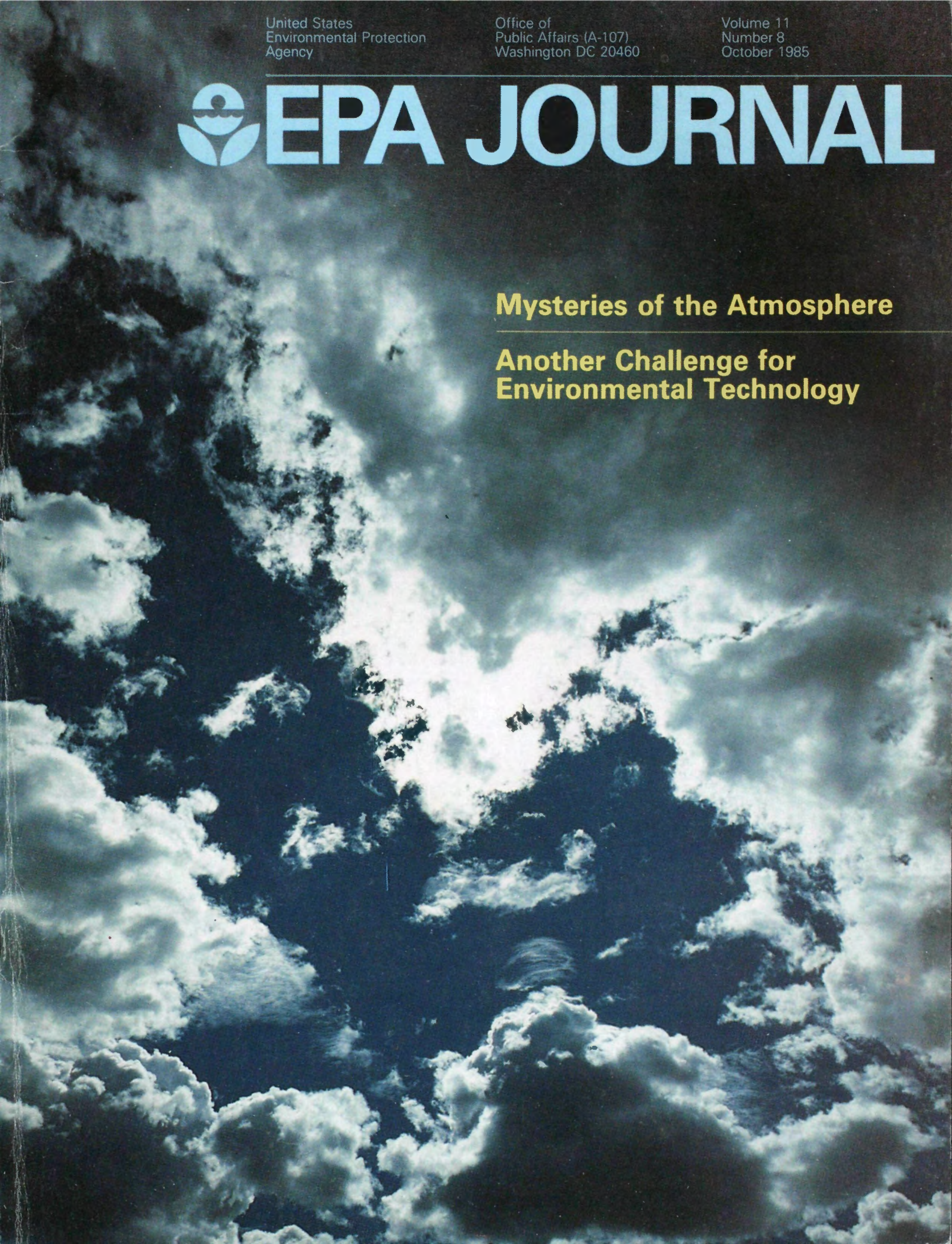
United States
Environmental Protection
Agency

Office of
Public Affairs (A-107)
Washington DC 20460

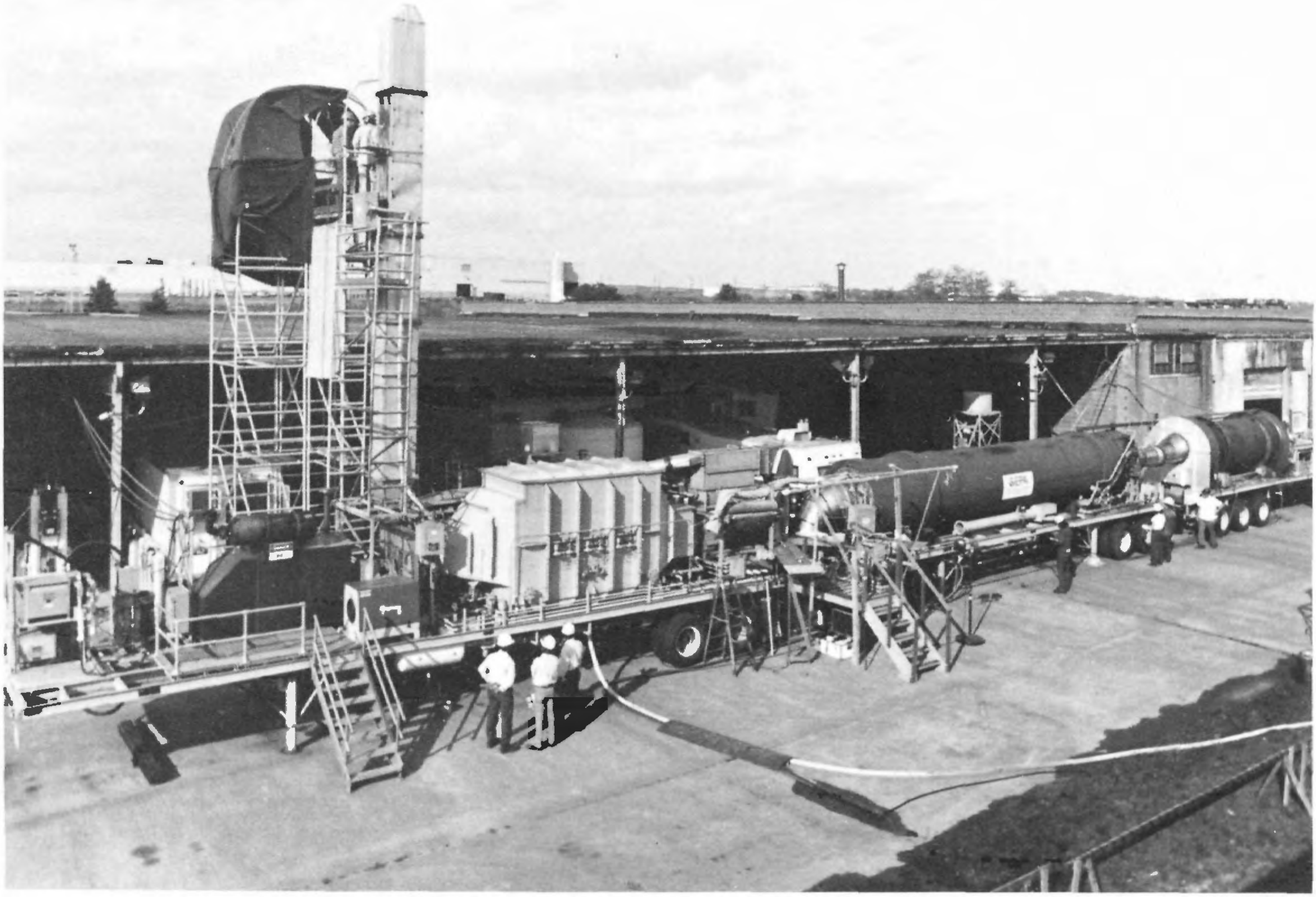
Volume 11
Number 8
October 1985

# EPA JOURNAL



## Mysteries of the Atmosphere

## Another Challenge for Environmental Technology



*EPA's mobile incinerator in operation during a 1982 trial burn in Edison, N.J. The incinerator's success demonstrates how technology can help clean up the environment.* *(See story on page 17.)*

# Technology and the Environment

Behind the cleanup of the environment stands a powerful workhorse—technology. This issue of the *EPA Journal* examines technology's role.

EPA Administrator Lee M. Thomas sets a perspective, explaining how science and engineering are evolving rapidly in support of cleanup measures.

A new research frontier at EPA is featured in a piece explaining how the everyday world is being used as a testing site to advance environmental understanding.

Other articles describe the current technological effort to clean up coal, developments in techniques to deal with hazardous waste, and modern approaches in municipal wastewater treatment.

Congressman James H. Scheuer explores the changing relationship between technology and the environment. Scheuer is Chairman of the House Subcommittee on Natural Resources, Agriculture Research and Environment.

Also discussed in this issue are the recent success of EPA's mobile incinerator—the Blue Goose—in destroying dioxin, and EPA's use of an airborne laser system to help solve air pollution problems. From EPA's Environmental Research Laboratory at Corvallis, Ore., comes a report on an innovative use of computers.

In other stories, a feature describes how the New England states have gotten together to stop evasion of hazardous waste disposal rules. A new approach to dealing with nonpoint-source water pollution is reported. An article explains what scientists know about the mechanisms that cause cancer.

A photo essay features a recent dive by EPA scientists in a submersible. The divers revisited an old dump site for low-level radioactive waste in the Pacific Ocean, 40 miles off the California coast.

The issue concludes with two regular features—Update and Appointments. □

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# EPA JOURNAL



EPA is charged by Congress to protect the nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

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*Front Cover: Sun behind clouds. (See story on page 18 regarding EPA's air pollution research with laser beams.)*

*Design Credits: Robert Flanagan; Ron Farrah.*

# Solving Tough Environmental Problems

by Lee M. Thomas

It wasn't too long ago that the American environment seemed beyond repair. Downtown, the air was so thick with smog that you couldn't see through it. The rivers were cesspools of floating sewage. Junk piles were proliferating all over the landscape. Pesticides were killing off irreplaceable wildlife, and toxic substances in minute but dangerous amounts could not be properly monitored, let alone managed.

Now, 15 years after the founding of EPA, conditions are much better. We have a long way to go before our surroundings become as clean and safe and healthy as we know how to make them, but we are on the road to recovery. The public is solidly behind the idea of scientific environmental management.

*The public is solidly behind the idea of scientific environmental management.*

Look how far we've come. Despite substantial increases in population and economic activity, despite millions more cars on the road, despite the continuing spread of exurban and recreational communities, we have seen steady progress in our efforts to combat surface-water pollution. The fish have returned to countless lakes and streams, and thousands of miles of once-contaminated rivers are open to swimmers. The changes in the urban atmosphere are even more obvious—the levels of almost all of the major pollutants have dropped, many dramatically, during the last decade and a half.

These advances have been possible because of EPA's strict enforcement of environmental laws passed during the 1970s. However, EPA programs don't work in a vacuum; behind them lies a largely untold story of rapidly evolving science and engineering. Without EPA's health and environmental research, sophisticated monitoring techniques, and new control technologies, we could not have accomplished as much in protecting the health and heritage of the American people. Our own findings are, of course, amplified by the work of academicians, environmentalists, and industrial laboratories.

To take one example of our progress, the widespread installation and gradual refinement of flue-gas scrubbers for industrial and utility smokestacks helped cut ambient sulfur dioxide 36 percent from 1975 to 1983. Nitrogen dioxide has come down more slowly, but studies indicate that we may be able to do better with computer-controlled improvements in combustion techniques. Meanwhile, stacks have become less smokey in general due to the installation of precipitators and baghouses; particulates dropped 20 percent from 1975 to 1983.

*We must also look to science for the ultimate solution to the hazardous waste problem.*

Automobiles pose a far less serious problem today because of the introduction of the catalytic converter in the mid-1970s. Complementing these engineered systems, by January 1, 1986, we will have removed by regulation more than 90 percent of the lead formerly used in gasoline.

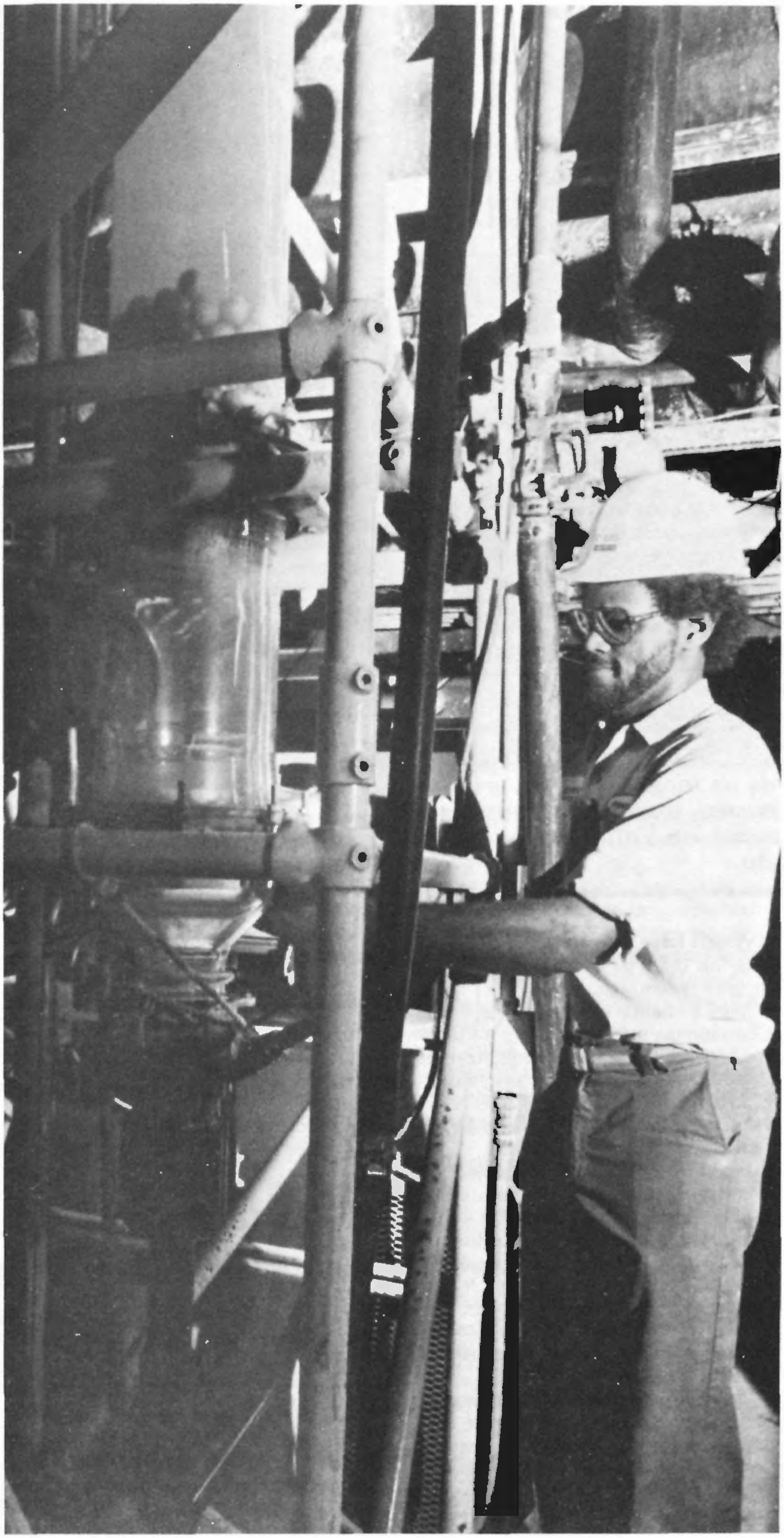
The nation's rivers have been a special challenge because of the volume and extraordinary variety of substances dumped into them from tens of thousands of sources. Conventional wastewater treatment technology has always relied upon screening, settling, aeration, and chlorination to skim off solids, clarify the water, and kill infectious bacteria. But that is no longer enough; EPA must regulate the toxic compounds entering the nation's waterways and aquifers as well. Intensive research is under way to identify and quantify toxics so we can tighten our control measures.

We must also look to science for the ultimate solution to the hazardous waste problem. Most communities are running out of places to dispose of these wastes, and under the 1984 amendments to the Resource Conservation and Recovery Act, they can no longer simply be dumped, not even in controlled landfills. Ironically, some wastes are generated by systems installed to prevent pollution of air and water. So we are looking for breakthroughs in safe, high-temperature incineration, chemical treatment, and natural or genetically engineered bacteria that can digest toxics and excrete them in harmless form. Initial signs are highly encouraging.

It goes without saying, however, that studying pollutants individually, though necessary, is hardly sufficient. We need to analyze entire metropolitan regions over long periods to determine how pollutants interact and how various strategies can minimize their impact. Philadelphia and Baltimore have pioneered in such research. Now Chattanooga, Tenn., is working with us to establish a baseline for the major contaminants so we can follow them over a number of years. The city and its suburbs will be a living laboratory for an integrated study of social, biological, and physical aspects of pollution in all its complex forms. (See story on page 4).

Environmental research is nothing if not multi-disciplinary. It examines everything from the fate of a small biological community to the fluctuation

*(Thomas is Administrator of EPA.)*



*At EPA's Air and Energy Engineering Research Lab in North Carolina, contract engineer Reggie Powell operates a wet scrubber pilot system. The system uses a mixture of water and limestone to remove sulfur dioxide from flue gases resulting from coal combustion. Technology developed in the lab and adapted by industry helps limit gaseous pollutants in the environment.*

of climate. EPA scientists study how pollutants are transported and chemically transformed in air, soil, and water; sometimes dispersed and sometimes concentrated by industrial, urban, agricultural, or purely natural processes. Such observations determine who and what is exposed to danger,

***We know much more about how the environment works as a total biophysical system than we did 15 years ago.***

how intensively, and how long. With the facts in hand, we can then work out appropriate remedies.

We know much more about how the environment works as a total biophysical system than we did 15 years ago. EPA scientists have been in the forefront of this historic effort, both in the lab and in the field. Indeed, environmental research is one of the best examples of American leadership in world science generally. In applied environmental engineering we are, on the whole, far ahead of other industrial nations. Yankee ingenuity is not only not dead, it's alive and well. It is solving tough problems and, not coincidentally, creating hundreds of thousands of jobs.

We still have a long way to go before the picture is complete, but in the course of the next decade or two we may learn enough to design a system of environmental management that is less reactive and more proactive than any possible today. That, in turn, would permit major advances in the protection of human health and the preservation of resources. From my vantage point, the prospects seem highly favorable, and we in EPA are anxious to get on with the job. □

# Charting New Research Frontiers in Chattanooga

Aerial view of Chattanooga. Lookout Mountain is in the background.

by Jack Lewis

Most people think of scientific testing as something very far removed from everyday life. They picture a scientist performing arcane experiments in a laboratory filled with test tubes and beakers.

But what if the everyday world were to become a lab? That is precisely what is happening in Chattanooga, Tenn. EPA has chosen this city from among 56 candidates to become the nation's first Environmental Methods Testing Site (EMTS).

This is not the first time a city has served as a site for environmental testing. What makes Chattanooga—and EMTS—unique is the duration of testing EPA has in mind, and the unprecedented foundation of basic data that will be gathered before testing begins.

For at least 10 years, and possibly as long as 15, Chattanooga will be the scene of a series of experiments, each one adding another vital link to our understanding of the environment.

Before experimentation begins, large quantities of data will be gathered to "characterize" the Chattanooga site. Scientists need such benchmark data before they can set up their field tests, and gathering it takes both time and money.

The EMTS will offer scientists a set of site characterization data unsurpassed in the United States. Having exact data on pollutant loadings will do more than save scientists time and money. It will also improve the design of field tests by indicating:

- How much new data should be gathered by projected field tests.
- Whether computer mapping procedures can be constructed to predict the best locations for field testing.
- What statements about exposure can be made on the basis of the data collected.

(Lewis is Assistant Editor of the EPA Journal.)

Improved experimental design will enhance the quality of field testing methods and procedures. A fixed location for experiments will also lead to greater consistency.

All the experimental advantages the EMTS offers are certain to improve EPA's understanding of the best means of monitoring human exposure to toxic substances. The Toxic Substances Control Act of 1976 charges EPA with developing and improving methods for monitoring such exposure. The agency's Office of Toxic Substances—in conjunction with the Office of Research and Development—decided that selecting and characterizing a single research site would greatly advance that mission.

*Chattanooga's biggest edge was its inclusion in a veritable treasure trove of computerized Tennessee Valley Authority data.*

EPA will have priority access to the EMTS, but other government agencies—federal, state, and local—will also have a chance to conduct field tests in Chattanooga once the site is initially characterized. One outside organization has already been assured access to the EMTS: the United Nations. The U.N. Environment Program and World Health Organization's Human Exposure Assessment Location (HEAL) project will be conducted in Chattanooga by EPA. The Chattanooga HEAL site will be one of only four such sites in the world.

What factors have made Chattanooga the focus for such intense scientific research? EPA's EMTS Project Coordinator Robert Jungers emphasizes that Chattanooga was not selected as any "dirty city showcase." Far from it, in fact. Although Chattanooga once had severe pollution problems, in recent years the city has made commendable progress on all environmental fronts. Chattanooga does have measurable pollutant loadings of the type scientists need to study, but other American cities have them, too.

The main reasons for Chattanooga's selection were altogether positive:

- A dynamic economy: Although still heavily industrialized, Chattanooga is forging a new economic position as a major distribution center in the Southeast. As EMTS Steering Committee Chair Michael Dellarco puts it, Chattanooga is making "an ambitious and coordinated effort to improve its economy and quality of life."
- Good location: Chattanooga's relative isolation from other major population centers makes it easier to get measurements specific to the city. That isolation does not cause inconvenience. Transportation in and out of the city is excellent.
- A strong public health network at the county level: Hamilton County, home county of Chattanooga, has done its own air pollution monitoring since the 1920s. The county also gained experience as a site for EPA field testing in the 1970s when the agency was studying nitrogen oxides as part of the Community Health and Environmental Surveillance System program.
- Support facilities: EMTS experiments can draw on the skills of commercial engineers and technicians in Chattanooga as well as those of academic experts at the University of Tennessee's Chattanooga campus.

And last but not least:

- Available data: Chattanooga's biggest edge over its competitors was its inclusion in a veritable treasure trove of computerized Tennessee Valley Authority (TVA) data. EPA estimates that the existence of this vast computer data base will shave an entire year off the time it takes to characterize the Chattanooga site.

The long process of characterizing the Chattanooga site is already under way. Even with the headstart from TVA, this

Chattanooga Air Pollution Control Bureau

demanding project will take a full year.

EPA has contracted the site characterization to the University of Nevada's Environmental Research Center (ERC). The Center will work closely with EPA's Environmental Monitoring Systems Laboratory in Las Vegas. Computer experts at EPA's lab in Research Triangle Park, N.C., will keep track of the growing data base in the federal mainframe computers at the National Computer Center.

The most up-to-date computer technology will be used to speed the EMTS site characterization. Consider the ARC/INFO Georeferenced Information System, better known as "GIS." GIS gives scientists the power to put spatial data into a computer data base. That is a great leap forward, because nearly all environmental data derive their significance from their position on a map.

As they are entered into the data base, GIS data are categorized according to "theme" and assigned to one of many layers in the computer's memory. Each "theme" layer corresponds to a specific data type: land use, hydrology, soil type, etc. GIS permits scientists to interact with all these stored data in an endless variety of ways. Never-before-possible correlations involving data from many different "themes" can now be done quickly and printed out in handy map form. No wonder words like "revolutionary" are often used to describe the potential impact of GIS.

A quick look at the types of data needed to characterize the Chattanooga site bears out its spatial dimension:

- Political boundaries
- Transportation systems
- Natural drainage patterns
- Streams, rivers, lakes
- Topography
- Land use
- Soil type
- Census geography
- Sewage systems
- Drinking water distribution systems
- Location of large public buildings
- ZIP code boundaries
- Location of industries
- Location of environmental monitoring sites
- Demography
- Agricultural practices
- Climatology
- Concentrations of environmental pollutants

Each of these "themes," once programmed for Chattanooga on the Georeferenced Information System, will be a magnet for thousands of bits of data: far more information than any human brain can correlate, let alone retain.

The EMTS site characterization team will have to locate all available data sets pertaining to the Chattanooga Standard Metropolitan Statistical Area, a 6-county region that spills over the Tennessee border into Georgia. A large portion of this information exists only on paper, buried in the voluminous files of these counties and states, as well as in the national files of EPA. To simplify the process, no data earlier than 1980 will be entered into the computer data base.

When no data exist for the years 1980 to 1985, the best available set of data will be used.

Compiling computer data bases will also require a massive effort. The Tennessee Valley Authority data base is the prime candidate for inclusion, but other needed information may come from the computers of the Bureau of the Census, the National Weather Service, the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, the Department of Agriculture, and the Department of Health and Human Services, as well as from existing data bases at EPA. Fortunately, the Georeferenced Information System is readily compatible with other computer data bases.

EPA's Office of Toxic Substances (OTS) has a valuable data base to contribute to the Chattanooga site characterization. This is GEMS, the Graphical Exposure Modeling System. GEMS already contains site characterization data extracted from many EPA data bases. OTS and many other GEMS users across the country use such data together with chemical fate and exposure models available in GEMS to predict levels of exposure to toxic substances. This innovative system has attracted national, and even international, attention over the past five years.

Many EMTS experimenters will have to wait until every last detail needed for the site characterization has been pinned down, and that can't be expected before October 1986. Other EMTS projects have the green light, however, because the data they are gathering will make valuable contributions to the site characterization itself.

A case in point is the Office of Toxic Substances' Pilot Geocoding Project. Scheduled for completion by the end of November, this project entails locating emission sources in Chattanooga using a special means of analyzing aerial photographs.

Another high priority project is the prestigious Human Exposure Assessment Location (HEAL) project for the United Nations. The HEAL project will generate an international data base of exposure and environmental monitoring data. The initial HEAL experiments at the Chattanooga site will generate data on several chemicals.

*Chattanooga has the chance to take environmental science out of the laboratory and into real life.*

EPA's Office of Research and Development and Office of Toxic Substances are jointly leading the HEAL effort in the United States. HEAL projects are already underway in Japan, Yugoslavia, and Sweden. It is expected that 12 to 15 nations will eventually be part of the international HEAL network.

Other projects already approved for EMTS testing include:

- An Office of Toxic Substances pilot test for monitoring levels of toxic chemicals in fatty tissue. This national survey will later be extended to human blood and possibly mothers' milk.
- Phase 2 testing of the Total Exposure Assessment Methodology (TEAM). EMTS testing in Chattanooga will be aimed at clarifying the differences between outdoor and indoor toxic air exposure.
- Diesel engines and other sources emit particulate matter into the air, and samplers are needed to monitor their exact level. The EMTS will test particle samplers developed by various manufacturers.
- The National Oceanic and Atmospheric Administration (NOAA) plans to conduct an in-depth climatological study at the EMTS.
- Analyses of gases detected during soil testing. Gases often emanate from landfills and hazardous waste sites, of which Chattanooga has its share.
- An evaluation of the merits of Chattanooga's new drinking water system technology.

The final item on this list should assure the citizens of Chattanooga that EPA intends to be a good neighbor. To promote better understanding and communication, the agency has included local as well as state representatives on the EMTS Steering Committee. This committee will screen all proposals for projects to be conducted in Chattanooga.

But an EMTS experiment doesn't have to have Chattanooga in its project prospectus to be pertinent to Chattanoogans. Because of the special nature of the EMTS, all experiments run at the Chattanooga site—even those originating from abroad—will be generating Chattanooga data, valuable to Chattanooga residents, businessmen, and government leaders. And EPA will make every effort to tap the extensive support facilities of Chattanooga in all aspects of EMTS testing.

The project also promises to bring prestige to Chattanooga. Dr. Michael Bruner, Assistant Commissioner for Environment in the Tennessee Department of Health and Environment, believes that the EMTS designation gives Chattanooga "the potential of developing into the national—and even the international—center for environmental methods testing."

Most important of all, the EMTS project could provide data crucial to the formulation of new theories about the effects of toxic substances on humans: how best to measure them, how best to reduce or eliminate them.

The daily life of Chattanooga can proceed unchanged as scientists look for new insights into these problems. At no risk or expense, and at little or no inconvenience, Chattanooga has the chance to take environmental science out of the laboratory and into real life, as a whole city becomes a lab of great value to scientists everywhere. □

# The Promise of Cleaner Coal

by Julian Josephson

Coal is America's "good news-bad news" energy source.

The good news is that it can be expected to remain a reasonably priced fuel over the next several decades—the time needed to develop renewable sources of energy on a scale large enough to meet the U.S. economy's needs. The bad news is that the expanded use of coal could cause additional air pollution because of increased emissions of particulate matter (fly ash and soot) and oxides of sulfur and nitrogen.

*The fly ash and soot are thought to contain trace amounts of toxic and cancer-causing substances.*

Coal combustion is a source of air pollution because of the composition of the coal and the manner in which it burns. Coal contains varying amounts of mineral matter, including pyritic sulfur—the crystals of "fool's gold" one often sees in lumps of coal. It also contains organic sulfur bound up in its molecular structure. During combustion, the mineral matter fuses to become fly ash and clinker. Incompletely burned coal forms soot. The pyritic and organic sulfur oxidize to sulfur dioxide. Atmospheric nitrogen and oxygen combine under the high temperatures of coal combustion to form oxides of nitrogen.

These materials do not affect only air quality and visibility. Atmospheric chemists now believe that oxides of sulfur and nitrogen combine with moisture in the air to form acid precipitation. Oxides of sulfur also form sulfates which contaminate surface water and soils, and can damage forests and crops. The fly ash and soot are thought to contain trace amounts of toxic and cancer-causing substances.

Because of these threats, existing limits on emissions of particulates and sulfur dioxide ($SO_2$) from stationary sources, such as power plants, will eventually be reduced further. Rules sharply restricting emissions of oxides of nitrogen ($NO_X$) can be expected sooner or later.

To comply with present and future emission control regulations, the user of coal has two options. One, presently the most widely used, is to remove particulate matter, $SO_2$, and $NO_X$ flue gas generated when coal burns. The other is to remove pollutants before they are taken up in the flue gas. The first option requires an elaborate installation of gas-cleaning equipment; the second consists of capturing pollutants during the burning process or taking potential pollutants out of the coal before it is burned. Cleaning coal before or during burning could reduce or eliminate the need for gas-cleaning installations.

### Cleaning Emissions

Before the coal is burned, it can be pulverized and washed to remove some of the mineral matter that forms ash and pyrites that oxidize to $SO_2$. After the coal is burned, particulate matter is captured with either an electrostatic precipitator (ESP) or a fabric filter. An ESP charges the particles electrically and catches them on plates of opposite charge. A fabric filter collects the particles as though it were a giant vacuum cleaner bag.

The gas is then passed through a "scrubber" in which a wet alkaline material, usually lime, removes the $SO_2$. Fabric filters and ESPs can capture more than 99 percent of the particulate matter. Scrubbers can achieve more than

*(Josephson is Associate Editor of Environmental Science and Technology, a publication of the American Chemical Society.)*

At this power plant in the southeastern United States, work is underway on installing a flue gas desulfurization (FGD) system to the left of the chimney and, to the right, an electrostatic precipitator. This particular FGD system produces commercial grade gypsum as a byproduct.

*A fabric filter collects the particles as though it were a giant vacuum cleaner bag.*

90 percent $SO_2$ removal. Most do not yet remove $NO_x$, although technology to accomplish this is developing rapidly.

Although gas-cleaning equipment has performed successfully, it still has several problems. For instance, an ESP or fabric filter cannot catch all of the solid particles. Small amounts of finer, inhalable particles can escape to the air. The solid material that is captured must be disposed of in some way. This problem could become more serious if these solids are designated as a hazardous waste. A major problem with scrubbers is that they are expensive and energy-intensive. A scrubber can add as much as 40 percent to the cost of a new coal-fired power plant. Its operation can consume up to eight percent of the plant's output.

Another difficulty is that scrubbing $SO_2$ with wet lime produces large quantities of sludge which must be disposed of somewhere. At a coal-fired power plant in western Pennsylvania, the sludge is submerged in a large artificial lake in which it settles to the bottom and is said to cause no contamination problem. At another plant, proprietary materials are mixed with the sludge to "fix" it in a concrete-like material that can be used for paving.

Newer technologies in use or in advanced stages of development bypass the sulfite sludge disposal problem. They can also produce marketable byproducts whose sale partially offsets the high capital and operating costs of flue gas cleaning equipment.

In one process developed in Japan, $SO_2$ is scrubbed with limestone over a catalyst made of silver. The limestone is converted to calcium sulfate (gypsum) which is used to make plaster and other building products.

Other techniques do not use lime or limestone. For example, at several plants, flue gas is scrubbed with a solution of caustic soda to produce sulfur, a marketable byproduct. In another process, $SO_2$ is captured with magnesium oxide. After the sulfur is removed, the magnesium oxide can be recycled to the flue gas cleaning system. This process also produces sulfur of marketable quality.

Flue gas scrubbing technology for removing both $SO_2$ and $NO_x$ is coming on line. One technique uses black copper oxide to capture $SO_2$. This reaction produces copper sulfate which, in turn, catalyzes the destruction of $NO_x$ by ammonia and the formation of water and nonpolluting nitrogen gas. Heating the copper sulfate restores the copper oxide and drives off $SO_2$ in concentrated form. This concentrated $SO_2$ is easily converted to sulfuric acid or sulfur, both of which are always in demand in many industries. A West German process produces ammonium sulfate, a fertilizer base, as the flue gas cleaning byproduct.

### Cleaning Coal during Combustion

Fluidized-bed combustion (FBC) removes $SO_2$ during combustion by a process known as sorption. Coal and limestone are crushed, then burned together in a bed suspended in midair by updrafts from below. As the coal burns, the limestone captures, or sorbs, the $SO_2$. Suspending the coal-limestone mixture on the updraft "cushion" makes it look like a flowing, bubbling liquid.

FBC takes place at lower temperatures than those needed for conventional or "fixed-bed" combustion. Typical temperatures for FBC are 750-950°C (1382-1742°F); fixed-bed combustion requires temperatures of 1400-1500°C (2552-2732°F).

*The development and commercialization of cleaner ways to burn coal is going forward.*

Because of these lower FBC temperatures, no slag or clinkers are formed from the mineral matter in the coal. That makes the ash soft and easy to handle. Lower FBC temperatures also lead to substantial reductions in the formation of $NO_x$ as well as the highly corrosive vapors of alkali and metal salts.

Between next year and 1989, several utilities in Colorado, Kentucky, and Minnesota expect to start up fluidized-bed combustion boilers to generate 100-160 megawatts of power. About 20 U.S. and 32 foreign companies are vying to sell FBC systems in what they see as a rich market, and a number of engineering firms are competing for orders to design such systems.

One problem with FBC is that most systems use the limestone sorbent only once to capture $SO_2$, and then dispose of it. However, scientists and engineers are developing sorbents that can be regenerated and recycled. They are also testing materials which can sharply increase the efficiency of these sorbents.

### Cleaning Coal before Combustion

This approach involves removing the mineral matter that would otherwise become fly ash and $SO_2$ before the coal is burned. Among techniques in use or being developed are simple washing,

Research Cottrell

conversion of coal to gases and liquids, and exotic procedures such as chemical treatment and microwave separation.

One coal-cleaning technology has completed one year of successful performance at a 100-megawatt power plant in California. Coal is reacted with steam and oxygen under very high pressure, to form a mixed gas consisting of carbon monoxide and hydrogen. This gas drives a turbine to generate electricity; it is then burned in a boiler to make steam which drives another turbine to produce more electricity. The coal's sulfur combines with the hydrogen formed by the gasification process. The sulfur can be recovered for possible sale. $NO_x$ formation is inhibited because of lower flame temperatures and oxygen concentration, and new burner and flame-shaping technology.

Solvent refining is another means of cleaning coal. The coal is dissolved in an organic solvent and heated to 750-850°F under pressures of 1800-2800 pounds per square inch. This process forms hydrocarbon liquids and gases, hydrogen sulfide, and water. The hydrogen sulfide removes some of the organic sulfur bound up in the coal. Ash-forming minerals and inorganic or pyritic sulfur are also taken out. Pilot studies of the process are being conducted in Alabama under the sponsorship of the U.S. Department of Energy, and several industry associations and companies.

**Why Not Full Speed Ahead?**

The development and commercialization of cleaner ways to burn coal is going forward, and shows promise for reduced air pollution and acid deposition. But why are these activities not moving ahead at full speed? One reason may be the present glut and price softness of oil. The economic situation has dampened incentives to improve coal cleaning and combustion technologies. However, the petroleum oversupply cannot last more than several years, at best. When oil and natural gas supplies become short once again, environmental regulations governing the use of coal will not be relaxed. Clean coal research, development, and commercialization must be accelerated so that coal and its products can tide the U.S. over between the time oil and gas become scarce once again and renewable sources of energy become technically and economically feasible for use on a large scale. □

# Deadline: 1990

by Suellen W. Pirages

Deadline: 1990. That is the year when land disposal of all hazardous waste will come to a complete stop unless. . .

Unless EPA has, by then, evaluated all listed hazardous wastes, determined which ones should not be disposed on land, and identified alternative ways—either by incineration or treatment—to manage those wastes.

Congress imposed the 1990 deadline on EPA last year, when it reauthorized the Resource Conservation and Recovery Act (RCRA).

What will happen if the land disposal prohibition takes effect before sufficient capacity to treat or incinerate hazardous waste exists?

Manufacturers will either have to store their hazardous waste until such capacity does become available, or they will have to stop producing goods that generate hazardous waste. Unfortunately, these goods include not only exotic chemicals with which the average American is little concerned, but also such essential items as medicines and medical supplies and such common everyday items as automobiles, household plumbing fixtures, paint, home computers, and clothing. Obviously, if production of these goods were to stop, the effect on both manufacturers and consumers would be drastic.

Can the congressional requirement be implemented by 1990? Perhaps. But several factors will limit the ability of both government and industry to restrict certain wastes from land disposal.

Two inescapable realities confront any attempt to ban land disposal of hazardous waste. First, the residues of some industrial wastes will require land disposal even *after* treatment.

Both organic compounds and inorganic elements are found in industrial wastes. Organic compounds can be destroyed using existing technology. But according to the laws of physics, inorganic elements—which occur naturally in the environment and include lead, mercury, chromium, cadmium, and sodium—can never be destroyed. The best option for managing these wastes is to solidify them to minimize the possibility of future migration, and to place them in a secure landfill.

*(Pirages is Director of the National Solid Wastes Management Association's Hazardous Waste Program.)*

Second, even though alternatives to land disposal are available now, limited capacity for treating hazardous waste could still make it difficult to meet the 1990 deadline.

A recent national survey conducted for EPA indicated that, even as early as 1981, 66 percent of the total national volume of hazardous waste generated was already being treated. Furthermore, an informal survey of selected commercial waste service firms revealed that, of the untreated waste accepted at disposal facilities, 30 to 60 percent was pretreated at the facility before disposal.

*No prudent businessman in today's economy will expand investments into an area plagued by uncertainty.*

In addition to conventional treatment options in use today (see Figure 1), new developments to improve treatment technology are emerging. Some of these are refinements of existing technologies that lead to more efficient destruction of hazardous chemicals. Others involve the development of "high tech" innovations that can reduce the hazard of chemicals that previously were difficult to destroy. Figure 2 illustrates some innovative technologies that have advanced beyond the experimental stage and are ready for investigation in larger demonstration projects.

But while commercial capacity for treating industrial waste exists, it is not evenly distributed throughout the country. EPA data suggest that unused treatment capacity nationwide stands at 30 to 45 percent. Some regions of the country use almost all their treatment capacity, but others do not. The greatest unused capacity apparently exists in the Midwest.

Unavailability of nearby commercial treatment facilities can force large generators to ship their industrial hazardous waste long distances for treatment or to treat the waste themselves; and it puts a real crunch on medium and small generators who cannot afford an in-house treatment capability.

## Barriers to Increasing Capacity

There are three major barriers to increasing commercial capacity for treating greater volumes of industrial waste.

**Lack of adequate regulatory standards** inhibits both commercial expansion of conventional treatment capacity and capital investment in new technologies.

Within the RCRA program, strict standards have been developed only for incineration and land disposal of hazardous waste. Other treatment alternatives are regulated only by the Clean Water, Clean Air, and Safe Drinking Water Acts, laws which do not regulate a diverse range of hazardous industrial chemicals.

EPA plans to develop health-based criteria with which to evaluate wastes for restrictions from land disposal. Once established, these criteria can be used to identify treatment standards for a broad range of land disposal alternatives.

Until then, however, no prudent businessman in today's economy will expand investments into an area plagued by uncertainty.

**Figure 1. Conventional Treatment**

**Chemical**
- precipitation
- oxidation
- reduction—dechlorination
- photolysis
- stabilization/solidification

**Biological**
- aerobic/anaerobic
- land treatment

**Incineration**
- liquid injection
- rotary kiln
- cement kiln

S. Mondshein

An American ritual: watching TV on Saturday morning. Production of many of the items in this room generates hazardous waste. Those items include the carpeting, paint, wood stain, television, and clothing, drapery, and upholstery fabrics.

**Constraints on commercial markets** arise from governmental actions at all levels. For example, many states and communities are attempting to restrict the movement of industrial wastes, either by preventing hazardous material transport through a city or by imposing high taxes on importation of hazardous waste for treatment and disposal. Some states attempt to impose differential tax rates on waste treated commercially and waste treated by a generator. New mandates by Congress to minimize waste generation can lead to uncertainty about future volumes requiring management. Expansion of commercial treatment technologies will continue to be constrained until such trends in taxation, transport, and composition and volume of industrial waste can be identified with greater certainty.

Another major constraint to development of commercial treatment capacity is the present slow pace of granting government permits for operation of a facility. RCRA permits must be obtained before construction of new facilities or expansion of existing facilities. To date very few permits have been granted. Some have been finalized for small treatment facilities in rural areas, but virtually no final permits have been granted for large multipurpose management facilities (i.e., facilities with incineration, treatment, and land disposal capacity for treatment residues).

Although EPA has stated that new treatment facilities will receive high priority in the permitting process, evidence of this promised change is not yet apparent. Since it takes time to raise capital to invest in better treatment processes and new equipment, the longer the permit process, the greater the delays that can be expected in implementing land disposal restrictions.

**Siting problems**—the Not In My Backyard, or NIMBY, syndrome—persist today as strongly as ever. Various models for an effective siting process for hazardous waste management facilities have been proposed, but to date none has been successful. Community resistance continues regardless of the type of facility being proposed. Between 1983 and 1985, for example, 15 different proposals were made around the country for development of treatment and incineration facilities and small landfills for disposal of treatment and incineration residue. None of the proposals succeeded.

But unless the United States returns to "caveman living standards," there will always be some volume of hazardous waste requiring treatment and disposal; it will not magically disappear. Each state and community must be willing to take some responsibility for its proper management.

It is relevant to recall the experience of California. In 1983, California became the first state to prohibit land disposal of hazardous waste. But this prohibition has yet to be implemented. In fact, state officials recently called for an extension of the legislative deadline for implementation. A major reason for the delay is a lack of alternatives for managing waste. In California, as in the rest of the nation, permitting and siting problems have hampered the development of facilities capable of using alternative technologies.

The immediate future is not rosy regarding restricting certain hazardous wastes from land disposal, but it certainly is not hopeless. The ability to treat hazardous waste using incineration, and chemical and biological destruction processes exists. Barriers to a timely implementation of land disposal restrictions are primarily institutional, not technological.

EPA has a very complex and difficult task before it. It may be necessary for Congress to assist EPA and industry by providing more time to promulgate restrictions and develop alternatives for land disposal. □

**Figure 2.**
**Emerging Technologies**

- Water oxidation
- Vertical-tube reactor
- Pyrolizing rotary kiln
- Penberthy pyro-converter
- Plasma arc
- High-temperature fluid wall reactor
- UV photolysis
- Pyroplasma processes

# Treating Municipal Wastewater: Tradition and Innovation

*A rotating biological contactor is a cost-effective municipal wastewater treatment system for smaller plants.*

by Carl H. Brunner

"Innovative and Alternative Technologies" is the name of the game as municipal wastewater pollution control moves into its second century.

Although the history of mankind's efforts to get rid of liquid wastes dates back to the sewer systems of ancient Rome, it was not until well into the nineteenth century that concern over the detrimental public health impact of such pollution led to significant attempts to develop wastewater treatment methods. Since that time, there has been a continuing recognition of new problems and of the need for new approaches. EPA research has been an important source of innovative, cost-effective solutions.

The earliest identified municipal wastewater problems were the presence of biologically degradable organic materials and disease-causing (pathogenic) microorganisms. In 1913, for example, outbreaks of typhoid in the Detroit area were traced to sewage pouring into Lake Erie, Lake St. Clair, and the Detroit River which joined them. The solution then was to relocate the sewer outlets in relation to drinking water intakes. Today, wastewater treatment technology is the answer.

In addition to the health problems caused by disease-related microorganisms, scientists became concerned about biologically degradable organic materials which caused a number of problems in the lakes and streams into which they poured. These organics reduced dissolved oxygen in the water to levels that caused unpleasant tastes and odors and prevented the existence of fish and other aquatic plants and animals. These problems are still important today.

*(Dr. Brunner is Chief of the Systems and Engineering Evaluation Branch of the Wastewater Research Division in EPA's Water Engineering Research Laboratory in Cincinnati, Ohio.)*

By the 1960s, scientists had expanded the list of problem substances in the concern over clean water to include nutrients—mainly phosphorus and nitrogen—and refractory, or treatment-resistant organics. The nutrients stimulate excess growth of algae and other plants which not only cause aesthetic problems but also "choke" the affected waters by reducing dissolved-oxygen levels to the point where fish can not live. The refractory organics were suspected of including chemicals that were toxic or otherwise harmful to humans. Continuing improvements in analytic techniques in the 1970s and 1980s reinforced these concerns.

*Added to the problem of pollution itself is the cost of providing adequate municipal wastewater treatment.*

Added to the problems of pollution itself is the cost of providing adequate municipal wastewater treatment. Progress towards the Clean Water Act goal of maintaining the "chemical, physical and biological integrity of the nation's waters" has already cost billions of dollars. The technology required to curb pollution from household and commercial sewage is one of the major costs involved. EPA construction grants presently help communities pay the price of state-of-the-art wastewater treatment plant construction, but escalating energy charges and other rising expenses keep increasing the cost of operating the plants. EPA scientists and engineers working on the development of innovative technologies must continually seek ways of getting more clean water for the EPA buck.

**Responding to the Problem**

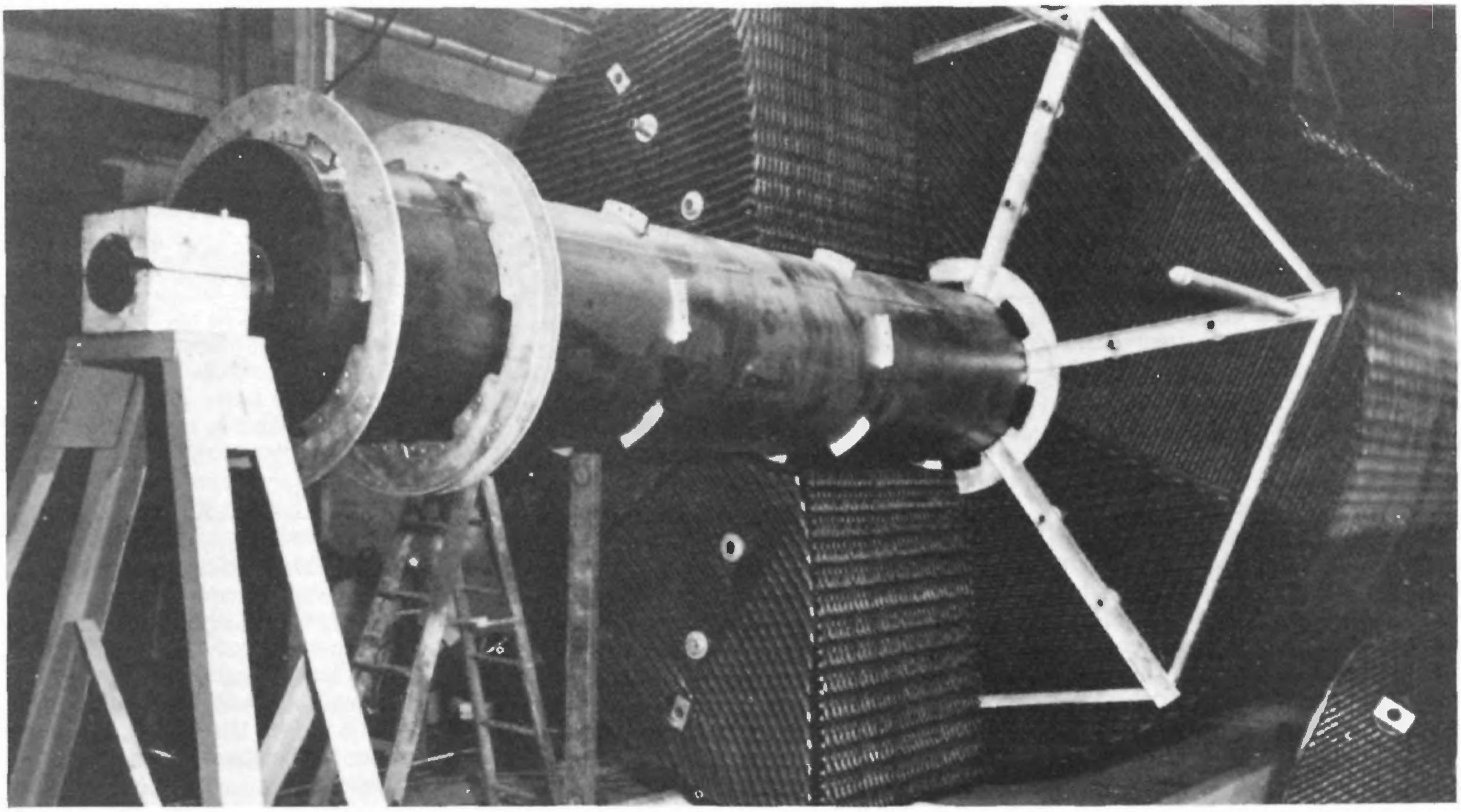
Many of the wastewater treatment techniques in use today are modified forms of approaches developed by early researchers, who took advantage of the ability of natural microorganisms to degrade organic matter when oxygen is present. Today's activated sludge process, in which air is blown through tanks containing the wastewater and microorganisms, and the process whereby wastewater is trickled over beds of high-surface material covered with microorganisms, are the "traditional" biological processes considered conventional for removal of organics and reduction of pathogenic microorganisms.

The battle against eutrophication—the excess fertilization that almost killed Lake Erie before massive wastewater treatment intervention—was first fought by adding iron or aluminum compounds to the biological treatment processes to remove phosphorus. Phosphorus was targeted because it was cheaper to remove than nitrogen. Most wastewater treatment plants requiring phosphorus removal still use this chemical approach.

Because it was found that some microorganisms can, under certain conditions, absorb abnormally large amounts of phosphorus, there has been a growing interest in utilizing biological methods. Some activated sludge treatment plants have been modified by adjustments in dissolved oxygen levels to make possible substantial phosphorus removal without requiring chemicals.

Ammonia, another nutrient found in wastewater, is a problem because it reacts with oxygen and can deplete the dissolved oxygen in surface waters. Conventional biological processes have been modified to allow the ammonia to be oxidized to nitrate. This method is already being widely used.

In the 1970s, there were a number of new developments in response to the need for more cost-effective,



Crane-Cochrane

energy-effective technology. Use of pure oxygen rather than air in the activated sludge process was one. In new or retrofitted plants, the size of the needed aeration tanks is halved. Because of the cost and complexity of producing the pure oxygen, this process is better suited to large plants. For smaller plants, a more appropriate new system has been the rotating biological contactor (RBC). This uses a series of rotating plastic disks covered with microorganisms, and functions much like a trickling filter.

*EPA research has been an important source of innovative, cost-effective solutions.*

**Technologies Program**

Clean Water Act amendments in 1977 led to the creation of the Innovative and Alternative (I/A) Technologies program, which accelerated the pace of technology development and full-scale evaluation. The amendments encouraged use of not fully proven systems that were potentially beneficial and cost- and energy-effective. Increased federal sharing in the costs of construction and modifications—if the new technology didn't work properly—was a major new incentive.

The I/A program has produced important changes in municipal wastewater treatment and accelerated utilization of research results. A very significant change has been the widespread adoption of such alternative technologies as land disposal techniques for wastewaters and sludges. Such treatment allows the wastewater to infiltrate the soil or run over sloped surfaces. Infiltration can produce a very high quality water for aquifer recharge or other uses. Overland flow lets biological pollutant removal occur at the ground's surface and produces water similar in quality to that from conventional treatment. Such systems are being used at more than 150 sites under the I/A program.

More than 200 alternative collection projects have been funded under I/A, resulting in combined savings of more than $100 million to small communities. The majority of these are pressure sewers, but there are also small-diameter gravity sewers which accept septic-tank effluent, and vacuum sewers.

The program has also helped accelerate adoption of energy-saving, fine-bubble diffuser technology in activated sludge processing. Replacing large, or coarse, bubble aeration systems with fine-bubble units equipped with individual air flow control devices can save as much as 50 percent on aeration energy requirements. Virtually all new aeration construction is expected to involve some form of fine-bubble diffuser.

Disinfection technology, too, has advanced significantly under the I/A program. Until recently, chlorination was virtually the only method in use, but concern about the appearance of harmful chlorinated organics in municipal wastewater led to the quest for other approaches. Over the last 10 years, EPA has played a major role in the development of ultraviolet light disinfection as a low-cost alternative to chlorination by supporting research and demonstration projects and funding facility construction. Ultraviolet disinfection systems are being utilized at over 50 wastewater treatment plants.

The treatment and disposal of sludge left over from biological wastewater treatment plants can represent as much as half the total treatment cost. What's more, the amount of sludge being treated—currently about seven million dry tons annually—is steadily increasing and there are significant changes in the way it is being handled. About a quarter of the residual sludge is being applied to the land as fertilizer instead of being incinerated or dumped in landfills. Properly done, the agricultural application of sludge reduces the need for chemical fertilizers. Composting of sludge to produce a soil enhancer for lawns and gardens is also increasing. The number of treatment plants composting sludge has increased from 10 to 50 in the past decade.

*Continued to next page*

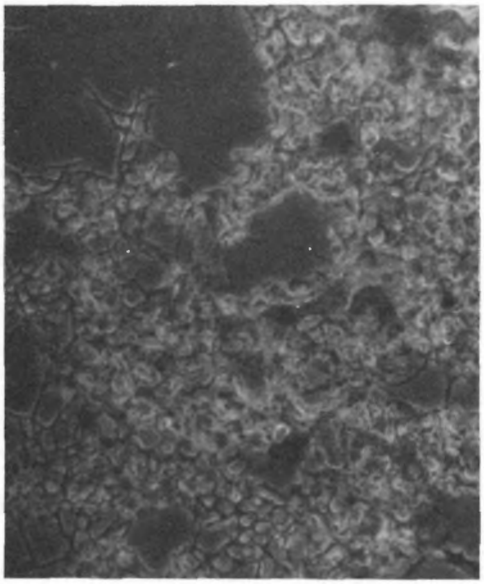
Although much of EPA's effort in developing wastewater treatment technology focuses on communities with centralized systems, agency research and development has not overlooked the 25 percent of our population not served by sewers. Some of the new collection methods developed under I/A are making practical the use of sewers in many such areas. Improvements have been made in the septic tank soil absorption system. Where even septic tanks are not practical, research has developed improved methods of wastewater disposal such as:

- Mound systems, where the ground-water level is too high or the aquifers unprotected.
- Evapotranspiration beds in arid regions with unsuitable soils.
- Improved sand filter designs which permit high quality on-site treatment for direct disposal to surface water where soils are unfit for infiltration.
- Wastewater segregation and conservation techniques which can extend the lives of marginally failing conventional backyard systems.

**Toxics Control**

Treatment systems have always coincidentally removed toxics from wastewater. Recently, however, municipal wastewater treatment objectives have begun to move beyond control of "traditional" pollutants to encompass specific individual toxics and overall biological toxicity caused by the complex mixture of materials found in wastewater. This added dimension, which is evolving as a national policy for the development of water quality-based permit limitations for toxic pollutants, recommends an integrated approach using both specific chemical analyses and biomonitoring with appropriate bioassays.

Pollution control based upon toxics leads logically to a broad systems engineering approach in which tradeoffs between municipal and industrial treatment to attain water quality goals at minimum cost must be considered. Modern, automated process controls will be a necessary tool in applying this approach. While such effective integrated wastewater treatment systems management has still to be fully realized, the elements for its achievement are rapidly emerging.


Polybac Corporation

Photomicrograph of Nocardia, a nuisance organism in activated sludge treatment systems. Nocardia causes scum to form on clarifiers, interfering with effective biological treatment of wastewater.

**Looking Ahead**

There are more than 15,000 municipal treatment plants today. There will be a need for 6,000 more by the year 2000. The estimated cost of the new plants, based on existing technology, is over $100 billion, to which must be added the cost of maintaining the existing plants. Future innovations and alternatives must answer the question, "How are these needs likely to be met?"

The great majority of plants planned before the year 2000 will be small, many of them good candidates for land-treatment systems that are simple to operate and inexpensive where cheap land is available. If some of these communities have stricter discharge requirements in summer, they may be able to develop cheap storage which will allow them to practice controlled effluent release at times when the receiving water provides greater dilution. For plants too large for land-based systems to be cost-effective, there will be a demand for higher rate processes with lower capital costs. Retrofitting an existing plant for pure oxygen is an example of what could be done to meet this need.

There are other new technologies which also have a potential for meeting future needs. The CAPTOR process, which utilizes many small sponges in the activated sludge aerator, and the Biological Aerated Filter from Europe are being looked at in the United States. For some kinds of plants, new construction approaches offer potential for lower capital costs. Plants that process wastewater in intermittent batches rather than continuously—as virtually all plants now do—offer the possibility of both cost savings and improved operational flexibility.

The effort to clean up Chesapeake Bay is a reminder that nutrient control—especially phosphorus—will continue to be important, and new biological methods of phosphorus removal will be increasingly used. There is evidence that additional adjustments of oxygen levels in activated sludge plants to levels beyond those made for biological phosphorus removal can also increase the rate of organic removal. At the same time, the amount of sludge actually produced would be reduced. And in the area of sludge treatment, such new technologies as high-rate, two-phase anaerobic digestion, autothermal-thermophilic aerobic digestion, and reduced energy incineration offer the prospect of lower production costs for residual matter with a reduced pathogen content.

The future of municipal waste treatment will capitalize on the conventional biological treatment processes' remarkable ability to remove large amounts of harmful organic materials. Combining the existing processes with physical/chemical methods can increase this ability. Such plants, therefore, will have the capability of handling a variety of hazardous materials in larger concentrations than the amounts commonly seen in most sewer systems.

This may make it more cost-effective to use centralized treatment to deal with hazardous and other highly polluted wastes that are now handled separately. We have the opportunity to increase this kind of activity which will, at the same time, reduce the possibility of negative cross-media impacts: that is, creation in one medium of a pollution problem that comes from cleaning up a problem in another medium. There is a need, however, to overcome legal and institutional constraints that can impede the expansion of the role of the municipal wastewater treatment plant. □

# Environmental Technology: Old Disappointments and New Hope

by James H. Scheuer

In the early 1970s, the relationship between technology and the environment seemed simple and obvious. Bad technologies were the ones that polluted the environment; good technologies were the ones that did not pollute, or ones which cleaned up after the bad technologies.

The solution to pollution seemed equally obvious: we ought to set clean air and clean water standards, and replace the polluting technologies wih ones that could meet those standards. This simple faith in the ability of technology to deliver us painlessly into a pristine future resulted in provisions requiring industries to install the "best available technology" to control pollution.

*We clearly underestimated the difficulty in cleanup.*

That early faith in technology was a product of the boundless optimism in our economy that pervaded the nation in those years. Americans had the sense that we could solve all our problems by simply calling on American science and engineering. After all, as the cliché went, if we could send a man to the moon, why couldn't we clean up our planet? In a time when double-digit inflation and the Japanese trade invasion were unimaginable, we had faith in the ability of American industry to absorb any necessary costs that might result from pollution controls. Certainly it should not be too difficult or expensive for industry to find a way to stop spewing pollutants into the air and water. Certainly the engineering talent in our automotive industry could come up with an innovative way to cut emissions from auto exhausts.

Fifteen years and over $500 billion dollars later, we remain far from the vision of fishable and swimmable waters and clean, healthy air that guided Congress' actions in the early 1970s. We clearly underestimated the difficulty in cleanup. Deadlines in several of our environmental statutes have been reached, extended, and reached again. Making a bad situation worse, the very nature of the problems we are now facing has changed. Today, we must deal with a veritable "alphabet soup" of toxic chemicals, heretofore unheard of by the public.

Our early faith in the bright promise of technology was not altogether misplaced. Much of the progress made in cleaning up our air and water is indeed due to significant technological developments and improvements, such as scrubbers and catalytic converters. It is also clear that developments in technology will play an even more important role in the future in addressing critical environmental issues such as acid rain and hazardous waste contamination.

But plainly our early assumptions were faulty. Part of the problem stemmed from our failure to take to heart the lessons of ecologists that the environment must be viewed as a total system.

The distinction between "good" technology and "bad" technology rapidly eroded as we began to realize that, in reality, technology often created new problems or presented a variety of trade-offs. We embraced technologies which cleaned up one part of the environment at the expense of another. Tall stacks meant to meet Clean Air Act requirements improved local air quality, but contributed to long-range acid deposition. Treatment technologies used to remove pollutants from water at sewage treatment plants cleaned the water, but released the pollutants directly back into the air. To clean up surface waters, hazardous wastes formerly discharged into water were stored at dumps, which subsequently leaked and contaminated ground-water sources across the country.

Technology also had the confounding effect of uncovering "new" subtle, pervasive, and threatening forms of pollution. Thanks to the rapid development of analytic technology, we became able to detect and measure toxic substances at ever lower levels of concentration, down to a few parts per trillion. As the threshold of detection increased, the apparent dimensions of the toxic contamination problem increased as well.

*Technology also had the confounding effect of uncovering "new" subtle, pervasive, and threatening forms of pollution.*

Ground water, which many scientists had believed only a few years ago to be protected from pollution, instead was found in many instances to be contaminated with a wide range of pollutants. The Congressional Office of Technology Assessment has identified over 200 substances found in the nation's ground water. Similarly, improvements in monitoring devices helped reveal the potential hazards of exposure to contaminants, such as formaldehyde and radon, found in indoor environments.

Over the last 15 years, our faith in technology has waned. While Americans have been quick to embrace the comforts and protections afforded by

(Scheuer is Chairman of the House Subcommittee on Natural Resources, Agriculture Research and Environment, in the Committee on Science and Technology. He is a Democratic Congressman representing the 8th District of New York.)

technology, we have nursed a quiet democratic distrust of elites of any sort, including the technological elite. As technology has proliferated over the last 20 years, touching every aspect of our everyday lives, it is not surprising that many citizens are increasingly distrustful and suspicious of technology which they cannot understand or control. Cars stuffed with byzantine emission control equipment can't be fixed even by the most ardent do-it-yourselfer; consumers erroneously dunned by bill-collecting computers can't find a "real person" to set the matter straight.

That distrust is not altogether unwarranted. Compiling a list of incidents which engineers and scientists said could not happen is not a difficult task.

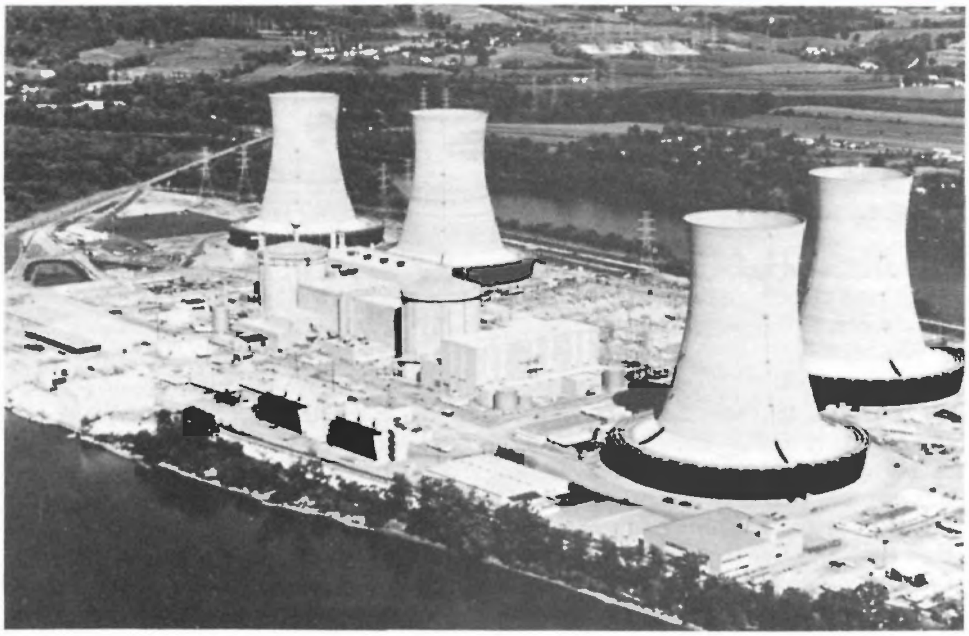
Three Mile Island was an accident which engineers performing elaborate risk analyses concluded was statistically impossible. Yet despite numerous mechanisms designed to ensure the safety of the plant, recent investigations show that the core of the Three Mile Island reactor came perilously close to a meltdown, closer than any scientist or engineer thought even theoretically possible at the time of the accident.

Similarly, for decades, scientists believed that ethylene dibromide (EDB) was safe to use as a pesticide because it was volatile and would leave no residue on food. Only in the late 1970s did researchers discover that EDB did not in fact dissipate, and that large quantities of flour and other grain were contaminated. The discovery that EDB could also leach into ground water came as a further surprise a few years later.

More recently, a sophisticated computerized system installed at Union Carbide's Institute, W. Va., plant to warn the community in the event of a toxic chemical release failed to work when toxic methylene chloride was accidently released at the plant, despite the high priority given to the system by the company in the wake of the Bhopal disaster.

It is not astonishing that the public is skeptical of statements from scientists working in the area of biotechnology that the development of new genetically engineered organisms pose no threat to the environment or human health.

While engineers and scientists are loathe to admit it, the fact is that they have no special exemption from Murphy's Law. Yet the failures mentioned above, and numerous others, have not stemmed from a failure of technology *per se*. By and large, the tools, machines, and computers—the hardware, if you will—have behaved as they were designed or programmed to do.



GPU Service Corporation

*The Three Mile Island Nuclear Station, located on the Susquehanna River south of Harrisburg, Pa. According to Congressman Scheuer, the 1979 accident at Three Mile Island — an accident that supposedly was "statistically impossible" — is one reason why Americans have become "distrustful and suspicious of technology."*

Rather, the failures have often come from human error, such as the case of Three Mile Island, or from a tendency of scientists and engineers to underestimate the complexity of the natural ecosystems within which they are working. Perhaps part of this tendency is caused by the nature of the scientific method, which requires the careful observation of a few variables at a time under controlled conditions. Nature, however, is rarely content with the simplicity of laboratory conditions, and scientists and engineers sometimes fail to appreciate potential interreactions or uncertainties about the particular ecosystem involved.

And yet it is precisely technology itself which holds out the best hope for our ability to understand and analyze the environment from an integrated and holistic view. Remarkable developments in satellite remote sensing, for example, can help build a much better understanding of the interplay of environmental factors over large regions of the earth. The truly global nature of many environmental problems—and the global nature of any solution—is being documented by this new tool. At the other extreme of the scale, sophisticated new research tools make it possible for us to measure and manipulate biological and ecological activities at the cellular level, helping us to understand the basic processes which must be known and understood to create an effective and total view of the environment.

Finally, and perhaps most importantly, the development of new generations of supercomputers creates the possibility of building complex models of the environment which can integrate the new wealth of information and begin, for the first time, to approximate nature's own complexity.

Such developments will be necessary if we are to solve the great global environmental issues—acid rain, desertification, deforestation, loss of species, and the depletion of natural resources—that will surely demand our attention well into the next century.

In recent years, Congress' view of technology and its ability to bring us effortlessly to a pristine environment has been tempered with a more accurate vision of the limits and perils of technology. We certainly know now that technology by itself will not solve our environmental problems; what is perhaps most needed is an improvement in our human vision of the interrelationship of the vast array of component elements which make up our environment. But it is equally evident that without technology, even inspired human vision will be unlikely to create the cleaner and healthier environment we all seek. □

# The Blue Goose Flies!

by Susan Tejada

In the January-February 1985 issue of the *EPA Journal*, Rowena Michaels, Public Affairs Director of EPA Region 7, reported on an upcoming experiment in southwest Missouri. In a field test in Barry County, Mo., EPA's mobile incinerator, known as the "Blue Goose," would be used to burn some of the dioxin-contaminated waste that had been spread years earlier at more than 40 locations throughout that part of the state.

"Upon successful completion of the project," Michaels wrote, "we will have demonstrated that no harmful contaminants entered the environment by any route from the process . . . We will have successfully, safely destroyed dioxin."

*Agency officials declared the tests were a "major breakthrough" in efforts to find solutions to the dioxin problem.*

This summer, EPA announced that the trial burns had succeeded. Final results showed that the system destroyed or removed 99.9999 percent of wastes contaminated with 2,3,7,8-TCDD, the most toxic form of dioxin, and that there were no detectable traces of 2,3,7,8-TCDD in the system's flue gas emissions, kiln ash, or scrubber-water effluent streams.

Michaels' prediction had come true. The Blue Goose had worked. Agency officials declared the tests were a "major breakthrough" in efforts to find solutions to the dioxin problem.

The mobile incinerator was conceived in 1976 by the EPA Office of Research and Development, Hazardous Waste Engineering Research Laboratory, in Edison, N.J., and built by outside contractors. Its effectiveness had been documented in a series of trial burns with fuel oil, iron oxide, carbon tetrachloride, o-dichlorobenzene, and PCBs in 1982 and 1983, and at the end of 1984 it was moved for dioxin testing to Missouri.

Four dioxin trial burns took place in the state between February and April, 1985. EPA's Environmental Monitoring System Laboratory in Las Vegas compiled results of the tests from more than 15,000 pages of analytical data.

The incinerator processed 1,750 gallons of liquids and more than 40 tons of soil contaminated with dioxin, destroying a total of 3.84 pounds of 2,3,7,8-TCDD. Emissions from the system met and exceeded all federal and state requirements for the incineration of the dioxin-contaminated material.

Because the mobile incinerator burned the 2,3,7,8-TCDD so completely, EPA has proposed to de-list, or designate as not hazardous, the residues from future burns in the incinerator.

Despite the incinerator's success, use of the system is not practical at certain sites such as Times Beach, Mo., where dioxin contaminated an estimated 400,000 tons of soil. Since the unit was developed for mobility, its capacity is restricted by design requirements that had to satisfy "over-the-road" limitations. Generally, the unit can process up to one ton of contaminated solids per hour and up to one gallon of contaminated liquids per minute.

Although not suited for Times Beach, the Blue Goose can be used at other sites around the country with more limited amounts of dioxin contamination. The unit cuts waste transportation and storage costs and, since it operates on-site, it eliminates the possibility of accidental spills occurring in transit to a landfill.

*Generally, the unit can process up to one ton of contaminated solids per hour and up to one gallon of contaminated liquids per minute.*

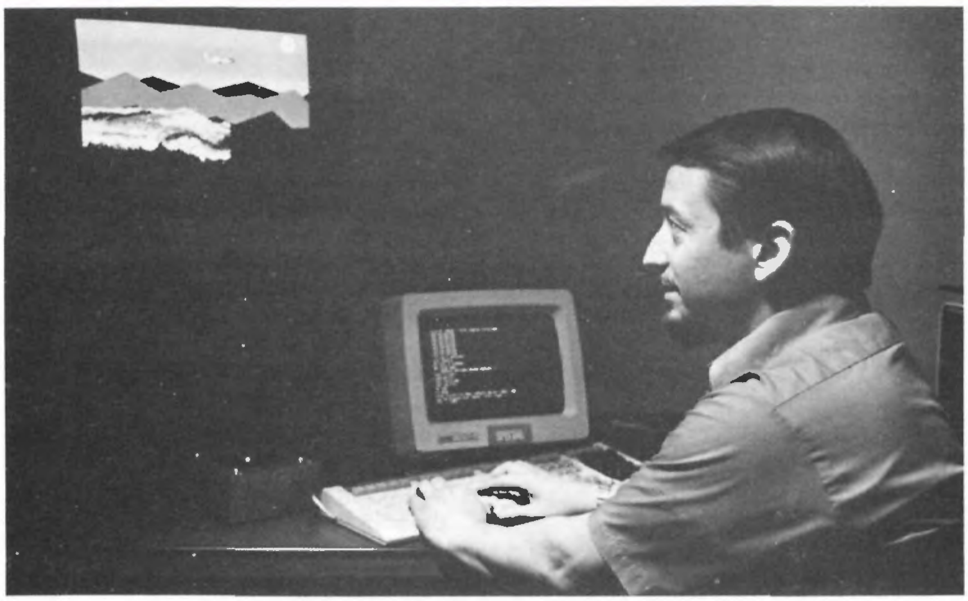
In an article on the development of the incinerator that appeared in 1982, the *EPA Journal* stated: "The mobile incinerator was the first of its kind . . . EPA is counting on the ingenuity of American industry to produce future generations of this technology." In fact, a number of major waste management companies have now indicated that they are interested in building similar units.

Scientific data, reports, and permit materials relating to the mobile incinerator are available on request from James Yezzi, U.S. EPA, Releases Control Branch, Woodbridge Avenue, Edison, N.J. 08837. □

*(Tejada is Associate Editor of the EPA Journal.)*

# Lasers Help Unravel Air Pollution Mysteries

by Donald T. Wruble



Lidar "slice" of the atmosphere above a Southern California mountain range. Darker portions show areas of greater particle density.

Curt Edmonds, EPA computer electronics engineer, examines video display of airborne lidar collection technique.

Lasers are helping EPA unravel the mysteries of air pollution. They not only help scientists describe the pollutants in the air you breathe, but also help determine changes in lake waters affected by acid rain produced in polluted air.

For years, a team of atmospheric scientists, optical physicists, and electronic engineers at EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nev., have been developing specialized airborne laser systems (called lidar) for studying movement of airborne particles and gases that can contribute to air pollution and acid rain.

Lidar is an acronym for Light Detection And Ranging. (Radar, developed during World War II, is an acronym for Radio Detection And Ranging.)

The principle behind each system is the same. Radar uses radio waves, and lidar uses light waves, to detect and range (measure the distance to) objects.

*Lasers not only help describe the pollutants in the air, but also help determine changes in lake waters affected by acid rain.*

Lidar enables detection and ranging of very small objects such as airborne particles, rather than large objects such as the airplanes and speeding automobiles that are detected by radar.

For air pollution monitoring, a very short burst of a laser light is beamed through a smokestack plume or through the air above a city. As the pulse of light travels through the air, particles of dust, smoke, and gas molecules absorb and scatter the light. A portion of the light pulse is scattered directly back to a telescope. The telescope, pointed along the laser light beam path, focuses the scattered light on electronic detectors. The detectors convert the scattering intensity into a "picture" of the air contaminants the beam has encountered.

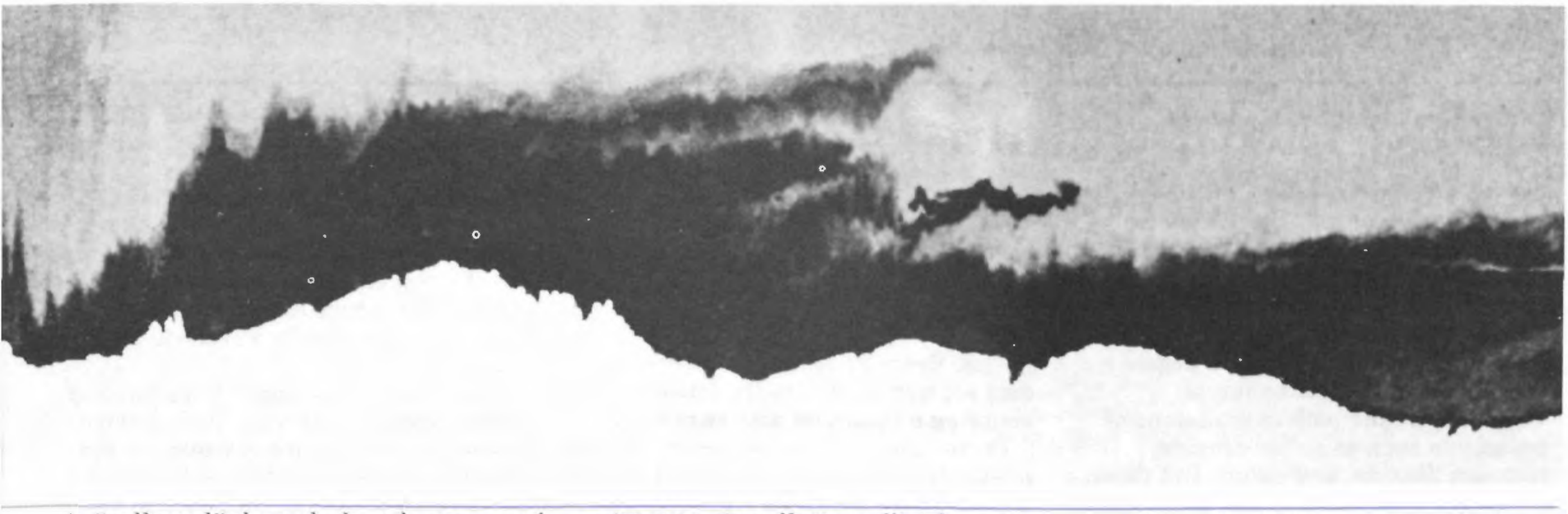
Various government, university, and private groups around the world are using ground-based lidar to conduct air pollution research. EPA is one of the few organizations to use airborne lidar. (Only two other groups in the United States employ such systems. SRI International operates an airborne system for various public and private organizations, including the Electric Power Resources Institute. The National Aeronautics and Space Administration (NASA) conducts research to develop lidar systems for global air monitoring from satellites.)

The EPA airborne lidars are dedicated to research studies to help EPA and the states understand the sources, chemical and physical transformation, and transport processes of air pollutants. The research data are used to develop pollution-control plans as well as add to our understanding of air pollution.

During operation of the EPA lidar, every second or two a laser emits extremely short pulses of light (lasting 17 billionths of a second) toward the ground through a hole cut in an airplane floor. The beam spreads out as it travels downward to ensure that the laser light energy at ground level will not cause eye damage to an observer who might be looking straight up at that instant.

As each short pulse of the laser beam light travels downward, the amount of particulates or gases the light pulse encounters affects the degree of absorption or scatter. When the beam strikes the ground, an even greater portion is reflected back to the aircraft. The light that travels back to the aircraft

(Wruble is Director of the Advanced Monitoring Systems Division at EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nev.)



is "collected" through the telescope, and the beam intensity and time-for-return are measured continuously with a complex ultra-high speed electronics system.

Since light travels at about 186,000 miles per second, super-fast electronics and onboard computers are required to differentiate how long a portion of the beam traveled outside the aircraft and to determine how far from the aircraft a given group of scattering particles were encountered by the beam. This system was developed by EPA engineers and computer scientists to enable handling the immense amount of electronic data produced at "the speed of light." In the airplane cabin, the electronic results of each laser pulse are displayed side-by-side on a video screen. The operators see a "slice" of atmosphere showing lighter and darker areas that portray particle or gas concentration and distribution below the aircraft.

Without this system, an armada of airplanes flying simultaneously at various altitudes collecting air samples one after another could only begin to collect a comparable number of air samples to describe the aerosol distribution, not to mention the years of laboratory analysis that would be required to determine the sample constituents. With the airborne lidar, all this is accomplished within a few micro-seconds. Multiple flight paths across an urban or regional area can produce data that describe the transport and transformation of particles and gases found in that atmosphere.

Importantly, the data provide an extensive three-dimensional picture of an air mass, not just an estimate such as would be gathered with only ground sampling stations and weather information. The "slices" can be studied either visually or with much greater sophistication using computer analysis techniques. In this manner, EPA scientists develop detailed mathematical models of air pollutant transport over mountains, cities, and countryside, or assist state air pollution officials in air pollution control planning.

Research studies in 1985 include:

- Mapping smoke plume from burning rice fields in the Sacramento Valley of California. After harvest, the rice fields are burned to prepare them for the next crop. This burn-off can create extensive smoke through a large area. Understanding smoke transport paths in different weather conditions enables farmers to plan burning periods during weather that will carry most of the smoke away from residents in the area.

- Mapping particulates associated with photochemical oxidants in air over Ventura and Santa Barbara counties in California. Lidar mapping allows assessment of the contribution of hydrocarbon gases from offshore oil drilling to onshore air pollution. Understanding the amount of pollution from this source versus pollutants from automobile exhausts is important for air pollution control planning.

- Mapping transport and diffusion of airborne particles in the Midwest (Kentucky, Ohio, Indiana). Tracking these manmade particles helps EPA meteorologists develop mathematical models describing movement of air contaminants that may combine with moisture to create acid rain.

In order to study acid rain origins from air pollutants, scientists at the Las Vegas laboratory are working on the next generation lidar, called an ultraviolet differential absorption lidar. This lidar will use a new technology laser, called an excimer laser. NASA scientists are cooperating in this development which will enable simultaneous measurements of ozone and sulfur dioxide, as well as particulate aerosols in the atmosphere.

Dr. Jim McElroy, who heads the laboratory's lidar research program, is enthusiastic about the use of lidar to help answer many of the research questions about air masses producing acid deposition. "We have an opportunity to capitalize on a space age technology development and apply it to an environmental problem that can affect us all. Airborne lidar can help us locate sources of air pollutants leading to acid rain, help us follow pollutant paths across the country, and help us understand the air flow patterns that determine areas of lakes and forests that are affected."

*We have an opportunity to capitalize on a space age technology development and apply it to an environmental problem that can affect us all.*

Airborne lasers can be used to test lake waters for changes resulting from acid rain. Dr. Mike Bristow, an optical physicist at the Las Vegas laboratory, has pioneered development of an airborne laser fluorosensor. This system uses different laser wavelengths that create fluorescent light when the beam strikes dissolved matter in water in lakes below the aircraft. This fluorescent light travels back to the aircraft to be electronically processed in a similar fashion to that of the lidar. As the aircraft flies several paths across the lake, the distribution of dissolved organic material across the lake is mapped. These and other data are computerized to assess acidity changes.

Dr. Bristow is working with Cornell University scientists who have made recent discoveries in spectral analysis of laser fluorescence using laboratory water samples. By marrying this technique to EPA's airborne laser fluorosensor, Dr. Bristow hopes to equip EPA with an advanced technology system for monitoring acid rain impact on lakes across the United States. □

# Using Computers to Isolate Pollution Causes

by Karen Randolph

About 20 years ago, people began noticing a deterioration of vegetation in the path of emissions of pollutants such as sulfur dioxide, nitrogen dioxide, and ozone. But these emissions were only a few among scores of variables that could be causing the damage. How to isolate the real culprits?

At EPA's Environmental Research Laboratory in Corvallis, Ore., answering this question is a major priority. Four years ago, the scientists there set out to design a system that would enable them to study plant responses under realistic air quality conditions. The result of their efforts is not only a sophisticated facility of plant growth chambers, greenhouses, and outdoor exposure chambers, but also a state-of-the-art computerized process control technology.

Thanks to their computer, the Corvallis scientists can go beyond the constraints of the 9 to 5, Monday to Friday work week to achieve continuous control and monitoring of environmental conditions in exposure chambers. Where once it took years of tedious observation to accumulate data under different growing conditions, they can now experiment with several variables simultaneously. And because the computer can dispense and control hourly concentrations of pollutants so precisely, scientists can also enter actual ambient site data from specific geographic regions to reproduce real-world conditions in the exposure chambers.

In studying plant response to ozone, for example, scientists use ozone data obtained from actual sites. The computer is programmed to replicate the hourly ozone concentrations over 30 days. Sample air lines feed back into monitors, providing continuous reading and adjustment of pollutant concentrations delivered to each chamber. Sensors in the chambers also feed back data on light, air, soil temperatures, and relative humidity. These data are displayed so that operators can monitor each chamber at a glance. Every 24 hours, the collected data are transmitted to the laboratory's mainframe computer and printed out.

During the first year of operation, the scientists looked at the effects of ozone on two important forage crops: alfalfa and tall fescue. Using exposure schedules based on air-quality data from a midwestern hay-producing state, they tested response under two conditions. One delivered ozone in varying peaks, frequencies, and durations; the other provided it in a consistent pattern. Throughout the growing season, plants in both groups were exposed to equal amounts of ozone.

In both groups, alfalfa growth decreased as ozone levels increased. But varying ozone concentrations reduced growth more than did consistent concentrations. Tall fescue, however, was only slightly affected under both conditions. Experiments last year with timothy hay showed the same response as the alfalfa studies: reduced growth associated with varying ozone levels.

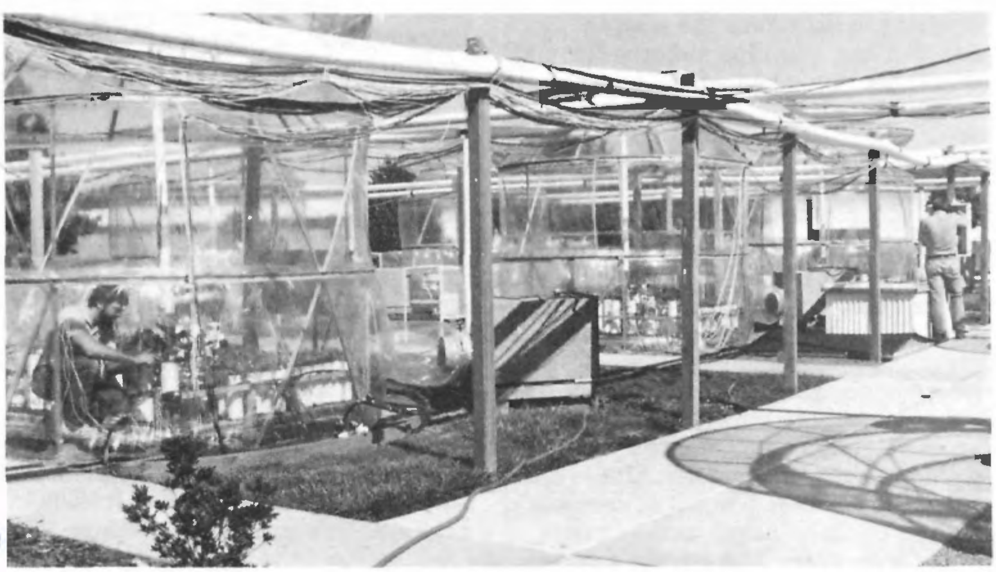
Another experiment involves the interactions of water stress and ozone on bush beans. Using different patterns of soil moisture and irrigation schedules, Corvallis scientists have found a pattern indicating that, under drought conditions, ozone does not affect plant growth as severely as it does under other conditions. Even short periods of drought, however, do reduce plant yields.

The lab also has begun a cooperative project with the National Park Service to study the influence of ozone on the growth of lodgepole and slash pine. By using realistic concentrations in their experiments, scientists hope to predict the effects of air pollutants as urbanization encroaches into wilderness areas.

Although there are other computerized systems to control pollutant delivery in experiments, the Corvallis system is unique in its ability to deliver realistic exposures, its reliability, and its track record for producing voluminous amounts of error-free data. Except for programming and quality-control checks, the system basically runs itself. It provides precise delivery and control, and is readily adaptable to changing research needs. And it doesn't take a computer specialist to operate it. Even student employees can monitor operations.

The Corvallis system was a prototype when it went on-line in 1982. Now, it's even faster and more accurate, handling ever more sophisticated studies. Computer technology has reduced the cost of data collection, increased the range of experimental control, and vastly extended the calculations that were possible back when scientists were limited to physical observations and a clipboard. □

*These field exposure chambers at EPA's lab in Corvallis, Ore., are designed to mimic natural air pollution conditions. Through computers, scientists deliver specific amounts of pollutants to the chambers, and study the effects of the pollutants on the controlled environment.*



(Randolph is Technical Information Manager at EPA's Environmental Research Laboratory in Corvallis, Ore.)

# A Compact to Track Down Waste Dumping Cheaters

by David Pickman

The greatest obstacles in the path of safe and economical waste management are the "waste cheats" who dump hazardous waste in city sewers or in convenient swamps which eventually poison water supplies. Some cheats are deliberate, but many are cheating from ignorance. According to EPA Regional Administrator Michael R. Deland, "Relentless tightening of regulations and computer storage of information by state governments are closing in on the deliberate cheats, and education is bringing the others into the system. In New England, it's a regional effort."

The Resource Conservation and Recovery Act (RCRA) was designed to provide cradle-to-grave security for hazardous waste. As most recently amended, it requires manifesting of waste shipments by all generators of 100 kilograms (220 pounds) or more of hazardous waste per month. Shipments must be accompanied by a manifest giving the name, address, and EPA identification number of the generator, transporter, and receiving facility. The law requires the generator to report to the state or EPA if the signed manifest is not returned within 45 days.

The six New England states have gone a step further in a regional compact designed both to track down the waste cheat and to give waste managers in government and industry the data base they need to plan the future. When the final RCRA hazardous waste regulations were just beginning to take effect in 1981, the New England Regional Commission (later absorbed by the New England Governors Conference) devised a uniform manifest for the six states and their western neighbor, New York. The system was in place in 1982 and needed only minor adjustment when EPA came up with its uniform manifest in September 1984.

*(Pickman is on the staff of the Office of Public Affairs of EPA Region 1.)*

The idea of a single computer and seven terminals was seriously proposed, discussed and debated, and eventually rejected for lack of agreement on where the computer would reside. The five computer systems now in existence are compatible, although operated independently by Connecticut, Massachusetts, New Hampshire, New York and Maine (which runs a three-state system for itself, Rhode Island, and Vermont). The three states in the Maine system comprise about 20 percent of the New England population of 12 million.

"When the New England states began to adopt programs so as to receive RCRA authorization, they recognized that this region was unique in its heavy reliance on out-of-region disposal facilities," says Mel Hohman, Director of Region 1's Waste Management Division. "The fact that a large portion of the waste is transported long distances and through multiple state jurisdictions led our states to focus on the need for tighter controls. Hence, a load-by-load tracking system was developed.

Unlike the national regulations, the state rules require that manifest copies be sent to the states when waste is shipped and again when it is received at the licensed facility. If waste is shipped first to storage and then to permanent disposal, the state gets two copies of each of two manifests.

Manifest forms are numbered so that the copies are easily matched and disappearance or destruction of a manifest is easily detected by the computers. If the receiver's copy does not join the generator's copy in a reasonable time, the computer "sends" an inspector to investigate.

Officials report sharp increases in reported "deficiencies" since the computerized system went into effect. Previously, many generators simply forgot about shipments once they were off the premises, and there was no check on transporters who might dump

*The "milk run" pickups cost about 20 percent of what a dry cleaner has to pay for independent waste hauling.*

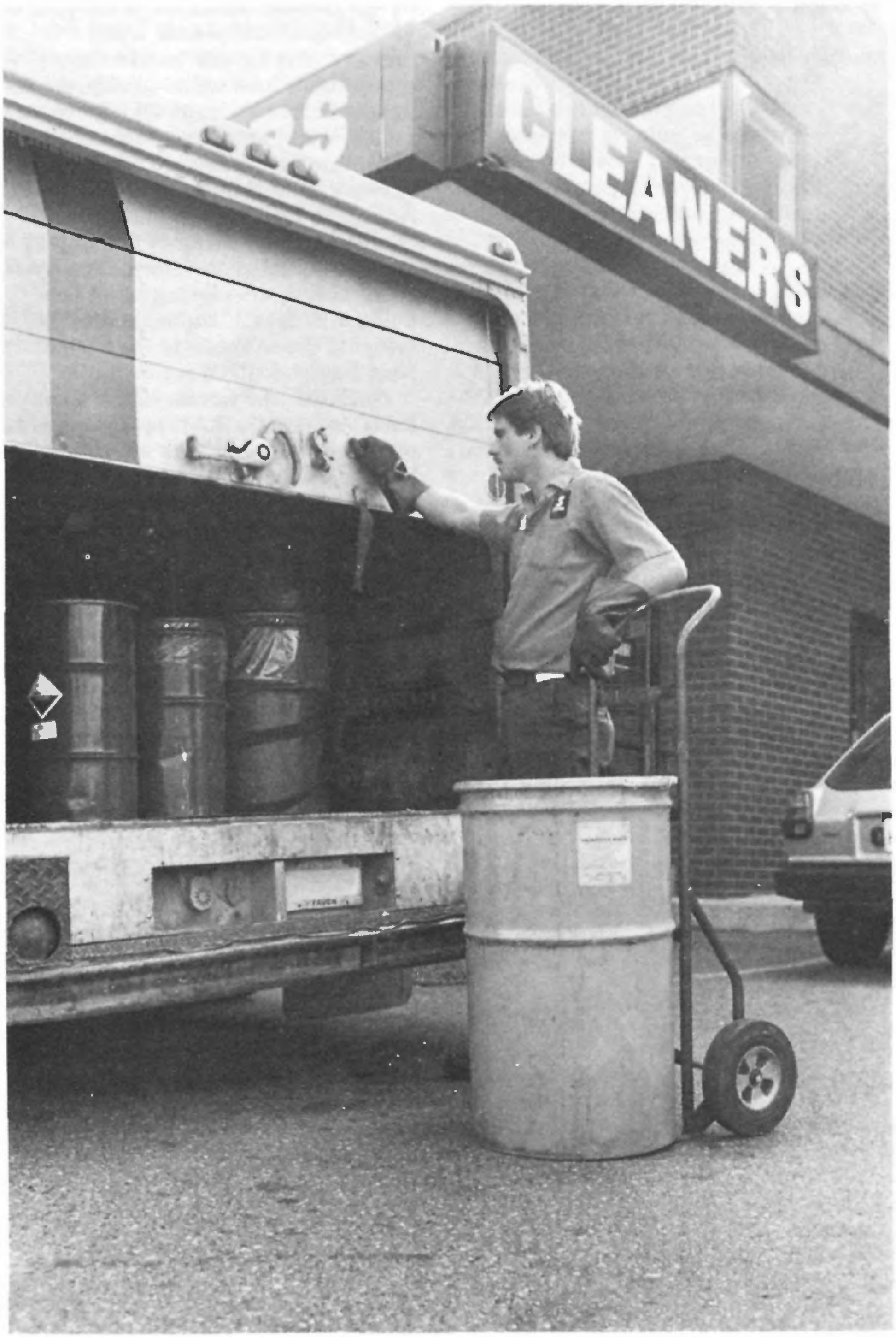
illegally. Numbered manifests and mandatory copies fed into the computer speed the detection of error and fraud.

"Under our system of load-by-load tracking," says Steven DeGabriele, deputy director of hazardous waste licensing and enforcement in the Massachusetts Department of Environmental Quality Engineering, "it would take a conspiracy of generator, shipper, and facility operator to beat the system. Once the generator has sent us a manifest, we lock onto that shipment until it reaches its final treatment or disposal site."

"Computerized load tracking is an excellent weapon against the waste cheat, provided the cheat is in the system," explains Andrew Lauterback, specialist in criminal cases in EPA's Office of Regional Counsel in Boston. "There is no automatic protection against the company that has never notified EPA that it is generating hazardous waste, has no identification number, and disposes of its waste on company property."

A high priority in each of the states is to identify these non-notifiers who are not yet "in the system." To do this, regulators are cross-checking manifest data with other data sources, including other environmental permits. States also are issuing lists of generators by community. Alert citizens and officials in these communities will be on the lookout for companies operating in their towns who are not on the generator lists.

State and federal statutes call for fines and prison terms for violation of hazardous waste regulations. Massachusetts, which produces about half the waste in the region, recently passed legislation authorizing administrative fines of up to $25,000 per day for violation of a variety of environmental regulations. But not all non-notifiers are consciously breaking the law, especially those small quantity generators who have only recently come




Steve Delaney

*At a dry cleaning shop, a driver from the Safety Kleen Corp. picks up waste fluids for recycling. Under a program initiated by the International Fabricare Assn. and implemented by Northeast Fabricare Assn., about 60 percent of dry cleaners in New England and New York use this waste management service.*

*States believe they can steer the largest quantity of waste into safe disposal by a judicious blend of education, hand holding, and enforcement.*

under federal regulation.

The states are not relying exclusively on enforcement at this stage. The goal is to educate dry cleaners (chlorinated hydrocarbons), auto body shops (paint removers and solvents), paint shops (paint waste), and other small enterprises. Printed instructions on waste identification, the use of the manifest, and the penalties for mismanagement are being mailed to thousands of small businesses. Seminars are planned. Slide tapes will be produced and circulated to trade associations. EPA has provided about $300,000 in grants to states for outreach to small generators. EPA's Hohman warned against underplaying enforcement. "It is the responsibility of industry large and small to comply with the regulations. If they cannot, they should ask EPA or the state for advice and direction. Non-compliers will be identified and enforcement action will be taken."

Trade associations have taken steps to bring their members into compliance. Northeast Fabricare Association organized a New England-New York "milk run" for dry cleaners. Safety Kleen Corporation of Elgin, Ill., picks up the waste cleaning fluids, helps the generators fill out manifests, hauls the waste to a recycling plant, and delivers the recycled product to many of the same customers. The "milk run" pickups cost about 20 percent of what a dry cleaner has to pay for independent waste hauling.

Only about 60 percent of the New England-New York dry cleaners are on the "milk run," according to Fabricare, because the minimum pickup has been three 55-gallon drums a year. Safety Kleen has now agreed to include all interested cleaning shops, and participation is expected to rise sharply.

Safety Kleen is also working with the states to bring more auto body shops into the system. Like dry cleaners, auto body shops produce fairly uniform and consistent waste which, if properly managed, can be recycled with a minimum of waste analysis and separation of incompatible substances. As with the dry cleaners, the object is to help with the paper work and cut costs for the proprietors.

The states have stressed education —the helpful approach—rather than total reliance on enforcement. Flagrant violations have been penalized, sometimes with fines of more than $20,000, but many violations are routine and result in notices of violation in which the generators are instructed in correct internal procedures to avoid future slip-ups. Every effort is made to communicate with generators through their trade associations and trade publications. The states agree that this will yield more returns at this stage than all-out enforcement against routine violations.

Enforcement is time-consuming. Even with administrative penalties that bypass court action, there is a lot of paper work. States believe they can steer the largest quantity of waste into safe disposal by a judicious blend of education, hand holding, and enforcement.

Russell Sylva, Commissioner of the Massachusetts Department of Environmental Quality Engineering, told an inquiring State Senate committee that waste load tracking was not primarily an enforcement tool, but was being used to "identify patterns of hazardous waste management." He added that compliance was at a high level. "We are finally seeing most of the large quantity generators come into compliance" and "we are now able to focus more resources on small quantity generators."

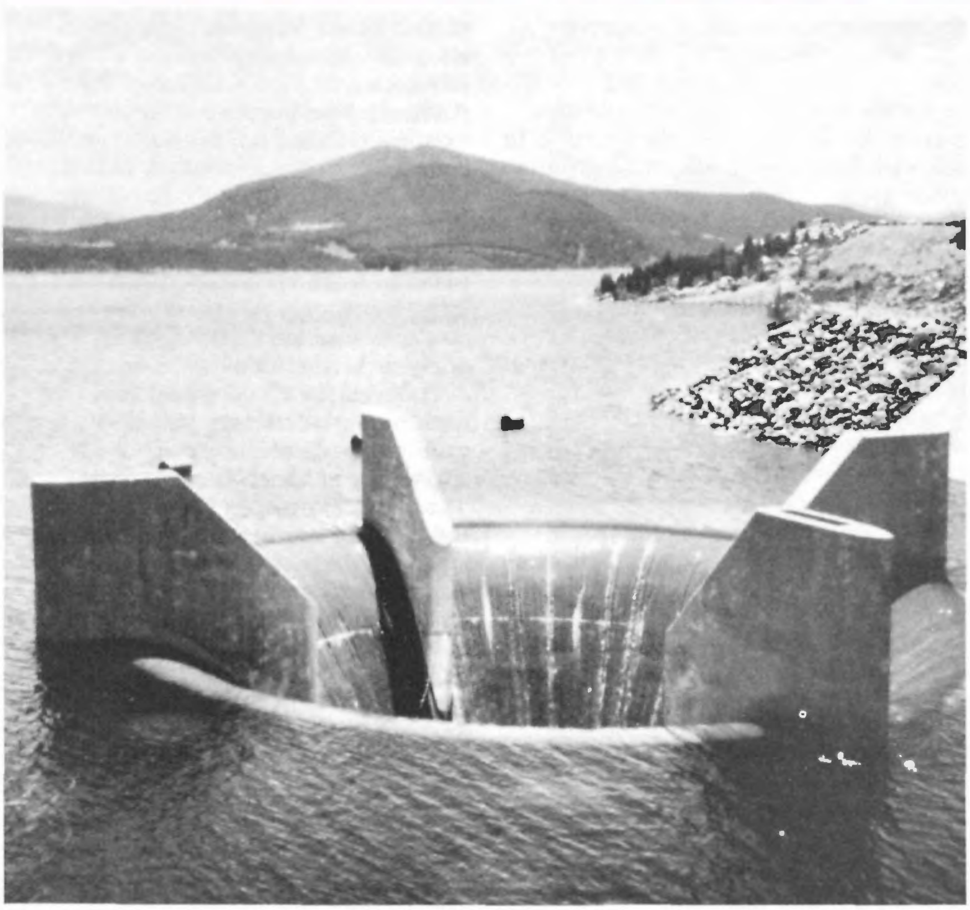
EPA is also interested in studying these patterns of hazardous waste management. Given the relatively strong data base in Region 1, the agency's Integrated Environmental Management Division (IEMD) is running a pilot project there. Regional data have been entered into a computerized model developed by EPA's Office of Policy Analysis. The purpose is to correlate existing information on waste volumes, constituents, transportation routes, waste management facilities, exposure probabilities, populations, and potential health and environmental effects. IEMD plans to work with state, local, and industry representatives to formulate waste management strategies for analysis by the model.

The model will calculate costs for each potential strategy and indicate each strategy's relative impact on regional waste management systems. The states are particularly interested in the model's use in demonstrating the need for waste management facilities. The region has no integrated waste treatment, storage, and disposal facility and depends heavily on out-of-region facilities. It is hoped that the pilot project will help the states and the New England Congressional Institute develop a truly regional waste management system with the right balance of waste reduction by industry, solvent recovery, incineration, chemical and physical treatment and, last and preferably least, land disposal.

Whatever success is achieved will be dependent on the region's wasteload tracking systems and the detailed information the states provide on the intricacies of the problem and the viability of various management strategies. The presence of an adequate waste management system in the region would also reduce the cost to the individual generator and, with it, the temptation to cheat. □

# Speeding Water Cleanup While Saving Money

by John Jaksch
and Diane Niedzialkowski


Northwest Colorado Council of Governments

Water pours into an overflow structure in the Dillon Reservoir. Colorado's Tenmile Range is in the background

(Jaksch and Niedzialkowski are on the Regulatory Reform staff of the Office of Policy, Planning, and Evaluation in EPA.)

A new approach that will speed surface water cleanup while saving local governments millions of dollars annually has been introduced in Colorado. The approach allows wastewater treatment plants to use low-technology treatment systems on runoff (nonpoint) pollution in lieu of expensive additional advanced controls on their own pipes or point sources. This "pollution reduction trading" at Dillon Reservoir is the first of its type in the nation.

While the concept of trading is not new, its application to point-nonpoint control of water pollution sources represents a significant innovation. The Clean Water Act envisions pollution control for both wastewater and industrial (point) sources, as well as streets, farms, and other runoff (nonpoint) sources. But nonpoint sources are not regulated at the federal level, and the two types of sources are rarely addressed by a coordinated program. The Act created an elaborate permit system with detailed effluent limits and enforcement provisions for the more obvious point sources, which have received most regulatory attention to date. However, the Act provides little detail and depends largely on local efforts for control of nonpoint sources. These less well defined runoff sources are becoming at least as important as industrial and municipal dischargers in many areas, including the Dillon Reservoir.

Dillon Reservoir is one of Denver's primary drinking water supplies, as well as the focal point for Summit County's ski- and recreation-based economy. Summit is one of the fastest growing counties in the nation, with a permanent population of 10,000 and a peak population exceeding 60,000 during the winter. This popularity could have been Dillon's downfall. By 1982, its deep blue color regularly changed to green as algae bloomed in summer, fed by phosphorus entering the lake from natural and human activities. Continuing population and algae growth were diminishing the lake's oxygen, threatening to cause it to become eutrophic.

Dillon has no industrial dischargers, and the four county treatment plants which discharge to the lake already use advanced techniques for removing phosphorus from sewage. A 1983 Clean Lakes Study found that continuing focus on point sources would not prevent Dillon from becoming eutrophic. Even if treatment plant discharges were reduced to zero by complex and expensive methods, nonpoint phosphorus discharges from development activities would cause continued algae growth. Control of nonpoint sources was necessary to avoid a sewer tap moratorium that would effectively freeze growth and severely restrict Summit County's booming economy.

Faced with a potential crisis, the Colorado Water Quality Control Commission asked local agencies to help develop a comprehensive management plan for addressing phosphorus pollution in the Dillon Reservoir Basin. The Northwest Colorado Council of Governments became the lead agency for what was known as the "Phosphorus Club." This consisted of representatives from the state, county, surrounding municipalities, environmental groups, local industry, and other parties with a significant stake in Dillon's water quality. The Club developed a consensus approach which took point source pollution into account, but fundamentally relied on systematic nonpoint source control to achieve water quality goals.

Several factors helped this multi-government trading approach develop and coalesce at Dillon. There were sufficient water quality data to evaluate the effects of various nonpoint source control strategies. All interested parties had continuing input. And effective, low-cost nonpoint source controls were available.

Previously, EPA's National Urban Runoff Project and other studies had indicated that low-technology "best management practices," such as settling ponds and percolation pits, could remove large amounts of phosphorus from urban runoff with far less cost, energy use, and sludge generation than advanced point source treatment. But these results had not been widely tested under real world conditions.

In 1982, the Northwest Colorado Council of Governments asked EPA to help fund and evaluate a pilot control facility at Dillon. At the pilot facility, urban runoff from an 81-acre watershed was collected in a plastic-lined basin, which overflowed into a settling pond. In eight major runoff events, this facility removed 68 percent of incoming phosphorus, at a cost of only $67 per pound removed. Available treatment plant improvements would have cost from $824 to nearly $8,000 for each pound of phosphorus removed.

The trading system ultimately developed at Dillon requires that existing nonpoint sources be controlled while phosphorus from future nonpoint sources is minimized through state-of-the-art controls. This allows for point source (and municipal) growth in the future, through compensating nonpoint source control. Dillon's phosphorus control strategy has five major elements:

- 1982 levels of phosphorus were set as the water quality target for Dillon. Each municipal sewage treatment plant was given a share of the available load, providing a "growth margin" through 1990.
- In addition to installing state-of-the-art phosphorus controls, new developments must contribute to a Nonpoint Source Facilities Investment Fund, which will be used to construct controls for pre-1984 nonpoint sources and help finance administration of the trading program;
- A "trading ratio" of 2:1 was established to assure environmental progress. For each pound of phosphorus a treatment plant is allowed to discharge above 1982 levels, two pounds of phosphorus must be removed from a nonpoint source existing before 1984;
- Both point and nonpoint dischargers receive Clean Water Act permits which define their phosphorus limits and their responsibilities for maintaining nonpoint source control devices. Failure to operate and maintain the devices will result in direct federal or state enforcement action.
- The Summit County Water Quality Committee was established to monitor the trading program and provide long-term water quality management.

The State of Colorado held public hearings on Dillon's proposed trading plan in May, 1984, and formally approved the plan in June, 1984. With approval by EPA Region 8 the next month, Dillon Reservoir became the first operating point/nonpoint source trading system in the United States.

Can this trading approach be used for other locations and types of nonpoint source pollution? Is Dillon unique? The quality of virtually all lakes is controlled by a delicate balance of nutrients such as phosphorus. Many coastal rivers and bays are also affected by phosphorus pollution. Trading offers potential control of nutrient pollution on all such water bodies, in ways which are non-intrusive, save tax dollars, and allow regulatory programs to operate more smoothly.

While trading shows great promise, Dillon left several questions unanswered. For example, will trading work on free-flowing streams or estuaries rather than lakes or bays, or for other nonpoint sources such as farms? Can the frameworks developed at Dillon be adapted to other locations? Will other types of nonpoint source control prove as cost-effective?

EPA headquarters, together with EPA Region 3 and the states of Pennsylvania, Maryland, and Virginia, is currently examining application of "Dillon type" approaches to the Chesapeake Bay, which has a major nonpoint source phosphorus problem due to agricultural and other activity in its stream drainages. In addition, EPA is looking for other sites where trading may apply, and which can also help answer these questions. □

# How Chemicals Can Cause Cancer

by Ronald W. Hart
and Angelo Turturro


Steve Delaney

That the average lifespan of humans has increased, there can be no doubt. Even in our lifetime, the improvement of public sanitation, reduction in famine (current conditions in Africa notwithstanding), and control of infectious diseases have contributed to an increase in average longevity worldwide. There is little doubt that our increased, and relatively newfound, scientific knowledge of the genetic differences in, and the biochemical complexities of man also have played an important role.

*We all make daily contact with a considerable number and variety of chemicals, many of which are known carcinogens.*

Attendant to this newfound knowledge is an increasing awareness and concern about the possible adverse effects of our exposure to chemicals—adverse effects like the production of cancer, or carcinogenesis.

No matter who we are, no matter what our station in life, no matter where we live, we all make daily contact with a considerable number and variety of chemicals, many of which are known carcinogens, others only suspected as being carcinogenic. Some occur naturally in the food we eat, some are a result of our lifestyles, some are manmade products which have benefits desired by members of our society, and some represent naturally produced compounds found in molds, fungus, and other plants and animal species.

Educated estimates indicate that there now may be more than 65,000 manmade chemicals in everyday use. Our food contains tens of thousands of natural, or "wild," chemicals which help comprise the flavor, aroma, or nutritional value of our daily fare.

(Dr. Hart is Director of the National Center for Toxicological Research and Dr. Turturro is a biologist at the Center.)

It would seem, then, that most of us face a risk. Just how great a carcinogenic threat do we face? How much do we really know? How great a risk really exists?

Because of important recent scientific gains, a clearer picture of how chemicals can induce cancer is emerging. Now it can reasonably be determined what interaction takes place between an organism and a chemical that causes cells to proliferate in an uncontrolled fashion (cancer) rather than in an orderly and controlled manner.

It's known that there are four methods by which an individual may be exposed to a potentially carcinogenic chemical: ingestion, inhalation, contact with the skin, or through normal body metabolism. It's also known that for many substances to become carcinogenic, they must either proceed through several steps or significantly modify one or more of those steps.

For those chemicals that act by inducing a series of events, such as the classical chemical carcinogens, each step appears to act as a particle filter. The probabilities that exposures to such carcinogens will induce the needed event at each step is low and is reduced by the operation of such filters. Now we can see that with the probabilities of progression reduced, so are one's chances of getting cancer, particularly when we realize that these chances also seem to be a function of the many physiological and environmental variables of the person involved. Clearly, these factors alone vary widely with each individual.

With all these "probabilities," "variables," and "chances," then, it might seem that we have very few hard facts about the disease. In fact, we have considerable information, so that now many "probabilities" have become known values, "variables" have become reduced in scope, and "chances" have become more predictable.

Essentially, and for purposes of illustration, one can conceive of seven steps by which substances can interact with an organism to induce cancer. Each of these steps can be influenced by several factors along the way, factors such as nutrition, route of exposure (ingestion, inhalation, skin contact, or a combination of these), and individual physiological factors. Other agents can act at different steps, at different times, and with varying degrees of impact and can thus increase the number of tumors observed or shorten the time to occurrence of cancer.

*Because of important recent scientific gains, a clearer picture of how chemicals can induce cancer is emerging.*

In the first step, there is the alteration of the agent at some surface of an organism by processes which occur at the surface. For example, we know there are microorganisms, called microflora, normally present in our intestines which aid digestion. We know, too, that certain substances can be altered by these microflora; that is, certain dyes

*Lifestyles, say the authors of this article, can be important contributors to cancer. Cigarette smoking, alcohol, and high fat diets have all been shown to induce cancer.*

can be altered chemically from innocuous chemicals to active carcinogens, or vice versa. This alteration is a natural phenomenon and occurs in each of us.

The second step is the actual penetration of the substance and the process of storage and distribution of the potential carcinogen in the body. This step involves the breaking down of this agent by normal organ functions (metabolism) and the distribution of the metabolized agent to other body parts or its elimination as waste. The metabolic process is complex, basic to life, and occurs throughout the body. The liver plays one of the most dynamic roles in overall body metabolism. It can detoxify some chemicals or metabolize others into a highly reactive state. As mentioned, however, metabolism does occur in other parts of the body, and the whole body must be considered when attempting to understand the processes of carcinogenesis.

Step three involves further metabolism, but now the substance is at the tissue and cell level, having "successfully" transcended the organism level of step two. Frequently, and because both steps involve metabolism, some scientists prefer to make no distinction between organ metabolism and tissue/cell metabolism.

With some substances, and during the process of organism or tissue/cell metabolism, there is often formed a compound called metabolite. This metabolite, in some cases, can be related directly to the ability of an agent to induce certain kinds of cancer. We know that some metabolites are highly potent. This condition of potency, when it occurs, is called "activation." By the same token, however, activated metabolites can just as suddenly be triggered into a state of deactivation, then reactivated again by other metabolic processes. Therefore, the ultimate effect is the sum of activation, deactivation, and reactivation.

Step four in the process of altering substances towards carcinogenicity involves that agent's interaction with DNA. DNA has been described, and rightly so, as one of major building blocks of life, and is considered the molecular basis of heredity in many organisms— thus, any alteration of it would be of major consequence to the physical well-being of an individual.

The DNA molecule is a double helix composed of nitrogenous bases, sugars, and phosphate groups. If a carcinogen attaches itself to a component of the spiral, it can distort the shape of the spiral; the genetic template provided by the DNA can then be misread, producing mistakes that could allow cells either to proliferate wildly or trigger the replication of cells that are altered. Distortion to the DNA molecule also can cause irreparable damage to chromosomes.

If a chemical acts by affecting the DNA, it must face step five, the DNA's "protective maintenance program." Step five consists of DNA repair, the ability of DNA to fix any induced change and processes allowing faithful cell replication. This capacity protects the integrity of the "genome," the genome being a term for the total DNA in a cell nucleus.

Breaching any of the protective barriers in step five greatly increases the chances of the substance becoming carcinogenic.

The sixth step is promotion. There is a widely accepted theory that some types of carcinogenesis involve a two-stage phenomenon. The theory states that in the first stage, certain substances called "initiators" attack healthy cells and initiate irreversible damage. While these initiated cells may be damaged and vulnerable, they are not yet cancerous. Initiated cells are like time bombs, ready to explode into cancer if conditions become right. Thus, a damaged initiated cell could remain dormant indefinitely. However, the initiated cell can be triggered suddenly into a cancerous condition by exposure to another substance called a "promoter." Some carcinogens appear to have the capacity to act as both initiator and promoter.

Promotion, then, is the ability of the carcinogen to stimulate cells into deviant growth control or neoplasia. Promotion seems reversible in a number of systems up to a certain point, but once the cell loses effective growth control, it seems irreversibly altered and neoplastic cell proliferation can proceed.

The final step, step seven, is the alteration and progression of the neoplastic cell in acquiring more cancerous-like properties. The cells have become a cancer. Step seven, in addition to progression, also may include metastasis, which is the growth or migration of cancerous cells to different parts of the body.

***It seems the more we learn, the more there is to learn, but progress is being made.***

Despite the tremendous scientific advances made in recent years, our understanding of carcinogenesis still is spotty. We still must characterize it with countless variables and hypotheses. While some aspects have been defined sufficiently to allow us to design mathematical projections, other aspects still are only descriptions of poorly understood phenomena, and speculation still must fill the gaps where we lack hard information.

Interestingly, important advances in our understanding of chemical carcinogenesis have been achieved as a result of work done with oncogens, which are carcinogenic genetic material related to viruses. With that work comes more and more evidence that viruses, chemicals, and other factors seem to act in similar ways to induce cancer.

It seems the more we learn, the more there is to learn, but progress is being made. While many physiological, nutritional, environmental, and lifestyle factors, as well as the substance itself, can influence the formation of a cancer, we are closer now than we have ever been to determining causes with accuracy and confidence. That goes a long way toward the prevention and eventual cure of cancer. □

# Vigilance in the Deep Sea Environment

by Margherita Pryor

This summer, EPA's Office of Radiation Programs (ORP) led a team of scientists on a cruise from California to some Pacific islands. Idyllic? Not this trip. Their port of call was almost a mile under water at a disposal site about 40 miles southwest of San Francisco . . . pitch dark, icy cold, subject to pressures of thousands of pounds per square inch, and, incidentally, home to the largest congregation of Great White sharks in U.S. waters.

The bleak Farallon Islands area is a bird refuge. Until 1954, it was also a an ocean disposal site for low-level radioactive waste, and scattered over the sea floor are about 3500 steel drums, dating back over 30 years.

Since 1974, ORP has monitored this disposal area on several occasions. Last June, ORP again directed an underwater survey of the site. Using a U.S. Navy state-of-the art deep submergence vessel and a highly sophisticated satellite navigation system, 11 specialists descended 900 meters (3,387 ft.) to observe conditions and take samples of sediment and marine organisms.

Did they find two-headed fish? Glow-in-the-dark tube worms?

No way, according to Bob Dyer of ORP and head of the scientific expedition. As in previous surveys at the Islands, there appeared to be no adverse impacts to either man or the marine environment from these early disposal operations; the surveyors found the normal complement of marine organisms at those depths and conditions. They also found, with the help of direct observations from the submersible, that over time, some of the drums have produced an artificial reef effect. Several species of marine organisms have attached themselves to the drums or established residence in the immediate drum areas.

Submersibles have radically improved our ability to study deep sea environments. Manipulator arms and cameras can provide immediate and accurate information, and the new generation of manned "mini-submarines" allows scientists to observe marine conditions and organisms as they really are. "There's no better way," says Dyer, "to get that far down and see what's actually happening." □

*(Pryor is Contributing Editor of EPA Journal.)*

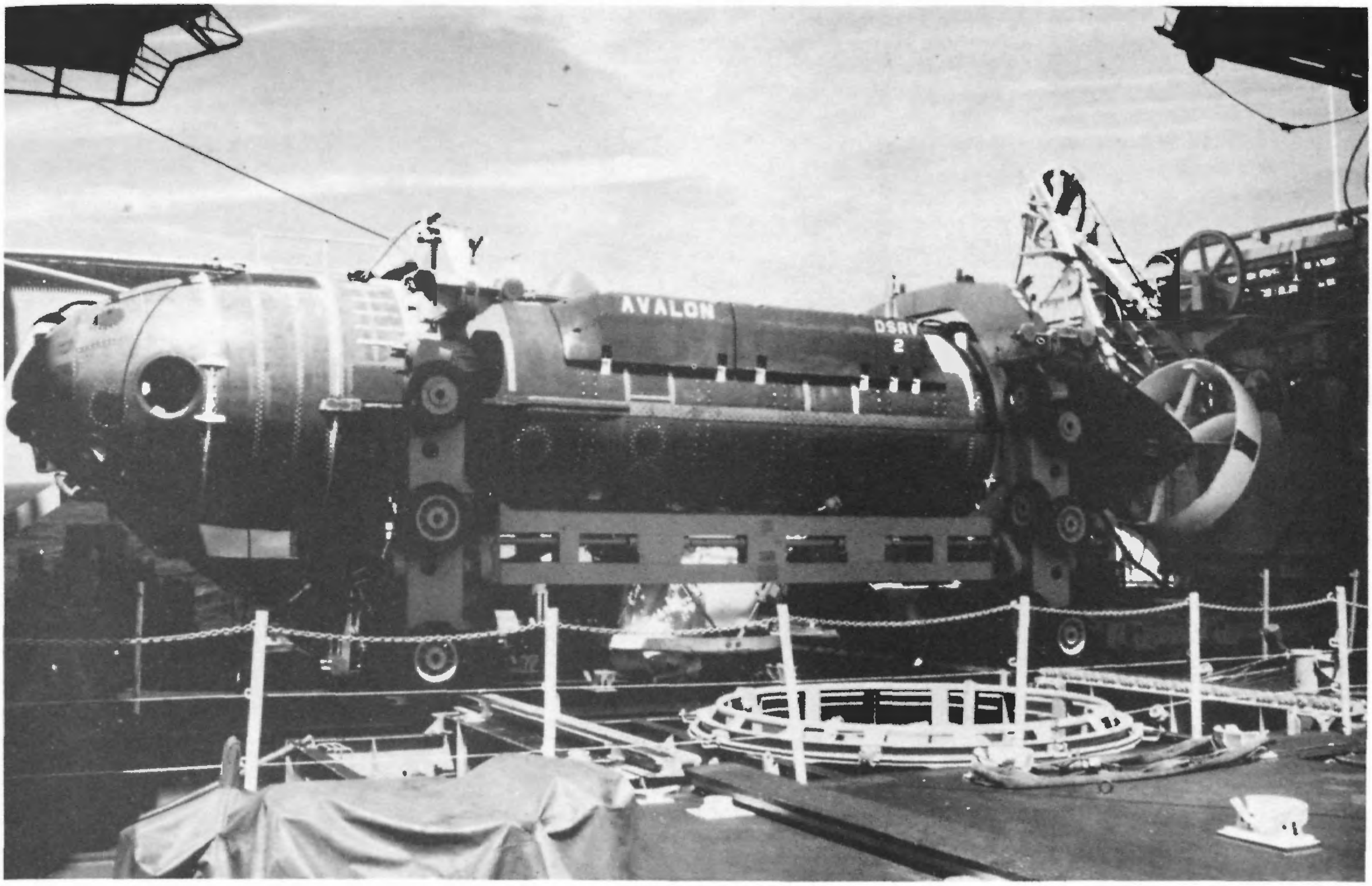
*Members of the scientific team and Navy support crew. From top left to bottom right: Dan Gotshall, California Department of Fish and Game; Ray Kissane, DSRV Avalon; Jim Gant, DSRV Avalon; Bill Pigg, DSRV Avalon; Deborah Penry, University of Washington, School of Oceanography; Mike Patricola, DSRV Avalon; Bob Dyer, EPA; Pete Colombo, Brookhaven National Laboratory; Sam Kelly, Interstate Electronics Corp.; and Hal Palmer, Marine Technology Society. Not pictured: Tomio Iwamoto, California Academy of Science; Earl Weiler, Interstate Electronics Corp.; and Brian Melzian, EPA, Region 9.*


Bob Dyer

*A drum packed with low-level radioactive waste and sealed with concrete. The drum has been identified as one that was left at the site between 1951 and 1954. Although sea pressure of about 1500 pounds per square inch has molded the steel inward, the drum still appears to be intact. The large object attached at the bottom left of the drum is a marine species called a glass sponge; underneath are two orange Thornyhead fish common to the area. Low-level radioactive waste consists of items such as contaminated protective clothing, paper, and broken laboratory glassware. At the left of the photograph is the equipment used to illuminate the sea floor.*

Bob Dyer

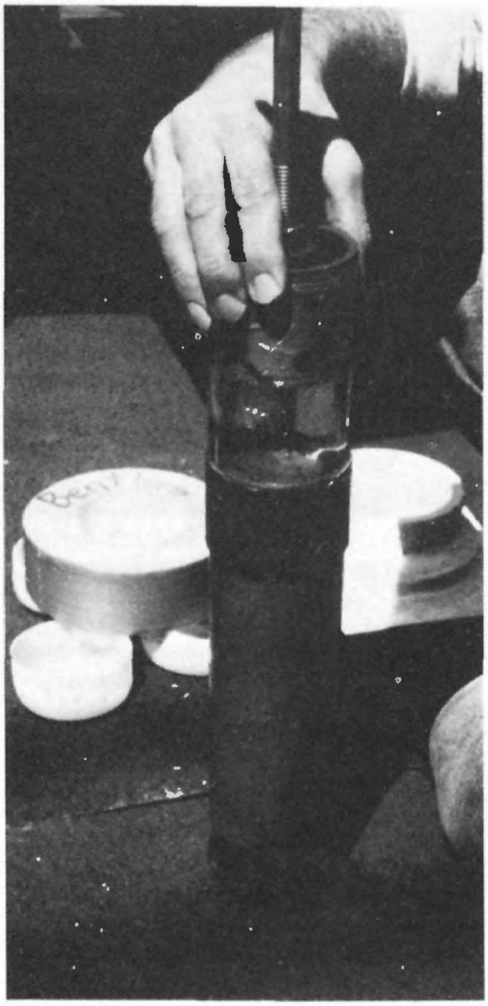
Daniel Gotshall




Daniel Gotshall

The DSRV (Deep Submergence Rescue Vehicle) Avalon on board its support ship, the U.S.S. Pigeon. EPA used the Avalon during its June survey of the Farallon Islands 900-meter disposal site. Because of its shape and color, Navy crew members refer to it as "the pickle"; a launch is called a "pickle dump." Rescue vehicles like the Avalon are much larger than typical research submersibles, carrying up to 27 passengers and crew.

Inside the Avalon's pressurized observation capsule. Observers are required to go shoeless to protect the capsule interior, even though temperatures can get as low as 40°F during a dive.



Bob Dyer

A 24-cm sediment core from 900 meters. As part of EPA's ongoing monitoring of the site, sediment samples have been sent to the Brookhaven National Laboratory, EPA's Eastern Environmental Radiation Facility, and the U.S. Army Corps of Engineers to be analyzed for geochemical properties, manmade radionuclide constituents, and the extent of burrowing activities by marine organisms. Retrieving these samples was a major goal of the expedition, along with observation of conditions at the disposal site and the drums themselves.

Hal Palmer

The Avalon being towed in to the mother ship for recovery onto the launch platform after an 8-hour dive. Unlike some other submersibles, the Avalon is not tethered to the support ship during its dives.

# Update

A review of recent major EPA activities and developments in the pollution control program areas

## AIR

### Four Substances Reviewed

The agency has announced its intent to list carbon tetrachloride as a hazardous air pollutant under the Clean Air Act.

This action triggers the development of emission standards for significant sources of this pollutant.

The agency also has completed its evaluation of manganese, chlorinated benzenes, and vinylidene chloride and has decided not to regulate these chemicals under the act at this time.

EPA has reviewed studies on carbon tetrachloride, a volatile organic liquid used in making refrigerants, pesticides, and other chemicals, and has concluded it is a probable human carcinogen. Because carbon tetrachloride is extremely stable in the atmosphere, emissions from all countries contribute to gradually increasing concentrations that can be measured virtually anywhere in the world.

### Heavy Duty Vehicle Emissions

EPA has issued final regulations allowing manufacturers of heavy-duty engines that do not have the technological capability to meet future, more stringent emission standards to pay penalties instead.

Without such a regulatory mechanism, some manufacturers unable to meet future standards might be forced out of the marketplace.

These rulemaking actions are the result of a unique process called regulatory negotiation, which allows industry, states, and public interest groups an opportunity to participate in the regulation's development through face-to-face negotiations.

## HAZARDOUS WASTE

### Small Quantity Waste Generators

Many producers of small quantities of hazardous waste will be required to send their wastes to federally approved disposal facilities starting next year, under regulations proposed by EPA.

In addition, these small quantity generators will be required to label their waste with the hazardous waste manifest form to ensure that it is sent to either an EPA or state-approved facility. This requirement and the proposed rule are both authorized under the Resource Conservation and Recovery Act.

### Liability Insurance Alternatives

The agency is considering alternatives to current requirements for third-party liability insurance that hazardous waste facility owners and operators must now have to stay in business under federal law.

Regulations published on April 16, 1982 under the Resource Conservation and Recovery Act (RCRA) require facilities to demonstrate liability insurance coverage for bodily injury and property damage to third parties resulting from both accidental sudden and nonsudden releases during the operating life of a facility.

However, such third-party liability insurance is becoming increasingly unavailable to segments of the industry. In addition, new amendments to RCRA require that all disposal facilities certify that they meet all financial responsibility requirements when submitting an application for a permit. Under the amendments, all facilities must apply for a final permit by November 8, 1985.

To respond to the dilemma posed by the growing shortage of third-party insurance available to facilities which need to certify compliance with financial responsibility requirements by November 8, EPA is considering, and seeking public comment on the advisability of, alternatives to the current requirements.

## PESTICIDES

### Continued Use of Dicofol

EPA is proposing to allow the continued use of the pesticide dicofol under certain conditions after determining that the substantial benefits of using this product outweigh the risks.

Dicofol is used to control various species of mites on cotton and citrus as well as other crops.

This announcement modified the agency's proposal in October 1984 to cancel dicofol. The earlier proposal was based on the high levels of the manufacturing impurities found in this insecticide, including DDT and the related compounds DDD, DDE, and tetrachloro-DDT (collectively known as DDTr). The agency had determined in the earlier proposal that these chemicals could result in unreasonable adverse effects on fish and aquatic bird populations, particularly certain endangered species.

In response to the earlier proposal, the registrants have indicated that the DDTr levels in technical dicofol ranging up to approximately 10 percent can be reduced in incremental stages up to 0.1 percent by July 1987. These small amounts will be indistinguishable from current background levels of DDTr and are not expected to pose any significant risk to the environment. According to agency risk estimates, these lower levels of DDTr will not cause eggshell thinning or other reproductive problems in birds or fish or otherwise represent a threat to endangered species or to the environment.

### Daminozide Notice

EPA has announced that it will be sending its Science Advisory Panel a draft notice of intent to cancel the use of daminozide, a pesticide used primarily on apples, as well as on peanuts and other fruits and vegetables. EPA is seeking the panel's review of the scientific basis for the agency's determination that lifetime exposure to food residues of this product may result in unreasonable risk to public health.

Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the agency is required to submit cancellation actions to the Science Advisory Panel for peer review before final cancellation actions are taken. The agency also will be submitting this notice to the U.S. Department of Agriculture as required by FIFRA.

## RADIATION

### High-Level Radioactive Waste

The agency has issued final standards for the management and disposal of high-level radioactive waste from both commercial and defense sources. The rules provide public health protection for future generations from radioactivity from spent nuclear reactor fuel and high-level waste products generated by atomic energy defense activities.

The standards require isolation of these nuclear wastes far from man's environment. Current national law requires they be placed in mined geologic repositories several thousand feet below the earth's surface. The standards are expected to provide the regulatory framework and public confidence necessary for the federal government to proceed in developing and demonstrating geologic repositories for disposing of these radioactive materials. □

# Appointments at EPA

## WATER

### Offshore Oil and Gas

EPA has reported that it is proposing rules to control the discharge to the ocean of substances such as drilling fluids, drill cuttings, well treatment fluids, and sanitary wastes from offshore oil and gas facilities such as platforms and drilling rigs.

The rules would govern the quality of such wastes from all existing and future facilities located offshore in the Gulf of Mexico, the Atlantic and Pacific Oceans, and Alaskan waters. Oil and gas exploration, well drilling, and oil and gas production activities are the primary operations conducted by the affected facilities.

The rules would require the nearly 4,000 existing facilities to control the amounts of oil and grease, mercury, cadmium, chlorine, floating solids, and various oils discharged to ocean waters. The requirements are based upon treatment of the wastes by the best available treatment technology. In addition, the rules would limit the toxicity of drilling fluids being discharged. These fluids are mixtures of clays, minerals, oil, special chemicals, and water used in drilling an oil or gas well.

*Jennifer Joy Manson*

*Lawrence J. Jensen*

*Michael J. Quigley*

*Timothy Fields, Jr.*

**Jennifer Joy Manson** has been nominated to the post of Assistant Administrator for EPA's Office of External Affairs. She will be responsible for managing the agency's public affairs, Congressional relations, and liaison with other federal agencies, state and local governments, and environmental and other private organizations. She will be the national program manager for dredge-and-fill oversight under Section 404 of the Clean Water Act, and will be responsible for coordination of federal facilities compliance and the Indian policy efforts of the agency's Office of Federal Activities.

Since 1975, Manson has held policy and management positions with the White House, the Virginia governor's office, the U.S. Senate, and several political campaigns. Most recently, she managed the successful re-election campaign of Senator John Warner (R.-Va.)

Manson received a B.A. in Speech from the University of North Carolina in 1974.

**Lawrence J. Jensen** has been nominated to be Assistant Administrator for EPA's Office of Water. The position includes responsibility for all of the agency's water-quality programs, including drinking water standards; the development of effluent guidelines for industrial facilities and municipal wastewater treatment plants; the construction grants program; and the protection of ground water and marine and estuarine resources.

Jensen currently is Associate Solicitor for Energy and Resources at the U.S. Department of the Interior. From October 1981 to June 1983, he served as the department's Associate Solicitor for Indian Affairs, and from 1976 to 1979, he was a trial lawyer in the Civil Division of the U.S. Department of Justice. Before coming to Washington again in 1981, Jensen was an associate with the law firm of Jones, Waldo, Holbrook and McDonough in Salt Lake City, Utah.

Jensen received a B.A. in History from the University of Utah in 1973, and earned his law degree from Brigham Young University in 1976. He is a member of the Utah State Bar.

**Michael J. Quigley** has been named Deputy Director of the agency's Office of Municipal Pollution Control in the Office of Water. His major responsibilities involve management of the construction grants program, including the development of regulations, policy, and guidance for municipal treatment facilities. Quigley had been Acting Deputy Director of the office since December 1984.

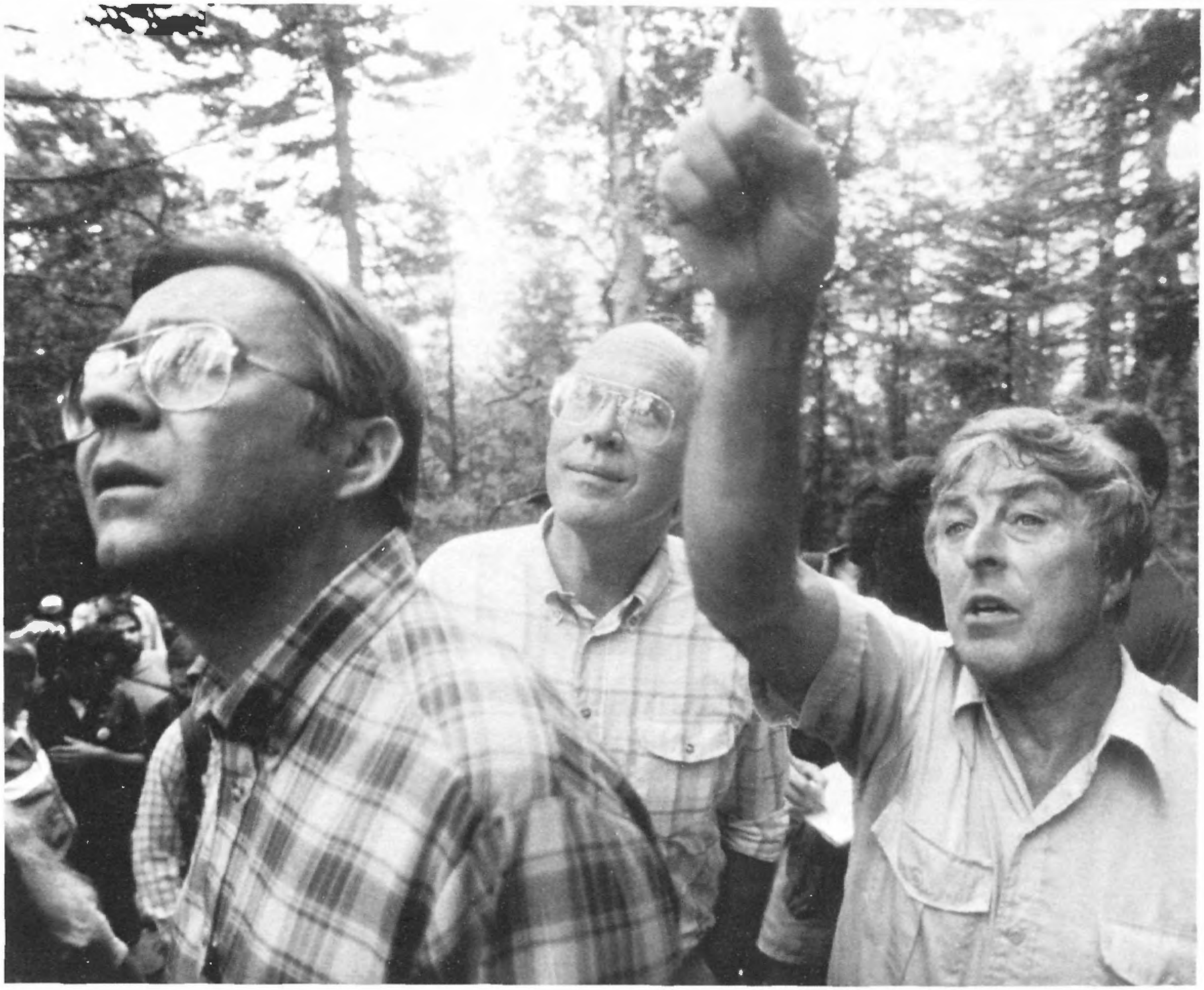
Quigley has been with EPA since 1971, primarily in the water program. His previous experience includes five years with NASA, and three years of service in the U.S. Air Force.

Quigley received his B.A. from Trinity College (Conn.) in 1961, and his law degree from Georgetown University in 1969. He also holds a master's degree in public administration from Harvard University, which he attended under EPA's executive development program. Quigley is an associate certified financial planner and a member of the Virginia Bar Association.

**Timothy Fields, Jr.**, has been appointed director of the Emergency Response Division of EPA's Office of Solid Waste and Emergency Response. His major responsibilities include the development and implementation of emergency response program policies for uncontrolled hazardous waste sites and releases of hazardous substances and oil into the environment. He has been Acting Director of the division since January of this year.

Fields has been with EPA since 1971, with most of his experience in the Office of Solid Waste.

He received his B.S. in Industrial Engineering from the Virginia Polytechnic Institute and State University in 1970. Under EPA's Long-term Graduate Training Program, he also attended George Washington University and received an M.S. in Operations Research in 1975. □


Jym Wilson, Burlington Free Press

EPA Administrator Lee Thomas, left, hikes Camel's Hump mountain in Vermont to study forest damage. Accompanying Thomas on the trek, which took place in August, are Sen. Patrick Leahy (D-Vt.), center; Prof. Hubert Vogelmann of the University of Vermont, right; and several government officials and environmentalists from Vermont and New Hampshire.

Back Cover: Leaves in the fall. Photo by Michael Philip Manheim, Folio, Inc.

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