stored underground in 177 tanks (about two-thirds of DOE's total tank waste). About a third of the tanks have leaked about a million gallons of waste.

Chemical manipulations

Steve Foelber, manager of engineering and technology for Bechtel Hanford Inc, a DOE contractor, oversees soil and groundwater remediation at the Hanford site. Bechtel has worked with EMSL scientists on many technical issues, including *in situ* chemical conversion of hazardous chromium-VI to inert chromium-III. In solving remediation problems, Foelber says, "it is important that we don't create new problems. EMSL will help us better understand the problems at a molecular level."

In some cases, it may be possible to exploit bioremediation, which uses microbial enzymes to attack soil and groundwater contaminants. Sunney Xie, a physical chemist at EMSL, uses single-molecule imaging and spectroscopy to study the molecular dynamics and chemical kinetics of enzymatic reactions. One microbial enzyme he is studying degrades trichloroethylene, which was used as a solvent in the reprocessing of spent fuel and then dumped into the ground. Another dissociates plutonium from EDTA, an agent that binds to plutonium, forming a highly mobile complex that can migrate through groundwater. (Immobilization doesn't render the soil clean, but prevents the pollutant from spreading to other areas.) The goal is to build on the knowledge gained from studying naturally occurring enzymes to genetically engineer enzymes that "work faster, are more stable and more selective," explains Xie.

The current treatment for contaminated groundwater at Hanford and other DOE sites is to pump and treat, and contaminated soil is dug up and moved to a designated waste site. Pumping and treating is okay for places like wells that are known to have very high concentrations of contaminants, says Xie. "But there is a lower, but still unacceptably high, concentration in other areas at Hanford. And you cannot pump and treat everywhere."

Tank waste

"The Hanford site is a series of problems that are previous solutions," says Gerald Stokes, PNNL's associate lab director for environmental and health sciences, and an astronomer by training. The Hanford tank waste, in particular, is poorly characterized: Three different chemical processing methods were used there over the years, and other chemicals were added in attempts to solve various problems that cropped up, such as corrosion of the carbon steel tanks. The result is a chemically and physically heterogeneous mixture. And so the first step in waste treatment is characterization. "We need to figure out how to spend limited resources to get the greatest risk reduction benefit," says PNNL's Gephart. The tank waste problems drive much of EMSL's research, which in turn is generating short- and long-term benefits for waste characterization, separation and processing.

Some methods for tank waste analysis have already been developed at EMSL. For example, in collaboration with a PNNL team, Steve Colson, associate director of EMSL's chemical structure and dynamics program, has developed a method that uses mass spectrometry for elemental analysis of material evaporated from a sample by laser ablation. Jay Grate, also at EMSL, has automated a radiochemical separation method to quantify the amount of radioactive strontium-90 in waste samples. But, Grate says, funds haven't yet been found to implement the technique. Other EMSL work focuses on understanding the viscosity and colloidal properties of the tank waste. "We are developing sedimentation models," says chemical engineer Jud Virden. "We hope that they will lead to determining the right viscosity" for processing the waste.

There is also much research on improving glassification methods, the process by which high-level waste is encapsulated in glass for long-term storage and disposal. One glass log costs about $1 million to produce and store, according to Gephart, "so the aim is to develop methods to load as much waste per volume of glass as possible." Researchers are trying to determine the solubility limits of the encapsulating glass, the effects of radiation on it and alternative approaches that could allow the waste to be packed at higher concentrations. "This could potentially save billions of dollars," Gephart says.

M. Lou Balmer, a materials scientist at EMSL, and her colleagues are looking in particular at cesium, which, when tank waste settles, remains in the liquid on top of the sludge. The cesium, which accounts for about half of the waste's radioactivity, is then separated from the rest of the liquid (which becomes low-level waste) by running the liquid through an ion exchange column. Balmer and her colleagues found that heating the ion exchange column causes a ceramic to form, trapping the cesium inside little chemical cages. "It's like shrink wrapping it," she says.

The cesium and ion exchange column complex is highly radioactive, so it still has to be packed in glass, but since the cesium doesn't have to be diluted, this treatment could reduce the total volume of glass by as much as 30%, according to Balmer. Thermal conversion of the ion exchanger also reduces the number of steps in cesium treatment, which reduces health risks to those who work with the waste, she adds.

It's a tremendous challenge for scientists to define what needs to be done to reach ill-defined cleanup goals, says Gephart. "Scientists ask, What cleanup standards are truly protective of humans and the environment?" This basic research approach to waste problems can be slow, and is often at odds with the need of site engineers to produce results quickly. In fact, it's widely acknowledged that relations between the two groups are strained, though things are getting better.

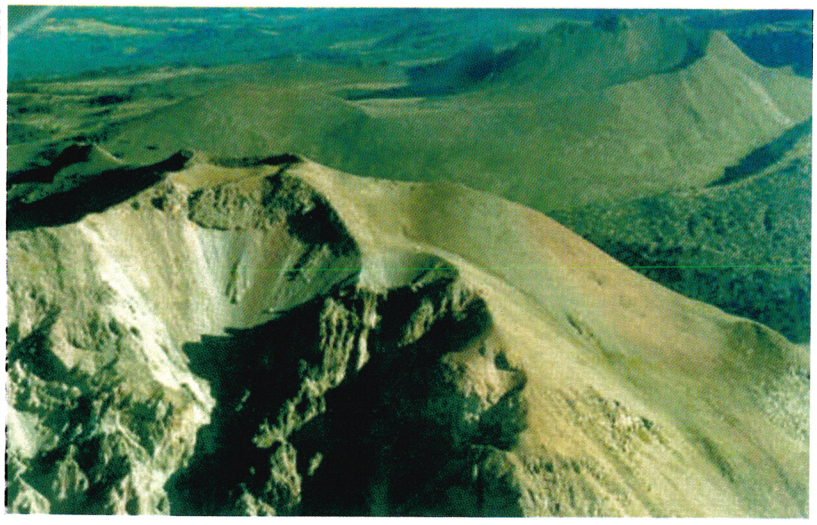
As Gephart describes the situation, "The contractors of the world are out there to accomplish as much work as possible in the shortest possible time. They are driven by business incentives to use existing technology." Gephart continues, "But the only way to get on with cleanup is to put existing technology to work. Scientists and engineers need to work together to solve practical problems. This will show us where the gaps in our knowledge and capability are, and these gaps should be the driving force for scientists." **TONI FEDER**

Puebla Site Chosen for Joint US–Mexican Radio Telescope

The Large Millimeter Telescope will be built on Cerro la Negra, in the Mexican state of Puebla, the American and Mexican partners in the project decided in February.

A collaboration between the University of Massachusetts at Amherst and Mexico's National Institute of Astrophysics, Optics and Engineering, the 50-meter LMT will be the world's largest detector of radio waves near 1 mm wavelength. It will also be the biggest investment in science that Mexico has ever made, says Alfonso Serrano, who heads the Mexican team.

The site was chosen because of its high altitude (4640 m): The low water vapor concentration at that height maximizes radiowave transmission. The telescope's large collecting area



ALFONSO SERRANO

CERRO LA NEGRA, where the Large Millimeter Telescope will be built, lies about 270 km southeast of Mexico City.

will allow detection of the weak signals of highly redshifted, just-forming galaxies, "and we'll be able to see lots of them at a time, in large swatches of sky," says Steve Strom, Serrano's US counterpart. "Unraveling the process of star formation" by studying the physics and chemistry of molecular clouds will be another major research area, says Serrano. He adds that many other related topics will be accessible for study, "since all molecules have rotational states that emit in the millimeter range."

The LMT dish will be made of 126 panels fitted with computerized sensors and motors that detect and correct for distortions to the dish's shape arising from temperature changes or from gravitational effects as it tracks objects across the sky. The panel design, adapted from the Keck telescopes in Hawaii, also cuts costs: The project planners estimate that the LMT's $50 million price tag is 60–75% less than it would cost to build a monolithic dish the same size.

Keeping costs down was crucial, particularly for the Mexican team, which, in addition to saving money, also had to promise funders that the project would provide Mexican industry with technological spillovers and educational outreach programs nationally. "It would never have been approved otherwise," says Serrano. Mexico is footing a bit more than half the bill, with funding from the Mexican government, the national Program for Science and Technology and the Puebla state government. (US funding is from the Defense Advanced Research Projects Agency, the Commonwealth of Massachusetts and the University of Massachusetts at Amherst.)

Educational and industrial outreach are not conditions of funding for the US team, but Strom says that he wants to develop programs that will reach out to Hispanic high school students in the Amherst area.

Construction will begin on the LMT this fall, after a road to the site has been built. And the telescope is scheduled to begin operating in 2002.

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Interactive Journal Is Launched on the Web

Earth Interactions is a new, Web-based journal that is intended to exploit electronic media to take formal scientific discourse beyond the capabilities of the printed page. Published jointly by the American Geophysical Union, the American Meteorological Society and the Association of American Geographers, *Earth Interactions* covers interdisciplinary Earth systems sciences, with an emphasis on interactions between the lithosphere, hydrosphere, atmosphere and biosphere in the context of global issues or global change.

The journal's electronic features include videos and animation of data and interactive math. The reader can zoom images, vary parameters in graphics, download data, or enter and analyze other data. Hypertext links to supplementary materials and other relevant work will be incorporated on an ongoing basis, including adding future citations. When corrections are necessary, they will be flagged and appended, but the original content will not be altered. To assess the various components and formats of submitted articles, peer review is necessarily done electronically.

Producing this journal won't be cheaper than producing a comparable print journal, but it's too early to tell what it will cost, according to Keith Seitter, AMS's director of publications. "In electronic publishing, you save on printing and mailing costs. But, at least for now, these savings are being eaten up by other expenses," such as structuring, formatting and creating hypertext links in the journal. To get started, *Earth Interactions* has received technical support and about $700 000 from NASA, but the plan is for the journal to become financially self-sufficient within a few years.

The first article was posted on 27 January. Articles will be published as they are accepted, rather than in periodic issues, and subscribers will be alerted by e-mail when new articles appear.

A one-year subscription costs $45 for individuals, including software for viewing and interacting with articles, which are coded in Standard Generalized Markup Language. (So far, access to SGML is available only from IBM-compatible PCs.) There are currently about 500 subscribers, and the publishers expect this number to grow to several thousand. Subscribers will have continued access to articles from paid-for years, even if the subscription is subsequently dropped.

The publishers hope that *Earth Interactions* articles will be considered in tenure decisions, something that has been a problem for electronic publications to date. "We plan for this electronic journal to become an authoritative source—it will have more information [than the printed page can provide]," said AGU executive director Fred Spilhaus, in a talk he gave at the American Association for the Advancement of Science meeting in Seattle in February.

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For more information, see the Web site at http://EarthInteractions.org.

IN BRIEF

The *Directory of Graduate Education in Acoustics*, recently published by the Acoustical Society of America, is a reference for students who are interested in pursuing a graduate degree in acoustics. It lists universities in the US and Canada that offer graduate work in at least one area of acoustics, along with contact names within the relevant departments. The directory is available from ASA, 500 Sunnyside Boulevard, Woodbury, NY 11797; phone 516-576-2360, e-mail asa@aip.org. It is also available on the ASA Web site, http://asa.aip.org. To add or correct a listing, contact Wayne Wright, Physics Department, Kalama-