Consensus Study Report

August 2019

HIGHLIGHTS

Review of the Final Draft Analysis of Supplemental Treatment Approaches of Low-Activity Waste at the Hanford Nuclear Reservation

At the request of Congress, the U.S. Department of Energy (DOE) commissioned a report to assess options for immobilizing and disposing of low-activity waste from nuclear weapons production at the Hanford Nuclear Reservation. As a check on that work, Congress also requested that the National Academies of Sciences Engineering, and Medicine review the commissioned report in terms of its technical merit and its usefulness in informing DOE's decision-making.


Photo Credit: United States Department of Energy

One of the nation's biggest and most complex nuclear cleanup challenge is at the Hanford Nuclear Reservation (Hanford), which is located in the state of Washington. From 1944, when the first reactor produced plutonium for the Manhattan Project, until 1987, when the ninth and last reactor was shut down, Hanford had produced about two-thirds of the nation's plutonium stockpile for nuclear weapons. The production processes resulted in substantial amounts of radioactive and other hazardous wastes; presently, about 56 million gallons of waste are stored in 177 underground tanks. The waste is chemically complex and diverse, which makes it difficult to manage and dispose of safely.

DOE plans to use vitrification, or immobilization in glass waste forms, for all of the "high level waste" at Hanford, which comprises about 10 percent of the volume and 90 percent of the radioactivity. The remainder—about 90 percent of the volume—is designated "low-activity waste," some of which also will be vitrified. DOE is constructing a Waste Treatment and Immobilization Plant to perform the vitrification.

However, because of capacity limits at the new plant, not all of the low-activity waste can be treated there. DOE must determine how to immobilize the remaining low-activity waste—referred to as "supplemental low-activity waste" or SLAW—so that it will be safe for disposal in a near-surface disposal site. To help inform its decision, DOE contracted with a federally funded research and development center (FFRDC), specifically Savannah River National Laboratory, to analyze and report its findings about at least three potential technologies for immobilizing the SLAW: vitrification, grouting, and fluidized bed steam reforming (see Box 1).

This National Academies review provides an "overall assessment" of the FFRDC report subject to public comments and issuance of the final FFRDC report. This review does not, however, independently evaluate the SLAW treatment approaches, nor does it recommend any particular approach.

Box 1. Three Waste Form Technologies Assessed in the FFRDC Report

Vitrification: This is a high temperature technology that blends the SLAW with glass forming materials at about 1150°C, incorporating most of the radionuclides and metals into a glass waste form.

Grouting: Grouting technology operates at room temperature (about 25°C) and blends the liquid SLAW with dry inorganic materials to produce a cementitious waste form.

Steam Reforming: This high temperature technology blends the liquid SLAW with dry inorganic materials at 750°C, forming dry granular mineral particles with a chemical structure that retains the radionuclides and metals.

CONCLUSIONS OF THE FFRDC

The FFRDC team concluded that a SLAW treatment and disposal option that meets regulatory requirements for disposal could be developed using any of the three treatment technologies evaluated. Regarding time and costs, the FFRDC's final draft analysis concluded that:

- The vitrification technology would take 10 to 15 years to implement and would cost $20 billion to $36 billion.
- The grouting technology would take 8 to 13 years to implement and would cost $2 billion to $8 billion.
- The fluidized bed steam reforming technology would take 10 to 15 years to implement and would cost $6 billion to $17 billion.

In addition, the FFRDC report notes that for some treatment alternatives, "the required time for construction and startup require an immediate start to allow completion by DOE's target date of 2034 for SLAW treatment to begin in combination with the Waste Treatment and Immobilization Plant."

OVERALL ASSESSMENT OF THE FFRDC REPORT

After multiple iterations of comment and response between the FFRDC team and the NAS committee, this review finds that, while the most recent FFRDC report has improved considerably over its predecessors, it is not sufficient, taken alone, for DOE, Congress, regulators, or other stakeholders to rely upon to evaluate and decide upon a treatment approach for SLAW. It does not yet provide a complete technical basis needed to support a final decision on a treatment approach, and does not yet clearly lay out a framework of decisions to be made among treatment technologies, waste forms, and disposal locations.

Nevertheless, the report represents useful steps forward by:

(a) Establishing the likelihood that vitrification, grouting, and steam reforming are all capable, in principle, of meeting existing or expected regulatory standards for near-surface disposal, albeit with varying amounts of pre-treatment being required;

(b) Highlighting the importance of secondary waste in that it will contribute the greatest amount to the radiation dose that an individual could receive several thousand years after disposal of the waste in the Integrated Disposal Facility (IDF) at Hanford;

(c) Underscoring the regulatory and acceptance uncertainties regarding approaches other than vitrification technology for processing SLAW; and

(d) Opening the door to serious consideration of other disposal locations, specifically, the Waste Control Specialists, LLC (WCS) facility near Andrews, Texas, and possibly the EnergySolutions facility near Clive, Utah.

In addition, the cost estimates in the FFRDC report are based on technologies that, for the most part, have not yet been fully developed, tested, or deployed for Hanford's complex tank wastes. Instead, the report uses costs from similar technologies. As a result, there are large attendant uncertainties, suggesting that costs could be much higher than estimated, but are unlikely to be much lower.

Stakeholder Concern: "As Good as Glass"

The review committee was repeatedly told that the selection and implementation of an approach to treat tank waste would be hampered by the insistence by the state of Washington and some other stakeholders that any approach other than vitrification must be "as good as glass." The term "as good as glass" is not defined in law, regulation, or agreement, and it is only tentatively defined by its advocates. The report's analysis and public briefings provide a follow-on opportunity to further engage with stakeholders on this topic.

RECOMMENDATIONS

The following steps should be taken to better inform decision-making concerning selection of SLAW treatment alternatives.

Use the Report as a Pilot for a Full Comparative Analysis

This review recommends that the FFRDC report be accepted as a pilot or scoping study for a full comparative analysis of SLAW treatment alternatives, including:

- Vitrification, grouting, and steam reforming as treatments for SLAW;
- Pre-treatment to remove iodine-129 and technetium-99, and other long-lived radionuclides (e.g., selenium-79) to ensure that regulations are met or reduce cost, and pre-treatment to assure that the waste product meets land disposal requirements;
- Pre-treatment of strontium-90, if it is not removed during the cesium-137 pre-treatment process; and
- Disposal at the IDF, WCS, and (possibly) the EnergySolutions facility.

Organize the Report or Decisional Document around Four Interrelated Areas

The final FFRDC report or follow-on decisional document should include technical data and analyses to provide the basis for addressing four interrelated areas, as follows:

1. **Selection of a technology that will produce an effective waste form.** This has two parts:

- The treatment (immobilization) technology:
    - How well will it work? Is the technology well understood, tested or used under real-world conditions, dependent on other technologies, or relatively simple?
    - What types and volumes of residual waste are created by each technology?
    - What is the lifetime cost and duration, and uncertainties therein?
    - What are the risks (e.g., programmatic and safety) and uncertainties therein?
- The waste forms and associated disposal sites:
    - How effective is each waste form in immobilizing the waste (e.g., the materials science of the incorporation, corrosion, and release processes) and over what time periods?
    - What is their performance under the expected disposal conditions (e.g., release from the disposal facility and transport through the geosphere to a receptor)?
    - How do the waste form performances actually differ? This goes further than simply demonstrating compliance, but rather demonstrates an understanding of how the waste forms and disposal environments actually work.

2. **Selection among available disposal sites.** Selection requires an understanding of how each site will “work” over time in providing a barrier to the release and migration rate of key radionuclides, especially technetium-99 and iodine-129.

- What is the role of the hydrogeology at each site (the IDF and WCS) in preventing/slowing radionuclide release and migration?
- How might the disposal facility design be modified to enhance the performance of each waste form?

Important site related-issues include regulatory compliance, public acceptance, cost, safety, expected radiation dose to the maximally exposed individual over time, and differences among the disposal environments.

3. **Determining how much and what type of pre-treatment is needed to meet regulatory requirements regarding mobile, long-lived radionuclides and hazardous chemicals, and possibly to reduce disposal costs.** The congressional charge specifically mentions technetium-99 and iodine-129, but other long-lived radionuclides, such as selenium-79, may be relevant.

4. **Consideration of other relevant factors.** Other factors that would affect the selection of a SLAW treatment alternative, for example:

- The costs and risks of delays in making decisions or funding shortfalls in terms of additional resource requirements and the increased chance of tank leaks or structural failures over time, and the need to address the consequences (all 149 single-shell tanks have exceeded their design life and the 28 double-shell tanks will have exceeded their design life before the waste is slated to be removed);
- Thorough consideration of the experience at other DOE sites (e.g., Savannah River Site) and relevant commercial facilities; and
- DOE’s proposed reinterpretation of the definition of HLW waste could change the SLAW treatment plant’s size and performance requirements by altering feed volumes and chemical composition, depending on how the reinterpretation is implemented.

Provide Direct Comparison of Alternatives

The analysis in the final FFRDC report and/or a comprehensive follow-on decisional document needs to adopt a structure that pervasively enables the decision-maker to make direct comparisons of alternatives concerning the criteria that are relevant to the decision and which most clearly differentiate the alternatives.

Consider Parallel Approaches

The FFRDC report could also provide the springboard for serious consideration of adopting an approach of multiple, parallel, and smaller scale technologies, which would have the potential for:

(a) Faster start-up to reduce risks from tank leaks or structural failures, if adequate funding is available to support parallel approaches;

(b) Resilience through redundancy;

(c) Taking positive advantage of the unavoidably long remediation duration to improve existing technologies and adopt new ones; and

(d) Potentially lower overall cost and program risk by creating the ability to move more quickly from less successful to more successful technologies.

NEXT STEPS FOR THE STUDY

Publication of this review begins a minimum 60-day public comment period on both the FFRDC report and this review. For the final phase of the study, the committee will review all received public comments and will assess whether any comments change the committee's findings and recommendations of its review of the FFRDC's final draft analysis. Comments on the review and the FFRDC analysis may be sent to Hanford@nas.edu.

Photo Credit: United States Department of Energy

COMMITTEE ON SUPPLEMENTAL TREATMENT OF LOW-ACTIVITY WASTE AT THE HANFORD NUCLEAR RESERVATION

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For More Information . . . This Consensus Study Report Highlights was prepared by the Nuclear and Radiation Studies Board based on the Consensus Study Report *Review of the Analysis of Supplemental Treatment Approaches of Low-Activity Waste at the Hanford Nuclear Reservation* (2018). The study was sponsored by the Office of Environmental Management, Department of Energy. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the Nuclear Studies and Radiation Board web page at http://www.nationalacademies.org/nrsb.

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