2 quarts of lubricating oil, while 42 gallons of crude oil are needed to produce the same amount of lubricating oil.

Waste oil can also be used as a fuel or fuel supplement. This is the primary means of recycling oil in Massachusetts since there are no refineries in the Northeast. Recycling the used motor oil dumped by do-it-yourself mechanics in one year would generate enough energy to power 360,000 homes for a year. Re-refining this same amount would produce 96 million quarts of lubricating oil.

How is used oil recycled in Massachusetts?

Massachusetts consumers have an alternative to dumping their waste oil. State law requires all motor oil retailers to accept for free up to 2 gallons of waste oil per day from every customer presenting a valid proof of purchase. The retailer is responsible for having this oil recycled in compliance with the Department of Environmental Protection's (DEP's) Hazardous Waste Regulations. The consumer is responsible for bringing waste oil to the store where it was purchased, in a clean, secure, and unbreakable container. It is important that oil is not mixed with gasoline, antifreeze, water, or any other substances because contamination will hinder the recycling process.

In addition to providing disposal opportunities under state law, the Commonwealth is making oil collection units available through grants to towns and cities. Some communities have already set up waste oil collection centers where residents can bring their used oil for recycling. With these choices available, it is now up to citizens to ensure that they dispose of waste oil in a safe and environmentally sound manner.

For further information on recycling oil in Massachusetts, call DEP's Used Oil Hotline at (617) 556-1022.

Sources: AVR, *Teacher's Resource Guide*; Massachusetts DEP, "How to Safely Handle . . ."

Construction and Demolition Debris

DID YOU KNOW THAT nearly 2 million tons of construction and demolition (C&D) debris were processed for reuse in Massachusetts in 1993?²³ C&D waste is generated from construction, renovation, repair, and demolition of houses, roads, bridges, and large building structures. C&D waste is made up of wood, steel, concrete, masonry, plaster, metal, and asphalt. C&D waste is significant because it contains hazardous materials such as asbestos, creosote, lead, arsenic, chromium, and formaldehyde resins, and because it makes up a large share of the solid waste stream.

In Massachusetts, C&D waste is handled in three basic ways. It is disposed of at landfills or combustion facilities, processed for reuse, or transported out of state for disposal or processing. The preferred alternative for C&D handling is processing for reuse. Reusing C&D waste saves landfill space and conserves virgin materials.

There are many beneficial uses for recycled C&D waste. Unpainted and untreated wood is chipped and used as a compost bulking agent, or for landscaping and erosion control. Chips from painted or preserved wood are sold for boiler fuel. Metal materials are removed from C&D waste and sold to scrap metal dealers. Asphalt waste is crushed and mixed with new asphalt. Concrete, brick, and asphalt, after crushing and screening, are used for road base and the production of new concrete.

Tires

DID YOU KNOW THAT Massachusetts has an estimated 10 to 12 million old tires stockpiled, primarily at privately owned tire disposal sites? Annual generation of scrap tires in Massachusetts is estimated at six million. Massachusetts faces the challenge of cleaning up existing piles and preventing future piles by enforcing regulations that prohibit stockpiling of tires. Additionally, the DEP supports legislative actions that promote the reuse and recycling of scrap tires.

Massachusetts is approaching tire management in several ways. DEP encourages tire recycling by exempting tires from restrictive disposal regulations. It also regulates the disposal of tires by requiring shredding prior to disposal at landfills or combustion facilities. DEP has just permitted several new facilities to manage tires. Massachusetts is one of seven northeast states working together on a regional EPA supported project to develop a coordinated approach to tire management. Finally, DEP is working with the Massachusetts Highway Department to increase the amount of tire rubber used in asphalt pavement.

Biosolids

DID YOU KNOW THAT Massachusetts produces approximately 90,000 dry tons per year of biosolids?²⁴ Biosolids, or sludge, are the waste generated by wastewater treatment facilities. Sludge is disposed of by a variety of methods including sludge-only landfills and incinerators, co-disposal with MSW, and composting alone or with MSW.

The large quantity of sludge currently being disposed of at MSW landfills is the result of the successful advancement of the Commonwealth's water pollution control efforts. The anticipated

closure of many Massachusetts landfills, however, will severely restrict this option. One method of disposal that the state encourages as a replacement to landfilling is co-composting of sludge with the organic portion of MSW.

Source: Massachusetts DEP, *Master Plan: 1995 Update*

Household Hazardous Products and Waste

DID YOU KNOW THAT each person in the United States uses almost 6 pounds of household hazardous products (HHP) in a year? HHP are those products used around the home which contain hazardous chemicals. These chemicals can be dangerous to human health and to the environment. The products are used to clean, polish, disinfect, and maintain our homes. We also use these products for our personal care, car maintenance, pest control, yard maintenance, and hobbies.

Household hazardous waste (HHW) is a household hazardous product that is no longer used. HHW can be products that are degraded, outdated, contaminated, overstocked or no longer used. The average American stores 3 to 10 gallons of HHW at any given time. Hazardous waste can be solid, semi-solid (or sludge), liquid, or gaseous. It requires special handling, storage, disposal, and, sometimes, transportation to protect people and the environment.

Some common types of HHP include:

Cleaning supplies: e.g., cleansers, polishes, disinfectants.

Maintenance supplies: e.g., oil-based paints, stains, glues.

Automotive products: e.g., waste oil, antifreeze, batteries.

Personal care products: e.g., hair dyes, nail polishes and polish removers, hair bleach.

Hobby supplies: e.g., photography chemicals, leaded ceramic glazes, artist's paints.

Pest control products: e.g., pesticides that include herbicides (kill weeds and plants), fungicides (kill fungi, mold, bacteria), insecticides (kill insects), mothballs (repel moths and insects), rodenticides (kill rats, mice, gophers), wood preservatives (repel pests), nematicides (fumigate soil), and molluscicide (kill snails and slugs).

What is the definition of hazardous?

A product is hazardous if it has one of the following characteristics:



Toxic: A chemical capable of causing immediate or long-term illness, injury, or death through ingestion, inhalation, or absorption into the body. Potentially harmful to the health and/or the reproductive ability of humans and animals.



Combustible: Any liquid that gives off enough vapors to ignite at 100 °F or higher. This is called the *flash point*. Combustibles present a fire hazard, although they are a lower fire hazard than products labeled “flammable.”



Flammable: Any solid, liquid, or gas that will burn below 140 °F by spontaneous combustion or by coming in contact with a burning material.



Reactive/Explosive: A substance with a tendency to undergo chemical changes and release energy and toxic fumes. A reaction can be triggered by a source of heat, water, air, shock, pressure, or other chemicals.



Corrosive: A substance that can chemically change and eat through metal, skin, and other materials. Corrosive substances are either acidic, with a pH less than or equal to 2, or caustic, with a pH greater than or equal to 12.5 (on a pH scale of 1 to 14).

How can exposure to HHP and HHW occur?

People are exposed to HHP and HHW through direct hazards and indirect hazards. A direct hazard is direct exposure to hazardous products or waste when not managed or disposed of properly. This exposure can be a one-time acute incident, or a chronic exposure over a long period of time.

Indirect hazards exist during the mining, production, transportation, and disposal of hazardous products. Occupational exposure to hazardous chemicals can pose a threat to a worker's health through acute or chronic exposure. Another indirect hazard is the improper disposal of HHW down the drain, where it moves to the home septic system or the sewage treatment plant. If it moves into groundwater it can contaminate drinking water supplies.

How do hazardous products and hazardous waste affect human health?

Exposure to and injuries from HHP and HHW may be local or systemic. A local injury results from direct contact of the hazardous chemical with tissue such as the skin, eyes, or lungs. A systemic injury happens when a chemical enters the body through inhalation, ingestion, absorption, or injection, and then enters the bloodstream. Once in the bloodstream, it may cause injury to specific tissues or organs. Not all toxic chemicals follow the same pathway into or through the body. Some chemicals, for example, primarily damage the central nervous system, while others may damage the liver.

Toxins can be described as *carcinogens*, *mutagens*, and *teratogens*. A carcinogen is any agent that produces and/or accelerates the development of malignant tumors or abnormal growth of cells. A mutagen is an agent that affects DNA so that it may produce cancer or a mutation in a future generation. A teratogen is an agent that interferes with normal development of a fetus.

The amount of damage chemicals can do to the body depends on their toxicity. Toxicity is the ability of a chemical to produce harm or injury to a living organism when the chemical has reached a sufficient concentration. The Threshold Limit Value (TLV) is the estimated average safe concentration of a hazardous chemical that a human can tolerate on a repetitive basis, for an 8-hour period on a day to day basis.

How can one determine if a product is hazardous?

HHP can be identified by looking at the label on the product. The Hazardous Substances Act (the federal law that establishes labeling requirements for consumer products containing hazardous ingredients) requires the following labeling for products that have an acute (immediate) effect on people:

Signal words such as:

“danger”: highly toxic, flammable, or corrosive

“poison”: highly toxic

“warning”: moderately toxic

“caution”: slightly toxic depending on the level of danger

These words must appear on the front of the label. (“Nontoxic” is an advertising word and has no federal regulatory definition.)

A description of the hazard, such as “vapor harmful” or “flammable.” This must appear on the front of the label.

A statement warning users how to avoid the hazard. e.g., “Use in a well ventilated room.”

A common or chemical name for the hazardous substance.

If necessary, instructions for safe use and handling, including the proper usage amounts, safety equipment needed, and proper mixing procedures.

First aid instructions.

The name and location of the manufacturer, distributor, or repacker.

The statement, “Keep Out of Reach of Children,” or its equivalent.

What should you consider if you have to buy a household hazardous product?

Decide if you really need it

In many cases, a less toxic or nontoxic alternative is available. If there are no alternatives available, ask yourself if the risks involved are worth using the product. For information on alternatives, contact the Massachusetts DEP, (617) 292-5898, the Office of Technical Assistance for Toxics Reduction, (617) 727-3260, or your local Board of Health.

Read labels and compare products

Read labels and compare products to find the least toxic alternative. Check the warnings and hazards that are listed to find out the product’s danger to you and the environment. Labels provide information on short-term health effects, but not long-term health effects or environmental impacts. You can contact the manufacturer for a Material Safety Data Sheet for more information on these. Also, remember that disposal information is specific to each town.

Buy only the quantity that you need

Although it is often less expensive to buy products in a larger quantity, products may deteriorate over time. The less HHP you buy, the less you have to store and dispose. Disposal of HHP is very expensive.

How can HHP be used safely?

When it is necessary to use HHP in the home, be sure to follow these instructions for their safe use:

Always read and follow the directions on the label. It will tell you about safe use, storage, disposal, and emergency measures in case of an accident.

Always use proper safety equipment such as rubber gloves, safety glasses, face mask, or respirator. Be sure the safety equipment is the right kind for the job. For example, a variety of face masks are designed for specific exposures such as dust or chemical fumes. Gloves are also designed for specific uses such as chemical contact. Make sure you size and fit your equipment well.

Use products outside if possible. If you must use them inside, use in a well ventilated area. “Well ventilated” means that fumes are exhausted outside the building and not into other areas of the home. You still need to wear a respirator designed for the product you are using.

Don’t smoke near the HHP—fumes and vapors can ignite.

Keep a fire extinguisher nearby and know how to use it.

Never mix chemicals. It is possible to create an extremely hazardous chemical by mixing materials. Bleach and ammonia, for example, form a deadly gas.

Do not wear soft contact lenses when using volatile solvents, as they can absorb the chemical. The contact lenses can hold the chemical against the eye and cause a reaction.

What should I do if I spill a hazardous material?

Clean up spills immediately.

Try to contain in a small area, do not let it flow.

Place nonchemical-type clay cat litter or sawdust (for nonflammables) on the spill to absorb it. Put saturated material in a noncorrosive container with a lid for disposal.

Wash work area and yourself after chemicals have been cleaned up. Discard contaminated cloth, mop, or broom in trash or at a HHW collection. Flammables should be put outside to dry, then stored for disposal in a metal or hard plastic container to prevent air infiltration.

Clean-up after using HHP. Any cloths or sponges you use to clean with now are saturated with that product. Put them in a covered noncorrosive container for storage or disposal.

How should HHP and HHW be stored?

To protect your home and family, HHP and HHW should be properly stored for later use or disposal. The product label will provide some information on its storage.

Hazardous materials should be stored on a high shelf or in a locked cabinet away from children, pets, food, and living areas. A detached building is the safest location, particularly for flammables. Metal cabinets help protect chemicals from sparks and fires. The storage area should stay above freezing and be cool, dry, and ventilated. These conditions help to reduce deterioration of products and corrosion of product packaging.

Always store hazardous materials in a container labeled with permanent ink. The label should include hazards, warnings, ingredients, use, storage, disposal information, and the date of purchase.

Never store hazardous materials in a container previously used for another purpose. Children who cannot read may mistake the container's contents for a familiar product.

Never leave hazardous materials out in the open and unattended.

Do not mix or store products or wastes together.

Tighten caps on containers to prevent vapors from escaping.

Store incompatible chemicals apart from one another. For example, store reactives apart from each other and other chemicals.

How should HHW be disposed of safely?

The only reliably safe way to dispose of HHW is to store it until your community participates in a hazardous waste collection day. A licensed hauler will collect the material and take it to an environmentally safe hazardous waste disposal facility. Be sure that containers are labeled with information on purchase date, ingredients, hazards, warnings, handling, and disposal of the products.

Remember these Don'ts when disposing of HHW:

Don't mix wastes.

Don't change containers (without proper labeling). If a product is leaking, enclose the whole container in a new container with a lid.

Don't pour down a drain, dry well, toilet, or on the ground.

Don't put in regular trash.

Don't bury or burn HHW.

What are the problems created by improper disposal of HHW?

Careless disposal of HHP or HHW can:

Pollute drinking water supplies, ponds, harbors, and rivers.

Injure trash collectors during curbside pick-up, when chemicals mix together and cause fires, acid burns, and/or release of toxic fumes.

Allow evaporation of solvents from products such as paints, varnish strippers, and even fingernail polish, contributing to smog and other air pollution problems.

Injure fire fighters battling fires involving large amounts of flammable substances (e.g., gasoline or paint thinner), explosives, or pesticides stored in homes and garages.

Destroy important bacteria necessary to properly break down wastes in sewer and septic systems.²⁵

Sources: For a Cleaner Environment, Woburn, MA; Massachusetts DEP, "How to Safely Handle . . ."; MWRA, *A Healthy Environment*; AVR, *Teaching Toxics*

ENDNOTES

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Activities, Section I: What Is Waste?

What is Waste?

THEME:	Trash is composed of a variety of items.
GOAL:	Students will understand that trash is composed of basic materials.
METHOD:	Guessing game with discussion
SUBJECTS:	Language arts
SKILLS:	Comparing, observing
MATERIALS:	Garbage can filled with clean trash representing all types of household waste: newspaper, cardboard, notebook paper, brown paper bag, cereal box (boxboard), magazine, glass bottle, plastic soda or milk bottle, plastic-coated cardboard milk or juice carton, plastic wrap, plastic six-pack ring, aluminum can, aluminum foil or tray, wax paper, Styrofoam, disposable diaper, fabric pieces (natural and synthetic fibers), orange peel, chicken bone, leaves, twig, etc.; Ali Ka Zim rhyme on chart paper; wand
TIME:	45 minutes

GETTING STARTED

To get a sense of what the students think about trash, ask them what kinds of things they throw away. List their ideas on the board to later compare with what is in the sample trash can.

PROCEDURE

1. Invite students up one at a time to reach into the trash can while you recite the following rhyme and point to the words with your wand:

Ali Ka Zim, Ali Ka Zam
What is (student's name) going
To pull out of the can?

2. Have each child describe what the item they are touching feels like, without actually saying what it is. Have the other children try to guess what the item is and what it is made of.
3. Ask the children how they think the item is spelled and write it on the board.
4. After going through the entire contents of the can, compare the list of items with the one the students first made. Point out that trash often contains items that we might not ordinarily consider to be garbage.

EXTENSIONS

1. Hand out the attached worksheet, "A Smorgasbord of Trash." Have the children draw or cut pictures out of magazines for each of these items to create a trash dictionary. Make a bulletin board display illustrating examples of the same words.
2. Make a checklist of typical items a family might throw away in a week. (This might be the same as the worksheet list, or a shorter version.) Have the children mark an "X" next to an item every time they throw one out. Compare the students' tallies at the end of the week. Have them circle the ones that could have been recycled or reused, rather than thrown out.

3. Learn the “I Love Trash” song from Sesame Street. (Available on videotape: *Sesame Street’s 25th Birthday: A Musical Celebration*. 1993. 60-minute VHS. Produced by Random House in cooperation with Children’s Television Workshop, New York, NY.)
4. Have students complete the attached “Search-a-Word” puzzle to find the 16 words having to do with solid waste.
5. Have each student pick an item from the sample trash can. Have them write its life story: How was it made or grown? How was it used by its owner(s)? How was it consumed? How did it end up in the trash? What will happen to it now? Have the children draw pictures to accompany the story and put them together to make a book.

Sources: Adapted from Bell and Swartz, *Oscar’s Options*; Wisconsin, *Recycling Study Guide*; Kristen Walser

A Smorgasbord of Trash

Listed below are typical items found in many household trash cans. For each of these items, draw a picture or cut one out of a magazine and bind them together to make a trash dictionary.

paper plate

glass jar

aluminum can

plastic storage bag

corrugated packing box

Styrofoam cup

newspaper

plastic milk carton

cardboard cereal box

Styrofoam egg carton

plastic-coated cardboard milk carton

aluminum foil

orange peel or apple core

broken toy

grass clippings

brown paper bag

old rag

disposable diaper

plastic trash bag

junk mail

Styrofoam packing material

plastic margarine tub

dead leaves

cardboard egg carton

aseptic juice container

fast-food restaurant packaging

paper napkin

chicken bone

gum wrapper

Search-A-Word Puzzle

The words listed below are hidden within the puzzle of letters. Some are spelled as you usually see them, but others are spelled backwards or on the diagonal. How many of them can you find?

RECYCLE	GLASS	LANDFILL	OIL
BOTTLE	TRASH	NEWSPAPER	CAN
PAPER	COMPOST	PLASTIC	REDUCE
METAL	BATTERY	ALUMINUM	ENVIRONMENT

M	R	E	C	Y	C	L	E	H	Q	X	P	M
B	L	O	I	R	Z	A	L	T	I	M	E	U
Y	L	T	T	E	O	R	N	C	R	T	U	N
P	L	L	S	T	K	S	E	J	A	S	W	I
C	I	R	A	T	Q	U	P	L	V	T	E	M
O	F	G	L	A	S	S	P	A	K	Y	C	U
M	D	I	P	B	F	G	Y	A	M	D	U	L
P	N	K	O	T	R	A	S	H	P	U	D	A
O	A	M	C	W	P	I	T	Z	R	E	E	B
S	L	U	N	E	W	S	P	A	P	E	R	V
T	L	I	N	W	P	O	O	T	S	X	Y	N
T	N	E	M	N	O	R	I	V	N	E	L	A
P	T	I	N	R	C	E	L	T	T	O	B	D

When is it Trash?

THEME:	When is an object considered to be trash?
GOAL:	Students will consider when an object becomes trash and why careful and proper disposal is important.
METHOD:	Discussion
SUBJECTS:	Language arts
SKILLS:	Comparing, drawing conclusions, making value judgments
MATERIALS:	None
TIME:	30 minutes

GETTING STARTED

Have the students start by reviewing the typical components of trash. (See Activity 1-1.)

PROCEDURE

1. Ask the children what makes an item a piece of trash. For example, once a container of milk is empty, once they are finished reading the newspaper, once they have raked all the leaves off their lawn—are all these now trash? Have each child name a piece of trash and why they think it is no longer useable. What qualities do trash items have in common?
2. Ask the students why it is necessary to take trash to a special place (landfill or incinerator). Why not just leave it in their backyard or by the side of the road? Make a list of the children's responses (e.g., it is ugly, attracts animals, could catch fire).
3. Are there items that might be dangerous even if they are buried in a landfill or burned? Discuss hazardous items such as gasoline, radioactive chemicals, and so on. Why are they harmful?

EXTENSIONS

1. Examine how other cultures use items that our society might consider to be trash.

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Trash Can Scan

THEME:	The waste stream is comprised of many different kinds of objects.
GOAL:	Students will understand what garbage consists of and that it can vary in composition over time or by location of collection.
METHOD:	Classify, weigh, and graphically represent the composition of the classroom's trash
SUBJECTS:	Language arts, math, computer science
SKILLS:	Analyzing, comparing
MATERIALS:	"Components of Municipal Solid Waste" handout; 3 days worth of classroom trash; scale capable of weighing in ounces or grams; rubber gloves; large tarp or plastic sheet; construction paper and/or graph paper; computer, if available; spreadsheet/graphing software
TIME:	1 hour per day for several days

GETTING STARTED

Ask students what kinds of things they throw away. What are they made of? Find out what materials they think make up most garbage.

PROCEDURE

1. Distribute the "Components of Municipal Solid Waste in the United States" handout. Discuss the different categories of trash (paper, plastic, metal, etc.), and list examples of items in each category. Students can create trash category posters or collages using these lists and drawings or pictures from magazines and newspapers.
2. Collect all trash discarded by the class for several days. Lay a sheet on the floor, dump the trash on it, and let the students sort it according to category—i.e., paper, plastic, metal. For items that can fit into more than one category, have them decide which material is predominant. If many materials are equally represented, you might want to create a mixed materials category. Working in groups, have the students weigh a category of trash and record their results on the blackboard.
3. Have the students create a bar chart bulletin board display that compares the various components of the classroom waste stream. Each material can be represented by a different colored construction paper bar. Determine the scale to be used (e.g., 2 vertical inches equals 1 ounce).

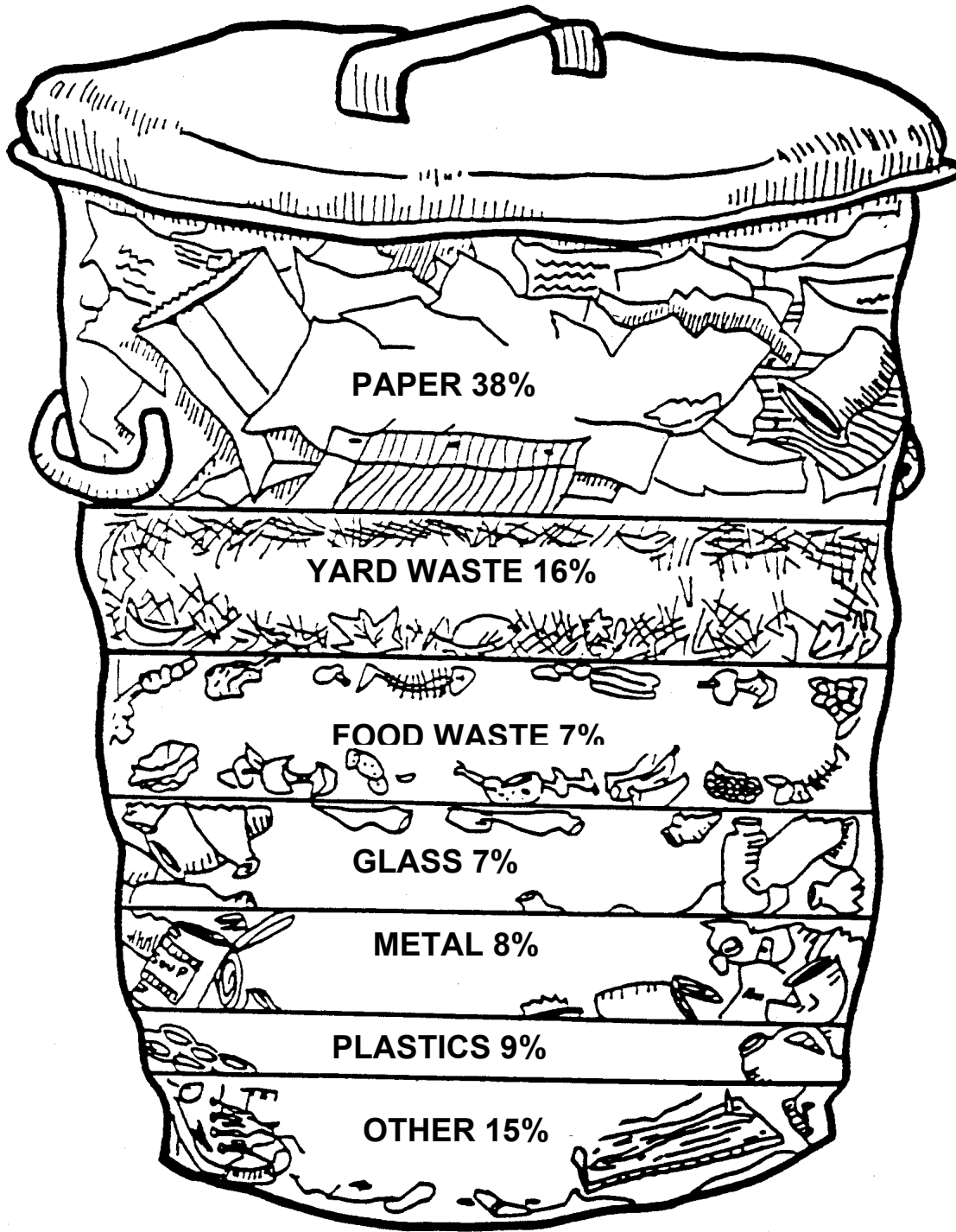
Alternately, the data from this exercise can be plotted on a computer if you have a graphics or spreadsheet program that can use the data.

4. Repeat this activity for three separate trials (e.g., 3 different days, weeks, or locations), each time separating and weighing the trash, recording the data, and constructing a bar chart. Students may also calculate the three-trial average. Have the class graph the results.
5. Compare your classroom results to the figures on the handout. What are the differences and similarities? Did the time of week when the trash was collected affect the results? How? Why?

EXTENSIONS

1. Discuss the difference between amount in weight and amount in volume. Would the category that is the heaviest also take up the most space in the trash can or at the landfill?
2. Have the different groups survey trash cans from other areas of the school (other classrooms, the library, the gym) or home, and compare the results with those obtained in your classroom. Does the composition of the waste stream vary at each location? If so, how and why? Discuss differences and similarities between the trash from different locations. Predict the results of this type of trash analysis for department stores, supermarkets, factories, and other institutions. What would be some of the differences and similarities in the composition and amount of their waste? Why?

Components of Municipal Solid Waste in the United States, By Weight



Source: U.S. EPA, *Characterization of Municipal Solid Waste in the United States: 1994 Update*

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Types of Waste: Product Profiles

THEME:	Trash can be divided into basic categories of materials (glass, metal, paper, plastic, etc.).
GOAL:	Students will identify the different categories of materials found in trash.
METHOD:	Classification of objects
SUBJECTS:	Science
SKILLS:	Comparing, classifying, interpreting
MATERIALS:	Trash items (cleaned and rinsed); several empty cardboard boxes labeled with different categories (paper, metal, etc.); labels for paper, plastic, glass, metal, rubber, textiles, organic, other; tape
TIME:	30 to 45 minutes

GETTING STARTED

Ask students to think about the composition of different items of trash. Have them name various categories of materials (plastic, food, etc.) and an example of each.

PROCEDURE

1. Line up a set of boxes on the front desk, one per category. Each box should have a label—metal, plastic, paper, etc.—with an accompanying sample or illustration. Give the class a brief explanation of each category and show them an example of each.
2. Divide the students into small groups. Give each group a set of trash items that includes at least one example from each material category, and a set of labels. Have the students sort and label the objects by material type. Some items may be made of more than one type of material and the students will need to decide which is the most predominant.
3. When the students have finished classifying their objects, ask each group to deposit them in the correct cardboard box in the front of the room. List the trash items by category on the board. Which category has the most items? Which has the fewest?

EXTENSIONS

1. Make a bulletin board display of a trash can. Cut out the shapes of different trash items and label them, using the same paper color for each category of material.
2. Set up a scavenger hunt in the classroom. Give each child or team of children a category of material. Tell them that within a certain time limit they have to find an object in the room that is made from that material and must label it by material type. Which category has the most items in it?
3. Set up the category boxes in one corner of the room. Have the students separate everything they throw away into the appropriate container. At the end of one week go through the boxes and look at the different types of items under each category. Could some items be classified under more than one category? Which category had the largest number of items? Which category of items took up the most space?
4. Divide the class into teams, each representing a different category of materials. Have each team develop a list of everyday items made from their material. For example, the plastics group might

include dishes, hairbrush, toys, etc. Have each team keep a daily log of the items they use made out of their material. Compare the lists between teams and discuss how important each of these categories of materials is to our society.

Source: Kristen Walser

Know Your Properties

THEME:	Basic materials have different properties.
GOAL:	Students will understand the properties of basic materials.
METHOD:	Classification of objects
SUBJECTS:	Language arts, science
SKILLS:	Comparing, drawing conclusions, observing
MATERIALS:	Boxes of trash (cleaned, rinsed) separated by type of basic material (see Activity 1-4); chart paper
TIME:	45 minutes

GETTING STARTED

Ask the students what the properties or characteristics of basic materials are. How might these affect what the materials are used for and how they are disposed?

PROCEDURE

1. Line up the boxes of separated trash (paper, metal, etc.) and have the children sit in a semi-circle around them. On the chalkboard, draw two columns for each category of material. Take an object out of one of the boxes and pass it around. Ask the students to describe it: what it looks and feels like, and different uses for it. For example, glass might be described as hard, breakable, clear, smooth, colored, holds water, round, etc. Write the words on the board, in the first column for that category of material. In a second column list the opposite characteristics (e.g., soft, unbreakable, opaque, rough, clear, porous, square, etc.). Repeat for different items in each of the categories.
2. Break the students into pairs and assign each group one set of opposite characteristics. Give each pair a set of trash items to sort into one of two piles based on their given characteristic or its opposite (e.g., breakable and nonbreakable, rough and smooth, etc.).
3. Do any patterns emerge? Is all the glass in the “round” pile? Is most of the metal in the “shiny” pile? Why?
4. Draw conclusions about how the properties of objects affect how they are made and how they are used. For example, ask students why manufacturers don’t put soda in paper bags or print newspapers on metal.

EXTENSIONS

1. Make a list of the basic characteristics—breakable, smooth, porous, etc. Have students categorize other items found around the classroom by these characteristics. Do they fit the same patterns discovered above?
2. Put a variety of trash items in a large bag. Without looking at the item, have each student reach into the bag and use their sense of touch to determine if it is made out of glass, metal, plastic, etc. Have them tell the other students how they made their decision.
3. Make a bulletin board display of the new vocabulary words describing the properties of items, grouped by opposites. Have the students cut out magazine pictures that illustrate examples of each

characteristic and its opposite. For example, under “round” they might display a picture of a bottle and a windowpane.

4. Introduce the concept of magnetism and what magnets can reveal about the basic properties of metals. Explain how magnets can be used to tell whether a can is made out of aluminum or steel. Using magnets, have the students test out other metal objects in the classroom. How might magnetism be used to sort metals that are brought to the recycling station?

Source: Kristen Walser

Sizing Up Waste: Volume vs. Weight

THEME:	Composition of trash by volume and weight can be very different.
GOAL:	Students will learn the concepts of volume and weight and how different types of trash affect the quantity of solid waste produced.
METHOD:	Classification and weighing of items
SUBJECTS:	Math, computer science
SKILLS:	Comparing, counting, drawing conclusions, measuring
MATERIALS:	Can of trash collected in the classroom for one week OR sample can of trash items prepared in advance; scale; graph paper; computer, if available; spreadsheet software
TIME:	1 hour

GETTING STARTED

Ask the students if all the items they throw away are the same size and weight. Have them name some examples that are small, large (bulky), light, heavy, etc. Ask the students to predict which materials make up the greatest portion of waste by volume, by weight, and by number of items.

PROCEDURE

1. Using the trash collected in the classroom for a week or a sample trash can of items prepared in advance, have the students separate it into the different categories of materials—paper, plastic, glass, metal, etc.
2. Ask the students which category of items they think is the heaviest? Which takes up the most room? Which contains the greatest number of pieces? Have the students write down their answers in order of heaviest to lightest, bulkiest to most compact, and most to least numerous.
3. Weigh each category of items. For the paper category, material could be divided into newspaper, cardboard, writing paper, and other. Then place the objects in a clear container and determine their volume by measuring how much space they occupy (width, depth, and height). Finally, count the number of items. Make a chart on the board showing the weight and volume of each category. Do the heaviest items also take up the most room?
4. Discuss how weight and volume of trash are both important in its disposal. Bulky items may not weigh much, but may take up more space in the landfill or trash compactor. How might the volume change if glass, cans, or boxes are crushed? Does the weight change if the volume changes?

EXTENSIONS

1. Extend the exercise by asking what other sorts of items are thrown away that were not represented in the trash can: yard wastes, white goods (refrigerators, washing machines), etc. Where do they fit into the spectrum?
2. Make a bulletin board display using different colored blocks to represent each part of the waste stream. Make one trash can showing the trash content by weight, another showing trash content by volume, and a third showing trash content by number of items. For each category of waste, cut out a band of paper representing its percentage of the total, so that when stacked one above the other, the three trash cans are full. What are the implications of these differences in terms of waste disposal?

3. Have students repeat the exercise at home. Have each student label a set of paper bags with the different material categories (paper, plastic, glass, etc.). Ask the students to put everything they discard for one or two weeks into the appropriate bag. Compare the students' home results with one another and with those derived from the classroom trash. Which category of items differs the most in the comparison? Why?

Be A Garbage Detective

THEME:	Humans produce a lot of garbage but are often unaware of what happens to their waste.
GOAL:	Students will define waste and consider the implications of throwing something away.
METHOD:	Creating pictures as a basis for discussion and story telling
SUBJECTS:	Art, language arts, science
SKILLS:	Comparing, drawing, inferring, researching
MATERIALS:	Drawing paper; magazines
TIME:	1 to 2 hours

BACKGROUND

All living creatures produce some sort of waste, but their ways of disposing of it vary greatly. Humans are very wasteful compared with other creatures on earth. Often we are unconcerned with what happens to our waste and unaware of the impacts it can have on the environment. By looking at how animals and plants minimize the amount of waste they produce, as well as the ways in which they deal with their garbage, we can learn some important lessons about efficiency and waste disposal.

GETTING STARTED

Ask the students to think about their house and about the kinds and amount of garbage their families produce. What do they do with their garbage? What do they think happens to it?

PROCEDURE

1. Ask each student to draw two pictures: one of his/her house and the other of an animal's "house." Have the students share their pictures with the class and start a discussion on where garbage fits into each picture. What is garbage? Do animals create garbage? Who produces more garbage, people or animals? What are some differences and similarities between waste generated by people and animals? Why do people dispose of so much more than animals do? How do people get rid of their garbage? Where does it go? What could people do to be more like animals in the production and disposal of waste?
2. Have the class create a story about the pictures they have drawn. Write the story on the blackboard for the students to read and/or write down and attach to their pictures.
3. Have the students create a poster or collage by cutting out magazine pictures of items that are usually thrown away after one use. Discuss the items on the posters. How can we avoid throwing away so many of these things? Review the following questions: What is garbage? Where does it come from? Why do people create more waste than other animals? Is this a problem? What can we do about it?

EXTENSIONS

1. Have the students research an animal of their choice to learn about its habitat, way of living, the kinds and amount of waste it produces, and its methods of dealing with this waste. The children could write and illustrate stories based on what they have learned and present them to the class.

Source: Reprinted from Washington, *A-Way With Waste* with permission

One Person's Garbage Can is Another's Gold Mine

THEME:	Some components of the waste stream are valuable resources; by reusing them we can help solve some of our solid waste disposal problems.
GOAL:	Students will re-examine waste as a resource by looking at other uses for it.
METHOD:	Reading and discussion
SUBJECTS:	Language arts, social studies
SKILLS:	Inferring, listening, predicting, reasoning
MATERIALS:	Excerpts from <i>Stuart Little</i> and <i>Charlotte's Web</i> ; drawing and writing paper
TIME:	1 hour (longer if children write their own stories)

BACKGROUND

The terms “waste” and “resource” are relative and reflect our own needs and values rather than any objective quality of an object. How we feel about garbage has a lot to do with how we take care of it. Some items that we might ordinarily consider worthless (e.g., garbage), may prove to be very useful to another individual, family, company, or industry. By changing our perceptions of trash and discovering alternative uses for it, we can prevent valuable resources from being wasted and reduce the amount of solid waste that needs to be landfilled or incinerated.

GETTING STARTED

Ask students what they think of when they hear the word “garbage”? Have them describe their feelings.

PROCEDURE

1. The children will probably have a negative reaction to the previous question. Explain that the class is going to read about someone who feels the same way they do about trash. *Stuart Little* is a mouse who lives in the city and is always getting into trouble. This passage relates one of Stuart's misfortunes, when he accidentally gets caught in a garbage can. Read the following quote from *Stuart Little*:

The men threw the can with a loud bump into the truck, where another man grabbed it, turned it upside down, and shook everything out. Stuart landed on his head, buried two feet deep in wet slippery garbage. All around him was garbage, smelling strong.

Under him, over him, on all four sides of him—garbage. Just an enormous world of garbage and trash and smell. It was a messy spot to be in. He had egg on his trousers, butter on his cap, gravy on his shirt, orange pulp in his ear, and banana peel wrapped around his waist.

Still hanging onto his skates, Stuart tried to make his way up to the surface of the garbage, but the footing was bad. He climbed a pile of coffee grounds, but near the top the grounds gave way under him and he slid down and landed in a pool of leftover rice pudding. “I bet I’m going to be sick at my stomach before I get out of this,” said Stuart.

2. Discuss how Stuart felt about garbage. Why didn't he like it? Explain to the class that what was unpleasant for Stuart might be a field day for someone else. Read the following quote from *Charlotte's Web*:

Lurvy dragged Wilbur's trough across the yard and kicked some dirt into the rat's nest, burying the broken egg and all Templeton's other possessions. Then he picked up the pail. Wilbur stood in the trough, drooling with hunger. Lurvy poured. The slops ran creamily down around the pig's eyes and ears. Wilbur grunted. He gulped and sucked and gulped, making swishing and swooshing noises, anxious to get everything at once. It was a delicious meal—skim milk, wheat middlings, leftover pancakes, half a doughnut, the rind of a summer squash, two pieces of stale toast, a third of a gingersnap, a fish tail, one orange peel, several noodles from a noodle soup, the scum off of a cup of cocoa, an ancient jelly roll, a strip of paper from the lining of the garbage pail and a spoonful of raspberry jello.

How did Wilbur feel about garbage? Point out that the garbage Wilbur ate was useful and not wasted. Our own garbage can also be a resource. Brainstorm some possible uses for our trash, including composting, feeding food waste to pet pigs or rabbits, building tree houses or scooters out of construction debris, fixing broken toys or using the old parts to make new ones, etc.

EXTENSIONS

1. Bring the children back to *Stuart Little* to find out what happens to him.

There was no way for him to get out of the truck, the sides were too high. He just had to wait. When the truck arrived at the East River, the driver drove out onto the pier, backed up to a garbage scow, and dumped his load. Stuart went crashing and slithering along with everything else and hit his head so hard that he fainted and lay quite still, as though dead. He lay that way for almost an hour, and when he recovered his senses, he looked about him and saw nothing but water.

The scow was being towed out to sea. "Well," thought Stuart, "this is about the worst thing that could happen to anybody. I guess this will be my last ride in this world." For he knew that the garbage would be towed twenty miles out and dumped in the Atlantic Ocean.

2. Discuss what happens not only to Stuart but to all garbage. Are they really going to dump it in the ocean? What effect will this have on the water and on the creatures living in it? Brainstorm positive alternatives that would treat garbage as a resource, as in *Charlotte's Web*. Mention that in addition to individuals using garbage as a resource, companies and industries can use it to manufacture useful products. For example, crushed glass can be used in street pavement to increase reflectivity.
3. Have students create their own adventure stories about an animal or another character and solid waste.
4. Create drawings, posters and/or a bulletin board display of the alternative uses for garbage that the class came up with during the discussion.

Sources: Reprinted from AVR, *Teacher's Resource Guide* with permission; excerpts reprinted from *Charlotte's Web* and *Stuart Little* by E.B. White with permission.

Waste Now... Worry Later

THEME:	Wasteful habits have negative impacts on the earth and its inhabitants.
GOAL:	Students will examine the concept and implications of waste.
METHOD:	Reading and discussion
SUBJECTS:	Language arts
SKILLS:	Drawing, inferring, interpreting, listening, writing
MATERIALS:	"Why People Have To Work," an African-American folk tale
TIME:	45 minutes

GETTING STARTED

Ask students what they think it means to be wasteful.

PROCEDURE

1. Consider using the medium of storytelling or reading aloud to present the attached folk tale, or have the students read it and/or act it out.
2. Discuss the story. What made the sky so mad? Why did the people waste the sky? What is something that we waste? Ask the students why they think we waste things. What can we do to avoid wasting important materials or resources?

EXTENSIONS

1. Have the students write down what they remember of the folk tale and illustrate their own version of the story.
2. Have the children write and illustrate their own stories about items that we waste and what might happen if we continue to do so.

Source: Kristen Walser

WHY PEOPLE HAVE TO WORK

The sky used to be very close to the ground. In fact, it wasn't any higher than a man's arm when he raised it above his head. Whenever anybody got hungry, all they had to do was to reach up and break off a piece of the sky and eat it. That way, no one ever had to work.

Well, it was a fine arrangement for a while, but sometimes people would break off more than they could eat, and what they couldn't eat they just threw on the ground. After all, the sky was so big there would always be enough for everybody to eat. What did it matter if they broke off more than they actually wanted?

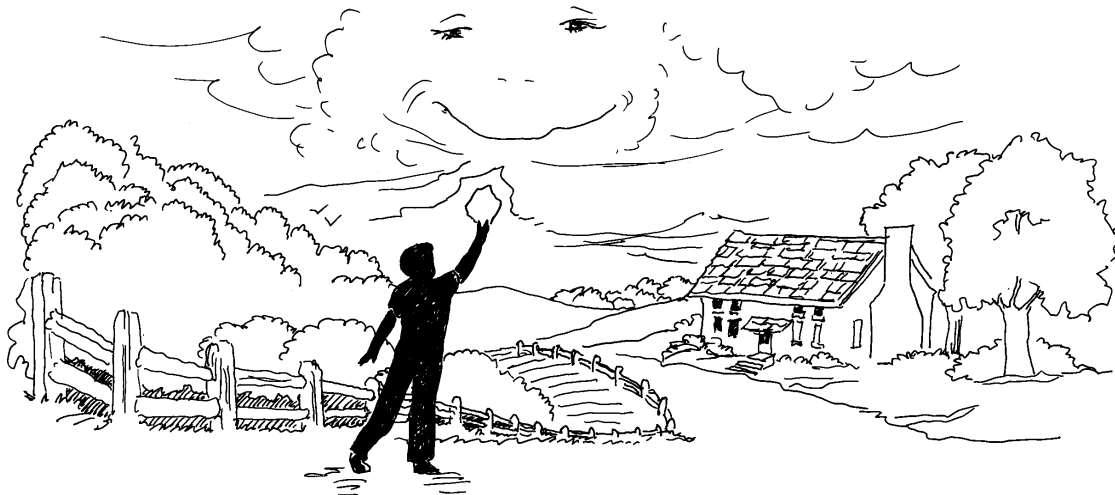
Maybe it didn't matter to them, but it mattered to the sky. In fact, it made the sky angry to see itself laying on the ground, half-eaten, like garbage. So one day the sky spoke out and said, "Now look-a-here! Can't have this! Uh-uh. Can't have you people just breaking off a piece of me every time your stomach growls and then taking a little bite and throwing the rest away. Now if y'all don't cut it out, I'm going to move so far away no one will ever touch me again. You understand?"

Well, people got the message. In fact, they were pretty scared, and for a while they made sure that no one ever broke off more sky than they could eat. But slowly they began to forget. One day, a man came by and broke off a chunk big enough to feed forty people for a month. He took a few little bites, looked around the edges, threw the rest over his shoulder, and walked on down the road just as happy and dumb as anything you've ever seen. Well, the sky didn't say a word, but with a great roar, the sky lifted itself up as high as it could, and that was pretty high.

When people realized what was happening, they began crying and pleading with the sky to come back. They promised that they would never do it again, but the sky acted like it didn't hear a word.

The next day, the people didn't have a thing to eat, and that's why people are working to this very day.

Source: Reprinted from Lester, *Black Folk Tales* with permission



The Resourceful Earth

THEME:	Everything comes from the earth.
GOAL:	Students will trace objects from their source and learn that everything we use is made from raw materials that come from the earth.
METHOD:	Skit of the manufacturing process
SUBJECTS:	Science, theater, performance skills
SKILLS:	Classifying, drawing conclusions, interpreting
MATERIALS:	Two cardboard boxes large enough for a child to fit through, with entry and exit doors cut out; string; garbage can filled with different items of clean trash; index cards labeled with headings: Minerals/Oil, Minerals/Rock, Plants, or Animals
TIME:	1 hour

BACKGROUND

Natural resources are the source of everything we make, use, and throw away. Some raw materials are used in their natural state (e.g., wood), while others are chemically altered. Many of these materials took millions of years to form. Current rates of human consumption and trash generation are starting to rapidly deplete many of the earth's natural resources.

Raw materials fall into two categories: renewable and nonrenewable. Renewable resources can be slowly replaced if they are managed wisely. Trees cut down to make paper or lumber can be replaced by new growth to ensure a continuous supply of wood. Other resources, however, are found in limited quantities; once the current supply is gone, no more is available. Once the earth's deposits of oil or copper run dry, no more can be grown. These are called nonrenewable resources.

GETTING STARTED

Repeat the Ali Ka Zim rhyme from Activity 1-1, "What is Waste?" while having each student pull an object out of the trash can. Ask the child into which category of basic materials the item fits (glass, plastic, paper, metal, etc.) and to name one characteristic of it.

Discuss the concepts of renewable and nonrenewable resources with the students. What are some examples of each?

PROCEDURE

1. Select an object from the trash can, e.g., a glass bottle. What is glass made from, and how? Explain that it is made of sand, soda ash, limestone, and feldspar, the purpose each of these components serves, and where they come from. Note that energy is used to melt the materials that are then blown or molded into different shapes. Repeat this exercise with examples from each of the basic categories.
2. Tell the children they are going to play a game called "Factory." Arrange the two large boxes side by side at the front of the room. Label one "Oven" and the other "Sawmill." Attach a string from the boxes to an electric pole drawn on the board to represent the use of energy in making goods. Explain that there is a separate factory for the wood because it is shaped by cutting rather than by melting. Select one student to be the factory operator and another to be a miner or logger. Hand the

remaining students an index card representing one of the four resource groups: minerals/rock, minerals/oil, plants, or animals.

3. The game starts with the miner “digging out” a certain type of mineral or the logger “cutting down” a tree. The miner/logger brings the raw material to the factory (oven or sawmill) and tells the class which of the four resource groups it represents (based on the card given to each student). The child then goes through the Factory box. Upon emerging from the other side, the student should say what type of basic material the raw material was made into (glass, metal, paper, etc.) and name one use for the product it has become. Hand the child an example of the object they suggested or write it on a card for them to hold.
4. After all the children have gone through the factory, ask them where they can get more raw materials. What if there was no more oil for heating homes or trees for making paper? Discuss which of these raw materials are considered renewable and nonrenewable resources. Emphasize that in some cases (e.g., oil) it took millions of years to make the material and it cannot be quickly replaced.
5. Have each child try to think of another way to make the trash item they represent without using virgin materials. For example, they could take the container back to the store for refills, or take newspapers to be recycled. How could a bottle be made without using any new sand? Is there a connection between our shrinking supply of natural resources and the growing amount of waste?

EXTENSIONS

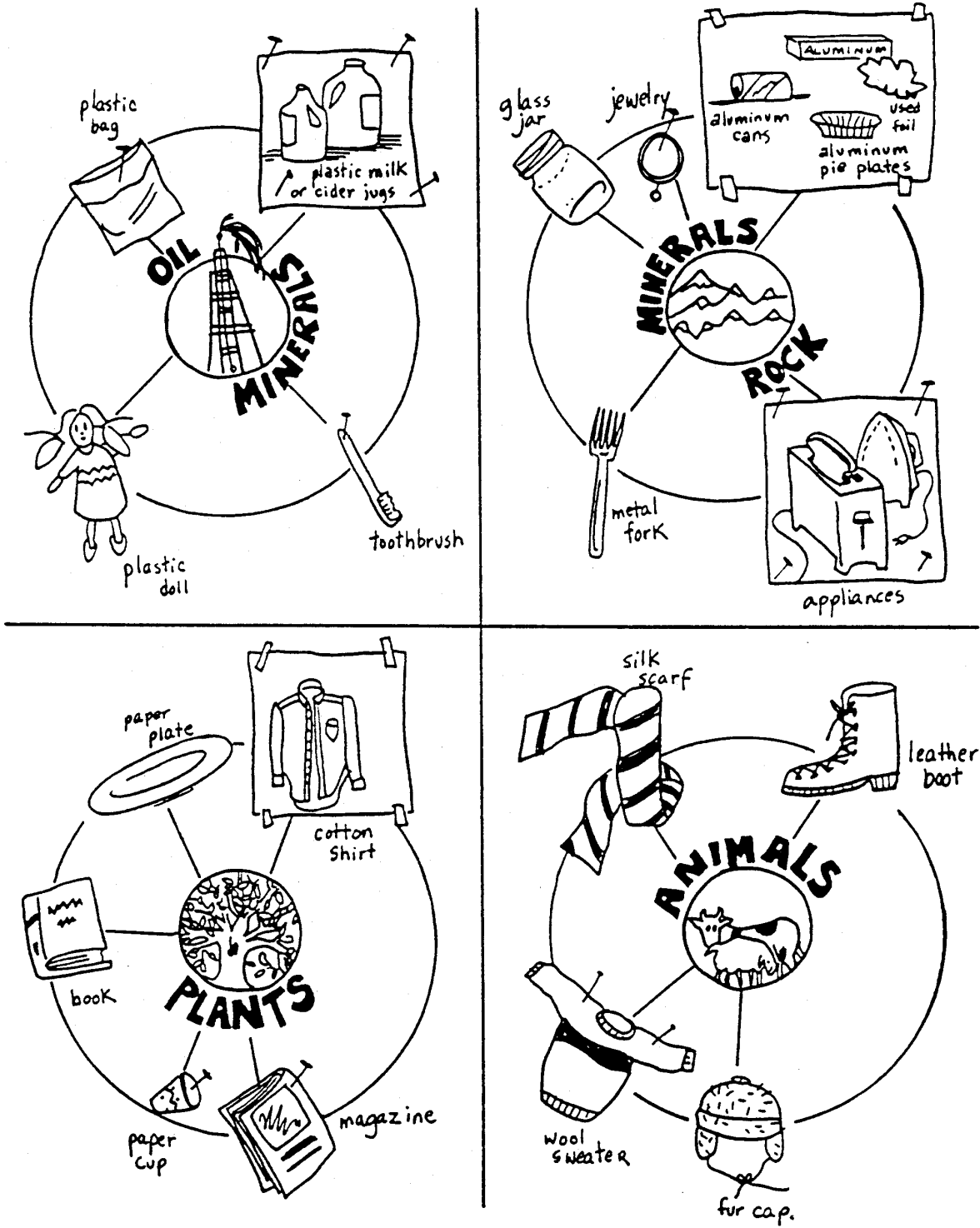
1. Have the children draw out the factory process, starting with the raw material and following what it is made into and what that is used for (e.g., sand > glass > bottle > milk container). This could also be taken another step by completing what happens to the container after it has been used.
2. Make a bulletin board listing the raw materials used to produce common products. Have the children cut out pictures of objects made from these to add to their trash dictionaries.
3. Take the factory exercise a step further by having the children take back the item they represent to the factory to be made into a different product. Have students suggest how items might be reused (e.g., newspaper used to manufacture cereal boxes).
4. Conduct a survey of items around the classroom and identify what kinds of raw materials were used to manufacture them. Which resource category and material type is represented the most?
5. Start a game of Twenty Questions based on raw materials and how they are used. Put trash objects or cards containing names of trash items into a bag. Let one student see a sample item or card. The class tries to guess what the object is by asking questions such as: Do I come from the earth? Am I made from a renewable or nonrenewable resource? Am I a container? Am I recyclable?
6. Make a Natural Resources Bulletin Board showing the four resource groups (see following example). Have students cut out magazine pictures of products made from each resource group.
7. Assign each student a materials category (e.g., paper, metal, etc.) and have them write a short essay addressing questions such as: How has (paper) contributed to the development of our culture? How are (paper) products used? What is the effect of (paper) use on our natural resources?
8. Increase the level of detail for older students. For example, assign each the name of a specific mineral (e.g., bauxite, cassiterite), rather than the broad category of minerals/rocks. Have the

students research where specific natural resources are plentiful and how they are used in the manufacture of products.

9. Distribute the worksheet, “What Are My Roots?” Explain to the students that, often, just looking at an item will not reveal much about the raw materials that were used to make it. For example, the soda can is made from aluminum which was manufactured from bauxite mined from the earth. Have the students work in teams to complete the worksheet or have them make posters tracing an item back to its raw materials.

Sources: Adapted from AVR, *Teacher’s Resource Guide*; Bell and Swartz, *Oscar’s Options*; Kristen Walser

Natural Resource Bulletin Board



Source: Reprinted from AVR, *Teacher's Resource Guide* with permission

WHAT ARE MY ROOTS?

Try to trace each of the steps that changed these items from raw materials into the product we use. For example, the milk you had with lunch came from cows, who ate grass and other grains, which grew from the earth.

MILK < COW < GRASS/GRAINS < EARTH

PLASTIC MILK CARTON

WOODEN TABLE

NEWSPAPER

GLASS BOTTLE

WOOL SWEATER

STEEL SHOVEL

STYROFOAM CUP

EGGS

LEATHER PURSE

COTTON THREAD



Source: Reprinted from Bell and Swartz, *Oscar's Options* with permission

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Creating Crayons

THEME:	It takes raw materials, energy, time, and money to manufacture products.
GOAL:	Students will examine how raw materials such as glass, metal, and plastic are transformed, often by heat, into other products.
METHOD:	Making crayons
SUBJECTS:	Language arts, science
SKILLS:	Comparing, interpreting, observing
MATERIALS:	Old crayons with the paper removed and broken into little pieces; oven; small aluminum pans; aluminum foil; timer
TIME:	40 minutes

GETTING STARTED

Ask students if they know how forks are made. Discuss the process of pouring molten plastic or steel into a mold.

PROCEDURE

1. Tell the students that they're going to be making crayons in much the same way that manufacturers produce forks, bottles, toys, or anything made out of metal, glass, or plastic. Explain that manufacturers start with a raw material, mix it with other raw materials, heat it, shape it, and then cool it.
2. Point out that the raw material used to make crayons is wax that has been mixed with coloring. Collect old and broken crayons, remove the paper, and distribute the pieces to the children.
3. Have the students create molds by wrapping aluminum foil around a small object like a thick magic marker and then carefully removing the marker. Fill the mold with broken crayon pieces.
4. Place molds in a pan and "cook" for approximately 10 minutes at 350 °F. If possible, show the students the crayons while they are still liquid. After cooling, remove melted crayon mixture from the molds. What happened to the crayons? What is the new product? What are the differences and similarities between the old and new products? How does this process compare to making crayons from virgin materials? Have the students write and draw about the process.
5. Show the students pictures of metal forges, clay kilns, and glassblowing or plastics factories. Explain that all of these processes use heat to transform raw materials into products that we commonly see and use. The energy for the heat comes from burning natural resources such as gas, wood, oil, or coal.

Source: Kristen Walser

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Running Out of Resources?

THEME:	Some of our natural resources are renewable, others are not. Once nonrenewable resources are depleted, they cannot be replaced.
GOAL:	Students will distinguish between items made from renewable and nonrenewable resources.
METHOD:	Worksheet and discussion
SUBJECTS:	Science, social studies
SKILLS:	Analyzing, evaluating, identifying
MATERIALS:	“Running Out of Resources?” worksheet
TIME:	45 minutes

GETTING STARTED

What are natural resources? Will there always be enough to meet human needs? Which resources can be replaced? Which cannot?

PROCEDURE

1. Discuss the concepts of renewable and nonrenewable resources, providing students with examples of each.
2. Have the class complete the worksheet “Running Out of Resources?” and discuss the following:
 - a. Which items on the worksheet do you use? Are they made from renewable or nonrenewable resources?
 - b. List some other items that you have and use. What natural resources are they made from?
 - c. What might you do to conserve both renewable and nonrenewable resources? What choices can you make about the items that you buy?

EXTENSIONS

1. Have students survey different items in the classroom and identify what natural resources were used to make them. Are they renewable or nonrenewable? Are more items made from renewable or nonrenewable resources? Can you think of an object made from a nonrenewable resource that could be replaced by one made from a renewable resource?

Sources: Adapted from Sonoma County Community Recycling, *Garbage Reincarnation*; Bell and Swartz, *Oscar’s Options*

RUNNING OUT OF RESOURCES?

Worksheet

Some resources come from plants and animals, which grow and reproduce. These can slowly be replaced if we use these resources wisely and plan ahead for the future. If we cut down a tree to make lumber, paper, or cardboard, we can plant a new tree. Since more trees can be grown, trees are called a renewable resource. Crops, animals, and other things that can be replaced are renewable.

There are some resources, though, that cannot be replaced or replenished in our lifetimes. These resources are nonrenewable. We can't grow or make new copper or other precious metals. And when the last oil well runs dry, there will be no more oil for heat, for cars or for use in the many plastic products that are now part of our lives. In addition to minerals and fossil fuels, water and air are also nonrenewable.

DIRECTIONS: Identify the resource that is used to make each of the items listed below. For example, cardboard boxes are made from trees. In addition, think about whether that resource can grow or be replaced so that we will have more. Mark an "R" next to those items that come from a renewable resource. Place an "NR" next to those items that are made from resources that cannot be replaced. They are nonrenewable.

cardboard box	<u>TREE—R</u>	aluminum pan	_____
steel bucket	_____	drinking glass	_____
copper pipe	_____	steak	_____
book	_____	corn on the cob	_____
leather jacket	_____	wool sweater	_____
wooden desk	_____	tire	_____
cotton shirt	_____	diamond ring	_____
polyester shirt	_____	plastic wastebasket	_____



Source: Reprinted from Bell and Swartz, *Oscar's Options* with permission

RUNNING OUT OF RESOURCES?

Teacher's page

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cardboard box	tree—R	aluminum pan	bauxite—N
steel bucket	iron—NR	drinking glass	sand/silica—NR
copper pipe	copper—NR	steak	animal—R
book	tree—R	corn on the cob	plant—R
leather jacket	animal—R	wool sweater	sheep—R
wooden desk	tree—R	tire	rubber tree—R
cotton shirt	plant—R	diamond ring	diamond, gold—NR
polyester shirt	oil—NR	plastic wastebasket	oil—NR

Source: Reprinted from Bell and Swartz, *Oscar's Options* with permission

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Taking Care of Our Land

THEME:	Our attitudes toward the natural environment affect how we use or misuse it.
GOAL:	Students will develop an appreciation of the Native American philosophy, characterized by a respect for the earth and a belief in the interconnectedness of all life.
METHOD:	Reading and discussion
SUBJECTS:	Art, language arts, social studies
SKILLS:	Comparing, evaluating, inferring
MATERIALS:	“Selling the Land” essay
TIME:	1 hour

BACKGROUND

Born in the vicinity of the city that now bears his name, Chief Seattle was the leader of the Dwamish and Suquamish Native American tribes. When the first white settlers came into the region, he greeted and befriended them. On January 22, 1855, Chief Seattle signed the Treaty of Point Ellington, thereby giving the land over to the settlers. His famous speech captures both the philosophy of Native Americans toward the land and his hope that its new stewards would treat it with reverence and respect.

GETTING STARTED

Do you ever think about your relationship with the natural world around you? Do you consider yourself superior to other living things? Why?

PROCEDURE

1. Read aloud the speech by Chief Seattle and discuss the following questions:
 - a. How did Native Americans feel about the earth?
 - b. Why does Chief Seattle feel that the land can never really be sold? Do you agree?
 - c. What does he mean when he calls the murmuring water the voice of his “father’s father” or the river his “brother?” What does this say about his relationship to nature? What importance does he place on it? How is it different from the way most of us think?
 - d. What do you think of the last line? If Chief Seattle were alive today what would he think of the condition of the earth?
2. Have the children write or draw a short story illustrating how they would change the way we treat the earth. Ask what changes they would make to keep the water clean, the air pure, and plants and animals safe?

EXTENSIONS

1. Tell the students to imagine that they have just been notified that a place they find special is about to be significantly changed or taken away. Have each student write a speech that reveals his/her

philosophy on the issues involved and how s/he feels about the event. Organize a class forum and have each student present his/her talk, followed by a group discussion on the issues raised.

SELLING THE LAND

How can you buy or sell the sky? The land? The idea is strange to us. If we do not own the freshness of the air and the sparkle of the water, how can you buy them?

Every part of this earth is sacred to my people. Every shining pine needle, every sandy shore, every mist in the dark woods, every humming insect. All are holy in the memory and experience of my people.

We know the sap which courses through the trees as we know the blood that courses through our veins. We are part of the earth and it is part of us. The perfumed flowers are our sisters. The bear, the deer, the great eagle, these are our brothers. The rocky crests, the juices in the meadow, the body heat of the pony, and man, all belong to the same family.

The shining water that moves in the streams and rivers is not just water, but the blood of our ancestors. If we sell you our land, you must remember that it is sacred. Each ghostly reflection in the clear waters of the lakes tells of events and memories in the life of my people. The water's murmur is the voice of my father's father.

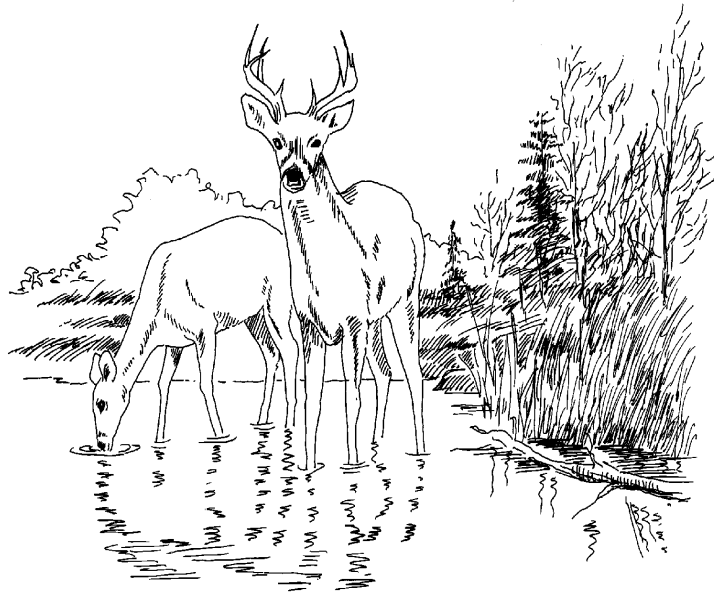
The rivers are our brothers. They quench our thirst. They carry our canoes and feed our children. So you must give to the rivers the kindness you would give any brother.

If we sell you our land, remember that the air is precious to us, that the air shares its spirit with all the life it supports. The wind that gave our grandfather his first breath also receives his last sigh. The wind also gives our children the spirit of life. So if we sell our land, you must keep it apart and sacred, as a place where man can go to taste the wind that is sweetened by the meadow flowers.

Will you teach your children what we have taught our children? That the earth is our mother? What befalls the earth befalls all the sons of the earth.

This we know: the earth does not belong to man, man belongs to the earth. All things are connected like the blood that unites us all. Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web he does to himself.

One thing we know: our god is also your god. The earth is precious to him and to harm the earth is to heap contempt on its creator.



CHIEF SEATTLE

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Learning About Litter

THEME:	Litter is a serious problem that we can all help solve.
GOAL:	Students will realize that their actions can help solve litter problems.
METHOD:	Litter walk and discussion
SUBJECTS:	Art, social studies
SKILLS:	Analyzing, examining, identifying
MATERIALS:	A rough scale map of the school grounds, divided into four or five areas; gloves; trash bags for collecting litter
TIME:	1 hour

GETTING STARTED

Do you see litter on your way to school or on the school ground? What kind? Why do you think people litter?

PROCEDURE

1. Divide the children into four or five groups and distribute trash bags and gloves. Send each group to a designated area of the school yard, as shown on the map. Have students collect the litter in their area (excluding broken glass or other dangerous items).
2. Have each group sort through their bag and identify the types of litter they collected and the number of pieces in each category.
3. Discuss the following questions after each group has recorded its data.
 - a. What kinds of litter did you find in your area? How much was there? Did you expect to find more? Less?
 - b. Where do you think it came from?
 - c. Did some areas have more litter than others? Why?
 - d. Were different kinds of litter found in different areas?
 - e. What are some of the negative impacts of littering? (e.g., it's ugly, it pollutes the earth, it may be dangerous)
4. As a class, brainstorm ways to reduce litter in and around your school. Start a campaign to educate your school about litter. Have students design anti-litter posters, write and perform skits for other students, or campaign for more trash cans at school.

EXTENSIONS

1. Have students read (or read aloud to each other) *The Wartville Wizard* by Don Madden (New York: MacMillan Press. 1986.). This book tells the story of a man given the power to make litter fly back onto the person who threw it away.

Source: Kristen Walser

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Hazards at Home

THEME:	Some products are hazardous and remain so even after they are put in the trash.
GOAL:	Students will learn that some products are poisonous and harmful to humans as well as to the environment.
METHOD:	Puppet show or teacher demonstration
SUBJECTS:	Science, theater
SKILLS:	Analyzing, communicating, value judgment
MATERIALS:	Two puppets; cardboard box approximately 1-1/2 foot square; pictures or empty containers of hazardous products: e.g., oven and drain cleaners, auto cleaners, paint thinner, varnish, used motor oil, gasoline
TIME:	30 minutes

GETTING STARTED

Introduce the concept of poisons. Ask the children if they know what it means if something is poisonous. Can they name some examples of poisons? Why might someone eat a poisonous product?

PROCEDURE

1. Explain to the students that some things used for cleaning, painting, killing unwanted bugs or plants, and maintaining cars can hurt them and other living creatures. Many can be harmful if eaten, inhaled, or touched.
2. Set up a stage on a front desk.
3. Introduce puppets Rebecca Rabbit and Rocky, and tell the children they have a story to share with them. If possible, have two different adults act the two parts.

* * * * *

(Play Begins)

Rebecca: Hi Rocky! How are you?

Rocky: Funny you should ask. I had to go the hospital last week. My stomach still doesn't feel very good.

Rebecca: Too much candy again, Rocky?

Rocky: Not exactly. I was having a good time playing house and ate something I found under the kitchen sink. It looked like something my Mom spreads on crackers at her parties. It made me very sick and I still have to eat special foods. At the hospital they told me that there are a lot of things in my house that are dangerous to eat, smell, and touch.

Rebecca: Really? (Rebecca looks in her cupboard—a cardboard box with a door—and pulls out containers or magazine pictures representing various household hazardous substances. For each item

she asks the students what it is used for and whether or not it is hazardous. Rephrase the questions by interchanging the words hazardous, poisonous, toxic, harmful, could make you sick, etc.)

Rocky: (Looks over all the objects from Rebecca's cupboard.) There are a number of items that are toxic at my house, too.

Rebecca: Well, forget it! If these things can make me sick then I don't want them in my house. (Rebecca starts to throw the hazardous materials in the trash, but is stopped by Rocky)

Rocky: Don't throw them in the trash, Rebecca! These things are also dangerous there. If they get buried at the dump, rain water can run through them and carry the poisons into our drinking water, or an animal could eat them.

Rebecca: Okay. I'll pour them down the sink instead.

Rocky: Don't do that, Rebecca! If you pour them down the sink they will go to the treatment plant where they try to clean the water. But these poisons can't be cleaned very well so they'll end up in the river or the marsh.

Rebecca: The river? That could hurt a number of my friends who live there if they were to drink the water. Let's see, there are the Scales, a fish family, and the Quacks—you know that nice family of ducks and their cousins from Canada, the Honkers. (To the audience) Do you know anyone who drinks water from the river?

Okay, I won't pour them down the drain. I know what, I'll send them to the incinerator where they can be burned and get rid of them that way.

Rocky: Sorry Rebecca, but that is just as bad. The toxins will then end up in the air or in the ground when the ash remains are buried. Burning it doesn't make it less dangerous.

Rebecca: What can I do, Rocky?

Rocky: Have your parents save these items in a safe place until your town has a hazardous waste collection day. People will come and carefully collect the poisonous materials in special containers and take them away to places where they can be disposed of more safely. Some can be burned in special ovens, while others, like used motor oil, can be reprocessed into new oil, saving energy and reducing pollution.

Rebecca: That sure sounds better than putting these harmful things in the water.

Rocky: It sure is; but do you know the best thing you can do?

Rebecca: What?

Rocky: Find substitutes to use in place of these toxic materials. There are a number of things you can clean with that are not hazardous. I make up a mixture of soapy water to kill the bugs on plants, and I use baking soda and water to clean the oven. Then no one has to worry, not the Scales nor the Quacks, not you and not me!

Rebecca: Thanks for telling me what to do about toxins, Rocky. But next time you want to learn something, please ask somebody about it. Don't just eat anything you find around your house. Promise?

Rocky: I promise

Rebecca: I like you, Rocky

Rocky: I like you too, Rebecca

THE END

EXTENSIONS

1. Have the students create a symbol that can be placed on hazardous items and which communicates "stay away." Have students make their own copies to take home and use.
2. Send students home with the handouts "Poisons in the Home" and "Safer Alternatives to Toxic Products" (see Activity 1-16). Have students discuss with their families. Ask students to test one of the nontoxic alternatives at home and report back to the class on its efficacy.
3. Make a bulletin board display, having children cut out pictures of products they think might be hazardous and ones that are not. Have the children discuss why they think the item is or is not harmful.
4. Give students a list of items that are commonly found around the home and may be toxic. Many of them are used to make things cleaner or to make our lives easier. The list might include paint thinner, oven cleaner, bathroom scouring powder, bleach, weed or bug killer, nail polish, turpentine, etc. Have the students draw a picture of a house and label where these items might be found. Discuss what precautions should be taken with these items. Have the students write a class letter to their parents telling them what they have learned about household hazardous wastes and asking for their parents' help in identifying these materials at home.

Source: Kristen Walser

Poisons In My Home?

Take a Closer Look

What Are Household Hazardous Materials?

Household hazardous materials are chemically-based products that can be dangerous to human health and the environment. They include (but are not limited to):

Cleaning Products: ammonia, spray cleaners, rug cleaners, furniture and metal polishes, drain cleaners

Garden Supplies: weed and insect killers, fertilizers, gasoline, charcoal lighter fluid

Auto Supplies: antifreeze, motor oil, transmission fluids, cleaners, waxes, gasoline, batteries

Paint Supplies: furniture refinishers, turpentine, oil-based paints, paint and varnish removers, caulking and sealing products, waxes and glues

Laundry Aids: bleaches, starches, detergents, spot removers

Recreation Supplies: swimming pool chemicals, photographic chemicals, craft and hobby supplies



Alternative BINGO—The Safer Way to Play

THEME:	Many common household and garden products are toxic and can be replaced by safer alternatives.
GOAL:	Students will become familiar with less toxic substitutes for poisonous home and garden products.
METHOD:	Bingo game
SUBJECTS:	Language arts, health, science
SKILLS:	Inferring, problem solving
MATERIALS:	Bingo grid; master cards; “Safer Alternatives” handout; a container (e.g., empty can); ten markers per student (e.g., beans, pennies, paper clips)
TIME:	45 minutes

GETTING STARTED

Ask the students if they think there are any poisonous substances at their house. Do their parents use any toxic materials when they work around the house or in the garden? If so, could they use anything else to do the same job?

PROCEDURE

1. Discuss the meaning of toxic and poisonous with the children. Point out that many items we use are poisonous and could harm us and the environment. Give some examples such as drain cleaners, paint thinner, flea dip, and oven cleaners. Point out that these toxic materials are usually expensive and that cheaper and safer alternatives often work just as well.
2. Distribute the “Safer Alternatives” information sheet and go over it with the students. Ask them if they are surprised by anything they see on the list. Have they seen any of the items used in their homes? Can the children think of additional items to put on the list? Do they think that their families would be willing to try some of the suggested alternatives? Which ones? Why? Why not? Brainstorm ways in which safer alternatives could be made more convenient to use.
3. Distribute a Bingo grid to every student. Each student should fill in the grid by randomly writing one of the headings listed on the safer alternatives sheet in each box (e.g., aerosol sprays, ant control, drain openers). No phrase or heading should be used more than once. Give each student ten markers.
4. Cut up the master cards and place them in the container. Draw one master card from the container and call out the substance. Students place one marker over a toxic substance on their grid that can be replaced by the alternative called. For example, if the teacher calls out baking soda, the students may place a marker over oven cleaner, scouring powder, or deodorizer. Players may choose any one of these substances but may use only one marker per turn. Students should be encouraged to refer to the “Safer Alternatives” sheet for help. Marking four toxics in a row horizontally, vertically, diagonally, or in the four corners of the grid, wins the game. Students may exchange grids for additional games.

EXTENSIONS

1. Have the students create illustrations, jingles, or skits advertising or promoting a safer alternative.

2. Have the students compare the costs of toxic products with an appropriate safer substitute. This may be done in pairs at a local supermarket (make sure to get permission from the store manager), or at home with their parents. Have the students record their findings on a chart and bring them to class for comparison and discussion.

Source: Reprinted from Bell and Swartz, *Oscar's Options* with permission

ALTERNATIVE BINGO

Source: Reprinted from Bell and Swartz, *Oscar's Options* with permission

ALTERNATIVE BINGO

MASTER CARDS

Cut each rectangle and place in a container:

LEMON JUICE AND VEGETABLE OIL	PAN WITH BEER
PUMP-STYLE SPRAY	MAYONNAISE AND SOFT CLOTH
OPEN WINDOWS FOR FRESH AIR	PLUNGER /PLUMBER'S SNAKE
HOT VINEGAR SET IN A DISH	SALT
BAKING SODA	WATER-BASED PAINT
FRESH CUT FLOWERS	OVERTURN CLAY POTS
DRIED FLOWERS WITH SPICES	COMPOST
GRATED LEMON RIND	SCREENS
STEEL WOOL	CREAM OF TARTAR
MECHANICAL MOUSE TRAPS	BIODEGRADABLE SOAP
SOAP AND WATER	VINEGAR AND SALT
EUCALYPTUS LEAVES	BREWERS YEAST

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SAFER ALTERNATIVES TO TOXIC PRODUCTS

The following is a list of safer substitutes for some household toxics. These products can generally be purchased in any grocery store.

AEROSOL SPRAYS

- Use pump-type spray containers whenever possible to replace aerosols (e.g., hair sprays).
- Use fresh flowers or sachets of dried petals mixed with spices instead of room sprays.

ANT CONTROL

- Sprinkle cream of tartar in front of the ant's path. (Ants will not cross over it.) Cream of tartar is a substance used in baking.

BUG SPRAY

- Place screens on windows and doors.
- Brewer's yeast tablets taken daily give the skin a scent that mosquitoes seem to avoid.

CHEMICAL FERTILIZERS

- Compost

COPPER CLEANER

- Pour vinegar and salt over copper and rub.

DEODORIZERS and AIR FRESHENERS

- Open windows or use exhaust fans as a natural air freshener.
- A dish of hot vinegar can get rid of fish odors.
- Baking soda placed in the refrigerator reduces odors.
- Fresh cut flowers or dried flower petals and spices can add a nice scent to a room; boiling potpourri or cinnamon and cloves in water will also produce a nice scent.

DETERGENTS (LAUNDRY and DISHWASHING)

- Replace detergents with soaps that are relatively nontoxic and biodegradable.

DRAIN OPENERS

- Pour boiling water down the drain. Do this every week for preventive maintenance.
- Use a plumber's helper (plunger) or a plumber's snake.

FLEA REPELLENT

- Place eucalyptus seeds and leaves around the area where an animal sleeps.

FLOOR CLEANERS

- Use soap and water.
- Use baking soda and water.

FURNITURE POLISH

- Use a soft cloth and mayonnaise.
- Mix one part lemon juice and two parts vegetable oil.

GENERAL CLEANERS (ALL PURPOSE CLEANSERS)

- Use baking soda with a small amount of water.

GLASS AND WINDOW CLEANERS

- Use cornstarch and water.
- Mix a 1/2 cup of vinegar and 1 quart warm water; wipe with newspapers.
- Use lemon juice and dry with a soft cloth.

OVEN CLEANERS

- Place liners in oven to catch any drips during baking.
- Sprinkle salt on spills when they are warm and then scrub.
- Rub spills gently with steel wool.

PAINT

- Water-based paints are less toxic than oil-based paints, and require no solvent for clean-up.

RAT POISON

- Put a screen over drains.
- Use mechanical mouse and rat traps.

SCOURING POWDER

- Dip a damp cloth in baking soda and rub.
- Use steel wool.

SNAIL & SLUG BAIT

- Place a shallow pan with beer in the infested area.
- Overturn clay pots; snails take shelter in them during sunny days and thus can be collected and removed.

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Tons of Trash

THEME:	Every person in Massachusetts generates trash and contributes to the solid waste stream.
GOAL:	Students will recognize that we all contribute to solid waste disposal problems and will visualize how much waste is produced by each person in Massachusetts.
SUBJECTS:	Math, science, social studies
SKILLS:	Calculating, inferring, measuring, predicting
MATERIALS:	A 7-pound bag of clean garbage (items that represent ordinary household trash); “How Much Trash Do You Figure?” worksheet
TIME:	One to two class periods

BACKGROUND

Each day, Massachusetts citizens fill trash cans with food scraps, bottles, paper, junk mail, disposable diapers, plastic milk jugs, and empty food containers. We pile worn out tires on the curb next to stacks of newspapers, and we tote broken furniture out of our homes to the transfer station. It’s trash, and since we don’t need it or use it anymore, we throw it away.

In 1994, Massachusetts generated approximately 10 million tons of solid waste. More than 7 million tons of this waste were from households, stores, schools, restaurants, and offices. This means that each person was responsible for approximately 1.2 tons of discarded waste in 1992, or roughly 7 pounds per person per day. The sheer amount of waste generated has increased dramatically due to technological advances, the production of less durable products, and an increase in disposable packaging. In Massachusetts, 2 million tons of packaging alone are discarded each year. The magnitude and increased complexity of our solid waste stream has had serious impacts on our waste disposal methods, costs, and technologies.

GETTING STARTED

Show the students the bag of trash and ask them how long they think it would take to produce that amount of garbage.

PROCEDURE

1. Lay an old sheet or cloth on the floor and empty the bag of trash onto it. Discuss what kinds of things are in the pile. What are some qualities that make us consider an item to be trash? Does this pile of garbage represent a lot of trash? Tell the class that roughly 7 pounds of garbage on the floor is equal to the amount of waste that is thrown out each day by the average person in Massachusetts. Ask the students how they feel about the fact that they are responsible for generating 7 pounds of trash per day, or almost 1 ton of garbage each year? Will this number ever change? How? Why? (Possibilities include: changes in population, lifestyle, environmental ethics, and legislation, for example.)
2. Have the students complete the worksheet “How Much Trash Do You Figure?” and discuss the following questions: Where does all the garbage go? What would we do with our garbage if there were no transfer stations, landfills, or curbside pick-up? How might this affect the amount of trash you and your family produce? What could you do to reduce the amount of garbage you produce?

EXTENSIONS

1. Have the students look through back issues of local or regional newspapers for articles on how the growing waste stream is affecting communities. The same thing can be done using magazines and newspapers that cover broader geographical areas. Have the class compare these findings to those in your region. Students could write a newspaper or magazine article summarizing the most common and/or most serious problems that they discovered. What are the future implications of these problems?

Source: Adapted from Wisconsin, *Recycling Study Guide*; data from Massachusetts DEP, *Master Plan: 1995 Update*

HOW MUCH TRASH DO YOU FIGURE?

1. If you generate 7 pounds of trash each day, how many pounds do you produce every:

week _____ month _____ year _____

2. Convert these numbers from pounds to tons. How many tons of trash do you produce every:

week _____ month _____ year _____

3. To visualize how much a ton weighs, use the following equivalent:

- a. The average weight of one horse is 950 pounds.
- b. Two horses weigh approximately 1,900 pounds, almost 1 ton.
- c. How many “horses worth” of trash do you make every:

week _____ month _____ year _____

4. How many people are there in your family? _____

If 7 pounds of trash are generated each day for every person, how many pounds/tons of trash does your family produce every:

pounds: week _____ month _____ year _____

tons: week _____ month _____ year _____

5. How many people are there in Massachusetts? _____

How many pounds and tons of trash are generated in the Commonwealth each:

pounds: day _____ weeks _____ month _____ year _____

tons: day _____ week _____ month _____ year _____

6. If every person in Massachusetts threw away one less pound of trash per day, by how much would our state’s solid waste stream be reduced? _____

Source: Wisconsin, *Recycling Study Guide*

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Throwing It All Away

THEME:	Our consumer-oriented society produces much waste.
GOAL:	Students will understand the sources, content, and magnitude of the solid waste we must dispose of.
METHOD:	Questionnaire and discussion
SUBJECTS:	Language arts, math, social studies
SKILLS:	Inferring, interpreting, predicting, problem solving, computer use
MATERIALS:	“Throwing It All Away” questionnaire
TIME:	One class period

GETTING STARTED

Ask the students what they know about the solid waste we produce. Does it create any problems?

PROCEDURE

1. As an introduction to the problems associated with solid waste disposal, distribute the “Throwing It All Away” questionnaire and allow time for completion. Students may also bring the questionnaire home and complete it with their families.
2. Discuss the questionnaire and encourage students to share their reactions to the answers. (See the questionnaire answer sheet for additional information pertaining to question.) Discuss the implications and problems associated with each of the questions, as well as possible solutions to some of these problems. What can we do to address these issues in our personal lives? As community members? As members of government, business, or industry?

EXTENSIONS

1. Have the students create their own questionnaire. Some of the same questions may be used but the survey should also include original questions that explore local solid waste issues. Have the students work together to come up with one set of questions for the class. Questionnaires can be filled out by other classes, the entire school, and/or by people in the community. Students can then tabulate the results to determine what people do and do not know about solid waste issues. (Various groups may respond differently, so students may wish to tabulate surveys separately.)
2. As a follow-up to the survey, have students create educational fact sheets that discuss the answers to the questions. Encouraging students to focus on providing information on those issues with which people are the least familiar. These information sheets can be computer generated or made into posters and illustrated. Once completed, students should distribute them and/or create a display in a public area of the school or town, such as the library or town hall. Again, depending on the results of the survey, different fact sheets may be necessary for different groups, especially if the survey population includes people of varying ages.

Source: Reprinted from AVR, *Teacher’s Resource Guide* with permission

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THROWING IT ALL AWAY

Questionnaire

Circle the answers that you think are correct.

1. How many pounds of residential trash does the average Massachusetts family of four produce each week?	25	550
	72	1020
2. In the past 50 years, the amount of waste discarded per person in the United States has:	stayed the same	decreased
	doubled	increased ten times
3. How many millions of pounds of edible food do Americans throw away each day?	1	100
	400	900
4. How many cars do Americans send to the junkyard each day?	250	1000
	10,000	20,000
5. How many TVs do Americans throw out each year?	100,000	5.2 million
	1 million	7.6 million
6. What percentage of packaging (boxes, bags and wrappers) is thrown out as soon as we open a product?	90%	75%
	50%	10%
7. How much paper do Americans use each year?	1 million tons	1 million pounds
	5 million tons	50 million tons
8. How many tons of municipal solid waste (from households, schools, stores, restaurants, and offices) were produced in Massachusetts in 1994?	500,000	1.5 million
	4.5 million	7 million

Source: AVR, *Teacher's Resource Guide*; data from Massachusetts DEP, *Master Plan: 1995 Update*

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THROWING IT ALL AWAY

Questionnaire Answer Sheet

1. The average Massachusetts family of four creates approximately 72 pounds of residential trash each week. Multiplied by 52 weeks, this equals 3,744 pounds, almost 2 tons, each year. To help envision this amount of waste, picture 4 horses (950 lb. each), 2 cows (1,800 lb. each), 2-1/2 pilot whales (1,500 lb. each), or 1/2 of a World War II German fighter plane (7,700 lb.). In addition, 100 lb. of solid waste per family of four per week are generated outside the home, by the commercial and institutional sector.
2. In the past 50 years, the amount of waste discarded per person in the United States has doubled. Increased packaging, a rise in the use of disposable products, developments in industry and production technology, an increase in personal wealth and purchasing power, and the switch to “planned obsolescence” as a design strategy all contribute to the increase in personal consumption and waste disposal.
3. Each day, Americans throw away 400 million pounds of edible food. In addition to our food waste, farmers in the United States produce a surplus of food that is not used and is often discarded. In contrast to the situation in the United States, millions of people are underfed and undernourished throughout the world. The United Nations estimates that 460 million people do not receive an adequate amount of the right kinds of food. The diet of these people is frequently lacking in:
 - Calories: Fewer than 2,200 calories per day is the norm in China, India, and much of Africa. The average United States citizen consumes more than 3,300 calories per person per day.
 - Protein: Average protein consumption in China, India, and much of Africa is less than 60 grams per day, compared with a 90 gram-per-day average in the United States.
 - Needed micronutrients: Very often a lack of variety in diet causes deficiencies in important nutrients, vitamins, and minerals.

Even people who get enough calories per day could be suffering from malnutrition because of protein or nutrient deficiencies. This is a common occurrence right here in the United States. In many cases malnutrition exists not because we do not produce enough food, but because of an unequal distribution of what is grown. The most affluent one-third of the world’s population eats well over one-half of the food produced.

4. We send 20,000 cars to the junkyard each day or 7 million cars (and 200 million tires) per year. Placed end to end, the cars discarded each year would reach two-thirds of the distance around the earth at the equator.
5. Some 7.6 million TVs are thrown away each year. Television sets last, on average, 10 to 15 years. The number of appliances and pieces of audio-visual equipment thrown out within only a few years of purchase reflects a fast turnover in technology as well as strong consumer desire for state-of-the-art equipment and new fashion. A planned obsolescence design strategy by producers, and the fact that it is often less expensive to buy something new than to repair something old also contribute to this high rate of appliance disposal.

6. Approximately 90 percent of packaging is thrown out right away. Packaging is increasingly made of plastic, which is noted for its nonbiodegradability and long life.
7. Americans use 50 million tons of paper each year. It takes 17 trees to produce 1 ton of paper, and 10,000 trees to print one edition of the Sunday *New York Times*. Newspapers are usually discarded within 24 hours of being purchased, and only one-fourth of the paper produced in the U.S. is recycled.
8. Approximately 7 million tons of municipal solid waste was produced in Massachusetts in 1994. An additional 2.7 million tons of waste, including industrial wastes, sludge from wastewater and industrial processes, demolition and construction debris, used appliances or white goods, tires, waste oil, and asbestos were generated that same year. These wastes require special handling and processing before and during disposal.

Source: Reprinted with permission from AVR, *Teacher's Resource Guide*; data from Massachusetts DEP, *Master Plan: 1995 Update*

Production By-Products—Getting to the Source

THEME:	Everything we do generates some type of waste.
GOAL:	Students will learn that every process creates byproducts or waste.
METHOD:	Research and interviews
SUBJECTS:	Language arts, science, social studies
SKILLS:	Interviewing, problem solving, researching
MATERIALS:	None
TIME:	Several weeks

BACKGROUND

When we look at our trash it is fairly easy to determine how these items became trash. Our garbage generally contains materials we no longer want, those products we've used up, and the byproducts of things we do or make. Similarly, industry and business produce waste as they convert raw materials into products we can use. The nature and amount of waste generated by industry depends on the type of products being manufactured and the size of the company. Safe disposal of this waste is an issue which industries and businesses must continuously address.

GETTING STARTED

Ask the students to consider the types and amount of waste generated in the production and processing of items that are part of our daily lives.

PROCEDURE

1. Have the class generate a list of items produced in Massachusetts and another list of industries and businesses in the state. Some examples of items are cranberries, fisheries and fish processing, furniture, plastics, and computer and electronics equipment. Have the students speculate on the kinds of waste each one generates. How do manufacturers dispose of these various wastes? Are some wastes more difficult to get rid of than others? Which wastes are the most costly to dispose of?
2. Have each student research one of Massachusetts' products or industries. Students should contact manufacturers to find out: What is involved in the production process? What kind of waste, and how much, is generated? What does the company do with the waste? Are their waste disposal costs increasing, decreasing, or staying the same? What affects disposal costs? Are they planning to make any changes in their waste disposal methods? Do they currently use any recycled products? If not, have they ever considered it?
3. Students should write about what they've discovered and suggest changes that could benefit the manufacturer, consumers, and the environment. (Waste reduction and recycling programs are two possible options.) Students could send these suggestions to the manufacturer or try to meet with them in person, or write an article for the local paper.

EXTENSIONS

1. Have the students draw diagrams to illustrate the manufacturing process. These should include raw materials used, conversion or production processes involved, by-products generated and where

they go, and the final manufactured product. This can be taken one step further to include the market and the consumer.

2. Have the class brainstorm possible uses for production wastes, as well as potential products that could be made out of them (e.g., fertilizer from fish remains).

Source: Adapted from AVR, *Teacher's Resource Guide*

The Lorax

THEME:	The rapid use of resources could require changes in our present lifestyle.
GOAL:	Students will explore the differences between necessary and unnecessary products and the impacts of excessive materialism on the environment.
METHOD:	Reading and discussion
SUBJECTS:	English, social studies
SKILLS:	Analyzing, problem solving, researching
MATERIALS:	<i>The Lorax</i> by Dr. Seuss
TIME:	40 minutes

GETTING STARTED

What are the consequences of our throwaway habits? What do you really need to live?

PROCEDURE

1. Have students read *The Lorax*. Start a class discussion based on the following questions: How did each step of the Once-ler's developing business destroy a piece of the ecosystem? At what point did the ecosystem cease to function entirely? Why was the Super Axe Hacker invented? Why did the Once-ler ignore the Lorax's warnings? What happened to the Lorax? What management techniques could have been employed to help sustain the ecosystem and the business?
2. Have students research real life examples of the following items in the story: Swomee-Swans, Brown Bar-ba-loots, Humming Fish, Thneeds, Smogulous Smoke, Gluppity-Glupps and Once-lers (e.g., Truffula Trees could represent tropical rainforests). Make sure they include the issues and potential solutions to the problems addressed on global, national, local, and personal levels.

EXTENSIONS

1. Have the students write their own story about our wasteful habits, modeled after *The Lorax*.
2. Have the class perform the story of *The Lorax* as a play for younger children. Students should lead a discussion after the skit about what the story was trying to say, asking the children how they might change their habits to be less wasteful.

Source: Adapted from AVR, *Teacher's Resource Guide*

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Plastic Pollution and Marine Wildlife

THEME:	Plastic litter in our oceans and beaches endangers the lives of seabirds, seals, marine turtles and other aquatic species.
GOAL:	Students will learn about the negative effects of plastic waste on marine wildlife.
METHOD:	Reading and discussion
SUBJECTS:	Biology, English, political science
SKILLS:	Analyzing, value judgment, research
MATERIALS:	“Plastics at Sea” article
TIME:	1 hour

BACKGROUND

When we picture litter we often think of it as something strewn on our roadsides and city streets. Yet, our oceans are becoming increasingly polluted with plastic debris that threaten many of the species that live in and around the sea. Some creatures mistake plastic bags for animals that they regularly feed on, such as jellyfish. Others become entangled in plastic six pack yokes and eventually choke to death. The harmful effects of plastic litter on marine life will increase if people do not take action to alleviate the situation.

GETTING STARTED

Ask the students what kind of litter they usually see at the beach. Where does it come from?

PROCEDURE

1. Have the students read the 1983 article, “Plastics at Sea,” and discuss the following:
 - a. In what ways does plastic litter affect wildlife?
 - b. Why is plastic litter even more of a problem than other kinds of trash?
 - c. Where did all the plastic come from? Is it all discarded directly by people? Why do people litter?
 - d. Do you litter?
 - e. What are some ways that you can protect marine wildlife and help solve the problems associated with plastic litter?
2. Have the students research and update the information in the article. Specifically:
 - a. What is the scope of the plastic pollution problem in the marine environment today?
 - b. What is the status of the following legislation mentioned in the article?
 - Clean Water Act (Federal Water Pollution Control Act)
 - Ocean Dumping Act (Marine Protection, Research, and Sanctuaries Act)

Have these laws been effective in addressing marine pollution?

Have any new American or international laws to protect the marine environment been passed since 1983?

- c. What international conventions, if any, have there been since 1972 or 1973 to address the problems of ocean dumping and marine pollution?

3. As an alternative, have some students choose a species of marine wildlife that has been affected by plastic waste and research some of the following questions: How has plastic litter harmed this species? What is the primary source of the litter? What will happen if this problem continues? What must be done to eliminate the improper disposal of plastic waste? What can you do?

EXTENSIONS:

1. Have students write a letter to the local newspaper outlining what they have discovered and what people can do to alleviate the problem of plastic litter on our beaches and in our oceans.
2. Prepare a class display using short stories and poems written by students on the effects of plastic litter on the marine environment.

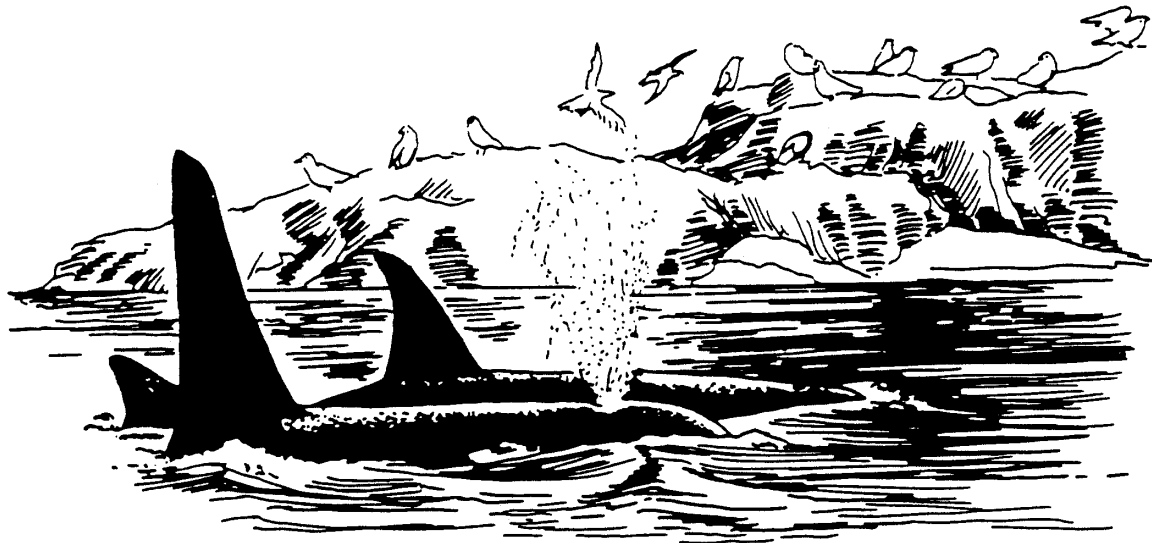
Source: Adapted from Washington, *A-Way With Waste*

PLASTICS AT SEA

Throughout the 1970s, a number of biologists studying the feeding habits of seabirds in different oceans of the world recounted the same story: the birds were eating plastic. Similar reports of plastic ingestion and of entanglement in plastic debris began to surface for other marine animals—fish off southern New England, turtles off Costa Rica and Japan, whales in the North Atlantic. At the same time, plastic particles turned up in surface plankton samples from both the Atlantic and Pacific oceans; plastic debris was retrieved by benthic trawls in the Bering Sea and Britain's Bristol Channel; and plastic pellets washed ashore in New Zealand in such large numbers that some beaches were literally covered with "plastic sand." By the close of the decade, marine scientists around the world had become aware of a new problem of increasing ecological concern—plastics at sea.

Two forms of plastic exist in the marine environment: "manufactured" and "raw." Manufactured plastic material along beaches and adrift at sea is primarily refuse from transport, fishing, and recreational vessels. In 1975, the National Academy of Sciences estimated that commercial fishing fleets alone dumped more than 52 million pounds of plastic packaging material into the sea and lost approximately 298 million pounds of plastic fishing gear, including nets, lines, and buoys.

Raw plastic materials—spherules, nibs, cylinders, beads, pills, and pellets—are the materials from which products are manufactured. These particles, about the size of the head of a wooden match, enter the ocean via inland waterways and outfall pipes from plants that manufacture plastic. They are also commonly lost from ships, particularly in the loading and unloading of freighters. Occasionally, large quantities are deliberately dumped into the sea.



Plastics turn up everywhere. Along portions of the industrialized coast of Great Britain, concentrations of raw particles have reached densities of about 2,000 pieces per square foot in benthic sediments. Near Auckland, New Zealand, 100,000 pieces of plastic were found every lineal feet of beach. Particles have also washed ashore on beaches in Texas, Washington, Portugal, Colombia, Lebanon, and at such remote sites as the Aleutian and Galapagos Islands.

Much of what we know about the distribution patterns and abundance of raw plastic in the world's oceans comes from plankton sampling of surface waters. Between 1972 and 1975, for example, the Marine Resources Monitoring, Assessment, and Prediction Program, a nationally coordinated

program of the National Marine Fisheries Service, recorded plastic particles in plankton samples collected between Cape Cod and the Caribbean Sea. The majority of the particles were found to have entered the coast of southern New England, and the highest concentrations were usually in coastal waters. Raw plastic, however, was ubiquitous in the open ocean and especially common in the Sargasso Sea. This suggests that winds and currents are instrumental in redistributing and concentrating particles in certain oceanographic regions.

Inevitably, many animals foraging in the marine environment will encounter and occasionally ingest these widely distributed plastic materials. One of the first records of plastic ingestion appeared in 1962 for an adult Leach's storm petrel collected off Newfoundland. Four years later, researchers in the Hawaiian Islands found that the stomach contents of young Laysan albatrosses contained plastic, apparently fed them by their parents.

For the most part, these early reports were treated as curious anecdotes included in the studies of the feeding ecology of a few sea birds. During the 1970s and early 1980s, however, with the proliferation of such anecdotes, biologists are paying closer attention and were surprised to find how frequently plastic occurred in the stomach contents of certain procellariids from the North Pacific and the North Atlantic (short-tailed shearwaters, sooty shearwaters, and northern fulmars) and alcids from the North Pacific (parakeet auklets and horned puffins). Lower frequencies were reported for other Northern Hemisphere sea birds, including phalaropes, gulls, terns, and also other procellariids and alcids. The feeding habits of marine birds in southern oceans have not been studied as extensively, but plastic ingestion has been documented for several species of procellariids (petrels, shearwaters, and prions) in the South Atlantic, South Pacific, and subantarctic water. To date, approximately 15 percent of the world's 280 species of sea birds are known to have ingested plastic.

Sea birds choose a wide array of plastic objects while foraging: raw particles, fragments of processed products, detergent bottle caps, polyethylene bags, and toy soldiers, cars, and animals. Marine turtles on the other hand, consistently select one item—plastic bags. In the past few years, plastic bags have been found in the stomachs of four of the seven species of marine turtles: leatherbacks from New York, New Jersey, French Guiana, South Africa, and the coast of France; hawksbills on the Caribbean coast of Costa Rica; greens in the South China Sea and in Japanese, Australian, and Central American coastal waters; and olive ridleys in the Pacific coastal waters off Mexico. Evidence points to plastic ingestion in loggerheads as well, based on liver samples containing high concentrations of a plasticizer (a chemical compound added to plastic to give it elasticity). Polystyrene spherules have been found in the digestive tracts of one species of chaetognath (transparent, wormlike animals) and eight species of fish in southern New England waters. They have also turned up in sea snails and in several species of bottom-dwelling fishes in the Severn Estuary of southwestern Great Britain.

Marine mammals are not exempt from participation in the plastic feast. Stomachs of a number of beached pygmy sperm whales and rough-tooth dolphins, a Cuvier's beaked whale, and a West Indian manatee contained plastic sheeting or bags. In addition, Minke whales have been sighted eating plastic debris thrown from commercial fishing vessels. Curiously, plastic has not been found in any of the thousands of ribbon, bearded, harbor, spotted, ringed, or northern fur seal stomachs examined from Alaska.

The obvious question arising from these reports is, Why do marine animals eat plastic? In the most comprehensive study to date, Robert H. Day of the University of Alaska maintains that the ultimate reason for plastic ingestion by Alaskan seabirds lies in plastic's similarity—in color, size, and shape—to natural prey items. In parakeet auklets examined by Day, for example, 94 percent of all the ingested plastic particles were small, light brown, and bore a striking resemblance to the small crustaceans on which the birds typically feed.

Marine turtles also mistake plastic objects for potential food items. Transparent polyethylene bags apparently evoke the same feeding response in sea turtles as do jellyfish and other medusoid coelenterates, the major food item of leatherbacks and subsidiary prey of greens, hawksbills, loggerheads, and ridleys.

Sea birds, marine turtles, and marine mammals all eat plastic. So what? Perhaps ingesting plastic is inconsequential to their health. After all, cows are known to retain nails, metal staples, and strands of barbed wire in their stomachs for more than a year with no ill effects. For marine animals, however, the evidence is growing that in some cases at least, ingested plastic causes intestinal blockage. George R. Hughes of the Natal Parks Board, South Africa, extracted a ball of plastic from the gut of an emaciated leatherback turtle; when unraveled, the plastic measured nine feet wide and twelve feet long. There is little doubt that the plastic presented an obstruction to normal digestion. Similarly, a mass mortality of green turtles off Costa Rica has been attributed to the large number of plastic banana bags eaten by the turtles.

The twenty dead red phalaropes discovered on a beach in southern California, all with plastic in their digestive tracts, present a less clear case. Did the birds suffer an adverse physiological response after eating plastic or were they already under stress because of a reduced food supply and eating the plastic in a last-ditch effort to prevent starvation? The same question applies to other instances of emaciated animals that have eaten plastic. At this time, we don't have an answer.



We do know that plastic is virtually indigestible and that individual pieces may persist and accumulate in the gut. Ingested plastic may reduce an animal's sensation of hunger and thus inhibit feeding activity. This, in turn, could result in low fat reserves and an inability to meet the increased energy demands of reproduction and migration. Plastic may also cause ulcerations in the stomach and intestinal linings, and it is suspected of causing damage to other anatomical structures. Finally, ingestion of plastic may contribute synthetic chemicals to body tissues. Some plasticizers, for example, may concentrate in fatty tissues, their toxic ingredients causing eggshell thinning, aberrant behavior, or tissue damage. When highly contaminated tissues are mobilized for energy, these toxins may be released in lethal doses.

Publication of data on plastic ingestion is in its infancy. As the problem gains notoriety, it will certainly be revealed to be even more widespread than is now recognized. There are already several known instances of secondary ingestion, in which plastic consumed by animals feeding at low trophic levels shows up in higher-level consumers. The remains of a broad-billed prion, together with the plastic pellets it had ingested, were found in the castings of a predatory South Polar skua in the South Atlantic; plastic pellets found in the Galapagos Islands were traced from transport vessels in Ecuadorean ports through a food chain involving fish, blue-footed boobies, and, finally, short-eared owls.

A more obvious effect of plastic pollution is the aesthetic one. Whether we venture deep into the woods, high atop a mountain, or out on the ocean to escape the trappings of civilization, our experience of the natural world is often marred by the discovery of human litter. Even more disturbing to the spirit is the sight of a young pelican dangling helplessly from its nest by a fishing line, a whale rising to the surface with its flukes enshrouded in netting, or a seal nursing wounds

caused by a plastic band that has cut into its flesh. Unfortunately, such observations are becoming more and more common, another consequence of plastics at sea.

During the last twenty years, fishing pressure has increased dramatically in all the world's oceans, and with it, the amount of fishing-related debris dumped into the sea. In addition, the kind of fishing equipment finding its way into the ocean has changed. Traditionally, fishing nets were made of hemp, cotton, or flax, which sank if not buoyed up. These materials disintegrated within a relatively short time and, because of the size of the fibers, were largely avoided by diving sea birds and marine mammals. With the advent of synthetic fibers after World War II, however, different kinds of nets came into use. These new nets were more buoyant and longer-lived than their predecessors, and some of them were nearly invisible under water.

The result of these changes in net materials has been a tragic increase in mortality of air breathing animals. A few examples are sufficient to give an idea of the magnitude of the problem. During the heyday (1972–76) of the Danish salmon fishery in the North Atlantic, the incidental catch of thick-billed murrelets amounted to three-quarters of a million birds annually; in 1980, 2,000 sea turtles off the southeastern coast of the United States drowned when incidentally caught in shrimp trawl nets. Incidental catch refers to nontarget animals that are accidentally caught in an actively working net. Another kind of net-related mortality is known as entanglement and refers to any animal caught in a net that has been lost or discarded at sea. Some government officials estimate that about 50,000 northern fur seals currently die in the North Pacific each year as a result of entanglement in fishing gear. Unlike working nets, which fish for specific periods of time, these free-floating nets, often broken into fragments, fish indefinitely. When washed ashore, they may also threaten land birds and mammals; in the Aleutian Islands, for example, a reindeer became entangled in a Japanese gill net.

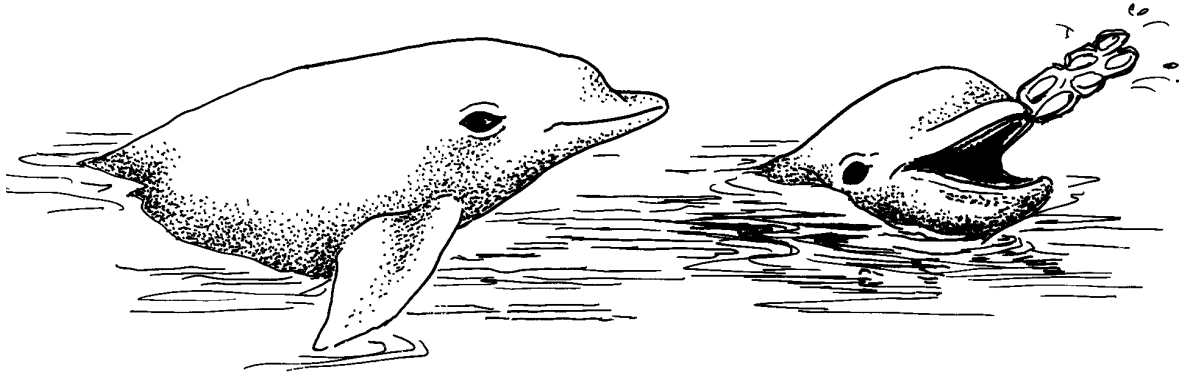
Plastic strapping bands—used to secure crates, bundles of netting, and other cargo—are another common form of ship-generated debris. Discarded bands are often found girdling marine mammals, which are particularly susceptible to entanglement because of their proclivity for examining floating objects. The instances of seal entanglement in plastic bands has increased so remarkably in the past two decades that fur seal harvesters in Alaska and South Africa now monitor the number of ringed animals.

Sea birds that frequent recreational waters or coastal dumps are also subject to ringing by the plastic yokes used in packaging six-packs of beer and soda pop. Gulls with rings caught around their necks are sometimes strangled when the free end of the yoke snags on protruding objects. Similarly, pelicans, which plunge into the water to feed, run the risk of diving into yokes. If the rings become firmly wedged around their bills, the birds may starve.

Not all encounters with plastic prove harmful to marine organisms. Some animals are incorporating the new materials into their lives. Algae, hydrozoans, bryozoans, polychaetes (marine worms), and small crustaceans attach to plastic floating at sea; bacteria proliferate in both raw and processed plastic refuse. Plastic provides these organisms with long-lived substrates for attachment and transport; in some cases, hitching a ride on floating pieces of plastic may alter an organism's normal distribution. Several species of tube-dwelling polychaetes construct their tubes of raw plastic particles present in benthic sediments. Other invertebrates, such as sand hoppers and periwinkles, find temporary homes in aggregates of plastic particles they encounter on beaches. Marine birds all over the world incorporate plastic litter into their nests, but in this case, the use of plastic may be harmful because chicks can become entangled in the debris and die.

Instances of marine animals adapting to this new element in their environment do not alter the predominantly negative effect of plastics at sea. The problem is global and will require international

cooperation. Historically, the high seas have, in many respects, been considered an international no-man's land. Recently, however, perception of the ocean as a finite and shared resource has caused many nations to express concern for its well-being.



In 1970, the U.S. Congress passed the National Environmental Policy Act which, among other things, pledged to “encourage productive and enjoyable harmony between man and his environment.” Subsequently, a number of laws on waste disposal were adopted, two of which affect pollution by plastics: The Federal Water Pollution Control Act (commonly known as the Clean Water Act) and the Marine Protection, Research, and Sanctuaries Act (the Ocean Dumping Act). The Clean Water Act does not specifically address the problem of persistent plastics but does require all significant polluters of U.S. waterways to obtain a federal permit, under which limits are set on, among other things, discharges of solid matter. The Ocean Dumping Act prohibits the deliberate dumping of significant amounts of persistent plastic materials at sea. Having these laws on the books, however, does not immediately solve the problem. Small-scale refuse disposal on the high seas is difficult to regulate; fishermen who claim to have unintentionally lost their nets at sea cannot be held responsible; and illegal large-scale dumping at sea is hard to detect. Granted, laws must be tightened, but enforcement is really the bigger problem.

On the international level, the problems of water pollution and litter in the oceans were highlighted at the United Nations Conference on the Human Environment held in Stockholm in 1972. The conference, with 110 nations represented, defined the need for international policy on marine pollution among coastal and maritime nations. Treaties to implement such a policy soon followed: the 1972 London Convention on the Prevention of Water Pollution by Dumping of Wastes and Other Matter (Ocean Dumping Convention), a part of which specifically prohibits marine dumping of persistent plastic material; and the 1973 London International Convention for the Prevention of Pollution from Ships (Marine Pollution Convention), which is broader in scope and regulates the control of oil pollution, packaged substances, sewage, and garbage. While neither of these treaties has been adopted by all nations, they represent a start toward global control of marine pollution.

In the meantime, the quantity of plastics in the world's oceans will undoubtedly continue to mount. Ironically, the very characteristics that make plastic appropriate for so many uses—its light weight, strength, and durability—lead to the majority of problems associated with its presence at sea. As organic material, plastic is theoretically subject to degradation by mechanical, oxidative, or microbial means. Owing to the strength of most plastics, however, mechanical degradation by wave action is generally restricted to the breaking of large pieces into smaller ones. Photooxidation and microbial action are limited by plastic's high molecular weight and its antioxidants, ultraviolet light stabilizers, and biocide additives, which effectively immunize it against degradation. The longevity of plastics in seawater is not known, but on the beach, particles may last from five to more than fifty years.

Given plastic's long life and projected annual increases in production, one thing is clear—the rate of plastic deposition in the marine environment will continue to be higher than the rate of disappearance. In a study of the accumulation of plastic on the beaches of Amchitka Island, Theodore R. Merrell, Jr., of the National Marine Fisheries Service recorded that 550 pounds of plastic litter were added to less than a mile of the beach in one year. He also found an increase of more than 250 percent in both the number and the weight of plastic items washed ashore over a 2-year period.

Outside the realm of laws and treaties, solutions to the problem can come from both inside and outside the plastic industry. The technology to manufacture biodegradable plastics is available. In fact, one of the beauties of plastic is that its properties can be altered and its life expectancy prescribed. Alaska has already taken steps toward reducing plastic litter by requiring that six-pack yokes be made of a self-destructing compound. Another, but perhaps less workable solution, given the logistics and expense involved and the degree of business and public cooperation required, lies in recyclable plastics. At the very least, all countries should require that the discharge of raw plastic materials from industrial plants be reduced by filtering outflow before it enters waterways. A recent decline in the uptake of plastic by marine organisms in southwestern England has been attributed, in part, to the efforts of one of the major contaminating plants to filter, collect, and reuse raw particles present in its effluent.

Consumers share with industry the responsibility to reduce the amount of plastic in the sea. Recreational boaters, beach-goers, and commercial fisherman all discard plastic refuse. Preferably, no trash plastic-bands, netting, or other debris should ever be tossed overboard or left on a beach. If six-pack yokes or strapping bands must be discarded at sea, the rings should be cut first so that they pose less of a threat to marine animals.

The first step in combating plastic pollution is to alert both industry and the general public to the gravity of the problem and the need to do something about it soon. Education alone cannot solve the problem but it is a beginning. Public awareness of a problem, combined with the resolve to correct it, can bring dramatic results.

Source: Reprinted from by Wehle and Coleman, "Plastics at Sea" with permission

The Resource Protection Game

THEME:	Human activity can affect our environment in a variety of ways.
GOAL:	Students will recognize the ecological impacts of different solid waste management practices on natural resources.
METHOD:	Resource Protection Game
SUBJECTS:	Science, social studies
SKILLS:	Analyzing, problem solving
MATERIALS:	“Resource Protection Game” handout; “Natural Resource Cards” handout
TIME:	45 minutes

GETTING STARTED

Ask the students in what ways their activities affect the environment.

PROCEDURE

1. As an introduction, review with the class the earth’s natural cycles and how human activities can affect these cycles and our natural resources.
2. Have students read through the list of sample situations. Discuss what effects these situations might have on our natural resources and some possible alternatives to each of these situations.
3. Divide the class into six groups. Distribute a natural resource card to each group and have a spokesperson from each group read its resource card to the rest of the class. The task of each group is to develop a strategy to protect that resource in each of the given situations.
4. Each group should answer the following questions in terms of their resource and each situation:
 - a. How does this situation help your natural resource?
 - b. How does it harm your natural resource?
 - c. Is this situation good or bad? How might it be improved? What alternatives might you suggest?

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RESOURCE PROTECTION GAME

SITUATIONS:

1. A mandatory curbside recycling program has just begun in your town. Residents must separate their newspapers, aluminum, steel cans, and glass for recycling. It is now illegal to send bags of leaves and yard waste to the landfill.
2. A local cheese factory produces several hundred pounds of whey waste each week. The milk haulers dump the whey illegally in local swamps, streams, and on unused fields when they think no one is looking.
3. A local developer wants to build 360 new condominiums on the side of one of the highest peaks in the state.
4. After heavy rains, untreated sewage and rainwater contaminated with automobile oil flows into water bodies used by Massachusetts residents for recreation and as reservoirs.
5. A print shop generates 40 pounds of chemical waste each month, which does not have to be reported to the state or disposed of with other regulated hazardous wastes. The print shop owner waits until he can fill several 55-gallon drums and then dumps them at the local landfill.
6. A fishing party out on the Connecticut River discards beer bottles, plastic sandwich bags, orange peels, and other litter overboard before the end of the trip. A few plastic six-pack rings and fishing lines were thrown in as well.
7. The landfill in your city is scheduled to close in six months. The city has decided to build a new landfill on the other side of town.
8. A trash-to-energy incinerator plant is being built in a nearby town. This plant will supply your town with some of its electricity. Some of the ash produced will be deposited in your town's landfill and may be toxic.

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RESOURCE PROTECTION GAME

NATURAL RESOURCE CARDS

AIR

Clean air is essential to all living things. Any smoke or other chemicals that enter the air result in air pollution. Protect the air from all forms of air pollution.

WILDLIFE, FISH, BIRDS, INSECTS

Fish and wildlife are essential members of the ecosystem. They also provide us with food and recreation, such as nature study and fishing. We and other living things are dependent upon them to live. We must protect them.

WATER

Fresh water serves two important functions. Not only do many living things need to drink it to survive, but many also need it for their homes. Salt water also supports many forms of life. It is essential to protect both kinds of water.

FORESTS AND PLANTS

Plants are an important natural resource. Not only are they beautiful, but they also help to purify our air through the oxygen they give off in photosynthesis. Plants are also a source of food and shelter for animals.

SOIL/MINERALS

Soil contains minerals and nutrients needed by all living things. There is, however, a limited supply of these minerals on our earth. The soil and its minerals must be protected.

PEOPLE

Human beings are a natural resource. We are part of many food chains and affect the ecological balance of the earth. We are also consumers of natural resources and must conserve them for future generations who will inherit the earth from us.

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Home Safe Home

THEME:	Many household substances can be dangerous and should be used with great caution.
GOAL:	Students will identify which household products are toxic and predict the results of improper use and storage.
METHOD:	Reading and discussion
SUBJECTS:	Health, language arts, science, social studies
SKILLS:	Inferring, predicting, problem solving
MATERIALS:	“Poisons in My Home?” handout (see Activity 1-5); “Unsafe Situations” worksheet; drawing materials
TIME:	1 hour

GETTING STARTED

Distribute the “Poisons in My Home?” handout and discuss it with the students. Do they have any of these kinds of products in their homes? Do they ever use them? If so, do they use any precautions (e.g., rubber gloves, face mask)? Where are these products kept? Did they ever consider how dangerous these products might be?

PROCEDURE

1. Distribute the “Unsafe Situations” worksheet and use it in one of the following ways. (Note the accompanying Teacher’s Page).
 - a. Have the students complete their predictions in writing. Discuss both their predictions and methods for rectifying the unsafe situations.
 - b. Read aloud each of the Unsafe Situations scenarios and have the students brainstorm both problems and solutions.
 - c. Have teams of students act out one of the scenarios and encourage classmates to suggest ways in which the situation might have been avoided.
2. After the students have completed the worksheet, discuss the results. Help them identify ways to minimize the chance of accidental poisoning (e.g., storing materials in original containers, keeping toxic materials on high shelves or in locked cabinets, using child proof caps). Discuss the best method for dealing with accidents involving hazardous household materials. If there is a local poison control center, inform students and discuss its purpose.
3. Distribute drawing materials. Have the students make a diagram of their home and label, by location, twenty items commonly found there which they believe may be toxic. Examples might include nail polish remover, furniture stripper, flea powder, spot remover, kerosene, toilet bowl cleaner, detergent, weed killer, motor oil, antifreeze, brake fluid, paint, deodorizers, oven cleaner, moth balls, bleach, scouring powder, bug spray, and charcoal lighter fluid. Brainstorm safer alternatives to these products.

EXTENSIONS

1. After the students have drawn and labeled their homes, have them trace the routes through which hazardous household substances could get into the environment. Possibilities include evaporation, leaching, seepage, runoff, and dumping. Point out that hazardous household materials are not only dangerous to humans, but can also affect other living creatures and the environment.
2. Have the students survey their homes to see how many toxic items are actually used by their families.
3. Point out to students that industry and business also use toxic materials. Have students research a well-known toxic catastrophe such as Love Canal or the Exxon Valdez oil spill, or, more locally, the contamination of wells in Hatfield or Woburn. How and why did these incidents occur? What were the acute effects? What were the chronic effects? Could these incidents have been prevented? How? Have students write reports summarizing their findings and present the information to the class.

Source: Adapted from Bell and Swartz, *Oscar's Options*

UNSAFE SITUATIONS

PRODUCT: drain cleaner
SITUATION: When the doorbell rang, the bottle was left on the bathroom floor. A baby was playing nearby.

PREDICTION:

PRODUCT: lemon furniture oil
SITUATION: When polishing some furniture, the cap was lost. Polish was then placed in a glass near the sink.

PREDICTION:

PRODUCT: antifreeze
SITUATION: After changing the antifreeze in a car, someone threw it into a ditch in front of the house.

PREDICTION:

PRODUCT: aerosol air fresheners/deodorizers
SITUATION: A cooking smell was unpleasant so air freshener was sprayed in the kitchen. The can was left sitting on the stove.

PREDICTION:

PRODUCT: chlorine bleach/ammonia
SITUATION: A bathroom tile wouldn't come clean using a bleach cleanser, so the person cleaning mixed some ammonia with the cleanser to make it stronger.

PREDICTION:

PRODUCT: furniture stripper
SITUATION: Your neighbor decided to strip the paint off of an old chair. He is working in his workshop and turns on the fan.

PREDICTION:

PRODUCT: hair spray
SITUATION: Your sister sprayed her hair to keep the style in place. She left the can on the radiator in the bathroom.

PREDICTION:

PRODUCT: pesticides
SITUATION: To kill ants in the kitchen, an insect spray was applied to the floor. People in the home are often barefoot.

PREDICTION:

PRODUCT: oven cleaner
SITUATION: Although the product called for the use of rubber gloves, the housekeeper felt they were too clumsy and used the product without them.

PREDICTION:

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UNSAFE SITUATIONS

Teacher's Page

PRODUCT: drain cleaner
SITUATION: When the doorbell rang, the bottle was left on the bathroom floor. A baby was playing nearby.

PREDICTION: Child could drink it; product is corrosive to skin and eyes.

PRODUCT: lemon furniture oil
SITUATION: When polishing some furniture, the cap was lost. Polish was then placed in a glass near the sink.

PREDICTION: Someone might drink it, thinking it was safe; color and scent make it attractive.

PRODUCT: antifreeze
SITUATION: After changing the antifreeze in a car, someone threw it into a ditch in front of the house.

PREDICTION: Pets have died from drinking puddles of antifreeze; they are attracted by its sweet taste; could leach into groundwater.

PRODUCT: aerosol air fresheners/deodorizers
SITUATION: A cooking smell was unpleasant so air freshener was sprayed in the kitchen. The can was left sitting on the stove.

PREDICTION: Fumes may adhere to food or make residents sick; can could explode due to heat.

PRODUCT: chlorine bleach/ammonia
SITUATION: A bathroom tile wouldn't come clean using a bleach cleanser, so the person cleaning mixed some ammonia with the cleanser to make it stronger.

PREDICTION: Mixing chlorine bleach and ammonia releases a toxic gas; the fumes can result in eye, throat, nose irritations and breathing difficulty; products should never be mixed.

PRODUCT: furniture stripper
SITUATION: Your neighbor decided to strip the paint off of an old chair. He is working in his workshop and turns on the fan.

PREDICTION: Using a fan in closed quarters will only recirculate the bad air; such products need extreme caution and plenty of fresh air.

PRODUCT: hair spray
SITUATION: Your sister sprayed her hair to keep the style in place. She left the can on the radiator in the bathroom.

PREDICTION: Fumes from chemical sprays can irritate and damage skin, eyes, and lungs; they can also cause internal harm by entering bloodstream through the lungs; containers can explode from the heat.

PRODUCT: pesticides
SITUATION: To kill ants in the kitchen, an insect spray was applied to the floor. People in the home are often barefoot.

PREDICTION: Chemicals can penetrate socks and be absorbed through the skin; health effects of pesticides, especially long-term effects, are not fully known.

PRODUCT: oven cleaner
SITUATION: Although the product called for the use of rubber gloves, the housekeeper felt they were too clumsy and used the product without them.

PREDICTION: The chemicals could cause the skin to burn or develop a rash; skin and eye contact should be avoided.

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Everywhere is Somewhere

THEME:	Toxic wastes have far-reaching effects on the environment.
GOAL:	Students will analyze our waste disposal practices and the serious environmental consequences that can result from them.
METHOD:	Reading and analyzing
SUBJECTS:	Science, English
SKILLS:	Analyzing, value judgments
MATERIALS:	“Everywhere is Somewhere” poem
TIME:	One class period

GETTING STARTED

What are some toxic materials that you use? After you use these materials, where do they go? How does this affect the environment?

PROCEDURE

1. Read the poem and discuss the following:
 - a. When people discard hazardous materials, do you think they usually consider the environmental impacts?
 - b. In light of the poem “Everywhere is Somewhere,” what problems do you foresee in the future, especially if we don’t change our toxic waste disposal methods?
 - c. How can we educate the public about the implications of our throwaway habits? The poem was one effective way; can you think of others?

EXTENSIONS

1. Have the students read Rachel Carson’s *Silent Spring* or Aldo Leopold’s *A Sand County Almanac*. What message(s) are these authors trying to get across? In what ways do our actions affect the world around us?
2. Have the students write a poem similar to “Everywhere is Somewhere” which discusses the effects of hazardous waste on a living creature(s). The poems should address where the poisons come from, how they affect different organisms, and how they affect the ecosystem.

EVERYWHERE IS SOMEWHERE

by Betty Miles

When people spray poisons into the air
to kill plant eating insects,
the insects may die
but the poison does not go away.
It stays, unseen, in the air.
And it falls, perhaps years later,
on other plants and on the land.
When the rains come, some poisons
wash off the plants
and run off the land
into ponds and lakes and rivers.
The poison is always somewhere.
It gets into water plants
and small water animals
and into the fish that eat them.
Birds of the air catch the poisoned fish,
or eat the poisoned insects,
and poison gets into the birds.
The poisoned bird lays eggs with soft eggshells.
No baby birds will come out of these eggs.
Some kinds of birds will never fly through the
air again.
They are gone forever,
because of poisons in the air.
In the air everywhere is somewhere.
Nowhere is away.

When you rinse garbage down the drain
of a sink,
or flush trash down the toilet,
it does not go away;
it goes somewhere.
Sewage and waste go into big pipes.
The pipes go into the river.
The river runs into a bigger river.
The big river flows to the sea.

Far, far away
in the middle of the ocean,
garbage and trash float on the sea water.
Pollution does not float away;
it floats somewhere.
And it will stay there,
floating and sinking under the sun,
for years and years.

When you rinse something down the drain,
it does not go away—
it goes somewhere.
In the water, everywhere is somewhere.

Source: Miles, *Save the Earth!*



Tracking Hazardous Wastes: Where Do They Go?

THEME:	Improper disposal of hazardous wastes is harmful to the environment.
GOAL:	Students will examine common disposal practices and gain an appreciation of better disposal options.
METHOD:	Role playing with discussion, research
SUBJECTS:	English, theater
SKILLS:	Analyzing, communicating, problem solving, making value judgments
MATERIALS:	“Where Does It Go?” “Where Should It Go?” handouts; Problem-solving exercise scenarios, cut into cards; Problem-solving exercise decision sheet
TIME:	1 to 2 hours; one follow-up class

GETTING STARTED

Ask the students what happens to household hazardous wastes if they are poured down the sink? Brought to the landfill? Burned in an incinerator? How are these practices harmful to the environment?

PROCEDURE

1. Distribute informational sheets, “Where Does It Go?” and “Where Should It Go?”. Discuss the information with the class. Have the students make a diagram of their homes indicating all avenues for disposal of household hazardous materials and where the material goes. This should trace, for example, the route of material poured down the kitchen sink, from septic tank to leach field or, when pumped, to a treatment facility, and so on.
2. Have students research the proper local disposal options for the items listed on the “Where Should It Go?” worksheet. Share the results in a subsequent class.
3. Tell students they are going to role play the decision making process for dealing with some common household hazardous substances. Divide the class into three groups and assign each a different scenario. The three scenarios are:

SCENARIO #1: Hilda discovers a can of gasoline in her garage. What should she do with it? If she decides to dispose of it, what options does she have?

SCENARIO #2: A group of neighbors is setting up a community gardening project. They have purchased the plot of ground and are meeting now to make some decisions about policy. The first issue they decide is whether to use Slug Bait in their garden.

SCENARIO #3: Nine individuals who have operated independent cleaning services have decided to combine their talents to create the Zippy Cleaning Service. As a group they need to make some decisions about the products they will use and the policies they will follow.

4. Each student should get one card listing a possible reaction to the question raised in their scenario. They must represent that point of view in a group discussion on how the situation should be handled. Point out to the students that there is not necessarily one correct answer to these problems. These are current situations for which the state—and society at large—are trying to find solutions.

5. Allow 30 minutes for discussion, at which time each group should make a recommendation concerning their particular dilemma. Have an assigned scribe keep track of the discussion (on the Decision Sheet) to tell the class what factors were considered prior to achieving a consensus.

EXTENSIONS

1. After completing one set of scenarios, allow the groups to discuss the other scenarios. Compare the final recommendations and the decisions made to reach those conclusions. How did they differ?
2. Have the students write an essay on how they would respond to one of the three scenarios.

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WHERE DOES IT GO?

When you wash your clothes in sudsy detergent, where does it go? When you clean your sink with cleanser, where does it go? When you pour a waste into the street drain, where does it go? It doesn't disappear; it all goes somewhere. It all helps or hurts someone or something.

All the drains in your house lead from the bathroom, kitchen, and laundry room down to one large drain. The watery wastes pass into a septic tank, if you live in the country. A septic tank is a large underground concrete container. Wastewater spends two or three days there. Solids settle to the bottom of the tank. Liquids are piped into a drainfield which allows them to seep slowly into the soil. This solid sludge must be pumped out approximately every five years. It is then taken to a sewage treatment plant.

If you do not have a septic tank, then your wastewater is piped from your house to the sewage treatment plant. Underground pipes mix the liquids from homes, stores, and factories. At the sewage treatment plant, wastewater is treated with bacteria. This can remove only some of the harmful materials. Then the waste is diluted with water and discharged into nearby lakes or streams.

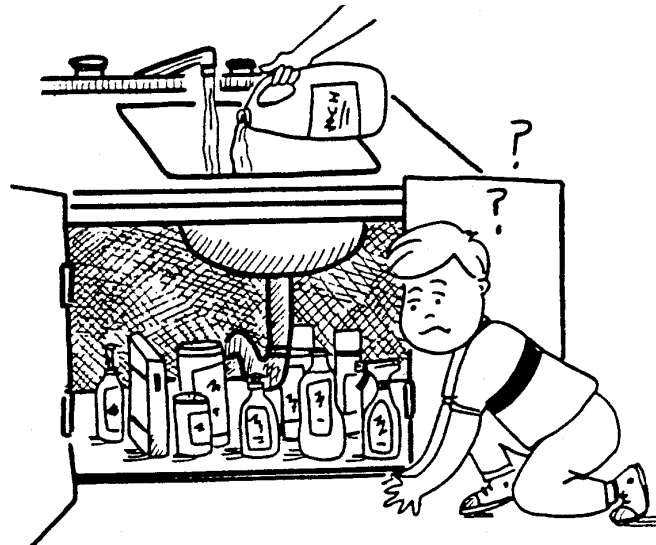
Pouring wastes into storm drains is illegal. That's because they lead directly to waterways. Many chemicals could harm the fish, or poison humans who eat the fish or drink the water.

Dumping wastes on the ground pollutes the soil. As the poison seeps into the soil, groundwater supplies may be ruined.

Burning toxic wastes is not a good idea, either. Harmful gases contaminate the air. Aerosol cans will explode.

There are only two good ways to deal with toxic materials. Use as little as possible. Then dispose of any wastes through a hazardous waste collection program.

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PROBLEM SOLVING EXERCISES

Scenario #1: Hilda’s Can of Gasoline

<p>Scenario #1</p> <p>You are Hilda’s neighbor, Nancy Nextdoor. You point out that gasoline evaporates. Maybe Hilda should just evaporate the gasoline. But, you know that the fumes are dangerous – poisonous, in fact. There are small children in the neighborhood. You also wonder if evaporation might cause some air pollution.</p>	<p>Scenario #1</p> <p>You are Lt. Jane Jones of the local fire department. It is very dangerous to store gasoline, as it is a fire hazard.</p>	<p>Scenario #1</p> <p>You are Hilda’s brother-in-law, Fred. You tell Hilda that gasoline is an effective weed killer. Hilda has a large patch of poison ivy in the corner of her lot. Maybe she should the gasoline on the ground around the poison ivy.</p>
<p>Scenario #1</p> <p>You are Joe Cleandrain from the sewage treatment plant. You tell Hilda that it is against regulations to pour gasoline down sink, sewer, or storm drains.</p>	<p>Scenario #1</p> <p>You are Pat, Hilda’s neighbor. You know that gasoline is a solvent. How could Hilda use a solvent? You suggest that Hilda check with a recycling center that takes solvents. But, the only one you know of is 25 miles away – clear over on the other side of the county.</p>	<p>Scenario #1</p> <p>You are Chris, Hilda’s son’s high school buddy. You say that your dad has always poured his excess gas down the storm drain in front of the house. It is such a small quantity that it can’t possibly hurt anything.</p>
<p>Scenario #1</p> <p>You are Peter Putrescible, a representative of the community landfill. You tell Hilda that the landfill will not accept flammable materials.</p>	<p>Scenario #1</p> <p>You are Hilda. You discovered a can of gasoline in your garage while you were cleaning. You don’t know exactly how long it has been there. Because you are worried that it may have water, oil, or rust in it, you have decided not to use it in your car.</p>	<p>Scenario #1</p> <p>You are Hilda’s son, Ralph. Another friend of yours says that his dad is glad when he has excess gasoline around. He uses it to start the barbeque.</p>

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PROBLEM SOLVING EXERCISES

Scenario #2: The Community Garden

<p>Scenario #2</p> <p>You are Bob Tool. You own the Valley Hardware and Garden Store. You know that Metaldehyde is the active ingredient in slug baits. It was first discovered in 1936 and has been around for a long time.</p>	<p>Scenario #2</p> <p>You are Sally Street. You have used salt on the slugs in your own garden. Last year you used saucers of beer to get rid of them. Although it worked pretty well, the saucers had to be changed often and sometimes it seemed like too much work.</p>	<p>Scenario #2</p> <p>You are Sandy Beach. You read in a gardening magazine that kelp or seaweed laid around the edges of the garden would get rid of slugs. They crawl over the salty surface of the seaweed and the salt causes them to dry out and die.</p>
<p>Scenario #2</p> <p>You are Polly Puregard. You checked with the local “Grow ‘Em” Community Garden people. They don’t allow any chemicals in their community gardens. If this project allows chemicals, you don’t want to participate.</p>	<p>Scenario #2</p> <p>You are Ned Punchly. You suggest that boards be laid around individual beds. The slugs will crawl under them during the day and someone can then turn the boards over and collect or kill them. Or, maybe the group could elect a member to go out at night with a flashlight and collect them.</p>	<p>Scenario #2</p> <p>You are Susan Feathers. You recommend that the group build two fences; one right around the garden plot and another 2 or 3 feet away from the first. The group could then put ducks and geese in this enclosed area. They would eat the slugs before they could get into the garden.</p>
<p>Scenario #2</p> <p>You are Rita Byeby. You recommend planting sacrificial rows of bok choy, lettuce, cabbage, or other vegetables, all around the perimeter of the garden. These vegetables will keep the slugs busy and they will never get into the “real” garden.</p>	<p>Scenario #2</p> <p>You are Dudley Doread. You read the label from a slug bait container and know that it is toxic to pets. Some pets have been poisoned by accidentally eating it in the garden. You also discovered that you are supposed to keep it away from the edible parts of the vegetables. What does this mean?</p>	<p>Scenario #2</p> <p>You are John Goodgardner. You have tried over the years to garden with a minimum of chemical pesticides and fertilizers. But last year you lost most of your lettuce to the slugs and that was a real disappointment. You also want the project to work and want everyone to feel comfortable with the decisions that the group makes.</p>

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PROBLEM SOLVING EXERCISES

Scenario #3: The Zippy Cleaning Service

<p>Scenario #3</p> <p>You are Annie Aerosol and are very concerned about aerosol cleaners. You know they are popular but not very cost efficient. Small droplets can land on other objects besides those being cleaned and some propellants can damage the ozone layer around the earth. Disposal of aerosol cans also creates problems because they may explode if they get too warm.</p>	<p>Scenario #3</p> <p>You are Carl Caustic and are concerned about alkalies found in dishwashing and laundry detergents, and oven and drain cleaners. Swallowing such products can result in severe stomach pains and burns in the mouth and throat. Inhalation can cause severe coughing and burns to the throat and lungs. Skin and eye contact can also cause burns and possible damage to the cornea.</p>	<p>Scenario #3</p> <p>You are Lisa Lemon and have researched some alternatives to commercial furniture polishes and recommend the following substitutes:</p> <p>1 teaspoon lemon oil 1 pint mineral oil</p> <p><i>or</i> equal parts of:</p> <p>turpentine, boiled linseed oil, and vinegar, plus a few drops lemon oil for fragrance.</p>
<p>Scenario #3</p> <p>You are Tom Smellnice and are concerned about disinfectants and deodorizers that end up down the drain or in the air after they are used. You realize that these products do not create a germ-free environment anyway. You also wonder about toilet bowl cleaners that are flushed into the sewer or septic tank. Does this create a problem?</p>	<p>Scenario #3</p> <p>You are Pricilla Polish and have been looking into the amount of hydrocarbons, petroleum distillates, and naphthas in polishes and cleaners. You have found that they can cause skin rashes, as well as eye, nose, throat, and lung irritation. They are also hazardous when ingested. Repeated exposure can result in liver and kidney damage.</p>	<p>Scenario #3</p> <p>You are Granny Smith and have researched some alternatives to conventional cleaners. For example, several teaspoons of vinegar in water works well for cleaning glass and marble. Baking soda is recommended for items that are particularly greasy, such as coffee pots, chrome, and tile.</p>
<p>Scenario #3</p> <p>You are Jack Cleanwater and are concerned about the phosphates in detergents, as well as the cleaning agent TSP. You heard that phosphates can threaten the health of lakes, rivers, and streams by encouraging algae growth.</p>	<p>Scenario #3</p> <p>You are Cloris Toxgas and are concerned with the human health hazards of chlorine. It is the basic ingredient of some bleaches and drain cleaners, and can cause burns and surface damage to eyes. If mixed with ammonia, a highly toxic gas is produced. Inhalation is especially dangerous to those with lung problems and can result in death.</p>	<p>Scenario #3</p> <p>You are Bob Bleach and have researched alternatives to commercial disinfectants. You have found that ¼ cup of bleach in 1 quart of water works well for cleaning many surfaces including counter tops, floors, toilet bowls, and bathtubs.</p>

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PROBLEM SOLVING EXERCISES

Decision Sheet

Which scenario? _____

Students in the group: _____

After each person in the group contributes information and the entire problem unfolds, what do you see as the ISSUES in this exercise?

POSSIBLE SOLUTION:

What are some tradeoffs to this solution?

What environmental or human health EFFECTS could result from this solution?

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What are some tradeoffs to this solution?

What environmental or human health EFFECTS could result from this solution?

FINAL DECISION: _____

Was the entire group satisfied with the decision? If not, why not? _____

Note any COMMENTS and QUESTIONS that your group had during the decision making process. Discuss these with the rest of the class.

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Household Hazardous Waste Audit

THEME:	The average household contains many products that could be designated as hazardous materials.
GOALS:	Students will identify hazardous household products, understand the health hazards associated with them, learn nontoxic alternatives to many commonly used household products, and become familiar with safe ways to recycle and dispose of household hazardous waste.
METHOD:	Household hazardous waste audit and preparing advertisement
SUBJECTS:	English, science, communications
SKILLS:	Analyzing, comparing, researching
MATERIALS:	Examples of toxic household products; household hazardous waste audit worksheets; Hazardous Waste Wheel [available from EHMI, 10 Newmarket Rd., Durham, NH 03824 (603) 868-1496]; Household Hazardous Waste Brochure [available from the Office of Technical Assistance for Toxics Reduction (OTA), Executive Office of Environmental Affairs, Room 2109, 100 Cambridge St., Boston, MA 02202 (617) 727-3260]
TIME:	45 minutes, plus several hours for audit

BACKGROUND INFORMATION

A hazardous material is a poison, corrosive agent, flammable substance, explosive, radioactive chemical, or any other material which can endanger human health or well-being if handled improperly. Many household products contain chemicals that, when improperly discarded, may contribute to the contamination of water supplies and other natural resources. To find out if a product is potentially hazardous, read the product label and look for words such as **WARNING, POISON, CAUTION, HARMFUL, CAUSTIC, FLAMMABLE, EXPLOSIVE, IRRITANT, or HAZARDOUS.**

GETTING STARTED

Ask the class to define household hazardous waste. Have the students bring in several examples or pictures of items that they think are or could be considered household hazardous waste.

PROCEDURE

1. Develop a class list of household hazardous wastes. Each student should contribute the names of ten items that they think are or could be called household hazardous wastes, and explain their rationale for choosing these items. Distribute list to all students.
2. Divide the class into small groups and assign each a set of items from the class household hazardous waste list. Using the Hazardous Waste Wheel (or “Safer Alternatives to Toxic Products” from Activity 1-16) and the OTA brochure, have each group determine:
 - If the product is potentially a hazardous waste
 - What toxic chemical(s) it contains and why they are harmful

- Possible alternatives
- Proper disposal methods

3. Distribute the Household Hazardous Waste Audit sheet for students to complete at home. After discussing the results, have each student choose one alternative product and use it in their house for one week. Each student should prepare a TV or radio commercial stating the advantages and disadvantages of the hazardous product and the alternative. Have the class evaluate the effectiveness of each of the commercials.

EXTENSIONS

1. Invite a speaker to talk to the class about household hazardous waste. Contact the Office of Technical Assistance for Toxics Reduction at the Executive Office of Environmental Affairs or a local environmental group for suggestions. Consult the Appendices in the back of the guide for additional speaker contacts.
2. Have students perform a school-wide hazardous waste audit similar to the one done at home. Determine alternatives and proper disposal methods for toxics that are found.
3. Have the class prepare a list of alternative household products to distribute to the entire school.

Sources: Amy Ballin and Tim Greiner

HOUSEHOLD HAZARDOUS WASTE AUDIT WORKSHEET

Directions:

You are from the Massachusetts State Office of Technical Assistance for Toxics Reduction. You have been asked to conduct an audit at the home of _____ to locate potential household hazardous substances. You will complete the audit locating all hazardous materials and then make recommendations to the family of _____ about ways to decrease their use of consumer products containing hazardous chemicals.

Number of persons living in the house: _____

AUDIT FORM

Product	Hazardous Substance	Product Use	Product Location	Storage Problems	Container Condition
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

HOUSEHOLD HAZARDOUS RECOMMENDATIONS FOR THE FAMILY OF

Prepared by _____

Below is a list of the hazardous materials in your household. For each hazardous product listed, I have suggested a less hazardous alternative, a technique to reduce the hazardous product's use and, where appropriate, a proper disposal method.

Hazardous Product	Alternative Product	Reduction Technique	Disposal Method
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

SECTION II: SOLID WASTE MANAGEMENT IN MASSACHUSETTS

SOLID WASTE MANAGEMENT IN MASSACHUSETTS

The Past

How was garbage handled and disposed of in the past?

Trash disposal is an ancient problem that has typically been dealt with in the cheapest, quickest way available. From the 1700s until the mid-1950s, communities in the Commonwealth relied on open burning and dumping for solid waste disposal. Trash from Massachusetts was disposed of in unpopulated areas considered unfit for development, such as river banks, wetlands, floodplains, marshes, swamps, and bogs.¹

By the mid-1800s, unsightly dumps were causing a number of health problems because they attracted rodents and other pests that transmit infectious diseases. As populations grew, so did refuse accumulation, and the question of what to do with household garbage intensified. By the late 1800s, communities began passing ordinances to clean up refuse areas.²

At the turn of the century, most communities in the United States still dumped their waste in marshes and wetlands. These areas were considered unsuitable for development and could be purchased at very low prices by local haulers and municipal governments.³ The prevailing belief was that the soil would act as a natural filter and that, as the waste residues percolated through the ground, the dilution process would render them harmless. No one anticipated the consequences of groundwater contamination and the effects on public and private water supplies. Garbage dumps were frequently established in areas where supplies of fresh groundwater are recharged by rainfall, the very places where many municipalities were also locating drinking water pumps and wells.

In the 1930s, much waste was burned in open pits to reduce its volume before burial. Open pit burning caused its own problems, however. First, surrounding neighborhoods lived with continuously smoky air. Second, the fire department always seemed en route to put out landfill fires. In fact, landfill fires used to be so abundant that they were used by fire departments to train newly-enrolled firemen.⁴

Communities responded by passing ordinances limiting open burning to specific areas. As the need for disposal grew and the availability of marginal land for disposal decreased, many cities built incinerators, which reduced the amount of land needed to bury garbage.⁵

What led to the regulation of solid waste facilities?

Public awareness of land-use issues and the importance of preservation grew dramatically during the 1960s and 1970s. Attention focused on wetlands, floodplains, and other water resources as scientists identified the role of these natural resources in maintaining our public and private water supplies. These were the very areas where household garbage and industrial waste were being dumped and buried. Most Commonwealth communities at the time still disposed of their waste in this manner. (See Section III for more information on landfills.)

Lobbying efforts by environmental groups such as the National Audubon Society and the Sierra Club led to legislative action, including passage of the National Solid Wastes Act in October 1965. This Act required all states to accept federal guidelines structuring regulations for solid waste management and disposal. Each state could add to these requirements as it saw fit.⁶

The establishment of the U.S. Environmental Protection Agency (EPA) in 1970 heralded further environmental and legislative reforms that reflected a growing public understanding of environmental issues. The EPA's mission was to administer and enforce anti-pollution laws directed toward air and water. The Clean Air Act of 1970 and the Clean Water Act of 1972 set standards and compliance procedures for industrial polluters and, for the first time, gave governments authority to levy fines against companies that failed to comply. Compliance with the new federal air emissions standards under the Clean Air Act required that all solid waste incinerators be retrofitted with costly pollution control devices. In Massachusetts all incinerators, except two, closed rather than take on the high cost of compliance.

National legislation passed in the last 20 years has given the federal government a greater role in waste management. Laws have been passed related to pesticide control, toxic substance control, air quality, water quality, low-level radioactive waste, and nuclear waste. The Resource Conservation and Recovery Act (RCRA) of 1976 created the first significant role for the federal government in waste management by launching a hazardous waste management program and addressing recycling and the conservation of energy and resources. The events at Love Canal, New York, in 1978, where houses were built on an abandoned hazardous waste site that leaked into nearby homes, created a fear of serious health effects that extended to all parts of the country. This new awareness of toxics and their effects led to the passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), known as "Superfund." This law established an elaborate system to study and clean up contaminated sites.

How did solid waste management become a public priority in Massachusetts?

In 1969, Massachusetts passed the Solid Waste Disposal Act, which surpassed the federal standards established by the 1965 National Solid Wastes Act. The Commonwealth's legislation established the authority of the Massachusetts Department of Public Health to write and enforce regulations governing the design and operation of sanitary landfills. This responsibility now belongs to the Department of Environmental Protection (DEP). The Act and the regulations:

Outlawed open dumps.

Required that sanitary landfills be sited, designed, operated, and closed in such a manner as to protect public health, safety, and the environment.

Prohibited "the occurrence of conditions of air, land, and water pollution and assisted in the abatement of such conditions when and where such pollution occurs."⁷

Approximately thirty municipalities closed their landfills in 1971, the first year that the Massachusetts landfill disposal regulations went into effect. The remaining municipalities either upgraded their landfills if they could afford to, or continued to operate them without meeting state regulations. In most cases, alternative options for disposal were not readily affordable.⁸ Between the years 1971 and 1985, many communities struggled with the closure of their landfills. Many simply stopped using the sites for dumping, but never formally closed them in accordance with regulations.

The Present

How is our solid waste handled in the 1990s?

In 1994, 28 percent of the Commonwealth's municipal solid waste was landfilled in one of its 91 active landfills.⁹ Twenty-five of these landfills were constructed with liners to prevent contaminated water from exiting the landfill into surrounding soil. In 1994, 66 older, unprotected facilities were still active. At least 23 of these were expected to stop operation by December 1995.¹⁰

The other major solid waste disposal option in Massachusetts is to burn trash in combustion facilities. As of 1994, Massachusetts had nine trash-burning plants. One of these is an older municipal incinerator, two are refuse-derived fuel plants that shred the trash prior to burning it, and six are mass-burn plants (see Section III, "Combustion"). Some of these facilities burn as little as 240 tons of trash per day, while the largest burns 2,700 tons of trash per day.¹¹ These plants burned approximately 31 percent of all the household and commercial solid waste produced in Massachusetts in 1988, and 34 percent of that generated in 1994.

As recently as ten years ago, the cost of solid waste collection and disposal was minimal, ranging from \$5 to \$20 per ton, and was a relatively small percentage of overall municipal budgets. In Massachusetts today, garbage disposal costs range from \$40 to \$150 per ton. Transportation costs add \$20 to \$40 per ton. On average, the cost of waste disposal has become the third largest municipal expenditure after schools and roads. These climbing costs provide local governments with an incentive to look beyond landfills and incineration facilities for ways to manage their waste.

In 1994, an estimated 31 percent of the Commonwealth's municipal solid waste stream was recycled or composted. Nearly every Massachusetts community offers its residents the opportunity to recycle, and two-thirds of the state's residents can recycle at the curb.

Section III provides details on the solid waste disposal methods discussed above.

What environmental safeguards exist for solid waste facilities?

Responding to public concern about potential threats to the environment and public health, state and federal officials have taken steps to strengthen environmental safeguards at all solid waste facilities, including landfills, combustion facilities, and recycling plants.

The DEP is the Commonwealth's lead agency for regulating solid waste facilities. DEP's Division of Solid Waste Management:

- Establishes standards that protect public health and the environment when siting, constructing, and operating solid waste facilities.

- Issues permits and regulates existing facilities to ensure they comply with these standards.

- Levies penalties for illegal dumping.

- Establishes and maintains the state's solid waste management priorities and planning strategies.

State-of-the-art landfill technology now includes standards for construction, operation, and environmental monitoring. Landfill operators are required to install impermeable clay or synthetic liner systems, groundwater monitoring devices, and gas collection equipment.

Safeguards at combustion facilities have also been established, requiring all new plants to have state-of-the-art air pollution equipment installed in their smokestacks to control emissions.

What is the cost of building a landfill?

The cost of building a new landfill or expanding an old one has risen drastically in recent years. Depending on geologic and other conditions, construction costs may range from \$250,000 to \$400,000 per acre. In addition to the land and construction expenses, these costs include air pollution control equipment, collection, insurance, and transportation. The additional expense of closing a landfill can range from \$125,000 to \$140,000 per acre. In total, it can cost upwards of \$500,000 per acre to develop, operate, and properly maintain a landfill site over its 20-year lifespan.

The Future

How do we plan to manage our waste in the future?

Answers to the question of how to best manage our waste are not simple. The Commonwealth is promoting an integrated solid waste management strategy that prioritizes reducing, reusing, and recycling waste before using combustion or landfilling as a management option. By placing source reduction, recycling, and composting at the top of the waste management hierarchy, the state and local municipalities will conserve resources and, possibly, money. Source reduction results in less waste to haul and dispose of, while recycling and composting can often cost less than combustion or landfilling. The waste management hierarchy is explained further in the following paragraphs.

Source Reduction

Source reduction means avoiding the generation of waste. When the amount and toxicity of waste are reduced, disposal costs are reduced and resources are conserved. Source reduction occurs when industry designs and sells products that are durable, use less packaging, and have minimum or no toxic ingredients. Consumers can also reduce their waste by avoiding disposable and over-packaged products, buying reusable products, and getting off of junk mail lists when possible. The Commonwealth's source reduction goal is 10 percent by the year 2000.¹²

Recycling and Composting

Recycling (including the composting of food and yard materials) and reusing of products prevents potentially useful materials from being buried or burned and extends the lifespan of landfills, thereby preserving valuable space. What was once treated as waste has become a major resource in the manufacture of new products. Using recycled materials in place of virgin materials also saves energy and natural resources. Composting food and yard trimmings produces organic material that can be used on gardens and farm fields. In 1994, the Commonwealth diverted 31 percent of its MSW through recycling and composting. Its goal is to divert 46 percent of the waste stream through recycling and composting by the year 2000.¹³

Combustion or Incineration

Combustion, or incineration, is designated for waste that cannot be reduced, composted, or recycled, but can be burned. Combustion facilities should be equipped with state-of-the-art pollution control and energy recovery equipment. Such facilities reduce the volume of nonrecyclable, nonrenewable waste, and convert the heating value of garbage to steam or electricity. The leftover ash is then disposed of in a monofill—a landfill that accepts only one kind of material. In 1994, the Commonwealth incinerated 48 percent of its municipal solid waste. Its goal is to reach and maintain a 50 percent incineration rate through the year 2000.

Landfills

Landfilling is the last resort as a waste disposal method. Landfills should be equipped with proper liners and leachate collection systems to protect the environment. DEP's goal is to create a system in which no waste is landfilled without first being processed and reduced in volume. The Commonwealth's goal is to reduce the amount of waste landfilled from 28 percent of all municipal solid waste in 1994, to 4 percent by the year 2000.

* * *

Communities that follow this hierarchy stand to reduce disposal costs while cutting down on air and water pollution. Recognizing that communities need assistance to comply with this waste management plan, DEP offers the following help to towns and cities:

Technical assistance in all areas of solid waste management.

Municipal grant programs for recycling and composting public education and equipment.

How might a community institute an integrated solid waste management system?

Take as an example the hypothetical town of Carneysville, which wants to comply with the goals of the state's 1995 Master Plan by establishing an integrated solid waste management system. Carneysville generates approximately 2,000 tons of municipal solid waste a year (30 percent is commercial and 70 percent is residential). The town is responsible for the collection and disposal of all 2,000 tons.

Following the list of preferred disposal options in the solid waste hierarchy, the town adopts an ambitious source reduction program to decrease its waste stream by 200 tons per year, or 10 percent.

The major business in the community, a shampoo manufacturer, is asked to consider using less packaging for its shampoo bottles and to identify pollution prevention opportunities in its manufacturing process. This will reduce the amount of waste consumers throw out and minimize the amount of discarded and toxic material resulting from the production process. The company also decides to initiate an office paper recycling program, and a buy recycled purchasing policy in their administrative offices.

Consumers (both in households and in businesses) are encouraged to shop selectively, avoiding disposable goods, toxic products, and excess packaging. The area supermarkets begin to sell shopping bags to encourage customers to purchase and use their own bags in the market. Some citizens write to the Direct Marketing Association in New York to request the removal of their names from junk mail lists. (Mail Preference Service, Direct Marketing Association, Inc., P.O. Box 9008, Farmingdale, NY 11735-9099)

Next, the town takes an inventory of what can be recycled in its community. They calculate that they can realistically recycle close to 30 percent of their waste stream, or 600 tons of paper, glass, metals, plastic, drink boxes, and leaf and yard waste a year. Carneysville joins forces with neighboring communities to form a regional recycling committee. A private contractor, attracted by the large projected volume of recyclable materials generated by the towns, constructs a regional processing center, a Materials Recycling Facility (MRF). The communities sign a contract to deliver their recyclable newspaper, glass, metal, and plastic to the facility for processing and subsequent sale.

Residents participate in the new recycling program by separating their paper, glass, metal, drink boxes, and plastic into specially marked containers. The remaining nonrecyclable trash is disposed of as usual in the trash bin.

The town also initiates a comprehensive leaf and yard waste composting program. During the fall and spring, the town provides curbside collection service. In addition, citizens can bring in their materials by car or truck. This organic yard waste is put in large piles. Through the composting process, microorganisms break down the materials into a nutrient-rich, soil-like substance called *humus*, which is used by the town for landscaping.

The town conducts two household hazardous waste collection days each year for materials that cannot be safely disposed of by conventional methods. These materials include drain and septic tank cleaners, nail polish, pesticides, medicines, and paint. The town initiates a toxics reduction campaign to educate consumers about the dangers of many household products and to offer consumers environmentally sound product alternatives.

Of the remaining 1,200 tons of refuse, the town estimates that 1,000 tons, or 50 percent of the total municipal solid waste generated, can be burned at a neighboring combustion facility. Carneysville negotiates a flexible contract with that facility that allows the town to adjust the tonnage it provides for burning based on its recycling rate.

The town is left with 200 tons of waste that cannot be reduced, recycled, or burned. In addition, there are approximately 100 tons of residual waste from the recycling facility and incinerator combined. Of these 300 tons of waste that are left, the incinerator ash will go to the nearby monofill that accepts only ash. The rest of the waste will go to the town landfill.

The result: The amount of waste being landfilled in Carneysville has been significantly reduced by establishing an integrated solid waste management program.

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1. Lambert, "Groundwater Protection."
 2. *Ibid.*, p. 22.
 3. *Ibid.*, p. 24.
 4. *Ibid.*, p. 25.
 5. *Ibid.*, p. 26.
 6. *Ibid.*
 7. Massachusetts, MGL 310 CMR 19.006.
 8. Lambert, "Groundwater Protection," p. 28.
 9. Massachusetts DEP, *Master Plan: 1995 Update*.
 10. *Ibid.*
 11. *Ibid.*
 12. *Ibid.*
 13. *Ibid.*

SECTION III: SOLID WASTE DISPOSAL METHODS

SOLID WASTE DISPOSAL METHODS

Source Reduction

What is source reduction?

Source reduction refers to industry and consumer practices that reduce the quantity and toxicity of waste generated. While industry can reduce waste and pollution from production processes, consumers can purchase products that are durable, reusable, less toxic, less resource intensive, or have less of a negative impact on the environment during use.

Frequent stylistic and technological changes in our society have increased the amount of waste we produce. Products deliberately designed for single or very limited use before disposal contribute to our throw-away lifestyle. Reducing the amount of trash produced will require changes in the attitudes and behaviors of most citizens. Product manufacturers and consumers must assume joint responsibility for their waste generation and make changes in production design practices and in purchasing decisions.

In response to the high cost of solid waste disposal and the overuse of nonrenewable resources, government officials, industry representatives, and consumers are devising and implementing strategies to reduce packaging. The following strategies will help to achieve source reduction of packaging waste:

- Reducing the total volume of disposable packaging material generated for domestic, commercial, industrial, and government use.
- Reducing the negative impacts of packaging waste disposal by changing to less toxic and more environmentally benign packaging material.

Source reduction also involves efforts by industry to reduce the amount of environmentally harmful ingredients contained in household products. Solvents found in paints, paint strippers, nail polish remover, and some cleaners evaporate and can react with sunlight to create smog. Some state governments are considering restrictions on the content of solvents in consumer products as a means of fighting smog. Drain, toilet, tub, and tile cleaners, and other toxic chemical products flushed down the drain during normal use can harm septic systems, sewers, and sewage treatment systems. Chemicals discharged from these systems can contaminate sewage sludge, rivers, lakes, and oceans, harming wildlife and natural ecosystem functioning.

Educational programs to inform and motivate consumers are critical to the success of any source reduction program. We can make choices for the environment rather than for our personal convenience. It is not always easy to change our attitudes and behaviors, but the consumer choices we make today will have a direct effect on the quantity of waste we must dispose of tomorrow.

Manufacturers provide some of the information that consumers need to make responsible environmental choices right on product labels. This product information often includes percentage of pre- and post-consumer recycled content; the technical recyclability of a product (some items can technically be recycled, yet there may be no collection of this item in your area); and the proper use, storage, and disposal methods. Read and compare labels to select the least wasteful and the most environmentally safe products.

How can the average consumer practice source reduction?

The cumulative effects of individual actions can have a significant impact on the amount of waste we generate as a society. The following actions are ones that individual consumers can take in their everyday lives, and are ones that will help reduce the amount of waste generated in their own community and beyond.

Select Products Carefully

Consider the environmental impact of each purchase you make. The product label often gives information about the product's ingredients, use, storage, and disposal. What is the product made of? Is it safe for the environment? Can it be reused or recycled? Is there a safer alternative product or type of packaging? Do you really need the product or its excess packaging?

Be picky about packaging. At the store, reach for the product packaged in materials that you can recycle in your community. 'Biodegradable' plastic bags, now widely offered at supermarkets, merely break up into smaller pieces of plastic under special conditions and are not truly biodegradable.

Avoid overpackaging. If the packaging isn't necessary to protect the product, or if it's simply eye-catching, buy the less packaged alternative. It will probably cost less too.

Avoid disposables. Don't buy products manufactured expressly for limited use, such as disposable razors and lighters, or plastic or paper plates. Do buy items designed for reuse: thermos jars, metal razors, cloth napkins, and sponges.

Buy in bulk. Avoid overpackaging and save money too. Bring your own container with you to the store and buy non-food items in bulk rather than the pre-packaged items. Massachusetts prohibits the use of your own containers for purchasing food items in bulk. Store brands and generic goods often have less packaging than other brands.

Reduce Waste From Fast Food

If you are a regular take-out patron, bring your own thermos or cup for beverages. If you are buying one product from a fast food restaurant and do not need a bag, ask not to be given one.

State Your Views

Talk to the store manager about your product and packaging preferences. Suggest that your grocer sell strong shopping bags or string bags designed for reuse. Encourage in-store recycling programs. Educate fellow consumers. Patronize businesses that offer recyclable products, less packaging, and the opportunity to buy in bulk. Write or call your state and federal officials to lend your support to legislation that favors recycling and reduces unnecessary and nonrecyclable packaging.

Reuse And Repair Things

When you no longer need clothing or household items, consider giving them to charity or a consignment shop. Don't discard items if they can be fixed. By patronizing neighborhood repair shops, you will help the local economy.

Compost Food And Yard Materials

Feed your garden and it will feed you. The Department of Environmental Protection's Division of Solid Waste Management has a free brochure about backyard composting. Your local Department of Public Works has a video on grass clipping management entitled *Don't Trash Grass* and your local library has a video on how to compost, *Turning Spoils into Soils*. (Contact the DEP if you are unable to locate either video.)

Teach Children To Practice Waste Reduction

Children may be highly susceptible targets for the lure of overpackaged goods, but they are quick learners and we can teach them to do it right from the start.

Source: Adapted from City of Berkeley, "*PRECYCLE*" Campaign

Recycling

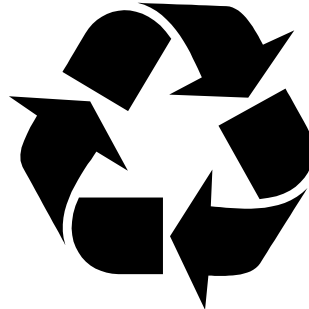
What is recycling?

Recycling is the conversion of discarded material into useful commodities or, put simply, turning trash into new products. Recycled material is reprocessed to be used in place of, or in addition, to virgin (new) materials in the manufacturing of new products. Materials that are commonly recycled include newspaper; office paper; corrugated cardboard; glass, metal and plastic containers; food wastes; and leaf and yard wastes. Less commonly recycled materials include batteries, aseptic packaging (drink boxes and gable top containers), and motor oil, for example.

Although recycling will not solve all of our solid waste problems, it is one means of handling significant portions of our waste stream with relatively little detriment to the environment.

How does recycling work?

Separation/Collection



Remanufacturing

Processing

The three arrows of the standard recycling logo represent the three components of the recycling process:

Separating recyclable products from other trash and **collecting** it.

Processing (e.g. cleaning, shredding) such products so that they can be substituted for virgin raw materials at manufacturing plants.

Remanufacturing recyclable material into useful commodities, usually as part of other products (e.g., cardboard can be reused in packaging, or glass processed to make reflective paint or other glass).

Step One: Separation and Collection

Residential recycling programs are either run by the local government or contracted out to private companies or nonprofit organizations. Commercial businesses are usually responsible for setting up their own recycling collection programs. Generally, the most effective programs are those that operate like the current trash collection systems as much as possible. Residential and commercial programs are typically one—or a combination—of the following four basic types.

Household Separation/Curbside Collection: This type of program is appropriate for communities that have curbside trash collection. Individual households are encouraged (or required by ordinance) to separate certain materials (such as bottles, cans, and newspapers) from the trash and put them at the curb for collection. Materials may be placed in special containers or bagged separately from ordinary trash.

Drop-off Centers: These are designated collection centers where people bring recyclables. This is the most common form of recycling in rural areas.

Buy-Back Centers: These centers pay consumers for bringing in recyclable materials such as deposit cans and bottles.

Commercial Collection: Private haulers collect recyclables from businesses, offices, institutions, schools, and industries that, often, are not served by municipalities. Commercial customers often generate large quantities of one type of waste, such as cardboard or white paper.

Sample Massachusetts Municipal Recycling Program

The City of Somerville has a recycling program that combines several recycling methods. Somerville, with a population of more than 76,000 people and covering 4.1 square miles, has had a drop-off recycling program since 1989 and a city-wide curbside program since 1993. White paper recycling in municipal buildings has been ongoing since 1990. As of July 1994, the following materials were accepted curbside: clear and colored glass; steel cans; aluminum cans, foil, and trays; #1 (PETE) and #2 (HDPE) plastic bottles; milk and juice cartons; drink boxes; corrugated cardboard; telephone books; newspapers with all inserts; magazines; junk mail; and office paper.

In addition to the curbside program, Somerville offers used motor oil and tire recycling, household hazardous waste collections, and a drop-off recycling center which has been opened to businesses at no charge.

Step Two: Processing Recyclables

Recyclables are processed to prepare them for market. Processing occurs after the recyclables have been collected and taken to a sorting facility. Processing involves a variety of steps, usually beginning with sorting and segregation by material type or color, and removing contaminants (e.g., the metal rings on glass bottles). Materials may then be crushed, shredded, flattened, or baled depending on industry requirements and shipping considerations (called *market specifications*). Market specifications can include instructions on:

- How to prepare materials: e.g., bale them, crush them, provide them loose.

- How to sort materials: e.g., separate clear #2 HDPE milk jugs from the color HDPE household containers.
- What contaminants to remove: e.g., remove plastic bags from shipments of newsprint.

Each industry has its own specifications. Materials that do not meet market specifications for one reason or another are difficult to sell, and may end up in either the landfill or the incinerator. Usually the return or disposal of a rejected load must be paid for by the sender.

Because processing is a specialized activity, and because end-markets tend to be large industrial factories, recycling is often more cost-effective when processing occurs on a regional basis. Regional processing facilities can accommodate large quantities of material and can assure fairly standard quality of output. After materials have been processed, they are marketed and transported to their next destination.

There are three levels of recycling:

Primary: A closed-loop system in which a product is recycled into the same type of product over and over. Examples include glass bottles that are remanufactured into glass bottles and steel cans that are remanufactured into steel cans.

Secondary: This type of recycling involves remanufacturing a recycled item a few times into the same type of product until it can no longer be remanufactured into the same product. For example, every time paper is recycled, its fibers are shortened. After recycling paper several times, the fiber can no longer be used to make high-grade paper products, so it is used to make a “secondary” product, such as toilet paper, that cannot be recycled again.

Tertiary: This type of recycling uses materials that can only be recycled once. Sometimes a product that has a short lifespan, such as a ketchup bottle, is remanufactured into a product with a longer lifespan, such as plastic lumber.

Step Three: Remanufacturing and Marketing—Closing the Loop

Recycling is not complete until the collected materials are remanufactured into desirable products and resold as new goods. Recycled materials removed from the municipal waste stream for remanufacturing are called *post-consumer* materials. Materials that are left over from the manufacturing process and product over-runs that are salvaged for reuse in the manufacturing process are called *pre-consumer* materials. These pre-consumer materials are also called *millbroke*.

Buyers of processed post-consumer materials are usually large industrial manufacturing firms that use the recycled materials as a substitute for virgin raw materials. Table 3-1 lists several examples of products that can be manufactured with recycled materials. Also listed are the natural resources those recycled materials displace.

Table 3-1. Common Products and Their Recycled-Material Feedstocks

END PRODUCT	VIRGIN RESOURCE FEEDSTOCK	RECYCLED MATERIAL FEEDSTOCK
Boxboard	Pulp from trees	Newspaper
Glass	Sand, soda ash, limestone	Glass
Aluminum	Bauxite ore	Aluminum
Steel	Iron ore, coal	Steel cans
Plastic	Resins from oil and natural gas	Plastic

Processing is the key to integrating recycled materials with virgin materials for remanufacture. End markets need uncontaminated, high quality materials that can compete with virgin materials. Recycled materials compete with well-established sources of virgin materials. That is why quality control in processing must be high. Marketing recycled materials requires identifying specific companies that can use the materials to make new products. Once these companies are found, the recycled materials are priced so that the buyer can afford to use them instead of the traditional supply of virgin raw materials.

How much does recycling cost?

One misconception about recycling is that it always generates revenue. This premise was based on the past when relatively small amounts of materials were being collected, primarily in volunteer drives. This type of recycling was not done for waste management purposes but to raise funds for community programs.

Today recycling is a means by which millions of tons of materials are managed. Extensive labor and equipment are required to collect, process, transport, and sell such large quantities of materials. While there will be revenues from the sale of some recycled materials, communities cannot, and should not, count on those revenues to entirely offset the costs of recycling.

While communities generally will not realize a net profit from recycling, they may realize savings in the overall cost of solid waste management if recycling is less expensive than combustion or landfilling. If a town can pay less per ton to recycle than to dispose of its waste via combustion or landfilling, the town can see a net savings per ton of material recycled. This savings is referred to as *avoided cost*.

How is the Commonwealth approaching regional recycling?

The Springfield Materials Recovery Facility

In January, 1990, the Commonwealth established a large-scale regional processing plant—a materials recycling facility (MRF) in Springfield, Massachusetts. The MRF accepts large quantities of recyclable materials and upgrades them into high quality feedstocks that provide economically-attractive alternatives to virgin industrial feedstocks.

The MRF is one of the largest projects of its kind in the country. It serves approximately 100 communities in the five western counties, or approximately 1,000,000 residents. DEP's recycling program in western Massachusetts involves a cooperative effort between the state and local municipalities. Communities bringing their recyclables to the state's 240-ton-per-day plant pay no tipping fee; they pay only to transport their recyclables to the facility.

A recent contract option allows towns to receive payment for their recyclables. (For more information call DEP at 617-292-5988.) In addition, the state provides many of these communities with household recycling containers, specialized recycling vehicles to perform curbside pickup, and/or large roll-off containers for collection of recyclables at drop-off recycling centers.

To participate in using the MRF, communities are required to pass mandatory recycling ordinances, collect recyclables from residences and deliver them to the MRF, and conduct ongoing public education activities. Communities may have a representative serve on the MRF Advisory Board with the DEP to oversee the MRF operations. The Advisory Board also assists towns in improving their recycling programs and increasing their recycling rate, and serves as a vehicle for communication between DEP and the towns on materials handled, operating policies, and education.

The MRF program is simple and is designed to be compatible with the trash disposal system residents currently use. Residents separate their recyclables and place them in the portable container provided by DEP. In communities where citizens have curbside collection, the recycling bin is set out for pickup on the designated collection day. In communities where residents must bring their trash to a landfill or transfer station, residents deposit recyclable materials in large containers at their recycling depot, usually nearby the landfill.

The MRF is operated by private recycling companies under long-term contracts with the state. The current private operator is responsible for processing the recyclables and marketing them.

The MRF provides the needed link between community collection of recyclable materials and use of recycled materials by manufacturers. It produces consistent quantities of high-quality materials for use in place of or in addition to virgin materials in manufacturing.

Other Regional Recycling Activities

In addition to western Massachusetts, several groups elsewhere in the state are exploring regional recycling strategies. Long-term possibilities being investigated include extensive cooperative market programs, regional drop-off stations, regional efforts to collect hazardous or difficult-to-manage wastes, and development of shared, multi-community MRFs.

What is the Commonwealth doing to increase recycling?

Identifying Barriers to Recycling

While recycling programs and markets have grown over the past few years, there are still barriers to increasing recycling that need to be overcome. DEP has identified the following barriers to recycling:

Recycling market uncertainty: In recent years, recycling programs have grown faster than demand for recyclable material, causing the prices paid for recyclable materials to fluctuate.

Transportation costs: Some municipalities must transport their recyclables over long distances to recycling facilities and industries. Many regions of the state have no means to consolidate their recyclables at transfer stations to make them cost-effective to collect and transport.

Insufficient public education: Businesses and residents need to be educated about what materials are recyclable, and what recycled-content products are available for purchase.

Poor regional cooperation: Cities and towns must work together to compensate for the lack of strong regional government in some parts of the state.

Waste disposal contracts that discourage recycling: Many communities have signed long-term “put-or-pay” contracts with combustion facilities, which commit them to sending a minimum guaranteed amount of their waste for disposal. When these towns remove recyclables from their waste, they often reduce the amount of waste to a level below the minimum guaranteed tonnage. Communities may be fined for these tonnage shortfalls.

Remaining capacity at unlined landfills: Although the state is closing all unlined landfills in the near future, the several unlined landfills still operating in the state provide disposal space that is cheap but, often, polluting. When these unlined landfills are shut down, new disposal facilities will be more expensive, providing municipalities with more of a financial incentive to recycle.

Not enough buying recycled: State and local municipalities need to set an example for their communities by purchasing products made from recycled materials. This may involve rewriting purchasing policies or passing an ordinance to mandate this change.

Addressing Barriers to Recycling

To address many of these problems, the Commonwealth developed a Ten Point Recycling Plan to expand recycling and composting in Massachusetts. Funding for the strategies, priorities, and proposals outlined in the Plan comes from the Clean Environment Fund (money from unredeemed bottle deposits across the state). The Ten Point Recycling Plan is as follows:

Ten Point Recycling Plan

1. **Municipal Recycling and Composting Equipment Grants:** These grants help cities and towns acquire equipment and educational materials for the start-up or expansion of recycling and composting programs.
2. **Public Education Recycling Campaign:** Funds are given to cities and towns to educate businesses and residents about recycling and composting opportunities available to them.
3. **Household Hazardous Waste Program:** This program targets the most common hazardous products for which recycling options already exist. Funds are granted to communities to establish facilities for operating used paint and used oil recycling or swap programs.
4. **Recycled Products Procurement Program:** This program encourages government, businesses, and individuals, to buy recycled. Funds are used to increase state government purchases of recycled products. The state Department of Procurement and General Services is researching the availability of recycled products and educating buyers about establishing a purchasing program for recycled products.
5. **Municipal Transfer Station Grants:** These grants are given to cities and towns for the construction of waste and recycling collection facilities. Transfer stations enable towns to consolidate solid waste and recyclables for a more cost-effective transfer to processing facilities.
6. **Municipal Guaranteed Annual Tonnage Recycling Assistance:** This program directly addresses the problem of towns being penalized for reducing their waste below the minimum tonnage guarantee to combustion facilities under put-or-pay contracts.
7. **Recycling Research and Development:** Funds are provided for studies at the University of Massachusetts focusing on obstacles to increased plastics recycling.
8. **Higher Education Recycling Initiative:** Funds support solid waste research at several higher education institutions with environmental programs.
9. **Recycling Investment Loan Program:** This program stimulates the development and expansion of recycling and composting industries by providing technical and financial support.
10. **Springfield Materials Recovery Facility (SMRF) and the Cooperative Market:** The SMRF will provide a market “safety net,” guaranteeing municipalities a market and a base price for collected recyclables. The MRF also serves to assure markets of a steady, reliable source of materials.

Commercial Incentives for Recycling

Commercial waste accounts for approximately half of the Commonwealth’s solid waste stream. The DEP, working with trade associations, businesses, and nonprofit organizations around the state, helped establish WasteCap in 1994. WasteCap is a voluntary, statewide,

nonprofit organization whose purpose is to educate and advise businesses and institutions on the benefits and processes of minimizing and recycling nonhazardous solid waste. The WasteCap program is modeled after similar programs in other New England states, where businesses take the lead in providing technical assistance to other businesses to minimize their wastes.

Composting

What is composting?

Composting is a natural process by which microorganisms break down organic materials such as kitchen, leaf, and yard materials into a soil-like substance called *humus*. Humus can be used to stabilize and enrich soil. In nature, this breaking down process can take a number of years, but under controlled conditions, with proper levels of moisture and air circulation, composting can take from as few as 2 weeks to 1 year.

The proper combination of temperature, oxygen, moisture, and organic materials produces the conditions needed for composting at a fast rate without offensive odors. The proper conditions allow a host of microorganisms to decompose the organic material. Bacteria and fungi are two types of microorganisms that are largely responsible for breaking down organic matter. During the eating and digesting process, these microorganisms break down organic matter into its basic elements—water, carbon dioxide, and humus. Other soil organisms, such as nematodes, mites, springtails, centipedes, and earthworms also contribute to the composting process by processing the organic matter as food.

What percent of the waste stream is compostable?

Approximately 65 to 70 percent of the municipal solid waste stream is composed of organic material such as food, paper, cardboard, wood products and by-products (paper sludge), and yard materials.¹ Leaf and yard materials (grass clippings, leaves, brush, and tree prunings) make up approximately 18 percent by weight of the household waste stream.² They are more efficiently processed by composting than by landfilling or burning because of their bulk and high moisture content.³ Since yard materials consist of relatively clean, biodegradable materials, landfilling them simply wastes space and burning them wastes energy.

How does composting fit into the Commonwealth's plan for waste management?

Composting is a vital part of the Commonwealth's integrated solid waste management strategy. It offers significant environmental and economic benefits, including:

A savings on waste transportation, management, and disposal costs because a heavy portion of the waste stream is pulled out at the source of generation.

Reduced volume of waste to be incinerated or landfilled.

Minimal negative environmental impacts.

Production of beneficial material—humus—that improves the productive potential of soil.

What are the different types of composting systems?

Composting is a versatile process that can be done at sites of varying size, using a variety of materials, and with different levels of technology. Composting system types are as follows:

Home Composting: A system in which residents compost food scraps and yard trimmings in their yard using a manufactured or home-made composting bin, or by making a free-standing pile. Households can reduce and convert their waste by as much as 50 percent by weight using this method.

Vermicomposting: Another residential system that can also be done on a small or larger scale. Vermicomposting means composting with worms contained in an enclosed bin perforated for air circulation. Certain types of worms (red wigglers) can eat and expel their own weight in organic material every day, so even a small worm bin can produce pounds of rich sweet-smelling compost. These worms cannot survive in freezing temperatures, so the bins must be maintained at temperatures between 40 °F and 80 °F.

Centralized Yard Composting: A community program at a landfill, transfer station, or farm, where residents can drop off leaves and brush.

Municipal Solid Waste Composting: A large-scale system run by public agencies or private businesses to manage MSW from homes and businesses. The organic portion of the waste stream is separated from recyclables and noncompostables, is picked up by waste haulers, and is taken to a large-scale composting plant.

Co-Composting: The simultaneous composting of two or more diverse organic waste streams. Co-composting systems are usually run by public agencies or private businesses to manage organic materials. As with MSW composting, the organic portion of the waste stream is separated from recyclables and noncompostables, is picked up by waste haulers, and is taken to a large-scale composting plant. It is mixed with another organic component of the waste stream, such as paper or sewage sludge.

Institutional Composting: A food scrap management system used by restaurants, markets, schools, institutions, and food processors. Food scraps are separated at the institution and composted either on-site at the institution or off-site at a farm or composting facility.

On-Farm Composting: A farm-based composting system using farm equipment. The compostable materials can include farm materials such as yard trimmings and manure, or other items, such as paper products and wood scraps (shredded for bedding and composting). Farms can also accept food scraps from restaurants, institutions, food processors, and supermarkets. The organic waste from these sources may be composted or used as animal feed.

What are the state's future composting goals?

The least costly of all waste management technologies, composting may account for nearly half of the state's municipal solid waste diversion by the year 2000. Organic materials

including leaves, wood, food, paper, paperboard waste, and yard trimmings account for 67 percent of total MSW by weight.⁴ To achieve maximum diversion of these organic materials from the municipal solid waste stream, the Commonwealth employs the following hierarchy:

1. **Source Reduction:** Organic materials that have traditionally required collection and centralized processing can be composted at the source of generation such as homes and businesses. The state is working to promote home composting by providing towns with training and education materials for their residents. The state also subsidizes the cost of home composting bins made out of 50 to 100 percent recycled Massachusetts plastic and sold by towns to their residents. The DEP has also revised the Site Assignment Regulations for Solid Waste Facilities to exempt institutions and small businesses that generate and compost less than 2 tons per week of source-separated food scraps from solid waste facility permitting requirements. These simplified regulations also allow small operations such as farms to compost while complying with state regulations.
2. **Leaf And Yard Waste Composting:** Municipal leaf and yard waste composting programs have been established in 239 Massachusetts cities and towns, as of 1995.⁵ Since April 1993, leaves, grass clippings, and brush (up to 1 inch in diameter), hedge clippings, and weeds have been restricted from disposal in Massachusetts landfills and incinerators.
3. **Municipal Solid Waste Composting:** Large-scale composting of either mixed solid waste or source separated degradable MSW has grown increasingly popular in the United States. The number of composting facilities in this country has doubled since 1991 to 21, most of which process and compost mixed municipal wastes. Since 1986, the Commonwealth has helped communities evaluate MSW composting options. Feasibility studies for Northampton, Franklin County, and the Southern Berkshires concluded that these projects are technically and economically feasible.

Combustion

What is a combustion facility?

Combustion facilities burn wastes to reduce their volume, thus conserving valuable landfill space. A 1,500-ton-per-day facility can typically achieve a reduction in waste of 75 percent by weight and 90 percent by volume.⁶ Leftover ash is landfilled. The three technologies employed by the nine facilities in Massachusetts are mass-burn, refuse-derived fuel (RDF), and incineration. Mass-burn and RDF facilities are frequently referred to as waste-to-energy facilities because they convert heat from the combustion process into electricity.

There are six mass-burn facilities in Massachusetts. Mass-burn plants burn solid waste just as it is received at the facility. In this technology, the furnace is lined with a water-filled wall. The heat from the burning garbage turns the water into steam. The steam is then sent to a turbine generator where it is converted to electricity. The electricity is sold to a utility or neighboring commercial business to offset a portion of the cost of the combustion facility.

There are two RDF facilities in the state. The types of furnace and boiler used by these facilities to generate steam are different from those used in mass-burn operations. RDF facilities first separate out ferrous metals, such as steel and cast-iron, then shred the remaining trash into fairly small, uniform pieces. This trash is then burned. The separated metal is recycled. This pre-screening of the metals, combined with the shredding process, creates a more homogeneous and consistent fuel for burning.

There is one incinerator in Massachusetts. This type of combustion technology simply burns trash without producing electricity. Incinerators have been operating in Massachusetts since the late 1800s, while mass-burn and RDF facilities are more modern technologies and have been operating since 1975.

Combustion facilities burning MSW can produce a number of pollutants, along with two types of ash. Air pollutants that can be produced include carbon monoxide, sulfur dioxide, and fine particles containing heavy metal compounds (e.g., from lead and cadmium). The release of these pollutants is prevented in modern facilities by air pollution control devices, though these do not always operate at maximum efficacy. The two types of ash produced are bottom ash and fly ash. Bottom ash is the unburned and unburnable matter that remains on the bottom of the combustion chamber after the waste passes through. It can contain heavy metals and other hazardous components. Bottom ash comprises between 75 and 90 percent of all ash produced. Fly ash is a powdery material that leaves the combustion chamber with the flue gases. Fly ash, which tends to have higher concentrations of certain metals and certain organic materials, is captured by the air pollution control devices. These two types of ash need to be disposed of properly to prevent the harmful substances in the ash from entering groundwater.

New standards for burn facilities in Massachusetts require additional air pollution control equipment to remove ash particles and gaseous materials from the air exiting the smoke stack. Massachusetts also requires that toxic ash residue from the combustion process be disposed of in monofills, landfills reserved exclusively for ash disposal. Under the Commonwealth's rules and regulations, a combustion facility must have a contract with a monofill for 20 years before it can receive a license to operate. These monofills are equipped with liners and leachate collection systems.

The Commonwealth's goal is to prioritize combustion over landfilling as a disposal option for nonrecycled waste. If 46 percent of the state's waste is being recycled by the year 2000, the state hopes to burn 50 percent and landfill the remaining 4 percent. In 1994, 34 percent of Massachusetts' MSW was disposed of by combustion.⁷

What is the future role of this technology?

Over the past decade the public has expressed increased concern over air emissions and the disposal of toxic ash residues. While major air pollutants and particulates have been significantly reduced by scrubbers and other air pollution control devices, heavy metals, acid gases, and organic compounds such as dioxins and dibenzofurans are still emitted into the air.

Combustion ash contains heavy metal particulates such as cadmium and lead, which are trapped by the air pollution equipment when trash is burned. The better the air pollution control equipment, the greater the concentration of metals in the ash. Operational handling requirements are becoming increasingly vigorous to protect workers and to ensure that ash is not released into the environment during its transfer from burn facilities to ash monofills.

Industry is presently researching potential uses for the ash residue, including its addition to concrete products for embankments, road-paving materials, pre-cast blocks, and other construction projects, as well as use as a landfill cover. Before state regulators certify such uses, however, these products must undergo further testing.⁸

Recycling competes with combustion because the higher-BTU components of the waste stream are paper and plastic. Most types of paper and many plastics are recyclable. Recycling is considered the most desirable end use of a product, so it should be the first management technique considered. Many communities in Massachusetts have signed long-term put-or-pay contracts with incinerators to provide a guaranteed minimum tonnage of trash at designated intervals. If the communities fail to send this minimum tonnage, they are fined. This discourages communities from reducing their waste stream through recycling and source reduction. In 1994, the state made a commitment to help communities change these contracts.

Landfills

What is a landfill?

A landfill is a site that is excavated and constructed for the disposal of solid wastes. Older landfills were located on pieces of land that were considered unsuitable for development, such as wetlands and gravel pits. These early landfills had no environmental controls to prevent the movement of the waste into the environment. The soil was thought to act as a natural—and adequate—filter.

After garbage is dumped into a landfill, it is spread into thin layers, compacted to the smallest volume, and covered with at least 6 inches of soil. A daily cover of soil prevents blowing litter and helps to maintain sanitary conditions.

Solid waste placed in a landfill undergoes some changes, but not as many as were once thought to occur. Most household waste is “entombed” in plastic bags, then placed in a landfill where virtually all light and oxygen are eliminated once the daily cover of soil is applied. Recent landfill excavations by archeologist William Rathje have turned up newspapers, food scraps, and other items showing little evidence of decomposition, having been neatly preserved for decades.⁹

Landfills are not inert, however. Some of the processes taking place inside the landfill are:

Anaerobic (in the absence of oxygen) decay of organic material, which produces landfill gases, primarily methane.

Movement of moisture from the surface of the landfill through to the bottom. This liquid, called *leachate*, picks up decaying and toxic components of landfilled waste as it moves downward through the landfill.

Escape of gases from the refuse, and lateral movement of the gases through the soil.¹⁰

Chemical oxidation of materials.

These changes are determined by the composition of waste, the amount of water, air, and sunlight entering the landfill, and the degree of compaction of the trash.

The engineering goal of modern sanitary landfills is to prevent leachate from contaminating the groundwater and to prevent the movement of methane gas into the surrounding communities. This is accomplished by installing impermeable barriers to isolate the disposed waste, and leachate and methane collection systems to transport the leachate and methane to a treatment area. The impermeable liners may be constructed of a nonporous clay material, plastic, or a combination of these materials. Collection pipes lie on top of this barrier layer within a drainage layer to remove leachate. Landfill construction costs, including clay, plastic liner material, drainage material, and labor range from \$250,000 to \$400,000 per acre.

What are some of the negative environmental impacts of landfills?

Groundwater Contamination

The principal environmental concern raised by landfills is the contamination of groundwater. Groundwater is found beneath most land surfaces and accumulates after precipitation percolates down from the surface. Geologists call this percolating process *groundwater recharge*, and the places where it occurs *recharge areas*. Once groundwater reaches a saturated or impervious layer underground, it begins to move slowly by the force of gravity through interconnecting surfaces until it reaches a discharge area, where it seeps or flows out into a wetland, spring, river, or pond to become part of the surface water.¹¹ Because these areas are valuable elements of our environment, it is imperative that our groundwater not become contaminated.

Leachate is a combination of liquid generated from the decomposition of solid waste, and precipitation that has fallen on the landfill. A large amount of leachate can be created by precipitation that filters through landfills. For example, a 5-acre landfill with an average infiltration rate of 21 inches of precipitation per year could generate over 2.75 million gallons of leachate annually.¹² If substances such as paint products, household cleaning supplies, pesticides, batteries, or motor oil are present in a landfill, their harmful ingredients may be dissolved or suspended in the leachate. Contaminated leachate can vary in make-up depending on the garbage content of any particular landfill.

The rate at which leachate travels along the surface, contaminating tributary ponds and streams, or percolates downward toward groundwater depends on the grade of the land and soil composition. On Cape Cod, for example, the typical hydrogeologic conditions consist of permeable soils and high water tables. These conditions virtually guarantee that wastes deposited on the land will end up in the groundwater.¹³

Biological and chemical reactions in a landfill influence the composition of leachate. Mounds of refuse offer dark, warm environments attractive to bacteria. When organic compounds are broken down by bacteria, many of the simpler compounds that are formed are acidic. When these substances dissolve in water that seeps through a landfill, they make the water acidic. This increases the water's ability to slowly oxidize heavy metals such as iron, copper, and mercury, adding concentrations of metals to the leachate.

If substances such as pesticides, cleaning products, or paints are discarded in landfills, the degree of contamination of leachate can increase. Products such as these contain synthetic organic solvents that can pollute the environment and threaten human health. Examples of organic solvents include toluene, acetone, benzene, vinyl chloride, and carbon tetrachloride.

As a landfill ages, leachate production and composition change. In general, most components of leachate become more dilute over time. Organic decomposition products are at their highest concentration during the first 3 to 5 years of leachate production, and decrease thereafter. Synthetic and petroleum-based organic solvents tend not to break down in landfills, but continue to be released for long periods of time. Similarly, the concentration of metals in leachate does not seem to decrease over time. Levels of metals and nondegrading organic solvents may need to be monitored even long after a landfill has been capped and closed.¹⁴

Methane Generation

Gas forms in landfills as a result of the decomposition of organic material. Landfill gas contains methane gas, which is flammable and explosive and can have undesirable environmental impacts. Landfill gas can move through refuse and surrounding soils to migrate away from the landfill. It has accumulated in buildings by entering through cracks, construction joints, sub-surface utility service openings, and almost any other weak spot in basement walls or building floors. Homes and businesses have been evacuated when explosive levels of methane were detected. Controlling landfill gas is a high priority when managing landfills because of the danger of explosion and fire.¹⁵

If there is concern about landfill gas migrating off the landfill site, probes are installed into the ground to monitor gas pressure, migration patterns, and methane concentrations. If engineering controls are necessary, systems such as passive vents or gas pumping systems are employed.

Passive systems rely on natural pressure and convection mechanisms to vent the landfill gas to the atmosphere. A gravel-filled trench excavated around the outside of the landfill intercepts gas that is moving through the soil and vents it through the gravel to the surface.

Active gas collection systems remove landfill gas from the landfill or surrounding soils by pumping it out of the ground. These systems may provide migration control or recover methane for energy recovery purposes. Landfills that employ active gas collection systems are usually quite large in size or generate large quantities of methane. The Fresh Kills Landfill in New York, the largest landfill in the world, also has the largest methane recovery system in the world.

What happens to inactive and abandoned landfills?

The majority of currently active unlined landfills in Massachusetts will close before the year 2000 either because they have reached their capacity to receive waste or because of environmental concerns. An amendment to the Massachusetts Solid Waste Act of 1993 replaces the strict closure deadlines for landfills with a public process meant to determine if the landfill poses an immediate threat to the environment or public health. Each existing landfill was assigned an estimated closure date based on site capacity and permitted tonnage or on operating permit expiration. In October 1993, owners of unlined landfills were asked by DEP to submit a notification of their intent to operate beyond December 1993. As part of this notification, the owners conveyed the date on which their facility would cease operation. Closure dates were then established by assigning either the date indicated by the owner, or a date based on the facility's classification as a threat to the environment and public health, whichever came first. Those facilities classified as a significant threat are assumed not to be operating beyond 1995. Those classified as potential, little or no threat, or insufficient data to classify are assumed to close before the milestone year of 2000, with the "potential threat" facilities closing first.

Once a landfill is filled to capacity, the entire area used for solid waste disposal must be closed or "capped" with an impervious layer of material. This minimizes the amount of precipitation seeping into the landfill and, therefore, reduces leachate production. As an integral part of constructing the cap, vents are inserted into the landfill to allow gas from interior regions of the landfill to escape. Groundwater wells are drilled around the site to monitor the production rate and toxicity of the leachate. Similar to construction costs for a state-of-the-art landfill, proper closure is an expensive procedure, ranging from \$125,000 to \$140,000 an acre.

The post-closure phase of landfill management extends for at least 15 years. Post-closure monitoring insures that the integrity of the landfill's final cover, liner(s), and groundwater or gas monitoring systems are maintained. Once landfill settling and environmental dangers have been addressed, the former landfill site might be reclaimed as a recreational area, such as a park or ball field.

What is the future of landfilling in the Commonwealth?

The Commonwealth has set a goal of diminishing the use of landfills from 42 percent in 1990 to 4 percent by the year 2000.¹⁶ Instead of being a primary solid waste disposal source, landfills will provide capacity for materials that cannot be reused, recycled, composted or burned.

ENDNOTES

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1. U.S. EPA, *Characterization: 1994 Update*.
 2. *Ibid.*
 3. U.S. EPA, *Yard Waste Composting*, p. 1.
 4. U.S. EPA, *Characterization: 1994 Update*.
 5. Massachusetts DEP, *Master Plan: 1995 Update*.
 6. U.S. EPA, *Let's Reduce and Recycle*, p. 57.
 7. Massachusetts DEP, *Master Plan: 1989*, p. 99.
 8. O'Leary and Tansel, "Land Disposal," pp. 17-18.
 9. Rathje, *Rubbish!*.
 10. Massachusetts Audubon Society, "An Introduction to Groundwater and Aquifers," pp. 1-2.
 11. Massachusetts Audubon Society, "Landfills and Groundwater Protection," p. 3.
 12. *Ibid.*
 13. *Ibid.*, p. 5.
 14. O'Leary and Tansel, "Landfill Gas Movement," p. 22.
 15. Massachusetts DEP, *Master Plan: 1994 Update*, p. ii.