

says Deupree. "It's a big trauma even if you didn't lose your home. They say it takes a year to really get back to normal, to feel right again. We've been slow getting back to work, but we're getting there."

Contamination concerns

LANL and the other DOE fire-stricken sites are also dealing with the public's concerns about environmental contamination. In Los Alamos, radioactivity in the air during and after the fire was slightly higher than normal, but "with forest fires you release lots of natural radioactivity," says Lee McAtee, LANL's deputy director for environment, safety, and health. Of more concern is that radioactivity and toxic chemicals could be carried from LANL into the Rio Grande, which is used by 13 million people for irrigation and other activities.

With the land bared and topped by a waterproof crust of resin from burned pine needles, runoff will be worse for a few years until vegetation grows back. Already, says McAtee, "in canyons where we normally see [water flowing at] half a cubic foot per second, we're seeing 800–900 cubic feet per second." That's with less rainfall than usual.

The lab, with help from DOE, the New Mexico Environment Department, and other local and federal groups, is doing a lot to reduce runoff: laying logs, straw-filled tubes, and hay bales to block and soak up water; breaking up the soil crust; reseeding the land; reinforcing road crossings; pouring concrete to catch water; and moving some of the most contaminated soil. Twenty percent of the total contamination in one canyon was at two places, says McAtee. "We dug that up."

McAtee insists that radioactivity from LANL land wouldn't add significantly to anyone's average annual dose. The lab moved the radioactive soil, he says, "not because it was a health risk, but because people don't want contamination from the lab flowing onto their land, and we should respect that."

But according to environmental engineer Greg Mello, director of the Los Alamos Study Group, which keeps tabs on LANL, it's not known exactly how much radioactive waste is scattered about lab land. "There is no inventory that any decision-maker could use with confidence—there are very few tools with which to work," he says.

Plutonium is plutonium

Meanwhile, raised levels of airborne plutonium at Hanford, the nation's

most radiologically contaminated site, were measured after a fire started by a fatal car crash scorched half of the site's 560 square miles this past June. The increased plutonium levels were probably caused by stirring up both contamination from Hanford activities and atmospheric fallout from past nuclear tests. "We don't exactly know the source," says Hanford technical adviser Wayne Glines.

"Plutonium is plutonium. Our real concern is that we don't have a public or worker health problem," Glines says, adding that the plutonium is not hazardous. The highest count was 0.0016 picocuries per cubic meter, or more than 1000 times above average. Says Glines, "If [the measured levels] persisted for an entire year, it would equate to 8 millirem. The [legal] limit is 10 millirem, and the average yearly background dose is 300 millirem."

Not surprisingly, Gerald Pollet, of the watchdog group Heart of America Northwest is not so sanguine: "For the first three days of the [Hanford] fire, DOE insisted that no areas of contamination had burned or were in jeopardy," he says. The burden of proof is on DOE, adds Arjun Makhijani, a nuclear fusion engineer and president of the Institute for Energy and Environmental Research in Takoma Park, Maryland. "LANL hasn't done a systematic study to estimate requirements for monitoring, so they don't know how much monitoring should be done to yield measurements of sufficient confidence. All these fires are severe warning signals that the nuclear labs—and other nuclear facilities—need to be much better prepared."

Public mistrust of DOE is nothing new, of course. It's one of the issues Thomas Leschine, a University of Washington professor who chaired the National Research Council's recent review, "Long-term Institutional Management of US Department of Energy

Legacy Waste Sites," wants to look at in a follow-up to the Los Alamos and Hanford fires: "What were the DOE's reactions? People's reactions? How were things reported in the media?"

Lessons learned

There is broad agreement that the threat to the public and the environment would have been much worse had the Cerro Grande fire reached the hundreds of wooden boxes of transuranic waste stacked above-ground waiting to be taken to the Waste Isolation Pilot Plant in southern New Mexico. Or had the Hanford fire reached 350 exposed barrels of depleted uranium. Or had any of the fires burned spent fuel, or blown up nuclear reactors or other facilities at the various DOE sites.

"I don't think it's luck" that these worst-case scenarios were avoided, says Ellen Livingston, DOE's senior policy adviser for environmental affairs. "Each site has a response plan that spells out procedures for preventive measures. This makes the potential for a really serious fire low." The measures include spraying dunes to immobilize contaminated sand, thinning trees, killing weeds, putting gravel around facilities, and focusing on keeping flames from attacking hazardous areas. Says LANL's McAtee, "It's been absolutely essential that we work with everybody else that has been impacted by the fire. We can't do it alone."

Adds Brad Bugger of INEEL, where fires also increased airborne radioactivity levels, "We are doing a 'lessons-learned' exercise. We have fires every year, and this is the first time we've been asked, Have you done the analysis for specific radionuclides? We understand now that the public has a different threshold. That's requiring us to be more specific."

TONI FEDER

Radio Astronomers Plan Mammoth Telescope

Plans for the largest, most sensitive telescope ever got a boost in August, when radio astronomers from 11 countries officially teamed up to shepherd the Square Kilometre Array to construction. Technical, financial, and organizational problems lie ahead, but planners aim to choose a design and location for the SKA in 2005, begin construction in 2010, and see first light in 2015.

With a collecting area of one square

Scientists on four continents are pushing technology to sink the tab to below \$1 billion for what they call the first "global-born" telescope.

kilometer, the SKA would be about 100 times more sensitive than the most powerful existing radio telescope, the Very Large Array in New Mexico. It would be able to detect surface brightness temperatures of 1 K with subarc-

second angular resolution, says Phil Diamond, head of the UK's MERLIN radio telescope array at Jodrell Bank. "That effectively means seeing cool hydrogen throughout the universe, or peering back to the earliest stages of galaxy formation."

The long list of things to look for with the SKA includes the intergalactic medium just after the Big Bang, star and galaxy formation and evolution, evidence of gravitational waves, and extraterrestrial signals. Says Harvey Butcher, a member of the SKA steering committee and director of the Netherlands Foundation for Research in Astronomy, "As with all megaprojects, it will provide ample scope for as yet unseen discoveries. Scientific fashions evolve on the timescale of large projects, and one does not wish to have an instrument that cannot address the hottest issues of the day, whatever those may turn out to be."

Technically, the SKA could be built today, but not at an affordable price. "We could build 200 copies of the Green Bank telescope, which just opened," says Diamond, but at \$70 million apiece, that would be \$14 billion (see box on page 72). "We have to prove that for \$1 billion, we can build the SKA to cover the science we want."

That will mean detecting signals across two frequency decades, from 0.15 to 20 GHz. SKA planners also want to multibeam, or collect data simultaneously from more than one part of the sky, and to counter interference from the ballooning telecommunications industry. "These capabilities will be ripe for implementation during the coming decade and will make the SKA an entirely new kind of telescope," says Butcher. One of the biggest challenges, adds Diamond, "will be to write clever software to handle all the data."

Another challenge will be choosing a site for the SKA—Australia, China, and the southwestern US are on people's lips. It's likely, says Diamond, that there will be one site with 50–70% of the collecting area, plus smaller outlying arrays scattered over thousands of kilometers, or even globally.

Mammoth to mini

So far, radio astronomers from Australia, Canada, China, Germany, India, Italy, the Netherlands, Poland, Sweden, the UK, and the US have signed on to the project. They're exploring designs for the SKA, ranging from a few mammoth dishes to many mini ones.



ARRAYS OF SPHERICAL LENSES are what Australian radio astronomers hope will prove economically and technologically best for the Square Kilometre Array. (Computer generated image courtesy of Ben Simons/Sydney VisLab/CSIRO.)

On the huge end is China's proposal to line 500-meter geological bowls, called karsts, with panels to form spherical antennas. Nicknamed "Super Arecibo," after the telescope in Puerto Rico on which it's modeled, the Chinese plan would be to create an array of 30 such antennas.

Next in size is the Canadian design, which would use 50–100 nearly flat reflectors, each some 200 meters across. The flatness puts the focal plane a few hundred meters in the air, so receivers would hang from tethered blimps. This design couldn't multibeam, but it's the only one that could cover the full frequency range, says SKA project scientist Russ Taylor of the University of Calgary, adding that manufacturing flat panels would make this design "10 times cheaper than any other."

Jumping down more than an order of magnitude in antenna size is the US idea for the SKA, which would use 50 000 satellite dishes 5 meters or so in diameter. This design is expected to work for a big chunk of the desired fre-

quency band, or 500 MHz–11 GHz (see next story). Metal mesh antennas being developed in India could bring down the price of this approach.

Scientists in Australia are looking into a completely different approach: spherical Luneberg lenses 5–10 meters in diameter that could look in many directions at once (see figure). The lenses would have small conducting splinters, to create an artificial dielectric with a wavelength-dependent index of refraction, embedded into cheap, lightweight Styrofoam.

On the tiny end is the Dutch proposal, with each antenna only 10–15 cm across and no moving parts. The small size would give a huge field of view, and arrays—some or all of the 10 million or so individual antennas—could be electronically steered by phasing signals to pick out a given part of the sky. The electric field, not the radiation energy, is recorded, explains Butcher. "So the interferometry can take place in the computer rather than in the focal plane before detection." This approach would give the best multibeam, flexibility, and suppression of unwanted noise, he adds, "but it costs too much for the higher frequencies."

It's too early to say which design will be used. They vary in frequency range, possibilities for simultaneous observations, cost, and other factors. "It's a friendly competition," says Taylor. "Everyone would like to have their technology be successful, of course. But I think that if we come up with what we think is best, everyone will fall behind it." Increasingly, radio astronomers expect the final SKA design to be a hybrid.

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Search for Extraterrestrial Life Gets a Steady Eye

Is anyone out there? The chance of spotting signals from extraterrestrials is about to soar, say SETI (Search for Extraterrestrial Intelligence) Institute scientists, who, together with radio astronomers at the University of California, Berkeley (UCB) have begun building the first telescope to look around the clock for life on other planets.

The new telescope got the go-ahead this past August, thanks to \$11.5 million from Microsoft cofounder Paul Allen, plus \$1 million from physicist

and former Microsoft technology chief Nathan Myhrvold. The telescope, an array of mass-produced satellite dishes, will be built at UCB's Hat Creek Observatory near Mt. Lassen, 290 miles northeast of San Francisco.

The Allen Telescope Array is being designed to pick up frequencies from 500 MHz to 11 GHz. SETI scientists will scan signal spectra for narrow bandwidth pulses and continuous waves; radio astronomers, for their part, will use the array in imaging mode to look at such things as pulsars,