The School Diversion and Environmental Education Law

School DEEL Resource Manual

November 2005

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Table of Contents

Acknowledgments

State Board of Education

California Department of Education

State Secretary for Education

Project Director

Tricia Broddrick (September 2001–March 2004)
Office of Education and the Environment
California Integrated Waste Management Board

Joanne Vorhies (April 2004–present)
Office of Education and the Environment
California Integrated Waste Management Board

Writing Team

Lori Mann, Lead Author
Consultant

Jennifer Rigby
Director
The Acorn Group

Gerald A. Lieberman, Ph.D.
Director
State Education and Environment Roundtable

Michelle Kirk
WestEd

Laura Powell
Consultant

Scientific and Technical Advisors

Bill Andrews*
Office of Environmental Education
California Department of Education

Rick Beall
HMS, Inc.

Theresa Bober
Office of Education and the Environment
California Integrated Waste Management Board

Tricia Broddrick*
Office of Education and the Environment
California Integrated Waste Management Board

* Reflects affiliation at the time these materials were originally prepared and published.

Catherine Cardozo
Diversion, Planning, and Local Assistance Division
California Integrated Waste Management Board

Simon Eching
Office of Water Use Efficiency
Department of Water Resources

Bruce Fujimoto, P.E.
Division of Water Quality
Senior Water Resources Control Board

Suzanne Garfield-Jones
California Energy Commission

Marshalle Graham
Diversion, Planning, and Local Assistance Division
California Integrated Waste Management Board

Terri Gray
Diversion, Planning, and Local Assistance Division
California Integrated Waste Management Board

Jeff Hohensee
TreePeople

Claudie Kiti*
State Consumer Services Agency

Pauline Lawrence
Office of Education and the Environment
California Integrated Waste Management Board

Tom Mays
Office of Public Affairs
State Water Resources Control Board

Rich Mills
Division of Financial Assistance
State Water Resources Control Board

Cara Morgan
Diversion, Planning, and Local Assistance Division
California Integrated Waste Management Board

Claudia Orlando
Energy Office
California Energy Commission

Tavia Pagan
Office of Education and the Environment
California Integrated Waste Management Board

* Reflects affiliation at the time these materials were originally prepared.

Dana Papke
Green Building Program
California Integrated Waste Management Board

Don Peri*
Office of Education and the Environment
California Integrated Waste Management Board

Thomas Phillips
Research Division
Air Resources Board

Martin Rigby, Ph.D.*
Consultant on Water Resources

Art Sussman, PhD.
WestEd

Valorie Shatynski
Office of Education and the Environment
California Integrated Waste Management Board

Patrick Schiavo
Diversion, Planning, and Local Assistance Division
California Integrated Waste Management Board

Rachelle Steen
Office of Education and the Environment
California Integrated Waste Management Board

Dave Todd
Office of Water Use Efficiency
Department of Water Resources

Carolyn Tucker
Office of Water Education
Department of Water Resources

Rebecca Williams*
Office of Education and the Environment
California Integrated Waste Management Board

Ed Wong
Office of the Ombudsman
Air Resources Board

* Reflects affiliation at the time these materials were originally prepared and published.

Introduction

Project Background

The School Diversion and Environmental Education Law (School DEEL) was signed into law in September 2001 (SB373, Torlakson, Chapter 926, Statutes of 2001). The law created a series of integrated waste management and education mandates for the California Integrated Waste Management Board (CIWMB). The legislation is intended to increase the presence of resource management programs, such as waste reduction, recycling, and composting on school district campuses statewide.

The School DEEL calls for developing, implementing, and adopting a plan for elementary and secondary schools in the state that includes the following elements:

- Coordinate instructional resources and strategies for providing active pupil participation with on-site conservation efforts.
- Promote service-learning opportunities between schools and local communities.
- Assess the impact to participating pupils on student achievement and resource conservation.
- Create models and school waste reduction tools for schools, school districts, county offices, and local agencies.
- Establish an Environmental Ambassador Pilot Program and a unified education strategy (UES).
- Provide grants to school districts to implement programs teaching source reduction, recycling, and composting.
- Identify and promote use of recycled-content materials and environmentally preferable products in the construction and modernization of public school facilities.
- Evaluate the effects of school waste reduction plans and other resource conservation efforts in the state's schools.

The School DEEL specifies that "Every school district and school site in this state will be encouraged to implement source reduction, recycling, and composting programs that ... (A) Reduce waste and conserve resources. (B) Provide pupils with a 'hands-on' learning experience." (Public Resources Code section 42630) The legislation calls for the development of "service-learning partnerships, in which schools and communities work to provide real world experiences to pupils in areas of the environment and resource conservation, including education projects developed and implemented by pupils to encourage others to utilize integrated waste management concepts." (Education Code section 51226.4)

Overview of the Resource Manual

This Resource Manual contains supplementary materials originally designed to assist Environmental Ambassador and UES schools in planning and implementing the service-learning component of the School DEEL program. Now that the School DEEL program has concluded, this document can provide other interested schools with the information necessary to design and implement comparable service-learning programs on their own campuses.

The manual is divided into three topical chapters: integrated waste management, energy and air resources, and water resources. “Integrated Waste Management” and “Water Resources” contain all four sections below, whereas “Energy and Air Resources” contains sections 1–3 only.

Section 1: Presents extensive background information for teachers that summarizes broad issues related to waste, energy, and water. Wherever possible, emphasis was placed on data specifically relevant to California.

Section 2: Includes primers that go into more depth on single subjects related to waste management, water, and energy. Many of these primers describe information or skills related to potential service-learning projects. Sample primer topics include building a compost bin (waste), pollution caused by diesel school buses (energy), and the history of the California Water Project (water).

Section 3: Provides an annotated listing of related educational resources, including publications and websites for teachers and literature appropriate for sixth-grade students. These materials were selected for their potential to assist teachers and students with audit-based service-learning projects on campus; they have been carefully reviewed and are included because of their particular applicability to the School DEEL and similar programs.

Section 4: Glossary of terms.

The fourth chapter contains a list of general educational resources. Some reflect environmental assessments on campus that could not be categorized specifically under waste, energy, or water. This chapter also provides teachers with background information to help them plan and implement service-learning projects, including environmental ones. Finally, it includes a list of environmentally focused websites designed for students that range from interactive games and virtual tours to links to federal agencies.

Integrated Waste Management

Integrated Waste Management: Section 1—Background Information

California's Waste Issues

In 1990, Californians generated approximately 50.9 million tons of waste—or about 1 ton per second—and disposed of approximately 42.4 million tons of waste. Now, California diverts more than 47 percent of its waste, resulting in disposal of approximately 35 million tons per year.[1] With a current population of more than 36,800,000,[2] that means we still throw away the equivalent of nearly one ton per person each year. Managing all that trash in such a way that is considered safe for both the people and the environment of our state is a challenge.

There are many issues associated with the generation and management of waste. Some of these issues relate to the initial extracting, processing, and use of natural resources. Other issues relate to the processing, transportation, and storage of waste. Environmental problems such as ecosystem disruption, loss of biodiversity, and land, water, and air pollution can be ameliorated by recovering resources from waste and processing them for reuse, and by reducing consumption. These efforts can also reduce human health and safety issues.

Ecosystem Disruption, Pollution and Resource Shortages

People depend on natural resources and use them as raw materials to manufacture and create the myriad of products we use daily. Trees, for instance, are used to produce paper, furniture, and fuel. Petroleum is pumped, refined, and used as a lubricant and to power everything from cars to ships. Gold, manganese and copper are mined, refined, and used as components of jewelry, dental work, steel, cast iron, and electrical wiring and equipment.

The natural systems that provide these resources to humans are equally vital to the plants and animals that live there. Removing resources for human use can degrade natural systems by damaging wildlife habitats, reducing biological diversity, and creating land, water, and air pollution. In turn, the degradation of natural systems can have detrimental effects on human health and communities.

As the human population increases, the demand for resources increases, compounding the environmental issues that are an inevitable part of extracting and processing raw materials. Extraction also requires a great deal of energy, further depleting available resources.

Resource recovery is the process of extracting materials such as paper, glass, and metals from municipal solid waste and processing them for reuse. These processes generally conserve both energy and resources that would otherwise be overloading landfills and, in turn, consuming even more of the landscape.

More and more companies are developing technologies that use recovered materials in manufacturing. This cycle of extraction, reprocessing, and manufacturing from recycled materials plays an important role in decreasing the effects of resource consumption on natural systems and human communities.

Landfill Siting

Most of California's waste is currently deposited into its 166 operating sanitary landfills.[3] Sanitary landfills are disposal sites where compacted trash is dumped, then covered with a layer of soil to prevent odors, litter, and pests. Newspapers, books, magazines, plastic containers, packaging, food scraps, yard trimmings, appliances, and other wastes from residential,

commercial, and some industrial sources can be disposed of in municipal solid waste landfills. Some hazardous materials are also accepted, though most communities have special regulations governing disposal of such materials.

Sanitary landfills replaced open dumps in the 1970s and 1980s. Open dumps were uncovered and unlined sites that allowed liquids from the decomposing waste to soak into the soil and contaminate the groundwater. Rodents, insects, and other pest species were attracted to the odors emitted by these dumps, creating further health hazards. Additionally, the combination of materials in these open dumps often created fire hazards.

Now, most landfills are designed, operated, and monitored according to strict federal and state regulations. State-of-the-art landfills that minimize ground- and surface-water contamination and air pollution can provide a safe and convenient way to dispose of municipal solid waste. Regulations require that landfills be located away from sensitive environments such as streams, rivers, or earthquake-prone areas, yet be as close to the source of waste as possible to minimize transportation costs.

Existing landfills are quickly filling up. Increasingly, strict federal and state regulations coupled with the growth and development of human communities make siting new landfills extremely expensive and difficult. As current landfills close, city managers must send their waste farther and farther away, increasing costs and energy use.

Materials deposited in landfills decompose slowly. The lack of sunlight and air in the compacted and soil-covered facilities minimizes the decomposition rate. Scientists have dug up 40-year old newspapers that are still readable and food that has barely decayed. So, things thrown in landfills take up space for many, many years, limiting the opportunities to continue using old landfills.

Leachate

Leachate is water that has percolated down through the waste, picking up chemicals and organic matter as it goes. Such leachate can cause significant contamination of surrounding ground and groundwater, especially in older landfills. Hazardous materials in landfills, such as paint products, used motor oil, cleaning chemicals, and batteries, can make the leachate even more dangerous. Modern landfill facilities are lined with clay and protective plastic to prevent leakage into the ground and groundwater. In addition, a network of drains collects leachate, which is sent to leachate recovery facilities for treatment.

Toxic Gases

Methane, carbon dioxide, ammonia, and sulfur gases are all produced in landfills as microorganisms break down wastes. If trapped beneath the landfill surface, these toxic gases pose health and safety threats. Methane, for example, can cause explosions and underground fires. Moving laterally beneath the surface of the landfill, methane can also expose adjoining land and homes to explosive gases and polluted air. Modern landfills have gas control systems to reduce pressure buildup and prevent these problems. In addition, facility owners now must monitor and collect explosive gases and regularly test nearby groundwater.

Hazardous Wastes

Hazardous wastes are those that are:

- Toxic—harmful or fatal when ingested or absorbed.
- Ignitable—create fire under certain conditions or spontaneously combusts.

- Corrosive—contain acids or bases that can corrode metal.
- Reactive—unstable under "normal" conditions and can cause explosions, toxic fumes, or vapors when mixed with water.

The United States Environmental Protection Agency (U.S. EPA) regulates the generation, management, transportation, and disposal of hazardous waste generated by businesses, institutions, or other facilities, sometimes including schools. The Federal Resource Conservation and Recovery Act covers all aspects of hazardous waste from "cradle to grave"—from the time the waste is generated at a factory or plant to the time it is discarded.

The U.S. EPA does not govern household hazardous wastes, or disposal of household products that contain hazardous ingredients. In California, it is illegal to throw household hazardous waste in the trash, down storm drains, or onto the ground. Management of these wastes varies from place to place; call Earth's 911, California's "environmental hotline," at 1-800-CLEAN-UP for automated information about procedures in your community.

Hazardous materials pose risks beyond possible contamination of surrounding land and groundwater surrounding landfills. Refuse and landfill workers are subject to health risks when unknowingly handling hazardous waste or exposed to chemical splashes and toxic fumes resulting from chemical mixtures and concentrated materials. Similarly, disposing of hazardous wastes in drains can destroy the bacteria needed to break down wastes in sewers and septic systems.

Incinerator Ash

Many communities use municipal incinerators to reduce the volume of waste being added to landfills. Burning refuse can reduce its volume by 70 to 90 percent.[4]

Prior to the late 1970s and the passage of the federal Clean Air Act, incinerators did not burn garbage completely and allowed pollutants to escape into the atmosphere. Today's incinerators burn waste at high temperatures (1,500-1,800 degrees Fahrenheit) and are far more efficient than their older counterparts.

Incineration produces two types of ash that must be disposed of. The majority is bottom ash or non-burnable materials such as glass and metal that remain in the combustion chamber after burning. The second type is fly ash, which is the residue from the air pollution equipment on the incinerator smokestacks. The ash is tested quarterly to determine whether it is hazardous because both types can contain toxic materials. In some cases, the ash can be treated with a cement mixture to minimize the release of potentially dangerous metals. It is then disposed of in landfills or used as a road base at the landfill. Hazardous ash must be disposed of in double-lined landfills according to special regulations.

Federal and state laws regulate the release of air emissions for nitrogen oxides, sulfur dioxide, carbon monoxide, particulate matter, total hydrocarbons, acid gases, and certain toxic metals. In California, emissions from incinerators are carefully monitored to ensure that they do not exceed standards set by the local air district, the California Air Resources Board, or the U.S. EPA. Pollution controls in state-of-the-art incinerators include temperature controls to guarantee complete combustion of materials, scrubbers to neutralize acid gases, and a filtering system to remove particulates from the exhaust. These measures remove most—but not all—emission pollutants.

The heat generated by waste incineration is captured in some plants to produce energy. These waste-to-energy facilities turn hot water to steam, which is then used to generate electricity that

can be sold to a public utility. The sale of electricity helps to offset the high cost of waste-to-energy facilities.

California has three waste-to-energy facilities, located in the cities of Commerce and Long Beach, and Stanislaus County. All were built in the late 1980s. Despite their effectiveness at reducing the volume of waste that needs to be landfilled, there is much public debate about the safety of incinerator emissions and disposal of ash. Those in favor of incineration say the release of toxic materials is well within levels determined to be safe and, as a secondary benefit, may reduce the amount of toxic leachates released from landfills. Opponents claim that emission testing is insufficient and that the ash contains high concentrations of toxic metals.

As with landfills, finding sites for incinerators is difficult. Most people do not want to bear the high costs or live near an incinerator facility with its associated truck traffic, noise, and litter. Siting decisions require extensive permitting processes, public hearings, and public input.

Integrated Waste Management

Integrated waste management combines a number of practices to handle municipal solid waste safely and effectively. U.S. EPA recommends the following hierarchy of management approaches:[5]

- **Source Reduction:** Source reduction is the design, manufacture, purchase, or use of materials (such as products and packaging) to reduce the amount or toxicity of waste generated. Source reduction can help reduce waste disposal and handling costs because it avoids the costs of recycling, municipal composting, landfilling, and combustion. It also conserves resources and reduces pollution.

- **Recycling and Composting:** Recycling is the process by which materials are collected and used as raw materials for new products. There are four steps in recycling: collecting the recyclable components of municipal solid waste; separating materials by type (before or after collection); processing them into usable forms; and purchasing and using the goods made with reprocessed materials. Recycling reduces the quantity of potentially useful materials placed in landfills or incinerated. Recycling can save energy and material resources and diminish the effects of extracting those resources from natural systems. Composting is a form of recycling that can divert organic wastes from disposal facilities.

- **Combustion and Landfilling:** Waste combustion and landfilling play a key role in managing waste that cannot be otherwise reduced, reused, or recycled. Combustion in specially designed facilities reduces the bulk of waste and, in some cases, can provide the added benefit of energy recovery. Disposing of materials in landfills will be a major component of waste management for the foreseeable future. The quantity of waste requiring incineration or land disposal can be changed by modifying practices related to the use natural resources and the production of manufactured goods.

Source Reduction and Reuse

Practicing source reduction requires changes in behaviors by those who produce goods and by those who consume. Some of the aims of source reduction include:[6]

- To produce and use fewer unnecessary or excessively packaged items.

- To lengthen the life span of products.

- To make products more reusable and recyclable.

- To use more recycled materials in the manufacturing of products.
- To make and use nontoxic alternatives to toxic products.

Changing packaging practices is one important method of source reduction. Packaging primarily serves to effectively contain and protect a product. Many manufacturers use attention-getting packaging to compete for consumer dollars, often resulting in more packaging than is necessary for a product's protection. Convenience also plays a role; one-serving, disposable items require more packaging than their bulk counterparts.

Manufacturers can also reduce the source of waste by using recycled materials in production. This may mean using recycled products to make new products, such as tables, benches, and carpets made from recycled plastic rather than wood. It may also mean finding ways to reuse material scraps that would otherwise be wasted.

With more than 6 million school children in California, great potential for source reduction in schools exists. One of the most preventable forms of waste on campus is paper waste. Printing handouts on both sides, taking notes and submitting homework on used paper, maximizing the use of the chalkboard and overheads, using scratch paper for telephone messages, and circulating copies of announcements to faculty are among the many ways of conserving paper.

There are many options for preventing waste. Food services operations offer numerous opportunities for source reduction. Reusable trays and utensils are among the items that can be used many times rather than thrown away after one use. Appliances and electronic equipment with good warranties adds to durability and extends a product's life span, as does repairing rather than replacing such items. Keeping proper air pressure in tires on school buses reduces tire wear and purchasing costs.

Sources for additional ideas are listed in the resources section of this manual.

Recycling

Many people recycle items like newspaper, mixed paper, glass, and aluminum. Recycling involves collecting items that otherwise would be considered waste and end up in a landfill or incinerator. Collection is a vital part of the recycling process, but the other steps in the process are equally important. The overall success of recycling depends on a three-part loop.

1. Collection—First, materials must be collected and sorted. Curbside collection programs are common in many communities; drop-off centers, buy-back centers, and deposit/refund programs are other collection methods. Communities often pick up recyclables from schools, businesses, and homes.

   Collected recyclables are then taken to materials recovery facilities where they are sorted, separated from non-recyclable materials, cleaned, and delivered to facilities that recover raw materials for use in the next step of the recycling process.

2. Manufacturing—The second step in the recycling loop is manufacturing. An increasing number of products are being made with recycled content. Aluminum is one of the most successful recycling stories; recycled cans are made into new cans in as little as 90 days after they are collected.[7] Recycled cardboard and newspaper are used to manufacture new boxes, paper, egg cartons, diapers, tissues, paper towels, and other paper goods. All steel products made in the United States contain some recycled steel. Recycled glass can be used in production of new glass containers and fiberglass, as well as in asphalt or road fill.

Two kinds of recycled plastic are regularly recycled. Polyethylene terephthalate (PETE) plastics, often found in soft drink and juice containers, can be used to make new carpets, insulating material for jackets and sleeping bags, bottles and containers, and auto parts. High density polyethylene (HDPE) plastics, found in milk, water, detergent, and motor oil containers, can be remanufactured into a number of products including plastic lumber, toys, trash bags, and trash cans. Not all communities recycle all kinds of plastics; a coding system indicates the type of plastic from which a product is made and how it can be recycled.

3. Purchasing—The final step in the recycling loop is purchasing products made from materials that were used once and then recycled into something else. It is this step that determines the degree of success of any recycling program. If there is no market for the final product, there is no incentive for manufacturers to use recycled material. People must buy recycled products in order for the entire recycling process to succeed.

Also known as "closing the loop," buying recycled is essentially a consumer decision. As individual and business consumers demand more products with recycled content, manufacturers are encouraged to promote this aspect of their business and develop new products. Postconsumer recycled content is the key to maximum effectiveness. Postconsumer refers to materials recovered or diverted from the waste stream after initial consumer use. (Recycled content can also refer to excess material generated during manufacturing processes; these materials were not used first by a consumer or collected through a recycling program.)

Composting

Over 30 percent of California's solid waste stream consists of organic materials including yard or landscape materials (leaves, grass clippings, and prunings); wood scraps, branches, and stumps; food scraps; and agricultural crop waste.[8] In California schools, food wastes often compete with paper in contributing most to the overall waste stream.

Many organic wastes can be recycled through a process called composting. Composting produces a soil-like material with a variety of beneficial organisms that can used as a soil amendment, mulch, or even to decontaminate natural habitats, stormwater, and abandoned industrial or commercial lands called brownfields. There are three types of composting: home or backyard; vermicomposting; and heat-based composting.

Home composting is the breakdown of materials by naturally occurring microscopic organisms. Vermicomposting uses the digestive process of earthworms to degrade organic materials. Heat-based composting uses high temperatures in municipal or commercial facilities to increase the rate of degradation.

Whichever process is used, the compost will contain both carbon and nitrogen sources—browns (leaves, straw, woody materials) and greens (grass and food scraps), respectively. With proper treatment, bacteria, fungi, and various invertebrates decompose the organic materials and convert them from waste into a useful product. Composting requires a proper mix of organic material, water, and oxygen. Not all organic materials are good for a composting system; meat scraps, fats, and oils should be avoided because they do not compost well and can attract pests.

Vermicomposting works on the same principles as other forms of compost, but depends specifically on worms to transform food waste into the finished nutrient-rich compost. Worms eat over half their body weight in organic matter each day. Their castings are rich in nutrients and can be used like other compost to enrich soil. Vermicomposting requires only an appropriate bin, bedding, worms, and food waste. Care involves maintaining proper temperature and moisture levels, but done correctly, this process is odor-free and relatively simple.

Integrated Waste Management: Section 2—Primers

Primer #1: The History of Waste Management[*]

Early Waste Management

The first known law prohibiting the dumping of garbage in the streets of a major city was issued in approximately 500 B.C. in Athens, Greece. The leaders of that advanced civilization also created the first municipal disposal sites when they required scavengers to dump their trash not less than a mile from Athens. Unfortunately, the Greeks' advanced practices in waste removal were not adopted in medieval Europe. In fact the people of Paris were throwing their wastes out of windows until sometime in the fourteenth century. Several hundred years later, as large numbers of people from rural areas sought jobs in factories in newly industrialized cities, some of the earlier waste disposal practices were renewed. As a result of the careless disposal of waste, the problems created by the garbage multiplied, and city governments were forced to take appropriate actions. Thus, the collection and disposal of garbage became a municipal responsibility.

As the cities began transporting their garbage to the countryside, scattered piles of refuse became common sights on the outskirts of such towns. The cities expanded and, thus, the open surrounding lands became smaller, the problems created at the dumps became intolerable, especially the terrible odors and the infestation of rats. It was at this point that pits were dug to restrict the dumping to certain areas. However, as the populations in Europe increased, the pits not only were taking up too much space but also were creating other problems, including the contamination of groundwater. A new solution to the disposal of garbage had to be found.

One of the first alternatives to the garbage pits was the incinerator, and the first one was tested in Nottingham, England, in 1874. Depending on what is being burned, incineration reduces the volume of waste by 70 to 90 percent, so those with responsibility for getting rid of garbage in the late 1800s heralded the new development. Those municipalities that could afford the outlay of funds soon built incinerators to handle their waste products, but the less affluent cities could not afford to adopt the new approach. In a short period of time, new problems came with the use of incinerators, namely a deterioration of air quality. Thus, many of the cities that had built incinerators to take care of their garbage abandoned the approach. The burial of waste continued to be the most widely used method to waste disposal in the early 1900s.

Although the states in the United States could intervene if there were risks to public health and safety, the primary responsibility for problems created by the improper disposal of solid waste rested with the federal government in the first half of the twentieth century. Some of the principal actions taken at the federal level to avert threats to human health were the Rivers and Harbors Act of 1899, which forbade the dumping of wastes on the banks of or within navigable waterways; a 1933 Supreme Court ruling that made it illegal to dump municipal waste in the ocean; and the 1948 Water Pollution Control Act, which promoted research into the causes and solutions of

[*] (1) This primer was reprinted, with minor modifications, from *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*, California Integrated Waste Management Board, Sacramento, California, 2000, Appendix B, p. B-1–B-8. (2) The material cited in part 1 of this footnote was originally adapted from *Closing the Loop: Integrated Waste Management Activities for School and Home*, K–12. California Integrated Management Board, Sacramento, Calif., 1993, p. D-21.

water pollution and directed the first enforcement procedures for reducing the pollution of interstate waters.

The principal concerns regarding waste disposal in California during the first half of the twentieth century were ones related to public health and public nuisance. In many areas around the state, the open burning of garbage was practiced during this period, and wastes of all types were being dumped into the rivers. In 1949 the legislators in Sacramento created the State Water Pollution Control Board, which was the predecessor to the State Water Resources Control Board. The focus of the Board at this time was on the pollution of the state's waterways caused by industrial and municipal sources; however, violations were usually handled administratively, because water problems associated with landfills were not yet considered significant.

Waste Management in the 1950s and 1960s

New products and new types of packaging in the 1950s resulted in an astonishing increase in the amount of waste generated in the United States during this period. Mixed materials in packaging, which makes recycling particularly difficult, became very common. An increase in the volume of packaging at this time led to the abandonment of open trash collection trucks, which had facilitated the recycling of garbage, and a shift to garbage compaction trucks. However, the increased volume of waste was so great that the shift to compaction trucks could not accommodate the new levels of waste that were being generated. Therefore, the cities began opening garbage transfer stations, where the garbage from compaction trucks was re-compacted for shipment to landfills. Along with the evolution in packaging came increased costs for handling waste, which resulted in an increased cost for dumping that also reduced the opportunities for recycling anything useful from the compacted trash.

In 1967 the California Department of Public Health, using funds from the federal Solid Waste Disposal Act of 1965, conducted a study of solid waste disposal methods in the state. Results of this study revealed significant environmental and public health and safety problems resulting from landfilling, including safety hazards, air and water pollution, vectors, and unsightly operations. At this time approximately 75 percent of all disposal sites were open-burning dumps. In addition, very little regulation of these facilities was taking place.

Waste Management in the 1970s and 1980s

As a result of the study initiated by the California Department of Public Health, Senate Bill (SB) 5 was passed in 1972 by the California Legislature (Nejedly-Z'berg-Dills, Chapter 342, Statutes of 1972). This legislation created the Solid Waste Management Board (SWMB). The SWMB was mandated to develop a State policy, including minimum standards for disposal facilities and for resource recovery. In addition counties, in cooperation with cities, were required to develop comprehensive solid waste management plans that were to be reviewed and approved by the SWMB. SB 1797, passed in 1974, required that before a new solid waste management facility could be established, it had to be found in conformance with the local County Solid Waste Management Plan (Nejedly, Chapter 541, Statutes of 1974).

In response to increasing concerns about solid waste disposal, the federal government passed the Resource Conservation and Recovery Act of 1976 (RCRA). Subtitle D of this act imposed requirements and restrictions on disposal of solid wastes. The first criterion was to perform an open dump inventory to ensure that facilities met federal standards. Second, those facilities that did not meet the standards were put on a list, and operators were to bring the facilities up to certain standards within five years. The inventory for the state of California was conducted by the SWMB. From 1979 to 1983 the SWMB staff inspected approximately 90 to 95 percent of the existing landfills and the majority of the closed facilities.

A 1984 amendment to the federal RCRA required states to develop programs for bringing the existing landfills into compliance with existing federal criteria within 36 months, and in compliance with new, revised criteria within 18 months after adoption by the U.S. Environmental Protection Agency (EPA). In addition new studies were commissioned to evaluate the adequacy of existing groundwater contamination standards and to study problems associated with emissions of dioxins at waste-to-energy facilities.

In California the design and operation of solid waste facilities were being improved in various ways, including the elimination of open dumps and the remediation of unsafe and unsanitary operating conditions. More comprehensive standards for facilities were developed, and assistance was provided to local government for planning and siting of new facilities. Approximately 450 landfills, 240 transfer stations, 3 composting facilities, and 5 waste-to-energy facilities were issued facilities permits by the local agencies.

In 1986 the California Beverage Container Recycling and Litter Reduction Act (Assembly Bill [AB] 2020, Margolin, Chapter 1290, Statutes of 1986) was passed to encourage recycling of aluminum, glass, plastic, and bimetal beverage containers.

In 1987, the Solid Waste Disposal and Site Hazard Reduction Act (AB 2448, Eastin, Chapter 1319, Statutes of 1987) created a fee-based account to support closed, illegal, and abandoned site cleanup. It required development of disposal site closure and long-term maintenance plans with financial assurances for their implementation.

The California Integrated Waste Management Act[9]

In 1989 legislation was passed that marked a dramatic shift in solid waste management principles and practices in California. The California Integrated Waste Management Act (AB 939, Sher, Chapter 1095, Statutes of 1989 [IWMA]) was the foundation of this new approach. This legislation renamed the SWMB so that it became the California Integrated Waste Management Board (CIWMB). It also established a new waste management hierarchy, starting with source reduction as the first priority (now referred to as “waste prevention”); recycling and composting as the second priority; and environmentally safe landfilling and transformation as the last options.

The Integrated Waste Management Act required that cities and counties divert 25 percent of all waste from landfills and transformation facilities by the year 1995, and 50 percent by the year 2000. Cities and counties are also required to reduce their solid waste, not just manage it.

The focus of this legislation was to shift away from reliance on landfill disposal of waste and turn toward a policy of preventing waste generation in the first place, reusing products and reducing packaging as much as possible, then recycling and composting whenever possible. This approach preserves natural resources and saves energy; it also reduces the generation of air and water pollution both in manufacturing and disposal practices.

Waste Management-Related Legislation

Since the passage of the IWMA, additional legislation was passed that broadens the scope of California’s integrated waste management programs and responsibilities. Some highlights of the legislation include the following:

Passed in 1989
AB 4 (Eastin, Chapter 1094, Statutes of 1989). Required increased procurement of recycled products by State and local agencies.

AB 1305 (Killea, Chapter 1093, Statutes of 1989). Established a phased-in mandate for recycled content for commercial consumers of newsprint, culminating in 50 percent postconsumer recycled content by the year 2000.

AB 1308 (Killea, Chapter 1091, Statutes of 1989). Provided bank and corporation tax credit of 40 percent for the cost of equipment used to manufacture finished recycled products.

AB 1843 (W. Brown, Chapter 974, Statutes of 1991). Established a major regulatory program to control the disposal of used tires.

Passed in 1991
AB 1381 (Areias, Chapter 843, Statutes of 1991). Required the CIWMB to develop and implement a waste prevention and recycling program for school districts.

SB 235 (Hart, Chapter 769, Statutes of 1991). Provided specific regulations for the manufacture and sale of rigid plastic containers. By January 1, 1995, all plastic containers were to meet one of the following criteria: be either source reduced by 10 percent, contain 25 percent postconsumer resin, be reusable or refillable, or meet specified recycling rates.

AB 2076 (Sher, Chapter 817, Statutes of 1991). Authorized the development of a used-oil recycling program within the CIWMB to promote and develop alternatives to the illegal disposal of used oil. This bill also included grants, public information, and certified collection centers.

Passed in 1993
AB 1220 (Eastin, Chapter 656, Statutes of 1993). Increased funding levels for cleanup of abandoned and illegal solid waste disposal sites, increased funding for market development and public education, provided funds for household hazardous waste, and consolidated “tipping fees” for waste disposal.

Passed in 1995
AB 1851 (Sher, Chapter 821, Statutes of 1995). Required specific levels of recycled plastic postconsumer material in the manufacture of plastic bags for sale in California.

Passed in 1997
SB 1330 (Lockyer, Chapter 875, Statutes of 1997). Required the CIWMB to create a program of grants to cities and counties to cover the costs of cleaning up solid waste that had been disposed of illegally on farm or ranch property.

Passed in 1998
AB 117 (Escutia, Chapter 1020, Statutes of 1998). Extended the fees for the California Tire Recycling Act to fund the continued cleanup of tire disposal sites because of the danger they pose to public health and safety and to the environment.

AB 228 (Migden, Chapter 1019, Statutes of 1998). Among other provisions, added abandonment of tires to the circumstances under which a person could be convicted of a crime.

Passed in 2000
SB 876 (Escutia, Chapter 838, Statutes of 2000). Raised and extended the tire fee to $1.00 per tire until December 31, 2006, thereafter reducing to $0.75. The retail seller pays the fee for each new tire purchased from a tire wholesaler. The bill also creates a tire hauler manifest system, strengthens enforcement, and provides for increased tire site cleanup.

Waste Management Timeline

The following timeline summarizes the history of waste management, noting specific events through the years:

300 million years ago: Wasps were making paper.

2.5 million years ago: First tools were made by man.

8000 B.C.: The old Stone Age ended, animals were domesticated.

Between 8000 and 7000 B.C.: Ground and polished stone axes were made.

Around 4000 B.C.: Meteoric iron was probably used.

4000 B.C.: Written history began.

Around/After 4000 B.C.: Copper was first smelted.

Between 4000 and 3000 B.C.: Bronze was first smelted; Bronze Age began.

3000 B.C.: Meteoric iron was used in Egyptian pyramids.

Between 2000 and 1000 B.C.: Iron was first smelted, Iron Age began, and glass blowing began in the Near East.

Around 1000 B.C.: Iron became abundant in Europe and the Near East.

500 B.C.: Athens, Greece, issued first known edict against throwing garbage into the streets; ordered waste to be dumped no less than one mile beyond city limits.

105 A.D.: Paper was first made in China.

1035: Paper-wrapped vegetables appeared in Europe.

1388: English Parliament banned the dumping of garbage in public waterways.

1400: Garbage accumulated outside Paris' gates and interfered with the city's defenses.

1620: First iron foundry was built in America.

1690: First paper was produced commercially in Philadelphia.

1739: First successful American glass foundry was operating in Salem, New Jersey.

1790: Paper was first made completely from wood in Vermont.

1801: Fourdrinier machine that produced continuous roll of paper was patented.

1810: First tin-plated iron can was patented as a food container in England.

1818: Tin-plated can was introduced in America.

1825: Aluminum was first isolated from ore.

1842: Research in England linked unsanitary conditions to disease.

1844: Vulcanization process was discovered by Charles Goodyear in the production of rubber tires.

1849: Pendulum press was patented, making possible production increases from 5 to 6 cans per hour to 50 to 60 cans.

1859: First important discovery of oil was made by Edwin Drake (lighting fluid).

1860: Citizens of Washington, D.C., continued to dump waste in city streets.

1869: Lithography label printing process for cans was developed.

1874: First systematic incineration of municipal refuse was tested in Nottingham, England, using "The Destructor."

1880-1890: Automatic can-making machinery was created.

1885: U.S. built its first garbage incinerator on Governor's Island in New York.

1886: Waste reduction plants, which compress organic waste to extract grease, oil, and other by-products, were piloted in the U.S.; the plants later closed because of noxious emissions. Charles Martin Hall isolated aluminum through electrolysis.

1888: First commercial production of primary aluminum occurred.

1898: First trash-sorting operation for recycling was introduced by the street commissioner in New York City.

1899: Rivers and Harbors Act made the disposal of debris on the banks of and into navigable waterways illegal.

1902: A Massachusetts Institute of Technology report revealed that 79 percent of U.S. cities provided regular collection of garbage.

1904: First aluminum recycling business was founded.

1908: Oil was discovered in the Middle East.

1913: Aluminum foil was first produced.

1914: Approximately 300 incinerators were operated in the U.S. and Canada.

1915: Activated-sludge sewage treatment process was developed.

1916: The U.S. produced 15,000 tons of paper a day, using 5,000 tons of used paper and resulting in a 33 percent recycling rate. First landfills were established.

1920: Reclaiming wetlands near cities with layers of trash and dirt became a popular disposal method.

1931: Neoprene rubber and fiberglass were invented.

1933: U.S. Supreme Court outlawed ocean dumping of municipal waste.

1938: Fluorescent lamps were marketed; polystyrene was invented.

1939: Dichlorodiphenyltrichloroethane (DDT) was found to be an insecticide.

1940: Nylon stockings were widely sold. Nontoxic pigments replaced lead in interior paints.

1941: Aerosol spray cans were introduced with chlorofluorocarbons (CFCs).

1942: Americans collected rubber, paper, scrap metal, and tin cans to help the war effort.

1943: Polyethylene plastic was invented.

1944: Silicone resins were marketed.

1947: Instant photos were introduced.

1948: The Federal Water Pollution Control Act authorized limited enforcement in interstate waters and established principles for a state-federal cooperative program.

1949: The State Water Pollution Control Act created the State Water Pollution Control Board and protected California waters from pollution by industrial and municipal wastes.

1953: Vermont passed the first container law in the nation; Detroit's first all-fiberglass car body and first U.S.-made polyester were developed.

1956: The Federal Water Pollution Control Act required states to establish ambient standards for water quality and to develop a program for enforcing them.

1957: Vermont's first container law was allowed to expire; first U.S. commercial nuclear power plant opened; aluminum was first used in metal can manufacturing.

1959: The American Society for Civil Engineers established a guide for sanitary landfilling, requiring the refuse to be compacted and covered with a layer of soil daily.

1960: The Organization of Petroleum Export Countries (OPEC) was formed; easy-opening cans were introduced.

1963: The Federal Clean Air Act provided federal government enforcement authority to control interstate air pollution.

1964: Consumers switched to biodegradable detergents.

1965: The Federal Air Quality Act provided air quality criteria and guidance on the best methods for preventing or controlling air quality problems; the Federal Solid Waste Disposal Act provided substantial grants to local governments for studying solid waste problems and prescribing solutions; tin-free steel cans were developed.

1967: The California Department of Public Health studied the condition of solid waste in California, utilizing federal Solid Waste Disposal Act monies; the California Mulford-Carrell Air Resources Act created the California Air Resources Board.

1968: More than one third of U.S. cities were practicing some form of materials separation for recycling.

1969: The National Environmental Policy Act required all federal agencies to take environmental factors into account when making policy.

1970: The First Earth Day was held (April 22); U.S. Environmental Protection Agency (EPA) was established; amendments to the Clean Air Act required states to prepare implementation plans for controlling air pollution; the California Porter-Cologne Water Quality Control Act established water quality control plans and waste discharge permits; legislation was passed in California to eliminate open burning; the California Environmental Quality Act required preparation of an Environmental Impact Report on any facility significantly affecting the environment; this was the peak year of U.S. oil production; the Federal Clean Air Act was created.

1972: Federal Water Pollution Control Act required U.S. EPA to establish national effluent standards for all point sources of water pollution.

1973: Senate Bill (SB) 5 was passed, creating the California Solid Waste Management Board; DDT is banned in the U.S.

1974: Oil embargo/Egyptian-Israeli War—U.S. experienced first oil price shock; the federal Clean Water Act was created.

1976: The Federal Resource Conservation and Recovery Act, Subtitle D, required U.S. EPA to set criteria for sanitary landfills.

1978: CFCs were banned as aerosol propellants.

1979: U.S. EPA closes its waste reduction branch and concentrated its efforts on managing hazardous waste; second oil price shock occurred; every state had some form of disposal regulation, but regulations varied greatly in content.

1986: The California Beverage Container Recycling and Litter Reduction Act was passed; Rhode Island enacted the nation's first mandatory recycling law.

1988: U.S. EPA estimated that at least 14,000 landfills had closed in the last 10 years; more than 70 percent of the facilities were operating at the time.

1989: Assembly Bill (AB) 939 established the Integrated Waste Management Act (IWMA), revolutionizing California's approach to waste management; 26 states had enacted some form of comprehensive mandatory recycling law; the first polystyrene recycling plants were opened.

1990: Manufacturers in the U.S. were required to stop using CFCs, which deplete the Earth's ozone layer. As part of Resources Recovery Act, Subtitle D, U.S. EPA released new regulations for sanitary landfills.

1991: The California Oil Recycling Enhancement Act of 1991 established State-certified oil collection centers.

1994: Californians recycled an estimated 202,000 tons of steel cans.

1995: California met the 25 percent diversion goal, as mandated by the IWMA.

1997: California adopted a Resource Efficiency Program to help businesses do more with less.

1998: Californians threw away an average of two pounds of trash per person per day—a great improvement over the three pounds per day estimated in 1990.

2000: California cities and counties required to meet the 50 percent diversion goal, as mandated by the IWMA.

Primer #2: What Are Plastics?[*10]

"Plastic" is a term generally used to describe any of numerous materials that can be molded, cast, drawn, extruded, or laminated into many types and shapes of parts, products, housings, containers, coatings, tubing, films, or fibers. Plastics are widely used because they are durable, lightweight, waterproof, chemically resistant, convenient for the consumer, and inexpensive to produce and transport. Their chemical structures are malleable to achieve just the right combination of properties for most applications. Some plastics are also recyclable.

The very first plastics were made from cornstarch, but most plastics today are made from nonrenewable resources, natural gas and crude oil. They are made by linking together in repetition relatively small molecules, called monomers, to build one large molecule, called a polymer. Polymers can be thought of as big buildings, and monomers as the bricks that go into them. These synthetic polymers vary in composition, depending on the type of polymer. The most common ones are made from hydrogen and carbon elements, with some also containing oxygen, nitrogen, and other organic and inorganic matter. Synthetic polymers fall into two basic categories: thermoplastics and thermosets.

Thermoplastics. Like wax, thermoplastic polymers liquefy at high temperatures and solidify when cool. This property makes it easy to melt the plastic and reform it several times into new objects. Thermoplastics are used in packaging, such as for milk, soda, and juice containers, bags for frozen foods, and bottles for detergents. They are also used in durable goods, such as electronic equipment, automobile components, and white goods. Polyethylene, polystyrene, polyvinyl chloride, polyethylene terephthalate, and polypropylene are types of thermoplastics.

Thermosets. Like concrete, once thermoset polymers are formed, they cannot change shape. Formed by combining different polymer molecules, thermosets cannot be melted and reformed into new shapes and are difficult to recycle. Thermoset resins are widely used in producing tires and in making plywood, fiberglass, furniture, toys, tableware, and other permanent uses requiring a hard plastic. Some types of polyesters, epoxies, certain rubbers, and melamine are all thermoset polymers.

In What Ways Are Synthetic Polymers a Problem?

The widespread use of synthetic polymers is a problem for two main reasons: plastics are made from a nonrenewable resource, and they cause special problems in the waste stream. Although some plastics are relatively inexpensive to manufacture, the crude oil and natural gas from which they are made come from limited supplies. As the extraction of these oil supplies becomes increasingly complicated, negative environmental and political consequences also increase; for example, oil spills and U.S. dependence on foreign oil become greater issues. In the process of extraction, other natural resources, like water and salt, are used and may be harmful to the environment.

The percentage of synthetic polymers, especially thermoplastics, in the waste stream is increasing in both real and in relative terms. Specifically, the amount of disposable plastic products manufactured is increasing each year, thus increasing the amount of plastic disposed of in real terms. In addition, materials (like paper, glass, and organics) are diverted from the waste stream in greater amounts, so that the relative amount of plastic in the waste stream is also increasing.[11]

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[*] This primer was reprinted, with minor modifications, from *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*, California Integrated Waste Management Board, Sacramento, California, 2000, Appendix C, p. C-10–C-13.

Plastics cause several special problems in the waste stream. The same characteristics that make plastic an attractive packaging material make it difficult to deal with as a waste. Though lightweight, plastic is bulky and difficult and expensive to compact for shipping to reprocessors or for burial in landfills. Another problem with the disposal of plastic is that it does not biodegrade and can persist in the environment as a litter problem. Although photodegradable plastic may break down into smaller pieces when exposed to enough sunlight, it never disintegrates completely.

Plastic litter causes particular problems in our oceans and on our beaches. Thousands of fish, sea mammals, and birds have died because they have eaten or gotten tangled in discarded fishnets, six-pack rings, plastic bags, and other packaging material. Virtually all beaches and waterways are now polluted with plastic waste. In 1997 the California coastal cleanup effort collected over 1 million pieces of debris, 63 percent of which was plastic.[12]

Foam packaging also creates problems. If expanded with chlorofluorocarbon (CFC), both the manufacturing of the foam and the packaging itself release into the atmosphere certain CFCs, which deplete the Earth's ozone layer. While manufacturers in the United States were required to stop using CFCs in 1990, CFCs are still used in other parts of the world. Rigid foam products account for one-quarter of the world's use of the two most ozone-threatening CFCs.

Plastics also cause problems in incineration. While they are made from fossil fuels and have a high energy (Btu) value, some plastics emit toxic fumes when burned. Burning polyvinyl chloride, for instance, can release chlorine compounds into the atmosphere, contributing to the depletion of the ozone layer. Other plastic ingredients can clog the inner workings of incinerators.

How Are Thermoplastic Polymers Recycled?

For recycling, thermoplastics are first sorted by resin type and color. They are baled or shredded for transportation to a reprocessing plant where the material is washed, dried, and extruded into pellets.[13] The pellets are then used as a raw material in the manufacturing of products containing recycled content.

The polyethylene terephthalate (PETE) used in soda bottles is shredded and processed to make fibers, which can be woven back into threads to make clothing or used to stuff sleeping bags, quilts, and parkas. The high density polyethylene (HDPE) used in plastic milk jugs, juice jugs, bleach bottles, and detergent bottles is commonly recycled into construction materials, such as railroad ties, parking blocks, and piping, or back into detergent and soap bottles.

Because plastic materials used for containers may absorb some chemical substances—like motor oil—from the contents of the container, recycled plastics are used very seldom for food containers.[14] They are sometimes used as a filler layer in food packaging as long as they do not come into direct contact with food.

The quality of recycled plastic depends on how well the scrap is separated prior to recycling. The less control there is over separation and contamination, the poorer the quality of the resulting product. The success of recycling plastics depends in part on the proper identification and separation of plastics. There are hundreds of different kinds of plastics, more than 46 of which are in common use. Just by looking at the plastic container, a person may be unable to distinguish the chemical recipes.

Why Are Plastics Difficult to Recycle and What's Being Done to Encourage Recycling?

The cost of collecting, transporting, sorting, processing, and washing postconsumer plastics makes recycling difficult, because it often puts recycled resin at a cost disadvantage to virgin resins. The very low prices of virgin resins, caused by their oversupply, make the economical situation of plastic recycling businesses critical.[15]

The Society of Plastics Industry (SPI) developed a coding system (see next page) that helps to identify and separate by sight the most commonly used thermoplastics, and thus facilitate recycling. A small number of companies have developed automated identification and sorting technologies, thus decreasing the cost of recycling plastics.[16] Research is also being done on melding unsorted plastics into a composite material, primarily for use as building material.

In California some types of plastics are being recycled in significant amounts. Because of the California Beverage Container Recycling and Litter Reduction Act, for example, the percent of PETE soda bottles that was recycled increased from 4 percent in 1988 to 71 percent in 1994.[17] However, the overall recycling of plastics is still very small; only about 3.5 percent of waste plastic in California is recycled or diverted from the waste stream.[18]

The California Integrated Waste Management Board has implemented several programs to develop markets for postconsumer resin. For example, one law specifies that trash bags intended for sale in California contain at least 10 percent recycled postconsumer plastic material, or the manufacturer must ensure that at least 30 percent by weight of all the manufacturer's plastic products intended for sale in this state be recycled postconsumer plastic. The Rigid Plastic Packaging Container Act requires that specific plastic containers be source-reduced by 10 percent, contain 25 percent postconsumer resin, reusable or refillable, or meet specified recycling rates.[19]

These efforts, along with advances in sorting and processing technologies, offer the potential to increase the amount of plastic recycled in California and in the United States.

Different Types of Plastics and Their Resin Identification Codes[20]

1-PETE

Polyethylene Terephthalate: Used for soft drink bottles, salad dressing bottles, cooking oil bottles, mouthwash bottles, peanut butter jars, and clear food tray containers.

2-HDPE

High Density Polyethylene: Used in milk, juice, and water bottles; bleach and detergent bottles; shampoo bottles; and margarine tubs.

3-PVC VINYL

Polyvinyl Chloride: Used in bottles for window cleaner, some cooking oil, and detergent powder.

4-LDPE

Low Density Polyethylene: Used in food packaging bags, shrink wrap, carryout bags, dry cleaner bags, and grocery bags.

5-PP

Polypropylene: Used in butter and margarine tubs, yogurt containers, screw-on lids, and drinking straws.

6-PS

Polystyrene: Used in cutlery and plates, foam coffee cups, egg cartons, meat trays, clear food container trays, and yogurt cups. May be clear, hard, or in foam form.

7-OTHER

Other plastics: includes containers made of more than one resin type, squeezable syrup and condiment bottles, and some microwave food trays.

Primer #3: Constructing Wire Mesh Composting Bins[*]

Wire mesh composting bins are versatile, inexpensive, and easy to construct. They may be used as holding units for slow composting or as turning units for hot composting. Each of the illustrated circular and panel designs has unique advantages. The circle bin (see Diagram 1) can be made for under $10 from hardware cloth or wire mesh. Although chicken wire can also be used, it quickly loses its shape with use and requires support posts. Hardware cloth creates a self-supporting circle, which is easier to manipulate, and more durable.

A panel unit offers a greater variety of uses than other types of units do. Panels can be added to enlarge the bin, and individual panels can be used for screening coarse materials from finished compost. A sturdy and attractive panel bin (see Diagram 2) can be made with 16-gauge plastic coated wire mesh for under $20.

The wood and wire bin provides a convenient way to compost moderate volumes of yard waste. This bin fits well in small spaces and may be used either as a holding unit for low COM posting or as a turning unit for hot composting. The bin can be easily moved to turn piles or to harvest finished compost: simply undo the latches, pull the sides apart, and move. Turn the compost at the bin's new location, and remove the finished compost from the bottom of the bin. The wood and wire bin (see Diagram 3) costs around $50 to build using new materials; less, if recycled materials are used.

1. Circular Bin

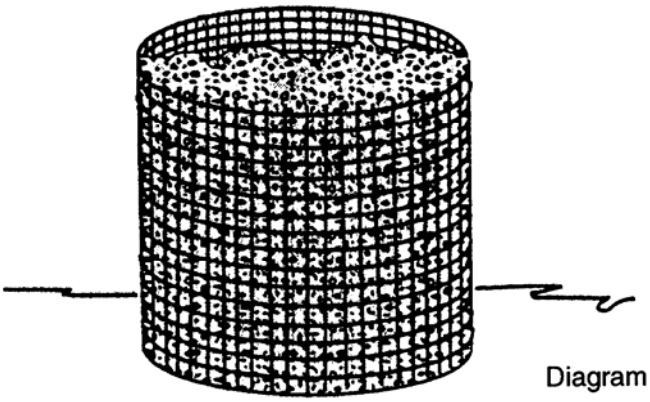

Diagram 1

Materials for the Circular Bin (3½ foot diameter)

___ 12½ feet of 36-inch-wide hardware cloth, or 18-gauge plastic coated wire mesh

___ Four metal plastic clips or plastic-coated copper wire ties

Tools

___ Heavy-duty wire or tin snips

___ Pliers

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[*] This primer was reprinted from *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*, California Integrated Waste Management Board, Sacramento, California, 2000, Appendix D, pp. D-1–D-2.

___ Hammer or metal file

___ Work gloves

Construction Details for Circular Bin

Roll out and cut 12½ feet of hardware cloth or plastic-coated wire mesh.

If using hardware cloth, trim or file each wire along the cut edge to ensure safer handling when opening and closing the bin. Bend hardware cloth into a circle and attach ends with clips or ties. Set the bin in place for composting. Plastic coated wire mesh bins are made in the same manner, except that bending this heavier material into a circular shape will require extra effort. Also, filing the wire ends may cause the plastic coating to tear. Striking the end of each wire with a hammer a few times will knock down jagged edges.

2. Five-Panel Bin

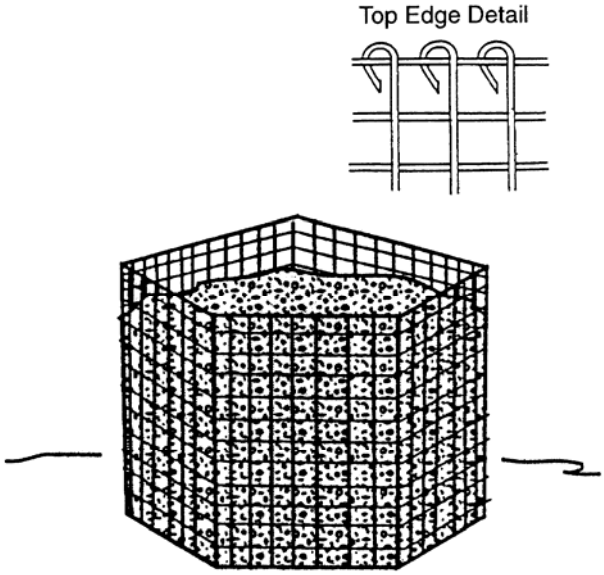


Diagram 2

Materials for the Five-Panel Bin

___ 15 feet of 24-inch-wide 12–16-gauge plastic-coated wire mesh

___ 20 metal or plastic clips or plastic-coated copper wire ties

Tools

___ Heavy-duty wire or tin snips

___ Pliers

___ Hammer or metal file

___ Work gloves

Construction Details for a Five-Panel Bin

Cut five 3-foot-long sections of wire mesh (24 inches wide). Make cuts at the top of the next row of squares to leave one-inch-long wires sticking out along one cut edge of each panel. This will

be the top edge of the bin. Use a pair of pliers to bend over and tightly clamp each wire on this edge. This provides protection against scraping arms when adding yard wastes to the bin. Attach panels using slips or wire ties.

3. Wood and Wire Bin

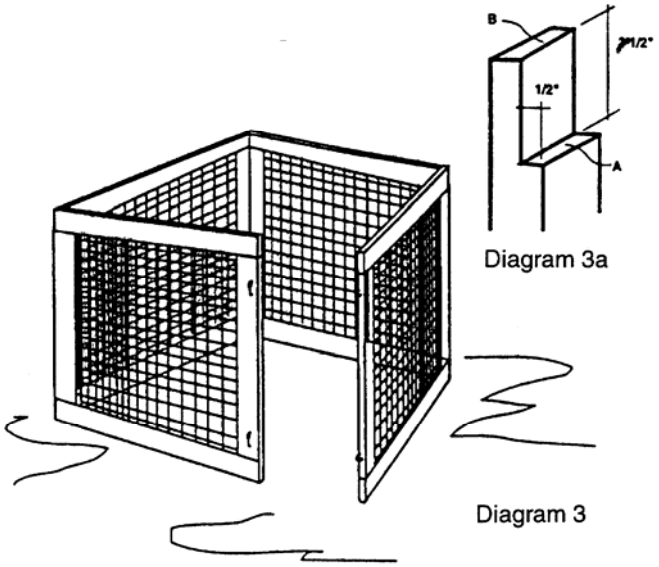


Diagram 3a

Diagram 3

Materials for the Wood and Wire Bin

___ Four 12-foot 2- by 4-inch pieces of fir

___ 12 feet of 36-inch-wide 1/2-inch hardware cloth

___ 100 1 1/2-inch galvanized No. 8 wood screws

___ Four 3-inch galvanized butt door hinges

___ 150 chicken wire staples or power stapler

___ One 10-ounce tube exterior wood adhesive

___ Six large hook and eye gate latches

Tools

___ Hand saw and chisel, or radial arm saw with dado blade, or circular saw, or table saw

___ Hammer

___ Screwdriver

___ Tin snips

___ Caulking gun

___ Pencil

___ Small carpenter's square

___ Eye and ear protection

Construction Details for the Wood and Wire Bin

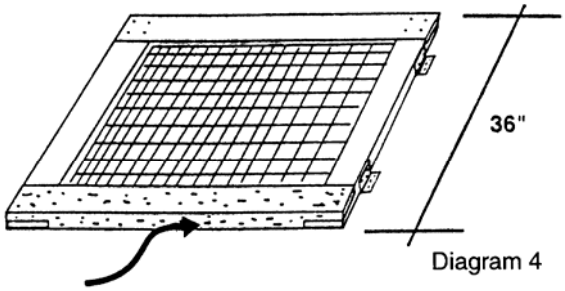
Cut each 12-foot two-by-four into four 3-foot-long pieces. Cut a 3/4-inch deep and 3 1/2-inch-wide section out of each end, for a total of 32 lap cuts. If using a hand saw and chisel, cut 3/4 inch down at the 3 1/2-inch line, at A in diagram 3a. Then cut a 1/2-inch deep groove into the end of the board at B in diagram 3a.

Place a thick wood chisel in the end groove and split the wood with a hammer to the 3 1/2-inch cut. If using a radial saw, circular saw, or table saw, set blade depth to 3/4-inch and make multiple passes until the whole section is removed.

Make four 3-foot square frames from the lap jointed two-by-fours. Put enough construction adhesive to fill the gaps when the lap joints are screwed together. Fasten each joint with four screws.

Cut the hardware cloth with tin snips into four 3-foot square sections. Bend the edges of the cloth back over 1 inch for strength. Lay one onto each of the four frames. Center and tack each corner with a poultry wire staple. Hammer place a staple every 4 inches along all four edges of the hardware cloth. Try to tension the cloth so it will not sag when filled with compost.

Connect each pair of frames together with two hinges. Then put the hook and eye gate latches on other ends so that they latch together.



Example of Wood and Wire Bin Panel

Note: It is not recommended to use pressure-treated wood for the composting bin. The treated lumber will contaminate the compost and possibly kill the microorganisms.

Primer #4: Maintaining a Vermicomposting System[*21]

Why Vermicompost?

What do worms, food waste, and landfills have in common? They are all part of the reason that people vermicompost.

Vermicomposting is the practice of using worms to transform food waste into a nutrient-rich finished product called vermicompost. Worms are efficient food waste digesting machines that eat over half their body weight in organic matter per day. The castings that they create are rich in nutrients, completely natural, and free!

Most people are becoming aware that putting garbage in a landfill is an option that is less and less desirable. While most people think about paper, plastic, and yard trimmings when they think about garbage, food waste can be a significant percentage of the total waste stream. In fact, for schools and institutions that recycle their paper, food waste is commonly the single largest element remaining in the waste stream.

In a school setting, a vermicomposting system can set the stage for teaching children about a number of different topics. While the biological and environmental lessons associated with vermicomposting are quite evident, teachers have used their worms to teach about a broad range of topics in an integrated curriculum.

The Basics of Vermicomposting

In short, vermicomposting involves setting up some type of container (hereafter called a bin): filling it with moist bedding materials; introducing worms and feeding them on a regular basis; monitoring the conditions in the bin; and adding food, water, and more bedding as the conditions warrant. It sounds so simple and it basically is. However, worms are living creatures and attention does need to be paid to ensure that their living environment meets their needs.

The Worm Bin

Worm bins can vary in size and type of material. Bin sizes can range from small shoe-box-sized bins to large 4- by 8- by 2-foot worm "estates." Obviously, the larger the bin, the more worms it will house and the more food waste they will consume. While several schools vermicompost in a large wood bin nearly all of the food waste they generate, the most common type of bin is a converted plastic storage box approximately 12 gallons in capacity used in the classroom.

The main attributes of a good bin are (1) it keeps the light out; (2) has a snug-fitting lid (for classroom bins); (3) provides ventilation and drainage; and (4) is big enough to handle the desired amount of food waste. The 12-gallon-sized bins can be started with 1,000 worms (about 1 pound) which, once acclimated, will process approximately 1/2 to 1 pound of waste a day.

Where to Put the Bin

Worms should ideally be kept in an environment that is 55 to 77 degrees Fahrenheit. Because of this, indoor locations are usually preferable for classroom or home bins. The larger wood bins can be kept outside, because the wood bin is thicker and has a larger mass of the vermiform-post that insulates the worms and protects them from relatively extreme temperatures. In most areas of

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[*] This primer, with the exception of "A Word about Worms," was reprinted from *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*, California Integrated Waste Management Board, Sacramento, California, 2000, Appendix D, pp. D-3–D-8.

California, a shady location will probably be best. In areas with very extreme climates, extra insulation (usually a hard foam core) may be needed to keep the worms active in outdoor bins. (Note: Worms will live at temperatures both above and below the 55 and 77 degree Fahrenheit range. In general, the larger the bin, the greater the ambient temperature flexibility in which the worms can survive.)

Worm Bedding

Once the bin is made, bedding needs to be added. The bedding provides a moist home for the worms, helps ensure a proper carbon-nitrogen balance, and minimizes the food waste odors. The bedding should be at least 6 inches deep after moistening. Along with the bedding, the food waste will be consumed and become vermicompost.

Shredded paper is the most common form of bedding, because it is readily available to most vermicomposters. While newspaper is usually used at homes, the white paper found in schools, offices, and institutions also makes a good bedding material. Glossy advertisements and magazines should be avoided because of the contents of the ink and inability to soak up water. The paper is turned into bedding by simply tearing the paper in long 1-inch-wide strips. If it is difficult to tear, try tearing in the other direction along the "grain of the paper," and it should be easier. Other common bedding materials include composted manure (not too fresh or hot), shredded corrugated cardboard, and straw.

As a general rule, fill the bin with dry bedding material and then dampen it to a point where it is thoroughly wet but not dripping wet. The worms can be harmed if the bedding is too dry or too wet. "As damp as a wrung-out sponge" is commonly used to describe the proper moisture level of the bedding and a three to one ratio (by weight) of water to bedding is a recommended guideline. A pint of water weighs approximately a pound. As water is added, continue to fluff the bedding materials to avoid compacted bedding and to ensure that all of the bedding is damp throughout the bin.

Obtaining Worms

A plastic box with moistened shredded newspaper in it will not be an effective vermicomposting system without worms! Once you obtain a nice supply of worms, place the worms on the bedding material and watch them burrow. Within ten minutes, they should all have disappeared into the bedding.

"Red wigglers" are the species of worm commonly used for vermicomposting. Also known as redworms or manure worms, red wigglers thrive in high-nutrient environments and like to live close to the surface. Worms are commonly sold in one-half pound increments and start at about $15 a pound. Several of the technical support resources listed in the "School DEEL and Environmental Service-Learning: Case Studies and Technical Support" Manual include worm suppliers. Many of these suppliers will ship worms via the mail. Bait shops often sell redworms but offer them in much smaller lots for a higher price. Remember that one pound of worms will consume one-half to one pound of food waste and bedding a day.

A Word about Worms:*

Red wigglers are not native to North America. While they are extremely effective at reducing waste and creating rich garden compost, they could also be extremely effective at denuding the natural duff layer of forests. Therefore, they should not be released into the wild.

When you harvest vermicompost, please make sure no worms are included.

*From Acorn Naturalists

Rather than buying worms, you may want to ask a friend who has a worm bin to share some of his or her worms, or look for them in piles of composted manure. (If the manure is fresh, smelly,

and messy, do not look in it for worms; you want the aged, less-smelly manure, which is more likely to have the red wigglers.)

Barring a worm tragedy, you should not have to buy more worms once you get your bin started. In fact, a properly balanced bin will produce enough worms to share with others. Extra worms can be used to start a second bin, shared with a friend, or sold. Releasing extra worms into the garden is not good for the worms, because it is not their normal habitat and is detrimental to the worms. However, the worms are a wonderful addition to a compost pile.

The worms commonly found in the garden are NOT the types of worms that go in a worm bin. Nightcrawlers and other garden worms like to burrow deep into the soil and do not like to be disturbed. They are not appropriate for a worm bin and will probably die. Do not try to use these worms for composting unless you are doing a comparative educational study or a designed experiment.

Feeding the Worms

Worms should not have to live on bedding alone; fruits, vegetables, coffee grounds, and grains are all welcome edibles. Try not to feed the worms any meat, dairy, or oily foods, because these items are foul smelling when they beak down. Some foods decompose slower than others do. It is best to chop up the large food items so they can break down quickly in the worm bin. Microorganisms such as bacteria and fungi aid worms, which do not have teeth, by breaking down pieces of food. Care should be taken to not overload the bin with acidic items, such as too many orange peels.

Placing the Food

Food waste should be placed under the bedding material or dug into the worm castings and not left on top of the bedding. This will minimize the food's potential for producing odors and attracting fruit flies. Add additional bedding when necessary, especially when the vermicompost is too moist. Rotate the burial of the food waste throughout the bin. Make a chart to help keep track of where the worms were fed last. Another way is to start in one corner of the worm bin with food placement and work around the bin until you return to that corner, and then repeat the pattern.

How Much to Feed?

In general, err toward underfeeding rather than overfeeding. If you get back to your initial placement location and find that not much of the food was eaten, consider reducing the amount of food or stop feeding for a while. A bin in which worms are fed less than they can handle will not be as productive as a bin that receives the perfect amount of food; but a bin that is overfed can smell bad, have lots of excess moisture, and result in massive deaths of worms. Important note: Worms in newly established bins should be fed lightly at first until they acclimate and become comfortable (and hungry) in their new surroundings.

Keeping the notes just cited in mind, you can schedule daily small feedings or less frequent larger feedings. Feeding should probably occur at least biweekly. This decision should be based on convenience and educational goals. It will be necessary to feed the worms during the school's break. It is important that you or a student take the bin home during the vacation.

The best method for determining how much to feed your worms is through observation. Divide the bin into quadrants/burial sites, so students can keep track of where they deposited food. Have the students monitor the amount and type of food. Rotate the burial sites. When they reach the

first burial site and there is quite a bit of food left, put the worms on a diet. Allow the worms time to process the food in the bin before continuing to feed.

Preparing the Food

The smaller the pieces of organic materials, the faster the materials will break down. Cut up large pieces of vegetables and fruits. Shred paper napkins, towels, scrap paper, etc. Some vegetables can take a long time to break down, including carrots, broccoli stems, and grape stems. Your class may choose to feed the worms weekly. Store the food waste in a tightly sealed container, such as a coffee can with a lid, so it will be available when the class is ready to feed the worms.

Other Things to Add to the Bin

Worms have gizzards and need a small amount of gritty material to help grind up the food waste. Finely crushed eggshells, rock dust, or a small handful of soil will help the worms digest their food better. Before adding the soil, check to make certain that the area where the soil came from was not treated with pesticides. Rock dust is from ground up rocks and is available at nurseries or garden stores. The rock dust is rich in minerals and will help balance the pH level in the bin.

Monitoring the Bin

When feeding the worms, it is a good idea to check the overall conditions of the bin. If children do the feeding, you may want to have them record certain bin conditions as a way of both monitoring the bin and teaching them about experimental observation.

Things you may want to add after starting the bin:

- Add additional bedding if there is excess moisture in the bin (add DRY bedding); there are lots of fruit flies in the bin; or the existing material is reduced and you want to continue feeding.
- Add additional water if the bedding looks too dry. This usually occurs in wood bins, because the plastic bins tend to retain moisture.
- Add rock dust to reduce the acidity of the vermicompost, to assist the worms in breaking down their food, and to discourage fruit flies.

Remember to monitor the bin to ensure that overfeeding is not occurring.

Harvesting the Vermicompost

Vermicompost is ready to harvest when there is a large amount of castings compared to the amount of food, paper, and worms in the bin. The finished product is rich, black, and relatively homogeneous.

Stop feeding the worms in all or part of the bin to prepare for harvesting. This enables the worms to finish off the remaining food and paper, creating a finished product. It is common to feed in one-half of the bin and wait for the other half to finish. In time the worms will migrate over to the section still being fed. For multiple bins, set up a schedule by not feeding one bin at a time. This way, the food waste is distributed to the other bin(s), thus facilitating the vermicomposting harvest and keeping the other vermicompost systems in production.

Once the bin contains fairly homogeneous vermicompost, it is time to harvest. It is not recommended that the vermicomposting material be completely uniform, because the more homogeneous the material, the more stressed the worms become. (Note: Some people prefer to remove the last bits of paper and food from the vermicomposted material and place them in a new

bin for additional processing.) Since worms are present in the finished area, a simple worm sorting process should be followed.

Place a tarp or paper on the ground or on a table in a well-lit area. Scoop out some vermicompost and shape it into a cone on the tarp or paper. The worms do not like the light, so they will burrow down into the vermicompost to get away from the light source. Remove the top layer of vermicompost, which will now be relatively worm-free, and place it in a container. Repeat the process until there is a small amount of vermicompost and lots of worms. Place these worms in a different container.

Scoop out more of the finished vermicompost from the bin and repeat the process until all of the finished vermicompost is harvested. Adding moist bedding, worms, and rock dust can restart the empty bin.

Harvesting Larger Bins

With larger bins it may be rather cumbersome to sort through all of the vermicompost for the worms. Therefore, it is recommended that worms in only one portion of the bin be fed; then wait for the worms to migrate over to the fresh food source. It could take a month or more for the migration to happen.

In addition deep bins may have a considerable amount of finished vermicompost underneath the unprocessed food and bedding. If the selective feeding method takes too long, consider removing the top six inches or so of unfinished food waste and bedding, setting this material aside, and harvesting the vermicompost underneath it. Most of the worms are located in the unfinished top section of the bin. Once the harvesting is complete, place the unfinished material back in the bin for further processing.

Using the Vermicompost

The finished material (also know as castings) is now ready to be put in the garden, in house-plants, or in outdoor plant pots. This is an excellent material to start seeds in, because it is complete with the required natural nutrients that a plant needs to grow. The vermicompost and extra worms are also valuable and can be sold as a fundraising project for the students.

Assembling Worm Bins

PLASTIC WORM BIN

Convert a plastic bin into a new home for worms and see your organic food waste transformed into nutrient-rich compost. Plastic bins are easy to assemble and maintain. Plastic bins also retain moisture and may require regular additions of dry bedding. This bin can be used indoors or outdoors and is a convenient size for the classroom.

Cost

A new 12-gallon plastic bin and one pound of worms (1,000 worms) can be purchased for approximately $25. Reduce the costs by asking a friend to donate worms from his or her established worm bin, and/or reuse an old plastic storage bin.

Materials

To create a plastic worm bin, you will need:

___ One non-transparent plastic storage container (21 inches long by 15 inches wide by 12 inches high) with a secure fitting lid

___ Four 2-liter pop bottle caps or wooden blocks (scrap wood blocks will work) for the base of the worm bin

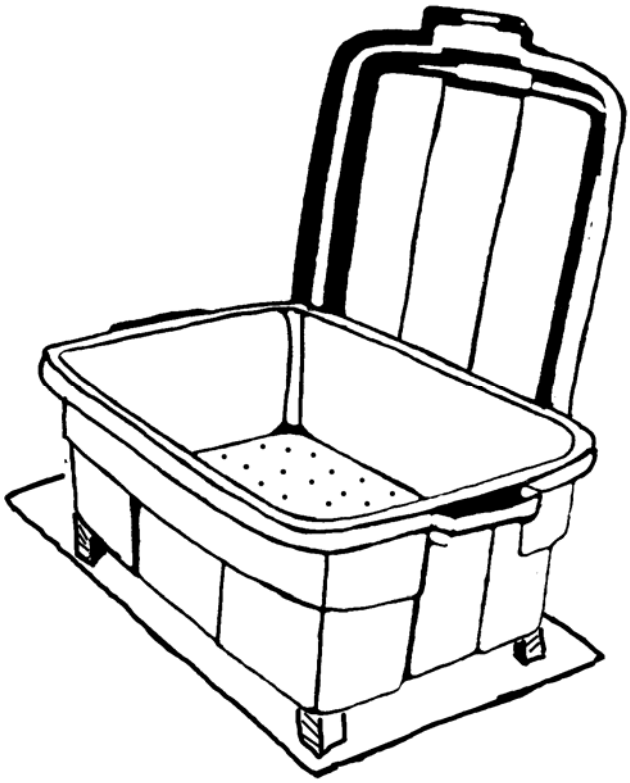
___ Four 5/8-inch screws or white glue to fasten the bottle caps or wooden blocks to the bin

___ Plastic sheet or tray for underneath the bin

Tools

Power drill with 1/4-inch bit

Note: Please be safe! Wear earplugs and eye protection when drilling.



ASSEMBLY OF PLASTIC BIN

Drill holes in the bottom of the plastic bin, approximately three inches apart, for ventilation and drainage. Attach the wooden blocks or plastic soda bottle caps underneath the four corners of the bin with the 5/8-inch screws or glue. This will allow air to circulate and the liquid to drain from the base of the worm bin. To collect any liquid or castings, place a sheet of plastic or a tray underneath the bin. (Hint: An old TV tray works great!)

Conclusion

The worm bin is ready for worms. Please refer to the front of Appendix D, section II, for information on maintaining a successful vermicomposting system.

LARGE WOODEN WORM BIN

Build a wooden worm bin estate! Basic carpentry skills are required to construct this wooden worm bin. If you follow the directions and diagrams, the project should be relatively simple. A wooden worm bin breathes well, so it may occasionally need watering to maintain the proper moisture content.

Cost

This wooden bin can be built for about $30 with new wood and hardware, or for less money if using recycled or scrap materials.

Materials

Lumber

___ One 4- by 8-foot sheet of 1/2-inch exterior grade plywood

___ One 8-foot 1- by 2-inch board

Hardware

___ 36 1-inch galvanized screws

___ Eight 1½-inch galvanized screws

___ Two 3-inch door hinges

___ Approximately 12 ½-inch galvanized screws

Tools

___ Tape measure

___ Saw

___ Two sawhorses

___ Long straight-edge or chalk snap line

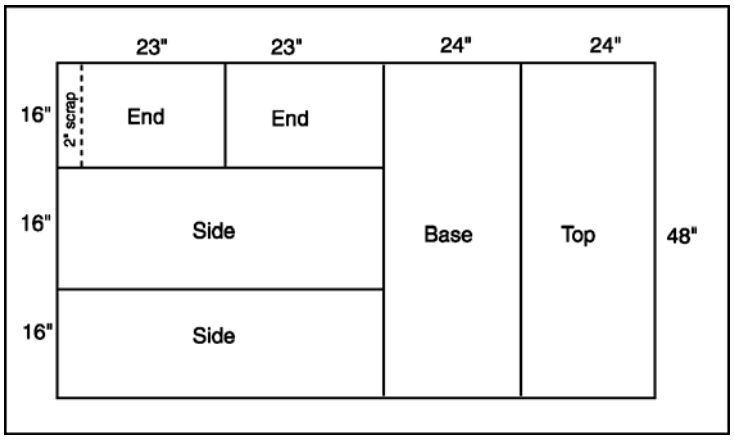
___ Power drill with ¼-inch bit

Note: Please be safe! Wear earplugs, eye protection, and a dust mask when sawing, hammering, and drilling.

ASSEMBLY OF WOOD WORM BIN

Preparation

1. Measure and cut the sheet of plywood as indicated in the diagram below.



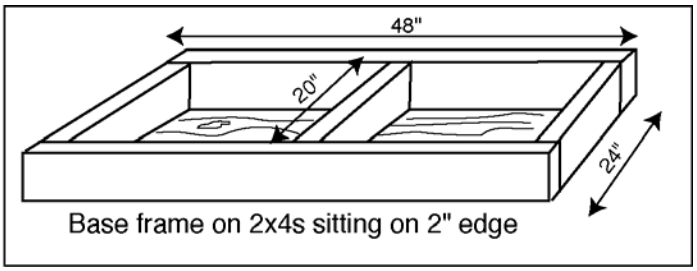
4’ x 8’ sheet of 1/2” plywood

Bin

1. Cut four 16-inch lengths from the 1- by 2-inch board.
2. Place one 16-inch piece on each side of the end panels, so they are flush with the top corner and edge of the end panels.
3. Secure the 1- by 2-inch boards using 1-inch screws. Four screws per board should be plenty.
4. Form the box by attaching the side panels to the end panels, as shown in Diagram 2.
5. Secure the side panels to the end panels by drilling 1-inch screws through to the 1- by 2-inch board at each corner of the box.

Base

1. Set the base panel on top of the box, so that the corners and edges are flush.
2. Secure the base panel to the box by drilling 1-inch screws through to the 1- by 2-inch board at each corner of the box.



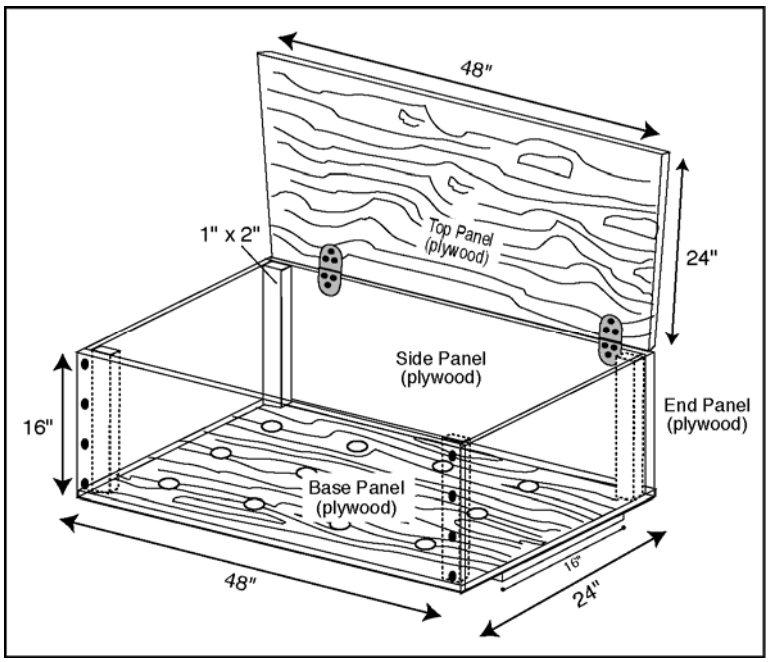
3. Using a 1/4-inch drill bit, drill holes into the base panel. One hole every 3 to 4 inches should allow for sufficient ventilation.
4. Cut the remaining 1- by 2-inch board into two 16-inch pieces. These will be the "feet" of the bin.
5. Set each piece on the base panel, over the end panel, so that the 2-inch side is horizontal.
6. Secure each 1- by 2-inch piece using 1 1/2-inch screws.
7. Flip the box over, so that the feet are touching the ground.

Lid

1. Attach the two hinges to one side of the top panel, as shown in Diagram 3, using 1/2-inch screws.
2. Secure the lid to the box by drilling 1/2-inch screws through the bottom of the hinges into the backside of the box. You may need extra hands to do this!

Conclusion

This worm bin can house approximately 4 pounds of worms and process approximately 4 pounds of food waste each day.



Wood worm bin diagram

Primer #5: What Is Hazardous Waste?[*]

Key Points

- Hazardous waste can be produced in the manufacturing process of many common products people use every day, as well as many common services.
- To protect human health and the environment, hazardous waste is regulated from the time it is produced to the time it is disposed of.

Many of the appliances, products, and materials used in everyday life are manufactured using processes that create hazardous waste. From the paint on your walls, to the components of your car, to the shingles on your house, it is likely that when these products were made, some hazardous waste was generated. Hazardous wastes are substances that exhibit one or more of the following characteristics:

- Toxicity—harmful or fatal when ingested or absorbed.
- Ignitability—creates fire under certain conditions or spontaneously combusts.
- Corrosivity—contains acids or bases that can corrode metal.
- Reactivity—is unstable under "normal" conditions and can cause explosions, toxic fumes, or vapors when mixed with water.

Hazardous waste is created by a variety of different industries, such as petroleum refining and pesticide, chemical, ink, paint, and paper manufacturing. It also is created by the activities of certain smaller businesses found in many communities, such as dry cleaners, vehicle maintenance shops, vocational schools, and photoprocessing stores. In addition, hazardous waste is created when businesses or facilities dispose of certain unused products.

Hazardous waste is an inevitable product of a thriving industrial society. It is important to be aware that the choices consumers make when selecting products, services, and materials have hidden environmental effects. Consumers also should realize that the management of hazardous waste is regulated by law and that facilities that produce, transport, or dispose of it must follow very specific rules to minimize environmental and human health problems. The primary law that governs the proper management of hazardous waste is known as the Resource Conversation and Recovery Act (RCRA).

How Do We Manage Hazardous Waste?

The RCRA regulations cover all aspects of hazardous waste—from the time it is generated at a factory or plant until the time it is discarded. This is known as "cradle to grave." This regulatory system includes many detailed rules that require hazardous waste to be tracked as it moves from place to place; one of the rules requires the use of a tracking paper known as a "manifest." This

[*] Reprinted from *The Quest for Less: Activities and Resources for Teaching K-6*, U.S. Environmental Protection Agency Office of Solid Waste, November 2000.

paper must travel with the waste wherever it goes (e.g., wherever it is stored, shipped, recycled, or disposed of).

Depending on how much waste a facility generates, it is regulated differently; bigger facilities that produce a large amount of hazardous waste each month have more rules than those that produce a small amount of waste.

After a company or factory generates hazardous waste, the waste must be packaged and labeled in special containers, and it must be transported by a regulated hazardous transportation company in special packages with specific labels. These trucks often can be identified on the highway by multicolored placards and symbols that indicate the type of hazardous waste they carry. The Department of Transportation is responsible for regulating these trucks.

Hazardous waste is usually transported to a facility that treats, stores, and/or disposes of it. Most hazardous waste must be specially treated with certain processes to alter its hazardous composition before it can safely be recovered, reused, or disposed of. Sometimes waste is stored temporarily in a regulated unit. When the waste is ultimately disposed of, it is transported either to a landfill or special combustion facility. Combustion facilities must take special precautions to prevent air pollution, and they must ensure that only appropriate wastes are burned.

Sometimes hazardous waste is transported to a facility that recycles hazardous waste. Certain hazardous wastes can be recycled and used again. For example, many solvents can be recovered, some metals can be reclaimed, and certain fuels can be re-blended. Hazardous waste recycling is regulated under RCRA to ensure the protection of human health and the environment.

To keep track of all of the facilities that treat, store, or dispose of hazardous waste and ensure that they follow the rules, U.S. EPA and many states have a permitting system. Each company must obtain a permit, which tells companies what they are allowed and not allowed to do. Inspectors check these facilities regularly by reviewing company records, observing operating procedures, and sometimes collecting hazardous waste samples. For further tracking purposes, U.S. EPA also requires all companies that generate hazardous waste to register and obtain a U.S. EPA identification number.

What Are the Benefits of Hazardous Waste Management?

Before RCRA took effect in 1970, companies could—and did—dispose of hazardous waste in rivers, streams, and other inappropriate places. By enforcing strict rules about the way waste is handled, U.S. EPA and other agencies can better control the effects of hazardous waste on the environment and human health. These controls, while not always perfect, allow the industrial production on which we all depend to continue in as safe a manner as possible.

In addition, EPA has made waste minimization practices and pollution prevention activities key requirements for companies that produce hazardous waste. Any company that creates a certain amount of hazardous waste each month must sign a statement indicating that it has a program in place to reduce both the amount and toxicity of its hazardous waste. These companies also must indicate that they have chosen a method of hazardous waste treatment, storage, or disposal that minimizes the present and future threat to human health and the environment.

It can be difficult for individuals to identify companies that have taken substantial measures to minimize hazardous waste and prevent pollution, and thus, it is not always possible to lend support for these activities by patronizing those companies. When information of this sort is available, however, consumer demand can make a difference.

What Are the Challenges of Hazardous Waste Management?

Just as people and communities generally do not want municipal solid waste facilities in their neighborhoods, they often do not want hazardous waste facilities near their homes and schools (the NIMBY mentality). When new hazardous waste generation or treatment facilities are sited near communities, the public can become involved in the process, but it can be a challenge for companies and communities to achieve mutually acceptable solutions.

The RCRA regulations allow the public to have an opportunity to participate in decisions about hazardous waste management. Through public meetings and other open forums, people can express their concerns about a new facility.

"Hazardous Waste" Versus "Household Hazardous Waste"

"Hazardous waste" is regulated by EPA. Businesses, institutions, or other facilities sometimes including schools) that generate it must comply with certain rules regarding generation, management, transportation, and disposal.

When individuals dispose of household products from their home that contain hazardous ingredients, such as pesticides, cleaners, batteries, or used oil, they create what is known as household hazardous waste. Individuals usually produce much less hazardous waste than businesses and other facilities, and they are not regulated by U.S. EPA. Even so, many communities require or prefer that household hazardous waste is handled separately from the regular garbage to prevent any potential risks to the environment or human health.

When disposing of household hazardous waste from your home, remember the following:

- Sharing leftover household products is a great way for people to use all of a product and avoid disposal. If you cannot share or donate leftover products, check with your local environmental or solid waste agency to see if your community has a facility that collects household hazardous wastes year-round or offers opportunities for exchanging products with other residents.
- If your community doesn't have a collection program for household hazardous waste, contact your local environmental or solid waste agency to see if there are any designated days in your area for collecting these materials. On such days, qualified professionals collect household hazardous waste at a central location to ensure safe management and disposal.
- If your community has neither a permanent collection site nor a special collection day, you might be able to drop off certain products, such as batteries, paint, or automotive supplies, at local businesses for recycling or proper disposal. Call your local environmental or solid waste agency or Chamber of Commerce for information.
- Some communities allow disposal of household hazardous waste in trash as a last resort. Call your local environmental or solid waste agency for instructions on proper disposal. Be sure to read the product label for disposal directions to reduce the risk of products exploding, igniting, leaking, mixing with other chemicals, or posing other hazards on the way to a disposal facility. Even empty containers of household hazardous waste can pose hazards due to residue.

Hazardous Waste Facts

- In 1997, companies produced nearly 40.7 million tons of hazardous waste.
- More than 20,000 large facilities generated hazardous waste in 1997.
- Many hazardous wastes can be generated in schools, such as solvents from cleaning, chemicals from chemistry labs, fluorescent light bulbs, computer monitors, and chemical residues from woodshops. (Source: U.S. EPA, 1997, 2000)

Additional Information Resources

Visit the following Web sites for more information on hazardous waste:

- U.S. Environmental Protection Agency (EPA): **www.epa.gov/**
- U.S. EPA Office of Solid Waste site on hazardous waste:
- **www.epa.gov/epaoswer/osw/hazwaste.htm**

To order the following additional documents on hazardous waste, call EPA toll-free at 800 424-9346 (TDD 800 553-7672) or look on the EPA Web site **www.epa.gov/epaoswer/osw/publicat.htm**.

- *The RCRA Public Participation Manual* (EPA530-R-96-007)
- *HAZ-ED: Classroom Activities for Understanding Hazardous Waste* (EPA540-K-95-005)
- *RCRA Orientation Manual: 1998 Edition* (EPA530-R-98-004)
- *RCRA: Reducing Risk From Waste* (EPA530-K-97-004)

Primer #6: Buying Recycled[*]

Key Points

- Buying recycled-content products encourages manufacturers to purchase and use recycled materials.
- Buying products with "postconsumer" content closes the recycling loop.
- Not all recyclable products can be recycled in every community.
- Buying recycled products saves energy, conserves natural resources, creates jobs, and reduces the amount of waste sent to landfills and incinerators.
- Today's recycled-content products perform just as well, cost the same or less, and are just as available as their nonrecycled counterparts.
- New products containing recycled materials, from construction materials to playground equipment to computers, are constantly being developed.

What Is "Buying Recycled?"

"Buying recycled" means purchasing items that are made from postconsumer recycled content—in other words, materials that were used once and then recycled into something else. This process is also known as "closing the loop."

Consumers "close the loop" when they purchase products made from recycled materials. After an item has been collected for recycling, sorted and processed, and remanufactured into a new product, it still has one more critical step to undergo: purchase and reuse. If no one buys recycled-content products, the entire recycling process is ineffective.

How Can People "Close the Loop?"

Consumers hold the key to making recycling work. Many manufacturers are already making the use of recycled materials a part of their official company policy. By buying recycled-content products, consumers can encourage this trend, making each purchase count toward "closing the loop." Purchasing recycled-content goods ensures continued availability of our natural resources for the future.

The first step in buying recycled-content products is correctly identifying them. As consumers demand more environmentally sound products, manufacturers are encouraged to highlight these aspects of their merchandise. While this trend is good, shoppers should be aware of the various uses of "recycled" terminology. To help consumers decipher product claims about recycled content, the Federal Trade Commission has issued guidelines to ensure that products are properly and clearly labeled. Here are some basic definitions:

- **Recycled-content products** are made from materials that have been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process or after

[*] Reprinted from *The Quest for Less: Activities and Resources for Teaching K-6*, U.S. Environmental Protection Agency Office of Solid Waste, November 2000.

consumer use. Recycled-content products also include products made from used, reconditioned, and remanufactured components.

- **Postconsumer content** indicates that materials used to make a product were recovered or otherwise diverted from the solid waste stream after consumer use. If this term is not noted, or if the package indicates a total recycled content with a percentage of postconsumer content (e.g., 100 percent recycled, 10 percent postconsumer), the rest of the material probably came from excess material generated during normal manufacturing processes. These materials were not used by a consumer or collected through a local recycling program.

- **Recyclable products** can be collected, separated, or otherwise recovered from the solid waste stream for use in the form of raw materials in the manufacture of a new product. This includes products that can be reused, reconditioned, or remanufactured. These products do not necessarily contain recycled materials and only benefit the environment if people recycle them after use. Not all communities collect all types of products for recycling, so it is really only recyclable if your community accepts it.

- **Products wrapped in recycled or recyclable packaging** do not necessarily contain recycled content. They can be wrapped in paper or plastic made from recycled materials, which is a good start, but the most environmentally preferable packaging is none at all.

Consumers must remember to read further than the recycling symbol or the vague language to find specific and verifiable claims. When in doubt about the recycled content of an item, asking the store clerk will not only help to inform the consumer, but also raise the store clerk's awareness of shoppers' interest in environmentally preferable products.

What Are the Benefits of Buying Recycled?

Important advantages to buying recycled-content products include:

- **Waste and Pollution Prevention:** Manufacturing products with recycled content generally creates much less waste and pollution, ranging from truck emissions to raw material scraps.

- **Resource and Energy Conservation:** Making a new product from recycled-content materials generally reduces the amount of energy and virgin materials needed to manufacture the product.

- **Economic Development:** The Institute for Local Self-Reliance in Washington, D.C., estimates that nine jobs are created for every 15,000 tons of solid waste recycled into a new product. These jobs range from low-skilled to high-skilled positions, including materials sorters, dispatchers, truck drivers, brokers, sales representatives, process engineers, and chemists.

- **Money Savings:** Products such as re-refined motor oil, retreaded tires, and remanufactured automotive batteries will often cost less than their virgin material counterparts.

What Are the Challenges of Buying Recycled?

Many people incorrectly assume that products made from recycled content, or used material, are inferior in quality to entirely new products. The challenge is to correct that misconception and convince businesses and consumers of the reliability of recycled-content products. According to the California Department of Conservation and the California Integrated Waste Management Board, in 1996, 97 percent of corporate purchasing agents reported that they were pleased with the performance of their recycled-content products. Though each product's quality and reliability must be judged individually, no evidence exists that recycled-content products are inferior to their

virgin material counterparts. Initially, some recycled-content products were less available and harder to find than virgin products, but today, every major national store chain and nearly all small chains or independent retailers carry recycled-content products at competitive prices.

What Are Some Emerging Trends?

A wider variety of recycled-content products are being produced every day. Some newly available items include electronic equipment, such as computers and printers, made from recycled parts; tape measures made from reconditioned and recycled parts; kitty litter made from recycled drywall; recycled-content plastic office products; and innovative clothing and accessories made from recycled tire inner tubes.

Buying Recycled in Action

Consumers hold the power in their wallets and on their shopping lists. Whether buying items for home, school, or work, consumers must think about the environment and the future as they consider products and brands. Below are activities that will help promote buying recycled:

- Buying recycled-content products personally and encouraging the use of recycled products at school.
- Teaching children about “closing the recycling loop” by organizing a tour of a local facility that manufactures recycled-content products, such as steel products.
- Organizing an exhibit of recycled-content products.
- Asking local stores to stock more recycled-content products.
- Looking for products that usually contain recycled materials, such as steel, glass, aluminum, egg cartons (paper), and cereal boxes.
- Purchasing remanufactured products and equipment, like toner cartridges, office furniture, auto parts, re-refined oil, or retreaded tires.
- Purchasing products that can be recycled in local communities.

A Recycled Product Shopping List

More than 4,500 recycled-content products are already available in stores, and their numbers are rapidly growing. Some of the everyday products people regularly purchase contain recycled-content. Here are some items that are typically made with recycled materials:

- Aluminum cans
- Cereal boxes
- Egg cartons
- Motor oil
- Nails
- Trash bags
- Comic books
- Newspapers
- Paper towels
- Carpeting
- Car bumpers
- Anything made from steel
- Glass containers
- Laundry detergent bottles

Buy-Recycled Facts

- Aluminum cans contain an average of 50 percent recycled postconsumer content, while glass bottles contain an average of 30 percent.
- How many recycled plastic soda bottles does it take to make...?

  1 XL T-shirt .....5 bottles

  1 Ski jacket filler.....5 bottles

  1 Sweater .....27 bottles

  1 Sleeping bag.....35 bottles

- Manufacturers in the United States bought $5 billion worth of recycled materials in 1995.
- One 6-foot-long plastic park bench can be made from 1,050 plastic milk jugs.

(Sources: Aluminum Association, 2000; Glass Packaging Institute; Recyclers' Handbook by Earthworks Group, 1997; Anchorage Recycling Center, 2000; American Plastics Council, 1999; National Recycling Coalition)

Additional Information Resources:

Visit the following Web sites for more information on buying recycled products and solid waste:

- U.S. Environmental Protection Agency (U.S. EPA): **www.epa.gov/**
- U.S. EPA, Office of Solid Waste site on buying recycled: **www.epa.gov/epaoswer/non-hw/reduce/wstewise/purchase.htm - purchase1**
- U.S. EPA, Office of Solid Waste site on recycling and buying recycled:
- **www.epa.gov/epaoswer/non-hw/muncpl/reduce.htm**
- King County, Washington: **www.metrokc.gov/oppis/recyclea.html**
- Green Seal: **www.greenseal.org/**
- The American Plastics Council: **www.plasticsresource.com/**
- The Official Recycled Products Guide: **www.recyclingdata.com/**
- The Global Recycling Network: **www.grn.com/**
- The Environmental News Network's Marketplace: **www.enn.com/marketplace/index.htm**
- Pennsylvania Resource Council's Recycling and Solid Waste Center: **www.prc.org/recctr.htm**
- Buy Recycled Business Alliance: **www.nrc-recycle.org/brba/index.htm**

To order the following additional documents on buying recycled and solid waste, call EPA toll-free at 800 424-9346 (TDD 800 553-7672) or look on the EPA Web site **www.epa.gov/epaoswer/osw/publicat.htm**

- *The Consumer's Handbook for Reducing Solid Waste* (EPA530-K-96-003
- *A Collection of Solid Waste Resources*—CD-ROM

U.S. EPA's WasteWise Program helpline (1-800 EPA-WISE) has additional resources available. These resources include information on the following:

- State Buy-Recycled Contacts
- *Buy Recycled Guidebook*

Integrated Waste Management: Section 3—Educational Resources

The materials listed below are readily available and can assist teachers with selecting and implementing service-learning projects following a campus waste audit or to supplement instructional content in the classroom.

Part 1—Publications and Software

Away with School Waste: A Teacher's Guide to Starting a School Waste Reduction, Recycling & Composting Project
Margo Crabtree (editor)
Public Schools Resource Conservation Project, Santa Cruz, California

Publication can be downloaded at www.wastefreeschools.org or call Ecology Action of Santa Cruz, (831) 426-5925

This 18-page guide was developed to help Santa Cruz County schools set up schoolwide waste management programs. The publication grew out of the Public Schools Resource Conservation Project, which was established in 1997, to engage students in community-based waste reduction efforts. It is written for teachers and includes tips on: putting a team together to implement and sustain a waste reduction program; conducting a campus waste assessment; starting recycling and composting (regular and vermicompost); reducing and reusing; and promoting the program to school staff, students, and parents. The technical descriptions are not detailed enough to fully guide most schools through setting up a recycling program. However, the guide draws on the experiences of teachers in 25 different schools and contains some helpful, pragmatic suggestions.

Closing the Loop: Exploring Integrated Waste Management and Resource Conservation, Kindergarten through Grade Six
California Integrated Waste Management Board
Office of Education and the Environment, MS-14A
1001 I Street
PO Box 4025
Sacramento, California 95812-4025
www.ciwmb.ca.gov/schools/

CIWMB Publication #322-99-009

This supplemental curriculum is a compilation of 50 activities that focus on solid waste and environmental awareness topics including landfills, recycling, packaging, resource conservation, waste prevention, worm composting, and more. The lessons are grouped into two specific grade level modules, a K-3 Grade Module and a 4-6 Grade Module. Each lesson encourages students to explore their natural environment, identify waste management issues, and engage in personal and community action projects. The appendices offer an overview of integrated waste management, some of which focuses specifically on California. There is an excellent history of waste management that includes a digest of waste management-related legislation in California since 1989, which could prove useful in setting a context for motivating waste reduction on school campuses.

A Collection of Solid Waste Resources on CD-ROM
United States Environmental Protection Agency Office of Solid Waste
U.S. EPA National Service Center for Environmental Publications
P.O. Box 42419
Cincinnati, OH 45242-0419
www.epa.gov/ncepihom/.

EPA #530C04002

The fall 2004 edition of this CD-ROM contains more than 300 publications and instructional materials on hazardous and nonhazardous waste. It also contains games and activities for kids. These subjects are among those included: Buying Recycled; Pay-As-You-Throw; Characterization of Municipal Solid Waste; Household Hazardous Waste; Public Participation; Climate Change and Waste; Composting; Recycling; Landfilling; Source Reduction; Life Cycle Management; Tribal Waste Management; Full Cost Accounting; Municipal Solid Waste Management; Used Oil; Hazardous Waste Management; and Oil and Gas. The CD can be used on any IBM-compatible computer with Windows 3.x or higher. This CD-ROM is available free of charge.

Composting in the Classroom: Scientific Inquiry for High School Students
Nancy M. Trautmann and Marianne E. Krasny
Kendall/Hunt Publishing Company
4050 Westmark Drive
Dubuque, Iowa 52002
www.kendallhunt.com

Composting in the Classroom provides background information and technical instructions for building and maintaining traditional and worm composting systems on campus. Unlike other resources, this publication also covers the science of composting; it explains the biology, chemistry, and physics of the process in such a way that composting can be integrated with high school curriculum. Some of the information could be adapted for lower grades. Scattered throughout the publication are suggestions for research possibilities for turning the process of building and maintaining composting facilities into successful inquiry-based learning.

Do the Rot Thing: A Teacher's Guide to Compost Activities
Alameda County Waste Management Authority
777 Davis Street, Suite 200
San Leandro, California 94577
www.stopwaste.org

Do the Rot Thing offers a series of activities and background information that introduce both basic and worm composting. Detailed instructions for setting up and maintaining a campus or classroom composting system are included, as are suggestions for integrating composting into classroom curriculum. Alameda County Waste Management Authority also distributes a "Do the Rot Thing" video, as well as a video entitled "Going to the Source: A Video About Waste Prevention."

The Life Cycle of Everyday Stuff
Mike Reeske and Shirley Watt Ireton
National Science Teachers Association
NSTA Press
1840 Wilson Boulevard
Arlington, Virginia 22201-3000
www.nsta.org

This book offers a unique look at the life cycle of everyday items from product design to disposal. By tracing the life of a telephone—including its history, design, raw materials, manufacturing, useful life, and disposal—and reflecting on the many decisions made throughout that process, students clearly connect product use and environmental impacts. *The Life Cycle of Everyday Stuff* can supplement the study of waste reduction, reuse, and recycling in a creative and meaningful way. There are countless sources of excellent teaching activities that can build context for a waste audit and campus waste-reduction project; the depth and specificity of this material merits its consideration.

The Quest for Less: Activities and Resources for Teaching K–6
United States Environmental Protection Agency
Office of Solid Waste (5305W)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
www.epa.gov

EPA530-R-00-008. Publication can be downloaded at www.epa.gov/osw

The extensive collection of fact sheets included in this supplemental curriculum module offer thorough, well-written background information on all aspects of waste and waste management. The topics includes: Natural Resources, Products, Solid Waste, Hazardous Waste, Recycling, Buying Recycled, Composting, Source Reduction, Landfills, Combustion, and Waste in Review. Each fact sheet provides a succinct summary of key points related to the topic. There is also a comprehensive glossary.

Smart Consumers: An Educator's Guide to Exploring Consumer Issues and the Environment
World Wildlife Fund
Distributed by Acorn Naturalists
155 El Camino Real
Tustin, CA 92780
www.acornnaturalists.com

In this comprehensive, interdisciplinary guide, middle schools students learn how their consumer choices affect the environment and how they can make a difference by buying differently. This 300-page toolkit includes an Educator's Guide, innovative activities, and an annotated list of resources for more information. A Community Action Guide with 25 consumer-related project ideas and step-by-step advice on organizing community-based group projects is included. The module is designed to help young people in grades 6–9 explore consumer issues and understand more about the links between what they buy and the health of the environment.

Trash Conflicts: Science and Social Studies Curriculum on the Ethics of Disposal,
Educators for Social Responsibility
23 Garden Street
Cambridge, MA 02138
www.esrnational.org

Designed for students in grades 6–8, *Trash Conflicts* investigates the links between waste management and environmental quality, challenging students to apply critical-thinking and decision-making skills as they explore a series of science-based experiments. The guide includes lessons, activities, student handouts, and readings to help integrate environmental education across disciplines.

The Worm Café: Mid-Scale Vermicomposting of Lunchroom Wastes
Binet Payne
Flower Press
10332 Shaver Road
Kalamazoo, Michigan 49024

Based on her long-term, successful example at Laytonville Elementary/Middle School (Mendocino County, California), the author describes an educational approach to mid-scale vermicomposting on campus. This book covers everything from the sorting system in the lunchroom to the technical aspects of designing and setting up worm bins, to the anatomy of the earthworm. It is a well-written, extensively illustrated, complete manual for setting up and maintaining a schoolwide system for worm composting of lunchroom wastes. Appendices include forms, worksheets, lesson plans, and an annotated list of student and teacher resources.

The Worm Guide: A Vermicomposting Guide for Teachers
California Integrated Waste Management Board
Office of Education and the Environment, MS-14A
1001 I Street
PO Box 4025
Sacramento, California 95812-4025
www.ciwmb.ca.gov/schools/

Publication can be downloaded at www.ciwmb.ca.gov/Schools/Curiculum/Worms/

This guide provides complete instructions for setting up a classroom vermicomposting bin along with suggestions for larger-scale systems for processing cafeteria food waste. *The Worm Guide* includes basic information on bins, bedding, worms, feeding, and harvesting the compost. Worm biology is explained, and other worm bin residents are identified. The guide includes three enlightening case studies and appendices highlighting educational materials, materials exchange programs (for reuse of materials), worm bin assembly, and worm and bin suppliers. Selected lesson plans from CIWMB's *Closing the Loop* curriculum are included.

Worms Eat My Garbage
Mary Appelhof
Flower Press
10332 Shaver Road
Kalamazoo, Michigan 49024

Twenty-five years of vermicomposting experience went into this volume, an expansion and revision of the 1982 book of the same title. *Worms Eat My Garbage* provides all the details needed to set up a worm bin system. It is oriented toward kitchen use and readily applies to any

small-scale worm composting effort. Information on types of bins, bedding, and worms is provided, along with trouble-shooting advice.

Worms Eat Our Garbage: Classroom Activities for a Better Environment
Mary Appelhof, Mary Frances Fenton, and Barbara Loss Harris
Flower Press
10332 Shaver Road
Kalamazoo, Michigan 49024

This supplemental curriculum guide was developed in response to users of the book *Worms Eat My Garbage*. It is a collection of teaching activities related to earthworms. The activities are organized into three sections: The World of Worms; Worms at Work; and Beyond the Bin. World of Worms introduces earthworms, kinds of worms, and their needs, habitat, and physical and behavioral characteristics. Worms at Work uses a story to present the concept of vermiculture. The activities take students through weighing setting up, maintaining, and observing a worm bin. Beyond the Bin includes activities on making use of worm castings as well as the benefits of vermicomposting for solid waste management. Many useful worksheets are included in the appendices.

Part 2—Websites

These websites have been selected to help teachers locate lesson plans and other ready-to-use resources for teaching about waste. A few student-oriented sites are included when they contain information useful to teachers. Additional student websites are listed in Section 4 of this guide.

Can Manufacturers Institute
www.cancentral.com

This trade association site offers background information and downloadable teacher's resource kits on recycling, the environment, and the can making process.

Cornell Composting/Composting in Schools
http://compost.css.cornell.edu/schools.html

The Cornell Composting site includes background information, lesson plans, instructions, quizzes, and science project ideas. Much of the information is specific to school sites.

EE Link: Environmental Education on the Internet
http://eelink.net/classroomresources-directories.html

EE-Link offers extensive links to curricula, lesson plans, software, student websites, and other classroom resources.

Environmental Protection Agency
www.epa.gov/education

This site provides background information, clip art, curriculum, and links to other online resources on solid waste and other environmental topics.

Environmental Protection Agency Region 9
Recycle City
www.epa.gov/region09/recyclecity

The EPA Region 9 site includes both recycling games and activities for students and ideas for teachers for using the site in the classroom.

The Green Squad
Natural Resources Defense Council
www.nrdc.org/greensquad/

This interactive website takes students through a simulated audit process on a school campus. An interactive library offers 27 fact sheets with project ideas in four categories: Air, Water, Health, and Planet. The Green Squad is a project of the Natural Resources Defense Council in collaboration with the Healthy Schools Network.

North Carolina State University Vermiculture
www.bae.ncsu.edu/people/faculty/sherman/vermiculture/curriculum.htm

This site provides links to vermiculture curriculum and general information compiled by the University Extension Solid Waste specialist.

Use Less Stuff
www.use-less-stuff.com

The Use Less Stuff site includes back copies of a now-discontinued source reduction newsletter. The site also offers *An Ounce of Prevention*, a middle school source reduction curriculum in PDF format created with the National Science Teachers Association.

Worm Woman's Website
www.wormwoman.com

Vermiculture educator Mary Appelhof established this website to provide educators and others access to books, videos, worms bins, equipment, and other resources.

Part 3—Student Literature

These titles have been identified by the publishers as appropriate for sixth-grade readers. Titles marked with an asterisk are also showcased in *Literature for Science and Mathematics: Kindergarten through Grade Twelve*, a collection of outstanding science- and mathematics-related literature for children and adolescents published by the California Department of Education. This online database can be found at **www.cde.ca.gov/ci/sc/ll/index.asp**.

Garbage and Recycling: Environmental Facts and Experiments
Authors: **Sally Morgan, Rosie Harlow**
Publisher: **Kingfisher**
Publication Date: **1995**

This book describes the natural origin of the materials used to make common objects, such as paper, glass, metal cans, and plastics, and offers ways to conserve these resources through recycling. Detailed illustrations help the reader to better understand the text. See other books in this series.

Just a Dream
Author: **Chris Van Allsburg**
Publisher: **Houghton Mifflin**
Publication Date: **1990**

A boy begins to understand the importance of taking care of the environment when he has a dream about a future Earth devastated by pollution. *Just a Dream* could serve to introduce an instructional unit dealing with pollution and conservation of Earth's resources.

Recycling (Earth at Risk)
Author: **Rebecca Stefoff**
Publisher: **Chelsea House Publications**
Publication Date: **1991**

Recycling (Earth at Risk) examines the evolution of recycling as a concept, its role in reducing waste, and implications for the future.

Recycling Glass (Waste Control)
Author: **Judith Condon**
Publisher: **Franklin Watts**
Publication Date: **1991**

Recycling Glass reviews benefits and costs associated with the manufacture and disposal of glass products, and discusses methods for recycling glass products as an alternative.

Recycling (Making a Better World)
Authors: **Gary Chandler, Kevin Graham**
Publisher: **21st Century**
Publication Date: **1997**

Recycling (Making a Better World) presents an overview of recycling processes and describes how recycled plastic, paper, fibers, and other materials can be used to create all kinds of new products.

Recycling (True Books: Environment)
Author: **Rhonda Lucas Donald**
Publisher: **Children's Press**
Publication Date: **2002**

Part of the *True Books: Environment* series, *Recycling* examines waste, the three Rs, composting and other means that offer alternatives to dumping.

Reducing and Recycling Waste (Improving Our Environment)
Author: **Carol Inskipp**
Publisher: **Gareth Stevens Publishing**
Publication Date: **2005**

The *Improving Our Environment* series examines important environmental issues. This particular book highlights waste issues, describes the causes and effects of waste-related problems around the globe, and offers specific suggestions for improving the environment and conserving limited resources.

Waste, Recycling and Re-Use (Protecting Our Planet)
Author: **Steve Parker**
Publisher: **Raintree Steck Vaughn**
Publication Date: **1998**

Waste, Recycling and Re-Use discusses efforts to save the environment through recycling and waste management.

Integrated Waste Management: Section 4—Glossary of Terms*

Advertisement: A public notice or announcement, usually paid for, of things for sale or of something needed.

Aerobic: Able to live or grow only where oxygen is present.

Aluminum: A silvery nonferrous metal found in bauxite; it is used in making hard, light, corrosion-resistant materials, such as beverage containers.

Anaerobic: Able to live or grow where there is no air or oxygen, as evidenced by certain bacteria; decomposition of organic wastes by anaerobic bacteria results in the production and release of methane gas.

Aquifer: Underground rock, sand, or gravel formations which store significant amounts of water.

Biodegradable: Material which can be broken down into simple chemical compounds by bacterial, fungal, and freely occurring biochemical actions; the properties of a substance that allow it to be broken down by microorganisms into simple, stable compounds, such as carbon dioxide and water.

Closing the Loop: The use of recyclable material to make another item (e.g., glass bottles or fiberglass insulation made from old glass bottles; aluminum cans or aluminum trays made from reprocessed aluminum cans; fiberfill jackets made from plastic soda bottles). "Closing the loop" also refers to the last stage of the recycling process, which is buying products manufactured from recycled materials.

Compost: Material resulting from the natural decomposition (breaking down) of organic material by bacteria, fungi, and other organisms; compost is a product used to condition or enhance soil.

Composting: The controlled process of breaking down organic material by living things (e.g., by aerobic bacteria and fungi) and by mechanical means. This is done by a layering process so everything decays into fertile humus.

Conservation: The protection or planned management of natural resources, such as forests, rivers, and fossil fuels, to ensure a future supply or presence by preventing loss, destruction, or waste; the conscious practices of using resources, both natural and manufactured, in a manner that minimizes their loss.

Conserve: To protect or use natural resources knowledgeably without wasting them or using them up completely.

Consumer: A person or other living organism that uses resources; an animal that eats plants and/or other animals; a person who buys goods or services for personal needs.

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* This glossary was reprinted from *Closing the Loop: Exploring Integrated Waste Management and Resource Conservation*, California Integrated Waste Management Board, Sacramento, California, 2000, p. E-1.

Corrosive: A chemical agent that reacts with the surface of a material, causing it to deteriorate or wear away; “corrosive” is one of the four characteristics of hazardous material or waste.

Crude Oil: A naturally occurring liquid consisting mostly of hydrocarbons and small amounts of compounds containing oxygen, sulfur, and nitrogen, which may be refined to make fuel products (e.g., gasoline) and other organic compounds; often referred to as petroleum.

Cycle: To circle, return, or occur again; a circular movement; a series of changes which lead back to a starting point; a repeated event or sequence of events; a complete course of events.

Decompose: To decay, rot, break up or separate into basic components or parts.

Decomposer: An organism, such as a bacterium or a fungus, which feeds on dead organic material and causes the material to break down chemically. Decomposers help recycle nutrients into the soil, which are then available for plants to use.

Decomposition: The process by which a substance is broken down into component parts or basic elements. Food and other plant and animal matter decompose under the proper conditions of light, air, and moisture. Decomposition is an organic process necessary for the continuation of life, because it provides nutrients that are essential to plants and animals.

Disposable: An item that is designed to be disposed of after a few uses; disposable items, such as aseptic juice containers, baby diapers, and polystyrene packaging and food trays are so-called “convenience” items that are normally not reused.

Dump: An uncontrolled area where people dispose of waste.

Durable: Capable of withstanding long use or wear and slow to decay; this word is usually used in relation to durable products compared to disposable products.

Earthworm: Any number of oligochaetes that burrow in the soil, especially any of the genus *Lumbricus*. Earthworms are very important in aerating and fertilizing soil.

Ecosystem: A complex community of living things interacting with each other and nonliving things. Examples of ecosystems are redwood forests, grasslands, oak woodland, chaparral, and tidepools.

Energy: The capacity to do work, for example, breaking the chemical bonds in petroleum molecules releases heat and/or electrical energy which can be used to move a car or power and electrical device.

Energy recovery: Obtaining energy from waste through a variety of processes (e.g., burning solid waste materials).

Ferrous metal: Metals containing iron; these are generally magnetic.

Fossil fuels: Nonrenewable energy sources, such as coal, petroleum, and natural gas, found underground in deposits formed in a previous geological period.

Garbage: Dry waste and food waste products. Animal and vegetable waste resulting from the handling, storage, sale, preparation, cooking, and serving of foods.

Groundwater: The supply of water contained beneath the Earth’s surface in a porous material, such as in cracks and cervices in stone, and in spaces between pieces of gravel and grains of sand; usually in aquifers, which supply wells and springs.

Hazardous material: Any material that poses a threat to human health and the environment because of its chemical makeup. Typical hazardous substances are toxic, corrosive, ignitable, explosive, or chemically reactive.

Household hazardous products: Hazardous materials (see above definition) that are typically used by individuals and families, such as cleaning products, motor oil, and gasoline.

Household hazardous waste: Toxic waste found in homes, such as paint thinner, used oil, and antifreeze, which can harm people, other living organisms, or the environment and are explosive, toxic, corrosive to metal or skin, disease-causing, radioactive, or otherwise dangerous. Because of their hazardous nature, they should be separated from the rest of household trash and properly stored and handled.

Household hazardous waste collection facility: A structure or area operated by a public agency, or its contractor, for the purpose of collecting, handling, treating, storing, or recycling household hazardous waste.

Humus: Organic material consisting of decayed plant matter. It provides nutrients for plants and increases water retention by soil.

Icon: Pictorial representation; a sign (as a word or graphic symbol) whose form suggests its meaning.

Ignitable: Materials and objects that easily catch on fire or start burning.

Inorganic: Composed of chemical compounds not based on the element carbon; generally composed of matter that is not and was not living.

Jingle: A verse with a melody, often used in advertising.

Landfill: A large, outdoor area specially designed for disposing of solid waste on land where the solid waste burial is controlled and managed. Layers of soil and waste are alternated.

Leachate: Liquid that has percolated through solid waste and/or has been generated by solid waste decomposition, and that has dissolved or suspended materials in it. If not managed properly, the liquid may contaminate ground or surface water.

Life cycle: A continual sequence of changes, which an organism or object undergoes from its earliest stage to the occurrence of the same stage in the next generation. The amount of time that an item (e.g., aluminum can) is used, reused, and recycled; the end of the life cycle of an item would be when it ends up in a landfill or is no longer being used.

Litter: Solid waste materials carelessly discarded or left in an inappropriate place, usually due to careless disposal practices or willful improper discarding. Littering is illegal in California, and anyone guilty of littering is subject to a fine.

Manufacture: The making of goods and articles, usually by machinery and often on a large scale.

Materials recovery facility (MRF): Centralized solid waste collection and recycling facility where waste, refuse, and recyclables are sorted and processed for recycling. Nonrecyclable materials are transported from MRFs to landfills. Recyclables are sorted by types of materials, then cleaned and compressed before they are shipped to reprocessing facilities.

Minerals: Naturally occurring inorganic substances that originally came from rock with specific chemical and physical properties, such as a crystal structure. Natural products of organic origin, that appear like rock, such as coal, can also be classified as minerals.

Natural resources: Living and nonliving components that may support life on Earth, such as plants, animals, water, air, soil, minerals, and energy sources, such as sunlight and fossil fuels; naturally occurring materials which people use to make things, such as petroleum, food, clothing, and other products.

Night crawler: A large earthworm (*Lumbricus terrestris*) that comes to the soil surface at night, commonly used as fish bait.

Nonrenewable natural resources: Natural materials that are considered finite in amount (e.g., petroleum, coal, copper); or exhaustible because of their scarcity, the great length of time required for their formation, or their rapid depletion.

Nutrient: A substance that provides food or nourishment and promotes growth, such as proteins, vitamins, minerals, or carbohydrates that sustain an organism.

Nutrient cycle: The movement of materials from living to nonliving things, and the return of those materials through decomposition and other processes.

Organic: Composed of living or once-living matter; composed of chemical compounds based on the element carbon.

Organism: A living thing; an individual with parts that are organized as a functional whole.

Packaging: A container or wrapping made out of any number of materials and used for storing, transporting, protecting, identifying, or displaying a product.

Petroleum: A naturally occurring flammable liquid solution of hydrocarbons of organic origin found in the Earth's crust and used to make such products as natural gas, gasoline, lubricating oils, and plastic; also called crude oil.

Petroleum products: Petroleum products are the chemicals, oils, and fuels that can be separated, refined, and produced from crude oil.

Plastic: A material, made from petroleum, capable of being molded, extruded, or cast into various shapes and films.

Poison: Substance causing illness or death when eaten, drunk, or absorbed through the skin. Some poisons can affect organisms in relatively small quantities.

Pollution: The result of harmful substances being left in the environment and leading to a dirty, impure, or unhealthy place; contamination of air, soil, water, or the atmosphere by the discharge of wastes or other harmful materials. These materials can harm living things.

Polymer: A large molecule containing a chain of chemically-linked subunits called monomers.

Postconsumer waste: Used materials that are collected from consumers prior to entering a landfill (e.g., newspaper, used office paper) and then made into new products (e.g., new newspaper and office paper).

Pre-consumer waste: Waste, most typically from a manufacturing process, that has not been used by consumers (e.g., scraps and trimmings from paper manufacturing plants and printing shops) and from which a new product can be made (e.g., new office paper).

Properties: A characteristic trait or distinctive behavior exhibited by a particular substance or object.

Public service announcement: An advertisement informing the public about a particular event or service. The announcement, and sometimes the event or service, is presented to the public at no cost.

Pulp: Moist fibrous material for papermaking from sources such as wood, rags, crop residue, and recycled paper, derived by chemical or mechanical processes or a combination of both.

Pulp slurry: Pulp that has been liquefied by the addition of water to be used in making paper or cardboard.

Raw material: Any basic material that has been mined or harvested for industrial processes, that has not previously been used (e.g., trees, iron ore, silica sand, crude oil, and bauxite), and that has not been made into a product.

Reaction: The mutual action of substances undergoing chemical change and the state resulting from such changes.

Reactive: In hazardous waste labeling, reactive means that the material may explode (see "Reaction").

Recoverable material: Any material that can be recycled and used again.

Recyclable: Previously used material (e.g., plastic, paper, glass, tin and aluminum cans, and used oil) that can be reprocessed and manufactured into new products.

Recycle: The process of collecting, sorting, processing, and using already manufactured materials for manufacturing of new products (e.g., newspaper recycled into newspaper or cardboard).

Recycled material: A substance (e.g., aluminum, paper, glass) that has been used and from which new products can be made.

Recycling: The process of collecting materials from the waste stream and separating them by type, remaking them into new products, and marketing and reusing the materials in new products.

Reduce: To lessen in any way, as in size, weight, or amount; the process of decreasing the amount of waste generated.

Red worm: Any of various small red annelid worms. Red worms are well suited to use in worm composting because they can process food waste quickly, are able to live within a small area, tolerate a wide range of temperatures, mate throughout the year, and reproduce quickly.

Refuse: Nonliquid, nonsoluble materials ranging from municipal garbage to industrial wastes that contain complex and sometimes hazardous substances. Refuse also includes sewage sludge, agricultural refuse, demolition wastes, and mining residues. Technically, refuse also refers to liquids and gases in containers.

Renewable natural resources: Natural resources (e.g., plants, animals, sunlight, water, air) which can be renewed, restored, or regenerated by natural ecological cycles or sound management practices.

Resin: Any of various solid or semisolid viscous, usually clear or translucent, yellowish or brownish organic substances exuded from various plants and trees; also, chemical modifiers used in synthetic plastics.

Reusable: Those objects which can be used more than once in their same form for the same purpose or for different purposes.

Reuse: The practice of using an object more than once in its same form for the same purpose or for different purposes to extend the life of the object. This can be done by cleaning it and using it again as is, by repairing or modifying it, or by determining new uses for it. For example, a peanut butter jar may be reused in the home as a container for leftover food.

Scavengers: An animal, which eats dead remains and wastes of plants and/or other animals.

Slogan: A catchy phrase used to advertise a product.

Soil: The surface layer of the Earth supporting plant life. A naturally occurring mixture of minerals, organic matter, water, and air that has a definite structure and composition and forms on the surface of the land.

Solid waste: All solid, semisolid, liquid, and gaseous wastes, including trash, garbage, yard waste, ashes, industrial waste, construction waste, and household discards, such as appliances, furniture, and electronic equipment.

Solid waste management: The controlling, handling, and disposing of all solid waste. One goal of solid waste management is to reduce waste to the least amount possible.

Source or waste reduction: Action by people to reduce waste through educated consumer choices.

Sustainable: The ability to support, endure, or keep up economically without depleting or damaging natural resources. Using a resource so that it is not depleted or permanently damaged; of or relating to a lifestyle that reflects an understanding of practices that maintain or prolong the availability of natural resources.

Topsoil: The upper layer of soil, usually darker and richer in minerals and organic matter than the subsoil; surface soil.

Toxic: Producing or containing a poisonous substance that may be harmful or deadly.

Trash: Dry waste; material considered worthless or offensive that is thrown away. Generally defined as dry waste material, but in common usage it is a synonym for garbage, rubbish, or refuse.

Used oil: Any oil that has been refined from crude oil, or any synthetic oil, that has been used and, as a result of use or as a consequence of extended storage or spillage, has been contaminated with physical or chemical impurities.

Vermicomposting: The use of red worms to transform kitchen scraps and other plant materials into compost.

Virgin paper: Paper made from raw materials, usually wood from trees.

Waste: Materials that have been used by manufacturers or consumers and are not reused, recycled, or composted.

Waste stream: The total waste produced by a community or society.

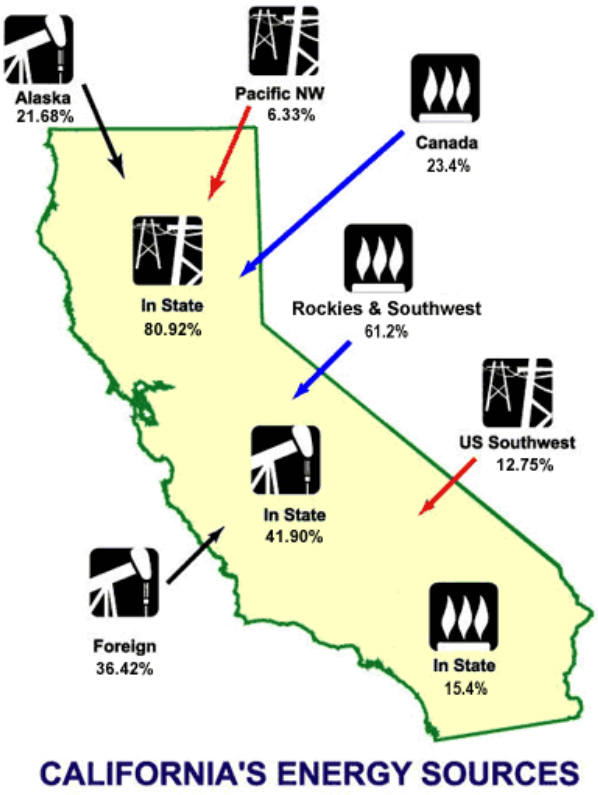
Water cycle: The cyclical movement of water from the atmosphere to the Earth and back again through these steps: evaporation, transpiration, condensation, precipitation, percolation, runoff, and storage.

Water table: The level below which the ground is saturated with water.

Worm castings: Excrement from worms (e.g., materials, soils, and bacteria excreted by worms as part of their digestive process), often used as a soil amendment or enhancer.

Energy and Air Resources

Energy and Air Resources: Section 1—Background



CALIFORNIA'S ENERGY SOURCES

Energy in California[*]

For many years, California has enjoyed successful energy management because of a guiding policy that the state's economy is best served by a diversity of energy supplies. This "portfolio" approach to energy planning has given California the world's most diverse electricity generation system and has established the state as an international leader in demonstrating new transportation fuels and vehicles. With the advent of deregulation, however, the state has been plunged into "uncharted territory" with tremendous challenges.

Energy Supply

Two primary fuels drive California's energy system: petroleum and natural gas. The state produces about 16 percent of the natural gas it uses, 42 percent of the petroleum and 77.7 percent of the electricity. The remaining energy is imported and consists of electricity and natural gas purchases from Canada, Pacific Northwest, Rocky Mountain states and the Southwest; and crude oil imported from Alaska and foreign sources.

According to the U.S. Department of Energy's Energy Information Administration, (**Primary Energy Consumed in California by Source, 1997** [www.eia.doe.gov/emeu/sep/ca/frame.html]), California ranked 3rd in the nation in production of crude oil; 11th in production of natural gas; 3rd in net generation of hydroelectric power; and 6th in nuclear electricity. While it ranks 2nd in the total amount of energy consumed, it ranks 48th in the amount consumed per person. California ranks first in the use of energy in the residential, commercial and transportation sectors and 3rd in the industrial sector. The state is 2nd in the use of natural gas, petroleum and electricity (after Texas).

Petroleum

California's sources of crude oil have changed dramatically since the mid-1970s. At that time, the state imported 33 percent of its crude oil from foreign sources, and oil-fired power plants accounted for over half of the state's electricity generation. Today, foreign imports once again make up about 34 percent of California's petroleum supply, but oil-fired electricity generation is below 1 percent, replaced with cleaner alternatives.

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[*] This section was reprinted with permission from the California Energy Commission website, **www.energy.ca.gov/html/calif_energy_facts.html**.

California obtains about one-half of its crude oil supply from inside the state. The state extracts the maximum amount of oil from its declining oil fields using techniques such as thermally enhanced oil recovery. Alaska is the state's other major source of oil supply. Although Alaska oil currently accounts for 23 percent of petroleum brought into the state in 2003 (down from 50 percent in 1994), its availability is declining more sharply than that of California-produced oil. As the state's and Alaska's supplies decline, oil imported from foreign sources is increasing.

Petroleum in California Page [www.energy.ca.gov/oil/index.html]

Gasoline and Diesel Page [www.energy.ca.gov/gasoline/index.html]

Natural Gas

For over a decade, natural gas has met more than 30 percent of the state's total energy requirements. Because of its low price and clean-burning characteristics, natural gas has become the fuel of choice within California, particularly for electricity generation, and is expected to grow in the coming years. Almost 84 percent of California's natural gas supplies are obtained from sources outside the state - 44 percent from the U.S. Southwest, 28 percent from Canada and 12 percent from the Rocky Mountain area.

In the last decade, three new interstate gas pipelines were built to serve California, expanding the over one million miles of existing pipelines connecting the state with gas-producing areas. Demand for natural gas in 1990 topped 2,025 trillion cubic feet. At full capacity, these new pipelines will provide California with a much needed additional 2.1 billion cubic feet of natural day per day.

During the next two decades, natural gas is expected to play a key role in achieving California's environmental objectives. One-third of the state's electrical energy is generated by gas. That amount is projected to rise to 38 percent by 2009.

Natural Gas in California Page [www.energy.ca.gov/naturalgas/index.html]

Electricity

During the drought of the late 1970s, when less hydroelectric power was available, over two-thirds of California's electricity was generated from oil and natural gas. During the decade of the 1990s, California has one of the world's most diverse resource mixes for electricity generation. In 2003, about 26.6 percent of the state's 276,969 gigawatt-hours of electricity production was produced by renewable sources (including large hydroelectric). In 2003, California imported about 22.3 percent of its electricity supply from the Desert Southwest and the Pacific Northwest.

Electricity in California Page [www.energy.ca.gov/electricity/index.html]

Transportation

The California economy depends critically on the state's transportation system. At the same time, the transportation sector is a major user of energy in the state. Transportation is responsible for roughly 35 percent of California's energy consumption and over 85 percent of total petroleum use--petroleum provides more than 99 percent of the state's transportation fuel needs. Because petroleum is an international commodity, prices depend on a world market. As a result, the transportation system, and therefore the California economy, is vulnerable to circumstances outside of the state.

California's transportation sector is growing faster than the population. Since 1987, the number of vehicles within the state has increased by 24 percent. Although the average fuel economy of these

vehicles has improved, the fuel savings achieved are overshadowed by an overall increase in the number of miles traveled combined with some erosion of fleet fuel efficiency.

California's nearly 26 million vehicles consume more than 15 billion gallons of gasoline and more than 2 billion gallons of diesel, making California the second largest consumer of gasoline in the world.

Gasoline and Diesel Page [www.energy.ca.gov/gasoline/index.html]

Energy Efficiency

California's energy efficiency regulations have set standards for the rest of the country. The Energy Commission adopts regulations for building and appliance efficiency.

Since their establishment, the standards have helped Californians save more than $20 billion in electricity and natural gas costs. It is estimated that number will climb an additional $57 billion by 2011.

The standards are updated periodically to allow consideration and possible incorporation of new energy efficiency technologies and methods. The current Building Efficiency Standards took effect June 1, 2001. New standards for 2005 have been adopted and will go into effect October 1, 2005.

Title 24—Building Efficiency Standards Page [www.energy.ca.gov/title24/index.html]

2005 Standards Page [www.energy.ca.gov/title24/2005standards/index.html]

Appliance Standards Page [www.energy.ca.gov/appliances/index.html]

*Motor Vehicles and the Environment**

Air Pollution

Pollution is any harmful substance deposited in the air, water, or on land that leads to a state of dirtiness, impurity, or unhealthfulness. Clean air means air that does not contain harmful levels of chemicals hazardous to people and other life forms.[22]

The two major chemicals that make up air are nitrogen (78 percent) and oxygen (21 percent). Clean air also contains water vapor, argon, carbon dioxide, and traces of helium, neon, methane, hydrogen, krypton, Xenon, and chlorofluorocarbons (CFCs, put in the air by human activities).[23] The chemical balance in the atmosphere is maintained by plants through the process of photosynthesis and by plants and animals through the process of respiration.

Air carries pollution and, because it moves constantly, it is difficult to keep the air in any given area clean. Acids, aerosols, and chemicals emitted by factories and automobiles interact with one another and create pollution in the atmosphere. The wind can blow the polluted air to other areas sometimes hundreds of miles away. Even though cities, counties, or states may have strict air pollution laws, polluted air originating from another city, county, or state can move into a “clean air area” as winds carry pollution from one area to another.

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In nature, air pollution is produced by volcanoes, forest fires, and by the decay of organisms, especially in marshlands. The burning of fossil fuels (oil, coal, and natural gas) is the leading cause of human-produced air pollution. Fossil fuels are used as an energy source to heat homes, to process various metals or wood in factories, and to manufacture consumer products. They are also used to power automobiles, trucks, and other forms of transportation. Polluted emissions from motor vehicles (as a result of burning gasoline and diesel) released into the atmosphere include: hydrocarbons, carbon monoxide, nitrogen oxides, particulate matter, and other toxic emissions (such as benzene and formaldehyde).[24]

Air pollution contributes to many environmental problems. It poses health risks to humans and other living things. Also, there is evidence that air pollution can influence the precipitation pattern over an area,[25] which can affect the productivity of crops and the health of ecosystems. In addition, air pollution directly ruins crops. Auto emissions in the United States cause annual yield losses of wheat, corn, soybeans, and beans estimated at $1.9 billion to $4.5 billion.[26] Finally, air pollution causes ozone depletion in the upper atmosphere and may cause global warming.

Air Pollution and Human Health

The long-term effects on human health of many chemicals found in air pollution are still unknown. It is difficult to get accurate information concerning deaths caused by air pollution, but in the United States estimates of annual deaths related to outdoor air pollution range from 7,000 to 180,000 people.[27] Air pollution damages the respiratory system and is the leading cause of such lung diseases as emphysema, bronchitis, asthma, upper respiratory infections, sinus problems, and coughs.[28]

According to the United Nations, one-fifth of all people breathe unhealthy air.[29] In 1988 the World Health Organization warned that nearly one billion city dwellers were being exposed to health hazards from air pollutants, with 50-85 percent caused by motor vehicles.[30]

People should understand the critical importance of maintaining healthful and uncontaminated air. Although relatively strict laws govern air pollution, not all cities are meeting the standards, even though it is usually easier and less expensive to prevent air pollution than to try to clean up the air once it is polluted. Education and additional legislation can help avoid further contamination of the atmosphere.

Smog and Ozone Depletion

The main sources of air pollution are the pollutants that are formed as a result of burning fossil fuels in power plants, factories, and motor vehicles. In cities where cars are most abundant, such as Los Angeles, London, and Mexico City, motor vehicles are responsible for 80-88 percent of the air pollution.[31] Cars are responsible for 80 percent of the carbon monoxide and 50 percent of the hydrocarbons and nitrogen oxides that produce smog.[32]

Smog forms in the innermost layer of the atmosphere, called the troposphere, which extends up to 11 miles above sea level. Photochemical smog is a mixture of pollutants (including carbon monoxide), which are created during the burning of fossil fuels. Some of these pollutants react with each other or with the components of air to produce new pollutants. Others react from the influence of sunlight. The result is smog, consisting of more than 100 chemicals and dominated by ozone.[33]

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Ozone (O_3) is a special form of oxygen (O_2). It occurs naturally in a layer in the upper atmosphere, called the stratosphere, located between 11 and 30 miles above sea level. The presence of ozone in the stratosphere keeps about 99 percent of the sun's harmful ultraviolet radiation from reaching the Earth's surface.[34] This radiation can cause skin cancer and blindness resulting from cataracts, and can also affect people's immune systems.[35] In addition to protecting terrestrial animals from the sun's harmful rays, an intact ozone layer also prevents damage to plants and aquatic organisms.

Some air pollution in the stratospheric layer stimulates chemical reactions that destroy the ozone and allow more ultraviolet radiation to reach the Earth. This air pollution is caused by certain human-made chemicals, such as chlorofluorocarbons (CFCs), which are used in air conditioners (although new models no longer contain CFCs), aerosol sprays, insulation, refrigerants, plastics, agricultural sprays, fire fighting materials, dry-cleaning fluids, some foam packaging, and electronics.[36] Other chlorine-containing and bromine-containing compounds also break down ozone. These compounds are found in fire extinguishers, pesticides, and solvents and are used as propellants in more than 160 consumer products, such as correction fluid, dry-cleaning sprays, and other aerosols.[37]

As long as the ozone is in the stratosphere, it is beneficial to life on Earth. But ozone closer to the Earth, as a component in smog, for example, is harmful to living things. This ozone damages plants and the respiratory systems of humans and other animals. It also destroys materials, such as rubber, textiles, and paints.[38]

Carbon Monoxide

Carbon monoxide (CO) is a gas that is colorless, odorless, and tasteless. CO, in sufficiently high concentrations and in enclosed spaces, such as offices, homes, and garages, can be dangerous to humans and pets. The hemoglobin in red blood cells transfers oxygen from the lungs to cells throughout the body; hemoglobin bonds more readily with CO than with oxygen.

When the lung absorbs sufficiently high enough concentrations of CO, the amount of oxygen being distributed throughout the body by the bloodstream is reduced. Breathing excessive concentrations of CO and the resulting lack of oxygen negatively affects brain function, weakens heart contractions, and can cause death.

Roughly 60 percent of the carbon monoxide in the global atmosphere is generated by human activities. In urban population centers, internal combustion vehicles, as well as combustion for generating energy, for cooking, and for industrial and commercial use, generate high concentrations of CO. Natural processes, such as oxidation of methane, hydrocarbon oxidation and emission processes in plants and in the oceans, and forest fires, generate the rest of CO in the atmosphere.

In the atmosphere, CO has a lifetime of two to six months. Atmospheric CO concentrations are reduced by chemical interactions in the atmosphere, uptake by plants and soils, and loss to the stratosphere. Global atmospheric CO concentrations are estimated to grow by 1percent per year.[39]

But carbon monoxide is more of an indoor pollution problem that affects human health.[40] From evaluations of the coroners' data from 1979-1988, it is estimated that breathing excessive concentrations of CO results in 44 accidental deaths in California annually.[41] The major sources

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of these deaths were heating and cooking appliances, followed by motor vehicles. Homes with improperly designed or poorly vented combustion appliances, such as fireplaces; natural gas furnaces, stoves, and water heaters; and wood stoves are likely to produce high concentrations of CO indoors. Home inspections by local utility companies and appliance and vent maintenance can prevent high CO concentrations. CO detectors can be purchased for homes and offices.[42]

The Greenhouse Effect and Global Warming

A greenhouse is a building used to grow plants. The walls of a greenhouse (usually made of glass) allow sunlight in and hold its heat inside. This process makes the greenhouse warm. Similarly, the sunlight penetrates the gases in the atmosphere of the Earth, and some of its energy is released as heat, which warms the Earth, allowing plants and animals to survive. "Greenhouse gases," such as methane and carbon dioxide (CO_2), act like the glass of a greenhouse, trapping heat near the Earth. The burning of fossil fuels produces excess carbon dioxide, which builds up the $C0_2$ concentration in the atmosphere. This extra $C0_2$ traps more heat, making the Earth warmer.

"Global warming" describes the slow rise in the Earth's air temperature because of the extra greenhouse gases in the atmosphere. As the world's average air temperature rises just a little, some low coastal areas may become permanently flooded because of the partial melting of the Earth's ice caps. Forested areas may become too dry to support trees, and agricultural areas may become deserts.[43]

In addition to the carbon monoxide produced as a result of incomplete combustion, each car produces approximately one pound of $C0_2$ for each mile it is driven. If a car gets approximately 20 miles per gallon, the car would produce about 20 pounds of carbon dioxide for every gallon of gasoline it bums.[44]

By using fossil fuels, the citizens of the United States produce six billion tons of atmospheric carbon dioxide each year, more than any other country. This amount is 178 percent of the world's total.[45] According to some scientists, to make a measurable impact on the global warming problem, the total emission of greenhouse gases must be cut by 20 percent.[46]

Trees remove carbon dioxide from the air during photosynthesis. Because deforestation affects this "carbon dioxide removal" cycle, reforestation and planting suitable species of trees in the community can help decrease the excess amount of carbon dioxide in the air.

Acid Rain

Acid rain is a result of burning fossil fuels in automobiles, large coal and oil-burning power plants, and industrial boilers. The emissions, such as sulfur dioxide (SO_2) and nitrous oxide, combine with other chemicals in the atmosphere. Sulfur dioxide reacts with oxygen and water vapor to become sulfuric acid. Nitrous oxide forms nitric acid. These acids are transferred by rain into lakes and other bodies of water, making the surface waters acidic and unfit for life. Acid rain also leaches toxic metals from soil and bedrock into ground and surface waters.

Particulates

Particulate matter refers to the particles in the air. These particles can come from chimneys and smokestacks, car and truck exhausts, construction projects, and agricultural activities. The larger

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particles fall to the ground, but the smaller particles remain in the air and can be inhaled, causing respiratory problems.

The Clean Air Acts

"In the United States, Congress passed Clean Air acts in 1970, 1977, and 1990, giving the federal government considerable power to control air pollution, with federal regulations enforced by each state. These laws required the U.S. EPA to establish national ambient air quality standards (NAAQS) for seven outdoor pollutants: suspended particulate matter, sulfur oxides, carbon monoxide, nitrogen oxides, ozone, hydrocarbons, and lead.[47]

Between 1970 and 1990, the United States has significantly reduced levels of five of the six major outdoor air pollutants. A typical new car in 1992 emitted only about 5 percent of the pollution a new car in 1972 did.[48] Catalytic converters on automobile exhaust have reduced carbon monoxide released from cars by 90 percent.[49] Emissions of nitrogen oxides have increased somewhat because of a combination of insufficient automobile emission standards and a growth in both the number of motor vehicles and the distances traveled.[50]

Energy Used in Transportation

The United States has only 4 percent of the world's oil reserves, yet uses 30 percent of the oil extracted worldwide each year.[51] It imported 51 percent of the oil it used in 1993 (up from 36 percent in 1973), and by 2010 it could be importing 70 percent.[52] Vehicles used for transportation consume 63 percent of all oil used in the United States (up 50 percent from 1973)[53] and 45 percent of all the oil taken from the Earth.[54]

Despite having only 4.7 percent of the world's people, the U.S. has 35 percent of the world's cars and trucks.[55] Each year, each passenger car burns about 500 gallons of gasoline, and each truck uses about 1,350 gallons, usually of diesel fuel.[56] In the U.S. a car is used for 86 percent of all trips, and only 2.5 percent of all trips are by public transit. The car is also used by 86 percent of people to travel to work.[57] About one-tenth of the oil consumed in the world carries U.S. motorists to and from work.[58] Of the people in the U.S. who commute to and from work:

- Seventy-five percent drive alone.
- Thirteen percent use car pools.
- Five percent use public transportation.
- Seven percent walk or use a bicycle.[59]

Land Used for the Transportation System

The use of cars has shaped the way land is used. Cars and highways made long commutes and distant shopping possible, leading to urban sprawl and reduced use of mass transit, bicycles, and walking. In the United States more land is now devoted to cars than to housing. In fact, half the land in an average American city is used for cars.[60]

In the United States 60,000 square miles of land have been paved over, and there are more than 3.9 million miles of streets and highways. Texas is the state with the most paved miles, and

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California is next.[61] Two-thirds of the area covered by downtown Los Angeles and other large cities is used for cars in the form of roads, parking lots, and service stations.[62] Yet in Los Angeles, traffic is so congested that drivers now use one of every four gallons of gasoline just idling their cars in traffic jams.[63]

Almost all the things we eat, drink, wear, or play with come from far away. Although many materials are flown or shipped from one area to another, once they get to the United States, roads (or railways) are needed for the transportation of these materials within the country. The various items Americans eat every day, from flour to juice to vegetables, have traveled an average of 1,500 miles by the time they reach their plates.[64]

Oil Spills and Leaks

Petroleum comes from the Earth's crust. Because drilling is the method used to obtain petroleum, there is a risk of spillage into the environment. Transporting petroleum can cause accidental spills, and if spilled in water, it will affect water quality and aquatic organisms.

On March 24, 1989, an oil tanker, the Exxon Valdez, hit a reef off the coast of Alaska. Over 11 million gallons of crude oil leaked from the damaged tanker into the waters of Prince William Sound,[65] a body of water that connects part of Alaska's southern coast with the Gulf of Alaska. Cleanup efforts were jeopardized by weather and a lack of readily available cleanup equipment. This accident was well publicized, yet more oil is released by the normal operation of offshore wells, the washing of tankers and subsequent release of the oily water, and from pipeline and storage tank leaks than oil tanker accidents.[66] Worldwide, about 10 percent of the oil that reaches the ocean comes from the atmosphere, mostly smoke from oil fires.[67]

What most people are not aware of is that each year U.S. citizens changing their own motor oil improperly dispose of more than 20 times the amount spilled by the Exxon Valdez.[68] Americans generate more than 600 million gallons of used motor oil each year, and about 240 million gallons of used oil enter and pollute the environment each year.[69] Crankcase oil drainings have been reported to account for more than 40 percent of the total oil pollution of the United States' harbors and waterways and, eventually, the ocean.[70]

Many people change their own automobile oil and often illegally dispose of the used oil on the ground, down sewer drains and sinks, on the street or down the storm drain, or in their trash. Lack of proper disposal opportunities and a limited knowledge of associated environmental and health hazards are prime causes of improper disposal.[71] Yet used oil can be rerefined and used again indefinitely as a lubricant.[72]

Rainwater or water from a hose allowed to run on the street will pick up pollutants that have accumulated on paved surfaces during dry weather and wash them off streets. This water will drain through the storm drain and into a nearby stream, river, or lake. Even particles of air pollution from car exhaust get washed into the storm drain. In areas where there are no storm drains, water will flow to the nearest ditch or gully and downhill to the nearest waterway. If used motor oil is poured down the storm drain, it will most likely end up in a nearby body of water.

Few communities have storm drains connected to their sewage treatment plants. This is because of the large volume of water that would need to be treated at the plant during the rainy season, and many sewage treatment plants were not designed to accommodate the additional volume.

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Also, most sewage treatment plants are not designed to eliminate the types of hazardous wastes washed through storm drains because of the high costs of filters and chemicals. Therefore, stormwater runoff is usually not treated at a wastewater treatment facility, but flows directly to local waterways.[73] Small amounts of oil can contaminate large water supplies. One gallon of oil can contaminate 250,000 gallons of water. With only five parts per million, oil in water can be smelled and tasted. Just one pint of motor oil can create a slick an acre in size on surface water and will kill on contact any floating aquatic organisms, such as diatoms and other algae. These organisms are the base of almost all aquatic food chains. In addition, oil contamination increases the growth of organisms that deplete dissolved oxygen in water. This dissolved oxygen is necessary for the survival of fish and other aquatic life.[74]

Some Solutions

Improving fuel efficiency of vehicles, decreasing automobile use, car pooling, using mass transit, and hauling freight more efficiently will conserve oil and reduce air pollution.[75] Currently, trucks burn 59 percent of the energy used to move freight in the United States. Freight can be shifted from trucks and planes to trains and ships. General Motors has even designed a truck trailer that can be used as a railroad car without unloading.[76]

Additional air pollution technology can lower pollution from motor vehicles. For example, catalytic converters on automobile exhaust systems have already reduced carbon monoxide released from cars by 90 percent.[77] Also, as a result of California's Clean Air Act of 1988 and the California Air Resources Board, a cleaner burning gasoline, called RFG (for reformulated gasoline), is the only type of gasoline that can be sold after June 1, 1996, at gas stations in California. RFG is designed to reduce vehicle emissions and, therefore, improve air quality. It bums more completely than conventional gasoline and reduces carbon monoxide and nitrogen oxide emissions by 11 percent; sulfur dioxide by 80 percent, and benzene (a carcinogen) by 50 percent. The California Air Resources Board estimates that using RFG is equivalent to taking 3.5 million automobiles off California's roads, and that means keeping three million pounds of emissions out of the atmosphere every day. There is a slight reduction in mileage—about one-half mile per gallon when using RFG, and the cost of this gasoline is five to 15 cents more per gallon.[78]

Another way that oil can be conserved and air pollution be reduced is by designing cars to get better gas mileage. Finally, vehicles can be developed that use alternative fuels, such as electricity.

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Energy and Air Resources: Section 2—Primers

Primer #1: Guide to Reading Meters

Energy use in homes and most buildings is measured with meters and gauges. Meter readings can be used to calculate the quantity of electricity and natural gas used in a building or part of a building over time. Tracking and comparing these numbers can help identify periods of high energy consumption, seasonal changes, and trends in use. Readings from different times can be compared to demonstrate the effectiveness of energy conservation efforts and may motivate more such efforts.

Electric Meters

Electricity is measured in kilowatt hours (kWh). A kilowatt hour is equivalent to the amount of electricity required to light 10 one-hundred-watt light bulbs for one hour.

Most electric meters use dials to register the cumulative energy use. Meters have four or five dials, measuring thousands or tens-of-thousands kWh. Each number corresponds to the ones, tens, hundreds, thousands, or ten thousands digit in the overall reading. The dials are read from left to right.

The direction of movement on the dials alternates between clockwise and counterclockwise. Each dial moves in an opposite direction from the one next to it.

The dials are read much like a clock. Each dial is numbered from 0 to 9. When the pointer on any dial is between two numbers, always read the smaller number. Note that 0 can represent either zero or ten and, because of its position on the dial, can be higher than nine or lower than one.

Subtracting one reading from a subsequent reading shows how many kWh of electricity were used during the elapsed time. The cost is calculated by multiplying the kWh of electricity used by the cost per kWh charged by the utility company. This cost per kWh is shown on each billing statement.

Natural Gas Meters

Natural gas usage is measured in hundreds of cubic feet. A cubic foot of natural gas provides the same amount of energy as about three tenths of a kilowatt. Since this is not much fuel, most gas meters measure natural gas in hundreds of cubic feet, or CCF, where the first C represents one hundred from the Greek numbering system.

Reading a gas meter is much the same as reading an electric meter. Gas meters usually have four dials. They also have smaller dials with no number that utility company employees use to test that the meters are working properly. The small dials are not included in the meter reading.

Primer #2: The Facts of Light

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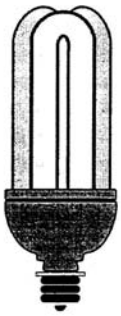


The facts of LIGHT

ABOUT A QUARTER OF EVERY DOLLAR WE PAY FOR ELECTRICITY IS FOR LIGHT.

INCANDESCENTS

Most of our light comes from incandescent light bulbs—the light bulbs that Thomas Edison designed more than a hundred years ago. These bulbs are not efficient; they produce a lot of light, but most of the energy they use (up to 90 percent) goes into heat. There must be a better way!

COMPACT FLUORESCENTS

New compact fluorescent lights (CFLs) use only one-fourth the energy that incandescents do and last thirteen times longer. These new lights produce a soft glow, but very little heat. CFLs can be used in almost any light fixture and, over the life of the bulb, CFLs cost less than half the cost of incandescents to produce the same amount of light.

Why doesn't everyone use CFLs? Lot's of people don't know about CFLs and the money and energy they can save. CFLs cost a lot more to buy, about $10–$20 each, compared to one dollar for an incandescent. It's hard for many people to understand that they can actually save 25 to 50 percent on their electric bills by spending so much more for the bulb.

Most people buy light bulbs at the supermarket or local discount store. It's a lot easier to pay five dollars for five incandescents than $100 for five CFLs. Americans must be convinced that lighting should be a long term investment that can really save them money, as well as save energy and help the environment.

Replacing a 100-watt incandescent with an equivalent CFL can:

- save 600 pounds of coal.
- reduce carbon dioxide emissions by 1,020 pounds.
- reduce sulfur dioxide emissions by four pounds.
- reduce nitrous oxide emissions by three pounds.
- reduce mercury emissions by 40%.

Saving energy is easy and simple:

- Turn off lights when you aren't using them.
- Use the smallest watt bulb that will do the job – most people use much more light than they need.
- Replace the lights you use most with CFLs.
- Use automatic turn-off switches and dimmer switches.

DO THE MATH

Do CFLs really save money?

COST	INCANDESCENT	CFL
Life of bulb (how long it will burn)	1,000 hours	10,000 hours
Number of bulbs to get 10,000 hrs	10 bulbs	1 bulb
x Price per bulb	$0.50	$10.00
= **Cost of bulbs for 10,000 hrs of light**	$5.00	$10.00
Cost of Electricity		
Total hours	10,000 hours	10,000 hours
x Wattage (divide by 1,000 to get kW)	100 watts = 0.10 kW	30 watts = 0.030 kW
= Total kWh consumption	1,000 kWh	300 kWh
x Cost of electricity per kWh	$0.08	$0.08
= **Cost of electricity**	$80.00	$24.00
Life Cycle Cost		
Cost of bulbs	$ 5.00	$10.00
+ Cost of electricity	$80.00	$24.00
= **Life Cycle Cost**	$85.00	$34.00

Primer #3: Energy Consumption

The information on the next six pages was extracted from the Energy Consumption module of the *Intermediate Energy Infobook*, a publication of The National Energy Education Development (NEED) Project (**www.need.org**). Copyright 2002. Used with permission; all rights reserved.

EFFICIENCY CONSERVATION

Energy Consumption

ENERGY USE

Think about how you use energy every day. You wake up to an alarm clock. You take a shower with water warmed by a hot water heater. You listen to music on the radio as you dress. You catch the bus to school. That's how much energy you have used before you get to school!

Every day, the average American uses about as much energy as is stored in seven gallons of gasoline. Energy use is sometimes called energy consumption.

WHO USES ENERGY?

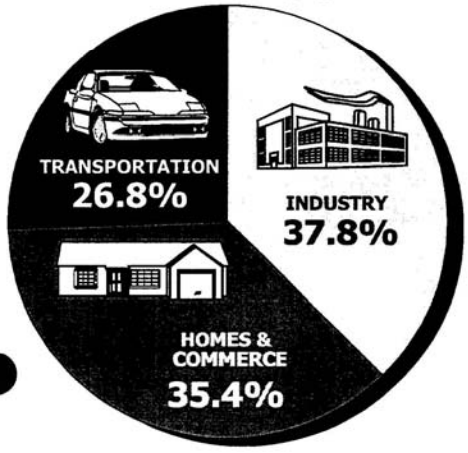
The U.S. Department of Energy divides energy users into three groups: residential and commercial, industrial, and transportation. These groups are sometimes called the sectors of the economy.

HOMES & COMMERCE

Any place where people live is considered a residential building. Commercial buildings include offices, stores, hospitals, restaurants, and schools. Residential and commercial buildings are grouped together for energy analysis because they use energy in the same ways—for heating and cooling, lighting, heating water, and operating appliances.

Together, homes and buildings consume 36% of the energy used in the United States today. In the last 25 years, Americans have reduced the amount of energy used in their homes and commercial buildings. We still heat and cool rooms, and heat hot water. We have more home and office machines than ever. Most of the energy savings have come from improvements in technology and in the ways the equipment is manufactured.

2000 Energy Use



SOURCE: ENERGY INFORMATION ADMINISTRATION

Heating & Cooling

It takes a lot of energy to heat rooms in winter and cool them in summer. Half of the energy used in the average home is for heating and cooling rooms.

The three fuels used most often for heating are natural gas, electricity, and heating oil. Today, more than half the nation's homes use natural gas for heating.

Most natural gas furnaces in the 1970s and 1980s were about 60 percent efficient. That means they converted 60 percent of the energy in the natural gas into usable heat. New gas furnaces manufactured are designed to be up to 98 percent efficient.

The second leading fuel for home heating is electricity. Electricity also provides almost all of the energy used for air conditioning. The efficiency of heat pumps and air conditioners has increased more than 50 percent in the last 25 years.

Heating oil is the third leading fuel used for home heating. In 1975, the average home used 1,294 gallons of oil a year. Today, that figure is only 833 gallons. That is a decrease of 35 percent. New oil furnaces burn oil more cleanly and operate more efficiently.

In the future, we may see more use of renewable energy sources, such as geothermal and solar energy, to heat and cool our homes and workspaces.

EFFICIENCY CONSERVATION

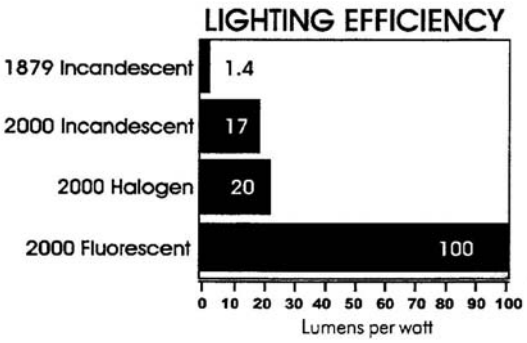
Lighting

Homes and commercial buildings also use energy for lighting. The average home spends 25 percent of its electric bill for lighting. Schools, stores and businesses use about 60 percent of their electricity for lighting.

Most commercial buildings use fluorescent lighting. It costs more to install, but uses a lot less energy to produce the same amount of light.

Most homes still use the type of light bulb invented by Thomas Edison over 100 years ago. These incandescent bulbs are not very efficient. Only about 10 percent of the electricity they consume is converted into light. The other 90 percent is converted to heat.

Compact fluorescent bulbs (CFLs) can be used in light fixtures throughout homes. Many people think they cost too much to buy ($10–$20 each), but they actually cost less overall because they last longer and use less energy than incandescent bulbs. *(See the Facts of Light Infosheet for more information on incandescent vs. fluorescent bulbs.)*



Appliances

Over the last 100 years, appliances have changed the way we spend our time at home. Chores that used to take hours can now be done in minutes by using electricity instead of human energy.

In 1990, Congress passed the National Appliance Energy Conservation Act, which requires appliances to meet strict energy efficiency standards. As a result of this Act, home appliances have become more energy efficient. Water heaters, refrigerators, clothes washers, and dryers all use much less energy today than they did 25 years ago.

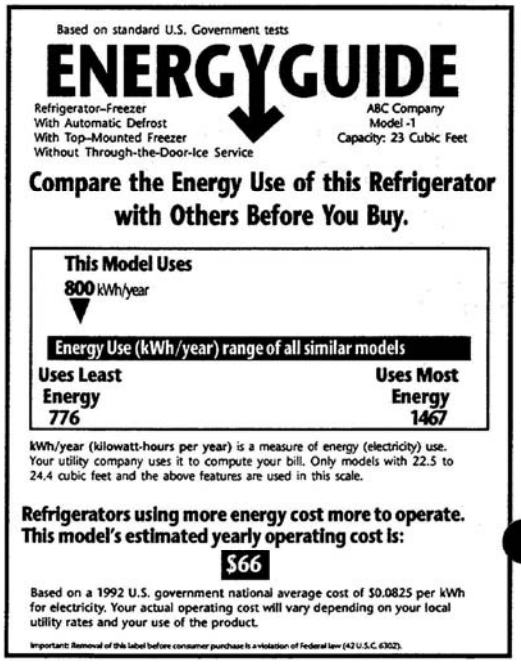
Appliance Efficiency Ratings

When you buy an appliance, you should pay attention to the yellow EnergyGuide label that is on every appliance. This label tells you the Energy Efficiency Rating (EER) of the appliance. The EER will tell you how much it costs to operate the appliance.

Payback Period

Whether you buy a furnace, hot water heater, or other home appliance, you must choose the best bargain. Since most high-efficiency systems and appliances cost more than less efficient ones, you have to know how much it will cost to operate the appliance each year and how many years you can expect to use it. The payback period is the amount of time you must use a system or appliance before you begin to benefit from energy savings.

For example, if you buy an efficient refrigerator that costs $100 more, but uses $25 less electricity each year, you would begin saving money after four years. Your payback period would be four years. Since refrigerators usually last ten years, you would save $150 over the life of the appliance and save natural resources.


Based on standard U.S. Government tests

ENERGYGUIDE

Refrigerator–Freezer
With Automatic Defrost
With Top-Mounted Freezer
Without Through-the-Door-Ice Service

ABC Company
Model -1
Capacity: 23 Cubic Feet

Compare the Energy Use of this Refrigerator with Others Before You Buy.

This Model Uses
800 kWh/year

Energy Use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
776	1467

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only models with 22.5 to 24.4 cubic feet and the above features are used in this scale.

Refrigerators using more energy cost more to operate. This model's estimated yearly operating cost is:

$66

Based on a 1992 U.S. government national average cost of $0.0825 per kWh for electricity. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase is a violation of Federal law (42 U.S.C. 6302).

EFFICIENCY CONSERVATION

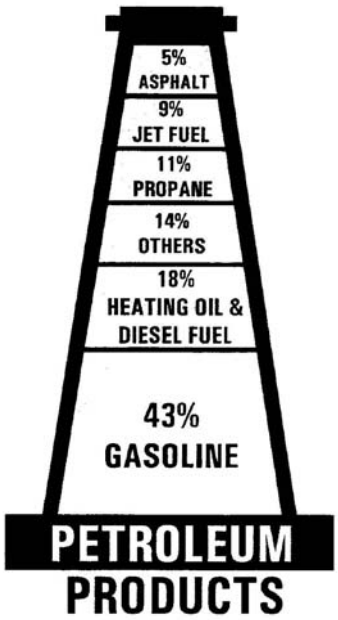
INDUSTRIAL SECTOR

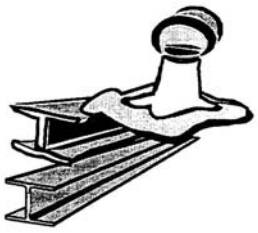
The United States is an industrialized country. We use a lot of energy. In 2000, the industrial sector used almost 38 percent of the nation's energy. Since 1973, the industrial sector has grown by 65 percent, but has used only 15 percent more energy to fuel that growth. Every industry uses energy, but six energy-intensive industries use most of the energy consumed by the industrial sector.

Petroleum Refining

The United States uses more petroleum than any other energy source. Petroleum provides the U.S. with more than 38 percent of the energy we use each year. Petroleum can't be used as it comes out of the ground. It must be refined before it can be used.

Oil refineries use a lot of energy to convert crude oil into gasoline, diesel fuel, heating oil, chemicals, and other products. Almost half of a refinery's operating costs (43%) is for energy. Refineries today use about 25 percent less energy than they did in 1975.





Steel Manufacturing

The steel industry uses energy to turn iron ore and scrap metal into steel. Hundreds of the products we use every day are made of steel. It is a very hard, durable metal and it must be heated to very high temperatures to manufacture it. Producing those high temperatures takes a lot of energy. The cost of energy in the steel industry is 15 to 20 percent of the total cost of making the steel. Most of this energy comes from coal, or electricity generated from coal.

Since 1975, the steel industry has reduced its energy consumption by 45 percent per ton of steel. New technology has made steel stronger, so that less steel is needed for many uses. For example, the Sears Tower in Chicago could be built today using 35 percent less steel.

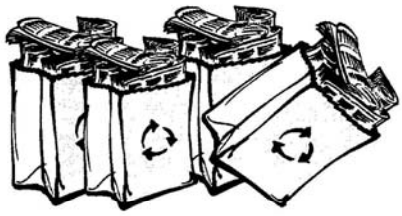
The use of recycled steel also saves energy. It requires 33 percent less energy to recycle steel than to make it from iron ore. Today, 68 percent of new steel is made from recycled scrap, making steel the nation's leading recycled product.

EFFICIENCY CONSERVATION

Aluminum Manufacturing

Aluminum is a very light-weight, versatile metal. We use aluminum to make soft drink cans, food wrap, car parts, and many other products. It takes huge amounts of electricity to make aluminum from bauxite, or aluminum ore. The cost of electricity is 30 percent of the cost of manufacturing aluminum.

Today, it takes 23 percent less electricity to produce a pound of aluminum than it did 25 years ago, mainly because of recycling. Using recycled aluminum requires about 95 percent less energy than converting bauxite into metal.



Paper Manufacturing

The United States uses enormous amounts of paper every day—newspapers, books, bags, and boxes are all made of paper.

Energy is used in every step of paper making. Energy is used to chop, grind, and cook the wood into pulp. More energy is used to roll and dry the pulp into paper. In 1973, the amount of energy needed to make one ream (500 sheets) of copy paper was equal to 3.7 gallons of gasoline.

Today, the energy used to make the same amount of paper would equal just two gallons of gasoline.

The paper and pulp industry uses 42 percent less energy today, mainly because of better technology. Many industries have lowered energy use by using recycled materials. In the paper and pulp industry, it is not cheaper to use recycled paper because it costs money to collect, sort, and process the waste paper. Recycling has other benefits, though. It reduces the amount of paper in landfills and means fewer trees must be cut.

Chemical Manufacturing

Chemicals are an important part of our lives. We use chemicals in our medicines, cleaning products, fertilizers and plastics, as well as in many of our foods.

The chemical industry uses energy in two ways. It uses coal, oil, and natural gas to power the machinery to make the chemicals. It also uses petroleum and natural gas as major sources of hydrocarbons from which the chemicals are made.

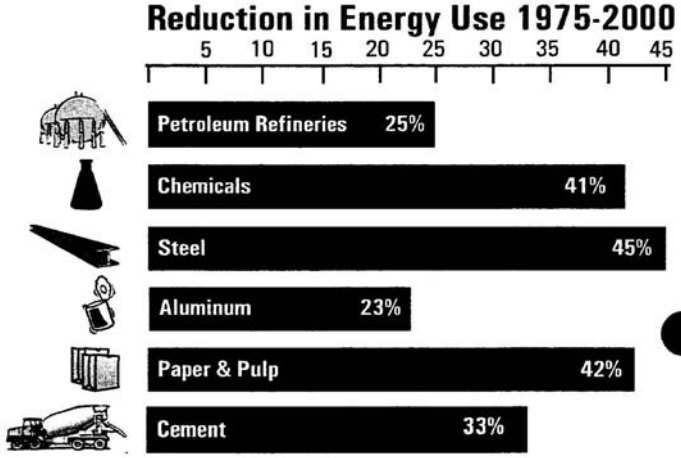
New technology has made the chemical industry 60 percent more energy efficient than it was 25 years ago.

Cement Manufacturing

Some people think the United States is becoming a nation of concrete. New roads and buildings are being built everywhere, every day. We use lots of concrete.

Concrete is made from cement, water, and crushed stone. A lot of energy is used in making cement. The process requires extremely high temperatures—up to 3,500 degrees Fahrenheit.

Cement plants have reduced their energy consumption by one-third using innovative waste-to-energy programs. More than half of the cement plants in the U.S. now use some type of waste for fuel. These wastes, such as printing inks, dry cleaning fluids and used tires, have high energy content. For example, the energy content of one tire equals that of two gallons of gasoline. This industry is using energy that would otherwise be wasted in a landfill.



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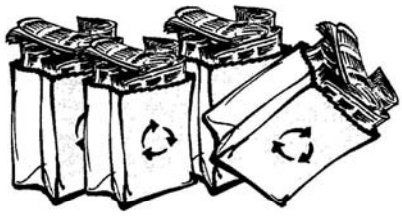

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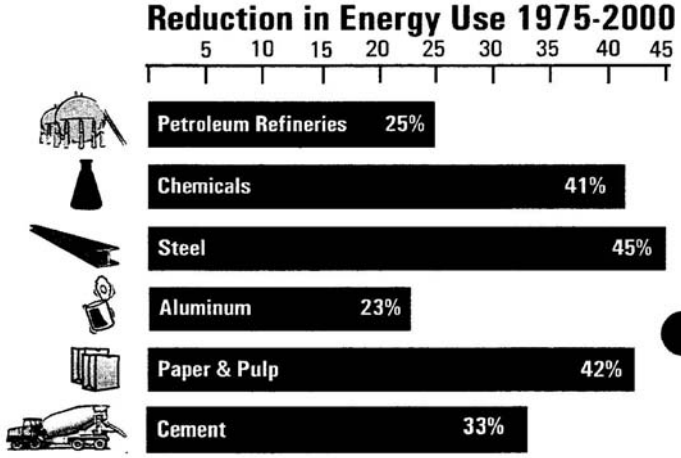


EFFICIENCY CONSERVATION

TRANSPORTATION SECTOR

The United States is a big country. Twenty-eight percent of the energy we use goes to moving people and goods from one place to another.

The Automobile

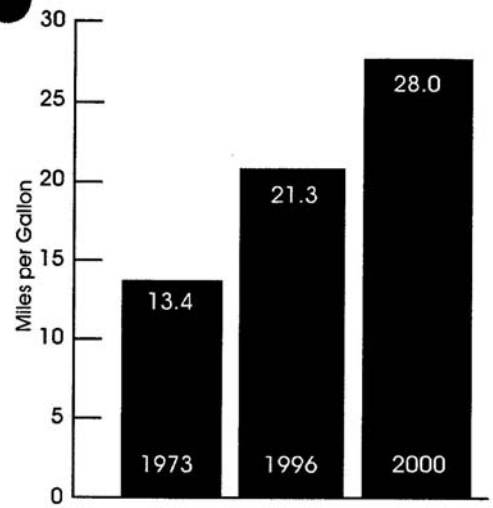
Americans love automobiles. We love to drive them. We don't want anyone telling us what kind of car to buy or how much to drive it.

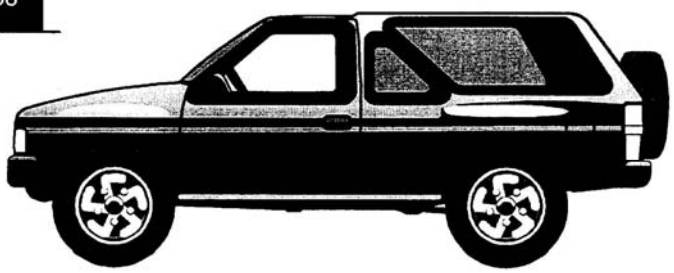
Twenty-five years ago, most Americans drove big cars that used a lot of gas. The gas shortages of the 1970s didn't change Americans' driving habits much. What did change was the way automobiles were built. Automakers began making cars smaller and lighter. They built smaller and more efficient engines.

One reason for the changes to cars was that the federal government passed laws requiring automobiles to get better gas mileage. With new technologies, cars now travel more miles on each gallon of gas. Today, passenger cars get an average of 22.5 miles per gallon. If automakers hadn't made these changes, we would be using 30 percent more fuel than we do today.

In 1973, there were 102 million cars on the road. Today, there are almost 150 million cars. There are more cars being driven more miles than ever before. And, in the last few years, Americans have begun buying big cars again.

Half of the passenger vehicles sold last year were sport utility vehicles and light trucks. These vehicles don't have to meet the mileage standards of passenger cars.





Primer #4: The Greenhouse Effect

The information on the next two pages was extracted from the Greenhouse Effect module of the *Intermediate Energy Infobook*, a publication of The National Energy Education Development (NEED) Project (**www.need.org**). Copyright 2002. Used with permission; all rights reserved.

Greenhouse Effect

EARTH'S ATMOSPHERE

Our earth is surrounded by a blanket of gases called the atmosphere. Without this blanket, our earth would be so cold that almost nothing could live. It would be a frozen planet. Our atmosphere keeps us alive and warm.

The atmosphere is made up of many different gases. Most of the atmosphere (99 percent) is oxygen and nitrogen. The other one percent is a mixture of **greenhouse gases**. These greenhouse gases are mostly water vapor, mixed with carbon dioxide, methane, CFCs, ozone, and nitrous oxide.

Carbon dioxide is the gas we produce when we breathe and when we burn wood and fossil fuels. Methane is the main gas in natural gas. It is also produced when plants and animals decay. The other greenhouse gases are produced by burning fuels and in other ways.

SUNLIGHT AND THE ATMOSPHERE

Rays of sunlight (radiant energy) shine down on the earth every day. Some of these rays bounce off clouds and are reflected back into space. Some rays are absorbed by molecules in the atmosphere. About half of the sunlight passes through the atmosphere and reaches the earth.

When the sunlight hits the earth, most of it turns into heat (thermal energy). The earth absorbs some of this heat. The rest flows back out toward the atmosphere. This keeps the earth from getting too warm.

When this heat reaches the atmosphere, it stops. Heat can't pass through the atmosphere like sunlight. Most of the heat energy becomes trapped and flows back to the earth. We usually think it's sunlight that warms the earth, but actually it's this heat energy that gives us most of our warmth.

THE GREENHOUSE EFFECT

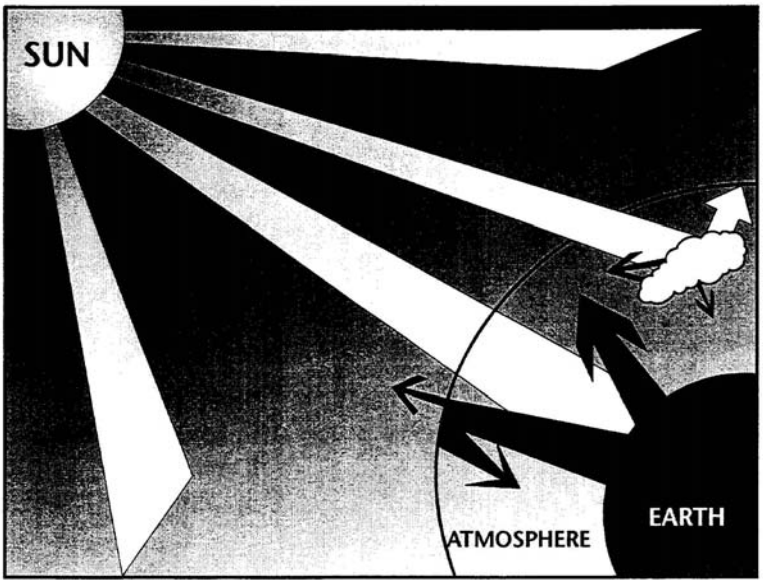
Solar energy (white) shines on the earth all day, every day. Some solar energy reaches the atmosphere and is reflected back into space. Some solar energy is absorbed by the atmosphere and turns into heat energy (black). Half of the solar energy passes through the atmosphere and reaches the earth, where it turns into heat.

Some of the heat energy is absorbed by the earth.

Most of the heat energy flows back into the air. The atmosphere traps the heat energy.

Very little heat energy escapes back into space.

The trapped heat energy flows back to the earth.



THE GREENHOUSE EFFECT

We call this trapping of heat the greenhouse effect. A greenhouse is a building made of clear glass or plastic. In cold weather, we can grow plants in a greenhouse. The glass lets the sunlight in. The sunlight turns into heat when it hits objects inside. The heat becomes trapped. The light energy can pass through the glass; the heat energy cannot.

GREENHOUSE GASES

What is in the atmosphere that lets light through, but traps heat? It's the greenhouse gases, mostly carbon dioxide and methane. These gases are very good at absorbing heat energy and sending it back to earth.

In the last 50 years, the amount of some greenhouse gases in the atmosphere has increased dramatically. We produce carbon dioxide when we breathe and when we burn wood and fossil fuels: coal, oil, natural gas, and propane.

Some methane escapes from coal mines and oil wells. Some is produced when plants and garbage decay. Some animals also produce methane gas. One cow can give off enough methane in a year to fill a hot air balloon!

GLOBAL CLIMATE CHANGE

Many scientists think these greenhouse gases are trapping more heat in the atmosphere as their levels increase. They think the average temperature of the earth is beginning to rise. They call this **global warming**.

These scientists think if the temperature of the earth rises just a few degrees Fahrenheit, it will cause major changes in the world's climate. They think there may be more floods in some places and droughts in others. They believe the level of the oceans might rise as the ice at the North and South Poles melts. They think there might be stronger storms and hurricanes.

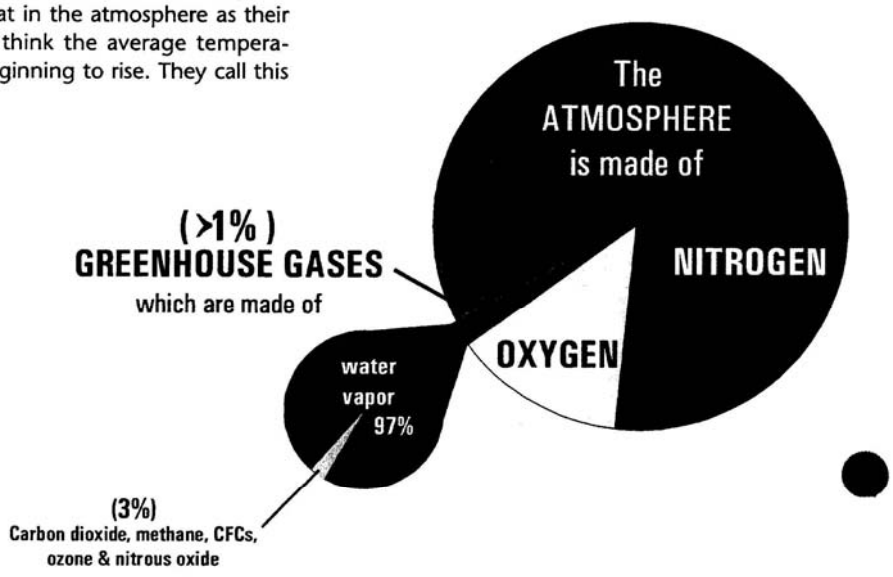
They believe that countries all over the world need to act now to lower the amount of carbon dioxide we put into the atmosphere. They believe we should lower the amount of fossil fuels that we burn.

Other scientists disagree. They don't believe the world's temperature is rising. They think it is too soon to tell if there will be long-term changes in the global climate because of increased carbon dioxide in the atmosphere. They are not sure that a little global warming would cause bad things to happen. They think some good things might happen, like longer growing seasons for crops, warmer nights, and milder winters.

They think we should study the problem more before we make major changes in the way we use fossil fuels.

Greenhouse gases make up less than one percent of the atmosphere.

Greenhouse gases are more than 97 percent water vapor.



Primer #5: Carbon Dioxide Calculator

Sunlight hits the surface of the Earth and is changed into heat energy. This heat energy radiates back into the atmosphere. Atmospheric gases trap that heat energy, keeping the planet at an average temperature of about 60 degrees, warm enough to support life. Without this greenhouse effect, Earth's surface temperature would average 4 degrees Fahrenheit.[79]

Burning fossil fuels—coal, oil, gasoline, and natural gas—produces large amounts of carbon dioxide, one of the atmospheric gases that cause the greenhouse effect. As the amount of carbon dioxide in the atmosphere increases, so does the capacity of the atmosphere to trap heat.

This can result in the gradual increase in surface temperature of the Earth, global warming. Changes in climate, increasingly violent storms, rising ocean levels, and extreme weather patterns are some of the changes that could result from global warming. Scientists generally agree that we can expect global changes due to the rising percentage of gases like carbon dioxide in the atmosphere, even if they do not agree on the overall threat that global warming presents.

The internal combustion engines that power most cars produce carbon dioxide. For each gallon of gasoline burned, almost 20 pounds of carbon dioxide are produced.[80] Plants use carbon dioxide in photosynthesis, the process of converting the sun's energy into chemical energy. So, photosynthesis is a natural way to reduce the amount of carbon dioxide in the atmosphere. However, it takes 65 trees to offset the impact of one car.[81] The average young tree removes about 25 pounds of carbon dioxide from the atmosphere per year.

Here are some interesting mathematical calculations to show how much carbon dioxide is produced by one car each year, based on some average figures. Of course, the same calculations can be done using actual miles driven per week and actual gas mileage per gallon.

- Miles traveled per week: 210
- Gas consumed in one week, based on an average of 30 miles per gallon: 210 miles/30 miles per gallon = 7 gallons of gas
- Carbon dioxide produced in one week: 20 pounds of carbon dioxide per gallon x 7 gallons = 140 pounds of carbon dioxide
- Carbon dioxide produced in one year: 140 pounds per week x 52 weeks per year = 7,280 pounds per year

Reducing overall miles driven, increasing automobile gas mileage, and planting trees can all help to reduce the amount of carbon dioxide emitted into the atmosphere.

Primer #6: School Buses[*]

Pollution from School Buses May Be Hazardous to Your Health: The Diesel Dilemma

SCHOOLYARD SMOKERS

More than 23 million children rely upon buses to carry them safely to school, and most of the 442,000 school buses on the road today are powered by diesel fuel. There is no warning sign on the outside of diesel school buses that the black smoke coming out of the tailpipe could be hazardous to children's health, but there should be.

HEALTH IMPACT OF DIESEL POLLUTION

Diesel emissions affect people of all ages, but children are particularly vulnerable. Since they are outdoors more often than adults, children's small bodies and maturing lungs experience greater exposure to harmful air pollutants. New studies in California find that air pollution not only exacerbates children's asthma, but may actually cause asthma in otherwise healthy children. And Yale researchers found that the air inside diesel school buses contained 5 to 15 times more toxic soot than the outside air.

Diesel school bus emissions can cause three types of public health threats:

Air toxics. Diesel exhaust contains 41 chemicals that the State of California has identified as toxic air contaminants. The health risks of air toxics vary from pollutant to pollutant, but are all serious, including cancer, immune system disorders, and reproductive problems. The State of California estimates that the combustion of diesel fuels causes 70 percent of all airborne cancer risk.

Soot. Most particulate matter emitted by diesel buses is tiny enough to evade the body's defenses and potentially lodge deep in the lungs. Numerous public health studies have linked diesel soot to missed school days, asthma hospitalizations, chronic bronchitis, heart disease, and even premature death.

Smog. Urban ozone and the other atmospheric pollutants that comprise smog, can impair the respiratory system, causing coughing, choking, and reduced lung capacity. On smoggy days, hospital admissions escalate, especially for asthma. Repeated exposure to smog may permanently injure lungs.

FUEL FACTS

» 2004 Natural Gas - Smog: 150 lbs/yr/bus Soot: 0.5 lbs/yr/bus

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[*] Compiled and used with permission from the Union for Concerned Scientists (Pollution from School Buses May Be Hazardous to Your Health: The Diesel Dilemma—**www.ucsusa.org/clean_vehicles/big_rig_cleanup/pollution-from-school-buses-may-be-hazardous-to-your-health.html** and Clean School Buses Across the Country—**www.ucsusa.org/clean_vehicles/big_rig_cleanup/success-stories-clean-school-buses-across-country.html**).

» 2004 Low Emission Diesel - Smog: 200 lbs/yr/bus Soot: 0.6 lbs/yr/bus

» 2004 Conventional Diesel - Smog: 200 lbs/yr/bus Soot: 5.6 lbs/yr/bus

» Average Bus on Road - Smog: 415 lbs/yr/bus Soot: 13.7 lbs/yr/bus

OLDER SCHOOL BUSES AND SAFETY

There are about 3,000 school buses on the road today that do not have to meet minimum safety requirements. Built before 1977, these buses do not have to meet standards for passenger seating and crash protection, rollover protection, body joint strength, and fuel system integrity. All newer buses have to meet a stringent series of federal motor vehicle safety standards designed to prevent accidents and provide our children with high levels of safety should a crash occur. Older school buses carry a double-edged threat: They are safety hazards as well as polluters.

EPA'S NEW REGULATIONS

Recognizing the dangers of diesel pollution, the EPA passed new emissions standards for diesel trucks and buses. These standards require that buses built after 2007 release 90 percent less soot and 95 percent less smog-causing emissions than today's buses. Unfortunately, diesel buses built before 2007 can continue to release high levels of soot and smog-causing pollution. In addition, the new regulations do not recognize that there are inherently cleaner fuels than conventional diesel that are available today.

CLEAN, SAFE ALTERNATIVES

There are clean and cost-effective alternatives to standard diesel-powered school buses. Compared with a conventional diesel bus, buses powered by alternative fuels such as natural gas can cut soot by 90 percent and smog-forming pollutants by nearly one-third. Cleanup technologies for diesel engines show the potential to slash soot pollution by 85 percent or more.

Natural gas buses have been on the road for more than a decade and have a long track record of success. Approximately one in seven transit buses currently on order in the United States is powered by natural gas, and half of California's new buses use natural gas. Natural gas transit buses are being used in cities throughout the country, including Los Angeles, New York, Tacoma (Washington), Phoenix, State College (Pennsylvania), Cleveland, Dallas, and Atlanta. School districts are learning from these transit districts and joining the clean air bandwagon on alternative-fuel school buses. One hundred thirty school districts in 17 states transport children to and from school in buses powered by alternative fuels. These districts include Sacramento and Desert Sands Unified School Districts in California. The California Energy Commission’s Safe School Bus Demonstration Program is working to increase the percentage of alternative fuel vehicles in the state’s school bus fleet. Their program has replaced 826 school buses built before 1977 with cleaner buses.

CLEANING UP OUR SCHOOL BUSES

Federal legislation to provide funds for clean vehicles will help ensure our children travel in safe and clean school buses. A $300 million grant program could fund the replacement of about 2,300 of our country's dirtiest diesel buses, built before more protective federal standards were enacted in 1991.

Success Stories

In 130 school districts across 17 states, children ride alternative-fuel buses to school. Below, we describe five areas around the country where school districts are enjoying the cleaner air, lower costs, and high driver satisfaction of an alternative-fuel bus fleet.

EVANSVILLE-VANDERBURGH, INDIANA

The Evansville-Vanderburgh School Corporation has one of the largest natural gas school bus fleets in the nation, with 140 natural gas buses on the road. Due to the price instability of gasoline and diesel, the district started converting its gasoline buses to natural gas in 1986. With savings from reduced fuel and maintenance costs, the district recovered the conversion costs of the buses within the first year of operation. The chief garage group leader, Curtis Fritz, is very pleased with his natural gas fleet, reporting that drivers like the way the buses handle, maintenance and fuel costs are lower, and the distance between oil changes has doubled. Fritz says, "The drivers that were initially hesitant about switching to natural gas now love these buses. When they have to drive other [gasoline or diesel] buses, they scream that they want their natural gas buses back."

For more information, contact Curtis Fritz, chief garage group leader, Evansville-Vanderburgh School Corporation, at (812) 435-8269.

LOWER MERION SCHOOLS, ARDMORE, PENNSYLVANIA

In response to community concerns about diesel engine noise and air pollution, the Lower Merion School District began purchasing natural gas buses in the mid-1990s. The district currently operates a fleet of 63 natural gas buses, for which it recently received the National Clean Cities Award. The reliability and durability of the fleet, which will soon pass the three-million-mile mark, has reinforced the district's commitment to purchasing only natural gas buses.

The school district has received funding and technical support from the U.S. Department of Energy, the Pennsylvania Department of Environmental Protection, and PECO Energy Company, a natural gas supplier. Mike Andre, supervisor of transportation for the district, is a strong advocate for the switch: "We really need...to change our perspectives about fuel. The U.S. government needs to start supporting alternative fuel."

For more information, contact Michael Andre, supervisor of transportation, Lower Merion School District, at (610) 645-1945.

TULSA PUBLIC SCHOOLS, TULSA, OKLAHOMA

The largest school district in the state, the Tulsa Public School District has 179 vehicles converted to natural gas. According to Larry Rodriquez, alternative fuel technician at the Tulsa Public School District, "The switch has probably saved the district around $1.6 million if one considers the fuel differential, engine longevity, and other matters. It has definitely been worth it." Even with the recent increase in the price of natural gas, fuel savings still average around $1,000 per year per vehicle based on 15,000 annual miles traveled per bus.

For more information, contact Larry Rodriquez, alternative fuels technician, Tulsa Public Schools, at (918) 831-2547.

NORTHSIDE INDEPENDENT SCHOOL DISTRICT, NORTHSIDE, TEXAS

Northside Independent School District has the second largest fleet of propane school buses in the country and is committed to maintaining a 100 percent alternative-fuel fleet. Northside employs

about 420 propane buses to carry 33,000 students to and from school every day, and the district plans to increase the fleet to 448 buses by 2005. Northside made the switch to propane nearly 20 years ago, motivated by the cheap price of propane relative to gasoline and diesel. Since propane comes from local sources, the district is not subject to the price fluctuations of other fuels. Northside has found that maintenance costs are low, gas mileage is good, and drivers are happy with the performance of the buses.

For more information, contact Randy Zanatta, transportation vehicle maintenance supervisor, Northside Independent School District, at (210) 695-3800.

THE CALIFORNIA ENERGY COMMISSION'S SAFE SCHOOL BUS DEMONSTRATION PROGRAM

The California Energy Commission's Safe School Bus Demonstration Program is paving the way to increase the percentage of alternative fuel vehicles in the state's school bus fleet. As a result of the program, 826 school buses built before 1977 have been replaced with cleaner buses. More than half of these buses are alternatively fueled—nearly 270 powered by natural gas and 150 by methanol—and all are equipped with advanced safety features. Partners John Deere, Blue Bird Body Company, Detroit Diesel Corporation, and Crown Coach are working to develop alternative-fuel school buses specifically designed to meet the needs of the School Bus Demonstration Program.

For more information, contact Bernard Treanton, associate engineer, Transportation Technology Office, California Energy Commission, at (916) 654-4512.

Primer #7: Renewable Energy—An Overview

The information on the next eight pages was produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory (NREL), a DOE national laboratory. The document was produced by the Information and Outreach Program at NREL for the DOE Office of Energy Efficiency and Renewable Energy.

Note that the Energy Efficiency and Renewable Energy Clearinghouse referenced in the document no longer exists.

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March 2001

ENERGY EFFICIENCY AND RENEWABLE ENERGY CLEARINGHOUSE

Renewable Energy: An Overview

What is Renewable Energy?

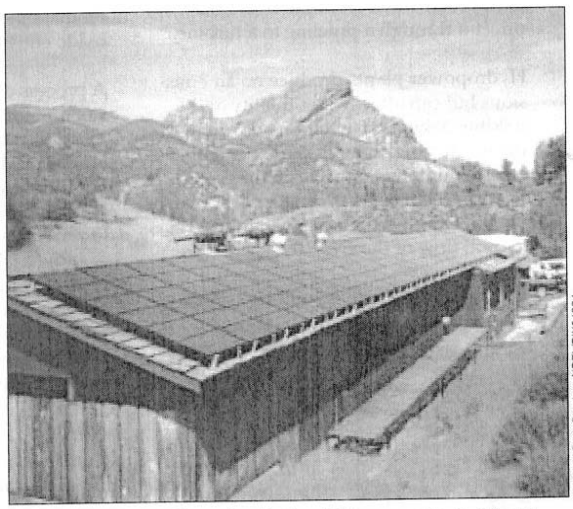
Renewable energy uses energy sources that are continually replenished by nature—the sun, the wind, water, the Earth's heat, and plants. Renewable energy technologies turn these fuels into usable forms of energy—most often electricity, but also heat, chemicals, or mechanical power.

Why Use Renewable Energy?

Today we primarily use fossil fuels to heat and power our homes and fuel our cars. It's convenient to use coal, oil, and natural gas for meeting our energy needs, but we have a limited supply of these fuels on the Earth. We're using them much more rapidly than they are being created. Eventually, they will run out. And because of safety concerns and waste disposal problems, the United States will retire much of its nuclear capacity by 2020. In the meantime, the nation's energy needs are expected to grow by 33 percent during the next 20 years. Renewable energy can help fill the gap.

Even if we had an unlimited supply of fossil fuels, using renewable energy is better for the environment. We often call renewable energy technologies "clean" or "green" because they produce few if any pollutants. Burning fossil fuels, however, sends greenhouse gases into the atmosphere, trapping the sun's heat and contributing to global warming. Climate scientists generally agree that the Earth's average temperature has risen in the past century. If this trend continues, sea levels will rise, and scientists predict that floods, heat waves, droughts, and other extreme weather conditions could occur more often.

Other pollutants are released into the air, soil, and water when fossil fuels are burned. These pollutants take a dramatic toll on the environment—and on humans. Air pollution contributes to diseases like asthma. Acid rain from sulfur dioxide and nitrogen oxides harms plants and fish. Nitrogen oxides also contribute to smog.



National Park Service, NREL/PIX04924

A PV-system at the Pinnacles National Monument in California eliminates a $20,000 annual fuel bill for a diesel generator that produced each year 143 tons of carbon dioxide—a greenhouse gas.

This document was produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory (NREL), a DOE national laboratory. The document was produced by the Information and Outreach Program at NREL for the DOE Office of Energy Efficiency and Renewable Energy. The Energy Efficiency and Renewable Energy Clearinghouse (EREC) is operated by NCI Information Systems, Inc., for NREL / DOE. The statements contained herein are based on information known to EREC and NREL at the time of printing. No recommendation or endorsement of any product or service is implied if mentioned by EREC.

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste

Hydropower is our most mature and largest source of renewable power...

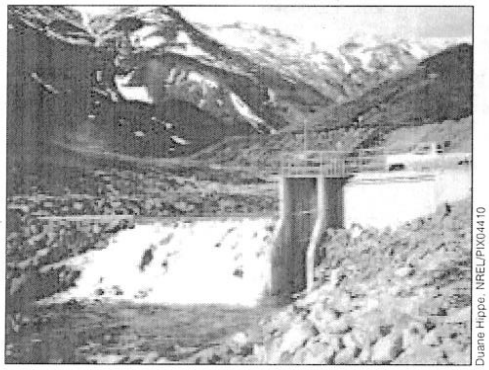
Renewable energy will also help us develop energy independence and security. The United States imports more than 50 percent of its oil, up from 34 percent in 1973. Replacing some of our petroleum with fuels made from plant matter, for example, could save money and strengthen our energy security.

Renewable energy is plentiful, and the technologies are improving all the time. There are many ways to use renewable energy. Most of us already use renewable energy in our daily lives.

Hydropower

Hydropower is our most mature and largest source of renewable power, producing about 10 percent of the nation's electricity. Existing hydropower capacity is about 77,000 megawatts (MW). Hydropower plants convert the energy in flowing water into electricity. The most common form of hydropower uses a dam on a river to retain a large reservoir of water. Water is released through turbines to generate power. "Run of the river" systems, however, divert water from the river and direct it through a pipeline to a turbine.

Hydropower plants produce no air emissions but can affect water quality and wildlife habitats. Therefore, hydropower plants are now being designed and operated to minimize impacts on the river. Some of them are diverting a portion of the flow around their dams to mimic the natural flow of the river. But while this improves the wildlife's river habitat, it also reduces the power plant's output. In addition, fish ladders and other approaches, such as improved turbines, are being used to assist fish with migration and lower the number of fish killed.



Duane Hippe, NREL/PIX00410

A small-scale hydropower system in King Cove, Alaska, provides residents in this remote area with a less expensive source of electricity.

Bioenergy

Bioenergy is the energy derived from biomass (organic matter), such as plants. If you've ever burned wood in a fireplace or campfire, you've used bioenergy. But we don't get all of our biomass resources directly from trees or other plants. Many industries, such as those involved in construction or the processing of agricultural products, can create large quantities of unused or residual biomass, which can serve as a bioenergy source.

Biopower

After hydropower, biomass is this country's second-leading resource of renewable energy, accounting for more than 7,000 MW of installed capacity. Some utilities and power generating companies with coal power plants have found that replacing some coal with biomass is a low-cost option to reduce undesirable emissions. As much as 15 percent of the coal may be replaced with biomass. Biomass has less sulfur than coal. Therefore, less sulfur dioxide, which contributes to acid rain, is released into the air. Additionally, using biomass in these boilers reduces nitrous oxide emissions.

A process called gasification—the conversion of biomass into gas, which is burned in a gas turbine—is another way to generate electricity. The decay of biomass in landfills also produces gas, mostly methane, which can be burned in a boiler to produce steam for electricity generation or industrial processes. Biomass can also be heated in the absence of oxygen to chemically convert it into a type of fuel oil, called *pyrolysis oil*. Pyrolysis oil can be used for power generation and as a feedstock for fuels and chemical production.

Biofuels

Biomass can be converted directly into liquid fuels, called biofuels. Because biofuels are easy to transport and possess high energy density, they are favored to fuel vehicles and sometimes stationary power generation. The most common biofuel is ethanol, an alcohol made from the fermentation of biomass high in carbohydrates. The current largest source of ethanol is corn. Some cities use ethanol as a gasoline additive to help meet air quality standards for

Green Mountain Power Corporation. NREL/PIX05768

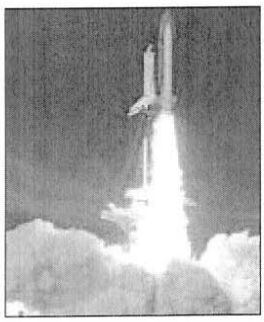
The 6-MW Green Mountain power plant in Searsburg, Vermont, consists of eleven 550-kW wind turbines.

1 or 2 MW. Large, utility-scale projects can have hundreds of turbines spread over many acres of land. Small turbines, below 50 kW, are used to charge batteries, electrify homes, pump water for farms and ranches, and power remote telecommunications equipment. Wind turbines can also be placed in the shallow water near a coastline if open land is limited, such as in Europe, and/or to take advantage of strong, offshore winds.

Wind energy has been the fastest growing source of energy in the world since 1990, increasing at an average rate of over 25 percent per year. It's a trend driven largely by dramatic improvements in wind technology. Currently, wind energy capacity amounts to about 2500 MW in the United States. Good wind areas, which cover 6 percent of the contiguous U.S. land area, could supply more than one and a half times the 1993 electricity consumption of the entire country.

California now has the largest number of installed turbines. Many turbines are also being installed across the Great Plains, reaching from Montana east to Minnesota and south through Texas, to take advantage of its vast wind resource. North Dakota alone has enough wind to supply 36 percent of the total 1990 electricity consumption of the lower 48 states. Hawaii, Iowa, Minnesota, Oregon, Texas, Washington, Wisconsin, and Wyoming are among states where wind energy use is rapidly increasing.

Hydrogen is high in energy, yet its use as a fuel produces water as the only emission.



NASA, NREL/PIX03814

NASA uses liquid hydrogen to launch its space shuttles and hydrogen fuel cells to provide them with electricity

Hydrogen

Hydrogen is high in energy, yet its use as a fuel produces water as the only emission. Hydrogen is the universe's most abundant element and also its simplest. A hydrogen atom consists of only one proton and one electron. Despite its abundance and simplicity, it doesn't occur naturally as a gas on the Earth.

Today, industry produces more than 4 trillion cubic feet of hydrogen annually. Most of this hydrogen is produced through a process called *reforming*, which involves the application of heat to separate hydrogen from carbon. Researchers are developing highly efficient, advanced reformers to produce hydrogen from natural gas for what's called *Proton Exchange Membrane* fuel cells.

You can think of fuel cells as batteries that never lose their charge. Today, hydrogen fuel cells offer tremendous potential to produce electrical power for distributed energy systems and vehicles. In the future, hydrogen could join electricity as an important "energy carrier": storing, moving, and delivering energy in a usable form to consumers. Renewable energy sources, like the sun, can't produce energy all the time. But hydrogen can store the renewable energy produced until it's needed.

Eventually, researchers would like to directly produce hydrogen from water using solar, wind, and biomass and biological technologies.

Ocean Energy

The ocean can produce two types of energy: *thermal energy* from the sun's heat, and *mechanical energy* from the tides and waves.

Ocean thermal energy can be used for many applications, including electricity generation. Electricity conversion systems use either the warm surface water or boil the seawater to turn a turbine, which activates a generator.

The electricity conversion of both tidal and wave energy usually involves mechanical devices. A dam is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. Meanwhile, wave energy uses mechanical power to directly activate a generator, or to transfer to a working fluid, water, or air, which then drives a turbine/generator.

Most of the research and development in ocean energy is happening in Europe.

Altogether about 2800 MW of geothermal electric capacity is produced annually in this country.

geothermal energy. Direct-use applications require geothermal temperatures between about 70° to 302°F—lower than those required for electricity generation. The United States already has about 1,300 geothermal direct-use systems in operation.

In a direct-use system, a well is drilled into a geothermal reservoir, which provides a steady stream of hot water. Some systems use the water directly, but most pump the water through what's called a *heat exchanger*. The heat exchanger keeps the water separate from a working fluid (usually water or a mixture of water and antifreeze), which is heated by the geothermal water. The working fluid then flows through piping, distributing the heat directly for its intended use.

The heated water or fluid can be used in a building to replace the traditional heat source—often natural gas—of a boiler, furnace, and hot water heater. Some cities and towns actually have large direct-use heating systems—called district heating—that provide many buildings with heat. Geothermal direct use is also used in agriculture—such as for fish farms and to heat greenhouses—and for industrial food processing (vegetable dehydration).

Geothermal Heat Pumps

While air temperatures can vary widely through the seasons, the temperatures of the shallow ground only range from 50° to 70°F depending on latitude. GHPs draw on this relatively stable temperature as a source for heating buildings in the winter and keeping them cool in the summer.

Through underground piping, a GHP discharges heat from inside a building into the ground in the summer, much like a refrigerator uses electricity to keep its interior cool while releasing heat into your kitchen. In the winter, this process is reversed; the GHP extracts heat from the ground and releases it into a building.

Because GHPs actually move heat between homes and the earth, instead of burning fuels, they operate very cleanly and efficiently. In fact, GHPs are at least three times more efficient than even the most energy-efficient furnaces on the market today.

Warren Gretz, NREL/PIX06537

This homeowner in Aurora, Colorado, uses a GHP to heat and cool his home.

Solar Energy

Solar technologies tap directly into the infinite power of the sun and use that energy to produce heat, light, and power.

Passive Solar Lighting and Heating

People have used the sun to heat and light their homes for centuries. Ancient Native Americans built their dwellings directly into south-facing cliff walls because they knew the sun travels low across the southern sky in the Northern Hemisphere during the winter. They also knew the massive rock of the cliff would absorb heat in winter and protect against wind and snow. At the same time, the cliff-dwelling design blocked sunlight during the summer, when the sun is higher in the sky, keeping their dwellings cool.

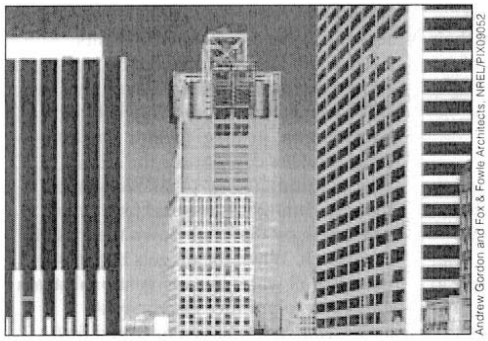
The modern version of this sun-welcoming design is called *passive solar* because no pumps, fans, or other mechanical devices are used. Its most basic features include large, south-facing windows that fill the home with natural sunlight, and dark tile or brick floors that store the sun's heat and release it back into the home at night. In the summer, when the sun is higher in the sky, window overhangs block direct sunlight, which keeps the house cool. Tile and brick floors also remain cool during the summer.

Passive solar design combined with energy efficiency will go even further. Energy-efficient features such as energy-saving windows and appliances, along with good insulation and weatherstripping, can make a huge difference in energy and cost savings.

Solar Water Heating

Solar energy can be used to heat water for your home or your swimming pool. Most solar water-heating systems consist of a solar collector and a water storage tank.

Solar water-heating systems use collectors, generally mounted on a south-facing roof, to heat either water or a heat-transfer fluid, such as a nontoxic antifreeze. The heated water is then stored in a water tank similar to one used in a conventional gas or electric water-heating system.



Andrew Gordon and Fox & Fowle Architects NREL/PIX09052

The Four Times Square Building in New York City uses thin-film PV panels to reduce the building's power load from the utility grid.

Passive solar building techniques turn homes into huge solar collectors.

There are basically three types of solar collectors for heating water: flat-plate, evacuated-tube, and concentrating. The most common type, *a flat-plate collector,* is an insulated, weatherproof box containing a dark absorber plate under a transparent cover. *Evacuated-tube collectors* are made up of rows of parallel, transparent glass tubes. Each tube consists of a glass outer tube and an inner tube, or absorber, covered with a coating that absorbs solar energy but inhibits heat loss. *Concentrating collectors* for residential applications are usually parabolic-shaped mirrors (like a trough) that concentrate the sun's energy on an absorber tube called a receiver that runs along the axis of the mirrored trough and contains a heat-transfer fluid.

All three types of collectors heat water by circulating household water or a heat-transfer fluid such as a nontoxic antifreeze from the collector to the water storage tanks. Collectors do this either passively or actively.

Passive solar water-heating systems use natural convection or household water pressure to circulate water through a solar collector to a storage tank. They have no electric components that could break, a feature that generally makes them more reliable, easier to maintain, and possibly longer lasting than active systems.

An *active* system uses an electric pump to circulate water or nontoxic antifreeze through the system. Active systems are usually more expensive than passive systems, but they are also more efficient. Active systems also can be easier to retrofit than passive systems because their storage tanks do not need to be installed above or close to the collectors. Also, the moving water in the system will not freeze in cold climates. But because these systems use electricity, they will not function in a power outage. That's why many active systems are now combined with a small solar-electric panel to power the pump.

The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, proper installation, and the tilt angle and orientation of the collectors. But if you're currently using an electric water heater, solar water heating is a cost-effective alternative. If you own a swimming pool, heating the water with solar collectors can also save you money.

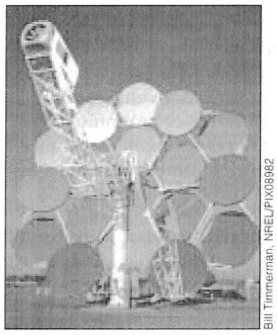
Solar Electricity

Solar electricity or photovoltaic (PV) technology converts sunlight directly into electricity. Solar electricity has been a prime source of power for space vehicles since the inception of the space program. It has also been used to power small electronics and rural and agricultural applications for three decades. During the last decade, a strong solar electric market has emerged for powering urban grid-connected homes and buildings as a result of advances in solar technology along with global changes in electric industry restructuring.

Although many types of solar electric systems are available today, they all consist of basically three main items: *modules* that convert sunlight into electricity; *inverters* that convert that electricity into alternating current so it can be used by most household appliances; and possibly or sometimes *batteries* that store excess electricity produced by the system. The remainder of the system comprises equipment such as wiring, circuit breakers, and support structures.

Today's modules can be built into glass skylights and walls. Some modules resemble traditional roof shingles, but they generate electricity, and some come with built-in inverters. The solar modules available today are more efficient and versatile than ever before.

In over 30 states, any additional power produced by a PV system, which is not being used by a home or building, can be fed back to the electric grid through a process known as *net metering*. Net metering allows electricity customers to pay only for their "net" electricity, or the



Bill Timmerman, NREL/PIX08982

This dish/Stirling solar power system in Arizona is capable of producing 25 kW of electricity.

Wind energy has been the fastest growing source of energy since 1990…

amount of power consumed from their utility minus the power generated by their PV system. This metering arrangement allows consumers to realize full retail value for 100 percent of the PV energy produced by their systems.

Grid-connected PV systems do not require batteries. However, some grid connected systems use them for emergency backup power. And of course in remote areas, solar electricity is often a economic alternative to expensive distribution line extensions incurred by a customer first connecting to the utility grid. Electricity produced by solar electric systems in remote locations is stored in batteries. Batteries will usually store electricity produced by a solar-electric system for up to three days.

What type of system to purchase will depend on the energy-efficiency of your home, your home's location, and your budget. Before you size your system, try reducing energy demand through energy-efficient measures. Purchasing energy-saving appliances and lights, for example, will reduce your electrical demand and allow you to purchase a smaller solar-electric system to meet your energy needs or get more value from a larger system. Energy efficiency allows you to start small and then add on as your energy needs increase.

Solar Thermal Electricity

Unlike solar-electric systems that convert sunlight into electricity, solar thermal electric systems convert the sun's heat into electricity. This technology is used primarily in large-scale power plants for powering cities and communities, especially in the Southwest where consistent hours of sunlight are greater than other parts of the United States.

Concentrating solar power (CSP) technologies convert solar energy into electricity by using mirrors to focus sunlight onto a component called a receiver. The receiver transfers the heat to a conventional engine-generator—such as a steam turbine—that generates electricity.

There are three types of CSP systems: power towers (central receivers), parabolic troughs, and dish/engine systems. A *power tower system* uses a large field of mirrors to concentrate sunlight onto the top of a tower, where a receiver sits. Molten salt flowing through the receiver is heated by the concentrated sunlight. The salt's heat is turned into electricity by a conventional steam generator. *Parabolic-trough systems* concentrate the sun's energy through long, parabolic-shaped mirrors. Sunlight is focused on a pipe filled with oil that runs down the axis of the trough. When the oil gets hot, it is used to boil water in a conventional steam generator to produce electricity. A *dish/engine system* uses a mirrored dish (similar in size to a large satellite dish). The dish-shaped surface focuses and concentrates the sun's heat onto a receiver at the focal point of the dish (above and center of the collectors). The receiver absorbs the sun's heat and transfers it to a fluid within an engine, where the heat causes the fluid to expand against a piston to produce mechanical power. The mechanical power is then used to run a generator or alternator to produce electricity.

Concentrating solar technologies can be used to generate electricity for a variety of applications, ranging from remote power systems as small as a few kilowatts (kW) up to grid-connected applications of 200 MW or more. A 354-MW power plant in Southern California, which consists of nine trough power plants, meets the energy needs of more than 350,000 people and is the world's largest solar energy power plant.

Wind Energy

For hundreds of years, people have used windmills to harness the wind's energy. Today's wind turbines, which operate differently from windmills, are a much more efficient technology.

Wind turbine technology may look simple: the wind spins turbine blades around a central hub; the hub is connected to a shaft, which powers a generator to make electricity. However, turbines are highly sophisticated power systems that capture the wind's energy by means of new blade designs or *airfoils*. Modern, mechanical drive systems, combined with advanced generators, convert that energy into electricity.

Wind turbines that provide electricity to the utility grid range in size from 50 kW to

Green Mountain Power Corporation, NREL/PIX05768

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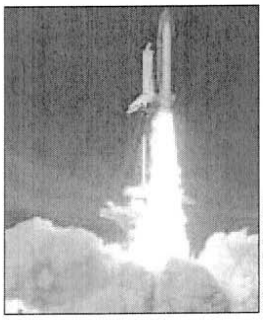

NASA, NREL/PIX03814

NASA uses liquid hydrogen to launch its space shuttles and hydrogen fuel cells to provide them with electricity

Hydrogen

Hydrogen is high in energy, yet its use as a fuel produces water as the only emission. Hydrogen is the universe's most abundant element and also its simplest. A hydrogen atom consists of only one proton and one electron. Despite its abundance and simplicity, it doesn't occur naturally as a gas on the Earth.

Today, industry produces more than 4 trillion cubic feet of hydrogen annually. Most of this hydrogen is produced through a process called *reforming*, which involves the application of heat to separate hydrogen from carbon. Researchers are developing highly efficient, advanced reformers to produce hydrogen from natural gas for what's called *Proton Exchange Membrane* fuel cells.

You can think of fuel cells as batteries that never lose their charge. Today, hydrogen fuel cells offer tremendous potential to produce electrical power for distributed energy systems and vehicles. In the future, hydrogen could join electricity as an important "energy carrier": storing, moving, and delivering energy in a usable form to consumers. Renewable energy sources, like the sun, can't produce energy all the time. But hydrogen can store the renewable energy produced until it's needed.

Eventually, researchers would like to directly produce hydrogen from water using solar, wind, and biomass and biological technologies.

Ocean Energy

The ocean can produce two types of energy: *thermal energy* from the sun's heat, and *mechanical energy* from the tides and waves.

Ocean thermal energy can be used for many applications, including electricity generation. Electricity conversion systems use either the warm surface water or boil the seawater to turn a turbine, which activates a generator.

The electricity conversion of both tidal and wave energy usually involves mechanical devices. A dam is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. Meanwhile, wave energy uses mechanical power to directly activate a generator, or to transfer to a working fluid, water, or air, which then drives a turbine/generator.

Most of the research and development in ocean energy is happening in Europe.

Resources

The following are sources of additional information on renewable energy. The list is not exhaustive, nor does the mention of any resource constitute a recommendation or endorsement.

Ask an Energy Expert
DOE's Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
Phone: 1-800-DOE-EREC (363-3732)
TDD: 1-800-273-2957
Fax: (703) 893-0400
E-mail: doe.erec@nciinc.com
Online submittal form: www.eren.doe.gov/menus/energyex.html
Consumer Energy Information Web site: www.eren.doe.gov/consumerinfo/

Energy experts at EREC provide free general and technical information to the public on many topics and technologies pertaining to energy efficiency and renewable energy.

DOE's Energy Efficiency and Renewable Energy Network (EREN)
Web site: www.eren.doe.gov

Your comprehensive online resource for DOE's energy efficiency and renewable energy information.

Organizations

Center for Energy Efficiency and Renewable Energy (CEERT)
1100 Eleventh St., Suite 311
Sacramento, CA 95814
Phone (916) 442-7785; Fax (916) 447-2940
E-mail: info@ceert.org
Web site: www.cleanpower.org

Promotes the development of renewable energy technologies and resources.

National Renewable Energy Laboratory (NREL)
1617 Cole Blvd.
Golden, CO 80401
Web site: www.nrel.gov

DOE-lab devoted to researching and developing renewable energy and energy efficiency technologies.

Renewable Energy Policy Project (REPP)
1612 K St. NW, Suite 202
Washington, DC 20006
Phone: (202) 293-2898; Fax: (202) 293-5857
Web site: www.repp.org

Works to advance renewable energy technologies.

Web Sites

CADDET Renewable Energy
Web site: www.caddet-re.org

Provides technical information on renewable energy projects and technologies from around the world.

Clean Energy Basics
NREL
Web site: www.nrel.gov/clean_energy/

Provides basic information on renewable energy technologies, including specific links for homeowners, small business owners, students, and teachers.

European Renewable Energy Exchange (EuroREX)
Web site: www.eurorex.com

Features information and news on renewable energy technology developments in Europe and around the world.

Planet Energy—The Renewable Energy Trail
United Kingdom Department of Trade and Industry
Web site: www.dti.gov.uk/renewable/ed_pack/index.html

Specifically gears its information for students and teachers, from grade school through high school.

Solstice
Center for Renewable Energy and Sustainable Technology (CREST)
Web site: http://solstice.crest.org

Provides an online source of information on renewable energy and technology development.

Further Reading

Achieving Energy Independence—One Step at a Time, J. Yago, Dunimis Technology, 1999, 190 pp.

Charging Ahead: The Business of Renewable Energy and What It Means for America, J. Berger and L. Thurow, University of California Press, 1998, 416 pp.

Clean Energy Choices: Tips on Buying and Using Renewable Energy at Home, DOE Office of Energy Efficiency and Renewable Energy, 2000, 48 pp. Print copy available from EREC (see "Ask an Energy Expert" above), and a PDF is available at www.nrel.gov/docs/fy00osti/27684.pdf.

The Real Goods Solar Living Sourcebook: The Complete Guide to Renewable Energy Technologies and Sustainable Living, D. Pratt ed., Real Goods, 1999, 562 pp.

Energy and Air Resources: Section 3—Educational Resources

The materials listed below are readily available and can assist teachers with selecting and implementing service-learning projects following a campus energy audit or to supplement instructional content in the classroom.

Part 1—Publications and Software

California Energy Commission
Media and Public Information Office
1516 Ninth Street
Sacramento, CA 95814
www.energyquest.ca.gov

The California Energy Commission offers a variety of teacher resources including downloadable curriculum materials and lesson plans, and lists of books, videos, DVDs, energy-related organizations, as well as grant and teacher training opportunities. Among the materials that can be accessed through the Commission's website is *Conserve & Renew: An Energy Educational Activity Package for Grades 4–6*. This resource offers energy education activities that focus on conservation and renewables. These can be used either as a unit on energy or as individual activities to complement existing curricula.

Cycles of the Earth and Atmosphere
University Corporation for Atmospheric Research
National Center for Atmospheric Research
UCAR Office of Programs
PO Box 3000
Boulder, CO 80307-3000

Publication available at no charge through www.ucar.edu/learn.

This 96-page module is part of the Project LEARN (Laboratory Experience in Atmospheric Research at NCAR) series and is intended to enhance earth and physical science programs for grades 6–9. Laboratory activities explore the functioning of earth as a system; water, carbon, nitrogen, and sulfur cycles as they relate to the atmosphere; and factors contributing to and consequences of greenhouse gases.

Energy for Keeps: Electricity from Renewable Energy
Educators for the Environment
664 Hilary Drive
Tiburon, CA 94920
www.energyforkeeps.org

Energy for Keeps is a guide for teaching middle school students the history, availability, management, and consequences of the use of various energy resources. It offers extensive background information and specific instructions for carrying out student activities that explore the realm of renewable, electricity-generating resources.

Full Option Science System (FOSS): Solar Energy, Grades 5–6
Lawrence Hall of Science
Available from Delta Education
80 Northwest Blvd.
P.O. Box 3000
Nashua, NH 03061-3000
www.delta-education.com

FOSS: Solar Energy is a complete module consisting of a teacher's guide, equipment and consumable materials (including student books) for a class of 32 students, *FOSS Science Stories*, teacher preparation video, and assessment materials. The *Solar Energy* module offers four investigations that explore the inexhaustible nature of solar energy, relative positions of the Earth and the sun, the use of compasses and thermometers to study orientation and solar energy transfer, and the design of solar water heaters and passive solar space heaters.

GEMS Acid Rain
University of California at Berkeley
Great Explorations in Math and Science (GEMS)
Lawrence Hall of Science #5200
Berkeley, California 94720-5200
www.lhsgems.org

Integrating mathematics and science, *Acid Rain* explores acids, bases, and the pH scale using laboratory investigations and simulated town hall meetings. Students construct "fake lakes" to determine how pH changes after an acid rainstorm; present a play on the effects of acid rain on aquatic life; determine the effect of various dilutions of acid on seed germination; and hold a town meeting to discuss possible solutions to the problem of acid rain.

National Energy Foundation
3676 California Ave., Suite A117
Salt Lake City, CA 84104
www.nef1.org

The National Energy Foundation offers a variety of resources including primers, curriculum guides, posters, and teacher resource kits. Two of the guides offer suitable activities that help students explore energy resources and energy efficiency: *Energy Action Activities* (grades 4–8) and *Energy Fundamentals* (grades 4–6).

The NEED Project (National Energy Education Development)
PO Box 10101
Manassas, Virginia 20108
www.need.org/

NEED provides professional development designed to help educators implement energy programs in their classrooms while developing student knowledge and leadership skills. The project has been in operation for more than 20 years. Workshops are offered by NEED trainers throughout the NEED network, currently in 37 states including California. Materials such as a booklet entitled *Energy Projects and Activities* offer some ideas for extending the reach of energy projects/education. Participating classes are eligible to apply for the NEED Youth Awards Program for Energy Achievement, which are based on goal setting, activities to reach goals, energy content, student leadership, community involvement, use of resources, project evaluation, and project documentation.

***Energy & Society* (2002)**
American Forest Foundation
1111 19th Street, NW, Suite 780
Washington, DC 20036
www.plt.org

Project Learning Tree's *Energy & Society* program kit provides tools and activities to help students in grades PreK–8 learn about their relationship with energy and investigate the environmental issues related to energy's role in society. Materials in the kit include: an *Energy & Society* activity guide, "Where is the energy?" and "What powers the move?" posters and six companion activities, ideas for action projects and science fair projects, energy-related case studies, a list of energy-related children's literature and other resources, "Energy & Me" music CD with 15 energy-related songs from singer/songwriter, Billy B, an "Energy & Me" music and dance video.

Renewables Are Ready: A Guide to Teaching Renewable Energy in Junior and Senior High School Classrooms
Union of Concerned Scientists
Two Brattle Square
Cambridge, MA 02138
www.ucsusa.org

Publication can be downloaded at
www.ucsusa.org/publications/report.cfm?publicationID=308#energy

Recently revised and updated (2003), this teacher's guide provides the background information for teaching a unit on renewable energy. In addition, it offers a range of activities for more advanced sixth-grade students that explores: renewable energy resources such as solar energy, wind energy, and biomass; the scientific and technological aspects of large-scale applications; and the economic and environmental costs associated with renewable and non-renewable energy resources.

Teaching About Climate Change: Cool Schools Tackle Global Warming
Tim Grant and Gail Littlejohn, editors
Green Teacher
PO Box 1431
Lewiston, New York 14092
www.greenteacher.com

This collection contains articles and activities reprinted from *Green Teacher* magazine. Taken together, they provide a strong overview of climate change issues. The volume provides useful background on climate change and ideas for student action relating to global warming, and thus to energy conservation and reduction of greenhouse gases. Activities include campaigns to safely bike or walk to school, a car trip reduction plan for schools, campus monitoring programs, and design of school grounds.

Part 2—Websites

These websites have been selected to help teachers locate lesson plans and other ready-to-use resources for teaching about waste. A few student-oriented sites are included when they contain information useful to teachers. Additional student websites are listed in Section 4 of this guide.

Alliance to Save Energy
www.ase.org/section/_audience/educators/lessons

The Alliance to Save Energy website offers free downloadable multidisciplinary energy education lesson plans. The lesson plans are linked to the Alliance's energy conservation and efficiency Green Schools program.

Department for Environment, Food and Rural Affairs, United Kingdom
Encyclopedia of the Atmospheric Environment
www.ace.mmu.ac.uk

This easy-to-use online encyclopedia contains background information on nine atmosphere-related topics: acid rain, air quality, atmosphere, climate, climate change, global warming, ozone depletion, sustainability, and weather. Two versions of the encyclopedia—one technical, one for student use—are included. The site provides a resource section for students (**www.ace.mmu.ac.uk/kids**) and links to other energy and atmosphere sites.

Easy Breathers
www.easybreathers.org

This site connects transportation choices to environmental impacts. It includes downloadable classroom activities that help use the site to its fullest effect. Topics include greenhouse gases, air pollution, the impacts of average vehicle occupancy, and more.

EE-Link: Environmental Education on the Internet
http://eelink.net/classroom resources-directories.html

EE-Link provides extensive links to curricula, lesson plans, software, student websites, and other classroom resources on a wide variety of environmental topics.

Energy Quest
www.energyquest.ca.gov/index.html

Energy Quest offers energy information and activities, tips on how to be energy efficient, and links to classroom activities. The site includes online calculators that convert a variety of measurements to different units of measure (**www.energyquest.ca.gov/calculator/index.html**). The site also offers links to other teacher resources (**www.energyquest.ca.gov/teachers_resources/index.html**).

Mobile Source Emissions
National Safety Council
www.nsc.org/ehc/mse.htm

This website provides fact sheets on topics relating to mobile source emissions, or non-stationary sources of air pollutants and contaminants. One page features a report entitled "Outreach and Education on Air Quality, Climate Change, and Transportation: Youth Initiatives Report," which may provide ideas for service-learning projects.

Part 3—Student Literature

These titles have been identified by the publishers as appropriate for sixth-grade readers. Titles marked with an asterisk are also showcased in *Literature for Science and Mathematics: Kindergarten through Grade Twelve*, a collection of outstanding science- and mathematics-related literature for children and adolescents published by the California Department of Education. This online database can be found at **www.cde.ca.gov/ci/sc/ll/index.asp**.

Cars: An Environmental Challenge (Saving Planet Earth)
Authors: **Terri Willis, Wallace B. Black**
Publisher: **Childrens Press**
Publication Date: **1992**

This book discusses the environmental damage and safety problems associated with the internal combustion engine, with an emphasis on emissions and air pollution, and examines various solutions and alternatives to the situation.

Cleaning the Air (Our World, Our Future)
Author: **Sharon Dalgleish**
Publisher: **Chelsea House Publications**
Publication Date: **2002**

Cleaning the Air reviews the composition of air and its critical role in the survival of organisms. It also discusses the implication of human activity on air quality, including ozone layer depletion, pollution, and acid rain, and offers simple suggestions individuals can follow to help reduce pollution.

****Dr. Art's Guide to Planet Earth***
Author: **Art Sussman**
Publisher: **Chelsea Green Publishing**
Publication Date: **2000**

Dr. Art's Guide to Planet Earth focuses on how Earth functions as a system involving cycles of matter, flows of energy, and webs of life. From evolution and extinction, to carbon and climate change, this book demonstrates the interdependence of life forms and complexity of Earth's life supporting systems.

Earth, Fire, Water, Air
Author: **Mary Hoffman**
Publisher: **Dutton Childrens Books**
Publication Date: **1995 (1st American edition)**

Drawing from stories and images from both Western and non-Western traditions, this book celebrates the four elements ancient people believed made up the universe: earth, fire, water, and air. Combining philosophy with science, the author examines how human activity has affected these elements and in turn, advocates the need for corrective steps.

Earth's Resources (Science Fact Files)
Author: **Steve Parker**
Publisher: **Raintree Steck-Vaughn**
Publication Date: **2001**

The volumes in the nine-book Science Fact series offer full-color photographs, cutaway views, maps, fact files, glossaries, internet links, and brief two-page spreads that provide for a general understanding of each topic. The series discusses several common resources such as soil, fossil fuel, and solar power, as well as less common resources such as bio-resources and precious stones. The final chapter addresses concerns about the future of the Earth.

Energy Alternatives (Essential Energy)
Author: **Robert Snedden**
Publisher: **Heinemann Library**
Publication Date: **2001**

Energy Alternatives offers an introduction to alternative energy technologies. It begins with an introduction to current energy practices, an explanation of why energy is essential, and a statement concerning the importance of considering alternatives to oil consumption, such as fuel cells, cogeneration, solar, wind, water, geothermal, and biomass energy generation. The book concludes with an outlook on the future of energy generation and offers basic energy statistics and a short glossary

Energy (Invisible Journeys)
Author: **Caroline Grimshaw**
Publisher: **World Book Inc.**
Publication Date: **1998**

Sophisticated graphics, including full-color photography of original equipment, intricate scientific instruments, and three-dimensional models, are combined with an informative text that focuses on the ideas and discoveries that have changed our perception of energy and the universe.

Energy Supplies (Action for the Environment)
Author: **Chris Oxlade**
Publisher: **Smart Apple Media (Creative Co.)**
Publication Date: **2005**

This new book examines the topic of energy supplies as one of the most important environmental issues facing the world.

Environmental Science: Energy
Author: **Billy Goodman, et al.**
Publisher: **Globe Fearon/Pearson Learning Group**
Publication Date: **1995**

Student book and teacher's resource manual provide background information on: human use of energy, non-renewable energy, renewable energy and the environment; nuclear energy and the environment; and energy conservation strategies. Field investigations and laboratory studies are also suggested and are covered in detail in the teacher's resource manual. Each chapter concludes with topics for review and discussion.

Eyewitness: Energy
Author: **Jack Challoner**
Publisher: **DK Children**
Publication Date: **2000**

Using the stunning graphics the Eyewitness Series is known for, this book examines the concept of energy from prehistoric times to modern civilizations. From the basic use of fire and stone tools to modern uses of electricity generated by a variety of means, energy has affected daily life throughout history. This book also examines the environmental consequences of energy consumption, including air pollution and nuclear waste.

Fossil Fuels (Energy Essentials)
Author: **Nigel Saunders, Steven Chapman**
Publisher: **Raintree Steve Vaughn**
Publication Date: **2004**

The Energy Essentials series combines reports, recounts, quotations, and newspaper articles that offer compelling reading material, specifically for the reluctant reader. Examples of the use and

implications of use of fossil fuels relate directly to the reader's lives; liberal use of photographs, sidebars, and search topics for the internet add interest to the pages.

Future Energy (Your Environment)
Author: **Sally Morgan**
Publisher: **Stargazer Books (Creative Co.)**
Publication Date: **2005**

This new environmental series examines key environmental issues, such as energy resources and the consequences of energy consumption; case studies and suggested activities add further interest.

Matter and Energy: Principles of Matter and Thermodynamics (Secrets of the Universe)
Author: **Paul Fleisher**
Publisher: **Lerner Publishing**
Publication Date: **2002**

Matter and the Laws of Thermodynamics are explained in a detailed, yet entertaining way, encouraging readers to rethink their assumptions about flow of energy and arrangement of elements in the periodic table.

Nuclear Power: Promise or Peril? (Pro/Con)
Author: **Michael J. Daley**
Publisher: **Lerner Publishing**
Publication Date: **1997**

The complex and controversial topic of nuclear power is examined in a non-biased, insightful manner in *Nuclear Power: Promise or Peril? (Pro/Con).*

Polluted Air (Green Alert)
Author: **Clayton Trapp**
Publisher: **Raintree Steck Vaughn**
Publication Date: **2004**

Critical environmental issues are explored in this new series. As deep questions are posed to the reader—Is it too late to solve environmental problems? What natural disasters appear inevitable?—the book provides real-life case studies and suggestions for further research.

Resources: Nature's Riches (EarthWorks)
Author: **Roy A. Gallant**
Publisher: **Benchmark Books (Marshall Cavendish)**
Publication Date: **2003**

One title in the *EarthWorks* series, *Resources* describes the importance of Earth's natural resources and discusses how their misuse and depletion can endanger life on the planet.

Teen Guides to Environmental Science, Volume 2: Resources and Energy
Author: **John Mongillo**
Publisher: **Greenwood Press: Westport, CT**
Publication Date: **2004**

Only available as a complete set, *Teen Guides to Environmental Science* presents a comprehensive look at the current state of the environment and what needs to be done to move toward a sustainable society. Volume 2 focuses on land, water, and energy resources; other volumes examine a variety of concepts.

What If We Run Out of Fossil Fuels? (What If?)
Author: **Kimberly M. Miller**
Publisher: **Children's Press (CT)**
Publication Date: **2002**

What If We Run Out of Fossil Fuels? examines human dependence on fossil fuels through scenarios that describe life without such basic items as oil heaters and gasoline-powered cars. The book also presents alternative energy sources and conservation strategies to the reader.

Water Resources

Water Resources:
Section 1—Background Information

The Water Planet[*]

Earth is often called the "water planet" and the "big blue marble." Water covers more than 70 percent of the Earth's surface. Although water appears to be a plentiful resource, both available water quantity and water quality are serious concerns.

Water is essential for sustaining life. It is one of the chief ingredients in all living things; the human body, for instance, is about 65 percent water. A tomato is 95 percent water.

Remarkably, water exists on Earth as a liquid, a solid, and as a gas and touches all physical, chemical, and biological features on the planet. Known as the universal solvent, water is especially good at dissolving many different substances. It plays a tremendous role in erosion, and carries many chemicals—both helpful and harmful—as it moves through its natural cycles.

Water constantly changes form, from liquid to solid, liquid to gas, gas to liquid, but for all practical purposes the total amount on Earth never changes. Important for the survival of all organisms, however, is that the quantity and quality of water available for use changes constantly as a result of our use and management practices.

Sources of Water

Groundwater

About 95 percent of the earth's fresh water lies underground, stored in spaces between soil particles and in cracks in rocks, much like water in a sponge. This underground water is called groundwater. Geologists estimate that there are at least 33 trillion gallons of groundwater stored in the United States.[82]

Aquifers are areas of rock and soil that store large amounts of groundwater. Aquifers vary dramatically in size, from a few feet to several hundred feet in thickness. Some extend hundreds of square miles. If all the water in California's aquifers were on the surface, the state would be completely covered in water. Areas with one or more aquifers are known as groundwater basins. There are more than 500 groundwater basins in California, even in hot, dry desert areas.

Because it has been filtered and purified by seeping through rocks, groundwater is a valuable source of clean, fresh water. It supplies half the population of the U.S. with their fresh water needs. Overall, agriculture is the biggest user of groundwater; across the country, 60 billion gallons per day are withdrawn for irrigation. In California, groundwater normally supplies about one-third of the water we use each year. In drought years, groundwater can be used to meet up to two-thirds of our water needs.

Groundwater moves slowly through the soil and rock until it arrives at the ocean, reaches the surface in a spring or river, or is drawn out through a well. It is replenished only very slowly by water that seeps down from the surface—from precipitation as well as seepage from water used for irrigation and from riverbeds, streambeds, and cracks.

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[*] This background material is adapted from information provided by the California Farm Water Coalition, the Water Environment Federation, and *Environmental Action: Water Conservation Teacher Resource Guide*, published by Pearson Learning, Lebanon, Illinois, 1998.

Removing too much water from an aquifer can lead to problems, including:

- The soil can compact—like a dried out sponge—and the land above can sink, damaging roads, buildings, and pipelines.
- The aquifer may no longer be able to hold water.
- Plants with roots into the groundwater may die.
- The land elevation may lower (up to 30 feet in some areas of California), in turn causing flooding or altering the soil and its ability to support agriculture.
- In coastal areas, seawater can enter depleted aquifers.

Groundwater is threatened by pollution that seeps in from poorly constructed landfills, septic tank systems, salted roads, livestock areas, household chemicals, polluted surface water, and many other sources. It is very difficult, expensive, and not always possible to remove contaminants from polluted groundwater because of its slow movement, the difficulty in reaching it, and its slow replacement by nature. Many communities whose groundwater drinking source has become contaminated have had to spend millions of dollars for cleanup, which can be effective but can also double or triple the cost of water. Therefore, preventing groundwater contamination is economically and ecologically important.

Surface Water and Watersheds

The water visible on the earth's surface—oceans, lakes, rivers, streams, estuaries, and wetlands—is called surface water. In California, we depend on surface water for about two-thirds of the water we use.

Networks of streams, rivers, and lakes, along with the lands surrounding them form watersheds. A watershed is a system including the lands sloping down to a river, lake, or stream and the body of water into which the water collects. Its edges are determined by the elevation of surrounding land, with the highest elevation points marking the boundaries.

Watersheds are also called drainage basins or catchment areas because they drain and catch the rain and snowmelt that falls onto the land. As water runs down the surface of the land, the soil and plants collect large amounts of water and release it slowly to the riverbed or lake below. This process prevents flooding and makes more fresh water available by slowing its flow to the ocean and allowing it to seep underground.

When land in a watershed is paved, covered with concrete or buildings, or the vegetation is removed, its ability to prevent floods and replenish the fresh water supply is diminished. As cities and towns grow, of course, land is cleared and developed and severely impacting the natural functions of the watersheds in which they are located.

People Using Water

We need water to survive; humans cannot live longer than a week without water to drink. We also use water in countless ways: to manufacture products, to make gasoline, grow our food, wash our clothes, take showers, wash cars, water our lawns, and irrigate crops. Worldwide demand for water has tripled since 1950.[83]

In the United States, as in California, agriculture is the biggest user of water. Especially in the western states, irrigation has enabled farmers to grow crops on land that was once arid. Water is used to grow food for people and to grow crops used to feed livestock, such as alfalfa, corn, sorghum, and wheat.

Industry is the second largest U.S. water user. Water is used to produce hydroelectric power, in manufacturing paper, plastics, and countless other products, as a cooling agent, and to clean and air-condition factories.

People in the United States use more water per household than in most other countries. In many parts of the world, flush toilets, kitchen faucets, lawn sprinklers, and bathtubs are considered luxuries. New building regulations and drought-driven conservation efforts have led to a decrease in per capita domestic water use since 1985.

Recreational uses also place demands on water resources. Boating, skiing, swimming, and other water sports all depend on the availability of clean and adequate supplies of water. Typically, recreation does not affect the overall quantity of water but it can affect water quality and the supply of clean water.

Water Development

People build dams, reroute rivers, and put streams in channels to provide water supplies, generate electricity, and control flooding. Dams and other water management practices have affected more than 90 percent of the river miles in the United States.[84] These developments meet important needs; managing the water supply, providing electricity, opening waterways for navigation, and meeting agricultural and industrial demand for water. These alterations come with a variety of environmental costs that must be balanced with the potential benefits.

In many areas, channelization and removal of wetland habitats has influenced the flow of rivers and caused serious flooding. Some rivers and wetlands have slowed to a trickle or even dried out, and many plant and animal species dependent on waterways are threatened. The salmon population, for instance, has been greatly impacted by changes to rivers.

Limited Supplies and Water Transfer

The ease with which we can turn on a tap and have water at the ready is deceiving. Potable, usable water is in relatively short supply. About 97 percent of Earth's water is salt water in the ocean, leaving very little fresh water (3 percent) available for people and terrestrial plants and animals to use. Almost 75 percent of all fresh water is frozen in ice caps and glaciers. Only 0.6 percent is fresh, liquid water. Of that, 98 percent is underground and unavailable due to the cost or difficulty of accessing it. Supplies of fresh water have become even more limited due to pollution.

Water availability varies from place to place and season to season. Patterns of water use and supply in California are incongruous; 75 percent of the rain falls in the north, but 75 percent of the use is in the south. Most of the precipitation occurs in winter, but demands are highest in summer. Because of this uneven distribution, Californians must transport water to where it is needed. The State-run California Water Project, a complex system of reservoirs, aqueducts, power plants and pumping plants, stores water and delivers it to 29 urban and agricultural water suppliers in Northern California, the San Francisco Bay Area, the San Joaquin Valley, the Central Coast, and Southern California. As a result of the complexities of water supplies, water agencies, cities, and farm owners have begun making their own agreements to buy and sell water. Water that was previously used for agriculture, for example, might now be sold to cities. As a result, farmers might plant fewer crops or grow a crop that doesn't need as much water. Many types of agreements are being made but the most common are transfers are from agricultural regions to cities.

Water Management Challenges

Maintaining both the quantity and quality of water resources is a major challenge in California and elsewhere. Contaminants such as pesticides, fertilizers, bacteria, oil, household chemicals, and industrial wastes are polluting water around the globe. Over 700 pollutants have been found in American drinking water.[85]

Point and Nonpoint Sources

The sources of water pollution are divided into two main categories: point sources and nonpoint. Point sources can be easily identified and managed. They include facilities like sewage treatment plants and factory discharge pipes. Since the passage of the federal Clean Water Act of 1974, significant improvements have been made in reducing point source pollution.

Nonpoint source pollution is spread out and comes from many different spots. It is harder to pinpoint and harder to control. Examples of nonpoint pollution sources include:

- Chemicals used on lawns and farms
- Uncontrolled stormwater runoff
- Runoff from streets, parking lots and yards
- Leaks from landfills, hazardous dump sites, septic tanks, and underground storage tanks
- Sediments from construction sites and forestry operations
- Overflows from city sewers
- Ash from burning fuels
- Animal wastes

Agricultural Practices

Agriculture is one of California's biggest industries. It represents 7.9 percent of the gross state product and provides 8.7 percent of all jobs in the state.[86] Agriculture also plays a major role in water use and management practices throughout the state. Improvements in irrigation efficiency, crop selection, laser-guided leveling of land, and water recycling have helped California farms improve their water conservation efforts. At the same time, however, agriculture is one of the state's greatest sources of water pollutants.

Pesticides, herbicides, and fertilizers spread on fields seep through the soil into the groundwater and are carried by rain and irrigation water over land into streams and rivers. Many of these chemicals are known carcinogens or are linked to other diseases in human and wildlife populations.

Livestock wastes can also pollute water. The impact is most significant on feedlots, where excess nitrates flow into nearby streams and groundwater. In addition, some irrigation methods cause a buildup of salts on top of soils, eventually killing crops and carrying excess salt into drinking water sources.

Industrial Practices

The enforcement of federal and state regulations has improved treatment of wastewater leaving factories. Yet, industrial waste is still a major source of water pollution in the United States. Chemicals, such as chlorine from clothing and paper industries, enter waterways and are widely

distributed through streams, rivers and lakes. Acid rain, caused in part by the burning of fossil fuels by industry and automobiles, falls on land and works its way into waterways.

Contaminants other than chemicals can also affect water quality. Erosion problems arising from logging and construction practices, can cause both the loss of topsoil and the clogging streams and rivers with sediments. Water used for cooling is often released from factory sites and power plants into streams, rivers, lakes, and oceans, where water temperatures rise and can cause damage or death to aquatic plants and animals.

Landfills, Hazardous Waste Dumps, and Gasoline Tanks

Seepage from the garbage in landfills and hazardous waste dumps can affect groundwater quality. Although modern landfills are required to have special liners to prevent leaching of chemicals into the water, some studies estimate that as many as 75 percent of landfills in the United States leak contaminants.[87] Tanks that are used to store gasoline and other chemicals both underground and on the surface can also leak, spilling a variety of chemicals onto the soil and potentially into the groundwater system.

Households and Community

People's daily activities contribute to water pollution. Most human wastes, washing and laundering water, and garbage disposal output go through municipal sewage treatment plants or through septic tanks. These treatment systems effectively remove pollutants from sewage waste. However, these treatment plants can overflow and septic tanks can leak, introducing pollutants to surface water and groundwater.

In most areas, water that flows into storm drains in the street flows directly into streams and rivers without any treatment. The stormwater control system is operated separately from the sewage treatment system. Rainwater and other urban runoff travels over concrete and asphalt, picking up pollutants as it travels, and carrying them directly into natural waterways or into the stormwater system. These contaminants include animal wastes, pesticides and herbicides from lawns, soaps and detergents from washing cars, oil from leaking cars, used automotive fluids that people illegally pour down storm drains, and litter and trash such as cigarette butts thrown on the ground. These nonpoint source pollutants are difficult and very expensive to manage.

Water Conservation

Water conservation includes using less water and maintaining the supply of clean water by reducing water pollution. As a result of new regulations and voluntary efforts, water use in the United States has declined about 10 percent since 1980.[88]

Farmers are using water-efficient sprinklers and drip irrigation. Industries are recycling and reusing water within factories. Towns and cities are treating and reusing wastewater to fertilize and irrigate fields. Individuals have installed water-saving devices, fixed leaky pipes, and replaced water-wasting toilets.

There are many actions people can take—including students on school campuses—to preserve both the quantity and quality of available water. Improvements in technology, such as low-flow toilets, and changes in practice, even as simple as watering plants during cooler times of the day, can be important elements in efforts to conserve water.

Water Resources: Section 2—Primers

Primer #1: Do's and Don'ts Around the Home[*]

The importance of education in bringing nonpoint source pollution under control is a recurring theme in this issue of EPA Journal. The reason for this is pragmatic: What you don't know can hurt the environment. When rain falls or snow melts, the seemingly negligible amounts of chemicals and other pollutants around your home and premises get picked up and carried via storm drains to surface waters. The ramifications include polluted drinking water, beach closings, and endangered wildlife.

So what can you do to help protect surface and groundwaters from so-called nonpoint source pollution? You can start at home. Begin by taking a close look at practices around your house that might be contributing to polluted runoff: You may need to make some changes. The following are some specific tips to act on—dos and don'ts, organized by categories, to help you become part of the solution rather than part of the problem of nonpoint source pollution.

Household Chemicals

- Be aware that many chemicals commonly used around the home are toxic. Select less toxic alternatives. Use non-toxic substitutes wherever possible.
- Buy chemicals only in the amount you expect to use, and apply them only as directed. More is not better.
- Take unwanted household chemicals to hazardous waste collection centers; do not pour them down the drain. Pouring chemicals down the drain may disrupt your septic system or else contaminate treatment plant sludge.
- Never pour unwanted chemicals on the ground. Soil cannot purify most chemicals, and they may eventually contaminate runoff.
- Use low-phosphate or phosphate-free detergents.
- Use water-based products whenever possible.
- Leftover household pesticide? Do not indiscriminately spray pesticides, either indoors or outdoors, where a pest problem has not been identified. Dispose of excess pesticides at hazardous waste collection centers.

Landscaping and gardening

- When landscaping your yard, select plants that have low requirements for water, fertilizers, and pesticides. Cultivate plants that discourage pests. Minimize grassed areas, which require high maintenance.
- Preserve existing trees, and plant trees and shrubs to help prevent erosion and promote infiltration of water into the soil.

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[*] Excerpted from Robert Goo, "Do's and Don'ts around the Home," *EPA Journal*, November/December 1991 (EPA-22K-1005).

- Use landscaping techniques such as grass swales (low areas in the lawn) or porous walkways to increase infiltration and decrease runoff.

Other landscaping tips:

- Install wood decking or bricks or interlocking stones instead of impervious cement walkways.
- Install gravel trenches along driveways or patios to collect water and allow it to filter into the ground.
- Restore bare patches in your lawn as soon as possible to avoid erosion.
- Grade all areas away from your house at a slope of one percent or more.
- Leave lawn clippings on your lawn so that nutrients in the clippings are recycled and less yard waste goes to landfills.
- If you elect to use a professional lawn care service, select a company that employs trained technicians and follows practices designed to minimize the use of fertilizers and pesticides.
- Compost your yard trimmings. Compost is a valuable soil conditioner, which gradually releases nutrients to your lawn and garden. (Using compost will also decrease the amount of fertilizer you need to apply.) In addition, compost retains moisture in the soil and thus helps you conserve water.
- Spread mulch on bare ground to help prevent erosion and runoff.
- Test your soil before applying fertilizers. Over- fertilization is a common problem, and the excess can leach into groundwater or contaminate rivers or lakes. Also, avoid using fertilizers near surface waters. Use slow- release fertilizers on areas where the potential for water contamination is high, such as sandy soils, steep slopes, compacted soils, and verges of water bodies. Select the proper season to apply fertilizers: Incorrect timing may encourage weeds or stress grasses. Do not apply pesticides or fertilizers before or during rain due to the strong likelihood of runoff.
- Calibrate your applicator before applying pesticides or fertilizers. As equipment ages, annual adjustments may be needed.
- Keep storm gutters and drains clean of leaves and yard trimmings. (Decomposing vegetative matter leaches nutrients and can clog storm systems and result in flooding.)

Septic Systems

Improperly maintained septic systems can contaminate groundwater and surface water with nutrients and pathogens. By following the recommendations below, you can help ensure that your system continues to function properly.

- Inspect your septic system annually.
- Pump out your septic system regularly. (Pumping out every three to five years is recommended for a three-bedroom house with a 1,000-gallon tank; smaller tanks should be pumped more often.)
- Do not use septic system additives. There is no scientific evidence that biological and chemical additives aid or accelerate decomposition in septic tanks; some additives may in fact be detrimental to the septic system or contaminate groundwater.

- Do not divert storm drains or basement pumps into septic systems.
- Avoid or reduce the use of your garbage disposal. (Garbage disposals contribute unnecessary solids to your septic system and can also increase the frequency your tank needs to be pumped.)
- Don't use toilets as trashcans! Excess solids may clog your drainfield and necessitate more frequent pumping.

Water Conservation

Homeowners can significantly reduce the volume of wastewater discharged to home septic systems and sewage treatment plants by conserving water. If you have a septic system, by decreasing your water usage, you can help prevent your system from overloading and contaminating ground water and surface water. (Seventy-five percent of drainfield failures are due to hydraulic overloading.)

- Use low-flow faucets, showerheads, reduced-flow toilet flushing equipment, and water saving appliances such as dish and clothes washers.
- Repair leaking faucets, toilets, and pumps.
- Use dishwashers and clothes washers only when fully loaded.
- Take short showers instead of baths and avoid letting faucets run unnecessarily.
- Wash your car only when necessary; use a bucket to save water. Alternatively, go to a commercial carwash that uses water efficiently and disposes of runoff properly.
- Do not over-water your lawn or garden. Over-watering may increase leaching of fertilizers to groundwater.
- When your lawn or garden needs watering, use slow-watering techniques such as trickle irrigation or soaker hoses. (Such devices reduce runoff and are 20 percent more effective than sprinklers.)

Other Areas Where You Can Make a Difference

- Clean up after your pets. Pet waste contains nutrients and pathogens that can contaminate surface water.
- Drive only when necessary. Driving less reduces the amount of pollution your automobile generates. Automobiles emit tremendous amounts of airborne pollutants, which increase acid rain; they also deposit toxic metals and petroleum by-products into the environment. Regular tune-ups and inspections can help keep automotive waste and by-products from contaminating runoff. Clean up any spilled automobile fluids.
- Recycle used oil and antifreeze by taking them to service stations and other recycling centers. Never put used oil or other chemicals down storm drains or in drainage ditches. (One quart of oil can contaminate up to two million gallons of drinking water!)

Community Action

- Participate in cleanup activities in your neighborhood.

- Write or call your elected representatives to inform them about your concerns and encourage legislation to protect water resources.
- Get involved in local planning and zoning decisions and encourage your local officials to develop erosion and sediment control ordinances.
- Promote environmental education. Help educate people in your community about ways in which they can help protect water quality. Get your community groups involved.

Primer #2: Preventing Nonpoint Source Pollution[*]

Urban Stormwater Runoff

- Keep litter, pet wastes, leaves, and debris out of street gutters and storm drains—these outlets drain directly to lake, streams, rivers, and wetlands.
- Apply lawn and garden chemicals sparingly and according to directions.
- Dispose of used oil, antifreeze, paints, and other household chemicals properly, not in storm sewers or drains. If your community does not already have a program for collecting household hazardous wastes, ask your local government to establish one.
- Clean up spilled brake fluid, oil, grease, and antifreeze. Do not hose them into the street where they can eventually reach local streams and lakes.
- Control soil erosion on your property by planting ground cover and stabilizing erosion-prone areas.
- Encourage local government officials to develop construction erosion/sediment control ordinances in your community.

Mining

- Become involved in local mining issues by voicing your concerns about acid mine drainage and reclamation projects in your area.

Forestry

- Use proper logging and erosion control practices on your forest lands by ensuring proper construction, maintenance, and closure of logging roads and skid trails.
- Report questionable logging practices to State and federal forestry and State water quality agencies.

Agriculture

- Manage animal waste to minimize contamination of surface water and groundwater.
- Protect drinking water by using less pesticides and fertilizers.
- Reduce soil erosion by using conservation practices and other applicable best management practices.
- Use planned grazing systems on pasture and rangeland.
- Dispose of pesticides and containers in an approved manner.

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[*] This information was reproduced from the U.S. Environmental Protection Agency's website (What you can do to prevent NPS pollution—**www.epa.gov/owow/nps/whatudo.html**). It also appears in EPA's 1994 brochure, "Polluted" (EPA 841-F-94-005).

Primer #3: California's State Water Project[*]

Planned, designed, constructed, operated, and maintained by the California Department of Water Resources (DWR), the State Water Project (SWP) is the largest state-built, multi-purpose, user-financed water project in the United States.

The SWP, spanning more than 600 miles from Northern California to Southern California, includes 33 storage facilities, 20 pumping plants, four pumping generating plants, five hydroelectric power plants, and approximately 700 miles of canals, tunnels, and pipelines.

The SWP's main purpose is to provide a water supply—that is, to divert and store water during wet periods and distribute it to areas of need in Northern California, the San Francisco Bay area, the San Joaquin Valley, the Central Coast, and Southern California. Other SWP purposes include flood control, power generation, recreation, fish and wildlife enhancement, and water quality improvement in the Sacramento-San Joaquin Delta.

Californai's existence and continued prosperity depend on water. More than two-thirds of the people of California receive at least part of their water from the State Water Project. Project water also supplies thousands of industries and irrigates hundreds of thousands of acres of California farmland.

State Water Project Milestones[†]

1950s

1956

Special session of the Legislature, called by Governor Goodwin J. Knight, creates a single State Department of Water Resources. It replaces the State Engineer's Office, the Water Project Authority, the State Water Resources Board, and the Division of Water Resources of the Department of Public Works. (Water rights jurisdiction is assigned to another new agency—the State Water Rights Board. In 1967, its functions are taken over by the State Water Resources Control Board.)

On July 5, 1956, the State Department of Water Resources comes into existence.

The new Department is organized with a Division of Resources Planning, Division of Design and Construction, Division of Administration, and a Southern California District.

DWR also acquires the duties of the State Water Board, later renamed the California Water Commission.

Governor Knight appoints a distinguished consulting engineer—Harvey O. Banks—to be its first director. Banks serves as DWR Director from 1956–1961.

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[*] The four introductory paragraphs in Primer #3 have been excerpted with permission from an upcoming revision of *California's State Water Project*, California Department of Water Resources, Sacramento, Calif., projected publication date, November 2005.

[†] Reprinted from Department of Water Resources website: **www.publicaffairs.water.ca.gov/swp/milestones.cfm** (October 4, 2005).

1957

The department completes the California Water Plan (Bulletin No. 3). It presents preliminary plans for developing all of the state's water resources to meet its ultimate water needs. Those plans include a system of reservoirs, aqueducts, pumping and power plants that would transport water from areas of surplus in the north to the water deficient south.

1959

State engineers recommend alternative routes for aqueduct systems to serve Southern California.

The Legislature enacts Burns-Porter Act, providing initial funding of $1.75 billion in general obligation bonds and authorizing construction of its facilities.

1960s

1960

California voters approve the Burns-Porter Act to finance construction of the State Water Project.

Whale Rock Dam, located near San Luis Obispo, is completed to meet the county's water needs. It was the first major dam designed and constructed by DWR.

1961

On January 1, William E. Warne is appointed director. Warne serves until December 31, 1966. (Mr. Warne died March 9, 1996.)

The department is reorganized with the Division of Resources Planning split into four branches situated in Sacramento, and a headquarters staff. The branches were the Bay Area, Delta, Northern and San Joaquin Valley, and a Technical Services Office. The Division of Operations and Maintenance is added, as well as the Division of Design and Construction was established, approved and financed by the Burns-Porter Act.

Construction begins on State Water Project facilities, including Oroville Dam, key water storage facility on the Feather River in the upper Sacramento Valley.

California and the U.S. Government sign an agreement to build the San Luis Joint-Use Facilities for storage, pumping, and conveyance for State-federal water operations.

1962

President John F. Kennedy and Governor Edmund G. Brown, Sr. join in a dedication ceremony for the San Luis Dam and Reservoir in the San Joaquin Valley west of Los Banos. (Governor Brown, a leader in developing the State Water Project, served as California's Governor from 1959 to 1967. The California Aqueduct was renamed the Edmund G. Brown California Aqueduct in his honor in December 1982. He died on February 16, 1996.)

1963

Construction begins on San Luis Dam. The San Luis Reservoir is planned for joint use by the SWP and the federal Central Valley Project, since both systems require storage of surplus flows pumped from the Delta.

Construction begins on the Harvey O. Banks Pumping Plant in the South Delta, starting point of the California Aqueduct.

The Baldwin Hills Dam failure dramatically impacts and restructures the Division of Safety of Dams.

The Power Office is created in October.

The San Joaquin District is established in Fresno.

1964

December storms cause severe flooding along North Coast rivers, including the Smith, Eel and Van Duzen. December flooding on the Feather River is checked by the partially completed Oroville Dam.

DWR moves into the Resources Building from 19 locations in Sacramento. The building is dedicated on January 8, 1965.

1965

Construction begins on A.D. Edmonston Pumping Plant, largest pumping facility of the State Water Project, to lift water almost 2,000 feet up and over the Tehachapi Mountains into Southern California. At peak capacity, the plant pumps almost 2 million gallons a minute through 10 miles of pipeline across the Tehachapi Mountains.

The new Division of Safety of Dams is created on July 1.

Bay Area District is established in Vallejo. It closes in 1968 and merges with the Sacramento District to form the Central District.

1967

Effective January 1, Governor Ronald Reagan appoints William R. Gianelli as DWR Director. Gianelli serves until April, 1973.

Feather River Salmon and Steelhead Hatchery below Oroville Dam opens to help compensate for the loss of natural spawning areas to the dam.

Construction is completed on Oroville Dam. At 770 feet high, Oroville Dam is the tallest earthfill dam in the nation. Its reservoir is the largest in the SWP, with a capacity of 3.5 million acre-feet.

Construction is completed on the San Luis Dam. With a capacity of two million acre-feet, the San Luis Reservoir in the eastern foothills of the Diablo Mountain Range, is the largest off-stream reservoir in the United States.

1968

Electric power generation begins at Oroville Dam.

On April 3, the department sells $150 million in bonds to pay for construction costs of the Oroville Division power facilities. This is the first sale of revenue bonds to finance SWP construction. (The department was able to retire the 50-year bonds by April 1, 1994.)

Banks Pumping Plant is completed. With seven units, its pumping capacity is 6,400 cubic feet per second. (In 1991, four more units are added, boosting total capacity to 10,300 cfs.)

1969

The Reclamation Board staff and responsibilities are transferred to DWR.

1970s

1971

On October 8, Governor Ronald Reagan starts the first pump at A.D. Edmonston Pumping Plant, as part of a ceremony celebrating the first water deliveries to Southern California.

1973

Initial facilities of the State Water Project are completed.

John R. Teerink, a career DWR engineer, is appointed director. He serves until 1975. (Teerink was killed in an automobile accident on July 30, 1992.)

1975

Governor Edmund G. Brown, Jr. appoints Ronald E. Robie, an attorney and legislative consultant on water law and policy, as DWR Director. Robie serves until 1983.

1977

The State Water Project Analysis Office is established to handle contract administration and negotiations, as well as project repayment and financial analysis for the SWP.

1979

The California Cooperative Snow Survey Program celebrates its golden anniversary, as does the Dam Safety program.

The Office of Water Conservation is established to bring together urban and agricultural conservation efforts.

1980s

1981

DWR celebrates its 25th anniversary at the Sacramento Convention Center.

1982

Voters reject Proposition 9 (SB 200) to build a Peripheral Canal along the eastern edge of the Delta. (In 1977, DWR had proposed a combination of state-federal programs and facilities, including a 42-mile canal to bypass the Delta and more efficiently move water from the Sacramento River south to CVP and SWP pumping plants. These later evolved into Senate Bill 200)

1983

David N. Kennedy, an engineer and water industry executive who worked for DWR as an engineer in the 1960s, is appointed Director of DWR by Governor George Deukmejian.

DWR becomes a bulk power agency to better manage its power needs, making the State Water Project the fifth largest electric utility in California. (DWR is also the 12th-largest public-owned electric system in the nation.)

1984

The Legislature authorizes construction of Los Banos Grandes, a 1.75 million acre-feet offstream reservoir south of the Delta. It would benefit the Delta by increasing export pumping flexibility to offset impacts on Delta fish. (The project is put on hold pending a Bay-Delta solution.)

1986

DWR and the Department of Fish and Game sign an agreement to determine mitigation measures for the Harvey O. Banks Pumping Plant. Often called the "4-Pumps Agreement," referring to the four additional pumps to be installed at the Pumping Plant. The agreement's primary purpose is to offset the direct losses of striped bass, chinook salmon and steelhead caused by the pumping plant's operation. Funding comes from an initial $15 million to support fishery improvement programs and an account funded by the State Water Contractors to offset annual fish losses. This engineering addition will add significant new capabilities to the SWP's Delta export program.

In February, DWR's Flood Operations Center becomes the headquarters for many Northern California flood fights after torrential rains, starting February 19, lashed much of the North State for more than a week. Flooding occurs along several major Northern California rivers. The toll: 12 dead, 67 injured, 1,382 homes destroyed, and 12,447 homes damaged. Total damage is estimated at more than $500 million.

The East Branch Enlargement begins to expand the capacity of the aqueduct to move more water south during wet years for storage in groundwater basins. The work includes raising the canal lining, building a new power plant, and modifying other facilities.

A ceremony marks the beginning of construction of the Suisun Marsh Salinity Control Gates, which will allow fresh water into the marsh to preserve it as the largest contiguous brackish water marsh remaining in the U.S. The gates are declared operational on November 22, 1989.

1987

The California Legislature recognizes 1986–87 as a critically dry water year and requests that DWR provide drought contingency planning assistance to the water industry.

The Office of Public Information and Communications (now known as the Office of Water Education) is established.

On November 24, after more than 25 years of negotiations and Congressional approval, Director Kennedy and David Houston, Regional Director, U.S. Bureau of Reclamation, sign the Coordinated Operation Agreement. It ushers in a new era of cooperation in operating the State Water Project and the Central Valley Project.

1987–1992

Major California drought impacts SWP water deliveries. DWR operates the Drought Information Center and expands water conservation education efforts.

1988

After more than two years of planning and negotiating, the Department purchases 19,900 acres adjacent to the Kern River, establishing the Kern Water Bank, a SWP groundwater recharge program.

1989

The week of May 1–7 marks the first statewide celebration of Water Awareness Week. The event is later extended over the entire month of May.

1990s

1991

Governor Pete Wilson reappoints David N. Kennedy as DWR Director.

DWR initiates a California Water Bank to facilitate transfers and sales of water during drought to meet water needs. The Water Bank was activated in the drought years of 1991, 1992 and 1994.

1992

In April, Governor Wilson announces a long-term comprehensive water policy that takes account of the needs and concerns of each of the major interests in water use and development. It includes fixing the Sacramento-San Joaquin Delta, protecting groundwater resources and fish and wildlife, and promoting water marketing, water conservation, and water recycling.

1993

In December, DWR begins construction on a 100-mile Coastal Branch. This pipeline project will allow State Water Project water to be transported to Santa Barbara and San Luis Obispo counties—a drought-vulnerable area—as a supplemental water supply. Completion of this $530 million project is expected in 1997.

1994

In July, State and federal agencies sign the Framework Agreement, whose principles set into motion processes to provide more reliable water supplies for Northern and Southern California, protect wildlife in the Bay- Delta ecosystem, and prohibit the listing of more endangered species. To help fulfill the agreement, the CALFED Bay-Delta Program was established and charged with developing long-term solutions to problems in the Bay-Delta estuary.

On December 1, negotiators for DWR and the State Water Contractors reach an agreement, known as the Monterey Agreement, to modernize the way the State Water Project allocates, stores, and sells water. These changes represent the most significant since contracts were signed in the early 1960s.

As a leading State agency, DWR signs on December 15 “The Principles for Agreement on Bay-Delta Standards,” a major agreement on Delta water supplies, water quality and environmental protection. The department will also serve as an active partner in the CALFED Bay-Delta Program process created by the agreement to develop solutions to Delta water supply and quality challenges.

1995

DWR relocates operational headquarters for the SWP from the Resources Building in downtown Sacramento to a renovated building north of the downtown. The new Joint Operations Center is shared with the U.S. Bureau of Reclamation, operators of the Central Valley Project, and the National Weather Service, a partner in DWR’s new Flood Center.

1996

Heavy rain and snowfall during January and February assure ample water supplies for 1996. On March 8, DWR announces it will deliver 100 percent of the water amounts requested (about 2.7 million acre-feet) by its 29 long-term water supply contractors in 1996.

DWR and USBR release environmental documents for a South Delta Program to improve flows for fish habitat, agriculture, and water exports. It includes installing three permanent flow control structure and a fish barrier, dredging channels, and constructing a new intake to Clifton Court Forebay.

1997

The 100-mile-long Coastal Aqueduct was completed and the project was dedicated on July 18, 1997. The pipeline project transports State Water Project water to Santa Barbara and San Luis Obispo Counties.

1999

Thomas M. Hannigan was appointed as Director of the Department of Water Resources by Governor Gray Davis.

In December, the State Water Project Atlas was published. This multi-color, illustrated reference book describes the major features of the State Water Project and is available for purchase by the public.

2000s

2000

The CALFED Bay-Delta Program published a plan to fix Delta water problems and address its major water challenges over the next 30 years. Agreement on the plan was jointly announced on June 9, 2000, by California Governor Gray Davis, U.S. Secretary of the Interior Bruce Babbitt, and California Senator Dianne Feinstein. The plan was formalized in a Record of Decision issued on August 28, 2000.

DWR assumed a leading role in the implementation of the CALFED plan, including programs related to water storage, Delta conveyance, Delta levee system integrity, watershed management, water use efficiency, and water quality

2001

The CALFED Environmental Water Account, or EWA, completed its first year of operation. The EWA provided 287,000 acre-feet of water for environmental purposes without reducing Project deliveries.

Water Resources:
Section 3—Educational Resources

The materials listed below are readily available and can assist teachers with selecting and implementing service-learning projects following a campus water audit or to supplement instructional content in the classroom.

Part 1—Publications and Software

Adopt-A-Watershed
P.O. Box 1850
Hayfork, CA 96041
www.adopt-a-watershed.org/

Adopt-A-Watershed is a comprehensive watershed education program with monitoring and service-learning components, though they are not necessarily campus-based. The program offers a catalog of publications, curricula, and other resources, and offers intensive professional development through their Leadership Institutes.

California's Water Resource Map
Metropolitan Water District of Southern California
PO Box 54153
Los Angeles, CA 90054
www.mwdh2o.com/mwdh2o/pages/education/sc_teacher/teach03_01.html

This map, designed for grades 3 – 12, shows water resources in California and clarifies local, state, and federal projects.

Conserve Water Educators' Guide: Water Conservation Activities and Case Studies
Project WET
201 Culbertson Hall
PO Box 170575
Montana State University
Bozeman, MT 59707-0575
www.projectwet.org/watercourse/

Designed for grades 6 – 12, this module explores water conservation from the perspective of water resources management. Real-life case studies of water management scenarios are provided; students apply analytical skills to think through the complex issues each presents. The module also includes activities, charts, and illustrations.

Discover a Watershed: The Watershed Manager Educators Guide
Project WET
201 Culbertson Hall
PO Box 170575
Montana State University
Bozeman, MT 59707-0575
www.projectwet.org/watercourse/

This 193-page guide contains 19 science-based, multidisciplinary activities that teach what a watershed is, how it works, and why we must all consider ourselves watershed managers. An extensive background section introduces readers to fundamental watershed concepts. Each

activity can be adapted to your local watershed, contains e-links for further internet research, and is correlated to the National Standards for Science.

The Geography of Water
Metropolitan Water District of Southern California
PO Box 54153
Los Angeles, CA 90054
www.mwdh2o.com/mwdh2o/pages/education/sc_teacher/teach03_01.html

Designed for grades 4 – 8, this curriculum includes a series of six maps of California that teach and integrate specific geographic and water related concepts. By coloring these maps according to the directions, students learn about the state's physical features, precipitation, population, industry and agriculture, and managing California's water supply. These map activities involve students in critical thinking, problem solving, and comparing statistics. The curriculum includes a teacher guide for each map, reproducible student maps and lessons.

Give Water a Hand Action Guide and Leader Guidebook
University of Wisconsin-Extension
210 Hiram Smith Hall
1545 Observatory Drive
Madison, WI 53706-1289
www.uwex.edu

Publication can be downloaded at www.uwex.edu/erc/gwah.

Both publications offer help in planning and implementing a service-learning project relating to water. The *Youth Action Guide* is written for students and contains checklists for assessing a site for possible water-related issues. The guide offers tangible ideas for students on how to carry out a successful action project. In particular, the Skills Bank includes tips to sharpen necessary skills, including brainstorming ideas, getting resources over the phone, taking notes, interviewing, working as a team, and publicizing a project. The guides include project ideas for school, community, home, and farms.

The *Leader Guidebook* accompanies the *Action Guide* and provides background information, contacts, a short list of award and grant opportunities, and suggestions for using Give Water a Hand in school settings (it was developed for use with youth groups). A list of project partners is also included; the list is annotated and provides contact information.

Healthy Water, Healthy People
201 Culbertson Hall
PO Box 170575
Montana State University
Bozeman, MT 59707-0575
http://www.healthywater.org

This innovative and comprehensive water quality education program combines classroom-based instruction and water quality testing applications. Co-sponsored by Project WET and the Hach Scientific Foundation, *Healthy Water, Healthy People* offers hands-on investigations that focus on specific water quality issues, offering students the opportunity to test for and analyze a number of water quality parameters.

Project WET Curriculum and Activity Guide
201 Culbertson Hall
Montana State University
P.O. Box 170575
Bozeman, MT 59717-0575
www.project wet

Project WET (Water Education for Teachers) is a water education program for educators. The program facilitates and promotes awareness, appreciation, knowledge, and stewardship of water resources through the dissemination of curricula, training and instruction. The *Project WET Curriculum and Activity Guide* contains over 90 science-based activities and lessons on all aspects of water and water management, and is only available through training workshops.

Protecting Our Watersheds: An Earth Force GREEN Action Publication
Earth Force GREEN
1908 Mt. Vernon Avenue, 2nd Floor
Alexandria, Virginia 22301
www.green.org/

Protecting Our Watersheds is a program for middle school-aged students to study their watershed and work on projects to improve its health. The program can be used in any watershed setting since the process is the same in freshwater ponds, lakes, streams, rivers, and bays, in wetland swamps, marshes, and bogs, and in coastal areas.

The activity notebook starts by providing background in watershed studies, moves through gathering essential information on a watershed through field research, and guides the selection of a watershed-related study problem. One chapter addresses ways in which human behaviors contribute to watershed problems. Students can apply their knowledge and skills by deciding what to do and taking action.

Low-cost monitoring equipment is available through their catalog, as are a number of additional publications. Exchanging information and working with schools across the country and around the world is a dynamic component of the program.

Tapwater Tour
LaMotte Company
PO Box 329
Chestertown, MD 21620
www.lamotte.com

This is a hands-on science curriculum and water test kit designed for use in grades 4 – 8. Students discover for themselves what is in their home or school tapwater using simple and safe reagent tables. Parameters include pH, chlorine, hardness, iron, and copper. Teacher units include lecture materials, illustrated handouts, test procedures, and games to reinforce key concepts in the unit.

Urban Water Quality Test Kit
LaMotte Company
PO Box 329
Chestertown, MD 21620
www.lamotte.com

Since it is often not feasible for a group of students to sample a stream, river, or lake, this kit has been developed to test water locally in the form of drinking water, urban runoff, puddles, and small ponds. The kit uses safe, easy TesTabs to analyze eight key parameters: chlorine, copper,

hardness, iron, nitrate, pH, phosphate, and temperature. The guide also includes a handbook for teachers.

Water Sourcebook: A Series of Classroom Activities for Grades K-2, 3-5, 6-8, 9-12
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
www.wef.org or www.legacyenved.com

Each book in the four volume series (K–2, 3–5, 6–8, 9–12) is divided into five topic areas: Introduction to Water, Surface Water, Wetlands and Coastal Resources, Drinking Water and Wastewater Treatment, and Ground Water. Each volume is a supplemental activity guide of over 60 hands-on activities designed to teach about water resources and water conservation. The books also include an extensive glossary, teacher fact sheets about water-related issues, and a curriculum correlation index. The fact sheets are extensive and could be useful in developing service-learning projects.

Water Times
Metropolitan Water District of Southern California
PO Box 54153
Los Angeles, CA 90054
www.mwdh2o.com/mwdh2o/pages/education/sc_teacher/teach03_01.html

Designed specifically for a sixth-grade audience, this water education newspaper creates an awareness of water in a unique and interesting way. It is relevant to sixth graders' lives, and is interdisciplinary and correlated to California standards. Subscriptions include consumable student newspapers and teacher's guides.

Watershed Patch Project
United States Environmental Protection Agency
Office of Water, Washington, D.C.
August 2002
EPA #840-B-02-001

Can be downloaded at www.epa.gov/adopt/patch/watershedpatch.pdf

EPA's Watershed Patch project is modeled after the successful Water Drop Patch Project, which is a collaborative effort between EPA and the Girl Scouts of the USA. This version is intended for use with schools, youth groups, science clubs, and others interested in watershed protection. The materials focus on watersheds, but most activities are not particularly relevant to campus-based service-learning efforts. Part III of the document, however, contains instructions and resources for carrying out eight different community projects and hands-on activities. The storm drain stenciling guidelines and some of the other suggested projects could be applicable at the school site. In addition, some of the background material might be valuable for teachers.

Part 2—Websites

These websites have been selected to help teachers locate lesson plans and other ready-to-use resources for teaching about waste. A few student-oriented sites are included when they contain information useful to teachers. Additional student websites are listed in Section 4 of this guide.

California Department of Water Resources
www.dwr.water.ca.gov/

Within the Department of Water Resources, the Office of Water Education website (**www.owe.water.ca.gov/education/index.cfm**) offers curriculum guides, videos, computer software and other resources to teach about water.

EE-Link: Environmental Education on the Internet
http://eelink.net

EE-Link provides extensive links to curricula, lesson plans, software, student websites, and other classroom resources on a variety of environmental topics.

GLOBE

www.globe.gov/

GLOBE is a worldwide, hands-on, school-based monitoring and measuring science education program. Students take scientifically valid measures related to several environmental factors and report their data through the Internet.

San Diego County Water Authority

www.sdcwa.org/education

The San Diego County Water Authority website offers resources that teach water quality testing procedures, as well as opportunities to obtain free materials, including curricula (school-site training is required).

Surf Your Watershed
United States Environmental Protection Agency
www.epa.gov/surf

This online service helps you locate, use, and share environmental information about your state and watershed. The site contains four separate sections; "Locate Your Watershed" is probably the most useful for classroom purposes. Using ZIP code submissions, the site provides links to localized U.S. EPA databases in categories affecting specific watersheds. Other sections include Adopt Your Watershed, Water Atlas, and environmental websites.

University of Wisconsin Extension
Educating Young People About Water
www.uwex.edu/erc/eypaw

This site includes links to water-related materials, guides, and curricula.

United States Geological Survey
Water Science for Schools
http://ga.water.usgs.gov/edu/

This USGS site offers background information on water systems, water questions and answers, and links to other organizations and agencies.

Water Education Foundation
www.water-ed.org

The Water Education Foundation offers posters, books, maps, curriculum, and other resources for schools. The site also offers background information for students.

Part 3—Student Literature

These titles have been identified by the publishers as appropriate for sixth-grade readers. Titles marked with an asterisk are also showcased in *Literature for Science and Mathematics: Kindergarten through Grade Twelve,* a collection of outstanding science- and mathematics-related literature for children and adolescents published by the California Department of Education. This online database can be found at **www.cde.ca.gov/ci/sc/ll/index.asp**.

Chattanooga Sludge: Cleaning Toxic Sludge from Chattanooga Creek
Author: **Molly Bang**
Publisher: **Harcourt Brace**
Publication Date: **1996**

The author traces the efforts to clean-up the Tennessee's heavily contaminated Chattanooga Creek where years of industrial dumping had created a toxic sludge. The work of one scientist who successfully experiments with bioremediating plants is showcased.

****Eco-Women: Protectors of the Earth***
Author: **Willow Ann Sirch**
Publisher: **Fulcrum Publishing**
Publication Date: **1996**

The author describes the lives of famous women who have worked to protect certain animals and their habitats. Included are Barbara Kerr who invented a way to provide clean water to developing nations; Jane Goodall, who dedicated her life's work to saving and learning about chimpanzees; and Wangari Maathai who spearheaded a movement to plant thousands of trees and other plants in Africa.

Environmental Science: Water & Air
Author: **Hunter, et al.**
Publisher: **Globe Fearon/Pearson Learning Group**
Publication Date: **1995**

Student book and teacher's resource manual provide background information on water supply and water quality, water conservation, along with other issues related to the atmosphere, air pollution, and air pollution issues. Field investigations and laboratory studies are also suggested and are covered in detail in the teacher's resource manual. Each chapter concludes with topics for review and discussion.

My Water Comes from the Mountains
Author: **Tiffany Fourment**
Publisher: **Roberts Rinehart Publishers**
Publication Date: **2004**

This is an engaging children's book about the journey of water to the Atlantic or Pacific Oceans, depending on which side of the Continental Divide the water falls. From alpine tundra to the prairies, the text reveals how water serves many uses on its way to the sea. Also emphasizes human use and how people can best protect valuable water resources from pollution and other threats.

****A River Ran Wild: An Environmental History***
Author: **Lynne Cherry**
Publisher: **Harcourt Brace**
Publication Date: **1992**

This book traces the environmental history of the Nashua River from the time a group of Native Americans settled there through the present. The story focuses on the impact of civilization on the river, the resulting pollution, and how a group of activists were able to clean up the water. The full-color paintings are bordered with miniature illustrations of local wildlife, artifacts, and scenes.

Water: Our Precious Resource (EarthWorks)
Author: **Roy A. Gallant**
Publisher: **Benchmark Books (Marshall Cavendish)**
Publication Date: **2003**

Water: Our Precious Resource offers engaging discussions of water resource issues, including the value of water and the influence of water on natural and social systems—from weather, farming, and fisheries to human recreation.

Water Pollution (True Books: Environment)
Author: **Rhonda Lucas Donald**
Publisher: **Children's Press**
Publication Date: **2002**

Part of the *True Books: Environment* series, *Water Pollution* examines water as a limited resource, sources of and implications for water pollution, and the role of wetlands and other services in cleaning waterways and water supplies.

Where Does Your Water Come From?
Author: **Judy Wheatley Maben**
Publisher: **Water Education Foundation**
Publication Date: **2003**

Where Does Your Water Come From? reveals sources of drinking water as well as the complex systems in place to deliver water to the tap. Colorful photographs and text describe the water cycle, watersheds, surface water, groundwater, sources of pollution, and what strategies help prevent degradation of water supplies.

****Who Really Killed Cock Robin? An Ecological Mystery***
Author: **Jean Craighead George**
Publisher: **HarperCollins**
Publication Date: **1991**

A 13-year-old boy tries to identify the reason for the death of a robin. He investigates his community's environment, tests water for contaminants, and traces the food webs of local organisms to unravel the culprit of the mysterious death. The solution to the mystery is intriguing.

World of Water: Essential to Life (Rocks, Minerals, and Resources)
Author: **Rona Arato**
Publisher: **Crabtree Publishing Company**
Publication Date: **2004**

This book examines the role of water as Earth’s most valuable resource, its composition and origin, how it travels through the water cycle, how it shapes landscapes, its use as an energy resource, and the effect pollution has on our freshwater supply.

Water Resources: Section 4—Glossary of Terms*

Accumulation: The process in which water pools in large bodies (such as oceans, seas and lakes).

Acid Rain: Rain with pH below 5.5.

Acre-Foot: The quantity of water required to cover one acre to a depth of one foot; equal to 43,560 cubic feet, or approximately 325,851 gallons.

Advisory: A report giving information on beach contamination status and often recommending action to be taken.

Aeration: The process of mixing air with water, which increases the amount of dissolved oxygen.

Alluvial: Sediment deposited by flowing water, such as in a riverbed.

Alum: A very sticky substance added to water during treatment that causes particles in the water to stick together.

Aquifer: An underground layer of rock, sediment or soil that is filled or saturated with water.

Aquitard: A layer of rock over an aquifer through which water cannot soak.

Artificial Recharge: The addition of water to a ground water reservoir by human activity, such as irrigation, or brought in from streams, wells, or recharge basins. See also Groundwater Recharge, Recharge Basin.

Bacteria: Prokaryotic unicellular round, spiral, or rod-shaped single-celled microorganisms that live in soil, water, organic matter, or the bodies of plants and animals (singular bacterium).

Brackish Water: Water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses. Considerably less saline than seawater.

Canopy: The uppermost spreading, branching layer of vegetation.

Catch basin: An opening on the side of the street, which is the entrance to the storm drain.

Coagulation: Caused by adding alum to water, coagulation occurs when small particles cling together, creating particles large enough to be filtered out.

Coliform Bacteria: Many strains of coliform bacteria are naturally present in our environment. Fecal coliform bacteria are present in the feces of humans and other warm-blooded animals but are rare or absent in unpolluted waters. Fecal coliform bacteria should not be found in sources of drinking water. Their presence in water serves as a reliable indication of contamination from human sewage or animal droppings. Although coliform bacteria themselves are not pathogenic, they occur with intestinal pathogens that are dangerous to human health.

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* The material in this glossary is used with permission from the Santa Barbara County Water Agency (Santa Barbara County Water Education Center—Terms & Definitions, **www.sbwater.org/Terms.htm**).

Condensation: The process of water changing from a vapor (gas state) to a liquid state.

Conservation: The wise use of a resource with minimum waste.

Contamination: The addition of an undesirable and potentially harmful material; pollution.

Creek: A stream that is smaller than a river and larger than a brook.

Critical Dry Period: A series of water-deficient years, usually an historical period, in which a full reservoir storage system at the beginning is drawn down (without any spill) to minimum storage at the end.

Critical Dry Year: A dry year in which the full commitments for a dependable water supply cannot be met and deficiencies are imposed on water deliveries.

Cubic Feet Per Second: A unit of measurement describing the flow of water. A cubic foot is the amount of water needed to fill a cube that is one foot on all sides, about 7.5 gallons.

Desalination: A process that converts seawater or brackish water to fresh water or an otherwise more usable condition through removal of dissolved solids. Also called “desalting.”

Disinfection: The removal or killing of bacteria and other disease causing organisms.

Dissolved Oxygen (DO): Dissolved oxygen is important to the health of aquatic ecosystems. All aquatic animals need oxygen to survive. Natural waters with consistently high dissolved oxygen levels are most likely healthy and stable environments, and are capable of supporting a diversity of aquatic organisms. Natural and human-induced changes to the aquatic environment can affect the availability of dissolved oxygen.

Drip Irrigation: A method of watering plants using hoses and emitters with small holes through which water drips.

Drought: A significant decrease in the normal amount of rainfall or frequency of rainstorms.

DWR: California Department of Water Resources (or successor agency).

Erosion: The process of mountains and rocks breaking down into smaller particles.

Estuary: The wide lower course of a river where its current is met by the tides of the ocean.

Eutrophication: Too many nutrients entering an ecosystem (nutrient loading) can cause large algal blooms or other growth spurts followed by natural die-off and decay which results in a decreased amount of oxygen available. This can lead to a dangerous cycle of die-offs, which use oxygen in the decay process leading to more die-offs due to low oxygen levels.

Evaporation: The change of liquid to a vapor or gas, usually by contact with heat.

Evapotranspiration: The total amount of water loss in plants due to evaporation and water loss through plant tissue.

Fecal Coliform Bacteria: Bacteria present in the feces of humans and other warm-blooded animals but rare or absent in unpolluted waters. Fecal coliform bacteria should not be found in sources of drinking water. Their presence in water serves as a reliable indication of contamination from human sewage or animal droppings. Although coliform bacteria themselves are not pathogenic, they occur with intestinal pathogens that are dangerous to human health.

Filtration: The process of running water through a filter to remove undissolved impurities. Filtration occurs naturally through soil.

Floc: Particles produced by coagulation.

Fumigation: The spreading of pesticide to kill unwanted creatures.

Furrow Irrigation: A type of irrigation, which allows water to flood furrows between crop rows.

Geological Maps: Maps, which show boundaries of countries, cities, and roads.

Groundwater: Water that is stored underground in the pore space of aquifers.

Groundwater Basin: A groundwater reservoir, together with all the overlying land surface and underlying aquifers that contribute water to the reservoir.

Groundwater Mining: The withdrawal of water from an aquifer greatly in excess of replenishment; if continued, the underground supply will eventually be exhausted or the water table will drop below economically feasible pumping lifts.

Groundwater Overdraft: The condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that replenishes the basin over a period of years.

Groundwater Recharge: Increases in groundwater by natural conditions or by human activity. See also **Artificial Recharge.**

Groundwater Storage Capacity: The space contained in a given volume of deposits. Under optimum use conditions, the usable groundwater storage capacity is the volume of water that can, within specified economic limitations, be alternately extracted and replaced in the reservoir.

Groundwater Table: The upper surface of the zone of saturation (all pores of subsoil filled with water), except where the surface is formed by an impermeable body.

Habitat: The area or environment in which an organism lives.

Hydrology: The scientific study of the properties, distribution, and effects of water in the atmosphere, on the earth's surface and in soil and rocks.

Hypothesis: A theory or assumption that can be tested by further investigation.

Infiltration: The process by which water seeps into the soil.

Invasive species: Non-native plants and animal species; plants and animal species that have been introduced to an area where they do not occur naturally.

M&I: Municipal and industrial (water use); generally urban uses for human activities.

mg/L: Abbreviation for "milligrams per Liter," the mass (milligrams) of any substance dissolved in a standard volume (liter) of water. Nearly the same as parts per million (ppm).

Maps: Representation on a flat surface (paper, plastic) of Earth or any part of it. Maps can also represent your hand or the sky.

Microorganism: An organism of microscopic or ultramicroscopic size. Pathogen Ñ is a specific causative agent (as a bacterium or virus) of disease.

Molecule: The smallest unit of matter, which holds its characteristics.

Native: Growing, living or produced originally in a certain place: indigenous.

Native Species: Plants and animal species that have evolved in a specific area over a period of time; naturally occurring species; indigenous.

Native Vegetation: Plants that are adapted to and occur naturally in s specific location. Non-native Vegetation: Plants that are not native to the local area. These plants are often invasive and compete with or replace native vegetation. This can affect habitat and food supply for native animal species.

Nitrate: Nitrate is a nutrient needed by all aquatic plants and animals to build protein. The decomposition of dead plants and animals and the excretions of living animals release nitrate into the aquatic system. Excess nutrients, like nitrate, increase plant growth and decay, promote bacterial decomposition, and therefore decrease the amount of oxygen available in the water. Sewage is the main source of excess nitrate added to natural waters, while fertilizer and agricultural runoff also contribute to high levels of nitrate.

Nonpoint Source Pollution: Pollution that cannot usually be traced back to its source. Pollution coming from many varied indeterminable sources. An example of point source pollution is a chemical spill from a factory. Nonpoint source pollution usually comes from stormwater runoff from urban, suburban, or agricultural areas. Human activities that add to nonpoint source pollution in stormwater run-off include improper disposal of pet and yard waste, use of pesticides and construction.

Organic Matter: Material that contains or is derived from living organisms.

Overdraft: Withdrawal of groundwater in excess of a basin's perennial yield. See also **Prolonged Overdraft.**

pH: pH is a measurement of the acidic or basic (or alkaline) quality of a substance. The pH scale ranges from a value of 0 (very acidic) to 14 (very basic), with 7 being neutral. The pH of natural water is usually between 6.5 and 8.2. In Santa Barbara, the pH of most of the water is higher than 8. Most aquatic organisms are adapted to a specific pH level and may die if the pH of the water changes even slightly.

PPM: Abbreviation for "parts per million," a measure of a substance's concentration in a solution or other mixture. Nearly the same as milligrams per liter (mg/l).

Percolate/Infiltrate: To ooze or trickle through a permeable substance.

Percolation: Water soaking into the ground through particles of soil.

Phosphate: Phosphate is a nutrient needed for plant and animal growth and is also a fundamental element in metabolic reactions. High levels of this nutrient can lead to overgrowth of plants, increased bacterial activity, and decreased dissolved oxygen levels. Phosphate comes from several sources including human and animal waste, industrial pollution, and agricultural runoff.

Point Source Pollution: Pollution that can be traced back to one specific source.

Pollutant: Any substance, biological or chemical, in which an identified excess is known to be harmful to desirable organisms (both plants and animals).

Pollution: Items and chemicals that endanger the quality of life and life itself. Some pollutants are toxic or poisonous. Others are dangerous because they stick to feathers (oil and tar) making it impossible for birds to fly or find food, or clog throats and stomachs, and entangle necks (plastic bags and strips) of marine creatures.

Pore Space: The space found between particles of soil, sand or gravel; in saturated aquifers, pore space is filled with water.

Potable: Water that is safe to drink.

Precipitation: The fall of condensed moisture as rain, snow or sleet.

Primary Treatment: The first stage of wastewater treatment; involves passing through a comminutor ("trash rack"), grit chamber, and sedimentation.

Prolonged Overdraft: Net extractions in excess of a basin's perennial yield, averaged over a period of ten or more years.

Recharge: The process of water seeping through soil into an aquifer or groundwater basin.

Recharge Basin: A surface facility, often a large pond, used to increase the infiltration of water into a groundwater basin.

Reclaimed Water: Water that is treated at a treatment plant after it was used once, and is now safe to use again for certain purposes.

Recycle: Using a resource more than once.

Relief Map: Maps, which show depth in real three-dimensional structures.

Return Flow: The portion of withdrawn water that is not consumed by evapotranspiration and returns instead to its source or to another body of water.

Riparian: Habitat found near the source of fresh water.

Riparian vegetation: Plants normally found along the banks and beds of streams, creeks, and rivers. 'Riparian vegetation' includes understory, ground cover, and wetland plants, not just trees.

Runoff: Rain that is not absorbed by the soil, and flows into the surface of the soil.

Safe Yield: The amount of water that can be taken from a water storage that will be replaced naturally.

Salinity: Generally, the concentration of mineral salts dissolved in water. Salinity may be measured by weight (total dissolved solids), electrical conductivity, or osmotic pressure. Where seawater is the major source of salt, salinity is often used to refer to the concentration of chlorides in the water. See also TDS.

Seawater Intrusion: A condition resulting from salt water penetration into a fresh water aquifer.

Secondary Treatment: The second stage of wastewater treatment during which the water goes through aeration, followed by the addition of aerobic bacteria.

Sediment: Soil particles that have been moved by water.

Sedimentation: A step in water treatment where particles in water fall to the bottom of a tank and are removed.

Serious Overdraft: Prolonged overdraft that results, or would result, within ten years, in measurable, unmitigated adverse environmental or economic impacts, either long-term or permanent. Such impacts include but are not limited to seawater intrusion, other substantial quality degradation, land surface subsidence, substantial effects on riparian or other

environmentally sensitive habitats, or unreasonable interference with the beneficial use of a basin's resources.

Silt: Sediments that are removed from water at a treatment plant.

Sludge: Sediments that are removed from water at a treatment plant.

Sprinkler Irrigation: A method of watering plants by sprinkling them.

State Water Project (SWP): A system of pipes, canals and reservoirs designed to collect, store and distribute water from northern California, where most of the state's rainfall occurs, to southern California, where most of the state's population lives.

Storm Drain: Low area or device designed to carry away extra rainwater; a pipe that travels from the catch basin to the creeks and ocean.

Stream: A current of water; a small river.

Surface Water: Water that is found on the Earth's surface: lakes, streams, rivers, reservoirs, etc.

SWRCB: California State Water Resources Control Board (or successor agency).

Tertiary Treatment: The third stage of wastewater treatment where water goes through coagulation, sedimentation, filtration, and the addition of chlorine.

Topographical maps: Maps that describe high and low areas on earth by thin lines labeled with elevation numbers.

Total Dissolved Solids (TDS): A quantitative measure of the residual minerals dissolved in water that remains after evaporation of a solution. Usually expressed in milligrams per liter (mg/l) or in parts per million (ppm). See also **Salinity**.

Transpiration: The exchange of water from plants and trees to the atmosphere.

Turbidity: Turbidity is the measure of the relative clarity of water. Turbid water is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter, and microscopic organisms. Water high in turbidity appears murky and contains sediments in suspension. Turbidity should not be confused with color, since darkly colored water can still be clear and not turbid. Turbid water may be the result of soil erosion, urban runoff, algal blooms, and bottom sediment disturbances which can be caused by boat traffic and abundant bottom feeders. Turbid water may also result in higher concentrations of contaminants and pathogens that bond to the particles in the water.

Understory: The underlying layer of vegetation between the canopy and the ground.

Understory Plants: Medium height vegetation, including bushes and shrubs, which grows below the tree canopy.

Virus: Any of a large group of submicroscopic infective agents that are regarded either as extremely simple microorganisms or as extremely complex molecules that are capable of growth and multiplication only in living cells, and that cause various important diseases in humans, lower animals, or plants.

Wastewater: Water that has been used by either humans or industry; any water that enters the sewage system.

Wastewater (Sewage) Treatment Plant: A treatment facility where the wastewater (sewer) is cleaned.

Water Cycle: The continuous cycle of evaporation, condensation, and precipitation in which water is continually being recycled.

Water Quality: A term used to describe the chemical, physical, and biologic characteristics of water with respect to its suitability for a particular use.

Water Right: A legally protected right, granted by law, to take possession of water occurring in a water supply and to divert the water and put it to beneficial uses.

Water Table: The surface of underground, gravity-controlled water.

Water Treatment Plant: A plant where water is treated to make it fit for potable use.

Water Vapor: Water in an invisible gaseous state or in a visible liquid state consisting of extremely small particles suspended in the air.

Watercourse: A natural or artificial channel through which water flows.

Watershed: A gathering place for water. An area where water flows off the land forming streams, creeks, and rivers, which come together flowing to a larger body of water (the ocean or a lake).

Weathering: The disintegration and decomposition of rock at or near the surface; the breakdown of parent rock into sediment.

Xeriscape: Landscape that thrives naturally in a dry climate and requires minimal watering.

Zone of Saturation: The part of the soil where all the pore spaces are full of water.

Additional Educational Resources

Additional Educational Resources: General

Blueprint for a Green School
Jayni Chase
Scholastic Inc.
555 Broadway, New York, New York 10012

Blueprint for a Green School focuses on creating environmentally safe and healthy school buildings and grounds. The book introduces a wide range of environmental problems and issues relevant to schools with regard to environmental and health issues, toxics, pesticides, nutrition, school gardens, water, energy, electromagnetic fields, science labs, art rooms, source reduction, recycling, cleaning products, and more. The text defines terms and provides background information (although some has become dated since publication), identifies risks, demonstrates where problems may occur on a school campus, and suggests alternatives and solutions. School surveys, audits, and guiding questions are provided to help assess a school's current situation and determine areas for improvement. *Blueprint* is a comprehensive sourcebook for virtually any environmental and health issue teachers, students, administrators, and parents might wish to explore on campus. Curriculum activities, environmental education materials, and supplemental information are also cited.

Campus Ecology: A Guide to Assessing Environmental Quality and Creating Strategies for Change
April A. Smith and The Student Environmental Action Coalition
Living Planet Press
PO Box 1679
Venice, California 90294

While geared quite specifically for college and university campuses and beyond the scope of most K–12 campus audits or service-learning projects, this book presents a thorough yet succinct approach to environmental change on campus. It begins with surveying the campus, and then includes clear and concise assessment questions, research sources, and recommendations on themes including solid waste, hazardous substances, wastewater and storm runoff, pest control, and air quality. Many of the suggestions are transferable to the K–12 setting, although they would need to be revised. The guide includes profiles of many college campuses across the country.

EcoVoyageurs, Reducing Our Ecological Footprints
Company for Education Communications Inc.
66 George Street, 3rd Floor
Toronto, Ontario M5A 4K8
Canada

Publication can be downloaded at www.ecovoyageurs.com/

EcoVoyageurs is a comprehensive curriculum for middle school students. It focuses on the concept of an "ecological footprint," a measurement of human impact on the Earth in the categories of food, water, garbage, energy, and transportation. The publications and website present an accounting tool that measures a student's ecological footprint based on answers to survey questions tracked over three days of observation. The unit is intended to be carried out in its entirety, which requires 15 hours of instruction. However, it can be broken into sections.

The program provides a unique measure of a student's individual impact. The tool is deeply simplified—as well it need be for the age group—and some of the survey questions are leading while others may not be particularly relevant to most students. The action ideas included in the unit are not very well developed, nor are they effectively targeted to a school campus. Still, it is interesting and effective to quantify the impact of one's daily choices.

***Education for Sustainable Development Toolkit,* Second Edition**
Rosalyn McKeown, Ph.D., with assistance from Charles Hopkins, Regina Rizzi, and Marrianne Chrystalbridge
Funded by the Waste Management Research and Education Institution, University of Tennessee, Knoxville

Publication is available online or as a PDF file at www.esdtoolkit.org/

The *Education for Sustainable Development Toolkit* describes itself as "an easy-to-use manual for beginning the process of combining education and sustainability and will help schools and communities develop a process to create locally relevant and culturally appropriate education. The Toolkit is based on the idea that communities and educational systems need to dovetail their sustainability efforts. Ideally, local educational systems can reorient existing curriculums to reinforce local sustainability goals."

The *ESD Toolkit* is more than a knowledge base related to environment, economy, and society. It also addresses learning skills, perspectives, and values that guide and motivate people to seek sustainable livelihoods, participate in a democratic society, and live in a sustainable manner. The *ESD Toolkit* also involves studying local and, when appropriate, global issues.

The toolkit is not likely to be useful for one service-learning project, but does an excellent job of defining the broader concept of education for sustainability and provides numerous worksheets to assist schools in reorienting their curricula around this concept.

Additional Educational Resources: Service-Learning

Note: This list does not include resources that make the case for service-learning. Rather, the resources listed here can help with the practical aspects of planning and implementing service-learning projects.

Essential Elements of Service-Learning
Pamela Toole, Ph.D., Ed.
National Service-Learning Cooperative
The National Youth Leadership Council Essential Elements Project
1910 W. County Road B.
Roseville, Minnesota 55113

Publication can be downloaded at www.nwrel.org/ruraled/learnserve/resrc.html

This publication introduces service-learning, and characterizes 11 essential elements for its effective practice. It also describes five essential elements of organizational support for service-learning. Written with the support and input of the National Service-Learning Cooperative, a group of 13 organizations funded by the Corporation for National Service, it is useful for both the

novice and the experienced practitioner. Each element offers specific benchmarks illustrating exemplary service-learning practice. Real-world examples bring each element to life.

GreenWorks! Connecting Community Action and Service-Learning
Project Learning Tree
American Forest Foundation
1111 19th Street N.W., Suite 780
Washington, DC 20036
www.plt.org/

This module from Project Learning Tree articulates a seven-step process for planning and implementing a GreenWorks! action project. *GreenWorks!* is the community action service-learning component of PLT, built around action projects that partner educators, students, and the community. Brief descriptions of several environmental action projects are included; for the most part, they are not campus-based projects. Appendices offer well-designed community needs assessment, action planning and budget worksheets that may be transferable to the school site. PLT-trained teachers are eligible to apply for GreenWorks! grants; more information is available at **www.plt.org/**.

Service-Learning: Education Beyond the Classroom
United States Environmental Protection Agency
Office of Solid Waste (5305W)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Publication can be downloaded at www.epa.gov/epaoswer/general/educate/svclearn.htm

This booklet contains 17 profiles of school-based and community projects that can provide inspiration for any service-learning program. The projects are categorized by the communities they serve: governments and businesses, neighborhoods, and schools. Contacts and resources are also included to provide information on how to start a solid waste service-learning program.

Service-Learning Toolbox: Work Pages and Checklists to Help You Get Started and Keep You Going
Northwest Regional Educational Laboratory
101 SW Main Street, Suite 500
Portland, Oregon 97204
www.nwrel.org/

Publication can be downloaded at
www.nwrel.org/ruraled/learnserve/resources/SL_Toolbox.pdf

While not specific to environmental projects, this toolbox outlines a general process for planning and implementing a service-learning project and provides guiding questions and checklists to assist teachers with that process. The work pages are divided into four key areas: preparation (project identification and planning), action, formal evaluation, and online resources.

Students in Service to America: A Guidebook for Engaging America's Students in a Lifelong Habit of Service
Corporation for National and Community Service
Washington, D.C.

Publication can be downloaded at
www.studentsinservicetoamerica.org/guidebook/index.html

Students in Service to America describes the hallmarks of effective service-learning programs in the context of developing habits of service in America's youth. While not environmental in focus, the publication offers clearly articulated steps for bringing service to the classroom. The most useful component is likely to be the chapter on tools and resources. Included are websites, potential partner organizations that offer funding and/or personnel resources, curriculum, civic education websites, national organizations that work in service-learning and youth development, service clubs and organizations, youth leadership clubs and organizations, and recognition programs.

Take a Class Outdoors: A Guidebook for Environmental Service Learning
Linda Clifton, Tammy Mauney, and Rebekah Falkner
National Dropout Prevention Center
College of Health, Education, and Human Development
Clemson University
209 Martin Street
Clemson, South Carolina 29634-0726
www.dropoutprevention.org

This simple guide introduces the concept of environmental service-learning and includes some useful tips for integrating projects into the curriculum. Of particular interest are ideas for obtaining funding, resources, and community involvement for projects in the areas of endangered species, school landscaping, weather information, recycling, and building an outdoor classroom. While these might not be the topics generated by campus audits, many of the ideas are transferable. The booklet also includes suggested strategies for sharing the word, reflection, and celebration.

Taking Action: An Educator's Guide to Involving Students in Environmental Action Projects
Project WILD with World Wildlife Fund
5555 Morningside Drive, Suite 212
Houston, TX 77005
1995
www.projectwild.org/

Taking Action is the result of a collaborative effort of Project WILD and World Wildlife Fund's Windows on the Wild program. The book articulates a well-developed process for planning and implementing environmental action projects, along with tips for overcoming barriers and resolving conflicts. The document includes more than 30 actual projects, many of which are campus-based, that can serve as a source of ideas for service-learning.

Additional Educational Resources: Student Websites

The following websites have themes related to waste, energy and air, and water resources. They have been designed for student use.

Ben's Guide to U.S. Government for Kids—**http://bensguide.gpo.gov/subject.html**

California Energy Commission's Energy Quest—**www.energyquest.ca.gov/**

Energy Efficiency and Renewable Energy Network: Dr. E's Energy Lab —
www.eren.doe.gov/kids/

FedStats Kids Pages—**www.fedstats.gov/kids.html**

The Great Green Web Game (Union of Concerned Scientists)—**http://www.ucsusa.org/game**

Green Schools—**www.ase.org/greenschools/**

The Green Squad (Natural Resources Defense Council)—**www.nrdc.org/greensquad**

Healthy Schools Network's Kids' Page—**http://www.healthyschools.org/kids.html**

Learn about Chemicals Around Your House–House Tour—**www.epa.gov/kidshometour/**

Metropolitan Water District of Southern California Student Resources—
www.mwdh2o.com/mwdh2o/pages/education/education01.html

Recycle City—**www.epa.gov/recyclecity/mainmap.htm**

Rocky Mountain Institute for Kids—**www.rmi.org/sitepages/pid468.php**

U.S. Department of Energy Kids Zone—www.energy.gov/engine/content.do?BT_CODE=KIDS

U.S. Environmental Protection Agency (Water—Kids' Stuff)—**www.epa.gov/ow/kids.html**

U.S. Environmental Protection Agency (Planet Protectors Club for Kids)—
www.epa.gov/epaoswer/osw/kids/index.htm

U.S. Environmental Protection Agency Air Quality for Kids Page—
www.epa.gov/airnow/aqikids/

U.S. Environmental Protection Agency Global Warming Site for Kids—
www.epa.gov/globalwarming/kids/index.html

U.S. Environmental Protection Agency Kid's Page (Energy Information Administration)—
www.eia.doe.gov/kids/

U.S. Environmental Protection Agency Environmental Explorer's Club: Garbage and Recycling—**www.epa.gov/kids/garbage.htm**

Watt's New Energy Game—**www.wattsnew.com/**

World Wildlife Fund's Virtual House—**www.virtualhouse.org/**

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