Tank mission “product”

High-level waste canisters
- 6,600 pounds of glass each
- ~ 7,200 to 27,800 canisters
- Temporarily stored at Hanford until National Repository opened

Low-activity waste canisters
- 13,000 pounds of glass each
- ~ 58,000 to 96,000 canisters
- Disposed on Hanford Site
- Current LAW Vitrification facility only sized to handle ~50% of this waste volume.

Source: System Plan 8
Current cleanup path under threat

2019 Hanford Lifecycle Scope, Schedule and Cost Report

$323.2 billion to $677 billion*

cleanup complete
2078 to 2102
Purpose & Scope of the National Academies of Sciences (NAS) Study

• Initiated by the 2017 National Defense Authorization Act

• “The Secretary of Energy shall enter into an arrangement with a federally funded research and development center (FFRDC) to conduct an analysis of approaches for treating the portion of low-activity waste at the Hanford Nuclear Reservation.”

• (1) An analysis of, at a minimum, the following approaches for treating the low-activity waste described in subsection (a):

  (A) Further processing of the low-activity waste to remove long-lived radioactive constituents, particularly technetium-99 and iodine-129, for immobilization with high-level waste.

  (B) Vitrification, grouting, and steam reforming, and other alternative approaches identified by the Department of Energy for immobilizing the low-activity waste.
Purpose & Scope of the NAS Study

(2) An analysis of the following:

(A) The **risks** of the approaches relating to treatment and final disposition.

(B) The **benefits and costs** of such approaches.

(C) Anticipated **schedules** for such approaches, including the time needed to complete necessary construction and to begin treatment operations.

(D) **Compliance of approaches with applicable technical standards** associated with and contained in regulations pursuant to CERCLA, RCRA, Clean Water Act, and Clean Air Act.

(E) Any **obstacles** that would inhibit the ability of the Department of Energy to pursue such approaches.
Simplified Study Process

Federally Funded Research and Development Center (FFRDC)

- Initiated and set boundaries of analysis

Congress

- Provides final report, including WA comments

DOE

- Provides final FFRDC analysis and review of technical quality and completeness

National Academies of Sciences (NAS) Committee

- Provides analysis
- Reviews analysis, recommends improvements

WA State, Public, other Stakeholders

- Provides input
Major Options Considered

- Vitrification
- Fluidized Bed Steam Reforming
- Grout
  - Onsite disposal (Hanford Integrated Disposal Facility)
  - Offsite disposal (Waste Control Specialists Low Level Waste Facility in Texas)
- Pretreatment to remove organics, technetium-99, and/or iodine-129
New Information Since the 2012 Tank Waste EIS

- Cost information from constructing the Hanford LAW facility
- Cost information from experience constructing/operating the Savannah River Saltstone (grout) disposal facility
- New high performance grout waste form performance data (laboratory results)
- Waste Control Specialists in Texas opened as a commercial Low Level Waste Disposal Facility
Waste Control Specialists, Texas

- Facility underlain by 600 ft of nearly impermeable redbed clays
- WCS facilities not over or adjacent to a drinking water aquifer
- WCS has high limits for Technetium or Iodine
- DOE signed agreement to take ownership of Federal Waste Cell after closure
- Offsite disposal of Hanford Supplemental LAW estimated to take 26 railcars per month for 28 years

Figure 5-2 A Waste Control Specialists Disposal Cell and Wastes Being Placed in Modular Concrete Canisters (note workers for scale)
General Findings

- The FFRDC believes that grout can meet performance objectives for onsite or offsite disposal, without removing Tc-99 or I-129.
- Additional R&D is needed before implementing grout for Hanford.
- Compared against vitrification, grout is less complicated (room temperature process).
- Compared against vitrification, grout produces less secondary waste (i.e., glass offgas effluents, which would be grouted anyway).
- Grout requires more disposal space than glass, but sufficient capacity is available.
- Grout is estimated to be significantly cheaper than glass.
- A near-term decision is needed for Supplemental LAW, but there is inadequate funding no matter the option chosen.
## Treatment Technology Comparisons

<table>
<thead>
<tr>
<th>Immobilization Technology</th>
<th>Risks/Obstacles</th>
<th>Benefits</th>
<th>Costs</th>
<th>Schedules</th>
<th>Onsite Regulatory Compliance</th>
<th>Out-of-State Regulatory Compliance</th>
</tr>
</thead>
</table>
| Vitrification             | • Most complex process  
                          • Most dependent on integrated facility performance  
                          • Highest throughput risk  
                          • Most impacted by feed rate variability  
                          • Lowest single-pass retention  
                          • Highest volume and curies secondary waste | • Most technically mature for SLAW feed  
                          • High temperature LDR organic/nitrate destruction  
                          • Lowest volume primary waste | Highest: ~$20 to ~$36B | 10-15 years | • Primary wasteform meets DOE Technical Performance Criteria (TPC)  
                          • Primary wasteform meets state permit requirements  
                          • May require mitigation for iodine-129 in secondary waste | • Primary wasteform not evaluated  
                          • Secondary wastes meet WAC requirements |
| Grouting                  | • LDR organics likely to require mitigation measures such as waste pre-treatment or System Plan feed adjustments  
                          • May require Tc treatment for onsite disposal  
                          • Highest volume primary waste | • Least complex process  
                          • Least dependent on integrated facility performance  
                          • Lowest throughput risk  
                          • Greatest stop/start flexibility  
                          • Room-temperature process  
                          • Lowest volume and curies secondary waste | Lowest: ~$2B to ~$8B | 8-13 years | • Primary wasteform likely to meet DOE TPC  
                          • Further validation of acceptable wasteform performance needed  
                          • May require mitigation for I-129 | • Meets WAC (assuming LDR organics addressed) and transportation requirements |
| Steam Reforming           | • Least technically mature for SLAW feed  
                          • Complex process  
                          • Requires rigorous process monitoring and control of fluidized bed and solids handling systems | • Lowest cost high temperature LDR organic/nitrate destruction  
                          • Little waste volume increase during treatment  
                          • No liquid secondary waste | Middle-range: ~$6B to ~$17B | 10-15 Years | • Monolithic primary wasteform likely to meet DOE TPC  
                          • Primary wasteform likely to meet state permit requirements  
                          • Further validation of acceptable wasteform performance needed  
                          • May require mitigation for I-129 in secondary waste | • Meets WAC and transportation requirements |
What’s so special about new grout?

- Cast Stone (grout) is the same formulation now as was assumed in the 2012 Tanks EIS.
  - EIS: 8.2% Portland Cement, 44.9% fly ash, 46.9% blast furnace slag.
  - BUT! The EIS used leaching data based on grout without blast furnace slag.
- Blast furnace slag is a strong reductant.
- In its chemically reduced state, Technetium becomes insoluble and is capable of binding to suspended solids and sediment (i.e., becomes less mobile)
- Reduced environments do not slow down iodine – in fact they may speed it up!
FFRDC Waste Form Performance Evaluation

• 2017 Hanford Integrated Disposal Facility – Base case analysis for the FFRDC Performance Evaluation:
  • LAW glass (first half only)
  • Solid secondary waste and liquid secondary waste from vitrification processing

• NAS additional study-specific Performance Evaluation cases:
  • 1\textsuperscript{st} half LAW and Supplemental (2\textsuperscript{nd} half) LAW glass
  • Supplemental LAW grout case
  • Supplemental LAW steam reforming case
  • Secondary solid and liquid wastes associated with all 3 primary waste forms (glass, grout, steam reforming)
Sensitivity Cases

• Three sensitivity cases (waste release rate) for each waste form
  • **Low performing** – based on range from laboratory testing
  • **High performing** – based on range from laboratory testing
  • **Projected best case** – based on the highest performance from laboratory testing (includes “getters” and likely requires additional study to assure results can be consistently obtained)
Grout performance changes

2012 Tank Closure & Waste Management EIS

Recent laboratory studies with new grout formulations

Source: NAS May 2019 meeting, FFRDC presentation
Grout performance changes

Effective Diffusion Coefficient for Technetium (cm²/s)

- "Low" performing grout
- "High" performing grout

Source: NAS May 2019 meeting, FFRDC presentation
Grout at Hanford is protective of groundwater for Tc-99 under “High Performing” and “Projected Best” case performance.
Grout at Hanford is only protective of groundwater for Iodine-129 under the "Projected Best" case grout performance.
Results of an “expert elicitation” Analytical Hierarchy Process decision-making exercise, included in the July 2018 FFRDC draft.

<table>
<thead>
<tr>
<th>Options Evaluated</th>
<th>Score (1 – 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2g2 - Grout with LDR pretreatment; Primary to WCS</td>
<td>87</td>
</tr>
<tr>
<td>2f - Grout with LDR and Sr pretreatment to HLVit, Primary to WCS</td>
<td>85</td>
</tr>
<tr>
<td>3b - Steam reforming to WCS, Secondary to WCS</td>
<td>77</td>
</tr>
<tr>
<td>1c - Vit to IDF, Secondary to WCS</td>
<td>67</td>
</tr>
<tr>
<td>2d - Grout with LDR pretreatment, Primary &amp; secondary to IDF</td>
<td>67</td>
</tr>
<tr>
<td>2 - Grout - Base Case</td>
<td>65</td>
</tr>
<tr>
<td>1g - Bulk vit in large container to IDF, Secondary to WCS</td>
<td>63</td>
</tr>
<tr>
<td>2e2 - Grout with LDR and Tc &amp; I pretreatment to WCS, Primary &amp; secondary to IDF</td>
<td>63</td>
</tr>
<tr>
<td>2e1 - Grout with LDR and Tc &amp; I pretreatment to HLVit, Primary &amp; secondary to IDF</td>
<td>62</td>
</tr>
<tr>
<td>1 - Vitrification - Base Case</td>
<td>56</td>
</tr>
<tr>
<td>1d - Bulk vitrification</td>
<td>55</td>
</tr>
<tr>
<td>3 - Steam reforming - Base Case</td>
<td>53</td>
</tr>
</tbody>
</table>

Academies’ review: “In brief, the committee believes the team’s draft report provides too little information in meaningful comparative formats useful to support decision-makers’ evaluations, while its use of its AHP results would supplant (or at least anticipate) the decision-makers’ evaluation by performing one of its own.”

Source: NAS July 2018 meeting, FFRDC presentation
Uncertainties/Issues

Are the new grout performance numbers reliable?

• The mechanism for the improved performance is not fully understood.
• Are lab results applicable to field implementation?
• How will variations in waste chemical composition affect grout setting/performance?
• Would "getters" actually work as predicted over time?
Uncertainties/Issues

• Grout degrades over time. Does it matter?
  • Moisture in cracks will undo the “reducing” chemical environment that holds Tc-99.
  • Studies have shown this effect to spread ~5cm radius from each crack.
  • NRC-funded studies of grouted waste forms demonstrate multiple grout cracks over relatively short timespans.
  • The IDF Performance Assessment assumes that the disposal facility will stay relatively dry.
  • The NAS working group therefore concludes that despite predicted cracking, the effect on radionuclide release will be minimal.
• Has the IDF Performance Assessment adequately considered uncertainty? We don’t know, because it isn’t public yet.
How critical is Supplemental LAW really?

- The NAS working group says that according to System Plan 8, we needed to start Supplemental LAW construction yesterday.
- But, System Plan 8 is built on assumptions.
- DOE’s Glass Scientist predicts future LAW melters will be more efficient.
  - 15 metric tons/day → 50 MTD if we remove unnecessary refractory liner.
  - Increasing crystallization tolerance in glass from 1% to 1.5% would reduce the mission by 20%
- A system model from the contractor in 2013 predicted no need for Supplemental LAW if a 3rd melter is added to the existing LAW facility.
- A new 2020 glass formulation model predicts no need for Supplemental LAW.
- How optimistic are we?
Complicating Factors

• The scope of the study is limited to the waste treatment system on the date of study initiation in 2017.
• Many new initiatives brewing could change the overall amount of Low Activity Waste produced.
  • Test Bed Initiative (at-tank cesium separation and grouting for disposal in Texas).
  • Direct-Feed HLW (i.e., limit or don’t finish the Pretreatment Facility).
  • New high-level waste definition (could change 90/10% split between HLW and LAW or allow in-place closure of tanks without waste retrieval).
• A large supplemental waste facility (e.g., glass or grout) could take waste away from the first LAW vitrification facility.
• Potential gains from glass process improvement.
What could this mean for cleanup?

• Could offsite disposal as grout offer a cheaper, less complicated solution for some tank waste?

• Washington State has held firm that tank waste disposed at Hanford must be “as good as glass”. Will the NAS report allow grout to meet this standard?

• If grout is good for half of the Low-Activity Waste, why not all?

• What could be the future of the existing LAW glass plant?
  • Keep it running?
  • Convert it to HLW glass-making?
  • DOE remains committed to DFLAW by 2023, then we’ll see.
Next Steps

• Oregon is working on a letter to the National Academies with our review of the FFRDC analysis.
• Next public meeting to occur in November in Richland, WA.
• Final report to Congress expected in Spring 2020.
If you want to learn more…

Google “NAS Supplemental LAW Hanford” to watch all the public meetings, read the reports, and hear the deliberations.