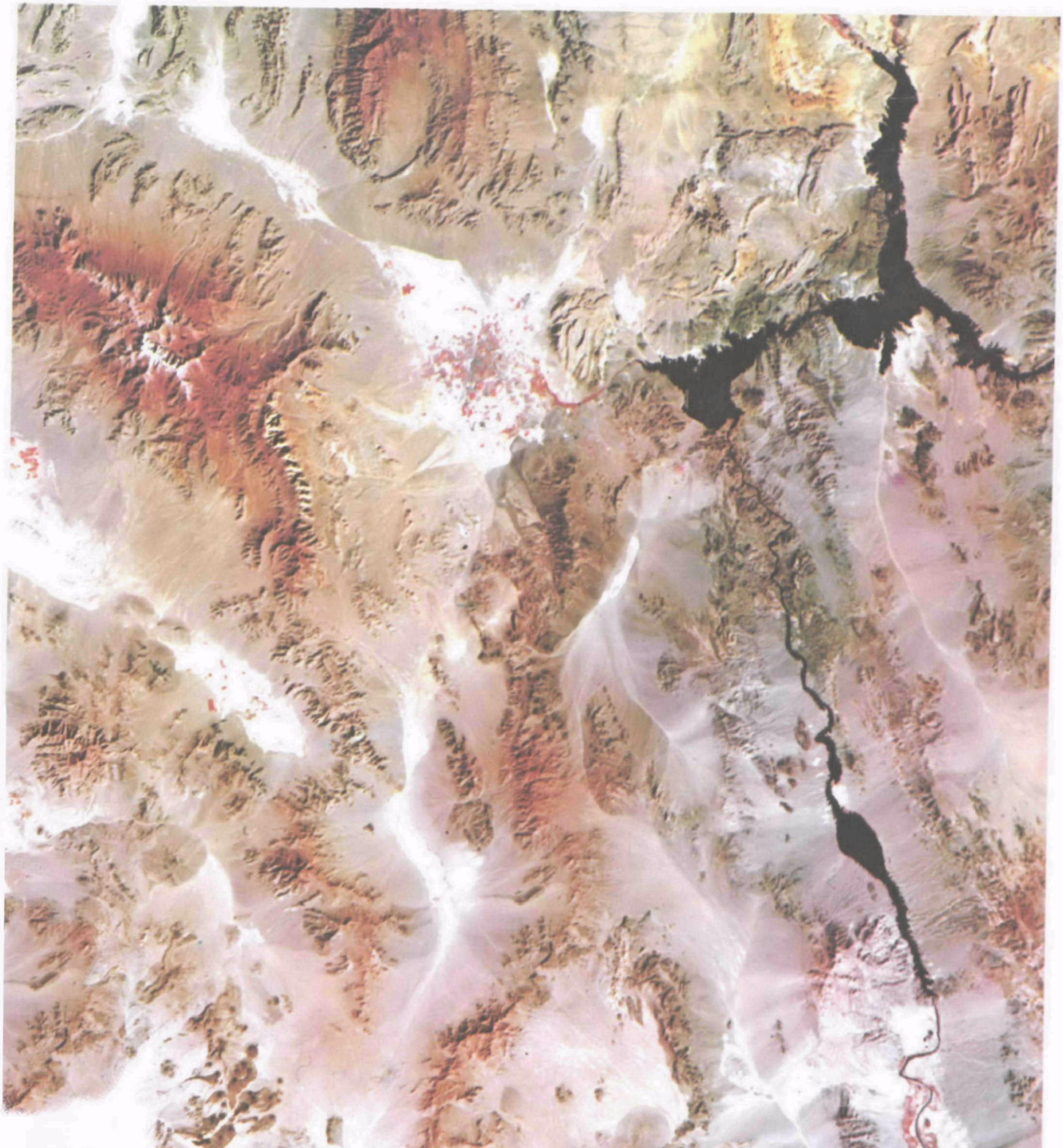
ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY

LAS VEGAS, NEVADA



ON THE COVER

This false color infrared image, acquired by a NASA Landsat satellite, represents one of many types of data used by EPA to monitor the environment. It shows an area of about 34,000 square kilometers that includes Lake Mead (upper right quadrant) and the city of Las Vegas (left of Lake Mead).

PROVIDING INFORMATION FOR SENSIBLE CHOICES

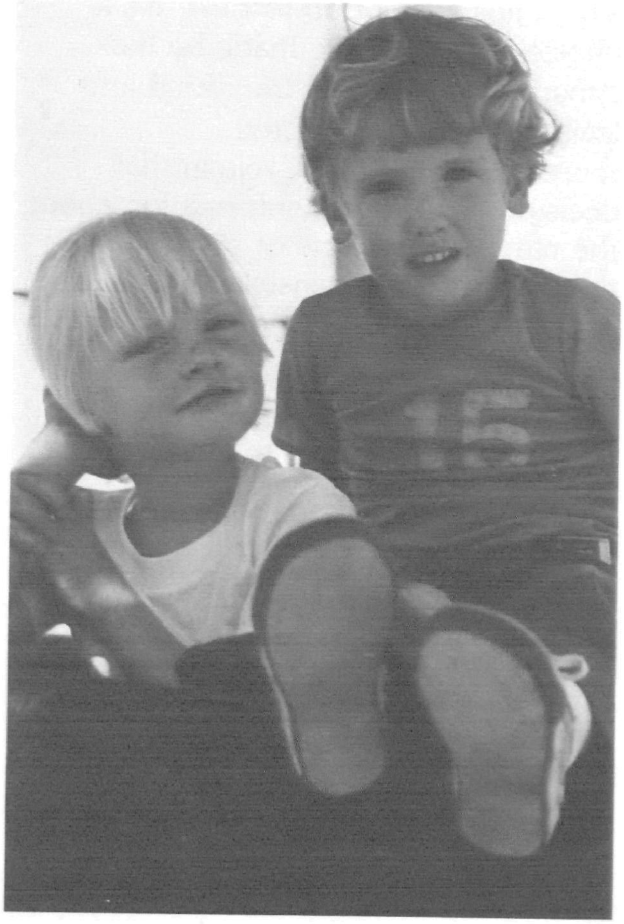
The U.S. Environmental Protection Agency was established as an advocate for the American people in asserting their right to a livable environment.

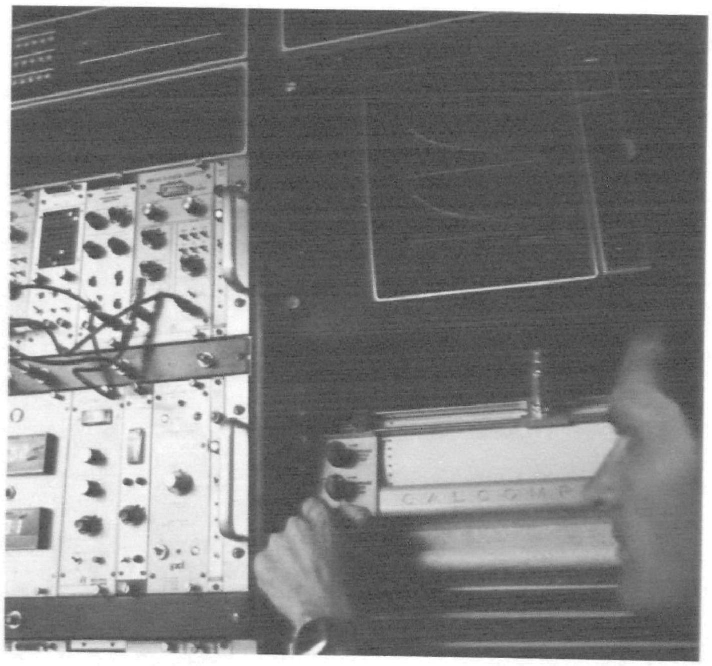
But the American people also have a right to improve the quality of their lives through technology. Technology that may change the environment.

The key to sensible environmental control is to determine which changes are tolerable or useful and which must be restricted because their harmful effects on human health and welfare outweigh their benefits.

That choice is not up to EPA. It's a choice that has to be made by the American people and translated into legislation by their elected representatives. EPA's role in that decision is to provide information about the nature and effects of pollution so that informed and sensible choices can be made.

This information comes from research which involves a study of complex interactions. First, the sources of pollution must be identified and its transport evaluated — both to determine where its effects are likely to be felt and to analyze any changes it undergoes after it leaves its source. Then the exposure to critical receptors,





usually human beings, must be determined as do the effects on those exposed.

From that information, criteria defining acceptable limits for the pollutants are developed, standards and regulations adopted, implementation plans developed and controls placed on the sources.

Then the cycle repeats, because the controls and the interactions they cause must be evaluated to assure the pollution is being abated and not replaced with other adverse effects.

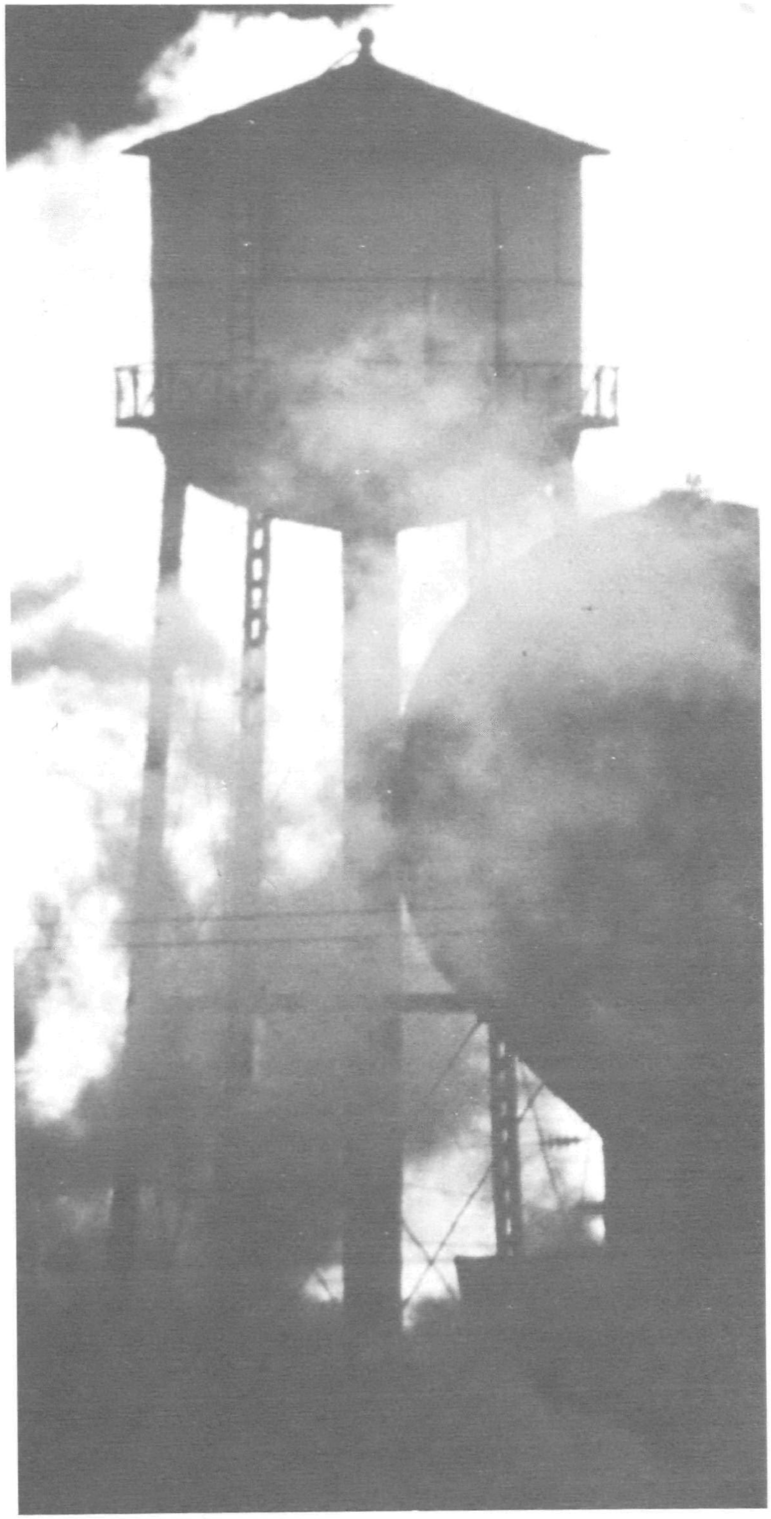
Each one of these steps requires monitoring by methods that must be accurate, reliable and cost effective. And as new pollutants are identified, new monitoring methods have to be developed to detect and measure them. The purpose of the Environmental Monitoring and Support Laboratory at Las Vegas is to help develop and apply this necessary monitoring technology in support of EPA regional and program offices.

All of the Laboratory's research projects can be traced to public laws that require EPA to establish or enforce standards limiting pollution. A research project is not undertaken unless the information it is expected to produce is necessary for EPA to carry out its legal mandate.

Almost all of the Laboratory's projects involve applied, rather than basic, research. In other words, it seeks ways to apply existing technology to environmental problems, rather than developing entirely new systems. This keeps research costs low and provides an operational monitoring capability in the shortest possible time.

DEVELOPING SYSTEMS FOR MEASURING ENVIRONMENTAL QUALITY

The Environmental Monitoring and Support Laboratory at Las Vegas conducts research and development programs to optimize existing monitoring networks and to develop new comprehensive systems to monitor specific pollutants.



Integrated Monitoring Systems

An important part of developing an environmental monitoring system is determining which measurements are significant. Technology has long been available to measure the concentration of, for example, sulfur dioxide in air.

However, that information alone is relatively useless in setting or enforcing emission standards. We also have to know the pollutant's sources, how it is transported, the chemical and physical changes it is likely to undergo in the environment, and its availability to the human population.

For this reason, the Laboratory conducts studies on specific pollutants that take into account all relevant characteristics of each pollutant in air, water and land.

Once a comprehensive data base is established, it is exhaustively analyzed and correlated, together with data from health effects research conducted at other laboratories. The goal is to identify the fewest and simplest possible measurements which, when found to be within specified limits, assure that the exposure of the human population to that pollutant is at a level currently believed to be safe (or, more realistically, at a level where the adverse health effects are small enough to be outweighed by the benefits from the technology that produces the pollution).

The value of this systematic, integrated approach was clearly demonstrated by applying it to the problem of environmental lead.

The first step in developing an integrated monitoring system is to identify those segments of the population most likely to suffer adverse effects from the pollutant being studied. For many air pollutants, this critical receptor is likely to be a person suffering from a chronic respiratory disease; for x-ray radiation, the critical receptor is a pregnant woman. If pollution standards can be established to protect the critical receptors, then it can be assumed the entire population is being protected.

From the review of existing information that precedes every research project, it was determined that urban children under six years of age are the critical receptors of lead. But the more-than-10,000 published studies on lead failed to identify the relative importance of the various ways a child can be exposed to lead.

For years, it was widely believed that the highest exposure of small children to lead was from lead-pigmented paints. But the Laboratory's study indicates this is a relatively insignificant source when compared to lead emitted from automobiles which settles inside homes as dust and is ingested when a child places his hands or a toy in his mouth.

As a result of this study, monitoring resources that might have been spent identifying leaded paint now are likely to be directed toward monitoring lead emissions from automobiles and measuring ambient concentrations of lead around highways in populated areas.

Predictive Models

The Laboratory is applying and testing mathematical formulas (models) that can help scientists predict the effects on the environment of specified events under a variety of conditions.

For example, air monitoring networks are being designed with the help of an airshed simulation model that predicts the concentration and distribution of pollutants over a given area from meteorological data and emissions inventories.

Scientists use the model to predict the pollution distribution for each weather pattern that is likely to occur in the area being studied. From this series of

simulations, they make pollution distribution maps. By overlaying the maps, they find the locations where the highest pollution concentrations should occur most often. After the predictions are verified with actual measurements, these locations are selected as sites for air monitoring stations.

In many areas, a few strategically placed sampling stations can monitor air quality for an entire metropolitan area, thus reducing the cost as well as improving the accuracy of air monitoring networks.

One predictive model under development will help reduce pollution, in addition to monitoring it. It predicts the effects of injecting waste into the ground, taking into account the physical characteristics of the subsurface environment, fluid characteristics of the wastes, and the chemical changes that could occur as the wastes interact with the underground environment. This information will be used to formulate rules and regulations on subsurface waste injection that will prevent contamination of underground water (groundwater), which is the major source of drinking water.

Biological Monitoring Techniques

In addition to mechanical and electronic sensing techniques, the Laboratory is studying the use of native plants and animals to monitor pollution. Studies are underway to determine the effects of specific pollutants and combinations of pollutants on plants and animals and to identify ways these effects can be monitored directly as well as from aircraft. Collecting microorganisms and plant tissues or monitoring vegetation from aircraft may prove to be the most effective and economical techniques for fulfilling some monitoring objectives.

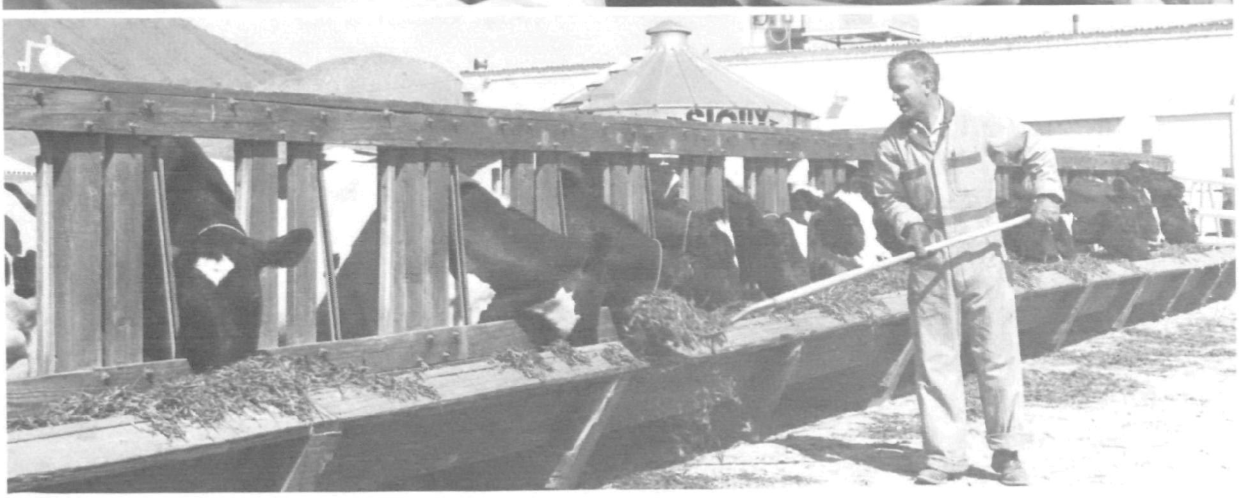
Experimental Farm

The Laboratory operates an experimental farm for the U.S. Energy Research and Development Administration (ERDA) at the Nevada Test Site, an isolated nuclear testing area that begins 65 miles northwest of Las Vegas.

The farm was established to determine whether radioactive contaminants from the tests can enter the human food chain through plants, animals and dairy products. It also is used to assess the effects of pollutants on plants and animals.

The farm includes a dairy herd, a beef herd, and other common farm animals such as hogs, goats and chickens. It has agricultural facilities and a reservoir.

A wide variety of pollutant transport and transformation studies can be conducted at the farm in a natural setting with hazardous pollutants at concentrations that could not be used in preliminary Laboratory studies.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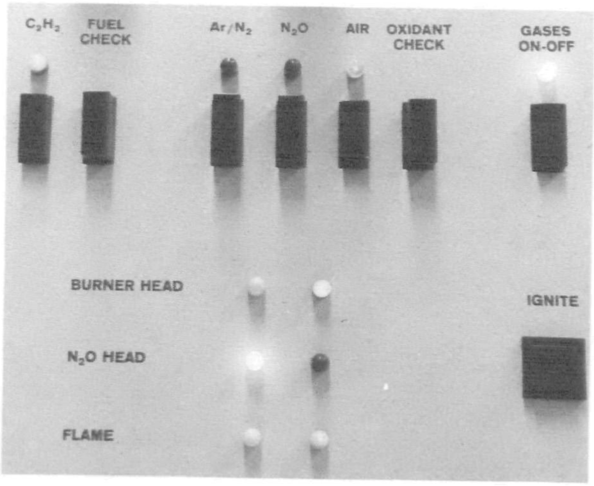
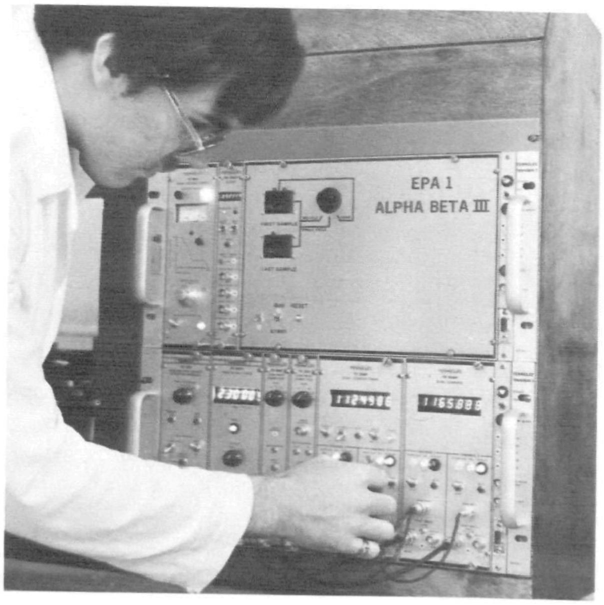


Analytical Support

The Laboratory characterizes and analyzes pollutants in environmental samples for EPA regional offices and for other Federal, state and local agencies involved in environmental monitoring programs.

State-of-the-art equipment is used and new instruments and analytical techniques are continually being developed to increase the number, precision and sensitivity of the measurements that can be made.

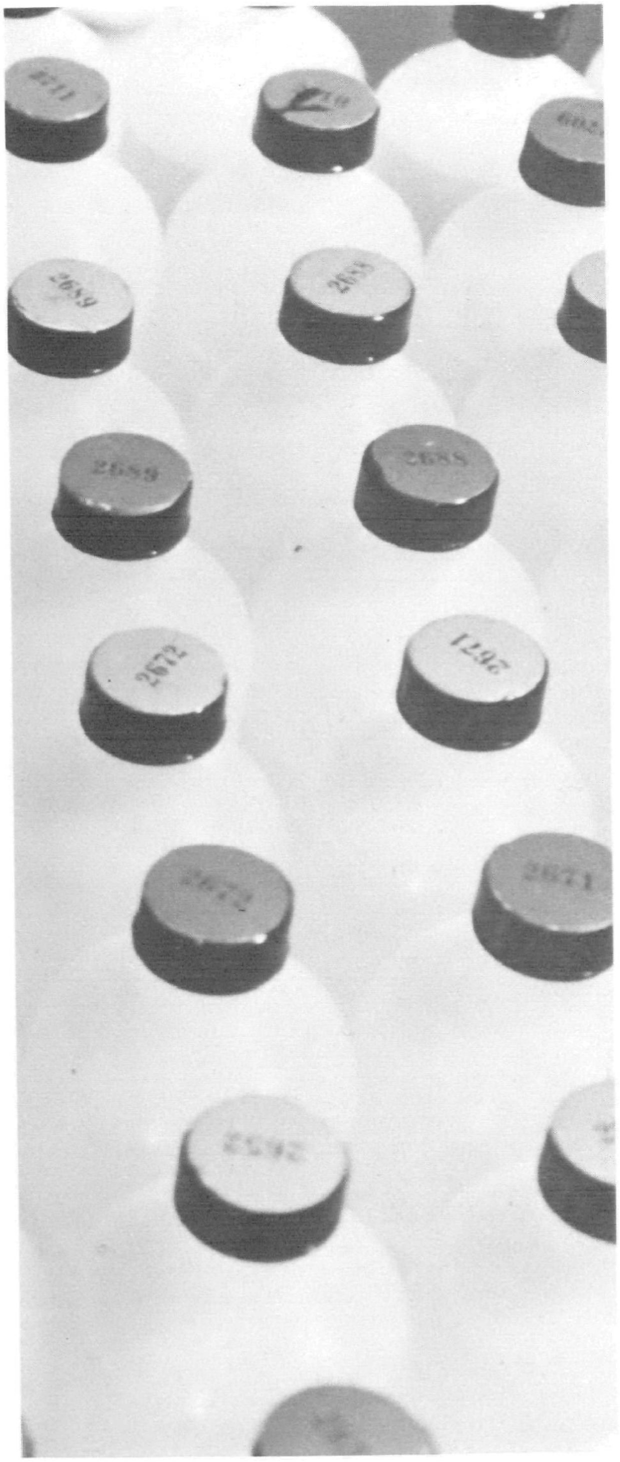
The Laboratory is conducting a research program that may allow it to identify the exact source of pollutants through chemical and physical analysis of soil, biological, water or air samples. Many pollution sources emit a mix of pollutants that is characteristic of that one source. Samples are being collected around selected pollution sources and analyzed for these pollutant mix "signatures." Once a large data base is assembled and categorized, it should be relatively easy to trace the source of pollutants found in future samples.



Quality Assurance

Data from a number of Federal, state, regional and local monitoring programs are used to establish and enforce pollution standards. To assure the standards are meaningful and fairly applied, measurements made by the various monitoring authorities must be intercomparable.

To help achieve this goal, the Laboratory is establishing itself as a center of excellence, where the facilities, equipment, procedures and skill levels available provide consistent results that other laboratories can use as a point of reference. The Laboratory has long been recognized as a center of excellence for radiation measurements and is developing a similar capability for trace metals and toxic materials in biological material and soils. Other EPA laboratories are responsible for quality assurance of measurements for other pollutants and for trace metals and toxic materials in air and water.



The Laboratory produces calibrated samples of known concentrations of pollutants that are provided to users on request. These are used for calibration, standardization and quality control.

The Laboratory develops EPA reference methods for laboratory measurement of environmental pollutants. Since the laboratories that ultimately use these methods will vary in size, facilites and skill levels, the methods and the written instructions that describe them must be validated through collaborative tests at a number of different representative laboratories.

The Laboratory sends each participating laboratory an identical set of numbered samples that includes various concentrations of a pollutant along with a description of the analytical method to be used. Measurements made by the laboratories are compared with the known concentrations to determine the success of the method. When an analytical method passes this test, it is published and distributed as an EPA reference method.

A similar testing service is offered to assure other laboratories that their measurements are accurate. Periodically, laboratories that participate in this intercomparison program each receive an identical sample of material that includes a pollutant to be identified and measured. They receive a report comparing their results to the actual values and to the mean of the measurements submitted by all the participating laboratories.

The Laboratory assures the validity of its own work through intercomparison tests with the National Bureau of Standards.

MONITORING OPERATIONS

As part of its research activities, the Environmental Monitoring and Support Laboratory conducts field studies to measure environmental quality in support of EPA regional and headquarters program offices. These studies provide the dual benefit of contributing important information about the environment at the same time new monitoring techniques and instruments are tested and demonstrated under actual field conditions. They also provide Laboratory researchers with first-hand information about the constantly changing problems and requirements of day-to-day environmental monitoring.

Water and Land Quality

The Laboratory studies water and land quality together because they are interdependent. Ordinarily, water quality is the main consideration because it usually has a more immediate and far-reaching effect on human health than land quality. Land use then would be examined to determine its impact on the aquatic system.

One example of the Laboratory's water quality monitoring is its participation in the National Eutrophication Survey, a study of the effects of pollution on the aging process of lakes and reservoirs. The survey involved joint efforts of two EPA laboratories, EPA headquarters and regional offices, and state and local agencies.

The Las Vegas Laboratory's role in the survey was to collect and analyze multiple samples from more than 800 lakes and reservoirs throughout the United States, and prepare individual reports on the trophic condition of each lake and reservoir.

The Laboratory developed computer programs to correlate data from all the lakes and reservoirs in the study. From this information, it has identified the measurements that are the best indicators of the water's condition and has suggested guidelines that define limits for each of these measurements which, if exceeded, indicate unacceptable water quality. Federal and state authorities can use these guidelines in establishing water quality standards and for setting priorities in clean-up efforts.

To gather data quickly and economically, the Laboratory developed an electronic sensor package that can be lowered into a body of water to measure temperature, conductivity, acidity (pH), dissolved oxygen and depth continuously as the sensor package descends.

The package and associated electronic monitoring equipment are installed on a helicopter. The helicopter flies to the area being studied, lands on the water and lowers the sensor package into the water. Scientists can determine water quality at given depths by monitoring the electronic instruments on board as the sensor package descends. As the package is raised, it can pump samples from whatever depths the scientists select for more detailed analysis in a laboratory.

In addition to electronic monitoring systems similar to those used in the National Eutrophication Survey, the Laboratory uses mobile laboratories and monitoring systems operated on land and from watercraft along with more conventional sampling techniques to monitor physical, chemical and biological changes caused by pollution.

Air Quality

The Laboratory monitors air quality with airborne and ground-based systems that can identify pollutants and determine their location and distribution.

Most of the Laboratory's air quality studies involve the use of helicopters that were originally acquired to collect data for the Regional Air Pollution Study (RAPS), a comprehensive research project in St. Louis, Missouri to analyze the movement of and chemical changes in pollutants. The helicopters are outfitted with instruments to detect and measure oxides of nitrogen, ozone, carbon dioxide, sulfur dioxide, methane, total hydrocarbons, airborne particles, temperature, humidity and materials used as tracers.

For long-range studies, the Laboratory uses fixed-wing aircraft with monitoring capabilities similar to those of the helicopters, plus the ability to continuously monitor gaseous hydrogen chloride. All the aircraft are equipped to collect air samples in special non-reactive containers for later laboratory analysis. For a monitoring assignment that requires additional capabilities, the necessary equipment can be added.

Air quality studies conducted by the Laboratory deal with such problems as:

- Pollution being transported to areas that may be as far as 100 miles, or more, from the pollution source.
- The contribution of a specific type of industry, or of a particular plant, to ambient pollution levels. This information can be used to set emission standards or to verify compliance with existing standards.
- Chemical changes that occur when pollutants are released into the atmosphere and react with the air or with other pollutants to form compounds that may be more hazardous than the original pollutant.
- Validating, or testing, mathematical models (formulas) that predict air quality over a given area under specified conditions from meteorological and emissions data.
- Providing data on pollution distribution over an area under different conditions to identify the locations that have the highest pollution concentrations. This information can be used by local officials to determine where to establish air monitoring stations.

Environmental Radiation

When it was established by the U.S. Public Health Service in 1954, the

Laboratory's purpose was to detect and measure radioactivity that might be released to public areas from nuclear explosives tests.

Over the years, the Laboratory has developed methods and equipment to measure very small amounts of radioactivity using aircraft, stationary instruments on the ground, and mobile units.

Since 1963, nuclear weapons tests in this country have been conducted underground and designed so that radioactive contaminants are not released to the atmosphere or carried away by underground water. The U.S. Energy Research and Development Administration (ERDA), which conducts the tests, has asked EPA to monitor for radiation to provide an independent assurance that radiation is being contained.

A continuing program of monitoring is conducted on a regular schedule within about 200 miles of the Nevada Test Site and at other sites that have been used in the past for nuclear explosive testing. If radioactivity is released, the Laboratory is prepared to monitor it anywhere in the United States.

Air sampling stations which draw air through glass fiber filters to collect airborne particles are operated continuously in Nevada and neighboring states. Three times a week, the filters are replaced, sent to the Las Vegas Laboratory and analyzed for radioactivity. Some of the stations are also equipped with charcoal cartridges to collect samples of reactive gases. Still another network of stations collects samples for noble gases and tritium in atmospheric moisture or gaseous form.

Water samples are regularly collected

from wells and surface supplies at more than eighty locations near sites of underground nuclear tests in Nevada, New Mexico, Colorado and Mississippi. Some of the samples are collected at depths of more than 6,000 feet using a special truck-mounted sampling rig.

Milk samples are also collected at locations surrounding the Nevada Test Site from family cows as well as from commercial dairies. Like the air and water samples, the milk samples are analyzed for radioactivity at the Las Vegas Laboratory.

Before each nuclear test at the Nevada Test Site, EPA radiation monitoring technicians in specially equipped trucks are stationed at locations off the site that would be most likely to be affected if any radioactive materials were accidentally released.

An EPA aircraft equipped with air samplers and radiation detectors flies over the test area immediately following the test. If any radioactivity is detected, the aircraft flies in a pattern of horizontal passes and vertical spirals so technicians aboard can determine the identity and amount of radioactive materials released. They also report the direction and rate of movement of the radioactive effluent so that the technicians on the ground can be positioned in its path for monitoring and sampling.

Anytime there is a release of radioactive

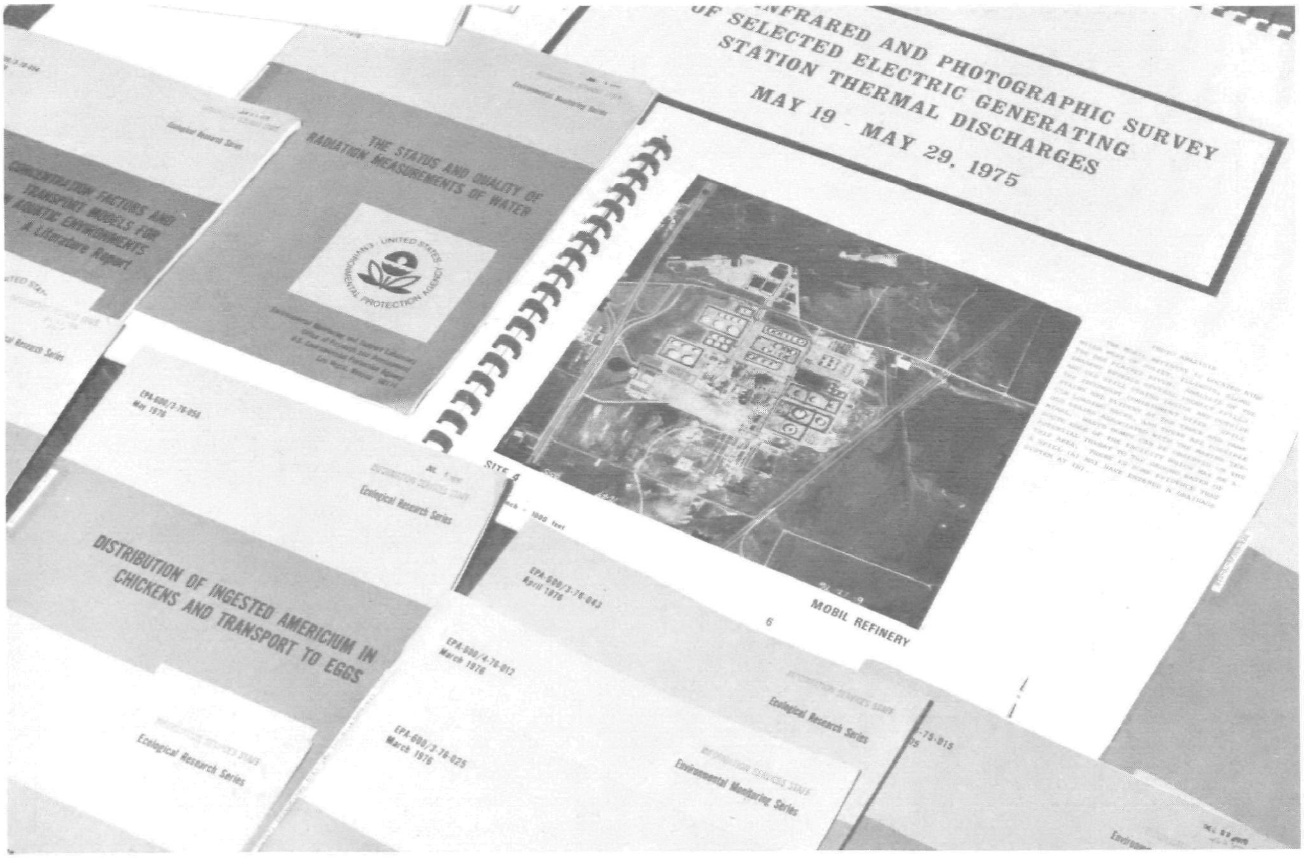
materials, the Laboratory can activate seventy additional air sampling stations that are already in place in the 21 states west of the Mississippi River. The samplers are operated on request by local residents or state or local agencies, who send the filters to Las Vegas for analysis.

The Laboratory has a similar arrangement for collecting additional milk samples. About 175 dairies in the 21 western states have agreed to send raw milk samples to the Laboratory whenever they are needed.

Aircraft Operations

The Laboratory maintains a small fleet of rotary and fixed-wing aircraft in Las Vegas to support its research and monitoring activities. All the aircraft owned by the Laboratory are military surplus that have been modified and, in some cases, rebuilt by the Laboratory for environmental monitoring.

When additional aircraft are required to fulfill research commitments, the Laboratory borrows them from other government agencies or hires private contractors.



Transfer of Technology

Most of the field studies conducted by the Laboratory, either because of their scope or because of the special nature of the study, require new, or modified, monitoring approaches.

Some only involve new uses for existing equipment. Others require instrument modifications, new combinations of equipment, or entirely new procedures. Sometimes, when data from a broad study are correlated, shortcuts can be found so that similar future studies can be simplified. This was the case with the National Eutrophication Survey. From the data collected in that survey, Laboratory scientists developed computer programs that can provide all the information normally needed to evaluate lake water quality from measurement of only four to six water quality parameters. Previously, it was necessary to measure at least 16 parameters.

Whenever a Laboratory field study suggests improved monitoring methods that could be used in future environmental monitoring activities by Federal, state or local agencies, or by private industry, details of equipment required and recommended procedures are published and made available to the public.

This false color infrared photograph was made to monitor vegetation stress caused by the strip mine in the center of the photograph. Healthy vegetation appears bright red, with lighter shades of red indicating stress. Variations in the color of the water are due to light reflected from the water's surface.

REMOTE SENSING

Aerial surveys of the Earth's surface have been used for years for military reconnaissance and, more recently, for general applications such as geologic, agricultural and land use studies. However, their application to environmental problems is relatively new.

Historically, pollution monitoring has been performed by collecting samples for later chemical analysis in a laboratory. During the last three decades, physical and automated methods have been developed to provide continuous measurements at specific monitoring sites.

Remote sensing supplements these contact monitoring techniques. It provides speed, perspective and mobility that allow the U.S. Environmental Protection Agency to collect important environmental information that would be either prohibitively expensive or impossible by contact monitoring alone.

The Environmental Monitoring and Support Laboratory devotes more than half of its remote sensing efforts to providing technical assistance to EPA regions and headquarters program offices. Among these are studies to:

- Delineate the thermal mixing zones from heated water discharged by electric power generating stations.
- Inventory rivers for waste discharge locations.
- Document harmful industrial air emissions.
- Locate feedlot and associated pollution sources.
- Document strip mining operating and reclamation practices.
- Locate targets for contact monitoring or compliance inspections.
- Locate and document major oil spills; provide guidance for containment and clean-up efforts.
- Determine the height of inversion layers.
- Map the distribution of pollutants over large areas.
- Analyze land use related to evironmental concerns.

In addition to providing technical support, the Remote Sensing Division develops and adapts new remote sensing systems and assists in monitoring the environmental impact of increasing energy development.

Remote Monitoring Systems

A wide range of remote sensing techniques and equipment is available because of research conducted for military, agricultural and other applications. The Environmental Monitoring and Support Laboratory is taking advantage of this research by finding ways to apply existing technology to environmental problems, rather than engaging in basic research on entirely new systems.

In many cases, the Laboratory has even been able to use existing data, gathered for an entirely different purpose by other agencies, to yield important information about the environment.

Among the systems now in use or under development are:

Aerial Photography — The Laboratory uses two kinds of aerial cameras: mapping cameras, to photograph large areas without distortion, and reconnaissance cameras. The reconnaissance cameras show exceptional detail because at the instant of exposure the film moves to compensate for the forward motion of the aircraft. The cameras use black-and-white, color and infrared film.

When interpreted by experts, photographs can be used to inventory pollution sources such as waste outfalls, industrial facilities, garbage dumps and feedlots. Information from aerial photography can help show environmental impacts of energy-related activities like oil shale extraction, strip mining, and rehabilitation of land disturbed by these activities.

EPA aerial photographs also are used to estimate the population density in a polluted or threatened area and to map oil spills and aid in assessing their long-term effects.

Thermal Infrared Scanning — The thermal scanner is sensitive to heat radiated from the ground. A sensor in the aircraft scans at right angles to the flight path. As the aircraft moves forward, the scanner covers adjacent strips on the ground. The aircraft speed and scan rate are controlled so that no ground remains unscanned.

The scans are recorded on film to produce a continuous image of ground features that resembles a photograph. They also can be recorded on magnetic tape, from which a computer can produce an isothermal map.

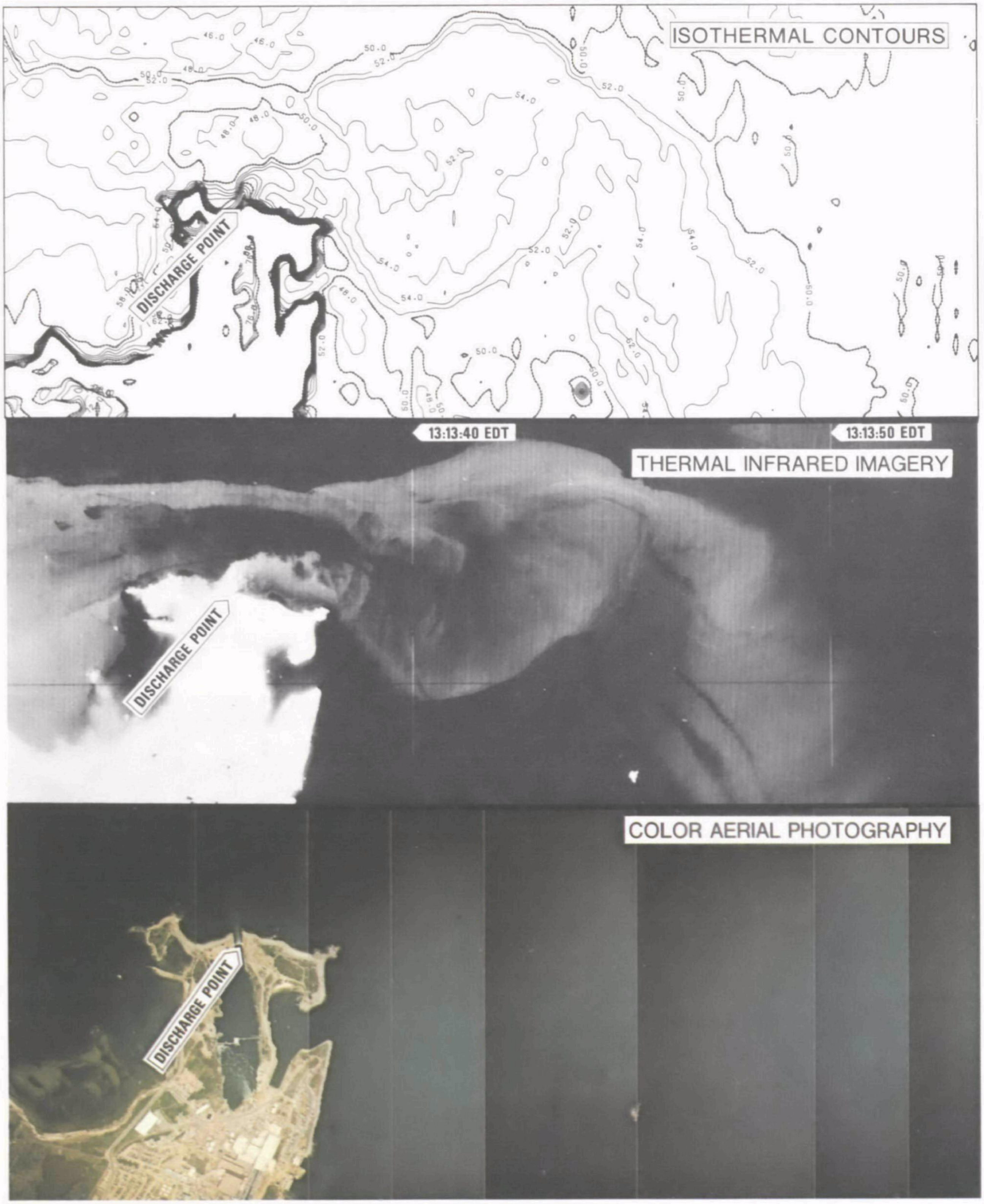
This technique can be used day or night and is sensitive enough to show temperature differences in water as low as one degree Celsius. Infrared scans are often used to show waste discharges into waterways.

Multispectral Scanning — Multispectral scanning is used to identify classes of objects on the ground from the light frequencies they reflect. Multispectral scanning can be used to remotely determine whether land used for strip mining has been properly reclaimed by identifying the vegetation it supports. It also shows promise in identifying water pollutants and in monitoring land use.

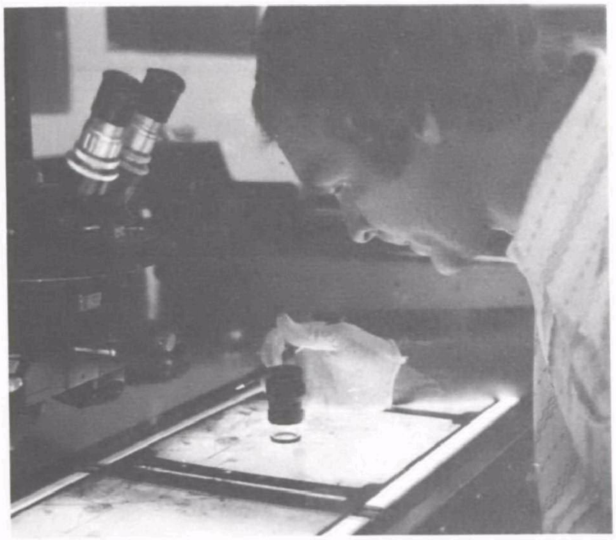
Image Exploitation — An ongoing research objective is to extract every possible bit of useful environmental information from surveys conducted by imaging monitoring systems.

Interpretation keys are being developed as an aid to photo interpreters at Federal, state and local agencies. The keys describe and illustrate characteristics of an aerial image that are evironmentally significant.

This panoramic color photograph is one of a series used to direct clean-up efforts after an oil spill on the San Juan River in Utah.



This composite color photograph (bottom) shows an area monitored by an airborne thermal infrared scanner to determine the distribution of heated water discharged from a power plant. Data from the scanner were recorded on film (center) and on magnetic tape. From the magnetic tape, a computer generated an isothermal map (top). The center image shows thermal mixing zones, with lighter areas indicating higher temperatures. The isothermal map shows the actual temperature in degrees Fahrenheit.

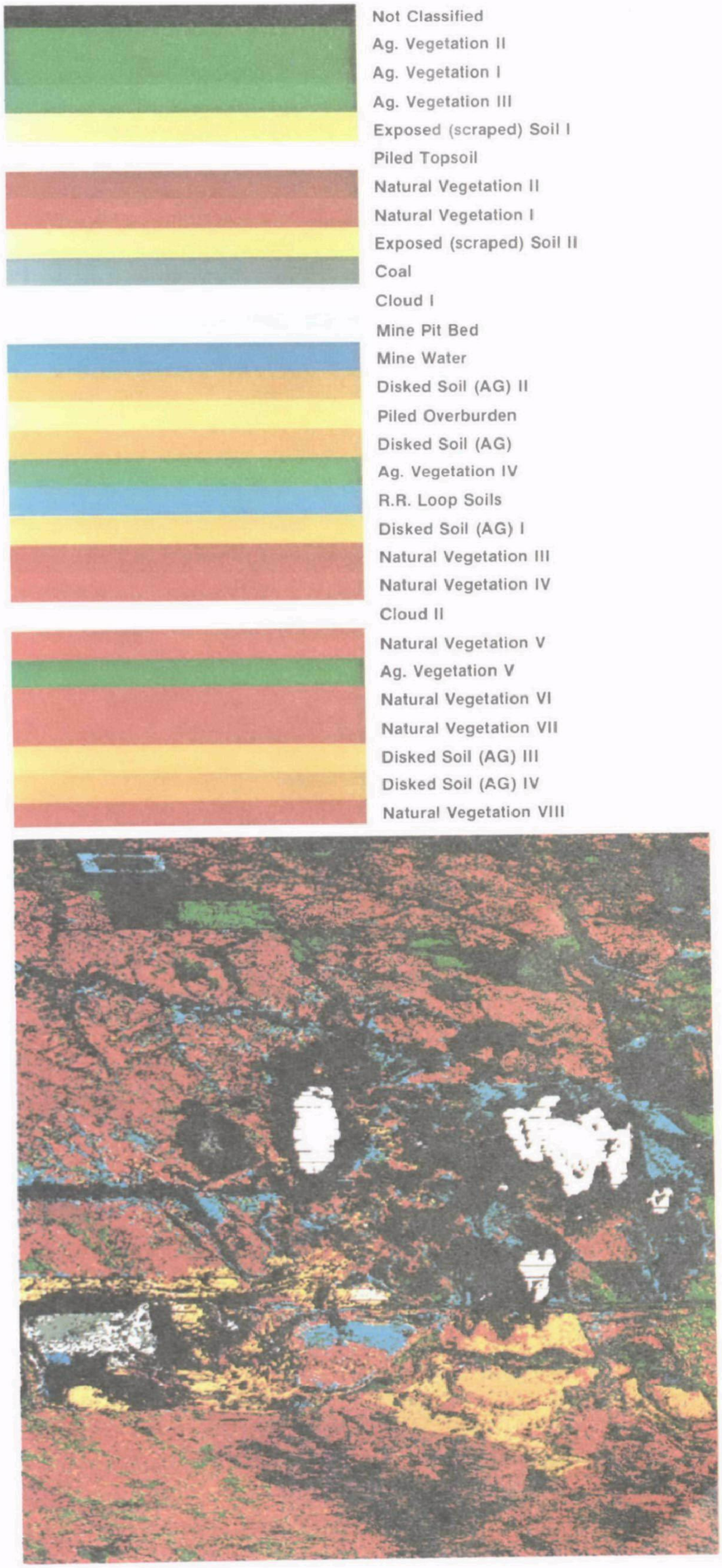


The Laboratory also is working with computer programs and techniques that increase the speed, quantity and accuracy of information extracted from the images.

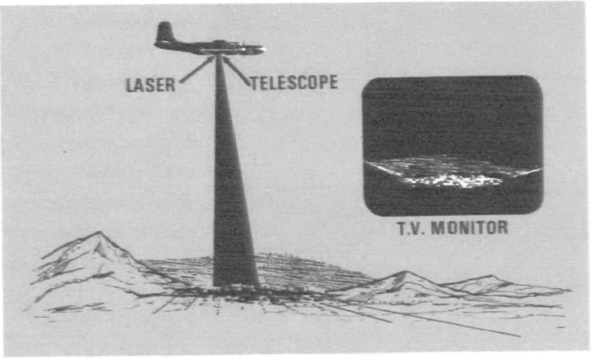
Through a field station at Warrenton, Virginia, the Laboratory maintains liaison with other agencies that use aerial imagery. This avoids duplication of effort and makes data collected for other purposes available to the Laboratory.

The Laboratory uses Landsat and Skylab satellite images of the Earth produced by the National Aeronautics and Space Administration (NASA) and aerial photography produced by a variety of government agencies.

Although most of these images were made for such uses as land use studies, mapping, and agricultural surveys, they can also be interpreted to yield significant information about environmental problems.



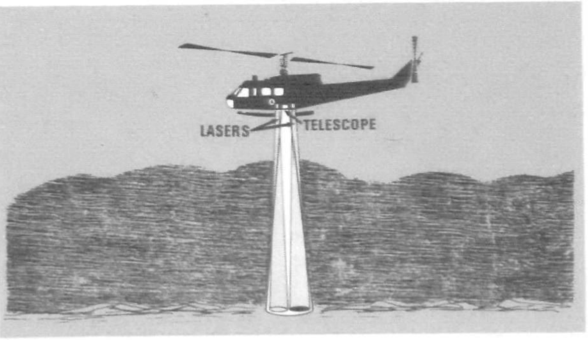
This image was generated by a computer from data collected by an airborne 11-channel multispectral scanner. The computer has identified objects on the ground from the light frequencies they reflect and assigned a color to each of 28 classes of objects. The colors are chosen arbitrarily and are not necessarily related to the colors of the objects. In this image, natural vegetation is shown as red, agricultural crops as green and most soils as yellow. Different classes of plants and soils have been identified and appear as different shades of these colors, as shown on the color key.



Lidar — Lidar is similar to radar and sonar. But, instead of using radio or sound waves, it uses light from a laser. The light, aimed at the ground from an aerial platform, is reflected by particles of liquids or solids suspended in the air (aerosols). The light reflected back is collected by a telescope, changed to electrical pulses, and stored on magnetic tape for later analysis. Simultaneously, the recorded information can be displayed on a television screen on the aircraft for immediate assessment of the aerosol layers.

From this information, EPA scientists can determine the range, concentration and location of aerosols, height of inversions, and locations of pockets or plumes of highly concentrated aerosols.

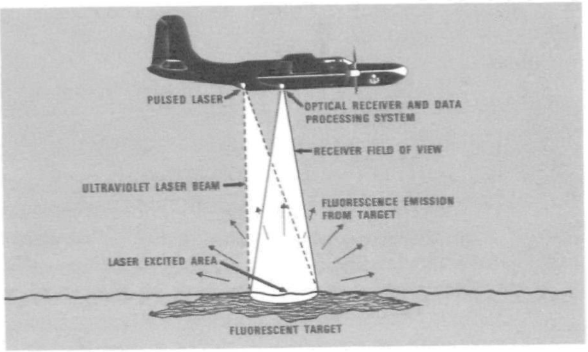
Earth Reflected Differential Absorption — This is an airborne system which uses two lasers to monitor specific gaseous pollutants in the air. It takes advantage of the fact that different substances absorb different frequencies (colors) of light. The frequencies of the lasers are adjustable. One is set so that it is absorbed by the pollutant being sought. The other is adjusted to a frequency that can pass through the pollutant unchanged. The difference in the two beams, after they have been reflected by the Earth and collected by a telescope in the aircraft, indicates the quantity and geographic distribution of the specific pollutant under study. Pollutants that can be monitored by this system include ozone and sulfur dioxide.



Laser Fluorosensing — Many substances emit visible light (fluoresce) when they absorb light in the blue or ultraviolet range. The color and intensity of this fluorescent emission is unique for different substances and can be used to identify them.

In laser fluorosensing, fluorescence is produced in a remote target by illuminating it with light pulses from a laser. The fluorescent emission is collected with a telescope and analyzed to identify the specific pollutants being monitored and to provide clues to their source.

Laser fluorosensing can be used to identify water pollutants and to monitor changes caused in vegetation by air pollution.



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Additional Information

The Environmental Monitoring and Support Laboratory at Las Vegas has established an Information Services Staff to disseminate information about its activities and to refer requests for technical information to the appropriate division. Queries should be directed to:

Information Services Staff
EPA Laboratory
Box 15027
Las Vegas, Nevada 89114

Scientific and technical reports published by the Laboratory are available for purchase from the National Technical Information Center, U.S. Department of Commerce, Springfield, Virginia 22161. A catalog of recent Laboratory publications is available from the Laboratory's Information Services Staff. A catalog of all publications produced by EPA's Office of Research and Development, including reports of the Las Vegas Laboratory, may be ordered from Technical Information Staff, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. Both catalogs are provided free upon request.

The Laboratory directly serves only EPA regional and headquarters program offices. However, others may take advantage of its services through the EPA regional office that serves their state.

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