Savannah River's $1-Billion Glassmaker

South Carolina will get the nation's first nuclear waste treatment plant; it is the largest of many cleanup projects at the Department of Energy

Aiken, South Carolina

OTHER states may balk when Washington offers to give them a radioactive waste plant, but not South Carolina. It has 33 million gallons of radioactive liquid and sludge on its hands from the nuclear weapons program and is eager to have the stuff packaged and shelved. South Carolinians do not seem to mind that the government has no place to bury the packages. That can be done later.

Today, the world's largest nuclear waste plant is rising among the pines of Aiken County, South Carolina, close to the Savannah River. It will be ready for testing in 1989 and should begin producing live radioactive glass in 1990. If the process works as promised, it will bring a welcome end to the 51 corroding waste tanks that sit precariously above the Tuscaloosa aquifer.

The new plant, called the Defense Waste Processing Facility (DWPF), offers South Carolina peace of mind. It is a nice plum as well, for it will keep several hundred people on federal pay through 2005. Other states, take notice. There's money to be made in nuclear waste packaging.

The DWPF is the biggest new project at Savannah River; in fact, it is the biggest construction job in progress in the Department of Energy (DOE) budget. This suggests that environmentalism truly has a foot in the door of the weapons program. It will cost $945 million to build the DWPF, not counting $161 million in ancillary facilities, and around $80 million a year to run it. It will employ about 460 people.

The Savannah River Plant was born in August 1950 when the government acquired 300 square miles of land on the swampy border between South Carolina and Georgia. Six little towns and 6000 people were relocated to make room for the plant. E. I. du Pont de Nemours and Company was hired to run it. The complex is second in size to the Hanford Reservation in Richland, Washington, and second in environmental headaches, too.

Everything at the Savannah River Plant is big. Du Pont takes pride in its "firsts." Cruising along a section of the 260 miles of internal roadway, an official points to an overpass and mentions that du Pont built the first cloverleaf in the state. Du Pont's expertise and the federal government's clout used to overshadow local government. The weapons program set its own priorities, and waste management was not on the glamour list. That is changing, and DOE has begun to defer to local authority.

However, DOE still insists it may set its own rules on "by-product material" and "mixed waste" containing significant amounts of radiation. The policy dates back to the 1950s when the Atomic Energy Act gave free rein to the weapons priesthood. The question of where DOE's authority ends and that of environmental agencies begins is still a live topic.

At Savannah River, the question comes up in discussions of how the plant should manage an old radioactive waste burial ground, how it should design monitoring wells, how many of the old contaminated pits should be cleaned up, how thoroughly they should be cleaned, and how essential it is to follow the costly decontamination procedures the state wants. On "borderline issues," one state official says, DOE seems to dig in and resist change. It is expensive to drill a well, particularly around the 195-acre burial ground, where no one can be certain what lies beneath the surface. If a drilling rig hits a bad pocket, it may expose the operator to excessive radiation and require burial of the rig itself. Thus, DOE sometimes prefers to avoid probing.

Recently, however, DOE agreed to stop dumping nitrate-laden sewage into open "seepage basins" around the chemical separations plants. According to law, it must do this by November 1988. Construction will begin soon on a $50-million plant to treat the water that now goes into the ground.

The House environment subcommittee on government operations, chaired by Mike Synar (D–OK), held hearings on these issues on 11 July 1985. Radioactive isotopes (mainly tritium) and nonradioactive chemicals (nitrates, solvents, chromium, lead, and mercury) have been found in the water under the Savannah River Plant. Synar said

Courtesy of DOE

Savannah River's newest addition. *At the center is the heart of the Defense Waste Processing Facility, the glassification plant. Behind, at left, are the foundations of the storage building that will hold 2300 canisters (5 years' output) of "hot" glass.*

the plant dumps about 200,000 gallons of mixed waste each day into unlined pits and demanded to know, "what is the theory for dumping waste into the ground?" Mary Walker, assistant secretary of DOE for the environment, safety, and health, said it had been assumed that the soil would trap short-lived isotopes like tritium (half-life of 12.5 years) and retain them within the plant boundaries while their radioactivity dwindled. Public waters were expected to receive only a tiny amount of pollution.

But as other testimony revealed, the plant operators miscalculated both the extent and the direction of the release. A large plume of pollutants thought to be moving toward the river is actually moving out toward the town of Jackson. DOE has proposed a remedial step for one area: flushing out the chemicals by water flooding. This idea evoked a protest from the Natural Resources Defense Council. Its attorney, Dan W. Reicher, said this approach will "introduce additional contamination into a complex and uncertain hydrogeologic system."

Reicher is applying legal pressure to compel the cleanup of other sites at Savannah River and would like an outside review of the entire cleanup program. DOE is not enthusiastic. It is haggling over which of the estimated 160 storage and dump sites at the plant must comply with federal hazardous waste laws. DOE has brought three into compliance, and Reicher contends that five to ten more should be covered.

While du Pont released some chemicals in open pits, it stored the truly lethal wastes from the separation plants in tanks. Du Pont has kept them there for 30 years while the experts debated what to do. In the 1970s, some of the tanks were found to be cracking and were replaced with new double-walled models. Then politicians began to push for a better solution. Georgians and South Carolinians lobbied the congressional armed services committees to persuade them that a waste plant was affordable. Congress appropriated the first money for the DWPF in the 1979 budget and gave the final green light in 1982.

This new billion-dollar plant will take liquids and radioactive sludge from 51 tanks around the site and pipe them into two streams, producing cement from one and glass from the other. The highly radioactive sludge will be mixed with borosilicate glass and poured into stainless steel "thermos bottles" about 10 feet tall and 3/8 inch thick. The radiation field at the outside surface will be a potent 6300 rads per hour, and each canister will generate about 660 watts of heat.

The canisters will be stored "temporarily" in a bunker-like building until a civilian deep repository is ready to receive them. DOE recommended and President Reagan agreed in 1985 that these military wastes could be "commingled" or buried in the same place with civilian reactor waste. Although DOE has chosen three candidate sites for the repository in the West, it stirred up a storm last year by postponing site analysis in the East. As a result, it will take longer to nail down the location of any repository, and the schedule has begun to slip. In the interim, the canisters will be put in racks at the Savannah River Plant and cooled by natural air circulation. They will need little maintenance.

The salt solution in the tanks, which is less radioactive than the sludge, will be stripped of most long-lived radionuclides, pumped to another spot near the glass factory, mixed with cement, and set in wide concrete vaults.

In a separate operation, solid material contaminated with long-lived "transuranic" isotopes (mainly plutonium-238) will be packaged in special drums or sealed in con-

The Greening of DOE

The plan to immobilize radioactive waste at the Savannah River Plant is a small but expensive part of a major cleanup of Department of Energy (DOE) weapons sites.

DOE spends over half its budget—about $8 billion—on about 18 weapons facilities it inherited from the Atomic Energy Commission. After 40 years of secret operation, these plants have produced the world's largest nuclear stockpile. They have also produced an enormous garbage pile, including about 357,000 cubic meters of high-level radioactive waste and 2 million cubic meters of low-level waste. Much of the radioactive material has been put in special burial grounds or "interim" storage areas. But the same is not true of hazardous chemicals.

Many chemicals were dumped directly into the ground with waste water, a practice that continues even now at some plants. DOE is not certain of the location of all such dumping grounds. But in the last 5 years, it has come under intense pressure to stop dumping and bring all of its facilities into line with private industry standards.

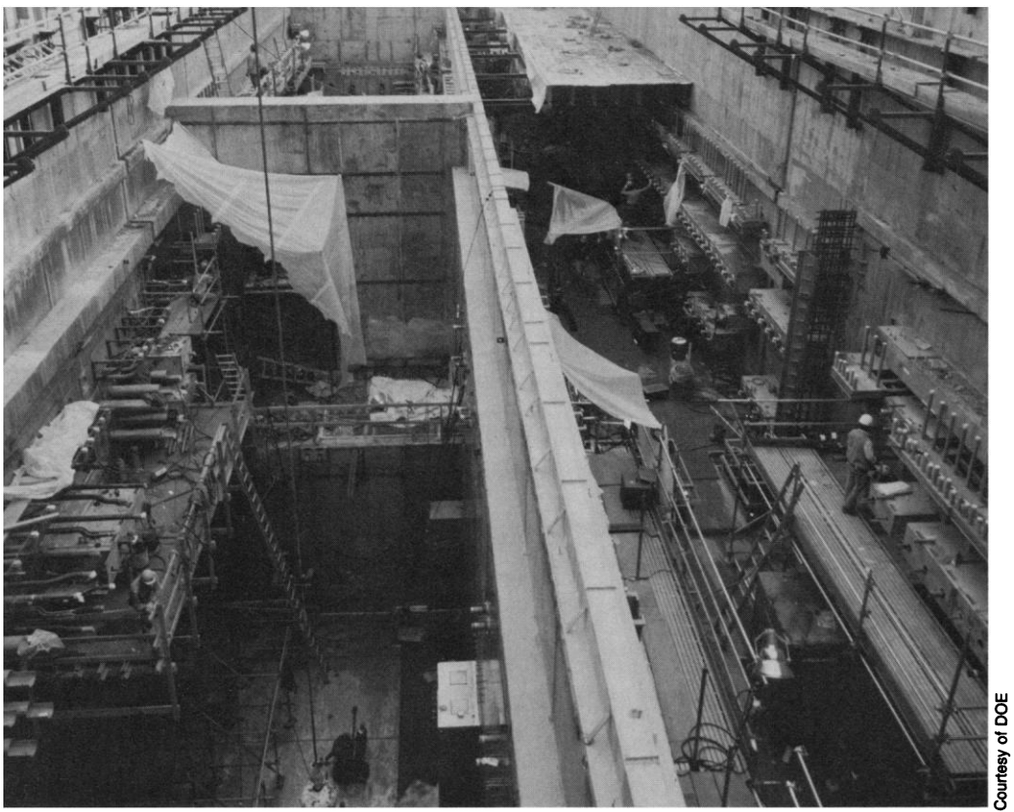
The impetus comes from the Resource Conservation and Recovery Act (RCRA), the toxic dump control law enacted by Congress in 1976. DOE at first insisted that the law did not apply to its secret weapons factories. But when it became known in 1982 that a plant in Oak Ridge, Tennessee, had spilled 2.4 million pounds of mercury and failed to inform the community, things began to change.

In 1984, a federal court in Tennessee rejected DOE's claim that it was exempt from toxic dump regulations. The secretary of Energy, John Herrington, commissioned an independent review of the agency's handling of environmental issues. In 1985, that report found DOE's office of environment, safety, and health to be "a disgrace" and "widely perceived as having no clout." Herrington overhauled the office, raised it to an assistant secretary level, and appointed a new head, Mary Walker. She has been busy ever since.

However, Walker's authority is limited because most environmental programs come under other budget headings. For example, at Savannah River, the glassification plant ($945 million) and a new waste water treatment facility ($50 million) are controlled by the local South Carolina directorate. Walker commands $70 million at headquarters, or just 0.5% of the DOE budget.

The General Accounting Office (GAO) conducted a survey of these issues and gave a report in September to Senator John Glenn (D–OH). It focused on 9 of DOE's 18 defense nuclear sites, finding ground water at 8 sites, including Savannah River, to be contaminated. "In some cases, solvent contamination exceeds proposed drinking water standards by a factor of 1000 or more," according to GAO. This "does not appear to pose an immediate threat to public health" because the facilities are removed from populated areas, but in at least three cases the contamination has begun moving beyond plant boundaries. DOE "does not have an overall . . . ground water protection strategy," GAO wrote, but appears to be moving on an ad hoc basis.

All DOE's plants are changing their waste management practices, GAO reported last fall. But it found that four still were not in compliance with the Clean Water Act. It will cost at least $200 million to get ground water problems under control at these sites, GAO estimated, and more than $1 billion to meet all the new nonradiation-related waste requirements. ■ **E.M.**



Courtesy of DOE

In the belly of the plant: *When workers finish installing radioactive waste process lines, these "canyons" will be closed and human access barred for the next 15 years or so. Ceiling cranes and robot devices will attach, disconnect, and move equipment.*

crete and prepared for transport to Carlsbad, New Mexico. There it will be buried in the Waste Isolation Pilot Project, a deep military vault. DOE hopes to get an additional $70 million in 1989 for a transuranic packing plant, which will be used to repackage 4400 cubic meters of transuranic waste already buried at Savannah River considered "certifiable" for shipment to New Mexico. Later, other facilities will be needed to handle messy transuranic waste considered "not certifiable."

The DWPF is a complex, interlinked system that uses multiple process lines, filters, and recirculation loops, all maintained by remote robot devices. Broken machinery must be hauled by crane into a huge, polished, stainless steel cleaning room. The walls are fitted with jets that spray the interior with an acid wash. After remote decontamination, workers in proper gear will be able to enter and make repairs. The "remotability" of the system (du Pont's term) adds greatly to the intricacy, but officials say they are relying on experience with similar gadgetry in the production lines and anticipate no trouble.

The value of the DWPF is "unquestioned," says a native who regularly tilts at DOE for its environmental blunders. As critics, "we can't touch it" because it is popular and politically out of bounds. But there are critics.

William Lawless, a former Savannah River Plant engineer and an occasional public gadfly, says the DWPF offers modest benefits at a great cost. He calls it "an automobile without wheels" because it seems to go nowhere. He points out that the DWPF will produce a final waste form before anyone knows what kind of rock it will have to fit into.

Rustum Roy, a materials scientist at Pennsylvania State University and for many years a participant in the nuclear waste debates, also sees the DWPF as "overkill." He agrees with a 1981 National Academy of Sciences study that urged DOE to mix all the waste with cement and pump it as "grout" into bedrock beneath the plant. That solution would have been cheap, but it had no public support. In 1983, a chemical solvent (trichloroethylene) was discovered in the Tuscaloosa aquifer below the plant. Du Pont officials say it leaked down the side of a faulty well casing, but others suspect it may have come from one of the dumping grounds. In any event, the contamination of the aquifer means the grout pumping scheme has no public credibility now.

For DOE, the glassification project solves a technical problem. It also has psychological value, because it will show that DOE can process, package, and store radioactive waste safely, and that a community that accepts the task will benefit.

But the technology at Savannah River will have limited use elsewhere. It will be used to package 600,000 gallons of waste left by a bankrupt commercial fuel plant in West Valley, New York. And some of Hanford's waste will be disposed of in the same way. But much of the waste at Hanford sits in dry cake in 149 fragile tanks. The old steel may not be able to take the stress of a removal operation. DOE is considering topping off these tanks with inert material and abandoning them.

The DWPF offers the civilian waste program even less. Reactor fuel exists in durable form already: uranium oxide packed in zirconium rods. Because these materials are as tough as glass and stainless steel, the best approach may be to package them in caskets without further treatment.

Meanwhile, the spent fuel collects in utility cooling vaults. By DOE's estimate, the volume of civilian spent fuel in 2020 may be ten times as much as that of all the military high-level waste. Thus, the DWPF will deal with only a fraction of the national waste inventory and still will not dispose of that fraction. However, its contribution looms large in South Carolina.

Apart from the issue of whether the DWPF is worth its price, other questions remain to be answered about the safety of the process and its environmental impact.

Robert Alvarez of the Environmental Policy Institute in Washington, D.C., believes DOE is taking a chance in rushing the glass melter into production. He argues that a small-scale pilot plant should have been tested first. Alternatively, he suggests it would make more sense to convert the high-level waste to powder by "calcining" until better information is in hand.

Du Pont researchers say this would delay the cleanup and could actually increase risks. M. D. Boersma, a research associate in the technology division, anticipates no great technical challenge in shifting from a nearly full-scale glass melter now in "cold" testing to the radioactively hot melter in 3 years. Scores of full-sized cold canisters have been poured. Meanwhile, N. E. Bibler of the Savannah River Laboratories has had a small (1/82nd-scale) glass furnace melting actual tank waste continuously since late 1984. No big problems have surfaced. In addition, Boersma points out that the French have used this technology since 1978 at a military plant at Marcoule, albeit on a smaller scale and with a more acidic liquid. A West German outfit recently began using it to glassify liquid commercial wastes at the defunct Eurochemic plant in Mol, Belgium. Japan and Great Britain are moving in the same direction.

The attraction of calcining is that it could be used to turn all the wastes at Savannah River into solids for storage, eliminating the

concrete to be buried on site. But it would also greatly increase the total volume of high-level waste in storage, perhaps by a factor of 30. It would require a much bigger process operation of no less complexity. The final product—powder—would be more dangerous than glass or concrete, du Pont researchers say, because it could be widely dispersed from a broken canister and inhaled.

Glass is versatile and well understood, and in South Carolina it seems to have beat out competing waste forms, including the less studied but tougher ceramics. The big unanswered questions are where to put it, and how long it can be expected to stay intact.

The radioisotopes of concern at Savannah River are strontium-90 and cesium-137, with half-lives of 28 and 30 years, respectively. Each canister will contain strontium (44,000 curies) and cesium (41,000 curies), which will make up 40% of the radioactive material at the outset. Other isotopes will be present, including a small amount of plutonium. A canister will emit around 6300 rads per hour at the surface, enough to give someone embracing it a lethal (LD_{50}) dose in 5 minutes. Obviously, these packages will have to be handled with care. Du Pont officials say the plant will store the first 5 years' output (2300 canisters) in a building on site. Because of uncertainty about the deep repository, plans are being made for two additional buildings, so that the Savannah River Plant could retain this deadly cargo indefinitely. That amounts to a promise to police the area indefinitely.

Preliminary lab tests indicate that the glass can be safely stored in any of the three types of western geologic formation under consideration. According to N. E. Bibler of du Pont, radioactive glass exposed to water and stress appears to meet the leaching requirements set by the Nuclear Regulatory Commission, with a good margin of safety. But more research is needed on the effects of iron in repository water and the ways radiation may affect leaching by various types of ground water in each formation.

In contrast to the well-studied problems of glass, relatively little is known about radioactive concrete. Du Pont officials see "saltstone" (concrete made from radioactive salt solution) as a logistical, and not a safety, problem. There has been only one outside regulatory review of this massive addition to the waste burial complex at Savannah River. It came when du Pont obtained an ordinary solid waste permit (number 217) from the state of South Carolina in October. The plant escaped federal environmental review because concrete, as a solid, does not fit the legal terms of "hazardous waste." For this reason, du Pont does not plan to follow the federal rules for burial of hazardous waste, which require that the burial pit be lined with a double layer of impermeable plastic and surrounded with special monitoring wells prescribed by the Environmental Protection Agency.

The concrete will contain 75 nanocuries of radioactive material per gram, including small quantities of such long-lived isotopes as iodine-129 and technetium-99. Although du Pont originally had planned to bury the concrete, this idea proved unworkable because of the probable effects of chemical leaching by water. The new plan calls for the concrete to be poured above ground in blocks 25 feet thick and 100 feet wide by 600 feet long. One block will be set each year for 15 years. Wells will be installed at the perimeter of the concrete field to monitor chemical and radiation leakage. Du Pont intends to have ground water around the beds meet drinking water standards. The Environmental Protection Agency and state officials have given the nod to these plans, conceding that they have no reason to doubt du Pont's promises and little legal basis to interfere even if they did.

The waste program in South Carolina is moving ahead on schedule and apparently within budget. The machinery is new and shiny, and local observers expect it to work as promised. The upbeat mood makes sense, given the nightmares the state hopes to put to rest. But promises made for nuclear technology have gone sour in the past, and it may be best to temper new expectations with some skepticism. ■

ELIOT MARSHALL

ERAB Sets Priorities for Energy Department's Physics Research

Support for basic physics research must increase substantially by 1992 to meet new research facility needs and to upgrade instrumentation at universities, says a Department of Energy (DOE) advisory group. The Energy Research Advisory Board (ERAB) is recommending a 50% increase in real funding above 1986 levels, but this does not include the Superconducting Super Collider (SSC).

The massive new particle accelerator should not be allowed to preempt other R&D priorities in physics, says the advisory board. While supportive of the SSC in concept, ERAB contends that "... The magnitude of this project ... means that it cannot be undertaken without a multibillion dollar incremental commitment to basic science over the next decade."

The findings are part of ERAB's review* of the National Research Council's eight-volume 1986 report, *Physics Through the 1990's*, which outlined the needs of the American physics community (*Science*, 11 April 1986, p. 156). The advisory body also recommends that existing physics research facilities, many of which are underutilized, be given adequate funding to operate at a "scientifically optimal" level—40 to 50 weeks a year.

Four new physics facilities have been identified by ERAB as priority projects that should be started between 1988 and 1991. The priority construction projects spotlighted by the advisory group include:

- The Compact Ignition Tokamak, which would begin construction in FY 1988—probably at Princeton. The $375-million machine would advance research in magnetic confinement fusion.
- The 6- to 7-billion-electron-volt (GeV) Advanced Photon Source at Argonne National Laboratory. The proposed starting date is FY 1988 and projected cost is $425 million.
- The $333-million Relativistic Heavy-Ion Collider at Brookhaven National Laboratory. Target date for construction is FY 1989.
- The advanced neutron source (Center for Neutron Research) at Oak Ridge National Laboratory. The estimated cost of this device is $400 million and construction is proposed for 1991. It would replace the aging High Flux Isotope Reactor.

Of particular concern to ERAB, which completed its review of NRC's work on 19 February, is the need to train physicists for major U.S. research efforts that lie ahead. ERAB suggests that DOE address the imbalance of supply and demand in part by starting new fellowship programs at the doctoral and postdoctoral level. Citing the "unsatisfactory condition of basic research in universities," ERAB concurs in the NRC's call for providing a small number of academic research groups with additional funding to augment ongoing research and to purchase new instruments. ■

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Review of the National Research Council Report: Physics Through the 1990's, Energy Research Advisory Board for the Department of Energy, March 1987. For copies write: Sarah Goldman, Department of Energy, ER-6, Room 3F043, 1000 Independence Ave., SW, Washington, DC 20585.