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EPA

Research and Development

1994 Research Accomplishments

Cover photo of geese on pond by S.C. Delaney/U.S. EPA

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Introduction

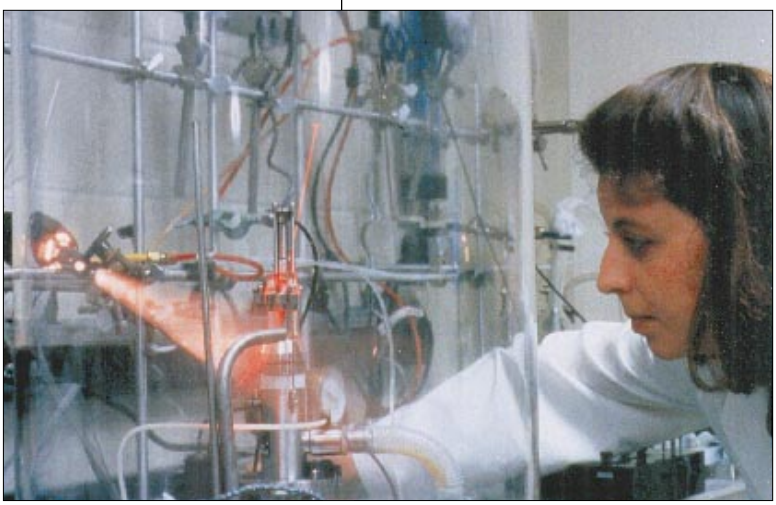
EPA is one of a few federal organizations that function both as a science agency and a regulatory agency. The challenge for the Agency's research arm, the Office of Research and Development (ORD), has been to provide information and technical support for federal, state, and local officials facing today's environmental problems and, at the same time, to expand the science and technology base needed for solving problems in the future.

In its 20-year history, ORD has developed, refined, and disseminated much of the basic technical know-how employed by EPA, other federal agencies, states, cities, industry, and others to protect our natural resources. For example, ORD laboratories developed many of today's basic methods for mapping complex ecological processes and assessing adverse effects from pollutants. They developed and continue to upgrade much of the standard sampling and analytical equipment necessary for directing effective pollution control efforts. They have revolutionized faster, more cost-effective technologies for disinfecting drinking water, reducing toxic air emissions, and cleaning up hazardous waste and oil spills.

ORD's scientists and engineers work closely with decision-makers to translate knowledge into action. Often in crisis situations, ORD experts have lent technical assistance in controlling environmental problems. ORD scientists provided critical scientific knowledge to help assess environmental damage from the Kuwaiti oil fires, to help Eastern Europe clean up decades of air and water pollution, to help the U.S. and Canada restore the Great Lakes, and to help cities in the U.S. and South America control outbreaks of disease from microscopic drinking water parasites.

As a way to decide where to focus attention and resources on diverse and seemingly unlimited problems, the Agency uses the risk assessment/risk management framework described by the National Research Council in its report, *Risk Assessment in the Federal Government: Managing the Process*, 1983. This framework helps to identify research that will have the greatest impact on increasing our understanding of the risks from pollutants and ways to prevent, reduce, or cleanup pollution. Better understanding of risks and ways to manage them helps to identify the areas of greatest need and to let us tackle the worst problems first.

This spinning top aerosol generator is used to characterize inlet efficiencies of sampling instruments.



The basic scientific questions surrounding risk assessment and risk management are grouped into four categories:

- effects
- exposure
- assessment
- management, i.e., prevention, reduction, and remediation.

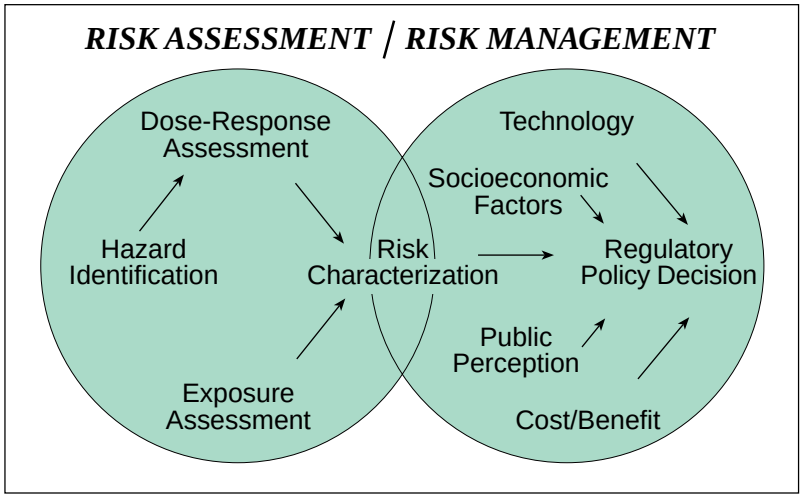
The first area, **effects research**, considers questions about pollutants in the environment and whether they cause harm. Methods are developed for use by EPA and others to detect those pollutants that have the capacity to cause a variety of health and ecological effects. Studies are conducted or analyzed to determine how much of a pollutant can cause those effects.

The next area, **exposure assessment**, determines what pollutants are in the environment, at what levels, where they go, and what happens along the way.

The third area, **risk assessment**, integrates information from the first two areas of research to estimate the likelihood and magnitude of impact from pollutants. Research also develops methods and models to reduce uncertainties in the risk assessment process.

The fourth area, **risk management**, determines the alternative solutions and associated costs. Activities include development of industrial processes that prevent pollution. A significant percentage of the Agency's resources have funded research to reduce risks, particularly from air and water pollution. Finally, independently and in collaboration with others, the Agency develops technology for cleaning up past environmental damage such as that found at waste sites and protecting the environment from pollutants being released today.

This report illustrates the kind of science questions ORD researches in each of the four categories and highlights accomplishments from fiscal year 1994.



The risk paradigm shows the relationship of each component of the risk assessment process and how each contributes to regulatory and policy decisions.

Effects

Research about the effects of pollutants on humans and ecosystems includes hazard identification and dose-response assessment. Hazard identification involves gathering and evaluating data about the types of health problems or diseases (e.g., cancer) that affect humans or the impacts on ecosystems that can be caused by a chemical or a pollutant.

Dose-response research addresses questions about how much of a chemical humans or plant and animal species have to be exposed to before they are affected and what is the type and magnitude of the effect. Notable effects research in FY 1994 includes the following:

Sulfate Effects Data for Revised Drinking Water Standard

EPA is reevaluating the current standard for sulfate levels in drinking water. Data on sulfate, which can cause diarrhea in children and adults, were available only from reports of individual cases. To fill the data gap, EPA's Health Effects Research Laboratory in Research Triangle Park (RTP), North Carolina, conducted animal and human studies to determine the dose at which effects would be seen for both infants and adults. ORD has been able to provide hard data on what doses produce adverse effects for judging the adequacy of the current standard.

Methanol Health Effects for Decisions on Fuel Additives

Scientists at EPA's Health Effects Laboratory in RTP, North Carolina, continued studying the health effects from exposure to methanol. Mouse studies are producing information on birth defects caused by methanol exposure as well as the dose and duration of exposure that causes defects. Findings have been published in journals, and future work in this area will address the similarities of methanol sensitivity between mice and humans in order to improve the scientific basis of conclusions about human effects drawn from mouse studies.

New Methods Promise Faster Toxicity Tests

ORD researchers at EPA's laboratory in Gulf Breeze, Florida, developed and validated a technique that promises to give scientists a faster, less costly way to identify chronic toxic effects from water pollutants. The method extrapolates chronic effects from acute effects, and could reduce from 28 days to two days the time needed for

A research biologist examines negatives of DNA as detected in rodent cells after exposure to pollutants.

assessing long-term health effects of pesticides and metals in runoff from agricultural and urban areas.

ORD revised and updated the manuals used as the basic technical guides by government and industry in testing discharges from sewers, holding tanks, and other sources to ensure that the amounts of potentially toxic materials released into streams, rivers, and estuaries stay within safe limits for fish and other marine life. ORD also developed a new generation of computer software to make it easier and faster for users to analyze data from the tests. Companies, cities, and states all across the U.S. rely on the sound, standardized results of these tests for seeking and granting permits under fundamental federal and state rules.

Health Concerns About Carpets Clarified

Scientists at EPA's Health Effects Research Laboratory in RTP, North Carolina, completed a study that has filled a critical data gap in our understanding of the health effects of carpet emissions. A commercial animal-testing facility produced a study that linked exposure to carpet emissions to serious heart and nervous system conditions and even death. However, ORD researchers could not replicate the reported test results and concluded that the facility's methodology was valid for testing for irritation effects but not for evaluating serious health effects. ORD's study has been used by judges when ruling on the use of animal tests in court cases where consumers are suing carpet manufacturers for alleged serious health problems.

EMAP Measures Ecological Conditions Across the Country

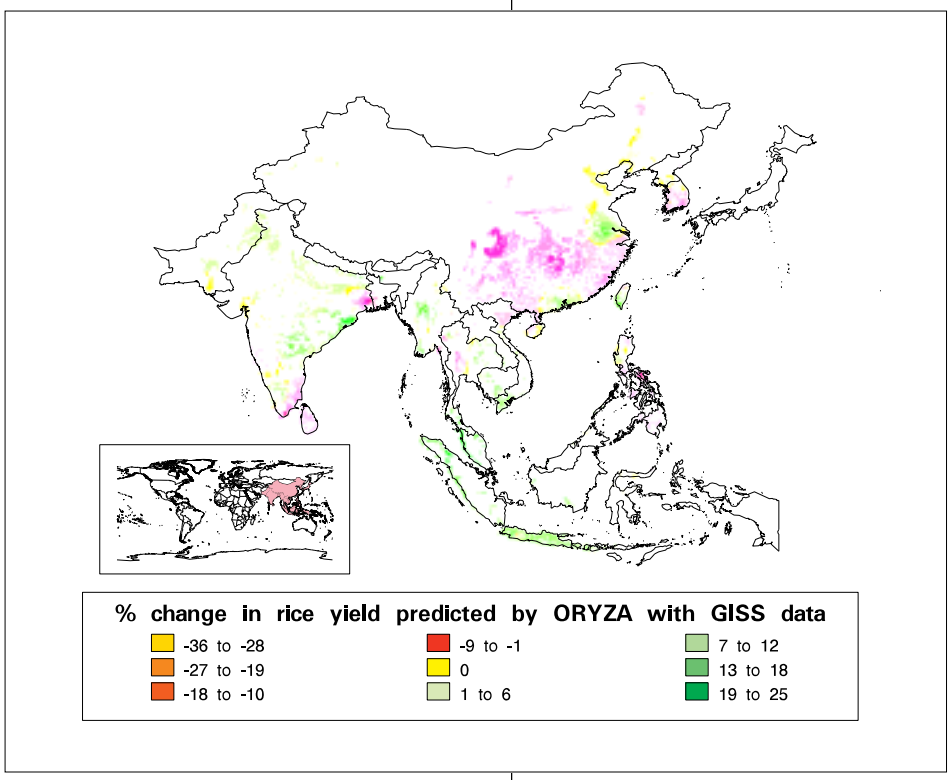
The Environmental Monitoring and Assessment Program (EMAP) is an applied monitoring and assessment program designed to describe the condition of our nation's ecological resources. In FY1994, an Arctic EMAP Program has been established with the State of Alaska to study arctic environmental contamination and train Russian scientists in EMAP approaches. EMAP also has generated data for describing the conditions of Northeastern lakes and evaluating effects from acid deposition. Under EMAP estuaries research, scientists have designed long-term monitoring plans, collected environmental samples, and conducted statistical analyses for the Chesapeake Bay, the Gulf of Mexico, Puget Sound, Long Island Sound, Delaware Bay, Tampa Bay, Sarasota Bay, Galveston Bay, Corpus Christi Bay, and Santa Monica Bay.

Global Change Research

The possibility of global change raises many scientific questions about the effects of climate change on activities such as farming, the decrease in the capacity of the ozone layer to shield the earth from ultraviolet radiation, and the health and ecosystem effects of increased exposure to ultraviolet radiation.

Nationally and internationally, ORD is studying the impact of farming, conservation, and other land uses on global climate change and, conversely, the impact of climate changes on agricultural resources. For example, an ORD study of the practice of leaving crop residue such as corn stalks on the ground to prevent soil erosion found that the practice also holds carbon in the soil, which helps reduce atmospheric levels of greenhouse gases. By quantifying this carbon retention, and extrapolating carbon levels that would be retained by alternative practices, ORD has reduced uncertainties about the role of harvested fields in global change equations.

Potential rice yield changes predicted by computer model.



As part of a multi-year study to understand how ultraviolet radiation makes people more susceptible to different kinds of infections, ORD's Health Effects Research Laboratory identified a strain of laboratory mice that has similar mechanisms of immune system suppression as those found in people. Consequently, laboratory studies using these mice may be a faster, less expensive way than human epidemiological studies for determining whether increased levels of UV-B pose a risk to the human immune system.

Exposure

Research to understand what pollutants are released into the environment, where they go in the environment, and what happens to them along the way is the focus of EPA's exposure research. Notable efforts in FY 1994 include:

"Living Room" Lab Measures Indoor Pollution

At its laboratories in RTP, North Carolina, ORD has built a room-sized laboratory chamber (one of only four in the world) to study and define emissions from paint, fabrics, furnishings, and other items typically found inside offices and houses. Using precise, sophisticated equipment, ORD simulates typical indoor exposures to pollutants under varying temperatures, humidity, and air flows, and then measures the environmental levels of contaminants under those conditions. These findings significantly reduce the uncertainty associated with complex, often subtle exposures to indoor air pollution, providing government, industry, and others with sound data for making well-reasoned decisions. Among further benefits, the chamber can be used by the private sector to test emissions from new products under real conditions, can be used to standardize testing procedures (thereby reducing confusion and promoting consistent data), and can be used to demonstrate the effectiveness of air cleaning devices.

Effects of Wind Borne Pesticides Studied

Scientists at ORD's Environmental Research Laboratory in Athens, Georgia, formed a government/industry consortium to evaluate the environmental problems caused by sprayed pesticides that drift on the wind into nearby fields, lakes, and streams. By linking industry data, EPA's exposure models, and U.S. Department of Agriculture's field studies, the consortium will develop a validated assessment tool to evaluate the risk of offsite drift, identify the right parameters for measuring pesticide drift, and estimate the amount of drift under different conditions. This consortium will help develop methods for evaluating the potential risks from pesticide spraying.

Photo by S.C. Delaney / U.S. EPA

New Technique Identifies Ozonation Byproducts

Responding to concerns that chlorination may create potentially harmful by-products when it reacts with certain kinds of organic matter in drinking water, ORD scientists have led research to evaluate ozonation as an alternative treatment to reduce the amount of chlorine needed for disinfection. In FY94, ORD also pioneered the development of new analytical methods that will help scientists assess whether ozonation itself creates by-products that would be of equal or greater concern. Applying specialized expertise, ORD researchers combined two techniques, mass spectroscopy and infrared spectroscopy, to identify for the first time some 20 different ozonation by-products in water containing high natural concentrations of bromide. The ORD findings, developed in collaboration with the University of North Carolina, also provide new insight into the complex processes that create the by-products.

ORD Tests Methods for National Human Exposure Study

In FY94, ORD signed agreements with three research consortia as a first step in launching the National Human Exposure Assessment Study (NHEXAS), a long-term "report card" that for the first time will give decision-makers consistent, nationwide information on human exposure to pollutants. Under the agreements, the consortias of universities and other not-for-profit research organizations are testing the concepts, methods, and approaches that are proposed for the long-term study. These pilot studies will provide sound building blocks for the innovative long-term effort.

Model Predicts Natural Sources of Smog

The atmospheric chemistry models that cities and regions currently use to estimate smog levels and to demonstrate attainment of the ozone standard include estimates of how much natural sources can contribute to these levels. Isoprene from trees, for example, reacts very quickly with other chemicals in the air to form smog. Scientists at

Atlanta skyline.

EPA's Air and Energy Engineering Laboratory and the Atmospheric Research and Exposure Assessment Laboratory in RTP, North Carolina, have developed a new model for estimating emissions from natural sources. The model, tested in Atlanta where there is light industry but large surrounding forests, predicted emissions that more closely matched measured concentrations. Because emissions from natural sources contribute significantly to ozone formation, they have to be factored into any strategy for meeting the ozone standard. This improved model will contribute to more cost-effective and realistic strategies for fighting smog.

Risk Assessment

To assess the risks of environmental contaminants, ORD scientists integrate the results and data from exposure and effects studies conducted in-house and by other public and private science organizations. However, the gaps in our knowledge result in uncertainties in the risk assessments. Scientists in ORD's research program address these knowledge gaps in both human health and ecosystem effects and develop the risk assessments that are then incorporated into Agency decisions.

Dioxin Reassessment Focuses Attention on Noncancer Effects

Scientists with EPA's Office of Health and Environmental Assessment and the Health Effects Research Laboratory in RTP, North Carolina, completed the external review drafts of EPA's reassessment of dioxin, which include research results on dioxin's noncancer effects on the immune, reproductive, and neurological systems. These drafts, the results of a 3-year effort, reaffirm the link between dioxin and cancer and conclude that dioxin exposure at some level may result in a number of noncancer health effects in humans. The reassessment also identifies sources of dioxin known to contribute to environmental contamination.

New Fuel Additives Raise Questions of Health Effects

Recent legislation encourages the development and use of reformulated gasolines and alternative fuels. ORD's program in this area evaluates additives or alternative fuels for their health effects. In FY1994, ORD conducted research and risk assessments as a result of questions raised by the State of Alaska and others about the health effects of MTBE, a gasoline additive that helps reduce carbon monoxide and the hydrocarbons that form ozone. ORD organized a joint

government-industry research program for a health risk assessment. Based on the uncertainties identified in the assessment, ORD is continuing research and assessment of MTBE and other compounds.

Extensive Health Effects Research Included in Assessment of Ozone

ORD research conducted in the past several years on the human health effects of ozone shows that exposure to ozone at concentrations below the current standard can cause significant pulmonary dysfunction—difficult breathing, coughing, and chest pain. Pulmonary dysfunction can occur even after exposure for only several hours and, appears to have long lasting effects. Research findings have been reported in 30 journal articles in FY1994 and ORD scientists contributed significantly to the Agency's consideration of revising the current standard. In addition, scientists from EPA's Health Effects Research Laboratory in RTP, North Carolina, recently authored the World Health Organization's Guidelines for Ozone.

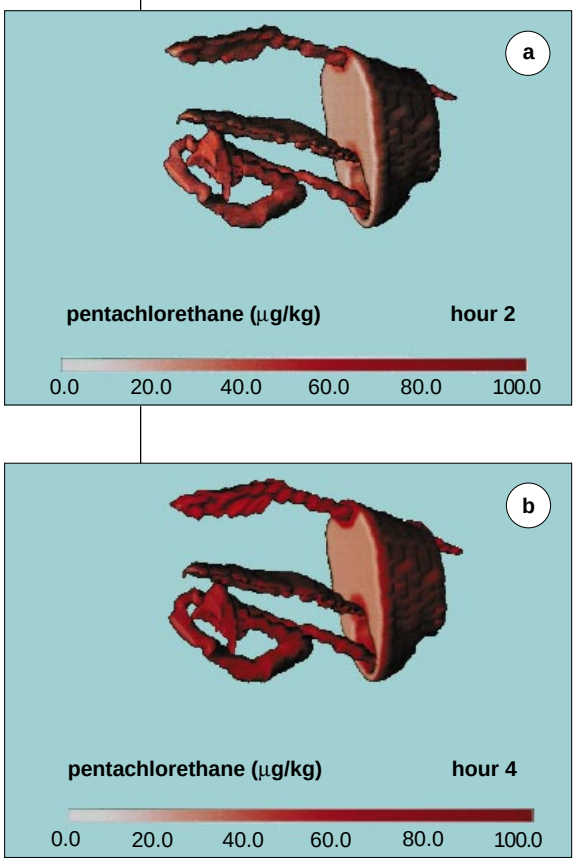
Advances in Ecological Assessment

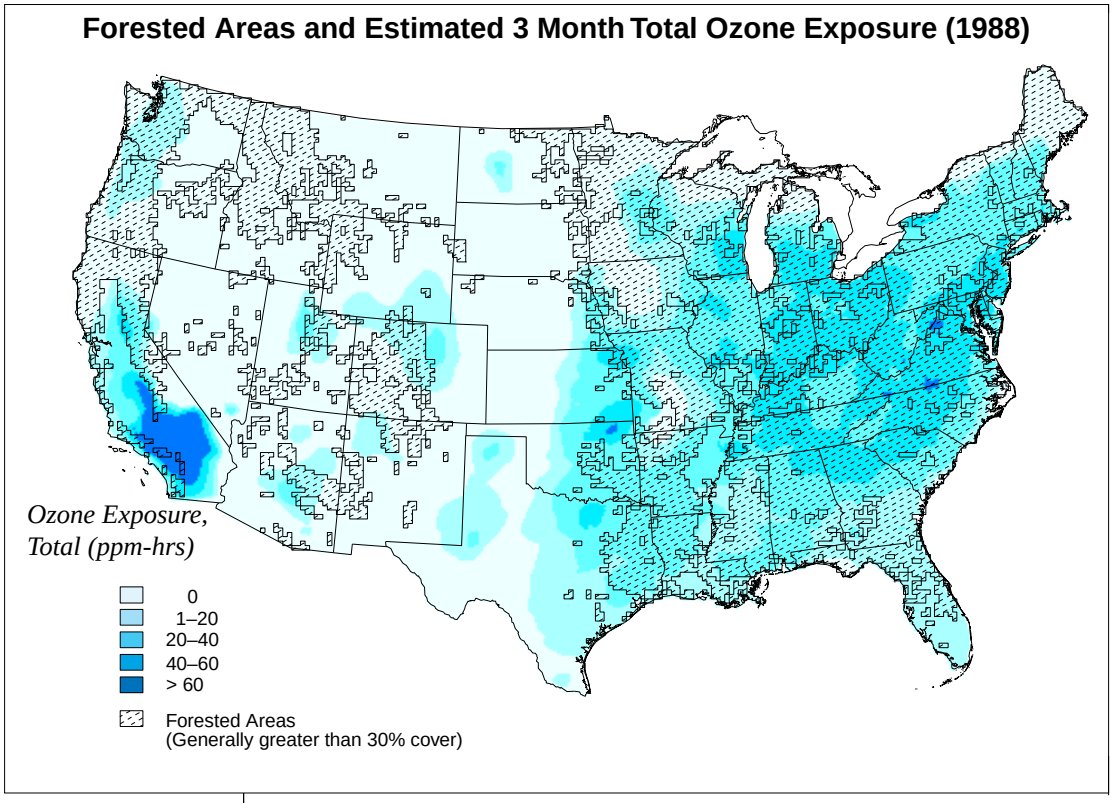
Risks to ecosystems from pollution are also important to understand and characterize. Changes to ecosystems can affect the condition and quantity of our natural resources, food production and supplies, and nature's ability to "heal itself" or recover from negative environmental effects. Highlights from EPA's FY1994 research in "ecorisk assessment" include the following developments:

Scientists at EPA's Environmental Research Laboratory in Duluth, Minnesota, have developed 3-D computer technology that simulates the accumulation of chemicals in fish. The 3-D technique explains relatively sophisticated principles of chemical accumulation and species extrapolation in an easily understood way. This project can be applied to all areas of toxicology and risk assessment that use models to describe how chemicals accumulate in organisms.

At EPA's Environmental Research Laboratory in Corvallis, Oregon, scientists completed an interim assessment of risk to forests from ozone. This

These 3-D computer-generated graphics show chemical accumulation in fish at 2-hour (a) and 4-hour (b) exposures. The chemical accumulation after 4 hours is shown, in descending order, by the bright red hue of the fat layer, the kidney, the intestines, and the liver.





Ozone exposure to forested areas estimated for a three month period in 1988.

program, which assesses impacts of ozone on natural resources, has examined 11 ecologically and economically important tree species in studies at sites across the country. This research provided significant information on the effects of ozone on trees for the Agency's 1995 Draft Criteria Document. Quantification of ozone effects on forests is needed to address the requirements of the Clean Air Act.

For the first time, important exposure data for performing ecological risk assessments has been summarized. Scientists with EPA's Office of Health and Environmental Assessment in Washington, D.C., developed the *Wildlife Exposure Factors Handbook*, a compendium of data on 30 species of birds, mammals, amphibians, and reptiles. The data, which includes body weights, ingestion rates, inhalation rates, diets, and home range sizes, is combined with toxicity data to conduct ecological risk assessments at contaminated waste sites or to support chemical criteria for wildlife.

Risk Assessment Landmarks

Risk assessment is a constantly evolving science. ORD is in the forefront of the research that seeks to reduce uncertainties of risk assessment by continually refining the methods and

data which support Agency-wide risk assessments and guidelines for conducting risk assessments. The guidelines, which are peer-reviewed by the wider scientific community, represent ORD's contributions to the "state of the science" of risk assessment. In FY1994, ORD contributed to the following :

Guidelines for Reproductive Toxicity Risk Assessment were proposed and reviewed by EPA's Science Advisory Board. These guidelines represent the first effort by any federal or state agency, nation, or international organization to provide guidance for interpreting, analyzing, and using data from studies on a variety of male and female reproductive effects. Cancer Risk Assessment Guidelines were revised and peer reviewed at a public workshop. Last published in 1986, the guidelines have been revised to incorporate the latest scientific thinking in the field and to build upon the experience gained in using the previous guidelines for the last eight years. These guidelines will be ready for public comment in FY1995.

With the 1992 *Framework for Ecological Risk Assessment*, ORD began developing Agency-wide guidance for improving the consistency and quality of ecological risk assessments. In FY1994, ORD published *A Review of Ecological Case Studies from a Risk Assessment Perspective* Volume 2. This report contains 17 peer reviewed case studies that evaluate ecological assessments of Agency activities such as pesticides and Superfund assessments and nine issue papers that explore topics of the ecological risk assessment process ranging from model development and characterization of effects to risk integration methods and ecological significance. Together, the case studies and issue papers will help provide the scientific basis for the development of the first Agency-wide ecological risk assessment guideline.

An EPA helicopter crew samples water for acidity.

Risk Management

Research and development in the risk management area covers prevention, reduction, and remediation activities that ORD conducts in its own laboratories and through agreements with public and private sector partners. The accomplishments for FY1994 reflect a wide range of activity.

U.S. Navy Considers CFC Replacements Identified by EPA

EPA's Air and Energy Engineering Research Laboratory in RTP, North Carolina, is conducting research to find chemicals that can be used to replace ozone-depleting refrigerants, chlorofluorocarbons (CFCs). Two of the replacements identified by the laboratory are being considered by the Navy for use in shipboard chillers. The substitute could save $500 million in retrofit and replacement costs and help timely phaseout of the CFC currently used. The Navy will make its final decision on a replacement chemical in 1995.

Particulate Matter Five-Year Research Strategy

ORD completed a strategy for research to support the Agency's court-ordered deadline to review the Particulate Matter National Ambient Air Quality Standard (NAAQS). The strategy outlines the policy and scientific issues and the research questions that must be addressed and it ranks the needed research. EPA program offices, industry, academia, environmental groups, other federal agencies, and states have had an opportunity to review and comment on this document. This document will guide EPA's research efforts for the next five years.

NARSTO Focuses Tropospheric Ozone Research

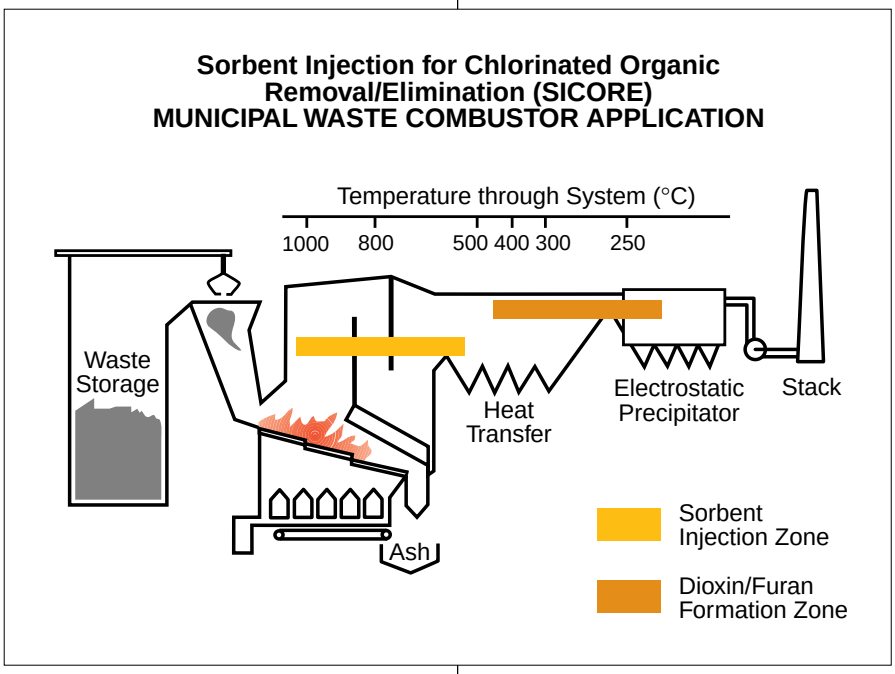
In response to the 1990 Clean Air Act Amendments and a 1991 National Academy of Sciences report calling for a national program of tropospheric ozone research, ORD scientists and stakeholders in the public and private sectors developed the North American Research Strategy for Tropospheric Ozone (NARSTO). The strategy established agreement to focus research on understanding the sources of emissions that effect the ozone level in the air we breathe and to coordinate research activities throughout North America. Coordination is important because there has been duplication of research across different regions of the country with serious nonattainment problems. These regions have had to reinvent measures, modeling, and emission categories. A charter outlining activities and partici-

pants was signed in February 1995 by EPA, other federal agencies, states, universities, and major industry organizations.

New Process Prevents Dioxin Formation During Waste Combustion

With pilot-scale testing completed, ORD is ready to identify a commercial partner to demonstrate its patented process for preventing the formation of dioxin and furan from burning waste. Approximately 75% of the 250 existing incinerators covered by EPA's regulations could be retrofitted cheaply with the technology called Sorbent Injection for Chlorinated Organic Removal/Elimination (SICORE). Efforts are underway to license the technology to a commercial partner interested in a demonstration project.

The SICORE process prevents dioxin from forming by reducing the amount of HCl available to form dioxin.



Water Weeds Clean Munitions Contamination

An experimental process developed by scientists at EPA's Environmental Research Laboratory in Athens, Georgia, uses common pond weeds to break down TNT, chlorinated solvents, and several other chemicals found at old munitions sites. The plants, which include stonewort, hornwort, and parrot feather, contain enzymes that initiate a chain reaction that breaks down the TNT molecule into biodegradable material. An EPA patent of the process is pending and field testing is scheduled for the spring at a closed Army munitions plant.

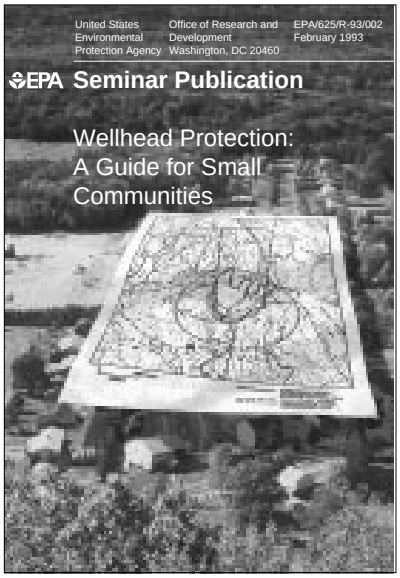
Technical Support for Agency Activities

ORD's research program supports the Agency's activities and provides site-specific technical assistance and technology transfer to state and local governments. For example, in FY94 scientists at EPA's laboratory in Ada, Oklahoma, and the Exposure Assessment Group in Washington, D.C., provided technical support and review of the Soil Screening Level

Guidance being developed by the Office of Solid Waste and Emergency Response. The guidance is a tool for site managers to streamline the Remedial Investigation/Feasibility Study process for Superfund sites.

ORD's Technical Support Center (TSC) in Ada, Oklahoma, provides the latest scientific information about the movement and fate of contaminants in the soil and groundwater at hazardous waste sites. TSC scientists and engineers advise on a range of questions about site characterizations, treatability studies, remediation designs, and cleanup levels. By the end of FY1994, TSC staff have provided assistance for almost 700 requests at over 400 Superfund and RCRA sites across the country. The data gathered through the years in the course of providing technical assistance have become a tremendous information resource for site cleanup managers looking for background on contaminants and remediation strategies that work.

Scientists at EPA's Environmental Monitoring Laboratory in Cincinnati, Ohio, developed a more sensitive method for measuring sewage contamination of drinking water. They also completed a survey of groundwater systems for enteric viruses that provides an indication of the nature and magnitude of viral contamination of vulnerable drinking water wells. EPA lacked virus occurrence data to support a regulatory level for virus inactivation in public groundwater systems.



EPA's Center for Environmental Research Information (CERI) in Cincinnati, Ohio, published a document for small communities on adapting alternative treatment technologies for smaller systems. Small communities are participating in ORD studies to evaluate treatment technologies. Results to date indicate that small systems can upgrade drinking water quality at a reasonable cost. CERI also published a handbook on groundwater and wellhead protection for delineating the boundaries of a wellhead protection area, identifying and evaluating potential contaminants and wellhead management options.

Innovations for Solving Environmental Problems

ORD develops and evaluates promising pollution prevention, pollution control and remediation technologies, as well as the monitoring devices and techniques that validate the results of technologies. In addition to in-house research, there are a number of programs that harness the resources and expertise of scientists and researchers in academia, other federal research

organizations and the private sector.
One such program, the Superfund Innovative Technology Evaluation (SITE) Program, begins its tenth year with 72 technologies in the developmental program and 115 technologies in the demonstration program. Through 1994, 69 field demonstrations and 38 developmental projects have been conducted. Many developers completing SITE projects credit their participation in SITE as integral to the success of their companies. A recent assessment of site remediation costs by four EPA regional offices shows that using SITE technology saved $358 million over the projected costs of conventional remediation.

Approximately 16 tons of contaminated soil were treated at this SITE demonstration project.

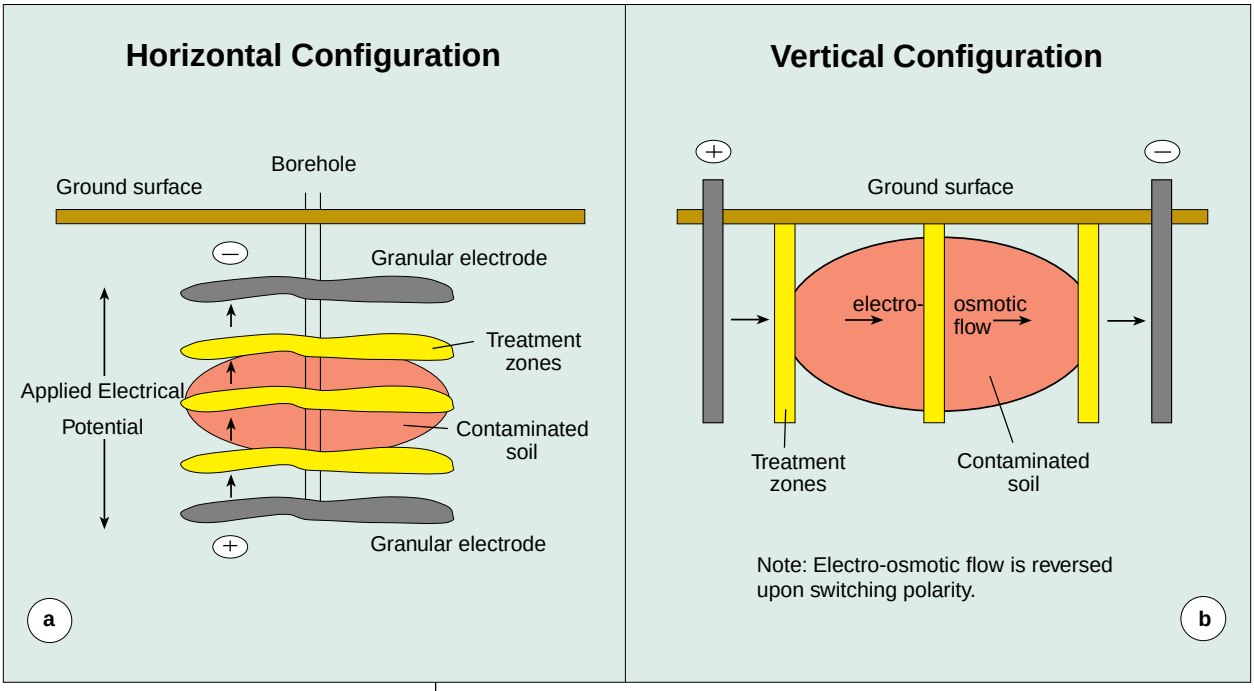
Since 1982, the Small Business Innovative Research (SBIR) Program has funded research in EPA program areas that could lead to significant opportunities and public benefits if the research is successful. Examples of success stories include:

National Recovery Technologies, Inc., developed a technology for sorting PVC plastics from recycle collections. NRT has grown from three people in 1981 to 30 in 1994.

RMC Group produced a pallet made of 100 percent recycled plastics from a range of resin types, including 50 percent post-consumer plastics. Currently they manufacture 400 pallets per week and expect to make 2000 per week by July 1995.

With 11 new Cooperative Research and Development Agreements (CRADAs) and 5 new licensing agreements in FY 1994, EPA has a total of 60 Federal Technology Transfer Act (FTTA) agreements and licensing agreements. Noteworthy agreements signed in FY1994 include:

The “Lasagna CRADA,” an agreement with Monsanto, DuPont, and General Electric to develop and field test new technologies for treating dense, clay-like soil at hazardous waste sites. Dubbed the “lasagna” process, it uses an electric



Horizontal (a) and vertical (b) configurations of the "Lasagna" hazardous waste treatment process. Flow reversal allows multiple passes of the contaminants through the treatment zones.

field to draw waste into layered areas called treatment zones. Once layered, the two wastes can be treated completely in place. This process promises to be more cost-effective than traditional cleanup methods.

Two licensing agreements with ETG Environmental, Inc., and Soil Tech ATP Systems, Inc., are marketing an EPA patented technology for cleaning up chlorinated chemical wastes. The technology, base catalyzed decomposition, involves adding a common base such as baking soda to the contaminated material and then heating the mixture. The process turns the toxic contaminants into non-hazardous materials.