ANALYSIS
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soils

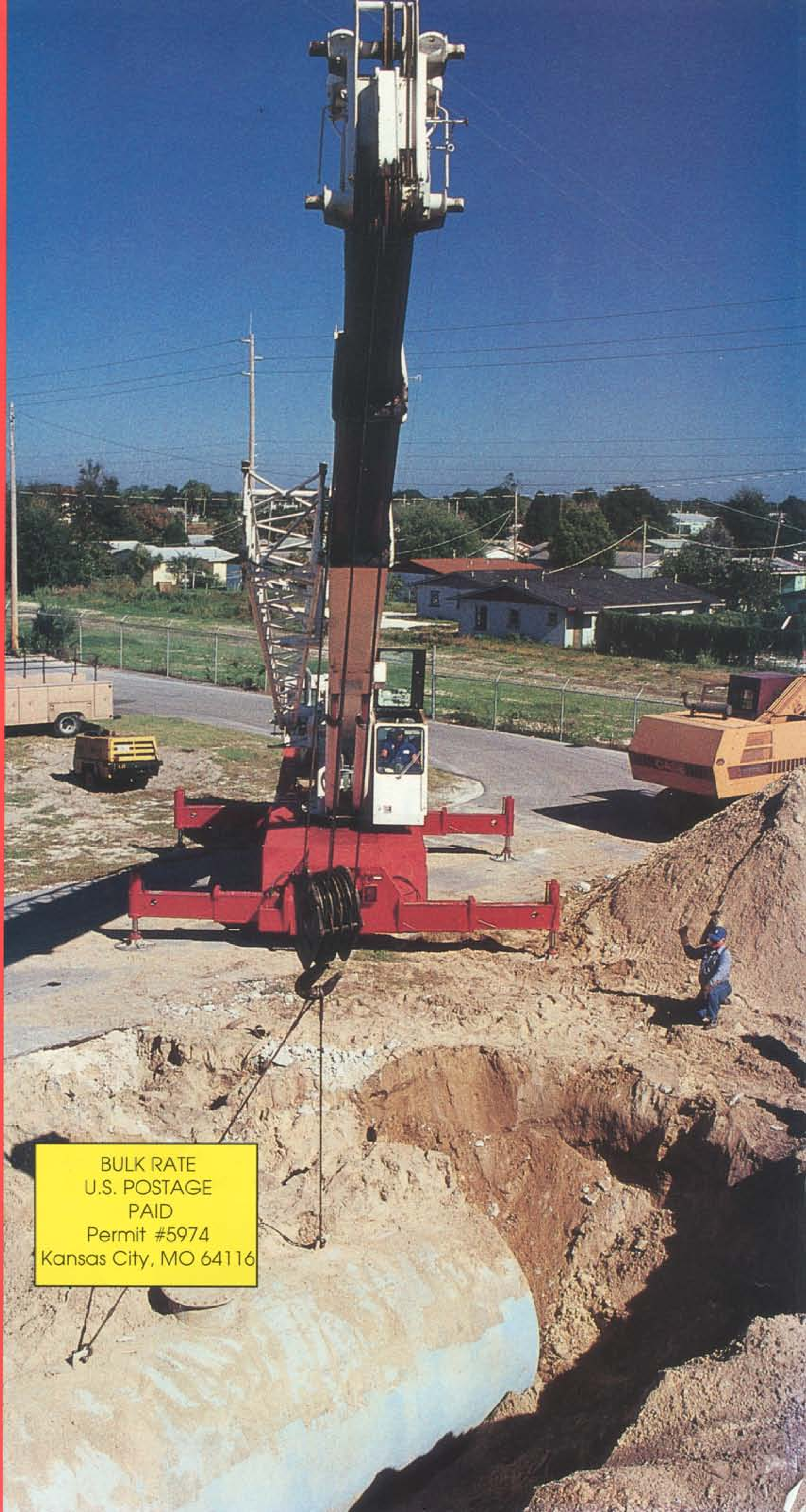
MAY-JUNE 1991

DOE's $200 billion cleanup market

Telerobotic excavators may aid in the cleanup of weapons manufacturing sites.

Ghost tanks—Beware! Haunted sites could scare you to the poor house

Solid-phase/slurry phase bioremediation



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Soil cleanup

$200 billion cleanup market

New technology needed to remediate weapons manufacturing sites

Haz-Trak, a force feedback telerobotic excavator developed by Kraft Telerobotics, Inc.

Estimates to clean up all the leaking underground storage tank sites range from $20 to 30 billion over the next decade. The estimated cost to clean up radioactive pollution at nuclear weapons sites over the next 30 years is $200 billion. And that estimate discounts a report released by the Congressional Office of Technology Assessment who, after an 18-month investigation, concluded the clean up may take much longer than 30 years, cost much more than $200 billion.

The Department of Energy (DOE), charged with the task of cleaning up hazardous wastes and contamination from more than four decades of weapons production, released a five year plan calling for $34.7 billion through fiscal 1996.

The waste generated by weapons manufacturing represents a unique technical challenge.

Solutions to these environmental problems are being actively sought from the private sector—U.S. industry, universities, other federal agencies—anyone with an idea is welcome.

According to Kathleen Hain, branch chief for the DOE Office of Technology Development (OTD), division of research and development, "industry expertise will be tapped through a variety of formal and informal mechanisms. Informal activities will include laboratory visits, personnel exchanges and scientist-to-scientist interactions. Formal mechanisms include collaborative research projects between industry and the laboratories, consortia, cooperative research and development agreements (CRDAs), user facility agreements, intellectual property licensing or consulting arrangements."

The private sector is being asked to help shape, guide and evaluate the entire program. The OTD exists to find, encourage and implement participation from industrial groups "such as those from the Fortune 500 list...to maximize involvement of the private sector in national waste management and environment restoration issues."

The DOE is starting with five sites across the country. These will be used for integrated demonstrations of a wide variety of technological applications.

Initial screenings at the Fernald Site in Ohio show six pits filled with wastes containing both uranium and thorium, three 80 foot diameter silos containing pitchblende (radium) residue and metal oxides, 13,000 steel drums of thorium, 44,000 drums of mixed waste containing uranium and thorium. The physical condition and structural integrity of the drums is not well known.

The Hanford Site in Washington contains 149 single-shell storage tanks (SSTs), located in 12 SST farms which have been used for the storage of process liquids and wastes since the early 1940's. In general, the tanks contain liquid, salt cake and sludge. Remediation is scheduled to begin in 1994 and is to be completed by fiscal year 2018. It is not well known what is in the tanks though 66 have either leaked or have been declared "assumed leakers."

Also at the Hanford reservation are some 1,100 'past practices' sites—including ditches and ponds—which need to be characterized and remediation developed and implemented by 2018.

Hanford also has 28 one-million gallon double shell tanks (DSTs) which contain radioactive contamination and toxic chemical constituents dating back to 1970.

More than two dozen separate burial locations at Hanford hold containers of unknown condition

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Information for this article was provided by the United States Department of Energy's Office of Environmental Restoration and Waste Management, Germantown, Md.,and Steve Harbur, director of product development, Kraft Telerobotics, Overland Park, Kan.

with partially known radioactive contents.

The Idaho National Engineering Laboratory (INEL) site contains two million cubic feet of hazardous, radioactive buried waste and six million cubic feet of similarly contaminated soil. This waste was received in cardboard boxes, steel drums, plywood boxes and as loose material. The methods used to bury these wastes did not consider future retrieval of the wastes. Sampling wells have indicated traces of plutonium in a bed of soil at 100 foot depth and carbon tetrachloride in subsurface water.

INEL has 11 single-shell stainless steel waste storage tanks containing high-level radioactive liquid and sludge. The tanks do not meet standards for double-wall tanks, there are technical concerns about the seismic stability of five of them and there is a lack of historical corrosion data on all the tanks.

Also at INEL, 2.4 million cubic feet of transuranic waste (waste that is contaminated with alpha-emitting transuranium nuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram of waste) in various barrels and boxes. Over 90 percent is considered to include excess free liquids, dispersible fines and deteriorated packages.

The Rocky Flats site outside Denver, Colo., has 178 spill, burial and process waste pipe sites thought to contain uranium, contaminated oils, burned oil residues and radioactively contaminated drums. There are five ponds containing sludges with uranium, plutonium and cadmium. The sludges also contain heavy metals. The asphalt liners of the ponds will probably have to be removed as the ponds will need to be eliminated.

There are several old burial sites, consisting of depleted uranium, plutonium, carbon tetrachloride (which has migrated), lithium, sodium and some americium (a daughter product of plutonium).

The Savannah River Site, in South Carolina, started reclamation and remediation efforts in 1981. The priority effort at Savannah River is the remediation of liquid waste seepage basins which are contaminating the ground water. The seepage basins receive low-level radioactive waste water from the laboratory and other process buildings. The current closure method consists of stabilization of basin liquids followed by backfilling and capping of the basin.

The five reactor areas at the site use earthen seepage basins to dispose of low-level radioactive purge waters from the reactor disassembly basins. There are 14 reactor seepage basins on the site. Seven are inactive. Six of these inactive basins were deactivated and backfilled between 1958 and 1977. Closure options for these basins are being evaluated. The sludge in these basins contains concentrations of radionuclides.

There are 51 high-level carbon steel radioactive waste tanks at Savannah River which have received or are receiving liquid

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wastes. Nine of the tanks show signs of leakage into secondary containment catch pans.

There are also an estimated 24,000 drums in interim storage.

The hazardous and mixed waste generated by the Savannah River facilities are comprised of tritiated oil, sludge, mercury, lead, cadmium, silver, benzene, scintillation fluid, contaminated laboratory wastes, salts and salt cake, radionuclides, aluminum and transuranic waste.

There are five soil-related projects on-going in 1991: cleanup of volatile organic compounds in saturated soil at Savannah River, S.C.; cleanup of volatile organic compounds in unsaturated soil in Hanford, Wash.; cleanup of non-volatile organic compounds in arid soils at Sandia National Laboratory, N.M.; cleanup of plutonium contaminated soil at the Nevada test site; and cleanup of uranium contaminated soil at Fernald, Ohio.

These projects will address scoping, site characterization, remedial action, closure and post-closure monitoring technologies.

The project at Savannah River for the cleanup or organics in saturated soil will develop and evaluate technologies for faster, better, safer and cheaper removal and destruction of organic contaminants from sites with saturated soil and groundwater.

The first phase was to perform a field demonstration of *in situ* air stripping, a process that combines vapor extraction and air injection. The process was tested using paired horizontal wells. The procedure consists of purging volatile contaminants from groundwater using a horizontal well installed below contaminated groundwater and removing purged materials along with residual contaminants in the vadose zone through a vacuum extraction horizontal well.

A preliminary, numerical multiphase model of the air injection process was developed in order to select optimum flow rates, frequency of data sampling and locations for the post-characterization boreholes. The entrapment of VOCs by low permeability layers was also investigated.

Many new directional drilling systems have been developed specifically addressing the needs of environmental restoration projects. In particular, the evaluations will include downhole mud motors and ultrashort radius water jets.

Characterization technologies to be tested include discrete depth sampling using subcore analysis, cone penetrometer with sensors, cone penetrometer with soil gas and water sampler, soil gas surveys and surface geophysics.

In the *in situ* bioremediation test, indigenous microorganisms will be stimulated to degrade trichloroethylene (TCE) *in situ* by the addition of nutrients to the contaminated zone and by surface treatment of contaminated off-gas and water. The horizontal wells that form the basis for the process are expected to provide increased surface area that will allow better delivery of nutrients and easier recovery of gas and water, as well as minimize clogging and plugging. The principal nutrient to be supplied is methane, at a low air concentration.

Following an initial methane injection, periodic addition of other nutrients, such as phosphate may be pursued to further stimulate the indigenous microorganisms.

Preliminary results from air stripping tests indicate that using a pressurized horizontal well below the aquifer, coupled with a reduced pressure well above the aquifer, will provide a significant gain and can be accomplished with excellent stripping efficiencies when compared to traditional pump and strip operations. Heated air will be injected into the pressurized horizontal well to measure the amount of enhancement as a function of temperature.

After heated air stripping, steam stripping will be tested as a mechanism to further enhance stripping efficiency. Data will also be taken for ambient air stripping, heated air stripping and steam stripping using fractured horizontal wells similar to

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those designed for enhanced gas recovery.

A second bioremediation technology under development uses microbes that are immobilized on support material. "Super hydrophobic" materials are being pursued as mechanisms to efficiently separate non-polar (TCE) substances from hydrophilic material.

The DOE Office of Technology Development has also released a Robotics Technology Development program (in three volumes) to characterize the potential for remotely operated manipulators and other equipment to work at these sites. Given the toxic and radioactive composition of material at these sites, reduced human exposure becomes a matter of survival. In addition, automation of some repetitive tasks could result in increased speed and productivity of operations.

One company with a sharp eye on the DOE plans is Kraft Telerobotics, of Overland Park, Kan. Kraft is poised to offer several robotic applications to hazardous cleanup situations.

The key to their technology is force feedback which allows the operator to "feel" what is being held by the manipulator as it does its work. For instance, if the manipulator is outfitted to dig with a shovel, the pistol-grip controller resists the operator's hand with the weight of the dirt moved. Through the hand control, the operator can "feel" the weight of the load lifted. And, in excavation work, the control allows the operator to instantly "feel" buried objects such as utility lines, pipes and rocks.

Kraft's remotely-operated, track-mounted excavator and material handling system, "Haz-Trak," uses force feedback technology to operate a backhoe shovel as well as barrel handling and other manipulative tasks. In the case of the thousands of DOE barrels in unknown degrees of deterioration, the Haz-Trak force feedback barrel handler actually allows the operator to apply the minimum force of grip necessary to pick up the barrel.

Brett Kraft, president of Kraft Telerobotics, says force feedback is not a new idea—it has been used for years in the nuclear power industry—but those systems were primarily mechanical, not electrical.

The hand controller to operate Haz-Trak is an intuitive system that instantaneously mimics the operator's hand, wrist, arm and shoulder movements. "If you can move your arms, you can operate one of these manipulators," says Steve Harbur, director of product development for Kraft.

Haz-Trak is equipped with two fixed color cameras for peripheral vision and a single pan and tilt mounted color work camera. The operator of Haz-Trak sits at a carefully designed console station with three color monitors to provide a panoramic view of the work environment.

Task recall is an enhancement that enables the operator to "teach" the arm routine or repetitive tasks for playback execution.

Kraft's remote manipulator systems have been used extensively by the offshore gas and petroleum industry in remote-controlled minisubs that inspect and maintain the underwater structures of oil drilling platforms. "Undersea work is a very hostile environment for any kind of machine," Harbur says. "Our manipulators are built to withstand that kind of environment."

The system works so well underwater it is being used to recover millions of dollars worth of gold coins from the wreckage of a steamship that sunk off the coast of South Carolina during a hurricane about 150 years ago. The manipulator arms, mounted on a remote-controlled minisub, can reach out and pick up gold coins lying on the ocean floor 8,000 feet below the surface.

Kraft's force reflecting controllers will also be used as part of NASA's flight telerobotic servicer (FTS) program, which is now in the development stages. The end result of FTS will be what Harbur describes as a "robot astronaut" which will be used for assembly, maintenance and inspection in unpressurized areas of the space shuttle and a planned U.S. space station. NASA researchers are now using Kraft technology to evaluate some of the capabilities of state-of-the-art manipulators.

Kraft's technology is also being used in a futuristic power utility truck developed by Aichi Sharyo Co. Ltd., one of Japan's largest manufacturers of aerial lifts and special purpose vehicles for Japan's utility industry. Hydro-Quebec, one of the largest power companies in North America is also incorporating Kraft manipulator technology in a power line service truck.

But, according to Harbur, U.S. companies are taking a "wait and see" attitude, although Kraft is willing to license their technology to large U.S. manufacturers.

"What we need is to have a few big companies recognize the value of our manipulator system so they can be produced in quantity for all kinds of different applications," Harbur says. "Right now, our manipulators are being produced in small quantities, so they're fairly expensive. But if you build them in quantity, they become very cost effective. The larger the market opportunity, the cheaper things become."

Harbur says Kraft plans to deliver eight Haz-Trak units at a cost of $525,000 each over the next 18 months.

DOE's Hain says the OTD is looking for technology that does not yet exist to clean up the hazardous weapons production sites. The DOE wants private industry to develop partnerships with the government to address these challenges. Innovative companies like Kraft Telerobotics developing futuristic technology are needed to step up to the line to reclaim our damaged environment.∎

Write in 355 on inquiry card for more information.