Research and
Development
(RD-681)

EPA/600/9-90/015
March 1990

EPA Pollution Prevention Research Plan

Report to Congress

PRINTED ON RECYCLED PAPER

EPA/600/9-90/015
MARCH 1990

POLLUTION PREVENTION RESEARCH PLAN

REPORT TO CONGRESS

Office of Environmental Engineering and Technology Demonstration
Office of Research and Development
U.S. Environmental Protection Agency
Washington, DC 20460

NOTICE

This report was prepared by the Office of Environmental Engineering and Technology Demonstration of the U.S. Environmental Protection Agency under the management of Gregory G. Ondich (Director, Program Development Staff). Production of this document was facilitated under Contract No. 68-02-4297. It has been subjected to the Agency's peer and administrative review and it has been approved for publication as a USEPA document.

Individuals and organizations throughout EPA contributed material that formed the basis for much of this report. Without their contribution the production of this document would not have been possible.

Foreword

The Office of Research and Development has been involved in minimization (a precursor to pollution prevention) of hazardous waste since 1987. The program has achieved early success in demonstrating the potential benefits of pollution prevention in solving environmental problems.

Over the past several years the importance of pollution prevention as a cost effective alternative to "end of pipe" pollution control has been recognized. Pollution prevention as a valid approach to environmental protection was promoted by the EPA Science Advisory Board in their Report Future Risk: Research Strategies for the 1990's. It is also becoming clear that progress in managing many of the newer environmental problems can be more readily achieved using a pollution prevention approach. As a result the Congress requested EPA to prepare and submit a multi-year, multi-media pollution prevention research plan.

This report was prepared in response to this request. It should be noted that the plan is part of a much broader EPA effort to develop a comprehensive pollution prevention program that addresses all of the Agency's programs including media specific and cross-media issues.

The plan builds on the current EPA pollution prevention efforts and the needs of the various organizations that will be instrumental in implementing pollution prevention techniques and programs. The six research program areas include: product, process, recycling/reuse, socioeconomic and institutional, anticipatory and technology transfer research.

The research program goals are designed to meet the identified organizational needs, and the objectives within each program area are intended to facilitate achievement of these goals. Example research projects under each research objective illustrate the types of research that could be conducted to achieve these objectives. These example projects do not necessarily represent the highest priority projects, but are included for illustrative purposes only.

Additional copies of this report may be obtained at no charge from EPA's Center for Environmental Research Information, 26 West Martin Luther King Drive, Cincinnati, Ohio, 45268, using the EPA document number found on the report's front cover. Once this supply is exhausted, copies can be purchased from the National Technical Information Service, Ravensworth Bldg., Springfield, VA, 22161, (702) 487-4600. Reference copies will be available at EPA libraries in their Pollution Prevention Collection. You can also call the Pollution Prevention Information Clearinghouse Technical Assistance Line at 703-821-4800 in McLean, VA, to inquire about the availability of this and other pollution prevention reports.

Alfred W. Lindsey, Acting Director
Office of Environmental Engineering
and Technology Demonstration

TABLE OF CONTENTS

LIST OF EXHIBITS

EXECUTIVE SUMMARY

The Fiscal Year 1989 Appropriations Act for the Environmental Protection Agency (EPA) required the Agency to submit a multi-year, multi-media pollution prevention research plan to Congress. The research plan contained in this report was prepared in response to this requirement, and the plan is part of a broader EPA effort to develop a comprehensive pollution prevention initiative that concerns all of the Agency's programs in air, water, toxics, and solid waste.

In the past two decades, EPA's environmental protection efforts have primarily focused on media-specific pollution controls. These "end-of-pipe" approaches have achieved significant reductions in discharge of pollutants, but further gains in treatment and control will, in most cases, be much more costly and difficult to achieve. Furthermore, many of the pollution problems facing our nation--such as global warming, ozone depletion, and non-point source pollution--are not totally amenable to traditional pollution control regulation and enforcement. Further strides in protecting the environment will require preventing environmental problems by reducing or eliminating the generation of pollutants. The reduction or elimination of pollution is not a new concept for the EPA in reducing health and environmental risks. "Pollution prevention," as used in this report, refers to the reduction, elimination, or recycling of pollutant discharges to the air, water, or land. It does not include treatment and disposal methods. Pollution prevention holds the key to future gains in environmental protection, and offers significant benefits to many sectors of society that are not available through traditional pollution control approaches. These benefits fall into two major categories:

- Reduced health and ecological risks
  - Avoiding the shift of pollutants among environmental media
  - Reducing the need for transportation and disposal of wastes
  - Reducing the total waste and pollutant burden
  - Reducing risks of exposure to toxic substances.
- Economic benefits
  - Reducing waste management, compliance, liability, and remediation costs
  - Increasing operating efficiencies
  - Creating markets for sale or reuse of wastes.

EPA recognizes that it will take a concerted effort by all sectors of our society to realize the full potential of the benefits of pollution prevention. Although these benefits are recognized by many organizations, lack of information and knowledge have been a barrier to implementing pollution prevention programs. Organizations often lack the capabilities, resources, or motivation to conduct the research necessary to fill these information gaps. Therefore, EPA has a crucial role to play, as a leader in pollution prevention, in forging partnerships with these organizations to conduct research and disseminate the information. As the SAB noted in *Research Strategies for the 1990s*, EPA is the only entity that is likely to exert leadership in conducting the basic environmental research needed to address future environmental issues and cross-media problems.

This research plan is the first step in developing the research component of EPA's pollution prevention initiative. This plan builds on the current EPA pollution prevention efforts, and identifies six research goals that broaden the scope of the Agency's pollution prevention efforts. The six fundamental goals of the research program are to:

(1) Stimulate private sector development and use of products that result in reduced pollution.

(2) Stimulate private sector development and implementation of technologies and processes that result in reduced pollution.

(3) Expand the reusability and recyclability of wastes and products and the demand for recycled materials.

(4) Identify and promote the implementation of effective socioeconomic and institutional approaches to pollution prevention.

(5) Establish a program of research that will anticipate and address future environmental problems and pollution prevention opportunities.

(6) Conduct a vigorous technology transfer assistance program that facilitates pollution prevention strategies and technologies.

Achievement of these goals requires a research program that covers six major program areas: (1) product research, (2) process research, (3) recycling and reuse research, (4) socioeconomic and institutional research, (5) anticipatory research, and (6) technology transfer and technical assistance. Each of the six research goals corresponds to a research program area, and each program area has a number of objectives that support achievement of the research goal.

Product Research

The product research program area is oriented toward studying the polluting characteristics and life-long pollution generating attributes of types of products, and facilitating private sector development of environmentally preferable types of products. The objectives of the product research program area are to:

(1) Establish standardized methods for evaluating the environmental impacts of specific types of products.

(2) Identify and evaluate the pollution generation characteristics of both existing and new types of products and of changing product-use patterns.

(3) Encourage private sector development of environmentally preferable types of products.

(4) Demonstrate and evaluate uses of cost effective and environmentally preferable types of products.

Process Research

The process research program area focuses on identifying and evaluating those aspects of production, use, maintenance, repair, and disposal processes that generate pollutants and excessive amounts of waste, and facilitating private sector development of environmentally preferable processes. The objectives of the process research program area are to:

(1) Develop industry-specific standardized methods for conducting process-oriented pollution prevention opportunity assessments.

(2) Conduct pollution prevention opportunity assessments in a variety of industries.

(3) Identify, demonstrate, and evaluate the effectiveness of pollution prevention techniques associated with existing and new processes.

(4) Identify and stimulate cross-industry applications of cost effective innovative production and processing technologies.

Recycling and Reuse Research

The recycling and reuse research program area focuses on evaluating waste streams, production feedstocks, capacities for inclusion of reclaimed materials in production processes and products, and the effectiveness of recycling/reuse programs. The recycling and reuse research program area objectives are to:

(1) Identify and evaluate new and innovative uses for materials that would otherwise be disposed of as waste.

(2) Identify, demonstrate, and evaluate strategies to increase the use of recycled materials in products.

(3) Stimulate the development and installation of additional capacity for utilizing recycled materials.

(4) Evaluate existing recycling and reuse programs and facilitate the development of cost effective model programs.

Socioeconomic and Institutional Research

The socioeconomic and institutional research program area focuses on identifying and evaluating non-technological factors that affect pollution prevention opportunities. The objectives of the socioeconomic and institutional research program area are to:

(1) Understand consumer behavior and identify effective approaches to modifying it in consumption decisions.

(2) Identify and assess incentives that may increase and obstacles that may inhibit implementation of pollution prevention measures.

(3) Identify and assess the effectiveness of existing and new pollution prevention approaches.

(4) Identify and assess trends in consumption and use patterns and pollution generation.

(5) Quantify the potential of pollution prevention practices for maximizing pollution reduction.

Anticipatory Research

The anticipatory research program area concentrates on emerging technologies that could be utilized to prevent or address future environmental problems, as well as changes in non-technological factors that could contribute to or prevent future problems. The objectives of the anticipatory research program area are to:

(1) Identify and explore emerging technologies and patterns in resource use and disposal that have long-term implications for the nation's programs in pollution prevention.

(2) Evaluate the effectiveness of the Agency's research program in meeting changing user information needs.

Technology Transfer and Technical Assistance

The technology transfer and technical assistance program area supports each of the other five research program areas by providing the mechanism for rapid and broad dissemination of information to potential users. This program area focuses on expanding the availability of information from the pollution prevention research initiative and other sources to accelerate the adoption of effective pollution prevention programs throughout the public and private sectors. It compliments similar pollution prevention outreach programs throughout the Agency. The technology transfer and technical assistance program area objectives are to:

(1) Stimulate the use of pollution prevention opportunity assessments in all pollution-generating activities.

(2) Expand the Pollution Prevention Information Clearinghouse to encompass additional, multi-media pollution prevention functions.

(3) Provide technical assistance to other federal agencies, states, local governments, industries, and citizens in implementing pollution prevention efforts.

(4) Support general and industry-specific information exchange via conferences and seminars in international, national, and regional settings.

The information needs of the various organizations that could be instrumental in implementing pollution prevention techniques and programs are the driving force for the research program. These needs lead to individual research projects through a linear

path that is illustrated by the flowchart exhibit on the following page. The flowchart depicts the logical design of the research plan by using an example within a particular program area. Information needs are the foundation upon which all the research is based. The goals of the research plan are designed to meet these information needs, and the objectives within each program area are intended to facilitate achievement of these goals. The research topics under the objectives are the types of research that could be conducted to achieve these objectives. Finally, example research projects under each research topic illustrate the types of projects the Agency might undertake for each program area. This design applies to all six of the research program areas presented in the research plan in Chapter 2. Seventeen example projects, several for each of the program areas, illustrate the variety of research that can be undertaken as part of this program. These example projects do not necessarily represent high priority research projects, but are included in the research plan to illustrate the types of studies envisioned by the Agency for each of the six program areas.

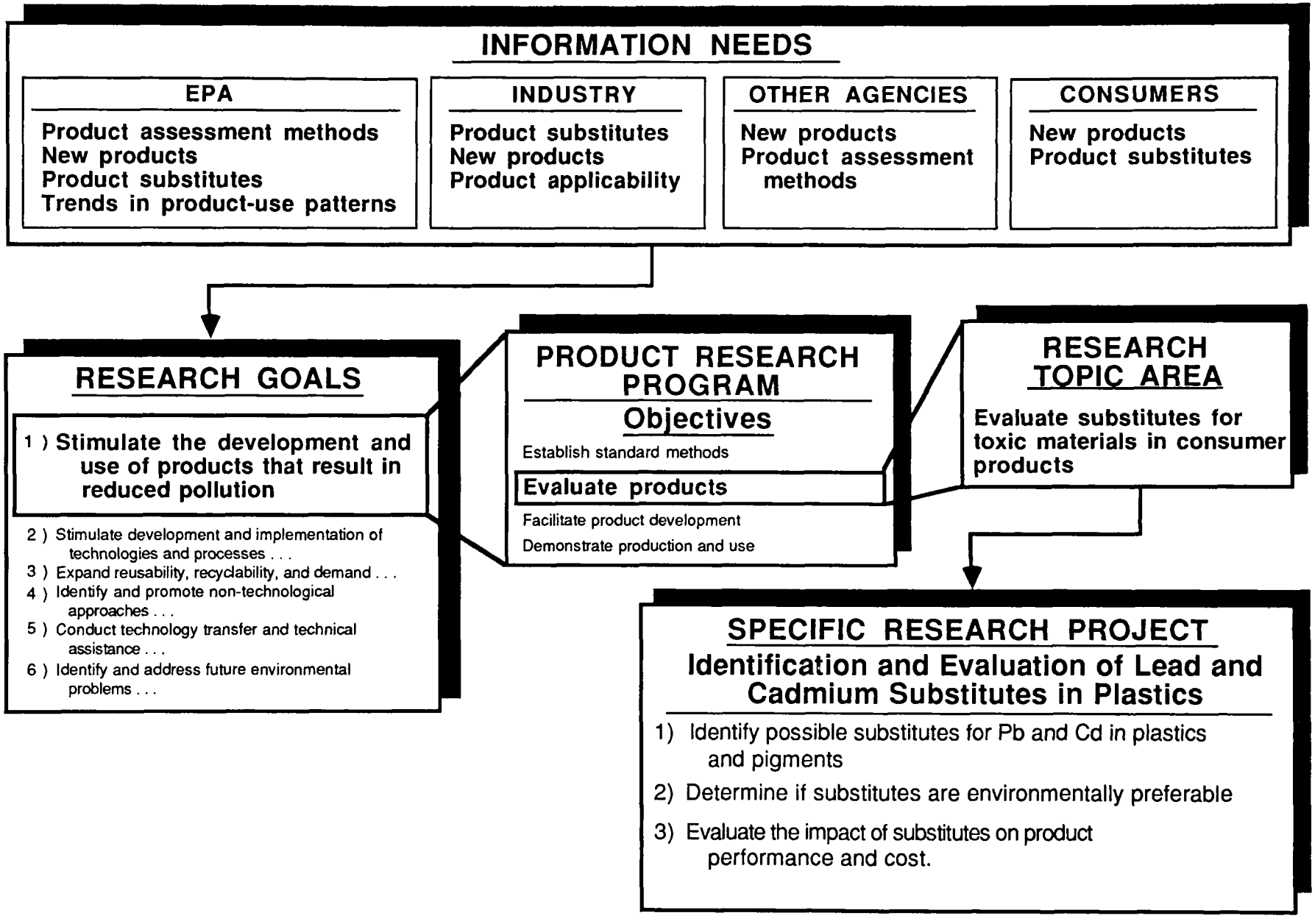
Implementation of the Research Plan

Over the past five years, the Agency has progressively expanded its efforts in source reduction and recycling. Passage of the Hazardous and Solid Waste Amendments of 1984 marked a significant milestone in refocusing the Agency's strategy from traditional regulatory control approaches toward pollution prevention. In 1986, EPA's Office of Solid Waste (OSW) published the Report to Congress on the *Minimization of Hazardous Waste*, which promoted source reduction and recycling as the nation's highest priorities over treatment and disposal. In 1987, EPA launched the Waste Minimization Research (WMR) program which focused on preventing or reducing the generation of hazardous wastes as regulated under the Resource Conservation and Recovery Act. Another milestone for the Agency's pollution prevention initiative was publication in 1988 of the Science Advisory Board's report, *Future Risk: Research Strategies for the 1990s*. In this same year, EPA created an Agencywide Pollution Prevention Office (PPO) to promote an integrated pollution prevention approach across all media. In 1989, the PPO issued a pollution prevention policy statement that promotes pollution prevention as the highest priority to reduce health and environmental risk, followed by recycling and reuse of wastes to reduce pollution. The PPO is also developing a comprehensive Agencywide pollution prevention strategy. The strategy will attempt to integrate program, research, and regional office activities into a comprehensive pollution prevention plan for the Agency. Also in 1989, OSW published *The Solid Waste Dilemma: An Agenda for Action* which is a national strategy for managing the nation's garbage problem.

OSW's activities, the WMR program, and the establishment of PPO signify EPA's commitment to achieving significant reductions in the generation of pollution. These Agency efforts provide the framework for the multi-media, multi-year pollution prevention research plan presented in this report. This research plan is an adjunct to the broader Agencywide pollution prevention strategy being prepared by the PPO.

The pollution prevention research program outlined in this report will support Agencywide research efforts. A number of EPA program, research, and regional offices will be responsible for implementing the proposed research plan. During the first year of the research plan, the Agency's highest priorities are to initiate research in the product and socioeconomic and institutional program areas. Although the priorities for initiating research activities that are presented in this plan reflect EPA's commitment to beginning effective research activities, funding levels in each program area may not be indicative of these priorities. This is due to the need to continue support for ongoing projects and the disproportionate costs of planning, initiating, and implementing specific projects in different program areas. EPA estimates that the pollution prevention research program described in this plan would cost approximately $14.5 million from Research and Development funds in FY90 and FY91. During this time, product research is expected

PRODUCT RESEARCH PROGRAM EXAMPLE



to cost around $3.9 million, socioeconomic and institutional research about $3.4 million, process research $3.7 million, recycling and reuse research $0.7 million, anticipatory research $0.4 million, and technology transfer $2.4 million. Although all six of the research program areas are of critical importance to the nation's pollution prevention initiative, EPA recognizes that immediate implementation of all six areas may not be practical. Therefore, the research plan addresses both the Agency's present priorities for initiating research activities and a mechanism for prioritizing future projects based on the effectiveness of the program and changing information needs. The priorities for the research program areas are based on the following factors:

- Overall impact on environmental results.
- Potential cost effectiveness of proposed activities.
- Degree of need for the information.
- Importance of EPA's contribution in this area.
- Ability to achieve near-term results.
- Number of organizations that could benefit from the information.
- Need to support the pollution prevention efforts of EPA program and regional offices.
- Need to continue efforts in ongoing pollution prevention research programs.

The pollution prevention research plan described in this report is a comprehensive program that includes both technological and non-technological research to address a broad range of pollution prevention issues. The Agency's efforts could be directed toward identifying pollution reduction and prevention potentials, meeting information needs, establishing an awareness of opportunities, stimulating investigation of alternatives, and adopting workable approaches for pollution prevention in both the public and private sectors. Because pollution prevention is not the responsibility of EPA alone, the pollution prevention research program requires the cooperation and partnership of government agencies, business, industry, academia, and public interest groups in conducting the necessary pollution prevention research, and transferring the results of this research to those who need the information in order to implement pollution prevention programs and take advantage of pollution prevention opportunities. The development of this research plan is a major step toward implementing a comprehensive risk reduction research program that has as its first priority the prevention of pollution. Such a research program holds tremendous potential for furthering the progress EPA has achieved in protecting human health and the environment from the risks posed by pollution.

CHAPTER 1
INTRODUCTION

This document is an Agencywide pollution prevention research plan submitted to Congress in response to the Fiscal Year 1989 Housing and Urban Development and Independent Agencies Appropriations Act, Public Law 100-404, which states:

> *"...a multi-year plan addressing the critical research elements to support an Agencywide multi-media pollution prevention initiative should be submitted by May 1, 1989."*

The research plan contained in this report was prepared in response to this requirement, and the plan is part of a broader EPA effort to develop a comprehensive pollution prevention initiative that concerns all of the Agency's programs in air, water, toxics, and solid waste.

The reduction or elimination of pollution is not a new concept for EPA in reducing the health and environmental risks associated with pollution. Since the passage of the Hazardous and Solid Waste Amendments in 1984, the Agency has been refocusing its environmental protection strategy from traditional regulatory control approaches toward pollution prevention. The term "pollution prevention," as used in this report, refers to the reduction or elimination of pollutant discharges to the air, water, or land. Pollution prevention approaches to environmental protection include:

- Eliminating pollutants by substituting non-polluting chemicals or products (e.g., material substitution, changes in product specifications), or altering product use
- Reducing the quantity and/or toxicity of pollutants generated by production processes through source reduction, waste minimization, and process modifications
- Recycling of waste materials (e.g., reuse, reclamation).

Pollution prevention approaches do not include treatment and disposal methods.

Pollution prevention must be an essential component of EPA's environmental protection strategy if the Agency is to fulfill its mission of protecting human health and the environment from the risks associated with pollution. Pollution prevention holds the key to future gains in environmental protection, partially because past pollution control approaches have focused primarily on reducing environmental discharges in a particular medium or cleaning up contaminated sites by employing engineering controls. These "end-of-pipe" approaches have achieved significant reductions in environmental discharge of pollutants, but further gains in treatment and control will, in most cases, be much more costly and difficult to achieve. Furthermore, many of the environmental pollution problems facing our nation--such as global warming, ozone depletion, and non-point source pollution--are not amenable to traditional pollution control regulation and enforcement. Pollution prevention offers EPA a means of attacking these environmental problems from a multi-media perspective that will eliminate approaches that merely transfer pollutants from one medium to another. Most important, pollution prevention will reduce the risks to both human health and the environment by reducing or eliminating the generation of pollutants that are detrimental to biological organisms, ecosystems, and global physical processes.

In a recent report to EPA, *Future Risk: Research Strategies for the 1990s*, the Science Advisory Board (SAB) recommended that a primary long-term goal for the Agency should be prevention or reduction of environmental risk. The report recommended that EPA shift the focus of its environmental protection strategy from command and control measures to preventing the generation of pollution. The

SAB defined a hierarchy for risk reduction research (see Exhibit 1-1) to help in setting research priorities and in achieving the Agency's overall goal of protecting human health and the environment. The first priority of the research hierarchy clearly emphasizes the importance of pollution prevention:

- Whenever possible environmental protection efforts first should be aimed at minimizing the amount of wastes or pollutants generated. Thus, waste reduction at its source--for example, through product design changes, industrial process changes, or material substitution--should be a primary objective.

The second priority of the research hierarchy focuses on the prevention or reduction of pollutants by recycling or reuse:

- For those wastes or pollutants that are generated, every effort should then be made to recycle or reuse them in an environmentally sound manner. For example, community recycling programs should be an important feature of the nation's solid waste disposal efforts, and industry should be encouraged to reuse as much of its process wastes as possible.

The SAB also recommended that EPA plan, implement, and sustain a long-term research program to support the new strategy of preventing the generation of pollution. In addition, EPA should expand its efforts to assist all of the parts of society that must act to prevent or reduce environmental risk.

In response to the SAB recommendation and the request for a research plan in the Appropriations Act, EPA's Office of Research and Development (ORD) held a workshop on November 9-10, 1988, to identify major research elements that would support an Agencywide pollution prevention initiative. Workshop participants included representatives from industry, academia, state and local governments, public interest groups, various offices within EPA, and other federal agencies. (A list of participants is included in the Appendix.) The workshop participants identified six major pollution prevention research goals and six research program areas. The results of this workshop and the efforts of an Agencywide work group form the basis of the research plan presented in this report. The Pollution Prevention Subcommittee of the SAB was invited to review and comment on the draft research plan. The subcommittee met on March 9 and 10, 1989 to discuss the report and submit their comments to EPA.

The remainder of Chapter 1 outlines the need for pollution prevention, the benefits of pollution prevention, the Agency's pollution prevention initiative, EPA's role in pollution prevention research, and the pollution prevention research goals. Chapter 2 presents EPA's pollution prevention research plan, and Chapter 3 discusses the resource and implementation requirements for the research plan, methods for establishing priorities for the research projects, and mechanisms for implementing the research plan.

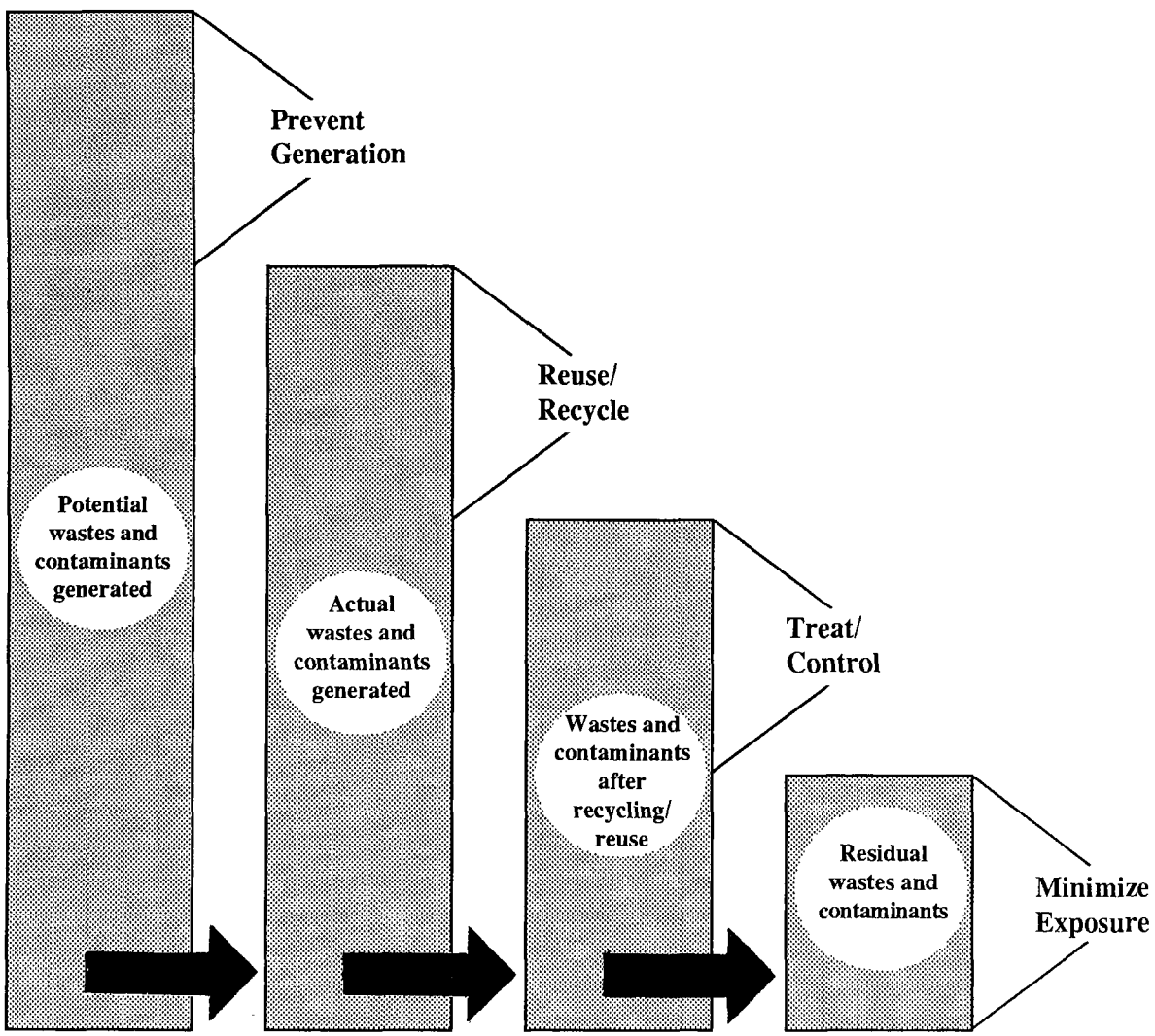
NEED FOR POLLUTION PREVENTION

When EPA was established, Congress gave the Agency specific responsibilities based on the most visible polluters and pollutants--soot and smoke from motor vehicles and smokestacks, and raw sewage and chemicals from municipal and industrial wastewater. Over the next 10 years Congress enacted a dozen major laws affecting air quality, water quality, endangered species, pesticides, drinking water, toxic substances, hazardous and solid wastes, coastal zones, and ocean pollution. EPA assumed its role as a regulatory agency responsible for setting and enforcing environmental standards called for in these statutes. Response to this legislation set in motion the regulatory machinery in operation today.

In the past two decades, EPA's environmental protection efforts have been successful in improving the air quality in most cities, cleaning up thousands of miles of rivers and streams, and restoring thousands of acres of lakes. In

EXHIBIT 1-1

PRIORITIES FOR RISK-REDUCTION RESEARCH



addition, significant progress has been made in improving the management of hazardous wastes, toxic chemicals, and pesticides. Command and control approaches have been effective tools in the reduction of health and environmental risk since the inception of EPA. Numerous examples of the successes of these approaches can be documented in each of EPA's program areas, some of which are described below.

All 50 states have adopted water quality standards, and all publicly owned municipal sewage treatment systems provide at least secondary levels of treatment. Through use of the National Pollutant Discharge Elimination System (NPDES), industrial dischargers have been required to meet discharge standards, often including pretreatment requirements that ensure the proper operation of municipal treatment facilities receiving the industrial discharge.

Implementation of air quality standards authorized by the Clean Air Act has resulted in steady improvement in air quality. Since the Clean Air Act was amended in 1977, the ambient levels of the six criteria pollutants, carbon monoxide, nitrogen oxides, lead, sulfur dioxides, ozone, and particulates, have decreased by amounts ranging from 13 to 87 percent from the 1977 levels.

Prior to the enactment of the Resource Conservation and Recovery Act (RCRA) in 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984, most waste generators, transporters, and treatment, storage, and disposal facilities were not covered under federal regulations. These laws promoted "cradle-to-grave" management of hazardous waste, from point of generation to final disposal location, and required EPA to focus on permitting land disposal facilities and eventually phasing out land disposal of some wastes. Under RCRA and HSWA, EPA has implemented a waste management program that includes permitting and inspection procedures to ensure that wastes are managed properly.

Before the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provided funding for cleanup of the worst abandoned or inactive waste sites in the U.S., no law addressed the cleanup of hazardous waste releases on land, and only one-third of the 3,383 waste disposal sites used since 1950 by the 53 largest U.S. chemical companies were covered by federal regulations. CERCLA, along with the Superfund Amendments and Reauthorization Act (SARA), has allowed EPA to begin cleaning up sites where the results of past disposal practices now threaten surrounding communities and the environment.

Controls on the production, use, and disposal of toxic substances such as persistent pesticides have resulted in dramatic recoveries of numerous species of birds, especially birds of prey, that were nearly decimated by bioaccumulation of pesticides in the years between World War II and the mid-1970s.

Although these past regulatory control approaches have been successful, there are three factors which limit the applicability of these approaches to address certain environmental problems. First, the nation's legal, organizational, and conceptual approaches have been problem and medium specific, with environmental controls oriented toward a single medium, often with insufficient regard for the impact of the approach on other media. Additionally, the interconnectedness of environmental media (e.g., acid rain impacts on aquatic life) and even the connection of all elements of a single medium (e.g., surface and groundwater) were insufficiently evaluated. EPA now administers nine separate statutes and parts of four others. Each statute has given rise to a virtually independent regulatory program, and each program focuses on a particular environmental problem. The "end-of-pipe" controls used to comply to the regulatory standards often result not in the eradication of a waste or pollutant, but in its transfer from one environmental medium to another.

The past lack of attention to cross-media effects of pollution control is understandable considering the media-specific nature of environmental laws like the Clean Air Act and

the Clean Water Act. Even though EPA was established explicitly to address the cross-media effects of pollutants, their sources, and their control technologies, the Agency's media-specific program structure, developed to implement media-specific legislation, has found it difficult to integrate cross-media concerns. A 1987 National Academy of Sciences report entitled *Multi-media Approach to Pollution Control*, indicated that the transfer of pollutants from one medium to another is a major problem and that it is essential for EPA to take a multi-media approach to managing pollution. Unlike past approaches, pollution prevention has a multi-media focus which takes into consideration its impact on all media.

The second factor is that past approaches have largely focused on reducing environmental discharges or cleaning up contamination by employing engineering controls such as wastewater treatment plants, air pollution scrubbers, and chemically secure landfills. Although these "end-of-pipe" strategies have been somewhat successful in controlling pollution once it is generated, further gains through technological treatment and control will be much more costly and difficult to achieve. Preventing pollution before it is created is the most promising means of eliminating the need for some "end-of-pipe" treatment and control technologies.

The third limiting factor is that EPA's past environmental protection efforts have relied almost exclusively on command and control--enforcing regulatory standards through inspection. Since it is virtually impossible for EPA to ensure compliance of every generator, there are inevitably some violators that are discharging pollutants in excess of the Agency's permissible limits. Enforcement is further complicated when there are numerous dispersed sources or non-point sources, such as farmers and homeowners. The only incentives for generators to comply with regulatory requirements are good will and the fear of an EPA inspection and subsequent punishment for violations. Unlike command-and-control approaches, pollution prevention offers a number of health, environmental, and economic benefits that would encourage voluntary action in the public and private sectors to reduce or eliminate the generation of pollutants.

While "end-of-pipe" oriented command-and-control programs have been successful in addressing a number of environmental problems, significant environmental problems still exist despite efforts to control them. These problems, some of which are described below, span all environmental media--air, water, and land.

Ambient air quality standards for ozone have been met in only one major U.S. city. Despite extensive air pollution control efforts, including controls on refineries and cars, no major urban area in the United States, with the exception of Minneapolis, is in attainment with the national health-based air quality standards for ozone. In addition, the standards for carbon monoxide levels are still exceeded in 142 cities and counties in the U.S.

EPA's drinking water standards for inorganic substances have been exceeded over the past decade for approximately 1,500 to 3,000 U.S. public water supplies using groundwater. EPA's 1980 Groundwater Supply Survey showed that 20 percent of all public water supply wells and 29 percent of those in urban areas had detectable levels of at least one volatile organic chemical. Additionally, a 1986 survey indicated that 30 states had wells contaminated with one or more of 60 different pesticides.

Beyond media-specific environmental problems, over the past 20 years there has been an unprecedented increase in the number and volume of complex chemicals introduced into the environment, and the volume of pesticide use and municipal waste has grown substantially. Since World War II, annual production of synthetic chemicals in the United States has risen from 6.7 million to over 100 million tons. Some 70,000 chemicals are in everyday use worldwide with 500 to 1,000 new chemicals introduced each year. Pesticide use in agriculture tripled in the U.S. between 1965 and 1985. Currently, about three billion pounds of pesticides are used each year in this country.

Over six billion tons of agricultural, commercial, industrial, and domestic waste are generated in the U.S. each year. As a nation, we currently produce about 160 million tons of municipal solid waste per year (approximately four pounds of refuse per person per day compared to 2.7 pounds per day in 1960) and approximately 275 million metric tons of hazardous waste each year. Complicating the municipal and hazardous waste problem is the fact that nearly 70 percent of the operating landfills in the U.S. are expected to reach capacity in 15 years and siting new facilities has received strenuous public opposition.

As evidenced by these statistics, the enormity of the increase in the release of pollutants to all media and the difficulty in fully achieving air and water pollution standards emphasize the need for pollution prevention. Many of these environmental problems cannot be alleviated by more stringent regulatory standards and technological controls. Treatment and control approaches have not been effective in achieving compliance and other approaches are needed. For some problems, such as hazardous and municipal wastes, traditional approaches are becoming too costly or less readily available. As the nation approaches the last decade of the 20th century, our strategy for reducing environmental and health risks must evolve in response to these changing circumstances. We are facing a number of environmental problems--like municipal and hazardous waste disposal, ocean pollution, acid rain, global warming, stratospheric ozone depletion, and radon infiltration--that are not attributable to individual sources of pollution and are not totally amenable to end-of-pipe, command-and-control solutions alone. In some cases, such as ground-level ozone, treatment and control measures have already been applied, but have not solved the problem.

Clearly, solutions used in the past are not likely to be as effective as they have been on the challenges of the future. Our future environmental protection strategies must recognize the interconnectedness of the environment and emphasize multi-media and cross-media approaches that focus first on pollution prevention, second on recycling and reuse, and then on treatment and control. EPA must adopt a more integrated and systematic approach to environmental protection and focus on preventing environmental problems as the highest priority of the Agency's strategy. Realistically, pollution prevention approaches will not completely eliminate the need for pollution treatment and control, nor will they rid the environment of all pollution problems. However, pollution prevention does offer a tremendous tool to make further strides in reducing pollution burdens and reducing the health and environmental risks associated with pollution.

BENEFITS OF POLLUTION PREVENTION

Pollution prevention not only offers an approach to reducing the risks associated with most of the serious environmental problems facing this country, it also makes good economic sense. As stated in the Agency's 1986 Report to Congress on the *Minimization of Hazardous Waste*:

> *"Aggressive action in favor of waste minimization is clearly needed... Incentives for waste minimization are already strong, so EPA must capitalize on them."*

There are benefits of pollution prevention, as well as incentives for preventing pollution, that affect many sectors of society. The benefits of pollution prevention can be significant, and can serve to encourage voluntary action to implement pollution prevention approaches in both the public and private sectors. The practical examples presented in Exhibit 1-2 illustrate how pollution prevention approaches can be utilized to reduce pollution and often save money, and how pollution prevention approaches can protect human health and the environment by eliminating or reducing the use and subsequent disposal of pollutants. In addition to publicizing successful pollution prevention applications, there is much to be learned from those applications which have proven less than fully successful. Pollution prevention approaches sometimes create product

EXHIBIT 1-2

EXAMPLES OF POLLUTION PREVENTION SUCCESSES

Product Substitution

The Department of Defense has developed a process in which small plastic beads are air blasted at the surface of an airplane to remove paint. This eliminates the need for hazardous solvents to remove the paint. The Department estimates that this process has decreased the amount of hazardous waste from 10,000 pounds of wet sludge to 320 pounds of dry paint chips and decomposed plastic material per aircraft. In addition, the amount of work required per aircraft to remove the paint by air blasting is eight times less than by traditional methods.

Process Modification

After analysis of the contribution of cleaning activities to its waste stream, a California chemical plant changed the reactor rinse and cleaning procedures to segregate and recapture phenol wastes from its sanitary wastes in its resin manufacturing operations. This allowed the company to recover the water-phenol mixture for reuse and reduced the use of organics by 93 percent.

Product Substitution

Riker Laboratories in California replaced an organic solvent with a water-based solvent for coating medicine tablets. As a result of this substitution, Riker realized a one-time savings of $180,000 in pollution control equipment that was deemed unnecessary once the switch to the water-based solvent dramatically reduced air pollution emissions. In addition, Riker is saving $15,000 each year by replacing the organic solvent.

Resource Recovery

An assessment of a steel-making facility showed that calcium fluoride (fluorspar) in the sludge generated during neutralization of the pickling line wastewater could be recovered. By recycling the fluorspar, the company will save the substantial amount of money spent to buy it, and also reduce by 30 percent the volume of sludge requiring disposal.

EXHIBIT 1-2 (continued)

Product Substitution

EPA initiated an investigation of four ethylene glycol ethers because of the potentially toxic effects of these substances. The Agency determined that the most likely substitutes were propylene glycol ethers (much less toxic than ethylene glycol ethers). As a result of EPA's investigation and fear of possible regulatory action, companies voluntarily reduced their use of ethylene glycol ethers in coatings by 50 percent over a period of four years.

Process Substitution

Control of cockroaches has become increasingly difficult, due to their increased resistence to pesticides. Integrated pest management (IPM) has been used successfully to provide acceptable levels of control for cockroaches by using a range of techniques, such as lowering temperature, removing food, eliminating moisture, reducing clutter, and filling hiding places, in addition to limited use of pesticides. IPM approaches are being demonstrated by EPA, in cooperation with other federal and state agencies, pesticide user groups, universities, and the agricultural chemical industry, for a variety of other pests, such as termites, turf pests, grasshoppers, and aquatic weeds. IPM is an effective alternative to the use of pesticides in managing pests, resulting in reduced pesticide use, disposal, and runoff.

Refrigerant Recycling

Automotive air conditioner refrigerant is the largest source of ozone depleting chlorofluorocarbons in the United States. EPA sampled and analyzed refrigerant from over 200 automobile air conditioners to develop a standard of purity for recycled refrigerant. In 1988, a committee that included representatives of the Motor Vehicle Manufacturers Association (MVMA), the Mobile Air Conditioner Society, and the Society of Automotive Engineers reviewed and approved this standard and recommended it to the MVMA. A program for certification of refrigerant recovery devices has subsequently been initiated. When fully implemented, this research could represent an important milestone in reducing the effects of automotive air conditioner refrigerant in depleting the earth's stratospheric ozone layer.

quality or productivity problems or are simply not cost effective. For example, in one case, a paper mill attempted to use recycled fiber in the manufacture of high quality specialty paper. After trying several grades of waste paper, the project was abandoned when it became clear that the recycled fiber interfered with the parchmentizing process practiced in that mill. Examples such as this should be made available to others so that past mistakes are not repeated and alternative approaches can be considered.

Industry, state and local governments, and the public are recognizing the need for pollution prevention and the potential benefits that can result from such approaches. These benefits fall into two major categories: (1) reduced health and ecological risks, and (2) economic benefits.

The health and ecological risks associated with exposure will be reduced as a result of preventing or reducing the generation of pollution or the use of toxic substances, especially when the impacts cannot be managed by treatment and control approaches. A pollution prevention approach can reduce risk in a number of ways. Pollution prevention can reduce the total waste and pollution burden, reduce the amount of waste requiring disposal, and prevent the need for remediating improperly managed disposal sites. Regulatory controls have often resulted in removing a waste from one environmental medium by introducing it into another. Pollution prevention will decrease this media shift problem by reducing the generation of pollutants. Reduced use of toxic substances and generation of less waste also will reduce the need to handle and transport these substances, resulting in decreased risk of accidental releases and the risk of human and environmental exposure. Furthermore, generation of less waste will reduce demand for additional waste storage and disposal facilities. Thus, pollution prevention is expected to reduce the health and environmental risks of exposures resulting from manufacturing, use, transportation, storage, and disposal.

Economic benefits of pollution prevention apply to federal, state, and local government, all sectors of commerce and industry, and the public. Preventing pollution allows the government to avoid some of the costs of enforcing regulations and ensuring compliance. For example, new federal requirements issued since 1970 under the Clean Air Act are projected to cost federal, state, and local government, industry, and the public about $256 billion from 1981 to 1990. Pollution prevention would also relieve the tremendous costs of remediating contaminated sites, such as Superfund sites, from federal and state agencies, potentially responsible parties, as well as the taxpayers. The average uncontrolled hazardous waste site on the U.S. National Priority List of 1,175 sites will cost between $21 and $30 million to clean up and take approximately six to eight years to complete. Pollution prevention could also save the government indemnification costs. For instance, the indemnification costs incurred by the federal government to purchase three pesticides whose uses had been banned exceeded $63 million, excluding the costs of treatment and disposal.

Pollution prevention approaches can economically benefit companies by increasing operating efficiency which reduces demand for feedstocks and energy; lowering costs associated with the treatment, storage, transportation, and disposal of wastes; and reducing compliance costs including permits, monitoring, and enforcement. EPA estimates that capital investment by industry for air pollution control equipment necessary to meet the requirements of the Clean Air Act will be about $102 billion from 1981 to 1990. Other economic benefits of pollution prevention for companies include reducing effluent and assessments for local wastewater plants, and generating income derived through the sale or reuse of waste.

Probably foremost in motivating pollution prevention are cost incentives, especially as traditional forms of waste management are becoming increasingly more expensive. U.S. industry currently spends $70-80 billion annually on pollution control. Costs of land disposal, while still the least expensive method of disposing of waste, have skyrocketed in some

urban areas from as little as $10 per ton of waste in 1978 to well over $250 per ton in 1988. Budgets for some municipal solid waste management agencies have quadrupled during the 1980s. Prices for alternative waste treatment are expected to rise as generators compete for scarce treatment capacity (such as incineration or chemical detoxification). Currently, incineration costs can be as high as $1,500 per ton. Moreover, these escalating disposal costs are only part of the bill that generators of waste are incurring. They must also pay for administrative and reporting procedures imposed by stringent regulatory controls and for insurance coverage against a host of liabilities that are associated with accidents and/or the mismanagement of wastes. These increasing waste management costs, combined with the cost savings associated with improved management of raw materials and pollution prevention production processes, are significant economic incentives.

Federal and state regulations have been the primary cause of increased costs in treatment, storage, and disposal of wastes, especially in relation to landfills, surface impoundments, and storage and accumulation tanks. The current series of land disposal restrictions under HSWA will limit the number of untreated hazardous wastes that can be disposed of on land and thus, are likely to increase the cost of disposal. HSWA also imposes more stringent standards on surface impoundments and storage and accumulation tanks. The recently promulgated underground storage tank rules will also increase waste management costs. Some of these rising costs can be avoided by reducing or eliminating the wastes.

Waste managers are seeking new treatment, storage, and disposal sites and planning to expand existing ones, but in the process they are encountering the familiar problem of "not in my backyard." While there are some instances where states have been successful in helping to site new waste management facilities, local resistance tends to be extremely hard to overcome. This local resistance is not limited to hazardous waste facilities, but extends to municipal solid waste landfills, incinerators, sewage treatment plants, and even to recycling facilities. This intense public opposition to the siting of many types of waste management facilities causes shortages to persist even when market demand is strong. The number of municipal solid waste landfills in operation has declined drastically from about 30,000 in 1976 to 6,584 in 1987. In many cases, therefore, the only alternative generators may have is reliance on source reduction and on recycling to reduce the amount of waste they would otherwise send to offsite management and disposal facilities. Additionally, even though the demand for new treatment and disposal capacity will be high, permitting procedures will tend to delay the availability of that new capacity, temporarily driving up the costs of all forms of treatment and disposal even further.

The liability of waste generators using offsite treatment, storage, or disposal is another incentive for pollution prevention. These generators face liability for two reasons: (1) there is a potential for mismanagement of wastes by facility operators, and (2) there is the possibility of improper design of the disposal facility itself. Even careful facility management cannot reduce these risks to zero. A generator risks incurring liability when the facility owner or operator cannot or will not pay for remedial or corrective actions made necessary by migration of wastes. In these situations, generators can be held liable under the Comprehensive Environmental Response, Compensation, and Liability Act for absolute, strict, joint, and several liability. The traditional means for obtaining coverage for potential hazardous waste management liability is through insurance, but, for many generators and facility owners or operators, liability insurance is no longer available or is available only at extremely high cost. In recent years, premiums have increased 50 to 300 percent, policies have been cancelled even where loss ratios have been excellent, and many companies have difficulty obtaining coverage at any price. When less waste is generated, it reduces potential liability for future disposal, and thus, is an incentive for pollution prevention.

The American public, in general, has become increasingly aware of risks posed by environmental pollution. The information reporting requirements of Title III of the Superfund Amendments and Reauthorization Act of 1986 have made the public more aware of the risks associated with pollutants in their communities. Citizens have organized to combat water and air pollution, and more recently, to protest the use of styrofoam packaging by fast food outlets and overpackaging of fruits and vegetables by grocery stores. Citizen groups have also been instrumental in establishing community recycling programs. While some of the strongest incentives for implementing pollution prevention techniques are probably economic, many companies are establishing pollution prevention programs out of sensitivity to public concern. This type of corporate good citizenship is felt to produce good relations between industry and the public.

EPA'S POLLUTION PREVENTION INITIATIVE

Over the past five years, EPA has attempted to redirect the nation's pollution control strategy toward pollution prevention by adopting a waste management hierarchy that placed priority on pollution prevention. The first two elements in the hierarchy, depicted in Exhibit 1-3, focus on source reduction and recycling. A milestone in the evolution of EPA's pollution prevention strategy was the passage of HSWA in 1984. In addition to authorizing very stringent treatment and disposal regulations, HSWA also contained as the nation's highest waste management priority a redirection towards "waste minimization" as a preferential strategy for protecting human health and improving environmental quality.

In 1986, EPA's Office of Solid Waste (OSW) published its Report to Congress on the *Minimization of Hazardous Waste*. This report reiterated the Agency's promotion of the waste management hierarchy, with source reduction as the highest priority, followed by recycling, treatment, and disposal. The report also committed EPA to collecting better data and other information for measuring EPA's progress in hazardous waste minimization. Furthermore, it emphasized a waste minimization technical information transfer program. The report concluded that mandatory standards of performance and required waste minimization management practices were not feasible or desirable at the present time. The term "waste minimization" has been used by the Agency to refer to reducing the generation of hazardous waste at the source or recycling of hazardous waste to reduce pollution. In 1990, an update on national progress in waste minimization and the need for further incentives and disincentives will be provided to Congress. Also published in 1986, the Office of Technology Assessment's *Report on Serious Reduction of Hazardous Waste* indicated that technology was not the only limiting factor in reducing the generation of hazardous pollutants. The report cited non-technological factors, such as sociological, economical, and institutional, as important contributors to reducing hazardous wastes.

In 1987, the Office of Research and Development (ORD) initiated a waste minimization research effort that was coordinated with OSW's efforts on the reduction and elimination of hazardous waste. This research effort, called the Waste Minimization Research (WMR) program, was designed to encourage the identification, development, and demonstration of processes and techniques that result in a reduction or prevention of pollution or in the recycling of hazardous wastes. This program has not yet been expanded to address pollution prevention issues for non-hazardous wastes or on a multi-media basis.

In an effort to facilitate the task of redirecting the Agency's environmental protection strategy to pollution prevention, the Pollution Prevention Office (PPO), in the Office of Policy, Planning, and Evaluation, was created in 1988. The PPO is charged with promoting an integrated environmental ethic stressing the prevention of pollution. This new office is the focal point for the Agency's pollution prevention activities and a major impetus behind an integrated, cross-media approach to pollution prevention.

EXHIBIT 1-3

WASTE MANAGEMENT HIERARCHY

- **Source Reduction**. The reduction or elimination of waste at the source. Source reduction measures include product and process modifications, feedstock substitution, improvements in feedstock purity, housekeeping and management practice changes, increases in the efficiency of equipment, and recycling within a process.

- **Recycling**. The use or reuse of waste as an effective substitute for a commercial product or as an ingredient or feedstock in an industrial process. It includes the reclamation of useful constituent fractions within a waste material or the removal of contaminants from a waste to allow it to be reused.

- **Treatment**. Any method, technique or process which changes the physical, chemical, or biological character of any waste so as to neutralize it, recover energy or material resources from it, or render it non-hazardous, less hazardous, safer to manage, amenable for recovery, amenable for storage, or reduced in volume.

- **Disposal**. The discharge, deposit, injection, dumping, spilling, leaking, or placing of waste into or on any land, water or the air.

Another milestone for the pollution prevention initiative was publication of the SAB's report, *Future Risk: Research Strategies for the 1990s*, in 1988. This report clearly emphasized the importance of pollution prevention, making it EPA's highest research priority.

On January 26, 1989, the PPO issued a *Pollution Prevention Policy Statement* for public comment. This policy statement encouraged organizations, facilities, and individuals to fully utilize source reduction techniques in order to reduce risk to public health, safety, welfare, and the environment, and as a second preference to use environmentally sound recycling to achieve these same goals. The PPO will examine existing legislation to eliminate obstacles to pollution prevention, as well as future legislation to incorporate pollution prevention. The PPO has begun working with each of EPA's program, research, and regional offices to develop a comprehensive Agencywide pollution prevention strategy. The strategy will form the basis for identifying the specific ongoing and planned activities for each of the EPA programs. The pollution prevention research plan described in this report is an adjunct to this broader Agencywide pollution prevention strategy under development by the PPO.

In February 1989, OSW published *The Solid Waste Dilemma: An Agenda for Action* which is a national strategy for managing the nation's garbage problem. The *Agenda for Action* emphasizes the importance of pollution prevention and recycling above treatment and disposal. It recommends a number of voluntary activities that can be undertaken by federal, state, and local governments, as well as industry and private citizens to reduce the amount of waste generated and increase the amount of municipal solid waste recycling. OSW has also recently completed several hazardous waste minimization initiatives including initiation of a technical assistance clearinghouse.

OSW's activities, the WMR program, and establishment of the PPO signify EPA's commitment to achieving significant reductions in the generation of harmful pollutants and wastes. It acknowledges the Agency's understanding that pollution prevention is a major avenue for achieving reduction in the pollutant loadings that pose threats to human health and the quality of the environment. The Agency has established seven specific goals for its pollution prevention initiative. They are:

(1) Promote a cross-media, preventive approach across all EPA activities. Examine existing legislative authorities and current and planned regulations and policies to determine when pollution prevention can be incorporated.

(2) Support the initiation and development of state and local multi-media pollution prevention programs. Encourage and strengthen the states' ability to work directly with companies and municipalities to prevent pollution. Help make pollution prevention integral to the implementation of all state environmental programs.

(3) Supply industry and the public with the tools they need to implement pollution prevention measures, including information and technical assistance on specific pollution prevention techniques, training in auditing facilities to determine potential preventive measures, and guidance in implementing pollution prevention approaches.

(4) Identify and implement incentives for pollution prevention, eliminate barriers to pollution prevention, and target opportunities for future progress, while acknowledging the importance of maintaining a stable regulatory environment.

(5) Make America aware of the need for pollution prevention and achieve a cultural and behavioral change at all levels of government, industry, and the public.

(6) Develop reliable indicators of pollution prevention, and implement a data collection and evaluation strategy to measure and evaluate progress.

(7) **Identify, prioritize, and coordinate research designed to increase pollution prevention and implement a cooperative program to conduct this research.**

The pollution prevention research plan presented in this report is designed to achieve the seventh goal of the Agency's pollution prevention initiative, and support the other six goals. EPA envisions an extensive extramural pollution prevention research program supplemented by a small intramural program to achieve this goal. EPA recognizes the importance of working with industry on technological research (products, processes, recycling/reuse), and the significant contribution of industry, academia, and public interest groups in conducting non-technological research (socio-economic and institutional).

EPA'S ROLE IN POLLUTION PREVENTION RESEARCH

Our ability to protect human health and the quality of the environment in the future will depend directly on our understanding of and ability to manage activities that affect the environment. Research is the primary vehicle for enhancing our knowledge base in these areas.

Past investments in research and development efforts have provided excellent returns. EPA research into air pollution controls, wastewater treatment systems, and the safe disposal of hazardous wastes has made significant contributions to cutting the cost and increasing the efficiency of controlling pollution. The "capacity to do research" was included in the Presidential directive that established the EPA in 1970, and still remains a fundamental function in a comprehensive environmental protection strategy. Without a substantial investment in R&D, we would not understand the processes and practices that cause pollution, the means by which it is transported, the mechanisms of human exposure, the risks posed by pollution, or ways to potentially reduce those risks. If we are to continue to enjoy the enormous health, environmental, and economic benefits of environmental research, then our research investments must be guided by a comprehensive strategy that focuses on the most efficient and cost effective approaches to reducing environmental risk in the future.

Over time EPA's research program has become primarily a support for the Agency's near-term regulatory responsibilities. While there are some incentives for pollution prevention (e.g., cost of waste management, lack of disposal capacity, liability, risk reduction) a fundamental change in the mindset of individuals and institutions is necessary to implement effective pollution prevention measures. Furthermore, regulatory programs often encourage the use of off-the-shelf technology instead of fundamental changes in products or processes which lead to pollution prevention. A rigorous pollution prevention research program is required to bring about these changes, and research focused on near-term regulatory needs will not be adequate for protecting environmental quality in the future. Program, research, and regional offices will have to work together to identify specific research needs, and future research efforts must be targeted at environmental problems posing the greatest risk to human health and the environment, with emphasis on pollution prevention.

Although the benefits of pollution prevention are recognized by many organizations, lack of information and knowledge have been a barrier to implementing pollution prevention programs. Designing pollution prevention techniques and identifying opportunities can require resources, R&D, and specialized engineering knowledge that many small- or medium-sized companies do not have and may not be able to obtain independently. In addition, information is needed by other organizations, such as state and local governments, EPA and other federal agencies, large businesses, regional and local agencies, consumers, and public interest groups in order to facilitate wide-scale implementation of pollution prevention techniques and approaches. Some of the pollution prevention information needs of these various groups responsible for implementing and contributing to pollution prevention programs are identified in

Exhibit 1-4. Awareness of such needs is fundamental to the design of a successful research program, since the goals, objectives, topic areas for investigation, and specific projects all must address the basic needs of the potential users of the information.

The pollution prevention research plan presented in Chapter 2 is intended to meet these information needs and to promote the identification, development, and implementation of successful pollution prevention approaches. Closing the information gaps identified in Exhibit 1-4, will require research in five major program areas--product, process, recycling and reuse, socioeconomic and institutional, and anticipatory research. A sixth major component of the research program is technology transfer and technical assistance to ensure that the information produced by the research efforts in each of the five program areas is disseminated in the most effective manner to those groups that require the information. It is essential that the research program also include an evaluation component that assesses the effectiveness of past and ongoing research projects, as well as the changing needs of the information users in society. These evaluations will enable EPA to refocus its research efforts and will assist the Agency in prioritizing future research projects.

In many cases, potential users of the information indicated in Exhibit 1-4 may lack the capabilities, resources, or motivation to conduct the research necessary to produce it. In these cases, EPA has a crucial role to play as a leader in pollution prevention, in forging partnerships with these users to conduct research and disseminate the information. For example, large industries can be expected to perform the process and product research needed to modify their own systems, and several large corporations have initiated pollution prevention programs which are already showing results. However, industry management and investors will target research to those areas that will improve their profits and enhance their company's competitiveness. As industry and academic representatives to the Science Advisory Board noted, no one company or industry is likely to generate broadly applicable research findings that will address future environmental issues and cross-media problems. EPA, often in collaboration with academia and industry, is the only entity that is likely to exert leadership in conducting the basic environmental research needed in these areas.

While large private companies will invest in finding ways to minimize or recycle the waste generated by their production processes to the extent that it makes economic sense, smaller firms may not have the resources or technical capability to conduct such research. For those industries composed of numerous, dispersed small facilities, EPA can play a valuable role in conducting research into processes, products, and recycling/reuse and then transferring the new technology widely within the industry. EPA can also play a useful role in discovering and promoting linkages between industries, since one industry's waste could become another industry's feedstock.

Local and state governments and regional agencies--important users of pollution prevention research--traditionally have not invested in such research since most of their resources are devoted to providing local services, such as health, transportation, solid waste management, sanitation, and drinking water supply. EPA research on recycling technologies, for example, could have an enormous beneficial impact on municipalities and other local entities nationwide, since these organizations need ways to reduce their rising costs of solid waste disposal.

EPA research and technology transfer efforts could also assist states and local governments in developing and implementing consumer awareness campaigns, creating local incentives, and promoting pollution prevention to all sectors. States and localities are anxious to learn from one another and share information on what techniques have been effective, how much such programs cost, and what steps must be taken to implement these programs. EPA can facilitate these exchanges by conducting research on the costs and benefits of the programs, and then disseminating the results of this research. In addition to coordinating and conducting technological research, EPA has a critical role to play

Exhibit 1-4
Pollution Prevention Information Needs

Information Users	Types of Information Needed by Various Users				
	Product	**Process**	**Recycling and Reuse**	**Socioeconomic and Institutional**	**Future Environmental Problems**
EPA Program and Regional Offices	Life cycle analysis methods Trends in use patterns New products Product life-span data State program strategies	Feedstock substitution Waste minimization assessment procedures Basic unit process data	National and regional market availability National and regional infrastructure capabilities State program strategies New process and product technologies	Incentives and disincentives Environmental effects Economic costs and benefits Consumer behavior trends Management strategies	Environmental trends Emerging technologies Life style change trends Emerging environmental problems Effectiveness of prevention strategies
Other Federal Agencies	Life cycle analysis methods New products Product life-span data State program strategies	Waste minimization assessment procedures State program strategies Feedstock substitution Basic unit process data	National and regional market availability National and regional infrastructure capabilities State program strategies	Incentives and disincentives Environmental effects Economic costs and benefits Management strategies	Emerging environmental problems Emerging technologies Environmental trends Effectiveness of prevention strategies
States	Product substitution Life cycle analysis methods Product life-span data New products Neighboring state strategies	Waste minimization assessment procedures Neighboring state strategies Feedstock substitution Basic unit process data	Regional and local market capacity Regional and local infrastructure capabilities Automated equipment and process Neighboring state strategies	Incentives and disincentives Environmental effects Economic costs and benefits Consumer behavior trends Management strategies	Environmental trends Emerging environmental problems Emerging technologies Effectiveness of prevention strategies
Regional and Local Agencies	New products Product substitution Life cycle analysis methods Product life-span data State program strategies	Waste minimization assessment procedures State program strategies Basic unit process data	Distribution and marketing Management strategies Automation State program strategies	Incentives and disincentives Environmental effects Economic costs and benefits Consumer behavior trends Management strategies	Environmental trends Emerging environmental problems
All Government Agencies as Consumers	New products Product applicability Safe handling, storage, and disposal Product substitution	Cleaning, maintenance, and repair Feedstock substitution Unit process waste generation assessment methods	Distribution and marketing Waste stream segregation Recycling and reusability of waste stream components Automation	Incentives and disincentives Economic costs and benefits Management practices	Emerging technologies Environmental trends
Industry: Large Business	Product substitution Life cycle assessment methods	Feedstock substitution Optimization methods Unit process waste generation assessment methods	Automation By-product recovery methods Closed loop methods Waste stream segregation On-site and off-site reuse opportunities Waste exchange opportunities	Incentives and disincentives Economic costs and benefits Management practices	Emerging technologies Environmental trends Emerging environmental problems
Industry: Small Business	Product substitution New products Product applicability Safe handling, storage, and disposal	Feedstock substitution Process change options Cleaning, maintenance, and repair Materials handling Unit process waste generation assessment methods	Closed loop methods Waste stream segregation Waste recapture and reuse On-site and off-site reuse opportunities Automation By-product recovery methods Waste exchange opportunities	Incentives and disincentives Economic costs and benefits Management practices	Emerging technologies
Individual Consumers and Public Interest Groups	New products Product applicability Safe handling, storage, and disposal	Cleaning, maintenance and repair Product substitution	Collection and distribution Waste stream segregation Recyclability and reusability of products On-site (in-home) and off-site reuse opportunities	Incentives and disincentives Environmental effects Economic costs and benefits	Emerging environmental trends

in coordinating and conducting non-technological research. This research would be useful to EPA, other federal agencies, state and local agencies, industry, and public interest groups in identifying and overcoming barriers to pollution prevention. Research could be conducted to help understand behavior modification and the link between incentives and the desired behavioral change. Socioeconomic and institutional research could be useful in assessing existing and new pollution prevention strategies and ways to improve them. Most importantly, socioeconomic and institutional research is essential to bringing about the fundamental change in the mindset of individuals and institutions that is necessary to achieve the benefits of pollution prevention.

EPA also has a significant role in educating and training the public and private sectors concerning the importance and the "how to" of pollution prevention. An additional role for the Agency is to provide technical assistance to small- and medium-sized companies, state and local governments, other federal agencies, and public interest groups in overcoming barriers to pollution prevention and promoting it in all sectors of society.

EPA has a leadership role among federal agencies for promoting pollution prevention. EPA cooperates with other agencies to shoulder a portion of the total U.S. pollution prevention effort. For example, the Departments of Energy, Agriculture, Interior, Commerce, Defense, and Transportation, among others, all engage in activities and have responsibilities in this arena. Federal agencies are also major consumers in our society, and therefore, have a responsibility to incorporate pollution prevention into their procurement specifications and waste management procedures. In addition, a number of federal, civilian, and defense agencies also control lands and facilities on which are located wastes that pose potentially serious environmental and health risks. EPA, as the only federal agency with a clear mandate to conduct research on pollution prevention, as well as to implement pollution prevention methods, needs to work closely with these other agencies to ensure that adequate, effective pollution prevention methods are employed for all available opportunities. The Science Advisory Board summarized EPA's role in pollution prevention research as follows:

> *EPA is the only entity that has a clear mandate to conduct research to gather information on effective approaches and to transfer that information to all who could use it nationwide. This information collection, evaluation, and dissemination role is a key component of the research function and one that EPA is uniquely suited to serve. In short, no individual local government or private business is likely to fund research needed by many local governments and private businesses to help reduce their waste streams. Yet, as more and more elements of our society become directly involved in the business of risk reduction, such research clearly is needed.*

EPA has already initiated a number of pollution prevention research projects under the WMR program. These projects are primarily extramural research efforts which have focused on the minimization of hazardous wastes. EPA intends to expand these projects to include not only non-hazardous wastes, but a multi-media focus as well. The research projects of the WMR, OSW's *Agenda for Action*, and PPO's *Pollution Prevention Policy Statement* form the cornerstone of the Agency's future pollution prevention research efforts. The WMR projects, outlined below, will provide much needed data on pollution prevention technologies and techniques to federal agencies, state and local governments, industry, academia, public interest groups, and communities.

- **The Waste Reduction Innovative Technology Evaluation (WRITE) Program** -- a program to identify, evaluate, and/or demonstrate new ideas and technologies that lead to waste reduction. WRITE is a program that unites EPA with private industry and other organizations to encourage the development and/or demonstration of effective techniques and technologies for hazardous waste minimization. Usually EPA conducts an evaluation and industry builds and operates the

equipment. Concept or equipment development costs may be shared for some businesses.

- The Waste Reduction Assessments Program (WRAP) -- a program to demonstrate EPA's Waste Minimization Opportunity Assessment Procedure and encourage the use of waste minimization assessments. WRAP is designed to encourage the use of waste minimization assessment as a tool for identifying options for reducing waste. It supports activities to demonstrate the procedure in various industrial and manufacturing settings. Individual subprograms will be developed for each of the major hazardous waste generating sectors.

- The Waste Reduction Evaluations at Federal Sites (WREAFS) -- a program to develop cooperative waste minimization technology demonstration projects with other federal agencies. WREAFS provides a structure for involving EPA in a wide variety of projects already being funded by other federal agencies, including the Department of Defense and Department of State. EPA's role is to conduct the initial evaluation and to provide technology transfer.

- The Waste Reduction Institute for Senior Executives (WRISE) -- a joint University/EPA-sponsored institute composed of senior individuals knowledgeable in the principles and practices of waste minimization. These individuals counsel EPA with respect to its waste minimization activities and serve as liaisons to private industry generators that the Agency wishes to encourage to adopt and demonstrate waste reduction techniques.

GOALS OF THE POLLUTION PREVENTION RESEARCH PLAN

EPA is the agency charged with the responsibility of protecting human health and the environment. Its basic mission is to reduce the level of risk to human health and the environment posed by pollution. EPA is expected to be, and needs to be, the leader in the area of environmental risk reduction. Therefore, it is essential that EPA plan and implement a risk reduction research effort whose first priority is the prevention of pollution. The health, environmental, and economic benefits of risk reduction research can be substantial. As the SAB noted in *Future Risk: Research Strategies for the 1990s*, successful risk reduction technologies developed through EPA research have saved the nation from $30 to over $1,000 for every research dollar spent on these projects.

In response to pollution prevention research needs and EPA's role in meeting these needs, ORD has defined six fundamental goals for the proposed pollution prevention research program. These goals build upon existing Agency pollution prevention efforts, and broaden the research scope to enable the Agency to identify, develop, demonstrate, and transfer effective pollution prevention technologies and techniques. These goals are to:

(1) Stimulate the development and use of products that result in reduced pollution.

This goal focuses on the pollution prevention problems related to the use and disposal of specific products. Although products are often considered to include only manufactured items, as used here, the term also includes chemicals used in manufacturing processes and service industries; packaging for parts, commodities, and manufactured items; and fluids and gases used as solvents, carriers, refrigerants, coatings, and lubricants, and additional items of commerce. These materials often are not viewed as wastes or industrial discharges, but do in fact impact the environment and pose a risk to health.

(2) Stimulate the development and implementation of technologies and processes that result in reduced pollution.

Numerous pollution prevention opportunities exist in manufacturing, mining, agricultural, and service processes. This goal addresses the need to focus research activities on these processes to enable broad-scale reduction in pollution generation.

(3) **Expand the reusability and recyclability of wastes and products and the demand for recycled materials.**

Research is needed to improve the reusability and recyclability of wastes and products, and to increase the capacity and demand for recycled materials in production processes. Such improvements will prolong the useful life of materials and reduce the environmental impacts of wastes and pollutants from all waste streams.

(4) **Identify and promote the implementation of effective non-technological approaches to pollution prevention.**

This research area should include socioeconomic and institutional factors that motivate behavior and foster changes in behavior as they relate to incentives for adopting pollution prevention techniques. Research is needed to understand the roles of non-technological factors in implementing pollution prevention approaches and their impact on the effectiveness of pollution prevention programs.

(5) **Establish a program of research that will anticipate and address future environmental problems and pollution prevention opportunities.**

Research is needed to assist EPA in anticipating and responding to emerging environmental issues and to evaluate new technologies that may significantly alter the status of pollution prevention programs in the future. A flexible program is needed for conducting research that may impact long-term pollution prevention program directions and objectives. This research program will enable EPA to anticipate and potentially prevent future environmental problems. In addition, this program provides the Agency with the ability to address emerging issues which will shorten the time between detection of a new environmental problem and EPA's ability to respond with an effective program.

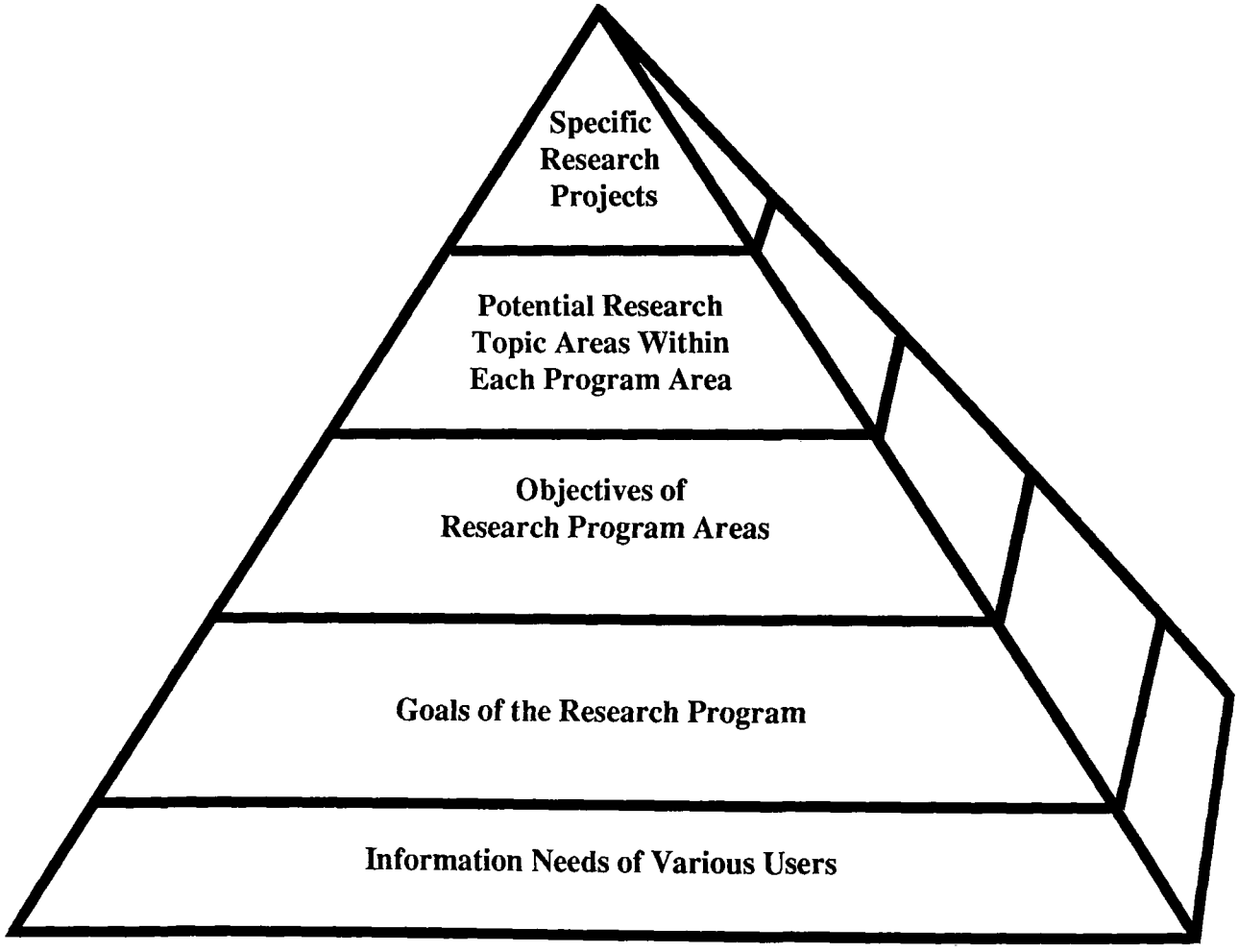
(6) **Conduct a vigorous technology transfer and technical assistance program that facilitates pollution prevention strategies and technologies.**

It is imperative that the results of research investigations conducted under this program or by industry and academic research programs are communicated to appropriate audiences. This goal addresses the need to ensure that new information can be evaluated and incorporated into pollution prevention programs rapidly.

The research plan presented in Chapter 2 of this report is designed to address these six pollution prevention goals and to build on the foundation established by program, research, and regional office activities. It identifies six research program areas and objectives for each program area, lists numerous topic areas of potential research, and provides selected examples of specific potential research projects. The information needs of the various organizations that could be instrumental in implementing pollution prevention techniques and programs, identified in Exhibit 1-4, are the foundation for the framework of the research plan presented in Exhibit 1-5. The goals of the research plan are designed to meet these information needs, and the objectives of the six research program areas are intended to facilitate achievement of these goals. The research topics within each program area and the individual research projects conducted within each topic are required to accomplish the program objectives.

EXHIBIT 1-5

FRAMEWORK FOR THE POLLUTION PREVENTION RESEARCH PROGRAM



CHAPTER 2
RESEARCH PLAN

To achieve the research goals stated in Chapter 1, EPA will assume a leadership and coordinating role in both research and implementation of pollution prevention. Ongoing and future pollution prevention research conducted or sponsored by EPA will be focused on achieving these goals. The development of this research plan is a major step toward implementing a comprehensive risk reduction research program that has as its first priority the prevention or reduction of pollution.

In recent years, research activities in both the private and public sectors have begun to address pollution prevention issues. As a result, progress has been made in identifying opportunities and developing technologies for limiting pollution generation. These efforts must be expanded. Some of the research activities described in the following sections are logical extensions of programs that were initiated under several Agency programs, such as ORD's WMR program, OSW's *Agenda for Action*, and PPO's grant program. For example, ORD's Waste Reduction Innovative Technology Evaluation (WRITE) program was initiated to demonstrate and evaluate new technologies and schemes for reducing hazardous wastes. This program is being implemented via cooperative agreements with six states--California, Washington, Connecticut, Minnesota, New Jersey, and Illinois. In each of these states, five industrial projects are targeted for waste minimization opportunity assessments over a three year period. Four primary industries that will be evaluated include chemicals, fabricated metals, electroplating, and printed circuit boards. As part of the process research program area discussed in this research plan, the WRITE program will be expanded to a multi-media focus and to include non-hazardous wastes and pollutants.

This research plan is intended to build on the existing knowledge and program, research, and regional office efforts, by providing structured research programs for gathering and evaluating data on major topics of concern, and stimulating progress in adopting pollution prevention technologies and strategies. Research to identify the current impact of pollution prevention practices and opportunities and to identify impediments to progress will play a principal role in helping to shape the nation's efforts to reduce pollution.

The research plan identifies six major program areas of pollution prevention research. These are:

- Product Research
- Process Research
- Recycling and Reuse Research
- Socioeconomic and Institutional Research
- Anticipatory Research
- Technology Transfer and Technical Assistance.

These program areas organize the pollution prevention research program into discrete subject areas of related activities. Exhibit 2-1 depicts the six program areas of the pollution prevention research plan and their associated goals.

As depicted in Exhibit 2-2, the research efforts in the first three research program areas (product, process, and recycling/reuse) will focus on the following three types of activities:

- Assessing current conditions and pollution prevention opportunities
- Identifying and evaluating existing and new technologies with regard to their effects on pollution generation

EXHIBIT 2-1

POLLUTION PREVENTION RESEARCH PROGRAM AREAS

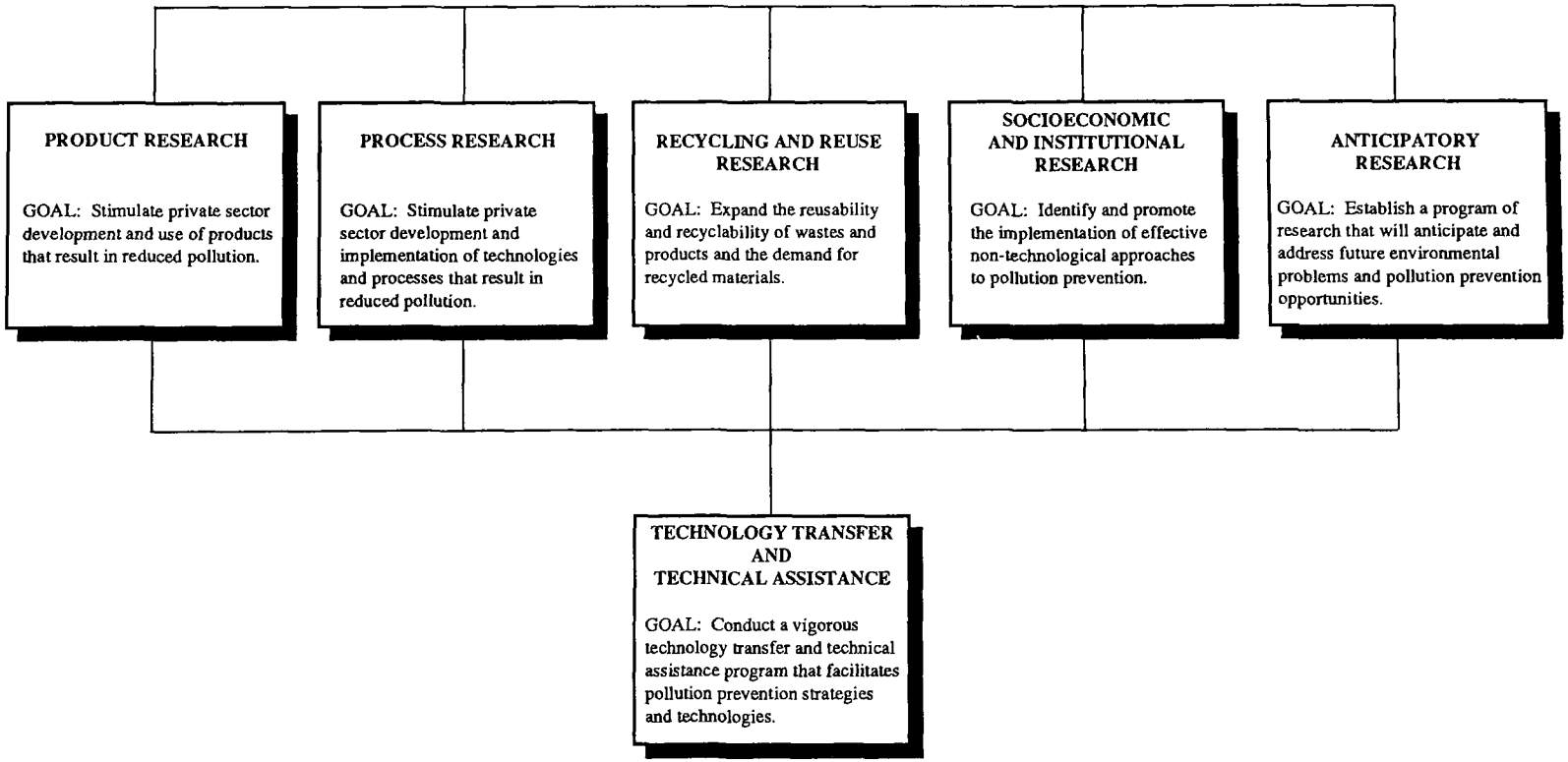
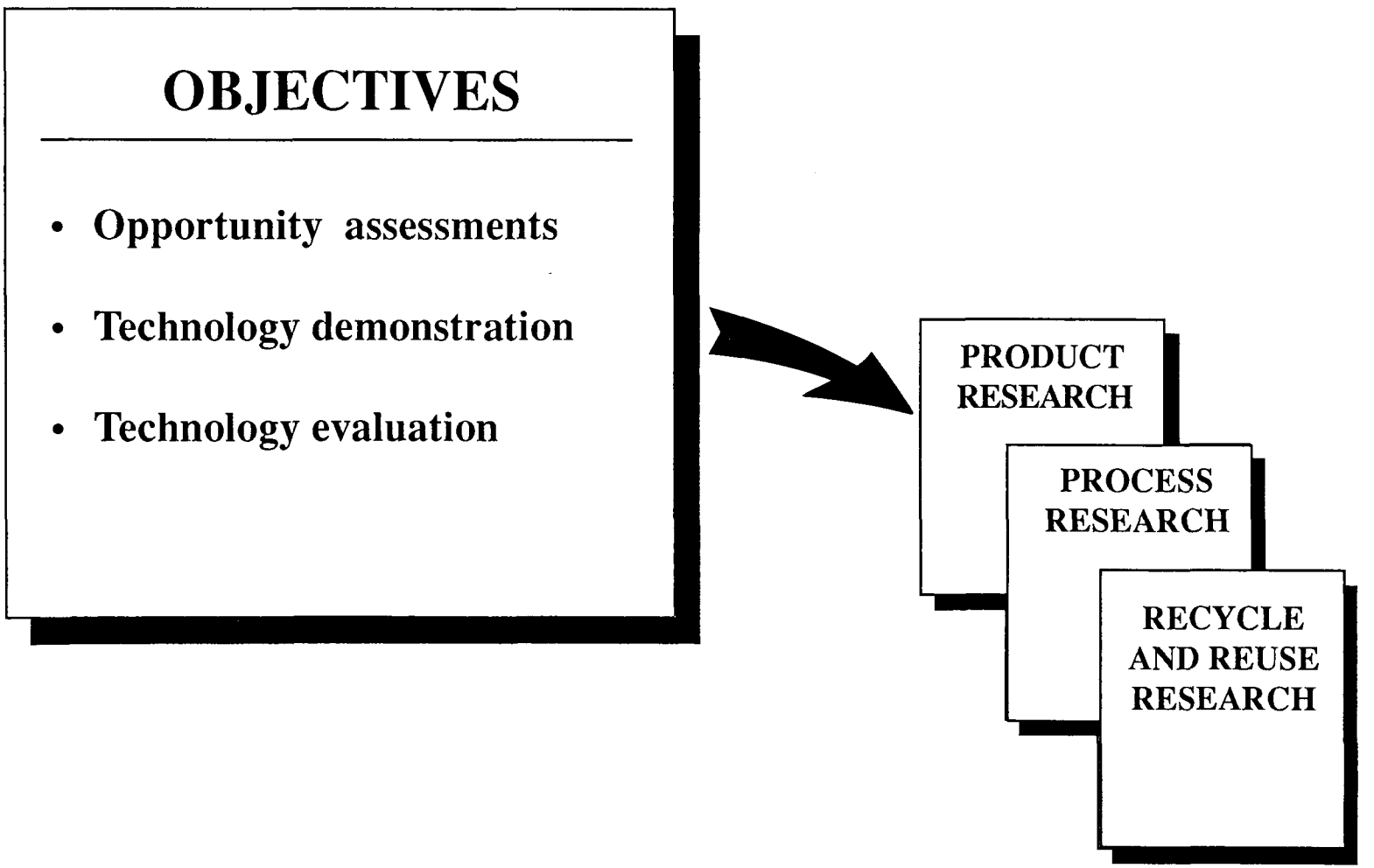


EXHIBIT 2-2

COMMON TECHNOLOGICAL RESEARCH OBJECTIVES



- Stimulating private sector development and demonstration of model technologies and programs designed to prevent pollution.

Product research is oriented toward understanding the polluting characteristics and life-long pollution generating attributes of products. The product research program will focus on establishing standardized methods for assessing products and their use patterns, using these standard methods to identify and evaluate the pollution burdens that are represented by various products, and stimulating private sector development and use of environmentally preferable products. Products addressed under this program may range from simple chemical compounds to complex manufactured items comprising numerous potential sources of pollution.

The process research program area is oriented toward identifying and evaluating those aspects of production, use, maintenance and repair, and disposal processes that generate pollutants and waste, and to facilitating and evaluating alternative, environmentally preferable processes. Process research will focus on establishing standardized methods for evaluating all types of processes using these standard methods to identify and assess pollution and waste generation, associated with these processes, and encouraging private sector innovation in adopting environmentally preferable processes and technologies. By supporting such efforts, EPA fosters the development of industry-specific data and the establishment of state level oversight and expertise in pollution prevention, as well as affirms its leadership role in promoting pollution prevention on a nationwide basis.

Research is needed to identify high-potential opportunities for further recycling and reuse and to identify the most effective existing recycling approaches. Research efforts in the recycling and reuse research program area will focus on evaluating waste streams, production feedstocks, capacities for inclusion of reclaimed materials in production processes and products, and the effectiveness of recycling programs.

Most of the technological research efforts in the areas of product, process and recycling/reuse will be carried out by private industry. This technological research should focus on the development of environmentally preferable products and processes, as well as recycling and reuse techniques that reduce wastes and pollutants. EPA will work with the private sector to eliminate technological bottlenecks and barriers, and identify pollution prevention approaches that are not only affordable, but improve the operating efficiency.

Socioeconomic and institutional research is an essential component of an effective, comprehensive research program that can identify the barriers to and incentives for an integrated program of efficient production, reuse, and recycling. Efforts in socioeconomic and institutional research will focus on identifying and evaluating non-technological factors that affect pollution prevention implementation opportunities. The socioeconomic and institutional research program area involves non-technological research to understand and overcome institutional, social, and economic obstacles to pollution prevention, and will include research in sociology, economics, and human behavior, as well as studies of institutional conditions that favor or inhibit implementation of effective pollution prevention programs. Much of the research in this program area will be conducted in cooperation with academia, industry, and public interest groups.

Anticipatory research is necessary to allow the Agency to be able to detect and respond to changing environmental, industrial, and consumer conditions. The anticipatory research program is intended to provide the ability to pursue long-term research on emerging technologies or topics of concern, to enable EPA to prevent future pollution problems. The anticipatory research program area will include both technological and non-technological research in order to address all aspects of future environmental problems, and will focus on emerging technologies that could be utilized to prevent or address future environmental problems, as well as changes in non-technological factors that

could contribute to or prevent future problems. Projects in this area will focus on anticipating and responding to emerging environmental issues and evaluating the effectiveness of emerging technologies and various pollution prevention strategies for reducing pollution related problems.

The technology transfer program area will support each of the five research program areas by providing the mechanism for rapid dissemination of information to potential users. It will focus on expanding the availability of product, process, technological, socioeconomic, institutional, and environmental problem information that can be used to accelerate the adoption of pollution prevention programs throughout all sectors of society. This program will also ensure that users have a mechanism to communicate their needs to the Agency.

Although significant achievements in pollution prevention can be attained in any one of the six areas, progress must be made in each area to achieve all of the pollution prevention research goals. As research and implementation efforts progress, new questions and opportunities for research will arise that cannot now be anticipated. This research plan has been designed to allow EPA to incorporate these new research topics into the overall research program and to conduct long-term research focused on approaches to anticipate, prevent, and manage future environmental problems.

Included in the description of each of the research program areas is a brief listing of some potential research topics and some specific examples of research projects that could be supported by the program. These examples are illustrative of research that could be conducted in each research program area. They do not necessarily represent high-priority topics, nor are they scheduled for immediate initiation.

PRODUCT RESEARCH

The focus of research efforts in this program area is specifically on products and their pollution burdens, as opposed to the processes by which products are manufactured. This research will provide the methods for conducting assessments, identifying opportunities for reducing the content of substances of concern in all classes of products, and facilitating the development and use of preferable products. These efforts will be directed both at identifying the pollutants generated in the course of manufacturing products and at evaluating the manner in which products may become pollutants in the course of their life-span.

Many environmental problems are caused by agricultural, industrial, or consumer products that are either misplaced in use or are discarded without proper concern for their environmental impacts. Because of the harmful effects ensuing from the use, exposure to, or disposal of some products, they have received special regulatory attention (e.g., the handling and disposal of pesticides, carcinogens, asbestos, and polychlorinated biphenyls, and the use of ozone-depleting chlorofluorocarbons as aerosol propellants). Several laws empower EPA to control the manufacture, use, and release of certain toxic compounds (Toxic Substances Control Act; Federal Insectide, Fungicide, and Rodenticide Act), solid and hazardous wastes (Resource Conservation and Recovery Act; Comprehensive Environmental Response, Compensation, and Liability Act), aquatic nutrients and toxicants (Clean Water Act), and atmospheric pollutants (Clean Air Act). However, not all products that can become pollutants are regulated effectively (e.g., hazardous compounds in municipal wastes, biomedical and infectious wastes, and nonpoint sources). Still other products are not regulated at the federal level (e.g., plastic wrappings, bags, and containers; most paper products; and household garbage). Essentially all products are potential pollutants, and it is desirable to develop methods that reduce the pollution impacts associated with products by ensuring that:

- Unnecessary releases and disposal of toxic or otherwise hazardous products are eliminated

- Products are not used or discarded unnecessarily or in inappropriate ways
- Product designs that result in the release or disposal of hazardous or toxic materials are eliminated, whenever possible
- Toxic or otherwise harmful components are eliminated from product formulations, whenever possible
- Product designs that result in the generation, release, or disposal of excessive quantities of aquatic or atmospheric pollutants or of excessive amounts of solid waste are discouraged in favor of less polluting designs.

Objectives

The product research program area has the following four objectives:

Objective 1: To establish standardized methods for evaluating the environmental impacts of specific products.

Identification of pollution generation characteristics and the opportunities for pollution prevention associated with a product will require analysis of the entire life cycle of the product. (A product's life cycle includes its design, manufacture, use, maintenance and repair, and final disposition, including potential reuse or recycling options.) Although such analyses have been conducted in both government and industrial settings, no standardized methods or guidelines for conducting these analyses exist. Standardized methods for conducting such analyses will ensure that management decisions based on product-specific data can be made considering all relevant factors on a consistent basis. This effort will include the development and use of criteria for evaluating the generation of pollutants associated with the life cycle of individual products. Such criteria must have general applicability to a broad array of products, and they must identify the pathways by which pollutants associated with products may enter the environment and the environmental effects associated with specific levels of the pollutants. They will be vital in conducting waste reduction or pollution prevention assessments, evaluating specific products to determine the total load of pollutants associated with them, developing priorities for promoting pollution prevention programs related to products, and stimulating state and industry programs to reduce the environmental impacts of products.

Objective 2: To identify and evaluate the pollution generation characteristics of both existing and new products and of changing product-use patterns.

Little data currently exist on the pollution impacts associated with the manufacture, use, maintenance, repair, and disposal of both existing and new products and shifting product-use patterns. Product-specific information of this type is needed to identify opportunities for pollution prevention and to compare impacts between products that can be utilized for the same function or application. However, data also are needed to allow comparison of the effects of product changes on total pollution loads (e.g., a direct reduction in a pollutant associated with a single product is desirable, unless it should cause an increase in the net pollution impacts; for example, by altering a manufacturing process in which it is used or if its substitute would be a pollutant of greater concern). This information will be especially helpful in stimulating product substitutions that would reduce total pollution loads. Data could be gathered from a number of sources within the Agency (SARA Title III, RCRA, FIFRA, TSCA, etc.) and outside the Agency to assist in these evaluations.

Objective 3: To encourage private sector development of environmentally preferable products.

Evaluation of the life cycle pollution generation characteristics of individual products and comparison of these characteristics among products is expected to reveal opportunities for modifying existing products and for developing new, environmentally preferable products. EPA will encourage these product development efforts, and cooperate with other government and industry research activities, as appropriate. In particular, EPA will seek to build upon existing relationships with the Departments of Agriculture, Defense, and Energy to ensure that their research efforts support pollution prevention objectives.

Objective 4: To demonstrate and evaluate uses of cost effective and environmentally preferable products.

Demonstration and evaluation of the production and use of newly developed products, especially as they involve industries dominated by small businesses, are required to ensure that products developed on an experimental basis can actually be produced in an economical manner while retaining their beneficial characteristics in pollution prevention. EPA could encourage demonstration projects and evaluate their results using standard methods.

The product-oriented research program will allow basic investigations into the characteristics of chemicals that are used or may be used as substitutes for other manufactured and consumer products. This research will be used to identify products that are environmentally preferable and will also consider their impacts on energy consumption and exposure of workers and consumers. A listing of some potential research topics and specific projects are presented in Exhibit 2-3 (see page 2-18). Information generated in this program will be made available for use by EPA program and regional offices, other federal agencies, states, industries, public interest groups, and citizens through activities conducted under the technology transfer and technical assistance research program.

PROCESS RESEARCH

Pollution prevention efforts in this program area will focus on identifying opportunities for preventing pollution in industrial processes, and on stimulating industries to develop and implement new processes that generate less pollution.

Numerous processes can generate pollutants. These processes include many of the day-to-day operations associated with agriculture, mining, construction, manufacturing, transportation, wholesale and retail trade, and service industries. Almost any activity associated with the production of a product or the delivery of a service represents a process that could contribute to environmental pollution. However, to ensure progress in risk reduction, it is important that research efforts are focused upon processes that are associated with the use or release of substances of concern, excessive resource consumption, or the production of excessive amounts of waste. Process-oriented pollution prevention research efforts are needed in the following areas:

- Prevention of unnecessary releases of pollution
- Substitution of environmentally preferable feedstocks that yield less pollution when used in production processes, while maintaining the desired quality of the products produced
- Development of process design alternatives to eliminate inherently polluting processes.

Objectives

Five objectives have been developed in support of the process research program:

Objective 1: To develop industry-specific standardized methods for conducting process-oriented pollution prevention opportunity assessments.

Existing waste minimization assessment procedures do not address the specific characteristics of different industries. Further, they are one-dimensional, and do not address the multi-media effects of wastes and pollutants. Within specific industries, methods must be developed to identify the kinds of pollutants and the degree of risk associated with different processes, including those processes associated with production, use, repair, maintenance, recycling, reuse, and disposal of products of all types. EPA will identify, evaluate, and modify existing pollution prevention and waste minimization opportunity assessment procedures to address the unique characteristics of non-hazardous and hazardous wastes and pollutants in various industries identified by Standard Industrial Classification division codes (agriculture, forestry, and fishing; mining; construction; manufacturing; transportation, communications, electric, gas, and sanitary services; wholesale trade; retail trade; finance, insurance, and real estate; services; and public administration) and will produce guidelines for conducting industry-specific pollution prevention assessments.

Objective 2: To conduct pollution prevention opportunity assessments in a variety of industries.

Research is needed to identify the current nature of both hazardous and non-hazardous waste streams. (Data currently available to EPA concerning the volume of wastes and the specific content of these wastes are from the 1981 and 1983 hazardous waste surveys. These hazardous waste data are outdated and of inconsistent quality due to differences in collection and reporting methods. Useful data are also contained in the SARA Toxic Release Inventory.) Comprehensive data are needed to assess the cumulative impacts of pollution-generating processes on all media. Pollution prevention assessments in a variety of industries will be used to update data on major pollutants of concern, and identify points in processes where these pollutants are released or discharged, and opportunities for reducing the loss of these substances to the environment. These assessments will be conducted in cooperation with the industries assessed. After assessment of several examples within an industry, general rules for identifying the primary pollution prevention opportunities will be developed and made available to businesses within the affected industry to streamline and accelerate assessment procedures.

Objective 3: To identify, demonstrate, and evaluate the effectiveness of pollution prevention techniques associated with existing and new processes.

Numerous businesses, industries, and government agencies have begun to utilize processes designed to reduce pollution. Few data exist to indicate the effectiveness of these processes or their applicability to other organizations. A comparative review of alternative processes is needed to identify the least pollution generating of alternative processes that can be used to produce, use, and maintain or manage specific manufactured and chemical products. In addition, as new processes for reducing pollution are developed, it will be necessary to demonstrate them and evaluate their effectiveness. Promising pollution prevention process alternatives will be identified in various industries. Examples could include: process modernization, upgraded maintenance, feedstock product substitution, spill and avoidable release prevention, recycling and reuse options, and waste stream concentration techniques. In cooperation with participating states and industries, these alternatives will be demonstrated at plant-scale and the results

of the demonstrations will be evaluated. EPA also will cooperate with selected industries to demonstrate and evaluate the effectiveness of pilot-scale pollution prevention processes or processes which minimize pollution production to ensure that they can be scaled up and still achieve their pollution prevention objectives while meeting requirements for product quality, worker training, workplace safety, production schedules, and costs. The effectiveness of these processes and the detailed methodologies employed will be made available to interested industries, government agencies, and the public.

Objective 4: To identify and stimulate cross-industry applications of cost effective innovative production and processing technologies.

A technology that is developed and utilized effectively in one industry may have potential pollution prevention applications in another industry or in different sized facilities within the same basic industry. Retrofitting such technologies requires identifying similarities among technologies, modifying the technology as needed, and implementing the transferred technology in the recipient industry. EPA will facilitate these activities through research to identify cross-industry similarities and required process modifications.

This research program will provide information that will help identify existing low pollution processes and will encourage private sector development of improved pollution prevention processes in the future. The majority of EPA's efforts in this program will focus on identifying process-related pollution prevention opportunities, and demonstrating and evaluating processes for reducing pollution generation. Some potential research topics and projects are presented in Exhibit 2-4 (see page 2-21).

RECYCLING AND REUSE RESEARCH

This program's major thrust will be in stimulating the development of new recycling and reuse opportunities when: (1) environmental and health risks of toxic, hazardous, or otherwise excessively polluting substances of concern can be reduced, or (2) energy and material conservation are possible.

Recovery, reuse, and recycling are important options within the overall integrated pollution prevention approach for reducing the volume of wastes generated by communities, industries, and governments, and for reducing demands on non-renewable resources. Community recycling programs usually involve segregation of recyclable municipal waste products for delivery to regional or local recycling centers or curbside pickup by contracted recyclers. Within industry, recycling programs involve numerous methods for reclaiming feedstock and waste materials for direct reuse within production processes, recycling on-site, recycling for off-site resale or for contribution to off-site recyclers, and exchange of wastes as input stocks among different processes or industries. Government recycling opportunities include those of both communities and of industries, in that large amounts of recyclable paper can be made available to off-site recycling centers, and internal reprocessing and recycling of solvents, lubricants, and excess feedstocks are important options for numerous government installations.

This program will rely heavily on the results of both the products and processes research programs. Opportunities for capturing and reusing or recycling waste stream materials that are identified in the products and processes programs will stimulate the testing and demonstration of new recycling and reuse technologies, and identification of viable markets.

An integral part of the success of recycling and reuse efforts is the availability of sustained internal and external markets for the materials. One of the most widespread recycling programs in the nation, newsprint recycling, is currently experiencing excess newsprint over the industry's reprocessing capacity. Pollution prevention research programs must therefore include stimulation of both the supply and demand for recycled materials.

Objectives

Four objectives have been identified for the recycling and reuse research program:

Objective 1: To identify and evaluate new and innovative uses for materials that would otherwise be disposed of as waste.

Product and process research program evaluations will identify numerous chemical and manufactured substances that are candidates for recycling or reuse. Environmental and health risk analyses will be conducted to determine the potential for recycling or reuse of these substances in light of product characteristics and process requirements. It is expected that numerous substances will be identified as candidates for recycling or reuse. The recycling and reuse research program will stimulate and coordinate research into new and innovative uses for these candidate substances. This effort will have a multi-industry, multi-product, multi-process focus, and will not be limited to the industries that generate the original substances of concern. For example, options may include reusing acid wastes from silicon processing operations as feedstocks for cleaning operations in metal plating industries. This cross-industry stimulation of recycling and reuse will be intended to discover as many alternative uses for waste products as possible.

Objective 2: To identify, demonstrate, and evaluate strategies to increase the use of recycled materials in products.

Efforts will be focused upon identifying feedstock type and quality requirements for both existing and new products and manufacturing processes. This information will be coupled with knowledge of materials found in industrial and municipal waste streams to identify possibilities for reusing known waste stream substances as feedstocks. This program will include evaluating the feedstock requirements of existing products, stimulating the development of new industrial or consumer products that incorporate recycled materials, and ensuring that newly developed products have longer lives and enhanced recyclability. A further emphasis of this program will be the preparation of guidelines for using recycled materials in production processes.

Objective 3: To stimulate the development and installation of additional capacity for utilizing recycled materials.

Adequate market opportunities must exist for recycled and previously used materials if recycling and reuse are to thrive. This program will include a major effort aimed at stimulating market opportunities for previously used materials, either for their original purpose or as new products after reprocessing and recycling. Mechanisms for stimulating these market opportunities will include support of research and development of new product and process designs and design modifications, use of government/industry partnerships to test potential products and processes, and use of financial and technical assistance to develop industrial processes and capacities for manufacturing operations that employ reused or recycled materials. Emphasis will be placed on developing methods to overcome barriers to expansion of existing recycling industries (e.g., newsprint) and developing opportunities for recycling in industries where products are not currently recycled (e.g., appliances).

Objective 4: To evaluate existing recycling and reuse programs and facilitate the development of cost effective model programs.

Community and industrial recycling programs are vital links to increasing the number of opportunities for use of previously used materials in products and processes. Such programs require planning, coordination, and management of logistic and financial activities to be successful. EPA will stimulate the development of model programs that demonstrate good

environmental and business practices in the collection, handling, storage, and marketing of reusable and recyclable products. The success of these model programs will be evaluated and guidelines will be prepared to assist other communities and industries in establishing environmentally effective, economically viable recycling and reuse programs.

Recovery, reclamation, and reuse techniques have been utilized for many years, and added emphasis should be placed on these techniques for pollution prevention. Exhibit 2-5 (see page 2-23) presents some potential research topics and projects that could be investigated under this program.

SOCIOECONOMIC AND INSTITUTIONAL RESEARCH

This research includes sociology, economics, human behavior, and the institutional conditions that may act as incentives for or obstacles to establishing pollution prevention programs. Understanding in these areas is critical to the effective nationwide implementation of pollution prevention programs.

Investigations in these areas are necessary because waste generation and waste management decisions are driven by numerous non-technological forces, including legal mandates, attitudes, habits, incentives, and benefits. Behaviors represent complex patterns of activity that are the result of numerous factors, including habits, beliefs, knowledge, and economic pressures. Behaviors may be altered when sufficient incentive exists to change habits, abandon beliefs, investigate new ideas, or pursue improved economic conditions. Perceived benefits to individuals, groups, corporations, or industries can motivate altered behavior in ways that reduce waste generation or discharge. Therefore, information about how attitudes, incentives, and benefits affect behavior is a key tool to be used in directing the development and implementation of mechanisms for reducing the generation of pollutants and improving the management of waste.

The most prominent and common incentives and disincentives affecting management decisions are economics and regulations. The relative economic costs and benefits of competing options strongly influence decisions. However, legislation or regulation may alter the economics of decision making to promote different choices. For example, potential liability for the results of waste management decisions is a recent but powerful incentive that has fostered pollution prevention to reduce future liability risks.

In addition to economic costs and benefits, a sense of public responsibility may be a factor considered in corporate decision making, particularly as a force affecting decisions about waste generation and management. To facilitate socially responsible behavior, additional information is needed to develop an understanding of the effectiveness and potential for widespread use of pollution prevention programs and the public's acceptance of and expectations for these programs. There is a need for research to support pollution prevention efforts by identifying trends in industry, consumer behavior, market characteristics, new product and process introductions, and changes in pollution management conditions (e.g., landfill and recycling capacities, air quality non-attainment, water pollution, and disposal of hazardous wastes). Additionally, there is a need to develop standardized tools that allow comparative risk assessments in differing applications, quantification of all economic costs and benefits of pollution prevention efforts, and standardized assessments of environmental costs and benefits of potential actions.

Objectives

Five objectives of the non-technological research program area are presented below:

Objective 1: To understand consumer behavior and identify effective approaches to modifying it in consumption decisions.

Consumers (including individuals, businesses, industry, and government) make choices about consumption and use based

on a multitude of different inputs--information, beliefs, and desires. Ultimately, success of pollution prevention efforts depends upon consumers altering their behavior to select environmentally preferable services and products that have been manufactured in pollution prevention oriented processes, using recycled or reused materials wherever possible. In some instances, lack of consumer information or fear of inadequate quality may prevent acceptance of products manufactured by pollution prevention processes. Research efforts are needed to ensure the applicability and quality of pollution preventing products and to stimulate their acceptance by all types of consumers. This program will support efforts to develop markets for products through research directed at information needs, consumer attitudes, quality requirements, and market acceptance.

Objective 2: To identify and assess incentives that may increase and obstacles that may inhibit implementation of pollution prevention measures.

Under this program, EPA will sponsor and conduct research to investigate the costs of pollution prevention and identify the levels of environmental and economic benefit that can result from effective programs. Since the economics of pollution prevention are only beginning to be elucidated, the results of this program will provide a means for waste generators to make more informed, voluntary choices about the kinds of pollution prevention programs that are of the greatest benefit for their specific situations. EPA will analyze several industries of different sizes to determine the effect of incentives on pollution prevention efforts. As part of this effort, EPA could develop model pollution prevention programs for application in different industries and different levels of government.

The costs of waste treatment and disposal are well documented. However, with the exception of some data from narrowly focused programs, surprisingly few data exist about the economic or environmental costs or benefits of pollution prevention and waste minimization as alternatives to treatment and disposal. Few extensive programs are in operation and few data are available about actual gains that have been achieved when pollution prevention is practiced. In addition, little documentation exists as to the effectiveness of existing regulations in promoting pollution prevention. Although some pollution prevention programs do exist, it has not been determined what incentives have stimulated the establishment of these programs or which regulations have had significant impacts on the design and success of established programs. These issues must be understood if future efforts are to be successful in establishing effective pollution prevention activities in the consumer, manufacturing, and government sectors.

Objective 3: To identify and assess the effectiveness of existing and new pollution prevention approaches.

A key to focusing EPA pollution prevention efforts is understanding where pollution prevention efforts have had an impact and where they have failed. Analyses of alternative pollution prevention strategies have not been conducted in a concerted, organized manner. There is a need to identify and assess the effectiveness of existing pollution prevention programs and the characteristics of the institutions where they are established. Research on pollution prevention strategies is needed to ensure that existing and newly planned programs use financial and human resources wisely in implementing successful, momentum-building pollution prevention programs. A need exists to establish baseline criteria for effective pollution prevention programs, identify characteristics of effective programs, identify unique characteristics of specific industrial, legislative, and regulatory environments that alter the effectiveness of pollution

prevention programs, identify methods that have been used to alter institutional inertia, and document the overall effectiveness of specific programs in achieving pollution prevention objectives. The information developed in these analyses will be useful in planning new pollution prevention strategies and improving existing pollution prevention programs. In addition, research is needed to determine the effectiveness of various information and education programs conducted by state and local organizations, industries, and public interest groups to alter consumption and use patterns. Some of this research could be focused on determining the conditions that favor successful outreach and education programs and that develop positive community involvement in pollution prevention activities.

Objective 4: To identify and assess trends in consumption and use patterns and pollution generation.

New analytical tools and supplemental data are needed to identify trends in consumption and use patterns. This research program will support the development of these tools and data, and attempt to identify significant changes in economic conditions and pollutant generation. These tools and data will be developed in cooperation with state and local governments and industries.

Consumption of industrial feedstocks, business materials and supplies, and consumer products and service materials respond to changing availability of specific products and evolving tastes and desires of the users. For pollution prevention programs to remain effective, a knowledge of national, regional, and local trends in consumption and usage of materials that may become pollutants will be required. Changes in regional economics and social conditions (such as have occurred in the Silicon Valley, or population growth and urbanization that are occurring on both coasts) are accompanied by changes in the need for and availability of numerous technologies and infrastructural capabilities for supplying, handling, and using materials that can become pollutants. However, existing data are not readily useful in identifying trends, due to lack of uniformity resulting from the manner of their collection and the purpose for which they were collected. These data were collected under media-specific programs and covered limited substances of concern, which varied from medium to medium.

Objective 5: To quantify the potential of pollution prevention practices for maximizing pollution reduction.

To enable planners and managers to place the evaluative information developed in this program area in context and to assist them further in targeting pollution prevention efforts, EPA will conduct research to quantify the potential for pollution prevention in various sectors, including agricultural, commercial, industrial, residential, and governmental. These data are needed to support efforts to manage and prioritize research efforts, to determine the information needs of potential users, and to assess the effectiveness of pollution prevention programs at meeting these needs. Collection of these data will rely upon the industry-specific procedures for assessing pollution prevention opportunities that will be developed in the product and process research program areas. Additional methods will be designed to estimate the potential impact of various technological, operational, and regulatory approaches. EPA's 1986 Report to Congress on the *Minimization of Hazardous Wastes* estimated that RCRA wastes could be reduced by 33 percent. To refine this estimate and develop estimates for other areas, it will be necessary to compile information on the best available practices for use in various pollution prevention applications. Additional research will be needed to conduct detailed evaluations of various industrial sectors to refine and validate data collection and evaluation tools prior to their release for widespread use.

Socioeconomic and institutional research program activities are essential elements of the overall research program. They allow the evaluation of information about social and economic conditions that impact the effectiveness of technological pollution prevention programs. In addition, they will provide data that can be used in planning and implementing industry-specific pollution prevention programs and to stimulate effective outreach and education programs. Exhibit 2-6 (see page 2-25) presents some potential research topics and some example projects in socioeconomic and institutional research.

ANTICIPATORY RESEARCH

Three major areas of long-term research that are essential to a comprehensive pollution prevention research program are:

- Anticipating and responding to emerging environmental issues and using pollution prevention approaches to mitigate these issues.
- Evaluating emerging technologies for their potential contribution to pollution prevention and stimulating those that are preferable to existing technologies.
- Evaluating the effectiveness of the Agency's pollution prevention research in meeting changing user information needs.

The ability to anticipate emerging environmental issues and respond quickly in an appropriate manner requires a well-developed environmental research program that tracks changes in major environmental conditions and economic activity. This research program area could represent a sustained commitment to a small number of research efforts and groups that are a vital infrastructure needed to respond to emerging pollution prevention issues. Activities in this area may include monitoring and evaluating technologies, environmental conditions, and business conditions to detect trends of importance in pollution prevention, and stimulating research that has direct or indirect prevention potential. Analysis of the implications of emerging innovative technologies and investigations to enhance the benefits or broaden the use of existing technologies promise substantial pollution prevention benefits. For example, the accelerated application of computers, process control technology, and automation can greatly reduce the overuse of chemicals, the production of unwanted toxic byproducts, and the generation of wastes. In textile dying, automated systems to rapidly change textile patterns may greatly reduce excess batch make-up dye wastes that are associated with conventional manufacturing. Another example is represented by the sustained research commitment that was successful in developing a dry powder coating technology that may reduce volatile emissions from conventional paint operations. However, this technology is beginning to emerge as a viable alternative only after a many year effort to develop this new technology for paint application and curing. Such a long-term commitment to pursuing wholely new approaches to providing specific products and services is essential to a comprehensive pollution prevention program.

Objectives

The innovative research for future environmental problems program area has two objectives:

Objective 1: To identify and explore emerging technologies and patterns in resource use and disposal that have long-term implications for the nation's programs in pollution prevention.

EPA will establish a program that will monitor major categories of resource consumption, waste disposal, recycling expansion, manufacturing technology innovation, and emerging environmental issues. Examples of topics that may be included in this program are: monitoring trends in consumer behavior, evaluating the effects photovoltaic and fusion power generation impacts may have on global and national pollution loadings, developing integrated systems of advanced pollution prevention techniques that incorporate source reduction, recycling, and treatment processes

into comprehensive pollution prevention strategies for selected industries, and developing methods to reduce the generation of biomedical and infectious wastes. Included in this research program could also be workshops that bring together visionary researchers in appropriate disciplines to identify emerging trends in resource consumption, use, and disposal and to discuss the implications of these trends for pollution prevention efforts.

Objective 2: To evaluate the effectiveness of the Agency's research program in meeting changing user information needs.

To ensure that the Agency's research program is meeting the needs of various users, a long-term research area will be created to identify and assess, on a continuing basis, user information needs and the efficiency of EPA's research programs in meeting these needs. This activity is essential to ensure that research efforts focus on important issues that may not be addressed by other sectors of society. The Agency will develop standard methods to assess the effectiveness of current research programs in meeting the information needs they were intended to fulfill. The results of these evaluations could be documented to allow their use as educational or technology transfer source material. Additionally, research activities could identify changing needs of various users and develop new strategies or approaches to address these changing needs. Also, evaluations could be conducted on a continuing basis to identify current and emerging environmental problems and promising pollution prevention research opportunities that could ameliorate these problems.

This research program area provides for investigation of emerging issues to ensure that EPA's pollution prevention research program remains comprehensive and capable of addressing future pollution prevention challenges. It gives EPA the opportunity to respond to emerging topics of concern or to ideas that promise to beneficially impact pollution prevention programs, by enabling discretionary investigation of topics that promise long-term benefits. This research program also enables EPA to determine the effectiveness of its pollution prevention research efforts in meeting user information needs, identifying changing needs, and redirecting the Agency's research efforts to better meet old needs and address new needs. Exhibit 2-7 (see page 2-28) presents some potential research topic areas, and some example research projects for the innovative research program area.

TECHNOLOGY TRANSFER AND TECHNICAL ASSISTANCE

Technology transfer and technical assistance are essential components of EPA's research efforts in pollution prevention. To a great extent, the success of a national program to encourage the development and adoption of new, more environmentally acceptable production processes and products depends on the quality and effectiveness of the information dissemination programs utilized. Information obtained as a result of the product, process, and recycling and reuse research programs will be assembled, summarized, and distributed in formats designed to meet the specific needs of the intended users as part of the technology transfer and technical assistance program. An efficient approach for collecting, organizing, and distributing data on substances of concern, production processes, and pollution prevention programs is needed. To do this job effectively requires identification of the types of data needed about specific industries, processes, and products, and of the audiences that need the information.

Objectives

The technology transfer and technical assistance program has the following four objectives:

Objective 1: To stimulate the use of pollution prevention opportunity assessments in all pollution-generating activities.

An active outreach and technology transfer program is needed to stimulate widespread

use of pollution prevention opportunity assessments of the production, release, or disposal of potential pollutants and wastes. Widespread use of these assessments will foster development of new pollution prevention activities in diverse industrial, agricultural, and consumer-oriented operation. This program will consist of two major components:

- Developing and disseminating "how to" guidelines for conducting pollution prevention assessments.

- Providing training and technical assistance in conducting pollution prevention opportunity assessments and in using the information generated to develop pollution prevention programs.

Objective 2: To expand the Pollution Prevention Information Clearinghouse to encompass additional, multi-media pollution prevention functions.

EPA is developing the Pollution Prevention Information Clearinghouse (described in greater detail in Exhibit 2-8 on page 2-30) to collect and disseminate technical, legislative, programmatic, and statistical information on source reduction and recycling to various groups. In addition to the Pollution Prevention Information Clearinghouse (PPIC), EPA is assessing the use of other clearinghouse networks for specific environmental problems. The PPIC was originally intended to focus primarily on hazardous materials, but it will be expanded and broadened as part of this program to include pollution prevention information applicable to air pollutants, water pollutants, and additional non-hazardous substances of concern. Included will be technical data, information sources, case studies, program descriptions, guidelines and procedures for conducting pollution prevention opportunity assessments, trend data, directories of personnel working in pollution prevention, and waste exchange and recycling information. Access to the clearinghouse will be available to federal and state agencies, as well as to industries and trade associations, universities, public interest groups, and community or citizen organizations.

Objective 3: To provide technical assistance to other federal agencies, states, local governments, industries, and citizens in implementing pollution prevention efforts.

Technical assistance is needed by many agencies, organizations, and individuals to implement effective pollution prevention programs. EPA will provide this assistance by conducting training sessions in pollution prevention strategies and approaches for government, industry, and citizen group representatives. These sessions will include guidance in evaluating pollution generation, identifying recycling markets for recovered materials, and improving maintenance and repair programs and operating efficiencies. Information generated in each of the research program areas will be made available to potential users, as appropriate, and technical personnel will be made available to assist in training programs and in evaluating especially complex situations and opportunities for cross-industry cooperation in pollution prevention. Included in this effort could be a program designed to contact top-level managers from government and industry to facilitate establishing pollution prevention programs throughout their organizations.

Objective 4: To support general and industry-specific information exchange via conferences and seminars in international, national, and regional settings.

EPA will sponsor information exchange via technical conferences, seminars, and workshops on pollution prevention. These activities will range from supporting community-based workshops intended to stimulate pollution prevention program development, to international colloquia on detailed technical issues that address advances in scientific and engineering knowledge about pollution prevention.

Technology transfer and technical assistance represent the most visible non-regulatory contact between EPA and most organizations that can become involved in pollution prevention. This program activity is vital to the effective utilization of research results, in that it will form the primary pathway for broad-scale dissemination of these results to all sectors of society. Several potential activities will comprise this program. Some potential topic areas and some example projects in technology transfer and technical assistance are presented in Exhibit 2-9 (see page 2-31).

EXHIBIT 2-3

PRODUCT RESEARCH PROGRAM

POTENTIAL RESEARCH TOPICS AND SPECIFIC PROJECT EXAMPLES

- Establish standard methods for evaluating the pollution impacts of products

  - develop criteria for product-related pollution assessments
    develop a multi-industry model for conducting product-specific life cycle analyses
  - develop methods for assessing the pollution loadings associated with complex manufactured products (e.g., automobiles, appliances, computers)
    develop criteria for evaluating the fundamental characteristics of chemical products to predict pollution loads
    develop methods for incorporating energy conservation, worker safety, and consumer safety aspects of products into standard evaluation methods.

- Identify and evaluate pollution impacts of existing and new products and of changing use patterns

  - assess specific products to determine their total pollution burdens and the means by which these burdens are generated
  - classify products, functions, and pollution management options (see *Rating the Transfer Efficiency of Paint Application Equipment* example, following page)
    evaluate alternative fuels for specific applications
    evaluate the indoor air pollution impacts of various household products
    evaluate the uncertainties of the use of biodegradable polymers for consumer products
    evaluate substitutes for toxic materials in consumer products (see *Identification and Evaluation of Lead and Cadmium Substitutes in Plastics* example, following page).

- Encourage private sector development of environmentally preferable products

  - evaluate methods for eliminating polluting residuals from products prior to distribution
    analyze methods to alter or substitute products to reduce their content of substances of concern, such as: volatile organics, toxics, and aquatic nutrients (see *Aerosol Evaluation* example, following page)
    analyze fundamental properties of chemicals that may serve as desirable substitutes for polluting chemicals
    evaluate the use of bulk storage facilities to reduce the number of pesticide containers requiring disposal
  - evaluate composite materials as substitutes for metals in products
  - evaluate methods to overcome technological barriers to substitutes
  - encourage the development of pesticide formulations that facilitate the removal of pesticide residues from containers.

- Demonstrate and evaluate uses of cost effective and environmentally preferable products

  - demonstrate specific applications of biodegradable polymers
  - demonstrate expanded uses for dry powder coatings
  - evaluate expanded use of low-CFC residual foam products as replacements for less desirable insulation products.

EXHIBIT 2-3 (continued)

SPECIFIC PROJECT EXAMPLE:
Rating the Transfer Efficiency of Paint Application Equipment

EPA has conducted research that permits the accurate measurement of the transfer efficiency of painting systems. Transfer efficiency is defined as the ratio of the quantity of paint sprayed from a paint gun to the amount adhering to the product surface. As transfer efficiency increases, the quantity of VOC pollution decreases due to a decrease in paint overspray. The development of this accurate measurement method for defining the painting efficiency of different systems has created incentives to improve the efficiency of these systems. Based on these initial studies, EPA could work cooperatively with industry to develop uniform criteria for rating paint application equipment and in developing more efficient paint application products.

SPECIFIC PROJECT EXAMPLE:
Identification and Evaluation of Lead and Cadmium Substitutes in Plastics

Minimizing the amount of toxic materials, such as lead and cadmium, in the municipal solid waste (MSW) stream enhances the safety of recycling and reduces the risk of exposure to these chemicals. Both lead and cadmium are present in variable quantities in many common products and have been found in high concentrations in municipal waste combustor ash and leachate from municipal solid waste landfills. Lead and cadmium are added to plastics as stabilizers and pigments in resins. In 1986, the MSW stream contained approximately 213,000 tons of lead and 1,800 tons of cadmium. Of the combustibles in the MSW stream, 71 percent of the lead comes from plastics and 24 percent from pigments; while 88 percent of the cadmium comes from plastics and 11 percent from pigments.

Research is needed to: (1) identify possible substitutes for lead and cadmium in plastics and pigments, (2) determine if these substitutes are environmentally preferable to lead and cadmium, and (3) evaluate the impact of these substitutes on product performance and cost. This research project could contribute significantly to the reduction of lead and cadmium in the MSW stream, thus reducing the concentrations of these toxic metals released into the environment.

EXHIBIT 2-3 (continued)

SPECIFIC PROJECT EXAMPLE:
Aerosol Evaluation

A need exists to evaluate the continued contribution of aerosol products to stratospheric ozone protection and ozone nonattainment problems. Integrated research could be conducted to identify the chlorofluorocarbon (CFC) and volatile organic compound (VOC) content of various aerosol products. (CFCs contribute to stratospheric ozone depletion. They are found in certain aerosol products that were exempted from a 1978 EPA ban, and are still used to a large extent in aerosols made in other countries. VOCs, found in numerous aerosol products, contribute to ozone formation in the troposphere.) Initial research activities could gather available information on the present-day contents of various aerosol products. Follow-on work could investigate alternatives to aerosol formulations and dispensing systems which may reduce the consumption and emissions of bothVOCs and CFCs. Exempted uses of CFC aerosol propellants could be reviewed to evaluate whether or not they should remain exempt from the EPA ban. Successful completion of this effort should generate information needed to reduce or eliminate problem CFC and VOC emissions to the environment by replacing them in aerosol products and by providing information for use by program offices, federal and state agencies, and other countries in reducing emissions of these compounds. This can significantly contribute to alleviating two major environmental problems: stratospheric ozone depletion and ozone nonattainment.

EXHIBIT 2-4

PROCESS RESEARCH PROGRAM

POTENTIAL RESEARCH TOPICS AND SPECIFIC PROJECT EXAMPLES

- Develop standardized pollution prevention opportunity assessment procedures

  - identify and evaluate waste minimization assessment procedures for specific industries
  - evaluate various industries to identify similar pollution prevention opportunities
  - identify feedstock quality requirements for various processes
  - develop guidelines for conducting pollution prevention assessments
  - expand the existing WRITE program's pollution prevention opportunity assessment procedures to address non-hazardous waste and pollution generation processes
  - develop analytical and computerized analysis tools to identify a wide array of pollutants in waste streams
  - investigate packaging alternatives and their impacts on pollution loading.

- Conduct pollution prevention opportunity assessments in a variety of industries

  - inventory input streams to processes and streams where pollutants are generated
  - identify fundamental characteristics of alternative feedstock products and their effects on processes
  - inventory waste stream components and identify where each enters the waste stream
  - evaluate leaks, drips, spills, and excess usage in liquid and gas streams
    characterize biomedical wastes and identify opportunities to reduce the quantities of contaminated and infectious waste requiring treatment and disposal.

- Assess the effectiveness of pollution prevention methods associated with existing and new processes

  review patent literature to identify the least polluting of alternative production processes for specific chemicals or manufactured products
  - evaluate in-process methods for collection and recovery of pollutants (see *Technology Research for Small Businesses in Metal Finishing* example, following page)
  - evaluate methods for eliminating polluting residuals created during the manufacture of products (see *Still Bottoms Reprocessing* example, following page)
  - evaluate models and control systems for cooling towers
  - evaluate alternatives to solvents for paint stripping and solids transport
  - evaluate microchip cleaning methods
  - evaluate increased automation of small scale processes, such as plating lines
  - evaluate low maintenance items such as gasketless magnetic pumps
  - investigate technologies to enhance emergency spill prevention methods and equipment
    evaluate the use of soft abrasives (e.g., plastic beads, sodium bicarbonate) in paint and coatings removal processes
    evaluate processes for minimizing the use of volatile organic compounds in production of insulating foam
  - evaluate pilot-scale continuous feed processes for dying fabrics to reduce dye lot wastes associated with batch processes.

EXHIBIT 2-4 (continued)

- Stimulate cross-industry applications of cost effective innovative technologies

  - assess the potential of pharmaceutical separation processes for applications in the electroplating industry
  - stimulate the use of unit operations analysis and management approaches in appropriate industries
  - evaluate precious metals cleaning processes for use in semiprecious metals and semiconductor cleaning processes.

SPECIFIC PROJECT EXAMPLE:
Technology Research for Small Businesses in Metal Finishing

The metal fabrication industry produces a significant percentage of hazardous wastes generated by small manufacturers in this country, through such operations as metal cutting, grinding, cleaning and degreasing, and painting. This research program would be designed to encourage the industry to develop pollution prevention options in this sector. This would include such areas as filtration to improve the life of cutting oils, material substitution of lime or borax soaps for polluting lubricating oils, development of water based or greaseless binders, development of water based rather than chlorinated solvents, substitution of high solids or dry powder coatings for solvent based coating processes, and non-liquid technologies such as soft abrasives for paint and enamel stripping. These process changes could substantially decrease the generation of deleterious gaseous and liquid wastes.

SPECIFIC PROJECT EXAMPLE:
Still Bottoms Reprocessing

"Still bottoms" from the manufacture of industrial chemicals is one of the major contributors to contamination in the soil and water around existing and abandoned small and large manufacturing facilities. Still bottoms are the complex tarry residues that remain in the reactors in the manufacture of a wide variety of chemical products. A specific example would be still bottoms waste from the manufacturing processes for vinyl chloride, chlorophenols, and chlorobenzenes.

Rather than treating and discharging still bottoms, changes in the manufacturing process for some chemicals could be modified to alter and use the waste within a closed-loop system. This program would encourage private sector research on methods such as:

- Chlorolysis, in which hyperchlorination of the still bottoms could be used to generate products such as carbonyl chloride and hydrogen chloride.

- Developing high efficiency resource recovery systems designed to recover heat and hydrochloric acid from still bottoms.

Research results from this proposed project would develop basic data which small as well as large manufacturers could employ to design and retrofit their manufacturing operations.

EXHIBIT 2-5

RECYCLING AND REUSE RESEARCH PROGRAM

POTENTIAL RESEARCH TOPICS AND SPECIFIC PROJECT EXAMPLES

- Identify and evaluate new and innovative uses for materials that would otherwise be disposed of as waste

  - identify opportunities to use waste acids and bases and volatile organic compounds as feedstocks in products and processes
  - identify opportunities to create new products or new processes for making existing products using wastes from multiple sources (e.g., ammonia sulfate fertilizer from off-gassing ammonia and sulfuric acid wastes)
  - evaluate mechanisms for recovering usable components of complex products (e.g., appliances, automobiles, computers, batteries)
  - evaluate the development of re-polymerized plastics for use in the manufacture of insulating foams (see *Chemical Recycling of Plastics* example, following page)
  - evaluate new uses for incinerator ash, air pollution control device residues, and "bottoms" from manufacturing and waste processing technologies.

- Develop strategies to increase the use of recycled materials in products

  - compare materials in waste streams against feedstock needs and feedstock quality requirements for product manufacturing operations
  - evaluate altering government procurement specifications to give preference to recycled materials
  - investigate the effects of paper coatings and coating removal technologies on the recyclability of paper products.

- Stimulate the development of additional capacity for using recycled materials

  - evaluate improved waste stream segregation technologies in residential, corporate, and industrial settings (e.g., compartmentalized bins, trucks, and storage facilities)
  - investigate options to increase capacity for use of recyclable materials (see *New Newsprint Manufacturing Technologies* example, following page)
  - investigate options to increase market opportunities for products containing recycled materials
    evaluate improved storage and supply stream management methods to provide constant, reliable sources of recycled materials or feedstocks
  - evaluate new markets for waste streams currently considered to be too contaminated for recycling (e.g., glossy paper, enameled steel)
  - evaluate new production technologies that use high percentages of recycled material as feedstocks
  - examine options for returning and refilling pesticide containers for reuse.

EXHIBIT 2-5 (continued)

- Evaluate existing recycling and reuse programs and facilitate development of cost effective model programs

  - improve and demonstrate in-house waste segregation methods for domestic, office, and industrial applications
    establish broad-scale pilot programs to use waste materials in construction materials
    evaluate alternative methods for applying municipal sludges as fertilizer, using adequate monitoring to identify total impacts of sludge disposal
  - evaluate risks associated with different recycling processes and programs
  - demonstrate new and innovative equipment and techniques for separating recyclable materials.

SPECIFIC PROJECT EXAMPLE:
Chemical Recycling of Plastics

Seven and one-half percent of the volume of all municipal solid waste is now composed of plastic material. In 1987, the U.S. public discarded over 22 billion pounds of plastics and the figures are expected to rise to 38 billion pounds by the year 2000. The trend in industry to cope with this problem is to emphasize the expansion of reclamation based on mechanical methods of reusing plastics, such as molding and extrusion. Because the technology in mechanical recycling of plastics is already well understood, there is no need for EPA research in this area. However, research could be well warranted in the chemical recycling of plastic materials.

The concept of chemical recycling entails the use of chemical means to break plastics down to their original components which are then re-polymerized to form new polymer compositions. Recent scientific studies have indicated that through a catalytic reaction with diethylene glycol, polyester resins are broken down into short-chain polyols. When these polyols are reacted with polyisocyanates and other material, they can be converted into rigid polyurethane foam. This example is just one indication of the range of possibilities for chemical recycling of the wide range of plastics. There are many opportunities for EPA to encourage private sector research that would significantly contribute to pollution prevention and material conservation.

SPECIFIC PROJECT EXAMPLE:
New Newsprint Manufacturing Technologies

In *The Solid Waste Dilemma: An Agenda for Action*, EPA indicated the need for improving the nation's ability to recycle paper and paperboard to meet national solid waste reduction targets. A perceived barrier to increasing the recycling rate for recovered paper is that new paper products are made almost exclusively in very large mills that were designed to accommodate virgin pulp. At the current time, the supply of newsprint and paperboard for recycling exceeds the capacity of these paper mills to use recycled materials, resulting in a glut of recyclable paper on the market. Additionally, very little construction of new paper making facilities is being undertaken, due to numerous factors, including the difficulty of obtaining adequate water supplies, environmental controls on emissions and water quality, and the massive scale of current paper making technologies. Research could evaluate clean, small-scale paper making processes that are designed to utilize recycled paper as the primary feedstock. Such paper making technologies could have a significant effect on increasing the recycling rate for recovered newsprint by reducing problems currently besetting the newsprint recycling industry: limited capacity for utilizing reclaimed newsprint, and lack of construction of increased capacity.

EXHIBIT 2-6

SOCIOECONOMIC AND INSTITUTIONAL RESEARCH PROGRAM

POTENTIAL RESEARCH TOPICS AND SPECIFIC PROJECT EXAMPLES

- Understand consumer behavior and identify effective approaches to modifying it in consumption decisions

  - establish a system for ranking the qualities (e.g., life span, life cycle pollution load) of alternative products
  - evaluate marketing approaches for products produced through pollution prevention processes
  - identify consumer attitudes, beliefs, and needs related to environmentally preferable products and services.
  - identify current market forces that effect pollution related decisions
  - assess methods to develop public support for pollution prevention.

- Identify and assess incentives that may increase and obstacles that may inhibit implementation of pollution prevention measures

  - investigate resource management strategies and their impacts on pollution generating activities
  - analyze incentives associated with state agency directed pollution prevention programs
  - develop industry-specific environmental and economic cost benefit analysis procedures and guidelines
  - evaluate model corporate pollution prevention programs that utilize comprehensive pollution and waste accounting procedures, training, and internal publicity
  - analyze incentives that have stimulated specific pollution prevention programs in selected industries
  - identify and evaluate economic, legal, regulatory, and institutional conditions that restrict the development of new or innovative products, processes, or recycling technologies and programs (see *Identification of Institutional and Regulatory Barriers to Increasing Recycling and Reuse of Materials*, and *Identification and Resolution of Military Specifications to Reduce Pollution Generation* examples, following pages)
  - investigate methods to increase the willingness of consumers to use recycled products and products that require less disposal of packaging materials
  - investigate methods to increase the willingness of industry, government, and consumers to participate in source separation and recycling programs
  - evaluate the effect of "cradle-to-grave" liability on the implementation of effective waste exchange programs.

- Assess the effectiveness of pollution prevention approaches

  develop a consensus based agency-wide standardized risk assessment methodology for use in comparative risk evaluations in all industrial, government, and consumer applications
  evaluate the effectiveness of state-wide pollution prevention programs (e.g., the Minnesota Technical Assistance Program, North Carolina's Pollution Prevention Pays program)
  - evaluate corporate management and infrastructure characteristics in industries where effective pollution programs exist
  - evaluate the effectiveness of EPA's pollution prevention programs

EXHIBIT 2-6 (continued)

- evaluate the effectiveness of pollution prevention programs in other countries to identify successful practices and approaches
- develop industry-specific standardized criteria for evaluating pollution prevention effectiveness
- evaluate the effectiveness of corporate pollution prevention programs (e.g., 3M Corporation's Pollution Prevention Pays program)
- identify and evaluate consumer-oriented pollution prevention programs
- identify and assess pollution prevention programs that are designed to reduce non-point sources of pollution (e.g., watershed and aquifier management programs, agricultural non-point runoff control programs).

- Assess trends in consumption/use patterns and pollution generation

  - identify and evaluate trends in water use and energy consumption
  - develop statistical trend detection tools to be used with EPA data and data from the Departments of Commerce, Interior, Labor, and Agriculture, and the Occupational Safety and Health Administration, and from industrial, state, and local sources
    assess data collected under RCRA, CERCLA, TSCA, FIFRA, CWA, and CAA to determine trends in use of specific substances
    consolidate and assess existing data on pollution generation to determine the effectiveness of pollution prevention approaches.

- Quantify the potential of pollution prevention practices for maximizing pollution reduction

  - evaluate current levels of pollution generation
  - design methodologies to assess pollution prevention by the industrial sector
  - quantify the potential for effective pollution prevention practices (see *Quantifying the Potential of Pollution Prevention* example, following page).

SPECIFIC PROJECT EXAMPLE:
Identification of Institutional and Regulatory Barriers to Increasing Recycling and Reuse of Materials

Awareness of recycling and reuse opportunities for many commonly used products (e.g., newspaper, glass, scrap metal) has existed for several decades. However, the industrial infrastructures have not been developed to support large-scale, high-volume recycling. Although some studies were conducted in the 1970s to evaluate the role of incentives in recycling, contemporary research is needed to determine the degree to which economic factors (e.g., tax inequities that favor virgin materials), regulatory constraints (e.g., unfavorable permitting or safety standards), and economic conditions (e.g., market uncertainty) continue to limit growth in this field. Successful identification of these barriers may lead to changes that will attract venture capital and stimulate growth in this industry. Specific investigations in this project could include evaluations of the effects of barriers and incentives at both micro- and macro-scales. For example, a micro-scale analysis of the effectiveness of user charges and "bottle bills" could be conducted for definable geographic areas (e.g., cities, states). Macro-scale analysis could include evaluations of the approaches taken in other countries to identify and overcome barriers to effective recycling and reuse. This project could significantly increase recycling and reuse of materials by both the public and private sectors.

EXHIBIT 2-6 (continued)

SPECIFIC PROJECT EXAMPLE:
Identification and Resolution of Military Specifications to Reduce Pollution Generation

Military specifications often become defacto world standards. This is due to the enormity of usage by the military, the regard of U.S. military procedures as state-of-the-art, and the use by foreign agencies of military specifications for civilian applications. This influence can be utilized to improve environmental conditions by rewriting military specifications to allow development and use of environmentally superior alternatives. For example, CFC-113 is widely used by the military and some industries as a cleaning solvent. The Department of Defense has agreed to change from prescriptive specifications to specifications based on performance, which will allow the use of any cleaning process that provides acceptable cleaning effectiveness. As a result, expanded use of ozone-safe aqueous cleaners and other no-clean solutions are allowed. Other military specifications that also need to be changed include the use of virgin solvents, specifications for corrosion-proofing agents, paint type and quality for specific applications, and numerous other specifications related to cleaning products, processes, and machinery maintenance. EPA could work with the DOD to identify and alter military specifications that unnecessarily require the use of toxic, hazardous, or high volume wastes. Military specifications that take into account pollution prevention could significantly reduce the amount of solid and hazardous wastes generated.

SPECIFIC PROJECT EXAMPLE:
Quantifying the Potential of Pollution Prevention

In the process of setting industry-specific environmental standards, EPA has developed a substantial body of procedures for assessing waste generating processes and setting discharge limits for them. This same type of expertise can be used to evaluate the current level of pollution generation both within industry and elsewhere, and quantify the potential impact of "best available pollution reduction practices" under a variety of scenarios that would take into account resource availability, standard industry operating procedures, regulatory settings, the degree of hazard posed by particular waste streams, and state-of-the-art of current technologies. This research could benefit EPA and other entities concerned with preventing pollution by identifying those industries and other sectors of the economy with the greatest potential for achieving significant reductions in pollution generation.

EXHIBIT 2-7

ANTICIPATORY RESEARCH PROGRAM

POTENTIAL RESEARCH TOPICS AND SPECIFIC PROJECT EXAMPLES

- Identify and explore emerging technologies and patterns in resource use and disposal

  investigate implications of increasing computerization on waste production
  - conduct a top-down analysis of the technical feasibility of fuel reallocation options (see *Hydrogen-Rich Volatile Shift* example, following page)
  - evaluate the pollution prevention implications of alternative energy sources, such as solar space heating, solar photovoltaics, and fusion
  - evaluate new strategies for integrated pollution prevention and advanced treatment (e.g., incineration) for municipal waste management
  - evaluate alternative strategies for reducing the generation of medical and infectious wastes
  - evaluate the use of robotic manufacturing as a potential new technology and understand its pollution generation implications
    evaluate on a multi-industry basis the overall or net pollution reduction which occurs with individual plant changes
  - monitor the development of new composites as structural materials for products (e.g., carbon filters) to instill pollution prevention alternatives
  - examine biotechnology alternatives for chemical synthesis as an alternative to existing chemical manufacturing processes
  - assess waste reduction in new specialty steel and other mature industries as they find areas in which future growth can be internationally competitive
  - evaluate diamond surfaces as an alternative for lubrication and as a new electronics material in which wastes might be low
    sponsor workshops among researchers in specific disciplines to explore the pollution prevention implications of identified trends in industrial, economic, and environmental issues.

- Evaluate the effectiveness of the research program in meeting changing user information needs

  - consolidate existing data on pollution generation and pollution prevention to document progress to date as fully as possible
    identify gaps in existing data that must be filled to achieve a comprehensive picture of progress in pollution prevention
  - determine the effectiveness of current research in meeting user information needs (see *Survey Protocol for Industrial Waste Generators* example, following page)
  - identify changes in user information needs
    identify information gaps that are not addressed by existing research projects
  - modify research strategies to address new user information needs
  - evaluate current and emerging environmental problem areas with the aim of identifying promising pollution prevention research opportunities.

EXHIBIT 2-7 (continued)

SPECIFIC PROJECT EXAMPLE:
Hydrogen-Rich Volatile Shift
A Top-Down Pollution Prevention Strategy Using Alternative Fuels

A very large portion of atmospheric volatile organic emissions result from the storage, transportation, marketing, and use of gasoline in motor vehicles and small engines. Additionally, NO_x, SO_x, and PM 10 emissions result from combustion of dirty fuels in stationary sources (e.g., industrial boilers), which requires application of control measures to reduce these emissions. An emission prevention strategy that involves shifting hydrogen-rich volatile fuels to non-emitting uses has the potential to reduce several major local and global air pollution problems. This top-down strategy is aimed at optimizing emission prevention by shifting hydrogen-rich volatiles from gasoline to high-efficiency stationary combustion sources that need clean fuels to reduce emissions. This hydrogen-rich volatile shift (HRVS) will also reduce carbon dioxide emissions where heavier carbonaceous fuels are displaced. The HRVS prevention strategy includes reducing volatiles and incorporating oxygenate extenders (such as methyl tertiary butyl ether) in gasoline, using methanol in heavy duty vehicles, and using non-polluting hydrocarbons and/or oxygenates (such as natural gas and methanol) in stationary combustion sources. The use of low-volatile gasoline to power automobiles, buses, trucks, and small mobile and stationary engines will help prevent numerous area source problems. The use of oxygenates in gasoline ensures improved combustion, which reduces emissions of carbon monoxide from area combustion sources. Prevention research is needed to review and assess integrated, top-down strategies that may employ numerous technical options. This research could help establish how multiple benefits can be achieved and implementation problems resolved. For example, implementation problems might exist in the following areas:

- control of volatiles from the storage, transportation and marketing of the modified fuels
- infrastructural requirements needed to facilitate shifts of displaced fuel fractions
- control systems for containment and recycling of volatiles
- minimizing aldehyde emissions.

SPECIFIC PROJECT EXAMPLE:
Survey Protocol for Industrial Waste Generators

Many companies have initiated pollution prevention programs, some of which have been highly publicized. It is clear from available information that these programs aim at very different targets and achieve very different results -- some focus only on RCRA wastes while others are multi-media, some use EPA's definition of pollution prevention while others include treatment and disposal. EPA could examine these programs to document, in a consistent and comparable fashion, the impact these programs have had on waste generation at individual companies. Data will come from many existing sources (e.g., permits, regulatory documents, industrial databases, published information on industry pollution prevention efforts), as well as new data gleaned through industry surveys, and actual site visits to facilities that have implemented pollution prevention practices. The results would clarify where pollution prevention programs are currently having an impact, and the success of these programs in reducing multi-media waste generation.

EXHIBIT 2-8

POLLUTION PREVENTION INFORMATION CLEARINGHOUSE

A program plan has been developed for a Pollution Prevention Information Clearinghouse, co-sponsored by the Office of Research and Development and the Pollution Prevention Office. This clearinghouse is intended to fulfill three purposes: collecting and disseminating technical, legislative, programmatic, and statistical information on source reduction and recycling; providing guidance and information transfer services to Regional Offices, states, local governments, industry, academia, and public interest groups; and fulfilling commitments made by EPA and requirements of Congress. The clearinghouse will include a staff, telephone hotline, electronic information exchange network, repository of documents, and system for providing copies of information on request. Currently, this clearinghouse focuses primarily on hazardous wastes. However, it will be expanded and broadened to include pollution prevention information related to industrial, municipal, agricultural, and bio-medical wastes. To enhance the clearinghouse in this way will require work in five areas:

- Obtaining much additional technical and program information for the clearinghouse database
- Procuring references and creating a repository, including establishing a method for disseminating information on request
- Publishing and distributing summaries, fact sheets, bulletins, reports, and bibliographies of information in the database, both to market the availability of the service and respond to requests
- Establishing and supporting a telephone hotline to handle requests for published information and access technical staff
- Developing and pilot testing an electronic bulletin board system and maintaining, monitoring, updating, expanding, and assuring the quality of its information files.

EXHIBIT 2-9

TECHNOLOGY TRANSFER AND TECHNICAL ASSISTANCE PROGRAM

POTENTIAL ACTIVITIES AND SPECIFIC PROJECT EXAMPLES

- Stimulate the use of pollution prevention opportunity assessments

  promote the use of industry-specific assessments (see *Training of Waste Minimization Trainers* example, following page)
  publish pollution prevention assessment guidelines
  provide technical assistance in conducting assessments in industries dominated by small businesses.

- Expand the Pollution Prevention Information Clearinghouse

  - incorporate multi-media pollution prevention assessment guidelines
  - include pollution prevention success stories and case studies
  - provide access to other federal agencies, states, industries, trade associations, public interest groups, communities, and citizen organizations
  - conduct a thorough search of pollution prevention information sources and include them in the clearinghouse
  - develop a national network for waste information exchange (see *Development of a National Recycling and Waste Exchange Network* example, following page)
  - provide fact sheets and summaries for specific industries
  - establish a link to the National Technical Information Service to share data and increase information dissemination.

- Provide technical assistance

  - assist other federal agencies, states, and trade associations in developing integrated programs that prevent pollution from non-point sources (see *Integrated Pest Management* example, following page)
  - distribute guidelines for conducting pollution prevention assessments
  - assist federal agencies, states, and industries in delivering pollution prevention training programs
  - contact top-level managers in industry and government to foster adoption of pollution prevention programs
    develop spill prevention guidelines for industry (see *Accidental Release Prevention Reference Manuals* example, following page)
    identify opportunities for cross-industry cooperation in pollution prevention
    expand the educational aspects of pollution prevention into technical and professional degree programs
    sponsor technical experts to assist in developing local and regional pollution prevention programs
    ensure all levels of industry are receiving some level of assistance
    improve expectations of acceptable performance in pollution prevention programs
    encourage every state to adopt a pollution prevention program
    develop retraining programs for continuing education of industrial and governmental environmental personnel
  - work with state agencies to incorporate pollution prevention concepts into elementary, intermediate, and secondary education curricula (see *Curriculum Development* example, following page).

EXHIBIT 2-9 (continued)

- Support information exchange via conferences and seminars

  sponsor seminars, workshops, and technical briefings for communities and small industries needing technical assistance in developing pollution prevention programs
  - sponsor international, national, state, and regional seminars and workshops addressing scientific and technical advances in pollution prevention
  - sponsor policy and program development working groups to evaluate and develop pollution prevention programs
  - develop catalog of existing seminar offerings on pollution prevention.

SPECIFIC PROJECT EXAMPLE:
Training of Waste Minimization Trainers

Training programs are needed to increase the ability of government and industrial personnel to recognize pollution prevention opportunities and implement prevention practices. EPA could target training programs at specific audiences, and develop industry-specific pollution prevention opportunity assessment software packages that are designed for small business owners and corporate environmental managers, by building on the experience the Agency has gained in conducting waste minimization seminars at the regional level. These training programs and software packages would ensure the assessment of true costs of current hazardous and non-hazardous materials management practices, and provide methods for calculating changes in costs resulting from specific waste reduction alternatives. EPA's intention would be to employ a "train-the-trainer" approach by providing materials and expertise to train state and local solid waste management officials to assist small businessmen, commercial, and industrial operators in conducting pollution prevention opportunity assessments. Materials would be developed first for the seven industries that have already been targeted at the regional level: chemical manufacturing, electronics manufacturing, petroleum refining, plastics, metal finishing, wood preserving, and textiles finishing and carpet manufacturing. Packages would then be developed for other industries in which waste minimization opportunities appear promising. This project could make a significant contribution to assisting public and private sector organizations in recognizing opportunities for implementing pollution prevention approaches.

SPECIFIC PROJECT EXAMPLE:
Development of a National Recycling and Waste Exchange Network

As part of its expansion of the Pollution Prevention Information Clearinghouse, EPA could create an interactive network of databases, organizations, and contacts to provide an industrial user an array of options for redirection of waste materials. Information provided by the network could include sources of non-virgin materials usable as raw materials, market assessments, case studies in viability for specific materials, sources for research grants or other funding, and technical evaluation and pilot study information. This network could also provide links, program descriptions and contacts with trade associations and industrial committees allowing networking of databases and information flow among municipal recovery facilities and industrial markets. In addition, this network could be developed into an international waste exchange information center that provides case studies, source listings, and broker dictionaries through bulletin board functions. This network would facilitate the exchange of waste materials among generators and potential consumers, resulting in reduced pollution discharge.

EXHIBIT 2-9 (continued)

SPECIFIC PROJECT EXAMPLE:
Integrated Pest Management and Low Input Sustainable Agriculture

Integrated pest management (IPM) uses all suitable pest control techniques and methods (including biological control agents, irrigation and tillage practices, crop rotation, timing of control efforts, pesticides, etc.) to keep pest populations below economically injurious levels. Widespread use of IPM approaches could result in reduction of the amount of pesticides used for agriculture, landscaping, and pest control in residences and other buildings. Reduced use of pesticides is desirable since pesticide use often results in loss of beneficial organisms and other non-target organisms, as well as target pest organisms. EPA's Office of Pesticide Programs (OPP) has provided technology transfer and technical assistance in IPM to the U.S. Department of Agriculture (USDA), the lead agency for agricultural IPM research. OPP efforts have included:

- development of a cockroach IPM demonstration project
- technical assistance on a grasshopper project for the Animal and Plant Health Inspection Service
- technical assistance on a gypsy moth IPM program for the U.S. Forest Service
- comparative studies of IPM for turfgrass applications in cooperation with the Golf Course Superintendents Association.

Additional research is needed to expand IPM projects into other agricultural and domestic applications and to develop and transfer ecologically sound IPM programs to user groups. Also, there is a need to pursue cooperative research with the USDA in low input sustainable agriculture (LISA), which promises to reduce agricultural use of fertilizers, water, and high impact tillage practices, as well as reducing the use of pesticides through IPM practices. Increased use of IPM and LISA should reduce the use of pesticides and chemical fertilizers thus decreasing the runoff of these chemicals.

SPECIFIC PROJECT EXAMPLE:
Accidental Release Prevention Reference Manuals

Currently, many small non-chemical industrial facilities handle extremely hazardous substances and do not have procedures in place for reducing the likelihood of accidental releases. A need exists to conduct research on spill prevention and use the results to develop industry-specific manuals that identify opportunities for reducing the risk of spills and describe procedures for implementing accidental release prevention programs. The purpose of this research and the resultant manuals would be to provide specific industrial sectors with an understanding of the potential hazards of the chemicals they handle and the causes of accidental releases, and to document the availability of prevention measures. These manuals would provide a summary of available information and references to more detailed engineering information. This project could provide the information needed by facilities to reduce the possibility of and risks associated with accidental releases.

EXHIBIT 2-9 (continued)

SPECIFIC PROJECT EXAMPLE:
Curriculum Development

Pollution prevention will be an increasingly important component of all ways of life in the future, and trained professionals that have a pollution prevention perspective will be needed in all communities, businesses, and industries. EPA could work closely and cooperatively with universities and colleges to include pollution prevention concepts in curriculum plans for all levels of education, from elementary school to universities, and especially in curricula for professional degrees in engineering, science, economics, business, government, and law. Implementing this effort would involve identifying cooperating institutions, providing technical assistance in developing course materials and program contents, and co-sponsoring pilot testing efforts. Incorporating pollution prevention concepts in training and education programs at all levels should help bring about the cultural change necessary to institutionalize pollution prevention in all sectors of society.

CHAPTER 3
RESOURCE REQUIREMENTS AND IMPLEMENTATION MECHANISMS

RESOURCE REQUIREMENTS

Research activities in two of the six research program areas identified in Chapter 2 began under the waste minimization research (WMR) program initiated in 1987. The total ORD budget for these research projects was $2.4 million from Research and Development (R&D) funds in FY 1989. These research efforts focused on: (1) the evaluation of new production and recycling process technologies to prevent or reduce the generation of hazardous wastes, and (2) a technology transfer program to disseminate this information. The pollution prevention research plan presented in this report will build upon the foundation established by Agency program, research, and regional office efforts to develop an integrated program of pollution prevention research that has a multimedia focus and addresses both hazardous and non-hazardous pollutants.

The costs outlined in this research plan represent estimates for implementing a comprehensive, Agencywide pollution prevention research program. During FY90, resources will be focused to develop program-specific short- and long-term research plans, prioritize research projects, and initiate the research efforts. The approximate total estimated R&D cost of the pollution prevention research program outlined in this report is $5.4 million for FY90 and $9.1 million for FY91. The proration of funds among the six research program areas will be based on priorities for initiation of activities in each particular program area, as well as upon a need to continue funding for certain research projects within the areas.

Priorities Among Program Areas

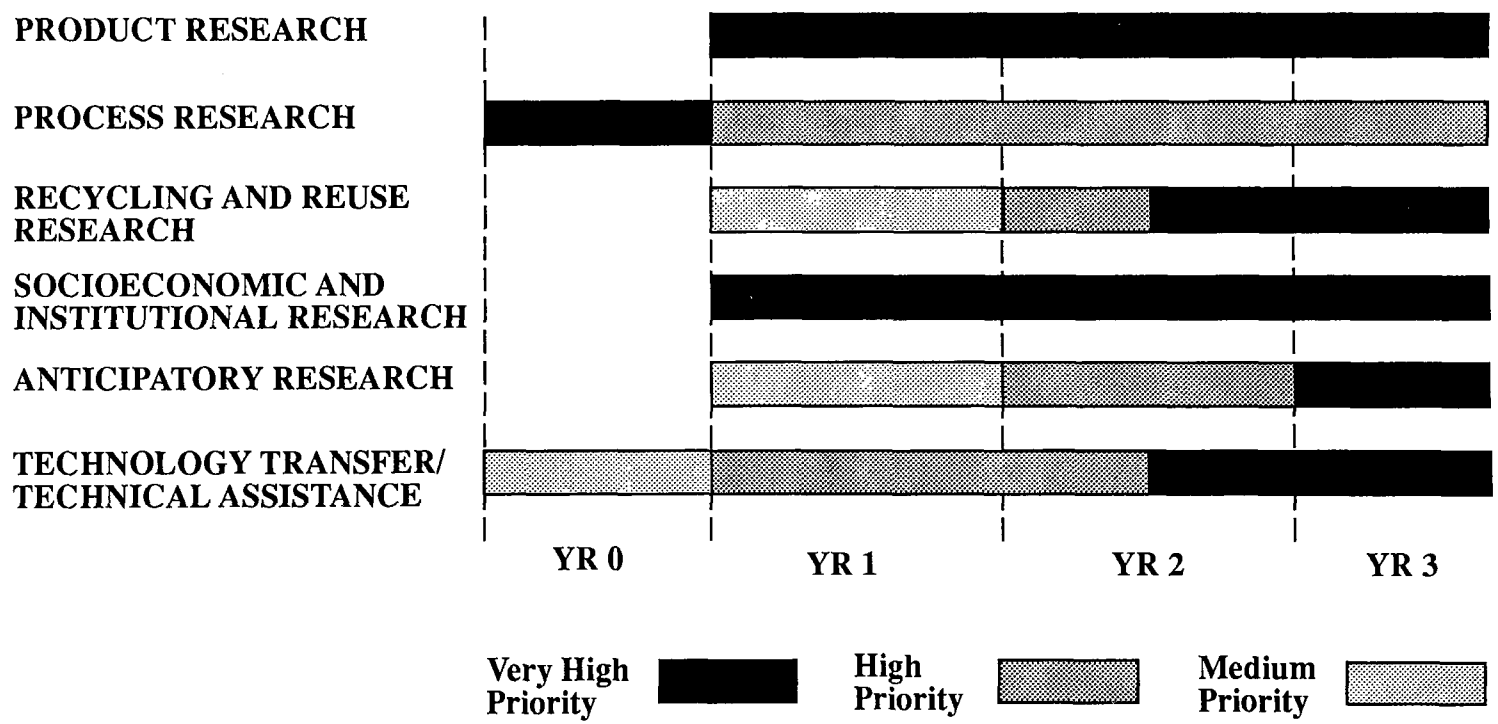
A key question for EPA's research efforts in pollution prevention is where and how resources should be directed to provide the greatest support to EPA's pollution prevention initiative. The obstacles currently inhibiting pollution prevention are by no means identical in the many sectors of society generating wastes. The most effective means for achieving pollution prevention in the chemical industry, for instance, may be very different than for metal fabricators, and neither set of inducements may be very appropriate for reducing the generation of agricultural or residential wastes. In some cases, technology may be a significant bottleneck; in others, institutional and economic factors may present serious obstacles. Identifying the impact of pollution prevention practices and impediments to progress will play a principal role in helping to set the Agency's research priorities.

The four new research program areas will be phased-in according to the priorities established in Exhibit 3-1. All of the six research program areas are of critical importance to the nation's pollution prevention initiative, and will be pursued. However, recognizing that immediate implementation of all six areas may not be practical, EPA has established priorities for initiating efforts among the areas. These priorities are based on the expected overall impact on environmental results, potential cost effectiveness of proposed activities, the degree of need for the information, the importance of EPA's contribution in this area, the ability to achieve near-term results, the number of organizations that could benefit from the information, the need to support EPA program and regional offices, and finally the need to continue building on Agencywide pollution prevention efforts that began through the source reduction and recycling programs of OSW, the Waste Minimization Research program of ORD, and the establishment of the Pollution Prevention Office.

Exhibit 3-1 indicates the priorities for initiating activities in each of the four new research program areas and continuing the two ongoing program areas. In FY90, the highest priority of the research program will be to

EXHIBIT 3-1

INITIAL PRIORITIES AMONG RESEARCH PROGRAM AREAS



initiate efforts in the product and socioeconomic and institutional research program areas. These two program areas rank very high in priority because little research has been done by EPA, other agencies, or industry in either of these areas. In addition, EPA recognizes the importance of launching research projects in these areas to address both technological and non-technological issues and to complement the pollution prevention activities the Agency has already started. EPA can rapidly build on the process research and technology transfer activities started under the WMR program and quickly implement additional research projects designed to achieve the objectives of these research program areas. The technology transfer program is expected to increase in importance as results are produced by the other research program areas. Initiation of recycling/reuse research and anticipatory research are of medium priority. Once a program is initiated and determined to be effective (including the existing process and technology transfer programs) there is high priority for maintaining continuity of the research efforts within the program.

The program area priorities depicted in Exhibit 3-1 represent the priorities for initiating research activities in each of the six research program areas on an annual basis, beginning with new activities in FY90. As the research program progresses and matures, priorities for initiating new research activities will change, and new research programs and projects may become more critical to the overall pollution prevention research program. Furthermore, research in a number of the program areas may be coordinated to address a significant environmental problem from several fronts. These factors will be considered when setting priorities for future research projects. EPA plans to use both external and internal representatives to help the Agency determine new directions for the research program, as well as prioritize specific research projects. This guidance can be solicited during workshops sponsored by the Agency. These workshops could address topics such as pollution prevention opportunities for specific industries or homeowners, or pollution prevention approaches for specific pollutants or media.

In addition to workshops, guidance concerning prioritizing research projects can be solicited from EPA's Pollution Prevention Program Advisory Committee. This committee includes representatives from all EPA program offices (director level) and several regions, and is currently co-chaired by the directors of OPPE and OSW. The committee meets monthly and could contribute to the identification of research needs as well as prioritization of research projects.

EPA could also utilize the Pollution Prevention Subcommittee of the SAB to identify future research needs and establish priorities among research projects. The SAB, which includes representatives from industry, academia, state and local organizations, and public interest groups, currently provides similar support to the Agency.

Financial resource expenditures for FY89 and estimates for FY90 and FY91, identified by research program area and topic, are presented in Exhibit 3-2. Priorities identified in Exhibit 3-1 may not be directly related to funding levels identified in Exhibit 3-2 in any single year, due to costs of ongoing programs and disproportionate costs of planning, initiating, and implementing specific projects in different program areas. In Exhibit 3-2, the estimates represent the Agency's current best approximation of the resources needed to conduct the research efforts described in this plan. In these two years, total estimated costs for process research is expected to be approximately $3.7 million, technology transfer and technical assistance $2.4 million, product research $3.9 million, recycling and reuse research $0.7 million, socioeconomic and institutional research $3.4 million, and anticipatory research $0.4 million.

Priorities Within Program Areas

Establishing priorities for research topics within research program areas is essential to

EXHIBIT 3-2

RESOURCES ESTIMATES
POLLUTION PREVENTION RESEARCH PLAN

Program Area	Approximate R&D Funding ($ thousand)		
	FY89	FY90	FY91
Product Research	0	1400	2500
Process Research	1700	1600	2100
Recycling and Reuse Research	0	300	400
Socioeconomic and Institutional Research	0	1000	2400
Anticipatory Research	0	200	200
Technology Transfer and Technical Assistance	700	900	1500
Total Research Program Resources	2400	5400	9100

marshal the Agency's resources toward research that offers the greatest impact on reducing health and environmental risk. There are different approaches to setting priorities for the technological research program areas (product, process, and recycling/reuse), socioeconomic and institutional research program area, and the anticipatory research program area. Priorities within the technological research program areas can be established by taking a practical problem-solving approach. The first step is to identify "pollution problem areas"--those areas not amenable to pollution controls or for which controls are ineffective. These environmental problems can be ranked in order of importance. The next step is to inventory factors that contribute to each problem. The third step is to conduct research that attacks these problems through the contributing factors. For example, a major contributor to the problem of ozone depletion is the release of CFCs in the environment. Therefore, research to reduce the use and release of CFCs is one research topic that will help EPA address the ozone depletion problem. Another method of identifying priority areas for research is to look at pollution problems by various sectors--agriculture, transportation, households, energy extraction and use, metals extraction and use, and chemical and industrial production--to identify pollution prevention opportunities and develop a generic methodology as well as specific strategies for preventing pollution in these sectors.

Although some socioeconomic and institutional research projects can be similarly prioritized by focusing on the severity of the environmental problem and the potential contribution of the research project to pollution prevention and to eliminating the problem, other non-technological projects are not driven by specific pollution problems. These types of projects focus on factors that affect pollution prevention practices, such as consumer behavior and motivation. Other projects, particularly those concerned with future environmental problems, focus on determining pollution effects before a specific pollution problem exists or poses a significant risk. Unlike the factors addressed in the technological research areas, these socioeconomic and institutional factors have only an indirect effect on achieving the desired result. Therefore, these projects must be prioritized according to their potential for achieving a significant impact on pollution prevention. It is also essential that the socioeconomic and institutional research projects be coordinated with research projects in other program areas in order to fully address certain pollution problems.

Since some of the research topics will contribute data to other topics within a program or must be conducted concurrently with research projects in other program areas, it may not be feasible to initiate all important research projects at the outset of the program. In addition, Agency decisions on resource allocation may limit the number of research projects that can be conducted simultaneously. Therefore, considerable planning is required early in the program followed by continual evaluation, reprioritization, and refocusing of research efforts to ensure that the research program is meeting its objectives.

Early in the program, efforts in product research are expected to focus on establishing standardized methods for evaluating product-related pollution generation, utilizing existing information to evaluate the impacts of specific types of products and product use patterns, and demonstrating and evaluating production and use of low-impact products. Efforts to establish standardized evaluation methods and to demonstrate and evaluate production and use of environmentally preferable types of products are expected to decrease as this research program area matures, while efforts in the evaluation of new and existing types of products are expected to increase, and research to stimulate the development of low-impact products are expected to be initiated. Ultimately, the program is expected to shift toward increased utilization of standardized methods to evaluate larger numbers of products, demonstrate the production and use of improved products and stimulate production of these low-impact products. During the early years of the program, approximately 40 percent of the effort in

product research is expected to be used for demonstrating and evaluating products and about 30 percent is expected to focus on evaluating both existing and new products. The remainder of the efforts in product research are expected to be divided approximately equally between establishing standardized product evaluation methods and encouraging product development. Much of the research is expected to be conducted in cooperation with industry and will focus on products produced or processed by industries dominated by small businesses.

Early efforts in process research have focused on developing standardized methods for evaluating manufacturing processes on an industry-specific basis, evaluating specific processes to identify problems and pollution prevention opportunities, assessing both existing and new pollution prevention methods for improving these processes, and stimulating cross-industry applications of pollution prevention approaches. Once standardized assessment methodologies have been completed, probably during the second year of the program, the remaining efforts of the program are expected to receive approximately equal emphasis and resources. Early in the program, about 35 percent of the effort in process research is expected to focus on conducting pollution prevention opportunity assessments, about 30 percent on evaluating existing and new pollution prevention methods, and about 25 percent on stimulating cross-industry applications of pollution prevention methods and technologies. The remaining effort is expected to be used to develop standardized process assessment methods. Much of the process research is expected to be conducted in cooperation with industry and will focus on processes utilized by industries dominated by small businesses.

Early efforts in the recycling and reuse research program are expected to evaluate potential new uses for wastes and pollutants and evaluate alternative strategies for increasing recycling activities and uses for recycled materials. As these efforts continue, efforts to stimulate the development of additional capacity for using recycled materials and to evaluate existing programs to develop model recycling and reuse programs could be initiated and then increased, as information and expertise increase. Over the first three years of the program, about 60 percent of the effort in recycling and reuse research is expected to be divided approximately equally between stimulating the development of new capacity to recycle materials and evaluating existing recycling programs, and the remaining effort is expected to be divided evenly between evaluating new uses for materials and developing strategies to increase the use of recycled materials. Recycling and reuse research will probably be conducted in cooperation with industry, academia, states, and public interest groups.

In the socioeconomic and institutional research program area, initial efforts will probably emphasize assessing methods for modifying consumer behavior and identifying and assessing incentives for and obstacles to pollution prevention. Assessing the effectiveness of existing and new pollution prevention approaches, assessing trends in consumption and use patterns, and quantifying the potential for pollution prevention could initially receive somewhat less emphasis. As research in this program area matures, efforts in these topic areas could increase as greater expertise and knowledge become available. Over the first three years of the program, about 75 percent of the research is expected to focus somewhat equally on assessing methods to modify consumer behavior, assessing incentives and obstacles, and assessing the effectiveness of different pollution prevention approaches, about 15 percent could focus on assessing trends, and the remainder could be used to quantify the potential for pollution prevention. Much of the socioeconomic and institutional research probably will be conducted in cooperation with academia, public interest groups, and state and local organizations.

Anticipatory research is expected to initially focus equally on identifying emerging technologies and patterns in resource use, and evaluating the effectiveness of current research program

efforts in meeting current and changing information needs. Slightly more emphasis is expected to be needed in subsequent years to evaluate the effectiveness of the research program in meeting information needs. Over the first three years of the program, the research effort in anticipatory research is expected to be divided approximately equally between identifying emerging technologies and patterns, and evaluating the effectiveness of research in meeting changing information needs.

The technology transfer and technical assistance program should emphasize all four of its topic areas equally. Over the first three years of the program, the efforts in this program area are expected to be approximately evenly divided among stimulating the use of pollution prevention assessments, expanding the pollution prevention information clearinghouse, providing technical assistance, and supporting conferences and workshops for information exchange.

IMPLEMENTATION MECHANISMS

EPA will serve as the leader in conducting and coordinating research and demonstrating pollution prevention techniques, and promoting research, development, and implementation of successful techniques within EPA and the following five sectors of society:

- Business and industry
- Universities and academia
- State and local governments
- Other agencies
- Public interest groups and the general public.

EPA's efforts will be directed toward establishing an awareness of opportunities, stimulating investigation of alternatives, and adopting workable approaches for pollution prevention in these five sectors of society. Implementation of the pollution prevention research program described in Chapter 2 will require expansion of EPA's intramural and extramural research activities, including contracts, grants, and cooperative agreements.

Because pollution prevention is not the responsibility of EPA alone, implementation of the pollution prevention research plan will require various strategies. For example, EPA's role in stimulating product and process related research in industries that are dominated by large companies may be limited to evaluating pollution prevention technologies, facilitating information exchange, evaluating regulatory constraints to innovation, and providing technology transfer services. However, for industries that are predominantly composed of small businesses (e.g., electroplating, air conditioner servicing, auto repair), EPA may provide technical assistance and research support to identify and address pollution prevention opportunities, as well as information exchange and technology transfer.

Intramural Research

In keeping with its leadership role in conducting environmental research, EPA's in-house research efforts will include activities in each of the six research program areas identified in the research plan. These efforts will be in support of EPA's responsibility to develop and prioritize the nation's pollution prevention agenda. This especially pertains to research that involves either generic studies to identify problems that are amenable to pollution prevention solutions or mechanisms that influence effective pollution decision making in other sectors.

The intramural pollution prevention research efforts will build on the current waste minimization research program being conducted by EPA, and will support ongoing and new pollution prevention efforts in program and regional offices. An important aspect of this research plan is expanding of the capability of EPA to carry out in-house research and manage extramural research activities in each of the research program areas. Currently, most of the Agency's activities in the areas of pollution

prevention research are extramural; however, EPA needs to develop expertise to interface with industry and other groups on pollution prevention efforts and manage the extramural research program.

The most important element in a plan for an intramural research program is the personnel involved. In carrying out the plan outlined in this report, the Agency would need to enhance its in-house capabilities by hiring technical personnel with experience and education that build EPA's expertise in areas that are extremely important in pollution prevention research and that are applicable to a number of the research program areas. One option would be to establish a program to allow up to six individuals from universities, research institutes, laboratories, and industry to work with the Agency under temporary appointments of from one to two years. In addition, facilities of the federal laboratories in which the in-house programs are to be carried out could be made available to industries with cooperative research projects. A small core of in-house research personnel, supplemented by professionals on temporary appointments, would ensure that the intramural research program is effective and the extramural research program is properly managed.

Extramural Research

Business and Industry

EPA has an important role in investigating ways that industry can reduce or prevent the generation of pollution. Even though finding ways to reduce, recycle, or prevent waste ultimately depends on conditions that are specific to each site or plant, basic approaches and procedures seem to hold promise for several different types of companies since they have already been employed successfully at many locations across the country. EPA will expand its contracts and cooperative agreements with industries to identify, demonstrate, and evaluate effective approaches to prevent pollution, and encourage the use of these successful pollution prevention techniques in industry.

Effective pollution prevention research in the business and industry sector should address each step in the product life cycle independently, as well as the total pollution burden associated with the entire life cycle of the product. The emphasis of this research should be to develop methods to reduce the total quantity, potency (toxicity or concentration), and the mobility of pollutants associated with manufacturing processes and the product produced. EPA does not have the resources to conduct the process- and product-oriented pollution prevention research that can be conducted by large businesses in developing, testing, and marketing their specific products and services. Therefore, EPA will cooperate with large industries and trade associations to establish pollution prevention assessment methodologies, assist in developing pollution prevention plans, and transfer technical information.

Unlike large businesses, small businesses often lack the resources to conduct research that may assist them in reducing their pollution loads. EPA's role is to assist industries that are dominated by small businesses in their efforts to reduce and prevent pollution. This research will include evaluation of pollution prevention opportunities associated with specific industrial unit processes. This research is applicable to both large and small businesses and will be used to assist small business operators in identifying pollution prevention opportunities and approaches. These efforts, coupled with targeted technology transfer, are expected to help small businesses move forward rapidly in pollution prevention.

EPA will work cooperatively with industries to ensure that a multi-media focus is maintained and that all appropriate avenues of pollution prevention are explored. Funding assistance may be provided by EPA for pollution prevention research related contracts and cooperative agreements. Such funding assistance would ensure that broad-based, multi-media pollution prevention research will be applicable to existing businesses and amenable for use in preventing pollution. Some pollution prevention research projects and technology transfer activities may

be conducted through an industry-government forum or institute that would function as a separate entity.

University and Academia

Numerous pollution prevention research questions involve either basic technological investigations or collection of socioeconomic information that lie outside EPA's expertise. In addition, much of the data collection effort associated with socioeconomic research may be facilitated by researchers who are not perceived as having direct government affiliation. Therefore, EPA could support university-based academic pollution prevention research efforts through grants and cooperative agreements. Research at these universities will comprise investigations into basic pollution prevention issues that are not directly related to product or process development or modifications. EPA-supported research at universities may include analyses of:

- Incentives and disincentives for pollution prevention
- Impacts of regulation on pollution prevention
- Recycling and reuse options
- Consumer behaviors (product preferences, recycling, etc.)
- Trends in consumer and industrial habits
- Outreach and technology transfer activities
- International activities in pollution prevention.

State and Local Government

State and local agencies are aware of the problems facing the commercial or manufacturing industries and consumers. Successful arrangements have been established with state and local waste reduction programs throughout the country. These programs have enabled EPA to leverage its financial and personnel resources to increase pollution prevention research and to demonstrate pollution prevention techniques. The Agency's expansion of these state/EPA partnerships would reflect its continued support of state agencies as the primary contact with the public in matters related to pollution prevention. A key element of EPA's support for state and local programs is the provision of an information network at a national level to insure that technical information is developed and made available to firms and groups that need the information and to states that are often the front-line advisors to many firms.

In addition, EPA could continue to sponsor formal programs of technology transfer to state and local governments, conduct seminars and courses in areas related to pollution prevention, issue technical manuals, and provide technical assistance to state and local research programs. Pilot projects to develop state capabilities to assess environmental problems, conduct analysis of cross-media issues, and establish priorities could be encouraged and supported. EPA could also support state technical assistance and educational programs for applied research on pollution prevention that can be implemented by other state and local governments. The Waste Reduction Innovative Technology Evaluation (WRITE) program, intended to identify, demonstrate, and evaluate new methods that lead to the reduction or prevention of pollution, could be expanded. The WRITE program is implemented in cooperation with states.

Other Agencies

Many agencies, including the Departments of Agriculture, Defense, Energy, and Interior, the Occupational Safety and Health Administration, the National Oceanic and Atmospheric Administration, the National Center for Atmospheric Research, the National Science Foundation, and the National Academy of Sciences, are involved in pollution prevention activities, either as supporters of studies and research in the subject areas for which they are responsible, as actual waste generators interested in reducing their waste streams, or as regulatory and administrative agencies responsible for maintaining environmental standards. Cooperation in

addressing pollution prevention research needs is necessary among federal agencies. EPA could establish cooperative efforts with other agencies to identify research needs and work with these agencies in determining methods to prevent or reduce their generation of pollutants. By working with other agencies, EPA can leverage additional resources to pursue pollution prevention as a national strategy to reduce risk. Possible research projects to be coordinated with other agencies include:

- Integrated pest management and non-point source pollution control (Department of Agriculture)

- Energy conservation and efficiency, alternative energy sources (alternatives to coal and oil), and renewable energy sources (Department of Energy)

- Environmentally preferable products and processes, recycling and reuse of wastes and pollutants, and revision of procurement and process specifications (Department of Defense)

- Indoor air pollution from building materials or natural sources, such as radon (Department of Housing and Urban Development)

- Less toxic feedstocks and alternative processes that minimize worker exposure (Occupational Safety and Health Administration).

The Agency could devote more resources to the Waste Reduction Evaluations at Federal Sites (WREAFS) program, which was initiated under EPA's existing WMR program. This program encourages joint pollution prevention assessment activities at federal facilities. EPA will also continue to participate in a DOD/DOE/EPA working group that was established to explore pollution prevention cooperative ventures. In addition, EPA will work with other agencies to develop an interagency strategy to incorporate pollution prevention as a means of risk reduction across all sectors of society.

Public Interest Groups

EPA will work cooperatively with public interest groups, including environmental and conservation groups, to support a variety of information exchange and technology transfer activities concerning pollution prevention. These information exchange forums assist EPA in disseminating research results, as well as obtaining information concerning pollution prevention implementation problems, opportunities, and additional research needs.

APPENDIX

ACKNOWLEDGEMENTS

EPA sponsored a workshop for the purpose of obtaining input from numerous perspectives about existing needs for pollution prevention research. This workshop was held on November 9 and 10, 1989, in Washington, DC. The participants in the workshop were important contributors to the identification of information needs, development of research program areas, and establishment of priorities for the plan presented in this document. The participants and their affiliations were:

NAME	AFFILIATION	LOCATION
Mr. John Atcheson	U.S. EPA	Washington, DC
Ms. Jane Bare	U.S. EPA	Research Triangle Park, NC
Mr. William Beck	du Pont Corporation	Kingwood, TX
Mr. William Burch	U.S. EPA	Washington, DC
Mr. William A. Cawley	Gulf Coast Hazardous Substance Research Center	Beaumont, TX
Dr. Anthony Cortese	Tufts University	Boston, MA
Mr. John Cox	U.S. Department of Commerce	Washington, DC
Mr. Jon DeBoer	American Water Works Association	Denver, CO
Mr. Mark Dorfman	INFORM	New York, NY
Mr. Alan Ehrlich	U.S. EPA	Washington, DC
Mr. Harry Freeman	U.S. EPA	Cincinnati, OH
Mr. Robert Hangebrauck	U.S. EPA	Research Triangle Park, NC
Mr. Steven Hendricks	General Dynamics	Fort Worth, TX
Ms. Jeanne Herb	New Jersey Department of Environmental Protection	Trenton, NJ
Mr. Joel Hirschhorn	Office of Technology Assessment	Washington, DC
Mr. Gary Hunt	Pollution Prevention Pays Program	Raleigh, NC
Mr. Kurt Jakobson	U.S. EPA	Washington, DC
Mr. Mark Joyce	U.S. EPA	Washington, DC
Mr. Joe Kamenski	U.S. Department of Defense	Alexandria, VA
Mr. Bala Krishnan	U.S. EPA	Washington, DC
Mr. Steven Levy	U.S. EPA	Washington, DC
Mr. Alfred Lindsey	U.S. EPA	Washington, DC
Mr. Joseph A. Lindsey	DOW Chemical USA	Midland, MI
Ms. Cindy McComas	University of Minnesota	Minneapolis, MN
Mr. Morton Mullins	Monsanto Chemical Company	Washington, DC
Mr. Ward Penberthy	U.S. EPA	Washington, DC
Mr. Robert Perea	Elliotts Designs	Rancho Dominguez, CA
Mr. William J. Rhodes	U.S. EPA	Research Triangle Park, NC
Mr. Dick Rosenberg	Chemical Waste Management	Riverdale, IL
Dr. Manik Roy	Massachusetts Department of Environmental Quality Engineering	Boston, MA
Mr. Marvin B. Rubin	U.S. EPA	Washington, DC
Mr. David Sarokin	U.S. EPA	Washington, DC
Ms. Susan Sherry	Local Government Commission	Sacramento, CA

Dr. Dean Smith	U.S. EPA	Research Triangle Park, NC
Mr. Ned Smith	National Resources Defense Council	New York, NY
Major Charles Snyder	Defense Logistics Agency	Alexandria, VA
Mr. Bern Steigerwald	U.S. EPA	Research Triangle Park, NC
Dr. David L. Thomas	Illinois Hazardous Waste Research and Information Center	Savoy, IL
Dr. John Warren	U.S. EPA	Washington, DC
Ms. Kathleen Wolfe	Source Reduction Research Partnership	Los Angelos, CA

A draft of this report was reviewed and extensively commented upon by the Pollution Prevention Subcommittee of the Science Advisory Board in a two day meeting held on March 9 and 10, 1989. Members of this subcommittee included the following individuals:

NAME	AFFILIATION
Dr. Joan Berkowitz (Chair)	Risk Science International
Mr. Richard Conway	Union Carbide Corporation
Dr. Anthony Cortese	Tufts University
Dr. Wayne Kachel	Exxon Corporation
Dr. Jack Kooyoomjian	Science Advisory Board
Dr. Joseph Ling	Consultant
Dr. Walter Shaub	Coalition for Resource Recovery and the Environment
Dr. Calvin Ward	Rice University

Draft materials for this report were prepared by numerous members of an EPA workgroup that was charged with developing the Pollution Prevention Research Plan Report to Congress. This workgroup consisted of representatives from numerous program offices, two laboratories, and contractor support staff. The workgroup members included the following individuals:

NAME	OFFICE
Mr. John Atcheson	Pollution Prevention Office
Mr. William M. Burch	Office of Pesticides and Toxic Substances
Mr. Joseph DeSantis	Office of Technology Transfer and Regulatory Support
Mr. Harry Freeman	Risk Reduction Engineering Laboratory
Mr. Jerry R. Garman	Office of Technology Transfer and Regulatory Support
Mr. Robert Hangebrauck	Air and Energy Engineering Research Laboratory
Mr. Mark Joyce	Office of Air and Radiation

Mr. Bala Krishnan	Office of Environmental Engineering and Technology Demonstration
Mr. Steven Levy	Office of Solid Waste
Mr. Alfred Lindsey	Office of Environmental Engineering and Technology Demonstration
Ms. Karen McCormack	Office of Pesticides and Toxic Substances
Mr. Ward Penberthy	Office of Pesticides and Toxic Substances
Mr. Frank Princiotta	Office of Environmental Engineering and Technology Demonstration
Ms. Diane Regas	Office of General Counsel
Mr. Marvin B. Rubin	Office of Water Regulations and Standards
Mr. David Sarokin	Office of Toxic Substances
Mr. Bern Steigerwald	Office of Air and Radiation
Mr. John Warren	Office of Policy Planning and Evaluation
Mr. Greg Ondich	Office of Environmental Engineering and Technology Demonstration
Mr. Tim Oppelt	Risk Reduction Engineering Laboratory

TECHNICAL RESOURCES, INC.

Technical support in the preparation of this document was supplied by Technical Resources, Inc., of Rockville, Maryland. Staff members who participated included the following individuals:

Ms. Beverly Campbell, Vice President
Ms. Joan Cox
Dr. Gerald Filbin
Mr. Mel Knapp
Mr. Ky Ostergaard
Ms. Joel Ann Todd