INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH

6935 Laurel Avenue, Suite 201
Takoma Park, MD 20912

Phone: (301) 270-5500
FAX: (301) 270-3029
e-mail: ieer@ieer.org
http://www.ieer.org

The Savannah River at Grievous Risk

Analysis of the Proposal to Allow the Department of Energy to Leave a Significant Portion of Its High-Level Radioactive Waste at the Savannah River Site in the Savannah River Watershed

Arjun Makhijani, Ph.D.
President, Institute for Energy and Environmental Research
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The U.S. Senate Armed Services Committee has passed a proposal that would allow the DOE to leave virtually any fraction of the high-level waste, now stored in large tanks, at the Savannah River Site in grouted form, if approved by the State of South Carolina. This proposal would convert SRS into a vast high-level radioactive waste dump in the watershed of the Savannah River. The State of South Carolina has already allowed high-level waste to be grouted in two tanks.

I have performed some calculations to illustrate the potential effect on the Savannah River of this proposal. In principle the proposal would allow any fraction of the radioactivity in the tanks to be left there permanently in grouted form in the tanks at SRS. There are currently about 400 million curies of radioactivity in the high-level waste tanks. Strontium-90 and cesium-137 each are about 100 million curies, plus an equal amount of the decay products of each in equilibrium with each of these radionuclides.

If only 10 percent, i.e., about 10 million curies, of the strontium-90 presently in the tank farms were left behind and grouted, the grout would have to work nearly perfectly for hundreds of years to prevent the Savannah River from becoming polluted above the present Safe Drinking Water limit of 8 picocuries per liter. Leakage of even a small fraction of the strontium-90 at SRS into the Savannah River would be disastrous to the river. This threat will persist for centuries.

Strontium-90 has a half-life of 29 years. Even after decaying for 100 years, a leakage of just 1 part in 10,000 per year of strontium-90 into the river would cause the Savannah River to exceed the Safe Drinking Water limit. This estimate is based on median river flow.

In the past (1991) major economic damage has occurred when the drinking water standard was exceeded for only a few days due to a tritium leak, even though the standard is calculated as an annual average and there was no annual violation. Maintaining the river within drinking water limits every month, even in low flow years and months, will likely require containment many times stricter -- on the order of 1 part in 100,000 per year. Even after 200 years a high degree of containment, better than 1 part in 10,000 per year would be needed to meet this goal. Further, containment would have to be ten times better that these figures if essentially all the strontium-90 were left in the tanks.

There is no experience with grout for such periods of time that can allow confident projections of containment of such perfection. On the contrary, experience with grout so far has been unsatisfactory, as we have discussed in the recent IEER report on SRS (*Nuclear Dumps by the Riverside*, an excerpt of which is reproduced below). For instance, waste cast into cement blocks at Rocky Flats disintegrated in a few years. The tanks themselves were not designed to last for hundreds of years. Grout simply cannot be relied on as a waste form to protect the river even if grout quality is improved. Shallow land burial of waste by grouting in the tanks or by creating grouted vaults onsite is a dangerous idea.

These problems will be exacerbated by the vast amount of cesium-137 now in the tanks. Due to gross mismanagement, the Department of Energy wasted 16 years and $500 million before abandoning as dangerous a process to extract and concentrate the cesium-137. A replacement process is needed. If the DOE simply abandons the Cs-137 in the tanks and leaves behind 10 percent of the strontium-90, then containment roughly twice as stringent as that estimated above for strontium-90 alone would be needed to maintain the usability of Savannah River water.

In addition, there are large amounts of various transuranic isotopes, including plutonium-238, plutonium-239, and americium-241. In Tank 17, for instance, the residual radioactivity of transuranic radionuclides planned to be left in the tank exceeds the low-level waste limit by more than 600 times (before dilution).

There are over 2 million curies of plutonium-238 in the Tank Farms at SRS. If only ten percent of the plutonium-238 were left behind in the tanks and diluted with grout 6 feet deep, the residual radioactivity in both tank farms would exceed the maximum Class C limit allowed for low-level waste by about ten times. Other residual transuranic radionuclides, such as americium-241 and plutonium-239, would add to the extent of the violation.

In sum, the performance of the grout would have to be such that leakage would remain at one part in 100,000 per year or better for a hundred years or more. If the grout fails to meet this test, the river may have to be written off for drinking water use. This is because once the tanks are grouted, it will be essentially impossible to remediate them. In other words, if the grout fails, South Carolina and Georgia will likely have to write off one of their most precious water resources. The resultant health and economic and ecological harm would be incalculable, far greater, in my view, than any benefit to be derived from shortening the cleanup period for SRS or reducing high-level waste management expenditures. Nothing less than the future of the Savannah River is at stake in the current debate over the management of tank wastes at SRS.

Attachment

Performance of Grout

This is an excerpt from *Nuclear Dumps by the Riverside* (IEER, 2004), pages 48 to 50. The full report can be downloaded from www.ieer.org/reports/srs, where full details of the footnotes in this excerpt can be found.

There is insufficient understanding of the long-term risks to groundwater and surface water from shallow land burial of grouted wastes. Given past experience with grouting of wastes (discussed below), these contaminants could leach out into the groundwater much faster than anticipated and add to the existing contamination in the groundwater, and eventually to the surface water. Moreover, grouting the tanks in place would put the residual wastes in a form that would be very difficult or impossible to retrieve were they found to be leaking. Grouting would also make remediation of the vadose zone even more difficult. DOE admits that "tank closure is, for all practical purposes, irreversible. DOE would have great difficulty undoing a closure [with grout] if it were later discovered that [a dose] estimate had been improperly developed, or that the performance had been improperly evaluated."[1]

According to a report on long-term stewardship by the National Academy of Sciences:

> Predicting performance in resisting water infiltration can be difficult because of uncertainties that include the degree to which the first layers of grout take up the residue, the water pathway effects of the cold joints between successive pours of grout, and the effects of preferential corrosion of the tank metal and penetrating structures (thereby offering a partial bypass path). Moreover, waste tank residue is likely to be highly radioactive and not taken up in the grout, so there is substantial uncertainty associated with the volumetric classification and average concentration of the waste and prediction of the isolation performance of the system.[2]

While experience at other sites with grout does not correspond in its details with that at SRS, it is indicative of the kinds of problems that have already been experienced with grouting. We examine two such cases here.

DOE sponsored studies on grout durability in the context of a grouting program at Hanford. The durability of grout depends on many factors, such as temperature and moisture, and the composition of the grout. The heat due to radioactive decay, for instance, and/or the heat that is released when the grout sets can raise the temperature above 90 degrees Celsius (194 degrees F). At such temperatures the grout may not set properly, and hence it may subsequently crack. According to a 1992 study of the durability of double-shell tank waste grouts at Hanford:

> The grouts will remain at elevated temperatures for many years. The high temperatures expected during the first few decades after disposal will increase the driving force for water vapor transport away from the grouts; the loss of water may result in cracking, dehydration of hydrated phases, and precipitation of salts from saturated pore solution. As the grout cools, osmotic pressure caused by the high salt content may draw moisture back into the grout mass. The uptake of moisture may have detrimental impacts on the behavior of the grout.[3]

The history of grout at Rocky Flats, the nearly decommissioned DOE plant near Denver, Colorado, where plutonium pits for nuclear bombs were made, indicates the risks in the real world, even in the absence of elevated temperatures.

Rocky Flats operations resulted in the generation of liquid and solid wastes containing radioactive and hazardous materials and large quantities of contaminated soil and groundwater. From 1953 to 1986, five ponds lined with asphalt and concrete (called Solar Ponds) were used to store and evaporate low-level waste contaminated with nitrates and radionuclides. Other waste was also dumped in the ponds from time to time.[4] The linings were ineffective, as demonstrated by the fact that the shallow groundwater in the area became contaminated with radioactive materials, nitrates, VOCs, and heavy metals.[5]

Because of the existing contamination and possible further contamination, DOE began phasing out the use of the ponds in early 1980s; it soon began another experiment with cement. In 1985, sludge from the solar evaporation ponds began to be mixed with cement to form large blocks of "pondcrete," which were packaged in fiberglass boxes and shipped to the Nevada Test Site for disposal. Soon after the project began, the waste had to be reclassified from low-level to mixed waste, because it was determined that the waste contained hazardous chemicals, regulated under the Resource Conservation and Recovery Act (RCRA). Over 16,500 pondcrete blocks of mixed waste were manufactured and stored onsite, outdoors, for nearly two years, while the permitting necessary for offsite shipment was being pursued.[6]

In 1988, it was discovered that some of the fiberglass boxes on the outdoor pad had deteriorated while exposed to the weather and some of the pondcrete blocks had crumbled and cracked. At least one box had spilled open. It was later determined that the ratio of cement to sludge waste in making the pondcrete was incorrect. The problem apparently arose because the equipment used to introduce cement plugged up intermittently. Over 8,000 pondcrete blocks, that is, about half of the blocks stored outdoors, had to be remixed and repackaged.[7]

The Nevada Test Site found that 25 of the 28 blocks of pondcrete that had not yet been buried were, contrary to specifications, with surfaces soft enough to be scored by a stick; it was decided to bury them anyway because no liquids were found. The Nevada Test Site determined that the approximately 2,000 blocks that had already been buried posed little threat of contaminant migration, based on its assessment of the 28 blocks, the distribution of the containers throughout the burial ground, and the dryness of the soil. However, in October 1988, the Nevada Test Site changed its acceptance criteria for the pondcrete. It required that the pondcrete be packaged in plywood boxes with a compressive strength of 4,000 pounds per square foot.[8]

Rocky Flats has been left with some of the legacy of the mess as well, despite the shipment of the pondcrete blocks to Nevada. The quantity of underlying contaminated soil under the Solar Ponds has not been fully determined, but is estimated to be slightly less than 153,000 cubic meters (200,000 cubic yards) in that general vicinity.[9]

DOE is pursuing a cleanup program under which soil with contaminant concentrations greater than specified radionuclide soil action levels (RSALs) will be removed. However, the proposed RSALs at Rocky Flats are quite high: 50 picocuries per gram of plutonium in the top three feet, and 3000 pCi/g (based upon concentration and area/volume) in the three to six foot depth range.[10] These levels are far too lax and represent an unacceptable risk to future generations by traditional radiation protection standards, which aim at protecting future farmers or ranchers who might settle on the site, in case site control and information about the contamination are lost.[11]

In sum, grouting residual high-level waste in tanks that contains significant quantities of long-lived radionuclides (including cesium-137 and plutonium-238, and plutonium-239/240) is a policy that poses considerable risks to the long-term health of the water resources in the region.

Endnotes

1. DOE-SRS, November 2001
2. NRC-NAS, 2000c, page 40
3. Lokken, Martin, and Shade, December 1992, page 2
4. BEMR, 1996. Rocky Flats Environmental Technology Site section
5. GAO, January 1991, page 3
6. GAO, January 1991, pages 1 to 6
7. GAO, January 1991, pages 2 to 4
8. GAO, January 1991, page 5
9. BEMR, 1996. Rocky Flats Environmental Technology Site section
10. Rocky Flats, 2003 , General Response, page 1
11. See Makhijani and Gopal, December 2001, for further discussion of setting radionuclide soil action levels for Rocky Flats.