BROOKHAVEN BULLETIN

Special Edition — January 1995

BROOKHAVEN NATIONAL LABORATORY

Brookhaven — Committed to the Health of Planet Earth

As you read this, you may be at your place of work or at your home, in Suffolk County, on Long Island, in New York State, in the United States — but all on the planet Earth.

Each of us inhabits a multitude of environments. And, from our personal dwellings or places of work to the global village, we have a right to expect that these environments will be healthy and nurturing.

Unfortunately today, this is not always true. The same technologies that have made this world so small and life easier for many of its citizens have sometimes caused real damage to the land, the sea and the air. Whether this damage is localized or widespread, it is always unacceptable.

Recognizing this, Brookhaven National Laboratory long ago turned much of its scientific expertise toward understanding the environment. This begins as basic research — seeking answers to the fundamental questions about our world, to understand how it started out, how human interference may have changed it and how damaging those changes might be.

The basic research conducted at BNL and elsewhere has revealed the fragility and current ill health of our planet. With this revelation has come an increasing sense of national urgency to prevent any further damage, maintain healthy systems and repair ailing ones.

Over time, then, as Brookhaven has responded to this national need, its focus has broadened. While BNL scientists still see basic research as the key to understanding the environment and developing new technologies to help it, they are increasingly involved in bringing the innovative ideas that so frequently arise out of their research into the public realm.

Today, most of Brookhaven's applied environmental research is carried out for the U.S. Department of Energy (DOE) by two departments: the Department of Advanced Technology (DAT) and the Department of Applied Science (DAS).

More and more often, scientists in these departments — either on their own or by teaming up with industry — have supplied valuable insights and real solutions to the problems besetting the Earth's land, sea and air. This research has current impact and exciting promise all around the globe, from Long Island and New York City to Africa, Russia and Eastern Europe. Many of these efforts are detailed in this special edition of the Brookhaven Bulletin.

"I am pleased that BNL has always been able to respond aggressively and effectively to rapidly changing national needs — and there is no question that our environmental research is of the utmost national importance," said Laboratory Director Nicholas Samios. "Nothing is more basic to our continued well-being, nationally and globally, than a healthy Earth and a healthy environment."

Waste Management in the Northeast Turns to NEWME

The United States produces more than 180 million tons of municipal solid waste annually — more than any other nation. The U.S. Environmental Protection Agency also estimates that the densely populated areas of the Northeast produce twice the national average of solid waste per capita annually.

Disposal of this huge amount of waste is very difficult because the number of options has dwindled due to a host of economic, environmental and political factors.

To meet the challenge of solid-waste disposal by using new technologies, a partnership between BNL and the private sector was established in 1993. Called the Northeast Waste Management Enterprise (NEWME), this partnership is being managed by BNL and the nonprofit Long Island Research Institute (LIRI), with the goal of revitalizing the U.S. waste-management industry to make it internationally competitive.

NEWME is currently funded by DOE, but the private sector is expected to bear an increasing share of its cost each year. Eventually, the enterprise is expected to be financially self-sufficient.

According to Allen Goland, DAS, who heads NEWME for Brookhaven along with co-principal investigator Edward Kaplan of DAT, "The focus of NEWME will be both the waste-management problems in the Northeast and DOE's major remediation efforts."

Kaplan said, "NEWME is gaining a detailed knowledge of the current environmental and waste-management needs of industry and DOE, so that we can better address their problems. In the past, the industry developed haphazardly, in a push-pull kind of way."

Cal Brewster (right), DAT, demonstrates the encapsulation process for treating radioactive, hazardous and mixed waste (see story below) to the managment team of the Northeast Waste Management Enterprise: (from left) Joanne Wortman, Long Island Research Institute (LIRI); Ed Kaplan, BNL; Allen Goland, BNL; and Philip Palmedo, LIRI.

"We hope to make this enterprise an international effort," added Kaplan, "so we are now evaluating several Russian waste-management technologies. If they prove to be useful, then we plan to bring them into partnerships with U.S. industries."

NEWME is evaluating four waste-management technologies in the U.S.: bioremediation, or using microbes to convert waste into environmentally benign or useful products (see story below); landfill containment, including new methods to cap and enclose landfills, and recover resources from them; pyrolysis, or burning organic waste in the absence of oxygen, which is cleaner than incineration and yields an industrially useful charcoal-activated carbon; and waste stabilization/ash utilization, which includes encapsulating waste in a safe, stable material for disposal, and using encapsulated incinerator ash for building roads, among other possible uses.

Joanne Wortman, who, with Philip Palmedo, manages NEWME for LIRI, said that technical and economic evaluation of each of these concepts will form the basis for decisions relating to eventual field demonstrations and commercialization.

"LIRI's role in NEWME is to bring together the technical expertise of federal laboratories, universities and private industry; help find investors for promising waste-management technologies; and write a business plan for interested companies," said Wortman. "With our strong ties to the local business, academic, research and financial communities, we are the perfect partner for BNL in this enterprise. As a result, NEWME will serve as a model for other regional programs." — Diane Greenberg

BNL Joins Industry in Quest to Solve Environmental Problems

Since 1989, BNL has signed 35 Cooperative Research and Development Agreements (CRADAs) with industry, and about one-fifth of these technology-transfer contracts involve solving environmental problems, for example:

Extracting toxic metals from contaminated sites:

DAS's A.J. Francis (shown below) and Cleveland Dodge have developed a patented method to remove toxic metals and radioactive materials from contaminated soils, sediments, sludges and ash. The process uses citric acid to bind up pollutants for later recovery, either by microbes or by sunlight. The recovered materials may be recycled.

BNL researchers and Forrester Environmental Services, Inc., a small company in New Hampshire, have demonstrated that the method is effective in removing lead from municipal incinerator ash. In addition to reducing expenses for municipalities affected by the U.S. Supreme Court's recent ruling that incinerator ash may be classified as hazardous waste, this method would enable valuable metals to be recovered for recycling.

Biochemical production of valuable materials from fossil-fuel wastes:

DAS researchers are working with EER Labs, Inc., an environmental remediation company in California, to convert toxic oil wastes, such as spilled oil and used motor oil, into useful products. When the researchers mix these wastes with selected bacteria at optimal temperature and oxygen concentration, the wastes can be biochemically changed to several environmentally safe products, including industrially useful bioadsorbants, biopolymers and surfactants.

Mow Lin (photo above, center, with Ludmila Shelenkova and Jeffrey Yablon, all of DAS) said that BNL's role in this CRADA is to scale up the most promising biochemical processes for engineering and marketing studies, then draft an economic study for prospective investors.

Biochemical technology for processing food-industry wastes:

Bioremediation uses selected nonpathogenic bacteria to degrade grease and organic solids into environmentally acceptable by-products — a better idea than cleaning up wastes by temporary mechanical methods, such as grease traps, or chemicals, like solvents or acids.

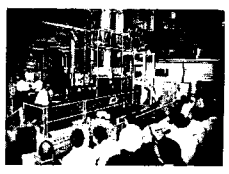
Environmental Solutions Corporation, a start-up waste-water treatment firm based at the High Tech Incubator at the State University of New York at Stony Brook, has installed many grease bioremediation systems in restaurants throughout the Long Island area. The company hopes to improve its current mixtures by using grease-eating strains of bacteria identified at BNL, under the direction of DAS's Eugene Premuzic (shown left below).

This effort is a spin-off of other BNL programs for developing environmentally acceptable biochemical technologies for upgrading fossil fuels, such as crude oils and other materials associated with refining and power production.

Treatment of radioactive, hazardous and mixed wastes:

Under this CRADA, a DAT team led by Paul Kalb (leading demonstration in photo above) and Vectra Technologies, Inc., a waste-management company based in Washington, have determined that a BNL-developed method of sealing radioactive, hazardous and mixed waste in polyethylene is applicable for encapsulating ion-exchange resins, radioactive waste generated at nuclear power plants.

Traditionally, ion-exchange resins have been placed in high-integrity plastic or metal containers for storage and disposal. But, with more stringent environmental regulations anticipated, Vectra Technologies was seeking a way to stabilize the resins by solidifying them in a monolithic waste form.



Detecting air leaks from hospital isolation rooms:

In collaboration with Perfect Sense, Inc., based in Islandia, Long Island, and the Long Island Research Institute (LIRI), a

(continued on page 4)

The Inside Stories . . .

Environmental Research With Impact Around the Globe — From Alaska to New Zealand, BNL scientists address environmental problems. **2-3**

Eye on the Environment: Looking Ahead, Around and Back — BNL researchers work to prevent future problems, maintain current systems and repair earlier damage. **4**

In an experiment at BNL's National Synchrotron Light Source, Sasa Bajt and Mark Fuhrmann work to determine the environmental fate of radioactive iodine (see story, page 4).

A Sampler of Brookhaven's Environmental Res

Oklahoma, Alaska and Western Pacific Ocean
Working Arm in ARM

Since the Industrial Revolution, the concentration of carbon dioxide in the atmosphere has increased — which may be correlated with global warming, as increasing carbon dioxide concentration may be the cause of an incremental change in what is called the greenhouse effect.

The Earth's atmosphere acts like a greenhouse: By trapping heat from the sun, the atmosphere is responsible for the planet's temperate climate. This natural effect is due to, among other factors, the atmospheric presence of carbon dioxide and other infrared-absorbing greenhouse gases.

The BNL arm of the ARM project: (clockwise from front left) Kathy Doty, Principal Investigator (PI) Stephen Schwartz, Sharon Baxter, Leonard Newman, PI Peter Minnett, Peter Daum, Tammy Kwan, Graham Campbell, PI Joyce Tichler and PI Michael Reynolds.

Two other factors involved in the greenhouse effect are water vapor and clouds. As a result, atmospheric scientists are particularly interested in the role of clouds vs. clear sky in the atmospheric feedback of radiation to the earth and its consequence on global temperature.

So, in 1990, DOE established the Atmospheric Radiation Measurement (ARM) program, involving eight DOE labs, including BNL.

The ARM collaboration is making what will be the most comprehensive set of atmospheric radiation and meteorological data ever assembled, from initially one and eventually three geographically distinct regions of the world— first in the Great Plains of Oklahoma, then in northern Alaska and the tropical western Pacific Ocean. These data are being obtained to improve computer programs known as global circulation models, which describe and predict climate and its change.

To interpret those data accurately, the Scientific Information Systems Group within the Analytical Sciences Division of DAS is compiling data on the data. The group is also gathering information from a variety of sources engaged in independent research and monitoring of the weather and related phenomena in the vicinity of ARM sites, which will also be used in conjunction with ARM data to analyze processes governing atmospheric radiation and climate.

Also in DAS, the Environmental Chemistry Division is obtaining atmospheric radiation profiles using remote-controlled aerospace vehicles and performing aerosol research, while the Oceanographic & Atmospheric Sciences Division is analyzing geostationary and polar orbiter satellite data, and deploying unattended ocean instrumentation to obtain meteorological and atmospheric radiation data.

— Marsha Belford

New York-New Jersey Harbor
Cleaning Up a Busy Port

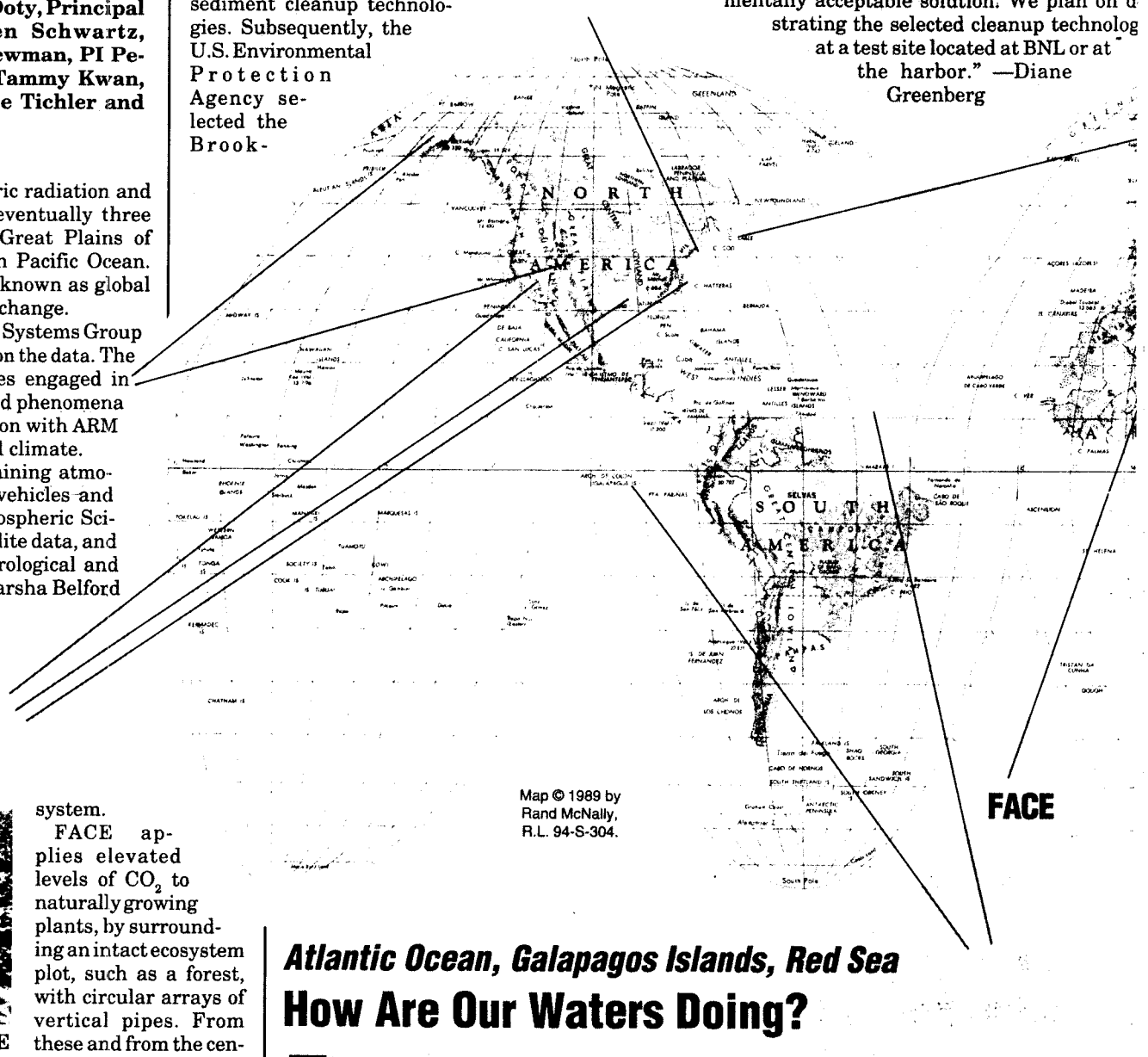
The third busiest port in the nation, New York-New Jersey Harbor handles 38 million tons of cargo per year. It is also one of the most polluted harbors in the U.S. and needs routine dredging to promote safe navigation.

Pollutants in New York-New Jersey Harbor include heavy metals, chlorinated pesticides, semi-volatile organics, PCBs and dioxins, many of which reside in the sediment that is dredged. These contaminants are also available to aquatic life up the food chain, and Congressional mandate and international law ban ocean disposal of many of these pollutants.

Said Keith Jones (photo right), DAS, principal investigator in the harbor cleanup project, "Without ocean disposal, alternate methods need to be found. It is our job to determine how sediment-decontamination technologies can play a role in the management of six million cubic yards of contaminated material that is dredged annually from the harbor."

The federal Water Resources Development Act of 1992 allocated $5 million for a pilot demonstration of sediment cleanup technologies. Subsequently, the U.S. Environmental Protection Agency selected the Brookhaven-Rensselaer Environmental Partnership Multistate Alliance, which includes Brookhaven, Rensselaer Polytechnic Institute, Stevens Institute of Technology, Rutgers University and the New Jersey Institute of Technology, for a four-year project starting this year. BNL is in charge of managing, integrating and evaluating the results of the cleanup demonstration program. Curr Brookhaven is evaluating proposals from all t vendors for cleanup strategies.

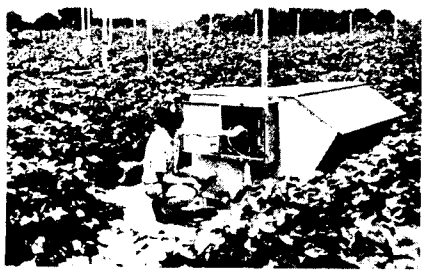
"This is a technology-transfer project, wit working directly with industry and academia t a pressing environmental problem," said Jone job for BNL and our university partners is tc the EPA and the U.S. Army Corps of Engin devise the most economically feasible and e mentally acceptable solution. We plan on d strating the selected cleanup technolog at a test site located at BNL or at the harbor." —Diane Greenberg



Map © 1989 by Rand McNally, R.L. 94-S-304.

Arizona, Mississippi, North Carolina, New Zealand and Switzerland
Face to FACE With CO_2

How are plants and forests being affected by the dramatic rise in atmospheric CO_2 due to the greenhouse effect (described in the story above)? To find out, George Hendrey and a team of other DAS researchers developed FACE — a free-air carbon dioxide enrichment system.



Keith Lewin of DAS, at the FACE station in Arizona.

FACE applies elevated levels of CO_2 to naturally growing plants, by surrounding an intact ecosystem plot, such as a forest, with circular arrays of vertical pipes. From these and from the center of the plot, CO_2 is released at a rate adjusted on a second-to-second basis using measurements of wind direction and speed.

"With this equipment, we can do experiments in which CO_2 is the only variable disturbed. A FACE installation is a user facility where experimenters study plant biology and ecology, in the same way that an accelerator is used for particle-physics research," commented Hendrey. "We can examine ecosystems at levels ranging from the whole forest canopy down to genetic mechanisms regulating photosynthesis."

Developed as a component of the U.S. Global Change Research Program and the International Geosphere-Biosphere Program, FACE has been used in field studies on cotton and wheat crops in Mississippi and Arizona. With the increased concentration of atmospheric CO_2 supplied by FACE, plants grew faster, biomass accumulated more quickly and carbon was retained in the soil at an accelerated rate.

The BNL FACE team also studies grasslands near Zurich with the Swiss Federal Institute of Technology, as well as tall forests in North Carolina and grasslands in New Zealand with other collaborators.

— Liz Seubert

Atlantic Ocean, Galapagos Islands, Red Sea
How Are Our Waters Doing?

The only national laboratory with a seagoing oceanographic research team, BNL has staff investigating phytoplankton around the Galapagos Islands, carbon dioxide (CO_2) uptake in the Atlantic Ocean from offshore Brazil to the Congo, and coral and nitrogen in the Red Sea — to name some of the studies made by DAS's Oceanographic and Atmospheric Sciences Division (OASD).

In support of the Ocean Margins Program, which is part of DOE's overall research on climate change, OASD's major focus is to understand how human activities along the coastal oceans affect ocean biology and chemistry. Led by Creighton Wirick, OASD develops advanced technology to measure key aspects of the health of the coastal ocean. This effort includes doing long-term surveys of oxygen and developing instruments to measure photosynthesis.

DAS's Paul Falkowski and Zvy Dubinsky of Israel's Bar Ilan University, at the Sinai Peninsula, during their study of corals in the Red Sea.

The Coulometric Titration Analyzer (CTA) designed by DAS's Kenneth Johnson has been used on research cruises worldwide by Douglas Wallace, DAS, and others. The CTA measures the total amount of dissolved inorganic carbon in the seawater with a remarkable accuracy of one part in 2,000.

Other BNL-developed instruments measure traces of Freons 11 and 12 and carbon tetrachloride, which give a picture of ocean circulation that can be modeled and compared to the CO_2 picture.

To test whether the amount of iron present affects phytoplankton, ocean plants that absorb CO_2 and produce oxygen, l Zbigniew Kolber joined a Moss Landing Marine Laboratory research voyage to the Galapagos in the Pacific Ocean last fall. Several techniques, including the fast repetition rate fluorometer designed by Kolber, were used to quantify phytoplanktons' activity before and after the addition of iron. Results indicated that photosynthesis in the equatorial Pacific is clearly limited by the presence of iron.

— Liz Seubert

BROOKHAVEN BULLETIN

Published
by the Public Affairs Office
for the employees of
BROOKHAVEN NATIONAL LABORATORY

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New photos for this issue taken by Roger Stoutenburgh.

Brookhaven National Laboratory is managed by Associated Universities, Inc., under contract to the U.S. Department of Energy, which provides funding for most of the programs detailed in this special edition of the Brookhaven Bulletin. For more information on this research, contact the individual researchers named in the stories or contact:

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Bldg. 134, P.O. Box 5000
Upton NY 11973-5000
Tel. (516) 282-2345; Fax (516) 282-3368

The Brookhaven Bulletin is printed on paper containing at least 50 percent recycled materials, with 10 percent post-consumer waste.

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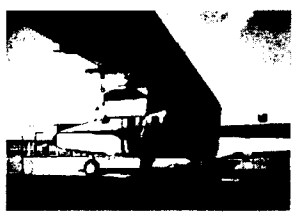
Measuring Pollution on the Wing

For the past two summers, DAS's Peter Daum, Larry Kleinman, Yin-Nan Lee, Steven Springston, Paul Klotz, Xion-liang Zhou and Daniel Leahy, with colleagues from three other institutions, have been flying over Nova Scotia and the North Atlantic to gather samples of air. Their goal has been to measure the chemical composition of pollutant plumes transported from the industrial regions of the northeast U.S. and Canada out over the ocean. These plumes may influence the environmental quality of the remote marine environment and alter the oxidizing capacity of the atmosphere over large scales.

Using two planes like the one shown here, equipped with an array of scientific instruments, the researchers sampled the air on more than 50 missions, flying as far as 1,000 kilometers (km) from the U.S. east coast at altitudes up to 6 km.

"We found plumes of photochemical pollutants, which are chemicals formed by the action of sunlight on emissions from automobiles and industrial processes, in well-defined layers of up to one kilometer thick, sometimes several hundred kilometers long — up to 1,000 kilometers out over the Atlantic," commented Daum. These plumes contained concentrations of ozone and other pollutants that exceeded EPA standards for the continental U.S. The ultimate fate of these pollutants is still under study. A particular concern is whether transport scales are large enough to influence air quality over the United Kingdom and western Europe. — Liz Seubert



Air pollution in Kraków is destroying ancient statues.

Kraków, Poland

A Question of Coal

A hub of Polish culture, Kraków is an industrial center — with one of Eastern Europe's largest air pollution problems. While Kraków's iron and steel works are the most visible source of air pollution, the most particulates and hydrocarbons are emitted by some 2,250 boilers and 100,000 home stoves that burn coal to supply almost half of the heat required by the city's 750,000 inhabitants.

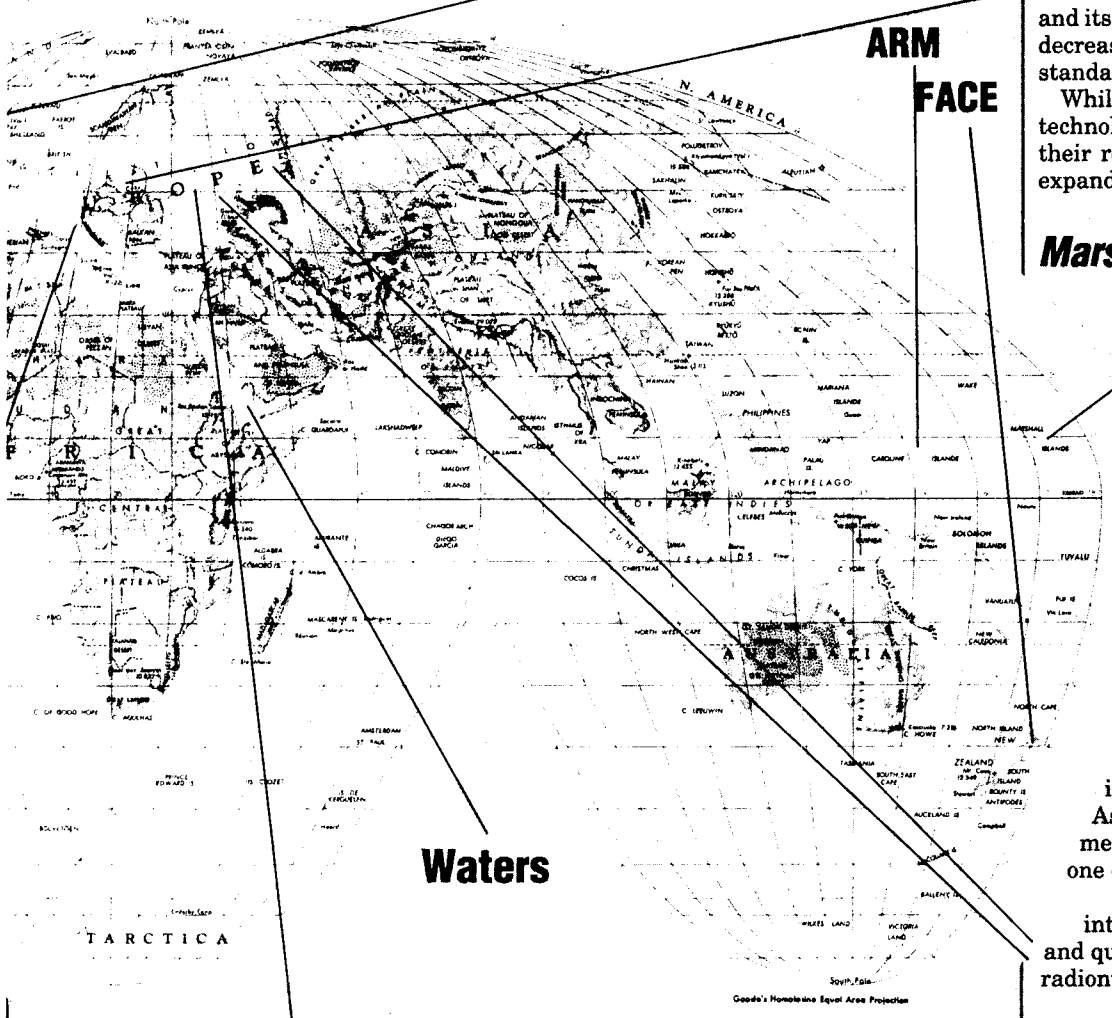
As a result of the Support for Eastern European Democracy (SEED) Act of 1989, DOE has been authorized to spend $30 million on Kraków in two air pollution-control projects, as seed money to open the door to Poland and the rest of Eastern Europe for U.S. firms specializing in air pollution-control technology.

Thomas Butcher and his colleagues in DAS's Energy Efficiency & Conservation Division have been major players in one of the two projects: the $20-million Kraków Clean Fossil Fuels & Energy Efficiency Project. The DAS team and their Polish associates have looked into the technology, economics and feasibility of converting small basement boilers from coal to natural gas, eliminating home stoves in the Old Town of Kraków, modernizing the larger boilers, and, in home stoves, using cleaner-burning coal fuels, such as briquettes.

In a recently released report, the DAS team showed that using better fuels and operating procedures will pay for itself in increased efficiency. They also found that home stoves are the most significant single source of particulates; so, by switching to fuels like briquettes and changing the operation of existing stoves, stove efficiency will increase from 60 to 70 percent, and particulate pollution will drop by a factor of ten.

An additional finding is that such measures will have the biggest impact in the Old Town and its immediate surroundings. If all the suggestions are followed, air pollution there will decrease by 40-50 percent. However, since this is still not enough to bring air quality up to standards, additional steps must be taken to control other pollution sources.

While eight U.S. companies selected by DOE have begun to demonstrate and market the technologies identified by the DAS team, Butcher and his coworkers have begun sharing their results with other cities in Poland and elsewhere in Eastern Europe, in hopes of expanding the program's impact throughout the region. — Marsha Belford



Marshall Islands

Measuring Plutonium

A ship outfitted with equipment for BNL's radiation safety program is moored near Rongelap atoll.

In the Marshall Islands, plutonium's potential danger as a health hazard has been a concern for many years — ever since the Utirik and Rongelap atolls were contaminated during a wind change at the time of a 1954 U.S. bomb test on nearby Bikini island. In 1957, the U.S. government asked BNL to detect and treat any diseases among the islanders that had possibly resulted from radiation exposure at that time.

A radiological monitoring and assessment program for the Marshall Islanders has been run by BNL for, first, the Atomic Energy Commission, then the Energy Research and Development Administration, and now, DOE. In the late 1970s, the BNL team became concerned that the islanders might be ingesting plutonium, so, in 1982, urine sampling for plutonium was added to the program. As a result, DAT's Anant Morthy developed an exceedingly sensitive method of measuring plutonium in urine samples, a technique that won a 1991 R&D 100 award as one of the year's top technological achievements.

Now, a team led by DAT's Edward Kaplan is working on putting the BNL method into general use, anywhere in the world where urine bioassays are needed to identify and quantify radionuclides and also to assess population doses from a potential intake of radionuclides. — Liz Seubert

Europe

Tracing Pollution Dispersion

Chernobyl and Bopal — while the first was a nuclear accident and the other a chemical mishap, what both had in common was the atmospheric release of a pollution plume that was capable of killing or harming those over which it traveled. Improved computer models to predict the atmospheric dispersion of pollutant clouds in such situations would mean earlier warnings and probably more lives saved.

With this in mind, Russell Dietz (in photo), who heads the Tracer Technology Center (TTC) in DAS's Environmental Chemistry Division, and his colleagues are participating in ETEX, the European Tracer Experiment.

As part of ETEX, 23 countries including the U.S. are evaluating the ability of atmospheric models to forecast the evolution of pollutant clouds over several days and thousands of kilometers (km). To do so, the Commission of European Communities conducted an experiment, using tracer technology developed by Dietz and his colleagues. In the first of two tests, a nonpolluting tracer was released in October 1994 over 12 hours in Brittany, France, to simulate the emission of a pollutant.

Over the next 60 hours, the exercise participants acquired the meteorological information necessary to calculate the tracer plume's evolution, updating their forecasts every six hours.

Since then, these forecasts are being compared with the real position of the plume, which was tracked during the experiment by 170 ground stations throughout Europe. Dietz and his colleagues developed the concept for the programmable sampler as well as the chromatographic technique used to analyze the 9,000-plus samples to determine tracer concentrations to parts per quadrillion.

In addition to ground monitoring, the plume was tracked in the air, using a computerized analyzer on board a British aircraft; that plane as well as German and Swiss aircraft also carried special samplers. This equipment, provided by the TTC, helped the research planes intersect the plume at distances of 400 to 800 km from the release site.

The results of this experiment and a second one carried out last November will have world-wide implications in emergency planning and management. — Marsha Belford

Russia and Eastern Europe

Improving Nuclear Reactor Safety

The explosion of the Soviet Union's Chernobyl-4 in 1986 was the worst nuclear reactor accident in history, and its long-term consequences still have not been fully calculated. But today, Russia operates a dozen of these Chernobyl-type, graphite-moderated, boiling-water reactors known as RMBKs, and another four are in use in Lithuania and Ukraine. The U.S. position is that they must be shut down.

In Russia's Kola Nuclear Power Plant, a worker seals a confinement weld.

Further, more than 42 Soviet-designed, pressurized-water reactors, known as VVERs, are operating in Bulgaria, the Czech Republic, Hungary, Russia, Slovakia and Ukraine, and more are being built. With safety improvements, these reactors could continue to function.

In 1993, the U.S. joined Britain, Canada, France, Germany, Italy and Japan in a program to improve the safety of nuclear reactors in Russia and Eastern Europe to meet Western safety standards.

"Because of BNL's prior experience with Soviet-designed reactors, we were chosen to manage the DOE program for three years," said DAT's Ann Reisman, who heads the program at Brookhaven. "The thrust of the project is to train the Russians and Eastern Europeans in safe operating and maintenance procedures for nuclear power plants, so they can eventually be self-reliant in attaining new safety goals."

This project is also a good example of technology transfer, as the bulk of the safety-improvement work is being subcontracted to the private sector, with U.S. companies making competitive bids on specific projects. Two Russian firms will also provide technical assistance.

James Guppy, DAT, who is one of about a dozen BNL scientists and engineers working on the project, said, "So far, we've identified 21 engineering upgrades at four different plants that are targeted for near-term risk reduction. Working with our Soviet colleagues, we will implement them soon." — Diane Greenberg

Eye on the Environment — Looking Ahead, Looking Around, Looking Back

In most instances, science and technology have made life in our time easier. But society has learned that using these powerful forces may produce adverse effects on the environment.

Society has also learned that, if science and technology create problems, then they can also solve them. As these examples show, Brookhaven scientists are working to protect our surroundings by looking ahead, to foresee and prevent future damage; looking around, to check on — and, maybe, check — present practices; and looking back, to rectify, learn from or improve on what was done in the past.

Preventing Future Damage

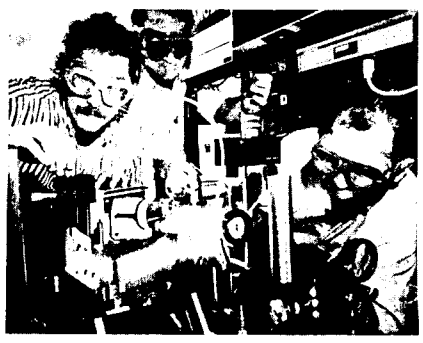
The Fate of Radioactive Iodine

As part of a remediation study of a nuclear fuel storage site near Buffalo, Sasa Bajt, University of Chicago, and DAS's Mark Fuhrmann (see photo on page 1) are working at BNL's National Synchrotron Light Source (NSLS). Their goal is to determine the oxidation state of iodine in environmental samples — in order to understand the environmental fate of iodine's radioactive forms, to see if they will migrate into groundwater or be converted to a vapor phase.

Because the metals and isotopes may be present in minute concentrations and in micron-sized regions, these x-ray fluorescence measurements are done with an amazingly sensitive x-ray microprobe. Data from results of this and other investigations, such as a study of how decaying plant roots can control the movement of toxic selenium in California wetland sediments, will be useful for developing environmental strategies in many areas.

Chemicals Leave Fingerprints

Resonance Raman scattering, a technique developed at BNL to identify chemicals from afar, promises to have far-reaching benefits for pollution control. In one of BNL's first applications of the process, at a Nevada test site, sulfur dioxide was detected coming from a calibrated source generator at a distance of 500 meters.



In Raman scattering, the wavelength of light scattered by a molecule irradiated with light is shifted into a pattern that relates to the vibrational structure of that molecule. Thus, each chemical has its own pattern or identifying "fingerprint." *Resonance* Raman is a way of enhancing the signal intensity up to a million times.

The current project to develop a resonance Raman remote-sensing system for arms-control verification is funded by DOE's Office of Nonproliferation and National Security. Working on resonance Raman experiments in their specially designed laser laboratory and mobile trailer, (above, from right) DAT's Cheng-Lin Chen, David Harder, Arthur Sedlacek and others achieved excellent results.

Said Joseph Indusi, who heads the program, "By choosing suitable equipment, we can produce a mobile detective lab for fieldwork. Also, industrial plants could install equipment to detect emissions and feed the information back through fiber-optic links to a central computer, making the technique especially useful for environmental monitoring."

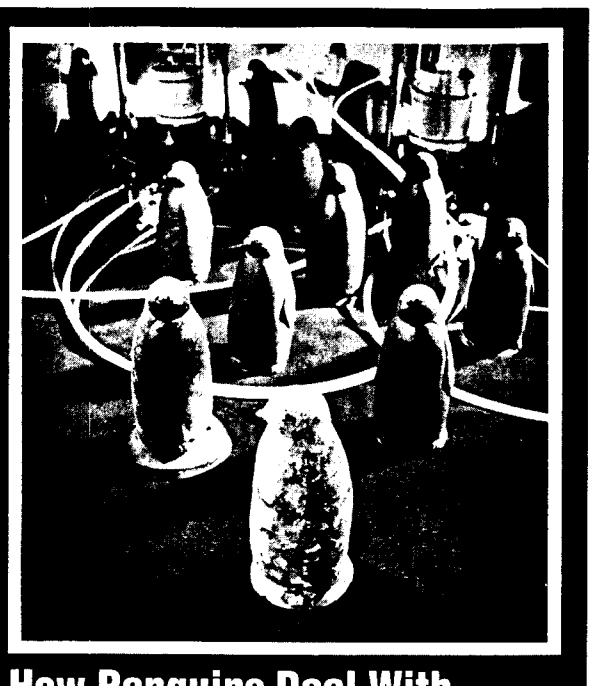
Safe Harnesses for Sunlight

In making photovoltaic modules, solid-state devices that convert sunlight directly into electricity, many hazardous materials and processes may be used.

For over a decade, DAS specialists have been providing DOE, the EPA, industry and others with environmental, health and safety assistance in producing, operating and decommissioning photovoltaic energy systems. They are also working with industry to start cost-effective recycling programs.

As part of their effort, DAS cooperates with the National Institute of Environmental Health Sciences to develop toxicology profiles of and safe working procedures for materials used in this industry.

"All our work is aimed at preventing accidents," said Paul Moskowitz, who heads the DAS effort (shown at left above with Vasilis Fthenakis, also of DAS). "In one project, we helped design and evaluate equipment and protocols to handle arsine gas, which is extremely toxic. Although we were not the only people involved, it was very satisfying to know that, because of the recommended protocols, no arsine was released from the plant located in southern California near the epicenter of the January 1994 earthquake."



How Penguins Deal With Underground Contamination

When is a penguin not a penguin? When it is a seal!

The DAT penguins are rare birds. Bronze-like statues, they are samples made from used testing material to display the new sealant compounds being investigated by staff at DAT's Environmental and Waste Technology Center (EWTC). The compounds will act as barriers that can surround and contain underground contamination from old dumps or failing waste containers, by sealing in waste to prevent leakage.

Underground barriers are constructed by pumping liquid grout into the soil and letting it set. After extensive research, EWTC found that polymer compounds, developed from the polymer concrete first made by BNL researchers in the mid-1960s, give excellent results.

Using commercially available polymers, EWTC has now completed 18 barrier materials that can be used to solidify radioactive, mixed radioactive, chemical and other hazardous waste; and established a valuable database on how the materials tested reacted as sealants.

Maintaining Present Systems

Supercomputers and Groundwater

With a single deep aquifer supplying drinking water for a population of some 2.5 million people, water contamination is a constant threat for Long Island. Groundwater-management programs and remediation strategies are therefore vital for guarding the Island's environment.

An important tool in these projects is numerical modeling that can simulate the movement and chemical reactions of pollutants in groundwater. DOE is funding the Partnership in Computational Science, a consortium of BNL, the State University of New York (SUNY) at Stony Brook and four other institutions nationwide, to focus their expertise on this complex area.

The team is developing an advanced computer code on a 500-processor Intel Paragon supercomputer at Oak Ridge National Laboratory and using a smaller Paragon at Stony Brook for testing. In developing a remote-visualization capability — seeing the results at BNL as they are being computed elsewhere — a major plus was the Fiber-Optic, Island-Wide, Super High-Speed Network (FISHNet), which links BNL to Stony Brook. Demonstrated here by Ron Peierls of DAS, this state-of-the-art system incorporating asynchronous transfer mode, or ATM, technology, was built by BNL, Cablevision Systems Corporation, Grumman Data Systems, and SUNY Stony Brook.

Using the ATM link and software developed at Texas A&M University, the team has demonstrated a simulation of contaminants leaking from a storage tank at an industrial site on the East Coast over a 20-year period. With data precomputed on Stony Brook's Paragon, the direction of the contaminant flow was visualized with color-coded animation at a computer workstation at BNL.

All stories in this section written by Liz Seubert.

Repairing Past Mistakes

One-Step Landfill Stabilization

DAS's Lawrence Kukacka and Marita Allan did DOE-sponsored remediation research on two old landfills at Sandia National Laboratories, one holding chemical waste, the other "mixed" waste, that is, a combination of chemical and low-level radioactive waste.

Said Kukacka, "The aim was to stabilize the landfill contents — for instance, change the chemically mobile chromium-6 into the less mobile form of the element, chromium-3, then encapsulate the whole area. Barriers are then placed around and below to prevent water ingress and possible leaching. All this had to be done using low-cost, readily available materials and technology."

After a year of experiments, the researchers developed a one-step way of stabilizing the landfills using a mix of Portland cement, waste-slag cement from blast furnaces, water and a super plasticizer. As a result, once solidified, BNL's landfill-remediation material is 1,000 times more impermeable than the EPA required standard. Thus, barriers around the solidified area can be quite thin, saving on material and labor.

How to Store Low-Level Waste

Currently, New York State is preparing its own disposal facility for commercial low-level nuclear waste (LLW) from hospitals, industry and nuclear power plants. But, until the facility is operating, waste may have to be stored at the site where it is generated.

To prepare for long-term storage, a coalition of New York nuclear utilities have funded DAT scientists Peter Soo (left in photo) and Laurence Milian to evaluate the performance of high-density polyethylene containers for storing radioactive resin wastes. The resin emits gamma radiation that might adversely affect polyethylene's properties.

After two years of experiments to test the containers' mechanical properties, chemical compatibilities and radiation embrittlement, Soo and Milian completed a study concluding that, for these types of resins, high-density polyethylene containers will give many decades of safe storage. They found also that these comparatively inexpensive containers are safe for shallow land disposal, as well as above-ground storage, so no repackaging will be needed when the state LLW facility is opened.

Soil Lead Attracts Sulfur

Soils in some regions of the U.S. have been contaminated with lead from mining, paints, leaded gasoline and industrial activities. At the NSLS, researchers from E.I. Du Pont de Nemours & Co., Inc., use x-ray absorption spectroscopy, a technique in which synchrotron radiation is the x-ray source for identifying chemical composition, to determine the various types of lead and other toxic heavy-metal compounds found in contaminated soils at waste sites. Collaborating with Du Pont in this work are researchers from BNL and the University of Delaware.

Said Du Pont's Michael Kelley, "One striking finding has been the attraction of lead in soil for sulfur. When the two elements combine, the resulting lead sulfide compound is highly insoluble, making it extremely unlikely that it would enter the drinking water supplies."

This type of research can be used to make decisions, for example, concerning public health. Since late 1991, Kelley said, Du Pont has used the results from these NSLS experiments as part of the justification for treatment plans submitted to regulatory authorities.

BNL Joins Industry (cont'd)

nonprofit corporation that promotes technology transfer on Long Island, a DAS effort led by Russell Deitz (see "Tracing Pollution Dispersion" inside) will soon demonstrate the feasibility of using perfluorocarbon tracer (PFT) technology to detect air leaks from hospital isolation rooms. As the number of AIDS-related tuberculosis (TB) cases increases, detecting leakages of air that may contain infectious, drug-resistant TB bacteria becomes increasingly urgent. No other detection system is currently available to address this problem. PFTs are an environmentally safe family of organic liquids for which BNL has developed several analyzers that can detect their vapors in air at 0.1 parts-per-quadrillion levels. Tests of the leak-detection technology are being conducted at several local health facilities. — Diane Greenberg