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Department of Energy's Push to Triple Nuclear Energy Ignores Cost and Difficulty of Managing and Disposing of Spent Nuclear Fuel

In March 2023, the Department of Energy proposed to increase nuclear energy electricity production in the U.S. by a factor of three. [1]

Leave aside for a moment the costs and technical challenges of designing, licensing and building more nuclear plants. Also, leave aside for a moment the fact that new nuclear power plants cannot be deployed in time to combat climate change and other problems.

The testimony of Dr. Kathryn Huff, Assistant Secretary for Nuclear Energy, January 18, 2024 tries to make consolidated interim storage sound like a solution and fails to acknowledge that the Department of Energy has no program to develop a permanent solution for the radioactive waste from nuclear reactors, the spent nuclear fuel. [2]

Huff, in the long tradition of the Department of Energy, ignores the looming enormous cost of spent nuclear fuel disposal and the technical challenges of attempting to confine the radioactive waste that poses a threat to all life on the planet.

The Department of Energy mischaracterizes the magnitude of the unsolved technical challenges for finding a permanent solution to the radioactive waste problem posed from nuclear energy. The Department of Energy's "Liftoff" document implies that the spent nuclear fuel problem isn't a big problem because the volume of spent nuclear fuel "is quite small" and stating that the volume of spent nuclear fuel "could fit on a single football field at a depth of less than 10 yards." [3]

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[1] Department of Energy webpage, Pathways to Commercial Liftoff: Advanced Nuclear, March 2023. https://www.energy.gov/lpo/articles/sector-spotlight-advanced-nuclear DOE discusses deploying about 300 gigawatts (GW) by 2050, with current U.S. nuclear capacity of about 100 GW. See also the related COP28 announcement at https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key

[2] Kathryn Huff, Assistant Secretary for Nuclear Energy, U.S. Department of Energy, Before the Committee on Oversight and Accountability, U.S. House of Representatives, January 18, 2024. https://oversight.house.gov/wp-content/uploads/2024/01/Dr.-Huff-Testimony.pdf

[3] Department of Energy webpage, Pathways to Commercial Liftoff: Advanced Nuclear, March 2023. https://www.energy.gov/lpo/articles/sector-spotlight-advanced-nuclear See page 35.

The fact is that the Department of Energy was needing 41 miles of waste emplacement tunnels (or drifts) at the proposed Yucca Mountain repository as limited by law to 70,000 metric tons of spent nuclear fuel. And this assumed repackaging and positioning the waste to limit the thermal heat load. [4] The football field analogy is highly misleading.

The commercial spent nuclear fuel already stored at 54 facilities in 28 states [5] will likely require repackaging for continued long-term storage, but neither the Department of Energy nor the U.S. Nuclear Regulatory Commission know who will pay for this repackaging. Neither does the technology for repackaging the spent fuel exist. Read more about the incomplete and speculative cost estimates for spent nuclear fuel disposal efforts in EDI's February 2024 newsletter. [6]

The Department of Energy does not like to admit that no money has been collected into the Nuclear Waste Fund from electricity generation by nuclear energy since 2014 because the DOE has no program for spent nuclear fuel disposal for either the nation's commercial spent nuclear fuel or for the nation's military and research-related spent nuclear fuel and high-level waste.

The Department of Energy does not describe the fact that even without any new nuclear power plants, the nation already needed two repositories the size slated for Yucca Mountain. And compounding the disposal problem is that many of the new reactor designs will require more space in a repository on an electrical energy generation basis. **For example, small modular reactors will require disproportionately more containers and more space in a repository, according to independent evaluations.** The nuclear waste from the variety of small modular reactors (water-, molten-salt-, and sodium-cooled SMR designs) has been evaluated and can be expected to "increase the volume of nuclear waste in need of management and disposal by factors of 2 to 30" for each megawatt produced. [7]

The Department of Energy and its nuclear boosters like to say that spent fuel reprocessing is the answer to the nuclear waste problem. But they don't like to discuss the unaffordable cost, the high radiological emissions, or the increased overall volumes of radioactive waste associated with reprocessing.

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[4] U.S. Department of Energy, *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, DOE/EIS-0250F-S1D, October 2007. https://www.energy.gov/sites/prod/files/EIS-0250-S1-DEIS-Summary-2007_0.pdf

[5] Kathryn Huff, Assistant Secretary for Nuclear Energy, U.S. Department of Energy, Before the Committee on Oversight and Accountability, U.S. House of Representatives, January 18, 2024. https://oversight.house.gov/wp-content/uploads/2024/01/Dr.-Huff-Testimony.pdf

[6] Environmental Defense Institute, newsletter article "Nuclear promoters continue to avoid realistic disclosure of the cost of spent nuclear fuel disposal or of reprocessing," February 2024. http://www.environmental-defense-institute.org/publications/News.24.Feb.pdf

[7] Lindsay M. Krall, Allison M. Macfarlane, and Rodney C. Ewing, *PNAS*, "Nuclear waste from small modular reactors," Received June 26, 2021, Published May 31, 2022, https://doi.org/10.1073/pnas.2111833119.

The NuScale small modular reactor project slated to put ratepayers on the hook for all the cost overruns if the project had progressed [8] was cancelled despite the promise of extensive taxpayer-funded Department of Energy handouts. Idaho Falls Mayor, Rebecca Casper had promoted the project with zeal and now questions "the free-market system" and blames the problems that led to the project's termination were mainly due to COVID-19 and sky-rocketing costs for steel. Thankfully, ratepayers were spared the additional construction cost increases that would likely have occurred had construction on the Idaho NuScale project actually started.

Doubling down on the failed technology that investors don't want, and ratepayers don't want, and that communities with stranded nuclear fuel don't want, and that increasingly leaves radioactive waste from decommissioning permanently at the shutdown nuclear plants, [9] the Department of Energy is seeking ways to nail ratepayers and/or taxpayers to exorbitantly expensive cost of building and operating nuclear plants. When the cost of spent nuclear fuel long-term storage, possible reprocessing and disposal is included, the cost of nuclear can be expected to be obscene — which is perhaps why the Department of Energy doesn't want to discuss it.

Department of Energy Idaho Cleanup Project Citizens Advisory Board Downplays or Omits Key Information Citizens Need to Know

The Idaho Cleanup Project Citizens Advisory Board (ICP CAB) meeting was held February 22, 2024 in Idaho Falls. [10] Presentations were given on cleanup project progress, including transuranic waste shipments, Integrated Waste Treatment Unit shutdown, and the investigation of vitrification technologies to treat the high-level waste called calcine that resulted from spent nuclear fuel reprocessing at the INL. The DOE's cleanup project has been working to make progress on difficult tasks, but the Department of Energy does not want to talk about the huge cleanup milestones that will be missed.

The ICP CAB meeting prominently featured the next five years of major milestones for the Idaho Settlement Agreement, Federal Facility Agreement and Consent agreements, Hazardous Waste Management Area/Resource Conservation and Recovery Act (HWMA/RCRA) Closure Plans and the Site Treatment Plan. Handouts and posters **excluded** the cleanup milestones beyond 2024.

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[8] Jeff Robinson, *The Idaho Falls Post Register*, "Failed CFPP [Carbon Free Power Project] can pave the way for future successes in new nuclear," February 21, 2024.

[9] Joe Hodkin, Susan Racine and Brita Lundberg, CommonWealth Beacon, "A warning about radioactive air pollution from Pilgrim," February 25, 2024. https://commonwealthbeacon.org/environment/a-warning-about-radioactive-air-pollution-from-pilgrim/ Pilgrim's decommissioning radioactive waste will be left locally in Massachusetts. Also, Dr. Richard Clapp conducted a study that showed infant mortality, thyroid cancer, and leukemia were all significantly increased after the Pilgrim nuclear power plant vented radioactive vapor. https://www.osti.gov/biblio/5735008

[10] Department of Energy, Idaho Cleanup Project Citizens Advisory Board February 22, 2024 meeting, see presentations at https://www.energy.gov/em/icpcab/articles/icp-cab-meeting-materials-february-2024

But the most important Idaho Settlement Agreement milestones are after 2024 and these important milestones cannot be met. The removal of spent nuclear fuel from the INL is a January 1, 2035 Idaho Settlement Agreement Milestone that there is no planning, funding or facilities to allow repackaging the spent nuclear fuel.

The Idaho Settlement Agreement also called for the high-level waste called calcine to be "road ready" by December 31, 2035. There is no planning, funding or facilities to package the calcine to be "road ready." There was also no mention that there no repository to send the waste to, even though a repository is the Department of Energy's responsibility.

The previous decision to use hot isostatic pressing (HIP) to package the calcine is still officially in place, but DOE now considers HIP to be of low technical maturity. It is seeking other solutions, including vitrification. In 2009, the Department of Energy selected hot isostatic pressing of the calcine instead of vitrification despite the fact that the state favored vitrification and vitrification was specified by the Environmental Protection Agency (EPA) as the best demonstrated available technology for treatment of radioactive high-level waste (HLW) in 1990.[11]

Vitrification is likely to be slow, expensive and can have high airborne emissions. **And in reality, vitrification for the INL's calcine is also an immature technology. It also suffers from a lack of data to verify performance of the waste form over the long term, meaning the leach-out rate from the glass that is laden with radioactive materials and chemical constituents.**

The Department of Energy has been slow-walking the calcine to nowhere for years. The Department of Energy admitted without any other discussion that it finds removal of the calcine from the bin sets to be difficult. **And the Department of Energy admitted that "direct disposal" of the calcine was still an option but did not explain what this meant.** Vitrification is likely to be slow and expensive, if Hanford's experience or the Savannah River Site's experience teaches anything.

The stated purpose of site-specific advisory boards (SSAB) like the ICP CAB is to focus on transparency and build trust (see Kelly Snyder's February 22, 2024 presentation). If that is the case, then perhaps the Department of Energy should not withhold information about operational and safety problems, and should not downplay the problems or the inadequacy of current programs. Specifically, in 2022 and 2023, DOE failed to discuss cleanup project DOE Occurrence reports, Environmental Protection Agency RCRA violations, and timely discussion of the leaking transuranic waste drums that required multiple waste shipments to WIPP to be returned to Idaho.

[11] Department of Energy, Idaho High-Level Waste & Facilities Disposition Final Environmental Impact Statement, DOE/EIS-0287, September 2002. See page 2-16, discussion of EPA's Federal Register notice 55 FR 22520, June 1, 1990.

The Environmental Management portion of the Department of Energy seems to try to "keep up appearances" even if it requires omission of facts of operational screwups or glossing over the operational, regulatory compliance or safety challenges. There can be a willingness to attribute failures to conditions beyond DOE Idaho Field Office control, such as the lack of a disposal repository. The history of missteps can get lost as Department of Energy managers cycle through and CAB members are limited to a six-year term.

The Department of Energy's propaganda about the status of cleanup at the INL isn't limited to the ICP CAB meeting. The Idaho National Laboratory director, who does not manage cleanup efforts, is actively championing DOE's cleanup status [12] while not mentioning the lack of progress in vital cleanup areas that put Idaho at risk, all while busily promoting making more radioactive waste at the INL while not seeking permanent disposition plans that protect human health and the environment.

At the February 2024 meeting, the DOE minimized the troubles of the Integrated Waste Treatment Unit, and glossed over the safety challenges of the thousands of transuranic waste drums. **It was mentioned that contaminants in the aquifer below the subsurface disposal area had "shifted." There was no mention of which contaminants or the actual data.**

The ICP CAB meetings have been shrinking in number, from about six per year, to only 3 or 4 per year. Even more importantly, the meeting hours at a meeting have been reduced, assuring that in order to stick to the schedule, there can be very few questions from the CAB members and no permission granted for the public to ask questions. This is a very deliberate tactic to control the spin and limit the CAB's understanding of the problematic issues.

I find myself wanting to cling to the hope that the Department of Energy's schemes will work even when I have serious doubts. But I find less and less to cling to, especially after witnessing over a decade of Citizens Advisory Board meetings. If the reality of the environmental damage, the worker health harm, the harm and risk to the public and the costs were actually comprehensively conveyed, everyone in the room would be sobbing with grief at the dangerous radioactive messes that the Department of Energy will never clean up. And meanwhile, the Department of Energy (Nuclear Energy side) ramps up its efforts to make more radioactive messes without transparency, planning, realistic cost estimates, or realistic technical maturity estimates for long term spent nuclear fuel storage or for spent fuel permanent repositories.

[12] John C. Wagner, *The Idaho Falls Post Register*, Opinion editorial: Strong partnerships advance nuclear research, cleanup milestones," February 7, 2024.

Transuranic Waste Drum Corrosion Issues Require Expensive Overpacks to Ship to WIPP

The ICP CAB February meeting presented the fact that certification of "difficult" transuranic waste remains a challenge, as does container integrity. The DOE continues to generate transuranic waste but goals for removal of newly generated waste were not provided. A site priority was listed as "continue implementation of DOE-STD-5506-2021 [13] for managing TRU waste" but there was no discussion of the problems or progress with storing waste drums with flammable gases or the failure to implement more reasonable assumptions in safety analyses.

Although not explained at the CAB meeting, DOE-STD-5506 is important for protecting workers and citizens during the cleanup and is extremely relevant to transuranic waste management at the Idaho Cleanup Project. [14] Despite aggressive TRU waste shipping efforts, there remain about 30,000 TRU waste drums to ship. The DOE is actively avoiding improved chemical compatibility assessments and improved handling of flammable gases. The deficient waste characterization and deficient chemical compatibility analyses caused four transuranic waste drums to overpressurize in 2018. DOE-STD-5506 also involves the need for DOE to improve its nuclear safety bases for material-at-risk and release fraction assumptions. But the DOE seems to prefer using assumptions that lower estimated radiological consequences in safety analyses documents even when those assumptions are not technically sound.

In 2022, shipments of transuranic waste to the Waste Isolation Pilot Plant (WIPP) in New Mexico were returned to the Idaho Cleanup Project after leaking containers were noted at WIPP. This problem was not disclosed to the Idaho Cleanup Project Citizens Advisory Board until months after the problem had occurred and multiple shipments of waste drums had been returned to Idaho.

The problem was found to involve certain transuranic waste streams. And yet it appears that the problems in 2022 were never adequately investigated. The managers at WIPP, not at the Department of Energy's Idaho Cleanup Project, demanded solutions so that radioactive and/or PCB-laden liquid would not leak from waste drums.

In 2023, the Idaho Cleanup Project had a Department of Energy Occurrence Report that identified that a corroded transuranic waste drum had leaked radioactive contamination at the Advanced Mixed Waste Treatment Facility building MWF-631. [15] The contamination exceeded 34,000 disintegrations per minute (dpm) for alpha particle decays. The DOE Occurrence

[13] Department of Energy Technical Standard, Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities, DOE-STD-5506-2021, 2021. https://www.standards.doe.gov/news/published-doe-std-5506-2021-preparation-of-safety-basis-documents-for-transuranic-tru-waste-facilities

[14] Defense Nuclear Facilities Safety Board letter to the Department of Energy, DOE Standard 5506 High-Priority Concerns (2021-100-026), July 26, 2021. https://www.dnfsb.gov/documents/letters/doe-standard-5506-high-priority-concerns

[15] Department of Energy Occurrence Report, Contamination from leaking drum discovered in WMF-631, EM-ID- - AMWTF-2023-0003, Notification date 05/11/2023, Final report 10/05/2023. Contractor: Idaho Environmental Coalition, LLC.

Reporting criteria was that contamination was more than 100 times the value in 10 CFR 835 Appendix D for outside of a controlled area.

The DOE's Occurrence report did not provide an estimate of how long the contamination on the floor had remained undetected. It appears that no bioassay of workers was conducted. The search for the breached drum found a BN510 waste stream drum located 110 drums back from the front of the row it was stacked in. This drum had come from the AMWTP compactor and had been closed in February of 2015. No other leaking drums were identified.

The problem in 2023 was found to be corrosion of the drum due to liquid in the drum. The age of the drum was also deemed to be a factor, but this drum had been packaged relatively recently in 2015. The corrosion problem was a previously identified issue at AWWTP in 2022 and supposedly the contractor had implemented mitigation actions.

The 2023 Occurrence Report acknowledged that the presence of liquids in Crit Cleanup pucks (packaged at the AMWTP compactor), as was the case in the corroded and breached waste drum, increases the likelihood of corrosion and a breach forming that allows the spread of contamination. It should be noted that the WIPP waste acceptance criteria prohibit free liquids in the waste drums.

None of this was discussed at the February 2024 ICP CAB meeting. But at the meeting, when asked what causes waste drum corrosion, the Department of Energy responded that they surmise the freeze/thaw cycles in the unheated waste storage buildings allows corrosion due to condensation. **That may also be true, but there was no discussion of the documented and known cause of corrosion due to <u>excess liquid in waste drums</u> in recent years or in 2023. Liquid in drums is prohibited and a condition that the contractor is required to prevent by the use of liquid absorbents.**

The Department of Energy's cleanup contractor, Idaho Environmental Coalition, LLC, shipped more transuranic waste drums in 2023 than in any other year over the last decade, 9,331 waste containers, according to reporting by The Idaho Falls Post Register. [16] There remain roughly 30,000 waste drums of the some of the most difficult waste drums, with drum corrosion and flammable gas generation and waste certification issues. The Department of Energy's safety management of these waste drums is known to be deficient and puts workers and the public and the environment at risk.

[16] Jeff Robinson, *The Idaho Falls Post Register*, "Cleanup Project head highlights successes for LINE Commission," February 24, 2024. The Leadership in Nuclear Energy (LINE) is a governor-created forum that has sought reduced state regulation and tax breaks for nuclear energy and sought state money for nuclear research facilities.

Integrated Waste Treatment Unit inoperable due to clog ups

Very little information was presented at the ICP CAB meeting in February about radioactive operations conducted last year at the Integrated Waste Treatment Unit (IWTU). But the problems at IWTU are so extensive that more small-scale pilot facility tests have been conducted at the Hazen facility in Colorado to seek ways to mitigate the problematic differential temperature excursions and "agglomerate formation" or as I describe it, "clog ups." There were also problems in too much mercury escaping to the filters.

Experts had warned that the IWTU would be prone to clog ups and recommended against the technology. [17] The Department of Energy went ahead with the IWTU and missed its milestone to complete treating the sodium-bearing waste in 2012. While treatment of the radioactive liquid sodium-bearing HLW started in 2023, it is expected that it will take many more years to treat all of the waste. The IWTU will remain an expensive, unsafe and challenging way to spend many more years struggling to treat the sodium-bearing waste left over from spent fuel reprocessing.

Worker radiation doses are likely to be high now that the plant has run radioactive material. That will make plant modifications and repairs costly in terms of worker health. If you think DOE's radiation worker protection standards will protect these workers – well, think again. Workers are not told of the potential for fertility problems or the actual risk of risk of birth defects. And workers are also not told that cancer rates are elevated in radiation workers for annual doses far below the allowable 5 rem.

The IWTU began radioactive operations in April 2023 and by September 2023 had treated 68,000 gallons of sodium-bearing radioactive liquid waste, filling 140 canisters. [18] About 830,000 gallons remain to be treated.

The reprocessing of naval reactor and of a variety of DOE research reactor fuels at INL resulted in recovery of enriched uranium that was so laden with radioactive contaminants that it was only used at the Savannah River plutonium production reactor. When that defense reactor shutdown, there was no use for that recovered enriched uranium because it would be too difficult to work with for fuel fabrication of other fuel types.

The liquid sodium-bearing waste is managed as high-level waste (HLW), despite DOE's reluctance to call it HLW. There is no waste repository that has accepted the treated sodium-bearing waste, but since the 1990s, DOE has hoped to send it to WIPP, yet in nearly 30 years has never obtained approval to send it to WIPP.

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[17] Department of Energy, Idaho High-Level Waste & Facilities Disposition Final Environmental Impact Statement, DOE/EIS-0287, September 2002. See that two studies recommended against the steam reforming method DOE ultimately selected. See page 2-35 and Appendix B regarding a National Academy of Sciences Assessment of Alternatives, 1999. And see TFA-0101 by Pacific Northwest National Laboratory, Technical Review of the Applicability of the Studsvik, Inc, Thor Process to INEEL SBW, TFA-0101, March 2001.

[18] Jeff Robinson, *The Idaho Falls Post Register*, "Cleanup Project head highlights successes for LINE Commission," February 24, 2024. The Leadership in Nuclear Energy (LINE) is a governor-created forum that has sought reduced state regulation and tax breaks for nuclear energy and sought state money for nuclear research facilities.

DOE Investigating Calcine Vitrification, But Keeps Direct Disposal in Idaho as an Option

The Department of Energy described at the February ICP CAB meeting that the agency was studying the feasibility of using vitrification to treat the calcine, a dry form of high-level waste (HLW) stored at the Idaho National Laboratory. The DOE has recently paid three contractors to study three different methods that might be useable for the vitrification of calcine and results are scheduled to be completed this fall. Vitrification involves heating the waste and adding glass until the materials liquidize, then cooling the glass/waste mixture.

The three vitrification methods being investigated are listed below:

(1) The Joule Heating Ceramic Melter (JHCM) technology will be studied by Catholic University. It has been used at the Savannah River Site and in Europe and Japan and is used to treat low-level waste (LLW) and high-level waste (HLW). There is over 30 years of operation in the DOE complex with JHCM.

(2) The Cold Crucible Induction Melter (CCIM) has been used in France, Russia and Korea to treat HLW. The Department of Energy recently visited France. [19]

(3) The "In-Container" method has been used only for LLW but there is interest in treating HLW.

Vitrification is a process of mixing the radioactive waste, usually in liquid form, with a combination of silica sand and other glass-forming chemicals, and heating the mixture to very high temperatures until it melts, and then pouring the molten mixture into stainless steel canisters where it cools to form a glass. [20]

The DOE enthusiastically pointed out that the French reprocess their spent nuclear, create a calcine waste form from the high-level waste liquid and then vitrify it. But, none of the costs, safety risks, and pollution were described. The fact that the French have not reprocessed their MOX fuel (plutonium and uranium fuel called "mixed oxide fuel,") was not described, nor that the French continue struggling with radioactive waste repository problems.

Vitrified High-Level Waste Performance Characteristics Unknown

When asked by a CAB member about the performance of vitrified HLW, the DOE gave a long answer that did not actually answer the question but stated that glass characteristics have been extensively studied, for example, at Pacific Northwest National Laboratory (PNNL).

Vitrified HLW would be required to be disposed of in a deep geologic repository. The glass containing radionuclides and chemical waste does corrode and leach radionuclides from the glass over time. There are many variables of the composition of the vit and of the repository water

[19] Environmental Management, Department of Energy, France Visit Enables Information Exchange to Advance EM Cleanup, June 20, 2023. https://www.energy.gov/em/articles/france-visit-enables-information-exchange-advance-em-cleanup

[20] U.S. Nuclear Waste Technical Review Board, Factsheet: Vitrified High-Level Radioactive Waste, Revision 1, November 2017. See nwtrb.gov.

infiltration, pH, and chemistry. There is considerable uncertainty over the performance of the vitrified HLW over geologic time frames and the specific waste and vitrified waste product must be evaluated. [21] The performance of the vitrified waste will depend on the particular constituents and the process used.

Vitrified high-level waste is a more stable waste form, however, than liquid or calcined HLW for continued onsite storage.

Continued Calcine Storage in Idaho is Unsafe

The calcine at the INL is the radioactive high-level waste (HLW) resulting from spent fuel reprocessing at INL that was processed into a dry form called calcine. The calcine also contains chemical waste, so it's a "mixed" waste of both chemical and radiological constituents. The calcine is powdery, and soluble. **It is stored in partially above grade and partially below grade in seven bin sets.** There are seven bin sets, each designed and constructed differently; see Figure 1. Each bin set for containing calcine is inside a concrete vault, and many that are partially above ground. The bin sets were designed to seismic standards but the seismic standards were inadequate and were later found to have underestimated the seismic hazard. The degree of vulnerability varied but was the worst for bin set 1. The Department of Energy has taken the approach of denial and secrecy and took decades to take any action such as moving calcine from bin set 1 to another bin set. A limited history of seismic evaluation is presented in 2003 report INEEL/EXT-02-1548 and see comment submittals by EDI. [22] [23] [24] [25]

It is important to understand that it is typical of all Department of Energy facilities built prior to this century – that the seismic hazard assumed was underestimated and this often resulted in seismically vulnerable structures and equipment at relatively small and frequent earthquake events. The Department of Energy has typically been slow to respond to the identified seismic vulnerability and has preferred secrecy, denial and inaction. The inaction on addressing seismic design deficiencies continued despite the requirement to address it when 10 CFR 830, the "safety basis" rule was issued over two decades ago.

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[21] Allison M. Macfarlane and Rodney C. Ewing, Editors, *Uncertainty Underground - Yucca Mountain and the Nation's High-Level Nuclear Waste*, The MIT Press, 2006. ISBN 0-262-13462-4

[22] Department of Energy Idaho Operations Office, INEEL/EXT-02-01548, "Structural Integrity Program for the Calcined Solids Storage Facilities at the Idaho Nuclear Technology and Engineering Center," May 2003. Find it at https://inldigitallibrary.inl.gov

[23] Chuck Broscious and Tami Thatcher, Subject: Public Comment for inclusion in the public record on US Department of Energy (DOE) Application to renew the Calcined Solids Storage Facility Mixed Hazardous Waste Permit (EPA ID No. ID4890008952) (Docket No. 10HW-1604), INL's calcine storage vulnerability, July 11, 2016. http://www.environmental-defense-institute.org/publications/EDICalcineComments.pdf

[24] Chuck Broscious and David B. McCoy, EDI Preliminary Comment to the Idaho Department of Environmental Quality on Calcined Solids Storage Facility Partial Permit Renewal, May 2017. http://www.environmental-defense-institute.org/publications/EDI-CSSF-Permit-S.pdf and http://www.environmental-defense-institute.org/publications/EDI-CSSF-Attach.pdf

[25] Tami Thatcher, Public Comment Submittal on the Department of Energy's Draft Basis for Section 3116 Determination for Closure of the Calcined Solids Storage Facility at the Idaho National Laboratory Site, December 2023 at http://www.environmental-defense-institute.org/publications/commentcalcine2023.pdf

Bin set 1, installed in 1963, was designed to a lower seismic performance category (PC-2) than the other bin sets that were designed to PC-3. And since the late 1990s, seismicity investigations have found the site more, not less, seismically challenging to plant equipment and building designs. Virtually all tanks at all INL facilities designed before around 2000 have not been seismically adequate to even PC-2 standards even when PC-4 was needed.

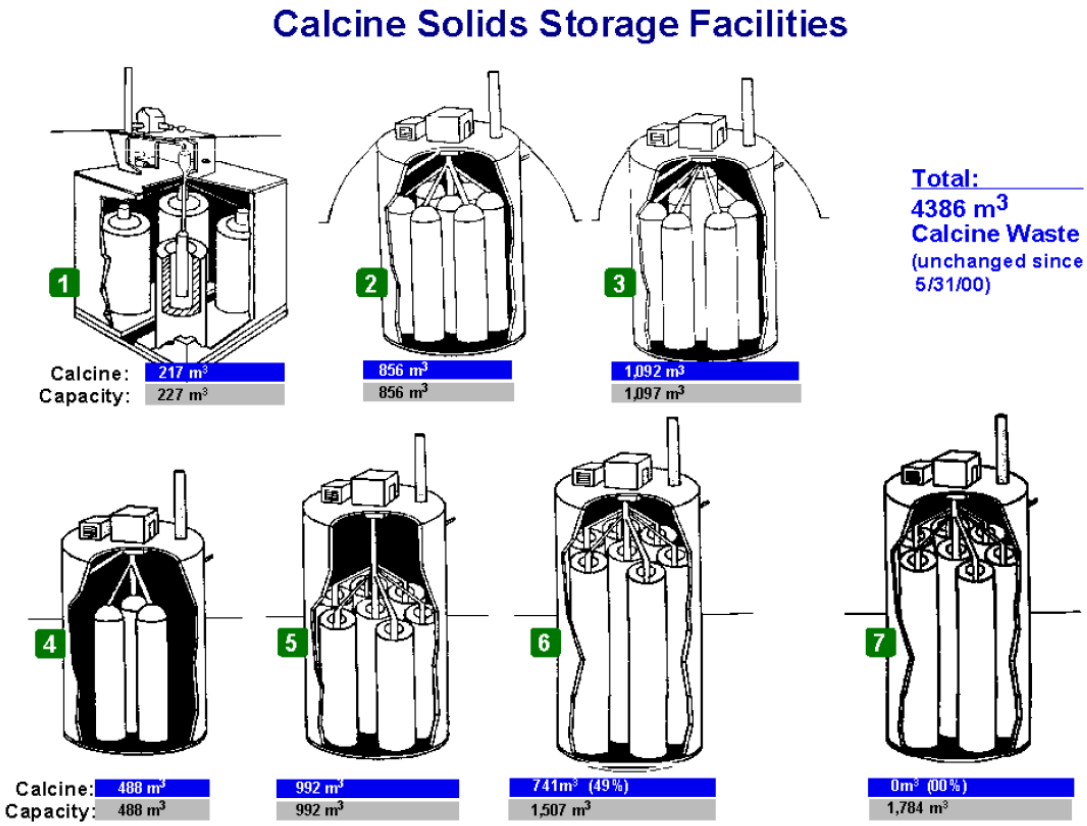

Figure 1. Calcine Solids Storage Facilities from INEEL/EXT-02-01548.

The metal portion of the bin sets as well as the concrete shell are designed in a variety of ways. The metal bin sets allow for retrieval of the calcine and are seismically vulnerable as well as flood vulnerable to "floating" and breakage of the metal components. The concrete outer structure lacks adequate documentation of the concrete and is likely seismically vulnerable.

The DOE does not like to admit to any safety deficiencies concerning the calcine, but I recall that the deficiencies caused dismay to the seismic consultants brought to INTEC years ago. The dismay was not only because of the poor design and inadequate documentation, it was dismay due to the DOE's attitude about ignoring the safety problems.

Department of Energy Backpedaling on Idaho Settlement Agreement Calcine Planning

The calcine at the INL's Idaho Nuclear Technology and Engineering Center (INTEC) poses an enormous radiological catastrophe if not contained. That is why the 1995 Idaho Settlement Agreement [26] had required DOE to choose a method to treat the calcine and get it ready for disposal out of state. According to the Idaho Settlement Agreement, DOE was to commence negotiating a plan and schedule with the State of Idaho for calcined treatment by December 31, 1999. A Record of Decision was to be issued not later than December 31, 2009. DOE was to submit to the State of Idaho its application for a RCRA Part B permit by December 1, 2012, for the calcine treatment facility. Treatment of the calcine to be "road ready" was to be completed by the "target date of December 31, 2035."

The Department of Energy had formally announced in 2009 the decision to use HIP as the method of repackaging the calcine for shipping and disposal. [27] The 2009 decision was actually amending previous decisions. The DOE issued a press release in 2009 stating that HIP was "an industrially mature manufacturing process" and that DOE was committed to completing the treatment by 2035 [28] This statement was in contrast to studies referenced DOE's own environmental impact study in 2002. [29] Then in 2018, to the surprise of the State of Idaho, the Department of Energy began back-peddling on the use of hot isostatic pressing to treat the calcine, pointing to a report by an independent review panel describing the possible treatment options for the calcine and which described HIP as "technically immature" and "which may represent unacceptable project risk." [30] The DOE is now emphasizing that hot isostatic pressing (HIP) is of low technical maturity.

Now, in 2024, treatment of the calcine by vitrification is being investigated for "feasibility" although feasibility was never questioned in the Department of Energy's 2002 Final Environmental Impact Statement (DOE/EIS-0287) that included calcine vitrification as an alternative, but was not selected as the preferred alternative.

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[26] See more about Idaho's Settlement Agreement at https://www.deq.idaho.gov/inl-oversight/oversight-agreements/1995-settlement-agreement.aspx DOE Environmental Management (EM) manages the spent fuel at the Idaho National Laboratory except for the naval spent nuclear fuel. Section D(1)(e) stipulates that naval fuel be among the early shipments to the first permanent repository or interim storage facility.

[27] Department of Energy Press Release, Amended Record of Decision: Idaho High-Level Waste Facilities Disposition Final Environmental Impact Statement REVISED BY STATE 12/21/09. http://www.id.doe.gov/NEWS/PressReleases/PR100104-HIP/Calcine%20ROD%20final_SIGNED_PDF.pdf In 2009 DOE had decided to select hot isostatic pressing (HIP) to treat the calcine.

[28] Department of Energy, DOE signs Record of Decision selecting Hot Isostatic Pressing Technology for Treatment of High Level Waste Calcine, webpage accessed 2/28/2024 at https://www.id.energy.gov/news/PressReleases/PR100104.htm

[29] Department of Energy, Idaho High-Level Waste & Facilities Disposition Final Environmental Impact Statement, DOE/EIS-0287, September 2002. See the study that recommended eliminating the hot isostatic pressing option, TFA, 2000, PNNL-13268 by Pacific Northwest National Laboratory, Assessment of Selected Technologies for the Treatment of Idaho Tank Waste and Calcine, July 2000.

[30] US DOE-EM, "Independent Analysis of Alternatives for Disposition of the Idaho Calcined High-Level Waste Inventory, Volume 1 – Summary Report," April 2016. https://energy.gov/sites/prod/files/2016/05/f31/Volume%201%20Calcine%20AoA%20Final%2004-19-16%20w_signatures.pdf

Around 2016, the Department of Energy had sought to dispose of the calcine in deep bore holes in North or South Dakota because even if a repository were built at Yucca Mountain, the soluble mixed waste calcine was a problem to dispose of at Yucca Mountain. But neither state would allow even the research to be conducted, perhaps worrying about the uncertainties they would face in terms of geological instability due to the drilling and potential entry of highly soluble radioactive calcine into their water supplies.

The powdery calcine is preferable to leaky tanks holding liquid waste like the ones at Hanford. However, calcine is a high- level waste form that could blow in the wind and leach into the ground and ultimately to the aquifer.

While vitrification technology has existed for decades, the particular constituents of the waste impact the process, the needed additives and the performance of the vitrified waste. Study of calcine vitrification was documented over two decades ago, [31] but despite the existence of vitrification technology, there are significant challenges with vitrification of INL's calcine.

The INL's calcine varies according to the fuels that were reprocessed. Key constituents in the calcine that vary include aluminum, zirconium and fluoride. The "recipe" and process temperatures needed in order to yield a good vitrification product could be tricky and will be especially difficult to master given the varied composition of the calcine that isn't necessarily clearly separated into particular bin sets, as I understand it. So, the in theory, vitrification may be viable and yet may involve greater technical challenges because of the varying calcine composition. The technical maturity of vitrification is likely far lower than might be implied.

Calcine HLW in Idaho Has No Repository

For perspective on the amount of radioactivity in the INL's calcine, if mixed with water, it would take over 800 Snake River Plain aquifers to dilute its strontium-90 to drinking water standards (1,975,000,000 billion liters) to 8 picocuries/liter. It would take 44 Snake River Plain aquifers to dilute the cesium-137 to drinking water standards, and 3 Snake River Plain aquifers to dilute the plutonium-238 to drinking water standards.

Vitrification is expensive and polluting; however, vitrified glass waste forms are certainly less vulnerable in storage than powdery calcine. But heating waste to create vitrified waste means off-gassing chemicals and radionuclides.

It is important for citizen to understand that while "high-level waste" requires deep geological repository disposal, low-level waste does not. The Department of Energy focused on granting itself the ability to reclassify high-level waste so that it is no longer high-level waste.

When high-level waste is reclassified as not high-level waste, it magically becomes low-level waste, regardless of its longevity and health hazard. And the Department of Energy's

[31] J. V. Crum and J. D. Vienna, Pacific Northwest National Laboratory and D. K. Peeler and I. A. Reamer, Savannah River Technology Center, for the US Department of Energy, "Formulation Effects for Direct Vitrification of INEEL Blend Calcine Waste Simulate: Fiscal year 2000. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13483.pdf

regulations allow disposal of low-level waste on its DOE federal sites, including the Idaho National Laboratory.

This saves DOE money but the DOE's regulations do not assure protection of the public from this waste. **The DOE's regulations, and in particular, DOE Order 435.1, *Radioactive Waste Management,* and DOE Manual 435.1–1, Chg 3, *Radioactive Waste Management Manual* does not provide any certainty that reasonable and protective decisions will be made.** The DOE Manual 435.1-1 allows DOE to bury its low-level or transuranic waste on DOE sites. The DOE Manual 435.1-1 allows DOE to approve any Performance Assessment and does not include a comprehensive set of waste burial performance criteria or Performance Assessment model standards. There is no waste compliance period. **Any level of radioactive migration from the disposal site at a DOE facility can be deemed acceptable by DOE, according to DOE Manual 435.1-1. DOE can change its regulations, at whim, without public notification. DOE can waive any of its regulations at any time.** Any reliance on DOE regulations, including DOE Manual 435-1-1, actually provides no assurance of the protection of the public and the environment.

DOE considering vitrification of INL's calcine HLW, but vitrification efforts struggle at Hanford and Savannah River

In addition to the high-level waste (HLW) in the form of dry, powdery calcine at the Idaho National Laboratory, the other HLW in the U.S. is stored at other Department of Energy sites: the Savannah River Site near Aiken, South Carolina, Hanford Site near Hanford, Washington, and the West Valley Demonstration Project near West Valley, New York.

At West Valley, which only operated from 1966 to 1972, the complete inventory of HLW (about 580,000 gallons) that resulted from processing commercial spent nuclear fuel blended with some defense SNF, was completed in 2002.

The DOE has used vitrification at the Savannah River Site and at Hanford. However, at SRS only 4.5 million gallons of HLW has been vitrified between 1996 and 2014 and 36 million gallons of liquid HLW remain to be treated at SRS. The current process resulted in generation of hydrogen and ammonia, so the DOE is upgrading the SRS vitrification plant to allow for safer processing of high-activity radioactive waste. [32]

Hanford's tanks of liquid HLW remain a continuing problem and Hanford has not vitrified any of its HLW. At Hanford, 55 million gallons of HLW remain in liquid form in leaking or leak-prone tanks. Hanford did apply a limited amount of vitrification on two

[32] Office of Environmental Management, Savannah River Site Vitrification Facility Undergoes Major Upgrade, May 24, 2022. https://www.energy.gov/em/articles/savannah-river-site-vitrification-facility-undergoes-major-upgrade.

separated radionuclides with relatively short radioactive half-lives, resulting in 34 canisters of vitrified cesium-137 or strontium-90, but not HLW. [33]

Despite the DOE continuing to tout vitrification as well-established technology, the Hanford HLW vitrification efforts that began in 2000, 24 years ago, have not resulted in vitrification of any HLW or in completing a facility. [34] In 2023, DOE estimated that the cost of treating the Hanford HLW ranged from $135 billion to $5 trillion. [35]

In 2023, the U.S. Government Accountability Office issued its report regarding over two decades of Hanford failing to vitrify any HLW and suggested DOE study alternative approaches such as mixing the liquid HLW with grout. [36]

The vitrification process requires adding materials to the waste in order to make the glass form. The calcine inventory of 4386 cubic meters increases according to the "waste loading" necessary for making the vitrified waste, and 8,500 cubic meters of vitrified calcine was assumed in the 2002 Environmental Impact State EIS-0287. When the volume of waste increases, more shipments of the waste are required and more space in a repository is required.

See Table 1 for a perspective on the original amount of HLW waste, the amount of vitrified HLW, and the potential total amount of vitrified HLW is conducted as planned for the Department of Energy's Hanford site, Savannah River Site, and the Idaho National Laboratory. The table also includes the relatively small inventory of vitrification conducted by the Department of Energy at the failed West Valley private reprocessing facility. The HLW was in liquid form for all of the facilities except for the dry calcine at the INL.

The previously selected treatment of the calcine at the Idaho National Laboratory's INTEC facility was hot isostatic pressing (HIP) and was estimated to require 5,700 HLW containers. The Department of Energy apparently ignored the lack of technical maturity of HIP, the higher airborne radiological emissions expected from processing HIP, [37] and the complete lack of waste form performance data or research programs to obtain such data for the HIP waste form.

There are various constituents and conditions that affect the performance of the vitrified waste over time. Vitrified waste can and will corrode and allow the leach-out of radionuclide contaminants and chemical contaminants over time. But vitrified waste forms are more stable

[33] U.S. Nuclear Waste Technical Review Board, Factsheet: Vitrified High-Level Radioactive Waste, Revision 1, November 2017. See nwtrb.gov.

[34] U.S. Government Accountability Office, *Hanford Waste Treatment Plant – DOE Needs to Take Action to Resolve Technical and Management Challenges*, GAO-13-38, December 2012.

[35] U.S. Government Accountability Office, *Hanford Cleanup: DOE Should Validate Its Analysis of High-level Waste Treatment Alternatives,* GAO-23-106093, May 2023.

[36] U.S. Government Accountability Office, *Hanford Cleanup: Alternative Approaches Could Save Tens of Billions of Dollars,* GAO-23-106880, September 2023.

[37] Department of Energy, Idaho High-Level Waste & Facilities Disposition Final Environmental Impact Statement, DOE/EIS-0287, September 2002. See annual radiological emissions estimates in Tables 5.2-7 and C.2.9. I

than liquid HLW or powdery, soluble calcine, and more stable than spent nuclear fuel. Ceramic waste forms may be superior to vitrified waste forms, according to *Uncertainty Underground*. [38]

Table 1. Department of Energy high-level waste (HLW) existing and potential vitrified inventory, a rough perspective.

Storage Location	Radioactivity	Existing Vitrified Waste	Project Total Vitrified Waste or potential inventory, Assumed as HLW
West Valley	15 million Ci	245 m^3	245 m^3
Savannah River Site	332 million Ci	3,560 m^3	7,290 m^3
Hanford Site tank waste	134 million Ci	0	14,089 m^3
Hanford Site Cs, Sr (German glass)	8.2 million Ci	2.1 m^3	2.1 m^3
INL calcine (4386 m^3, current dry form)	33 million Ci	0	8,500 m^3 (12,000 HLW containers)

Table notes: Curies: Ci. Cubic meter: m^3. Source for data except for INL calcine is U.S. Nuclear Waste Technical Review Board, Vitrified High-Level Radioactive Waste (fact sheet), Rev. 1, November 2017, radioactivity for year 2017. Calcine inventory from DOE/EIS-0287-FEIS-02-2002, Table C.7-3, decayed to 2016. The INL calcine vit cubic meters of 8,500 m3 is assumed from DOE/EIS-0287-FEIS-01-2002, Table 3-2, early vitrification option. If the INL calcine HLW is separated, there would be far lower cubic meters of HLW but many low-level waste containers that are not HLW. The Hanford German glass may not be HLW but is included here because this special waste form is being held as (dubious) evidence of vitrification technical maturity. The INL calcine volume, without additives for vitrification is 4386 cubic meters according to INEEL/EXT-02-01548.

The drive to reduce the volume of HLW requiring deep geological disposal leads to the desire to separate the HLW into what DOE considers "low activity waste." There is no actual legally defined category for "low activity waste" and the category does not indicate the ingestion hazard, the migration leach-out hazard or long-term repository performance challenges.

While HLW legally is required to be disposed of in a licensed deep geological repository, the Department of Energy has asserted that it can reclassify HLW to low-level waste (LLW). Furthermore, the DOE has loosely named some waste as "low activity waste."

The DOE has stated in past ICP CAB meetings regarding the replacement for the RWMC burial ground at the INL that it does not deem itself required to consider the classes of low-level waste (LLW). **So, DOE has claimed it is not required to determine if the LLW waste**

[38] Allison M. Macfarlane and Rodney C. Ewing, Editors, *Uncertainty Underground - Yucca Mountain and the Nation's High-Level Nuclear Waste*, The MIT Press, 2006. ISBN 0-262-13462-4 See Chapters 21 and 22 and specifically Figure 22.4.

contains greater-than-class C (GTCC) radioactive waste for disposal on DOE sites. In fact, the DOE is disposing of concentrations of waste that are GTCC on the INL site even though DOE could have disposed of the waste at a DOE facility in Nevada.

Reliance on the presumption that Yucca Mountain or some other repository will spring up in a timely manner is also not based on adequate technical basis. Nearly all of the Department of Energy's past NEPA decisions are based on an assumed, but non-existent repository. Environmental Impact Statement alternatives are presented as though based on sound science when that is not necessarily the case. **The DOE's EIS documents are often not a sound basis upon which to make a decision for action.** This continues to cause high costs and continued delays for meaningful cleanup at the Idaho National Laboratory, Hanford and other DOE sites.

Longstanding Department of Energy NEPA Implementation Problems Illuminated by Idaho Cleanup Problems

While preparing this month's newsletter, I am reminded how the Department of Energy's environmental impact statements under the National Environmental Policy Act (NEPA) documents, such as the 2002 DOE/EIS-0287, often do not have an adequate technical basis and do not adequately evaluate the technical immaturity of the various alternatives.

It is interesting to read the public comments from the Department of Energy's 2002 Final Environmental Impact Statement (DOE/EIS-0287) used for selecting hot isostatic pressing instead of vitrification for the high-level waste (HLW) calcine stored at the Idaho National Laboratory, given that the Department of Energy formally issued a Record of Decision selecting HIP in 2009 after years of study but now is investigating vitrification. The DOE selected steam reforming technology for treating the liquid sodium bearing waste at the Integrated Waste Treatment Unit based on DOE/EIS-0287, but has struggled with the technology for over a decade finally beginning radioactive operations last year. The struggles to operate the IWTU can be expected to continue but now at greater worker radiation doses.

There are studies referenced in DOE/EIS-0287 and many comments, that now in hindsight, foretold of the problems that continue to have at the Idaho Cleanup Project at INL.

While even the studies in DOE/EIS-0287 recommended against the problem-plagued steam reforming technology that DOE selected for the IWTU and recommended against hot isostatic pressing for treatment of the calcine, DOE ignored those recommendations.

Although a complex set of alternatives were presented in DOE/EIS-0287, that does not mean that any of the alternatives were very good. The costs, technical immaturity and problematic nature of dealing with nuclear waste, in reality, tend to result in only bad alternatives to deal with the problem. It becomes a choice between bad alternatives and worse alternatives and catastrophe.

When there is no affordable, reliable, sound choice, the Department of Energy tends to spin any alternative it decides on in a positive light, no matter how costly or technically immature or

polluting or unsafe. The positive spin provides cover not just for the Department of Energy, but for the entire nuclear industry. Keeping up appearances of an adequate solution to handle the radioactive waste problem is a very high priority for the Department of Energy and the Nuclear Regulatory Commission.

The Nuclear Regulatory Commission's application of NEPA is not superior to the Department of Energy's. The NRC's "waste confidence" rule that later became the "continued storage of spent nuclear fuel" rule relies on wishful thinking now and undesigned and unproven action in the future, all with complete avoidance of the question of "who pays" to address spent nuclear fuel management and disposal. [39]

The Council of Environmental Quality's (CEQ) revised regulations for the National Environmental Policy Act (NEPA) went into effect during September 2020, and according to the Union of Concerned Scientists, the changes are "making it more difficult to integrate scientific evidence and community input into future decisions." [40] In addition, the changes remove mandates to study cumulative impacts, ignore climate change and reduce the time allowed for public review.

But even prior to changes to NEPA in 2020, the DOE's and NRC's NEPA documents prior to that suffer from NEPA documents that present alternatives that are not based on technically sound science or adequate analyses. In addition to unrealistic analysis of the alternatives, the NEPA documents do not press the Department of Energy to avoid delays in implementing NEPA actions, or to properly manage safety prior to completion of the NEPA actions.

The Department of Energy has often continued relying on inadequate nuclear safety basis studies both in NEPA documents and for continuing operations. When NEPA documents present Department of Energy Orders and Standards as an argument for adequate safety and management, it must be underscored that DOE can modify or waive any of its regulations at whim.

Safety problems remain such as those highlighted by the Defense Nuclear Facilities Safety Board and it's highlighting of the need to improve the DOE's safety bases documents for transuranic waste handling, relevant also to DOE-STD-5506-2021. [41] The DOE's practice of embracing assumptions that are not technically sound in the Department of Energy's nuclear safety analyses of storage and treatment is also something that the DOE is loath to address, usually citing cost concerns as the reason to not address worker and public safety deficits.

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[39] U.S. Nuclear Regulatory Commission, Continued Storage of Spent Nuclear Fuel, webpage, accessed 2/28/2024 at https://www.nrc.gov/waste/spent-fuel-storage/wcd.html The NRC's generic environmental impact statement was published in 2014.

[40] Union of Concerned Scientists, Fifty-Year-Old Science-Based Legislation, NEPA, is Gutted, October 6, 2020. https://www.ucsusa.org/resources/attacks-on-science/fifty-year-old-science-based-legislation-nepa-gutted

[41] Department of Energy Technical Standard, Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities, DOE-STD-5506-2021, 2021. https://www.standards.doe.gov/news/published-doe-std-5506-2021-preparation-of-safety-basis-documents-for-transuranic-tru-waste-facilities

Over twenty years ago Department of Energy nuclear facility safety basis documentation requirements were strengthened in 10 CFR 830, Nuclear Safety Management. [42] But new requirements were not necessarily assessed or implemented. The Los Alamos National Laboratory (LANL) could be the poster child for this problem, but would face stiff competition from the Hanford site and other DOE sites.

NEPA also does not assure timeliness or adequate aging management. For the Department of Energy, aging management and long-term storage of radioactive materials, whether transuranic waste in drums, liquid high-level waste in tanks, or spent nuclear fuel in pools or dry storage, has often been egregiously ignored. The State of Idaho's 1995 Idaho Settlement Agreement imposed milestones on the Department of Energy because the DOE tends to not impose any such incentive for itself. The DOE prefers to save money now by leaving problems to the future.

Even if an adequate NEPA analysis were conducted and a good choice made, compliance with the assumptions and commitments made in NEPA Environmental Impact Statements is not assured. For the Department of Energy, amnesia isn't unusual.

When Department of Energy sites are so contaminated that they are designated as Superfund CERLA sites, cleanup criteria and schedules for cleanup can apply. But the reality is that EPA cleanup standards are rarely met because of the high cost of cleanup. The tabulation of the contamination remaining at "forever" sites has been poorly documented. [43]

Environmental monitoring programs of Department of Energy sites is generally spotty and inadequate. There are a variety of ways that radiological monitoring is conducted in order to coverup the extent of the contamination or deflect identification of the source of the contamination. See EDI report, *Airborne Radiological Releases from the Idaho National Laboratory and the Increasing Radioactive Contamination in Southeast Idaho,* for trends in DOE's reported INL radiological airborne effluent releases, the Department of Energy's estimated effective whole-body dose from the airborne releases, and the levels of radioactive contamination in air, milk, lettuce, wheat and soil from the DOE's environmental surveillance program. [44]

DOE's NEPA documents continue to rely on incomplete and biased radiation protection models. There are a number of problems, but one problem is that DOE's radiation protection

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[42] Code of Federal regulations, 10 CFR 830, Nuclear Safety Management, https://www.energy.gov/ehss/nuclear-and-facility-safety-policy-rules

[43] See the list of "forever contamination" sites at INL Waste Area Group Institutional Controls Report. Dated February 16, 2016: https://cleanup.icp.doe.gov/ics/ic_report.pdf and from the EPA page: https://cleanup.icp.doe.gov/ics/ Don't be surprised if the agencies have changed the links. See also EDI 2016 report by Tami Thatcher, "The 'Forever' Contamination Sites at the Idaho National Laboratory" at http://www.environmental-defense-institute.org/publications/EarthDayINLreport.pdf

[44] Special Report, Environmental Defense Institute, *Airborne Radiological Releases from the Idaho National Laboratory and the Increasing Radioactive Contamination in Southeast Idaho*, December 2021 by Tami Thatcher at http://www.environmental-defense-institute.org/publications/INLcontamination.pdf

models ignore the reality of harm to the unborn from radiological exposures and particularly from radiological airborne emissions that contaminate milk.

This harm is not accounted for in the study of survivors of the two World War II bombings of Japan. Independent studies have found such harm and yet the Department of Energy and the Nuclear Regulatory Commission continue to ignore this harm.

The underpinning for nuclear industry operations, from nuclear reactors to spent nuclear fuel disposal all depend on radiation protection models that allow generous polluting by the release on radionuclides to air and water. Radiation exposure from radioactive waste transportation can also result in unmonitored radiation exposure to the public. So, don't expect the industry to update its radiation protection standards or admit to any problem, because it would cost the industry more money.

Fortieth Anniversary of Three Mile Island Accident and Why It Matters Now

I wrote a series of articles about the 1979 Three Mile Island Accident (TMI) in 2023. See the earlier Parts in the May, June, July, August and September 2023 Environmental Defense Institute newsletters.

In the May and June TMI newsletter articles, I reviewed conditions contributing to the accident and inadequate worker radiation protection during the accident. In the July and August TMI newsletter articles, I reviewed epidemiology studies conducted in populations living near the 1979 accident. In the September article, I review some studies that have found radiation-induced cases of thyroid cancers in the populations living near the 1979 Three Mile Island Accident.

To recap, unbeknownst to the nuclear plant operators, about half of the Three Mile Island Unit II reactor core melted about two hours after a reactor trip occurred due to interruption of normal condensate supply to the steam generators. Airborne radioactive emissions were released from multiple areas of the plant. The accident involved numerous plant design problems, operator training deficits, and multiple failures of the U.S. Nuclear Regulatory Commission to heed reports of safety problems even when identified by an NRC inspector.

It is estimated that about 70 percent of the airborne release occurred within the first 30 hours of core melt. The call for evacuation of pregnant women and children did not occur until two days after the accident began. The release of airborne radionuclides was inadequately monitored and estimates of the radiological release are speculative. Environmental monitoring was conducted but inadequate. Assertions that the radiological releases were low and yielded less than 100 millirem radiation dose to the public from external gamma radiation was based on wishful thinking, if not outright lies. Inhaled beta radiation dose was ignored.

Some of the epidemiology for Three Mile Island found elevated cancer rates (of many types of cancer), yet it was asserted that because estimates of the radiation doses were low, the

elevated number of cancers could not have been caused by the TMI accident. The epidemiologists guessed that the elevated rate of cancers (see Table 2) might have been due to the stress of the accident. **The highly speculative radiation doses resulting from the TMI-2 accident were treated as though based on sound radiological monitoring, which was not the case.**

Table 2. Selected cancer and leukemia case numbers five years before and five years after the March 1979 Three Mile Island nuclear accident.

Grouping	1 - Lowest fallout	2 - Next to lowest fallout	3 - Next to highest fallout	4 - Highest fallout	
Age, 0-24 years	Childhood Cancers				Total cases
1975-1979	17	1.3	8.7	6	31.83
1981-1985	17	13	12	5	47
Age, 0-24 years	Childhood Leukemia				
1975-1979	1	0	0	0	1
1981-1985	1	0	2	1	4
Age, 25 years or above	Adult Leukemia				
1975-1979	7.8	11.2	6	2	27
1975-1979	14.1	16.3	11.6	7	49
Age, 0-24 years	All Cancers				
1975-1979	538.6	525.5	403.8	254.1	1722
1981-1985	845.9	874.8	707.4	401.8	2829.9
Age, 0-24 years	Lung Cancer				
1975-1979	45.1	63.2	50.7	35	194
1981-1985	88.2	137.4	120.5	93.9	440

Table notes: Data based on Maureen C. Hatch, PhD, Jan Beyea, Jeri W. Neives and Mervyn Susser, MB, BCh, American Journal of Epidemiology, "Cancer Rates after the Three Mile Island Nuclear Accident: Radiation Emissions," September 1990. Fractional case numbers are from splitting a case into different study tracts when the correct tract was not known. Cases in 1975 known to be undercounted in hospital records. The "all cancers" data include the lung cancers presented here.

A study published in 2013 found an increased incidence of thyroid cancer in Pennsylvania counties south of TMI. The average incidence rates from 1990 through 2009 were greater than

expected in York, Lancaster, Adams, and Chester Counties, compared to local and national data. The increased thyroid cancer may be due to chronic low level radiation exposure. [45]

In southeast Idaho and elsewhere in the US, the thyroid cancer rates had been rising since 2006, about 3 percent annually. The counties in southeast Idaho also received weapons testing fallout from the Nevada Test Site. I compared the estimated NTS fallout doses for several counties and the 2013 to 2017 thyroid cancer incidence rates for the counties, but the NTS fallout does not correspond to the elevated thyroid cancers in various counties.

In Idaho, in the counties surrounding the Idaho National Laboratory, there is double the incidence of thyroid cancer compared to the State and the U.S. reported for 2013 through 2017.

Counties of Butte, Bonneville, Madison, Jefferson, Bingham and Fremont had thyroid cancer incidence rates that ranged from 42.8 per 100,000 for Butte to 27.9 per 100,000 for Fremont. These cancer rates are double, or more, the US and the Idaho state average rates, with are 15.7 per 100,000 for the US and 14.2 per 100,000 for Idaho. [46] [47]

Fallout from the Nevada Test Site does not appear to be the cause. Bingham County, for example, received less NTS fallout than Bannock or Bonneville County. Bingham county and Bonneville County are closer to the Idaho National Laboratory, and both counties have higher incidence rates for thyroid cancer than Bannock County, which is farther from the INL.

Bonneville County had 30.9 per 100,000, Bingham County has 28.6 per 100,000, Butte has 42.8 per 100,000, but Bannock County has only 11.1 per 100,000, for incidence of thyroid cancer (for 2013 through 2017).

A doubling of the cancer rate is unusual and is significant. The draft Versatile Test Reactor Environmental Impact Statement included the cancer rates for some cancers in selected counties near the Idaho National Laboratory, near the Savannah River Site and near Oak Ridge. These Department of Energy sites have long histories of radiological releases. **No counties near Savannah River or Oak Ridge had a doubling of expected thyroid cancer rates.** But DOE's own draft EIS showed four counties having double the expected rate for thyroid cancer near the INL. If small population counties are included, even more counties have double the thyroid cancer rate. The Department of Energy is silent on the obviously elevated thyroid cancer rate

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[45] Roger J. Levin et al., *The American Laryngological, Rhinological, and Otological Society, Inc.*, "Incidence of thyroid cancer surrounding Three Mile Island nuclear facility: the 30-year follow-up," August 2013. https://pubmed.ncbi.nlm.nih.gov/23371046/

[46] C. J. Johnson, B. M. Morawski, R. K., Rycroft, Cancer Data Registry of Idaho (CDRI), Boise Idaho, Annual Report of the Cancer Data Registry of Idaho, *Cancer in Idaho – 2017*, December 2019. [Cancer incidence is from 2013 to 2017.] https://www.idcancer.org/ContentFiles/AnnualReports/Cancer%20in%20Idaho%202017.pdf

[47] Environmental Defense Institute July 2020 newsletter article "Understanding the Thyroid Doses in Idaho from Past Nuclear Weapons Testing," at http://www.environmental-defense-institute.org/publications/News.20.July.pdf (For thyroid articles, see also April 2020 and FebMar 2020 newsletters.

near the INL, which appear to have been caused by the airborne radiological releases from the Idaho National Laboratory.

The nuclear industry is good at licensing reactors despite serious safety deficiencies, good at covering up the true curie amounts of radionuclides released, and good at denying the cancers and other adverse health effects that are caused by the released radionuclides.

The truth about the nuclear industry matters now more than ever, as the Department of Energy is betting taxpayer money on a strategy that cannot be deployed in time to combat climate change, takes money away from more effective and affordable solutions and creates crushingly high spent fuel management and disposal costs for future generations. The failure to confine the radioactive materials during routine operation, during decommissioning, during accidents and following disposal is harmful to all life on the planet.

Three Mile Island Accident Spotlighted Numerous Industry Deficiencies

In the 1970s there was a growing awareness of the deficiencies of the nuclear reactor coolant system designs. Loss of Coolant Accidents were given considerable attention in the analysis of nuclear reactor safety. The uninterrupted availability of shutdown systems and cooling capacity were needed to ensure that large releases of radioactive gases and particulates did not occur from a light-water reactor. In the event of a loss of cooling event, the fuel cladding fails to maintain fuel rod structure. The thin cladding holds the uranium pellets in a vertical stack. The melting of cladding allows the fuel pellets to collapse in a heap, a configuration that wasn't analyzed. Prior to the 1979 Three Mile Island accident, there was controversy over the effectiveness and reliability of the systems to prevent a Loss of Coolant Accident. [48]

In the 1970s, testing was planned at the Idaho National Laboratory regarding loss of coolant accidents in pressurized water reactors. The first test at INL's loss of fluid testing (LOFT) took place in 1978, to represent a broken coolant pipe. More tests had been planned, but plans adapted following the 1979 accident at Three Mile Island. [49] The LOFT program ended in 1986. [50]

In addition to the role that the Idaho National Laboratory played in evaluation of the loss of coolant accidents before and after the 1979 Three Mile Island Unit 2, the TMI accident created work for many professionals in the nuclear industry throughout the country as well as in Idaho and for well over a decade. Many people in the Idaho Falls area, both at the INL and other businesses, worked in some way associated with the belated efforts to make nuclear power plants safer by addressing the numerous problems identified following the TMI accident.

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[48] Anthony V. Nero. Jr., *A Guidebook to Nuclear Reactors*, University of California Press, 1979. ISBN 0-520-03482-1

[49] Susan M. Stacy, Proving the Principle – A History of the Idaho National Engineering and Environmental Laboratory 1949-1999, DOE/ID-10799, 2000. ISBN 0-16-059185-6. The name of the Department of Energy laboratory changed in 2005 to the Idaho National Laboratory. The book has several uncorrected errors and contains unreliable and biased information particularly regarding the 1961 SL-1 accident.

[50] Department of Energy, Idaho National Engineering Laboratory Historical Dose Assessment, DOE/ID-12119, Volume 2, Appendix A, August 1991. Before the INL was INEEL, it was the INEL. The assessment claims only 8800 curies were released to Idaho skies from the final July 9, 1985 test.

Nuclear accident prevention, accident progression, and post-accident monitoring were among the technical issues that needed far more study to address the far-ranging and multiple unsafe conditions of the TMI nuclear reactor. The TMI Unit 2 reactor was a pressurized water reactor that had been licensed by the U.S. Nuclear Regulatory Commission. The nuclear operators at TMI, several who also had nuclear navy reactor experience, were also licensed by the NRC.

By the 1970s, there had been industry-wide concerns about the adequacy of reactor coolant systems and the understanding of plant response. There had been problems specific to the Babcock and Wilcox design used at TMI. But none of the concerns deterred the NRC from licensing new plants, including TMI-2. In fact, the NRC actually refused to investigate the concerns raised by abnormal events at other B&W nuclear plants similar to TMI-2 and chose instead to berate the NRC inspector who raised concerns. There is a very readable book devoted describing the reactor design and operational problems identified but not addressed prior to the TMI accident, called *The Warning – Accident at Three Mile Island*, by Mike Gray and Ira Rosen. [51]

Despite the complaints of onerous regulation by the NRC, the "mind set" or the predisposition of the NRC has been and remains that nuclear reactors are safe enough and that the costs of safety upgrades are detrimental to the industry. The NRC's belated and tepid response to the 2011 nuclear accident at Fukushima are described in Gregory Jaczko's *Confessions of a Rogue Nuclear Regulator*. [52]

People who pressure the NRC to reduce regulations and grant new plant exemptions to safety requirements and to shrink emergency planning zones and Price Anderson liability coverage generally don't have any comprehension of the hazards posed to the public from nuclear energy.

Many people don't know that the spent nuclear fuel debris resulting from the 1979 accident at the Three Mile Island Unit 2 in Pennsylvania is stored in Idaho. That spent fuel debris, minus the radionuclides that went airborne or flushed to the river, or captured by resin beds during or following the accident, is not sealed like spent fuel canisters are normally sealed, but actually are filtered and open to the environment. Leakage of radionuclides from the TMI spent fuel containers is expected but only estimated. In addition, the radiological monitoring programs are not adequate to detect certain difficult-to-detect low energy beta emissions of iodine-129, for example, or to discern what is released from TMI dry storage or from other INL operations.

The TMI-2 dry fuel debris storage at the INL leaks radionuclides to the Idaho skies. One of the radionuclides that was held up in the debris is iodine-129, with a 16-million-year half-life. The annual estimated airborne release of radionuclides from the Three Mile Island Unit 2

[51] Mike Gray and Ira Rosen, *The Warning Accident at Three Mile Island – A Nuclear Omen for the Age of Terror*, W. W. Norton and Company, 1982. ISBN:978-0-393-32469-3

[52] Gregory B. Jaczko, *Confessions of a Rogue Nuclear Regulator*, Simon & Schuster, 2019. ISBN 978-1-4769-5576-2 Jaczko is a former chairman of the U.S. Nuclear Regulatory Commission.

core debris stored at the Idaho National Laboratory are significant, especially the release of iodine-129. [53]

The airborne releases from many operations at the Idaho National Laboratory vary each year. The estimated releases are reported in annual environmental monitoring reports by the Department of Energy's environmental monitoring contractor and the contractors and names of these reports continue to change.

There is a federal limit on annual airborne radiological emissions from the Department of Energy's Idaho National Laboratory, but in most cases, the radiological effluents are not monitored. The basis for "guesstimates" of the curie amount of the annual radionuclide emissions from the INL are not provided to the public. The environmental monitoring of airborne contamination is prone to unexplained lapses and unexplained reductions in specified accuracy of detection equipment.

Articles by Tami Thatcher for March 2024. Additions made following early posting on 2/27/2024. Additions were made regarding technical immaturity of hot isostatic pressing in contrast to Department of Energy claims in 2009 and the recommendation by the National Academy of Sciences who recommended against the steam reforming technology selected for the Integrated Waste Treatment Unit. An article was added regarding problems in the Department of Energy's implementation of NEPA. Editing for clarity was also made throughout.

Thatcher has a Bachelor of Science degree in Mechanical Engineering and worked as an Advisory Engineer for a Department of Energy contractor, specializing in nuclear facility probabilistic risk assessment and safety analysis. For over a decade, she has studies and written about nuclear energy accidents and risks, Department of Energy nuclear facility accidents and risks, environmental contamination around the Idaho National Laboratory, radiation protection issues for workers and the public, INL legacy cleanup issues, and spent nuclear fuel and high-level waste storage and disposal issues.

[53] G. G. Hall, CHP, Idaho National Laboratory, Annual Radiological Environmental Monitoring Program Report for the Three Mile Island, Unit 2 Independent Spent Fuel Storage Installation, February 2012. ML12066A171. Table 4, based on the 1998 TMI Environmental Impact Statement.