Public Comment Submittal on the U.S. Department of Energy Interpretation of High-Level Radioactive Waste, ID: DOE_FRDOC_0001-3696

Comment submittal by Tami Thatcher, January 9, 2018

Send comments to *HLWnotice@em.doe.gov*.

These comments address the proposal by the U.S. Department of Energy to allow the DOE to reclassify high-level waste (HLW) to non-HLW waste.

The DOE proposes that the DOE be allowed to make the determination that its *"reprocessing waste is non-HLW if the waste:*

I. Does not exceed concentration limits for Class C low-level radioactive waste as set out in section 61.55 of title 10, Code of Federal Regulations or

II. Does not require disposal in a deep geologic repository and meets the performance objectives of a disposal facility as demonstrated through a performance assessment conducted in accordance with applicable regulatory requirements.

Under DOE's interpretation, waste meeting either of these criteria is non-HLW and may be classified and disposed of in accordance with its radiological characteristics."

1. **DOE must explain how much High-Level Waste (HLW) may end up shallowly buried on DOE sites, including Hanford, Savannah River Site and the Idaho National Laboratory, due to its proposed reclassification of HLW**

While the Department of Energy may wish to dispose at least some of its HLW at the Waste Isolation Pilot Plant (WIPP), a deep geologic repository in New Mexico, once DOE reclassifies it's HLW, it will be low-level waste (LLW). If the low-level waste qualifies as defense-related transuranic waste and is accepted by WIPP for disposal it could be disposed of at WIPP. But currently WIPP does not accept spent fuel reprocessing HLW.

Low-level waste exceeding Class C concentrations of radioactivity, also known as Greater-Than-Class C waste, can be as hazardous at HLW as there are no limits on the concentrations of long-lived fission products, activation products and transuranic radionuclides in Greater-Than-Class C "low-level waste."

The DOE historically and currently buries low-level waste on its DOE sites without needing to comply with U.S. Nuclear Regulatory Commission regulations. The DOE can and will bury this reclassified "low-level waste" shallowly on DOE sites, arguing that the risk the human health and the environment is acceptable, based on its decision that the risk is acceptable as indicated by its biased and unrealistic "performance assessments."

The "performance assessments" estimate the rate at which radionuclides will leach out of the waste burial site into groundwater, soil and air. But there is no requirement that the performance assessments be accurate or actually protective of human health and the environment. There is no requirement for the DOE to heed bad news indicated from any risk or performance assessment.

While conducting a performance assessment can be useful for comparing options for radioactive waste disposal, the state-of-the-art performance assessments can't predict waste migration performance over a few decades, let alone over the hundreds of thousands of years that the radioactive waste needs to be isolated.

The DOE's performance assessments tend to include various assumptions that bias the resulting performance of the waste disposal site toward the appearance of low groundwater contamination as the radionuclides are modeled as slowly trickling out from shallow burial sites.

Performance assessments are complex and the complexity and jargon fools many people into having unwarranted confidence in the stated results. The reality is that the rate at which radionuclides leach out into groundwater is going to be variable and groundwater will be unsafe to drink, perhaps for many years on end. The way that performance assessments are conducted allows focusing on average values of groundwater contamination. It's as though having one foot in ice water and one foot is scalding hot water means that on average, but with a "best estimate" analysis, its declared that you're comfortable. But in the context of drinking radioactively contaminated water, it means illness, shortened life spans, and increased birth defects.

The reality of this "risk informed" exercise is analogous to "tobacco science" — a tortured, biased propaganda exercise — not a balanced analysis to understand the realities and uncertainties of the risk to human health and the environment posed by shallow burial of vast amounts of long-lived radionuclides at DOE sites over geologic time frames, over one million years.

The DOE's HLW typically contains Greater-Than-Class C (GTCC) low-level waste, transuranic waste also called TRU, and toxic chemicals for nuclear fuel or irradiation target separations. TRU waste is a subset of Greater-Than-Class C low-level waste based on exceeding curie concentration of certain transuranic alpha-emitters. Both GTCC and TRU waste have long been recognized as needing deep geologic disposal. **The reclassified HLW would become low-level waste, with no limit as to how high the concentrations of long-lived fission products, activation products or transuranic can be. The hazard of the reclassified waste will be unchanged but the DOE will have removed the federal regulations that apply to disposal of HLW. On DOE sites, the DOE can create, interpret (and ignore) its own regulations for disposal.**

The DOE's proposed reclassification of HLW isn't about clearing up ambiguity of what is and is not HLW or correcting "artificial standards." The DOE's proposed reclassification of HLW is about the following:

- Eliminating NRC or other federal requirements pertaining to HLW disposal
- reclassifying **vast amounts of high-level waste**, not just a tiny fraction of waste remaining in tanks
- removing tank closure requirements of the Section 3116 law (which were already too lenient) that has applied to the Idaho National Laboratory (INL) and the Savannah River Site (SRS) but not Hanford

- allowing DOE to leave any and all tank waste behind in the HLW tanks at Hanford, INL and the SRS in order to save money

Terms with no technical definition like "low activity" are often used to imply a low hazard even though the hazard from disposal of this waste to human health and the environment continues over geologic time frames (over a million years) from the long-lived, so-called "low activity" radionuclides. High activity and corresponding higher levels of decay heat and shielding requirements do complicate waste storage, especially for the first few hundred years before the cesium-137 and strontium-90 largely decay away; but the easily shielded alpha and beta emitters of certain fission products and the transuranic radionuclides dominate the hazard of migrating contaminants.

Unlike the radioactive uranium bound up in rock before being mined and milled, in radioactive HLW, the highly concentrated and soluble formed of unfissioned uranium are more readily leached into groundwater, along with various long-lived fission products, activation products and transuranic radionuclides.

The DOE is already mixing the HLW with grout or concrete at the INL and SRS and claiming that it will provide reasonable assurance that the waste is adequately disposed of, when there isn't actually an adequate technical basis for understanding how the grouted mixtures will perform to limit leaching of radionuclides over time. The DOE is relying on technically unjustified assumptions in its performance assessments that artificially create the appearance of slow and low migration of radionuclides into the environment, when in reality, human health and the environment will not be protected.

2. **DOE must explain how this proposal to reclassify HLW may affect its current nuclear waste commitments with states of Washington, S. Carolina, Idaho and current laws in New Mexico for WIPP.**

In the proposal, DOE makes it sound as though their main objective is to classify waste in accordance with the hazard posed from the waste. Implicit is that the public should just trust the DOE to decide whether the hazard is low enough to just shallowly bury the waste on DOE sites. DOE is emphasizing that money will be saved. But the DOE must explain its current legal agreements and commitments to these states and how this proposal may affect these commitments.

3. **DOE must describe to the public its HLW including where the waste is now, the amount of HLW (volume and curie level) and must provide the total curie amounts of each of the long-lived radionuclides that tend to dominate long-term hazard from waste leaching into soil and groundwater**

"Low activity" does not mean low hazard for radioactive waste disposal. The total activity, or curies, of all radionuclides combined can allow a general comparison of the amount of the toxic soup generally. But in order to understand the biological hazard of the waste, you must know the

curie amount **of each radionuclide** in the waste. The toxicity of the particular radionuclide when inhaled or ingested and its solubility and mobility from the disposal site, and its radioactive half-life, are essential for understanding the hazard to human health and the environment.

DOE has long avoided discussing its releases of long-lived radionuclides to the environment, even when they were well aware of it. By focusing on tritium releases, for example, the DOE implied that there were no other significant radiological releases from the INL historically — but it was a sham. But just because DOE avoided admitting the long-lived radionuclides it was releasing and because these alpha-emitters tend to be difficult to monitor, doesn't mean the low curie amounts of uranium, transuranic radionuclides like plutonium and americium, and other long-lived radionuclides were not extremely harmful.

DOE knew that the public wouldn't like the sound of long-lived radionuclides poisoning our air, water, soil and food. The DOE likes to use vague terms that imply that the hazard is low, like "low activity." The DOE wants the public to believe that its vast amounts of long-lived radionuclides in its HLW or "low activity" or "low-level" waste can be shallowly buried with "reasonable assurance" that human health and the environment will be protected for the hundreds of thousands of years, over one million years, that the waste is radiotoxic.

DOE is counting on citizens to accept that the DOE's "performance assessments" will adequately protect the soil, water and air over millennia despite the DOE's long track record of polluting the environment, and harming workers and the public with radioactive releases from weapons testing, reactor testing and routine operations.

Generally, the composition of spent nuclear fuel depends on fuel type and the "burn-up" or how long it was in an operating reactor exposed to neutron bombardment. The composition of the radiological waste depends on spent fuel and any irradiation targets that were dissolved during reprocessing. The waste composition also depends on the specific methods (and chemicals) used for reprocessing. The extraction of plutonium for weapons was the focus at Hanford and Savannah River, while the extraction of uranium-235 was the primary focus of reprocessing at the Idaho National Laboratory.

In a light-water reactor, the spent fuel would consist of about 93.4% uranium (and about 0.8 percent uranium-235 and the rest uranium-238), 5.2% fission products, 1.2% plutonium (about 12 kg of plutonium) and 0.2% other transuranic radionuclides including americium, neptunium and curium (assuming a burnup of 50 GWd/tHM). [1] After the first ten years, and for the first 100 years, the radioactivity is dominated by cesium-137 and strontium-90, which each have about a 30-year half-life. After a few hundred years, the radioactivity is dominated by uranium and transuranics including plutonium, americium, neptunium and curium. The long-lived fission products iodine-129 and technetium-99, although in small curie amounts, are also important to the biological hazard over time because they tend to easily migrate out of the waste disposal site.

[1] Harold Feiveson et al., "Spent Fuel from Nuclear Power Reactors – An Overview of a New Study by the International Panel on Fissile Materials," draft, June 2011. http://fissilematerials.org/library/ipfm-spent-fuel-overview-june-2011.pdf GWd/tHM is the amount of thermal energy in gigwatt-days releases per metric ton of heavy metal (HM) of the fuel.

The DOE's spent fuel and target material differ from that of typical commercial nuclear reactors. The DOE often used highly enriched uranium-235 fuel, over 60% enriched versus about 3 to 5% enriched for commercial light-water reactors. Blanket fuel of depleted uranium (high in U-238) used at Hanford was low enriched and contained fewer fission products, but also include long-lived transuranic waste. DOE's highly enriched fuels had high-burnup and more fissioning of U-235 than lower enriched light-water reactors have. The waste from dissolving irradiation targets used to produce transuranic radionuclides may have been added to DOE's HLW tanks.

A compilation of the DOE's HLW, albeit incomplete and out-of-date, is provided in Table 1. In addition to total curie amount and volume, it is important for DOE to disclose the curie amounts of each radionuclide that tends to dominate the long-term hazard of waste disposal when the waste leaches into soil and groundwater, or air. Incomplete HLW information about Idaho's HLW concerning presence of GTCC and TRU is outlined in Table 2 and needs to be provided by DOE.

The large curie levels of cesium and strontium are important for the first 500 years and the heat they generate complicates the storage of radiologically and chemically hazardous HLW. But the long-lived radionuclides that are "low activity" that are easily shielded but harder to detect and are in what would appear to be low curie amounts actually pose the greatest hazard to soil and groundwater over time. And once these long-lived radionuclides enter our air, water and soil, they are permanent additions to the environment that we live in and our air, water and food and inside our bodies they cause more damage than we are already exposed to from naturally occurring radiation.

Table 1. Department of Energy's high-level waste (HLW) and various obligations cited in 2010 and 2011 reports.

Site	Canisters	Tank Waste (gal.)	Tanks	Agreements (information may not be current)
Hanford, WA	0 existing ~9,700 to 12,100 projected	53 million	177	• "Tri-party Agreement" between DOE, EPA and Washington State • Sets forth dates for vitrification of HLW • Requires retrieval of all single-shell tanks by 2040 and completing treatment of tank waste by 2047 (pending DOE change request) • Removal of HLW from site, date not established
Savannah River Site, SC	~2,900 existing ~6,300 to projected	33.1 million	49	• Construction of Salt Waste Processing Facility at site to treat and separate the tank waste • Federal Facility Agreement, Site Treatment Plan, and Consent Order in place. • Requires all tank waste to be removed from canisters by 2028 • No date set to require the removal of HLW from the site
Idaho National Laboratory, ID	0 existing SBW projected canisters ? ~3,590 to 11,200 projected for calcine 82 to 135 projected canisters for pyro-processing waste from	0.9 million Sodium Bearing Waste managed as HLW	4	• 1995 Idaho Settlement Agreement • Required NEPA Record of Decision for Calcine Treatment and Disposal (January 4, 2010, Amended Record of Decision by DOE to use hot isostatic pressing to treat the calcine for shipping out of Idaho • Requires treatment of Sodium Bearing Waste in the Integrated Waste Treatment Unit. DOE has said the treated SBW will be disposed of at WIPP at TRU or at a geologic repository for HLW. • Requires repackaging facility for Spent Nuclear Fuel • Requires shipping DOE's SNF and HLW, including treated Sodium Bearing Waste out of

Site	Canisters	Tank Waste (gal.)	Tanks	Agreements (information may not be current)
	sodium-bonded fuel			Idaho by 12/31/2035 (except certain Naval fuel). • DOE's HLW from the Materials and Fuels Complex has been recognized to include HLW from pyroprocessing. DOE has said it would use electrometallurgical treatment of its sodium-bonded spent nuclear fuel and would dispose of the resulting metallic and ceramic waste forms at high-level radioactive waste, according to the U.S. Nuclear Waste Technical Review Board, March 2016 and DOE's Record of Decision for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel, 2000.
West Valley Demonstration Project, NY	275	(600,000 was treated)	Tank waste converted into 275 glass logs	• West Valley Demonstration Project Act of 1980 made DOE responsible for solidifying the HLW, disposing of waste created by the solidification, and decommissioning the facilities used in the process. • HLW vitrified logs are stored onsite in canisters on a concrete pad
Total	~3,175 existing ~19,856 to 21,365 projected	90 million gal. tank waste 8,000 to 17,000 MTHM total HLW		

Table notes: MTHM Metric Tons Heavy Metal. HLW High-Level Waste.

Table information sources:

VanNess Feldman Attorneys at Law, "Federal Commitments Regarding Used Fuel and High-Level Wastes," Prepared for: Blue Ribbon Commission on America's Nuclear Future, Revised November 12, 2010.

Blue Ribbon Commission of America's Nuclear Future (BRC), Disposal Subcommittee, draft, June 1, 2011. https://www.nrc.gov/docs/ML1209/ML120970323.pdf Table 2 of this report differs from the VanNess Feldman report in several ways. This draft includes the Idaho National Laboratory's electro chemical

Site	Canisters	Tank Waste (gal.)	Tanks	Agreements (information may not be current)
processing (also called pyroprocessing or electrometallurgical processing) waste but does not include INL's sodium-bearing waste. The number of canisters for the DOE sites also vary. 1995 Idaho Settlement Agreement U.S. Nuclear Waste Technical Review Board March 2016 fact sheet and December 2017 report. West Valley Demonstration Project information at https://www.energy.gov/em/articles/em-s-west-valley-site-halfway-complete-relocating-high-level-waste U.S. DOE presentation to Idaho Cleanup Project Citizens Advisory Board on February, 21, 2018 states that "Sodium Bearing Waste considered high-level waste until reclassification to transuranic waste through the Waste Incidental to Reprocessing mechanism is approved." Department of Energy, "Assessment of Disposal Options for DOE-Managed High-Level Radioactive Waste and Spent Nuclear Fuel," October 2014. https://www.energy.gov/sites/prod/files/2014/10/f18/DOE_Options_Assessment.pdf Robert Alvarez, Senior Scholar, Institute for Policy Studies, "Radioactive Wastes and the Savannah River Site," February 2013. http://www.srswatch.org/uploads/2/6/7/3/26733671/bob_alvarez_on_risks_of_srs_nuclear_waste_february_2013.pdf Sandia National Laboratories. "Evaluation of Options for Permanent Geologic Disposal of Used Nuclear Fuel and High-Level Radioactive Waste Inventory in Support of a Comprehensive National Nuclear Fuel Cycle Strategy," FCRD-UFD-2013-000371. SAND2014-0187P; SAND2014- 0189P. Revision 1. 2014. Anthony Kluk et al., "Management of High Level Waste and Used Nuclear Fuel at DOE Sites – 11478, U.S. Department of Energy, WM2011 Conference, February 27-March 3, 2011, Phoenix, AZ. http://archive.wmsym.org/2011/papers/11478.pdf				

Table 2. Suspected composition of Idaho's high-level waste (HLW).

High-Level Waste	Short-lived radionuclides (Cs-137, Sr-90) exceed Class C?	Long-lived fission products (Tc-99, I-129) exceed Class C?	Long-lived transuranics (Pu, Am, Np, Cm) exceed Class C?	Uranium and its progeny similar in magnitude transuranics that exceed Class C?	RCRA waste?
Idaho's calcine at INTEC	Y	Y	Y	Y	Y
Idaho's liquid sodium-bearing waste (900,000 gallons) at INTEC	Y	Y	Y	Y	Y
Idaho's pyroprocessing waste at MFC	Y ?	Y ?	Y	Y ?	Y ? (sodium)
Radiation target separations (currently classified as LLW)	N	N	Y (current air release and shallow burial at INL)	N	N
Table notes: High-Level Waste (HLW); Low-Level Waste (LLW); Materials and Fuels Complex (MFC); Idaho Nuclear Technology and Engineering Center (INTEC); Idaho National Laboratory (INL).					

The Department of Energy creates its own low-level waste regulations which do not distinguish Classes A, B, C or GTCC waste. However, for the DOE to send waste to an NRC licensed or NRC Agreement state facility, DOE must evaluate low-level waste classes in accordance with the radionuclide concentrations in U.S. Nuclear Regulatory Commission 10 CFR 61.55 Tables. Classes A, B, and C are the lowest concentrations of waste. Concentrations above Class C, known as Greater-Than-Class C, have no limit on curie level for the radionuclides.

Uranium was not conceived of as a waste and is not included in U.S. NRC regulations such as 10 CFR 61.55 concentration limits. However, extensive damage to the environment and to human health has already occurred from uranium mining, milling, concentrating and fuel fabrication from the so-called natural uranium and its progeny. Even more environmental damage is poised to occur from disposal of depleted uranium, waste from FUSRAP and the disposal of HLW, whether or not any regulations cover it and whether or not it is called HLW, LLW, "below regulatory concern," or something else — like "pixy dust."

4. DOE Must Explain the Waste Disposal Options It is Considering and Not Via the Opinions of Others

Some waste disposal options for DOE's HLW (or reclassified non-HLW) are presented in Table 3 for the sake of discussion. Deep geologic disposal in Yucca Mountain has long been the stated destination for HLW disposal. Disposal at the salt deep geologic disposal facility, WIPP, may be desirable, but it has been proposed for basically every one of DOE's problematic waste streams despite commitments made to the state of New Mexico that only defense transuranic waste and not spent nuclear fuel or high-level waste would be disposed of at WIPP. I do not wish to imply that the disposal options presented in the table, especially of shallow burial, are necessarily feasible or appropriate.

Table 3. Problems for possible waste disposal options for INL's HLW.

HLW or Reclassified HLW	**Yucca Mountain**	**WIPP defense-TRU**	**Commercial LLW Disposal, i.e., Clive, Utah Or Andrews, Texas**	**Grouted in tanks at INL**	**Buried at INL RH LLW disposal facility**
Repository/ Disposal Operator and Status	NRC to regulate and DOE to operate. Currently not granted a license to construct by the NRC.	WIPP is DOE-operated under federal and state laws and EPA and State of NM permits.	NRC-licensed/ Agreement State	DOE chooses the regulations and decides on acceptance of the risk to human health and the environment	DOE chooses the regulations and decides on acceptance of the risk to human health and the environment

HLW or Reclassified HLW	Yucca Mountain	WIPP defense-TRU	Commercial LLW Disposal, i.e., Clive, Utah Or Andrews, Texas	Grouted in tanks at INL	Buried at INL RH LLW disposal facility
Calcine	Calcine waste form has problematic effect on repository performance due to its chemistry and solubility.	WIPP currently prohibits HLW and reprocessing waste that has ever been HLW tank waste. RCRA waste	Would exceed Class C Packaging and shipping expenses limit cost savings. RCRA waste	DOE LLW that is highly soluble and exceeds Class C RCRA waste Over the Snake River Plain aquifer. Flood plain. DOE's unrealistic assumptions in PA and assuming forever maintenance of soil caps, etc.	DOE LLW that is highly soluble and exceeds Class C RCRA waste Over the Snake River Plain aquifer. Flood plain. DOE's unrealistic assumptions in PA and assuming forever maintenance of soil caps, etc.
Treated SBW	See calcine.	See calcine.	See calcine.	See calcine.	See calcine.
Sodium-bonded fuel HLW ceramic/metal waste forms	Doesn't exist and DOE hasn't tried to address problems in the waste form or acceptance at Yucca, may be problematic for NRC licensing	Problematic RCRA waste form unless treated. DOE already doing this?	Would exceed Class C. Packaging and shipping expenses limit cost savings.	Permanent (interim) storage in buried metal containers at the Radioactive Scrap and Waste Facility?	DOE already burying over the aquifer? DOE failed to include sodium-bonded SNF in the Yucca Mountain license application. Classifying ceramic and metallic waste products from the electrochemical treatment of sodium-bonded SNF as HWL

HLW or Reclassified HLW	Yucca Mountain	WIPP defense-TRU	Commercial LLW Disposal, i.e., Clive, Utah Or Andrews, Texas	Grouted in tanks at INL	Buried at INL RH LLW disposal facility
					and disposing of these wastes in a geologic repository will require action to ensure that the waste products meet acceptance requirements. (See US NWTRB)

Table notes: High-Level Waste (HLW); Low-Level Waste (LLW); RH (remote handled); Idaho National Laboratory (INL); Resource Conservation and Recovery Act (RCRA); Sodium-Bearing Waste (SBW); Class C from U.S. Nuclear Regulatory Commission 10 CFR 61.55 regulations, Code of Federal Regulations (CFR).
U.S. Nuclear Waste Technical Review Board, Spent Nuclear Fuel and High-Level Radioactive Waste in the United States, Fact Sheet, Rev. 1, November 2017. https://www.nwtrb.gov/docs/default-source/facts-sheets/overview_snf_hlw.pdf?sfvrsn=15

The Radioactive Waste Management Complex and its replacement, the remote-handled low-level waste disposal facility at the Idaho National Laboratory's ATR Complex accepts low-level waste including some Greater-Than-Class C waste, doesn't require NRC licensing, doesn't require state approval and is designed to leach long-lived radionuclides into the Snake River Plain Aquifer.

The Idaho National Laboratory's Radioactive Scrap and Waste Facility (RSWF) at the Materials and Fuels Complex (MFC) is 4-acres of below ground carbon steel storage of spent nuclear fuel and radioactive waste. Sodium-bonded SNF treated separated by pyroprocessing (also known as electrochemical or electrometallurgical treatment) has long been thought to create high-level waste. DOE's shifting stance on the radioactive waste at the RSWF, including what is or has been considered HLW, is difficult to follow.

The low-level radioactive waste facility at Clive, Utah doesn't seem to mind accepting transuranic radionuclides, depleted uranium, beryllium and just about anything – especially if INL doesn't inform them of what's in the drums INL sends there. Clive, Utah doesn't accept Greater-Than-Class C waste, but can DOE use dilution of the waste in order to send it there?

Andrews County, Texas wants the nation's Greater-Than-Class C waste. Since it wants that and the DOE and NRC are eager to find options for radioactive waste disposal, maybe Andrews, Texas will accept the DOE's HLW, if reclassified to GTCC.

5. DOE's Telling Idaho One Thing and Other DOE Sites Another Concerning Idaho's Calcine and Sodium-Bearing HLW Waste

As a required milestone in the Idaho Settlement Agreement, the DOE issued a Record of Decision regarding the treatment of calcine in order to have it road-ready for a repository by 2035. [2] [3] The DOE's 2009 amended Record of Decision says DOE decided to use Hot Isostatic Pressing to package the calcine for transportation and disposal. But at the same time, the DOE was telling community groups outside of Idaho that the calcine is "orphan" waste, the DOE was telling the Idaho Leadership in Nuclear Energy (LINE) chair Brad Little that there wasn't enough money to treat the calcine, and the DOE continued to tell the Idaho Cleanup Project Citizens Advisory Board that everything is on track for treating the calcine as stated in the DOE's 2010 amended Record of Decision for the calcine. [4] [5] [6] [7] [8]

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[2] In order to ship the calcine out of Idaho, it needs a repository to ship to. It needs to be packaged into canisters for shipping and disposal. Calcine retrieval must be performed regardless of the choice of repository or choice of canister packaging method such as Hot Isostatic Press (HIP) (see our June 2017 newsletter). 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. The 2009 decision was actually amending previous decisions. Now it appears that the 2009 decision may be changed again because the Department of Energy recently issued a report by an independent review panel describing the possible treatment options for the calcine.

Both the CAB and DOE-ID both agree in 2017 that calcine retrieval needed to continue uninterrupted. Environmental Defense Institute has previously submitted comments to the Idaho Department of Environmental Quality about the calcine. More background on the calcine can be found in the July 2017 EDI newsletter and in other reports listed.

Sec. Moniz: "At the Idaho National Laboratory, 4,400 cubic meters of calcine high-level waste, which exists as granular and powdered solids, is currently planned for treatment, but may be more safely and efficiently packaged without treatment and disposed in a borehole or in a defense waste repository. The same is true for granular solids resulting from fluidized bed stream reforming of 900,000 gallons of sodium-bearing liquid wastes that will be treated at the Idaho site."

DOE has now suspended its two repository approach and its borehole research.

[3] 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.

[4] 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

[5] See the Idaho National Laboratory Citizens Advisory Board meeting presentations for June 22, 2017, for the Idaho Cleanup Project at www.inlcab.energy.gov

[6] Chuck Broscious and David B. McCoy, "Preliminary Comments on Calcined Solids Storage Facility," Submitted to Idaho Department of Environmental Quality, May 9, 2017. http://www.environmental-defense-institute.org/publications/EDI-CSSF-Permit-S.pdf and pictures at http://www.environmental-defense-institute.org/publications/EDI-CSSF-Attach.pdf

[7] Calcined Solids Storage Comment Submittal (Docket No. 10W-1604), by Chuck Broscious and Tami Thatcher, July 11, 2016. http://www.environmental-defense-institute.org/publications/EDICalcineComments.pdf

[8] 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

The DOE gave the Idaho Cleanup Project Citizens Advisory Board (ICP CAB) a biased and unbalanced document from the Energy Communities Alliance (ECA), an alliance that had excluded Idaho. The document that discussed calcine stored at the INL as being an orphan waste despite DOE not ever informing the ICP CAB that the calcine was considered "orphan" waste. The ECA document blamed DOE's waste problems on "artificial standards." [9] The document contained numerous biased and unsupported assertions and not a single reference to any technical reports for its assertions.

When the Idaho Cleanup Project Citizens Advisory Board was asked to vote to endorse DOE looking into waste reclassification, there was no presentation given, the brief discussion of the matter prior to the unannounced vote did not even mention HLW, calcine or sodium-bearing waste, and the issue was not included on the meeting agenda in any discernable fashion. Then the handouts on the issue were not planned to be provided to the public attending the meeting, but later were provided. The key handout from the DOE to the ICP CAB was the Energy Communities Alliance document that excluded Idaho and contained a very biased set of assertions and contained no one single reference to technical information. This handout was loaded with excuses for the DOE yet contained no information about the hazards of the waste or the problems of its disposal.

The Idaho LINE commission has been working on a factsheet about the calcine for at least two years with no published result so far. But at the LINE commission meeting last May 24, 2018 when it was acknowledged that its latest draft of the calcine factsheet included policy changes desired by the DOE, the commission realized that the factsheet could not be issued with policy changes the state had not actually agreed to. The draft calcine factsheet has never been made available to the public and neither have the LINE meeting minutes (more than six months after the meeting).

As if by simply wishing in order to make it seem TRU, the DOE's Site Treatment Plan for the INL does not refer to Sodium Bearing Waste as HLW because DOE has long hoped to send the steam-reformed solid powder form of Sodium Bearing Waste to WIPP. The DOE has called Sodium Bearing Waste "waste that it manages as HLW." Non-HLW means low-level waste which may be GTCC and may or may not qualify as defense-TRU and may or may not be accepted for disposal at WIPP. The DOE has been inconsistent in various documents about what is and is not HLW at the INL's Radioactive Scrap and Waste Facility at the Materials and Fuels Complex.

How can Idaho citizens, including Idaho Cleanup Project Citizens Advisory Board members, adequately comment when they are deliberately misinformed and uninformed about the actual plans DOE has and what actually is and is not currently HLW?

[9] Energy Communities Alliance, "Waste Disposition: A New Approach to DOE's Waste Management Must Be Pursued," September 2017. https://static1.squarespace.com/static/55c4c892e4b0d1ec35bc5efb/t/59ce7384cd39c3b12b97f988/1506702214356/ECA+Waste+Disposition+Report.pdf

6. **Part I of DOE's proposal to allow HLW reclassification if the waste is Class C waste is Unacceptable because of the vast amount of its HLW and because dilution is not the solution**

Part I of DOE's proposal to allow HLW reclassification ***if the waste is Class C waste*** is unacceptable because of the vast amount of the waste and because dilution is not the solution and should not be used in order to stay within Class C concentrations of radionuclides. The DOE has been crediting dilution of its HLW with grout in order to dilute the waste to meet Class C concentrations in its HLW tank closures at the INL and SRS.

The NRC low-level radioactive waste concentration criteria were not formulated with HLW in mind. The NRC's regulations in 10 CFR 61.55 are missing needed limits for uranium, thorium, certain transuranic radionuclides, chlorine-36 and other inconsistencies or omissions that also make this proposed option not protective of human health and the environment.

The NRC and the DOE have been excluding or inadequately limiting short-lived transuranic radionuclides that decay into long-lived alpha emitting radionuclides. The NRC regulations have ignored the disposal of vast amounts of depleted uranium and other radioisotopes of uranium. The NRC's regulations have omitted the needed regulations for the decay products of uranium/thorium such as radium and radon. The experience with NRC regulations shows there is actually a large human health concern due to the NRC's devotion to promoting cheaper disposal of uranium-related and other radioactive wastes.

7. **Part II of DOE's proposal to allow HLW reclassification to GTCC or TRU is Unacceptable because it will allow DOE to shallowly bury vast amounts of GTCC waste on its DOE sites**

Part II of DOE's proposal to allow HLW reclassification if the waste is Greater-Than-Class C (GTCC) is unacceptable because it will allow the DOE to shallowly bury vast amounts of radioactive waste in an unprotective manner. In many cases, the DOE cannot mix in enough grout to dilute the HLW to levels below Class C concentrations. This is why the DOE is trying remove federal regulations that apply to its HLW. The DOE's technically flawed and biased "Performance Assessments" will be conducted in order to present a result that it decides will be adequately protection of human health and the environment. But the reality will be devastating harm over time as the radionuclides leach out from the disposed waste into groundwater, air and soil and the nuclear industry makes ever more and more long-lived radioactive waste.

The DOE implies that non-HLW isn't very hazardous despite the fact that "low-level" GTCC and TRU waste both have very long-lived radionuclides that experts have long recognized needed to be isolated from the biosphere, in the same manner that HLW needed to be isolated from the biosphere.

8. **Giving DOE sole authority to reclassify HLW means allowing DOE to choose "Alternate Requirements" at whim because of its ambiguous and flexible implementation of DOE Regulations, Orders and Manuals**

The Department of Energy's Radioactive Waste Manual for 435.1-1 for DOE Order 435.1 allows any concentration of the waste to be called "incidental" and non-HLW. [10] The DOE's Order will not limit the shallow disposal of its waste to Class A, B or C wastes. The DOE Order and its waste manual allows that DOE may authorize "alternate requirements" that exceed Class C concentrations. Very importantly, the radionuclides that the DOE may shallowly bury would exceed Class C concentrations for long-lived radionuclides. There would be no upper limit on the total amount or on the concentrations of long-lived radionuclides.

The methods, assumptions, and standards by which the DOE may use to assess the risk using a performance-based approach are ambiguous and flexible in DOE regulations. Experience shows DOE's performance assessments to be driven to select whatever set of assumptions needed to achieve what they think will give the appearance of acceptably low waste migration rates and acceptably low predicted groundwater contamination. Although not always admitted, the currently accepted state-of-the-art for performance assessments do not accurately or conservatively estimate the rate of contaminant migration or the resulting radiation doses, largely from groundwater ingestion at most disposal sites.

Citizens have no reason to trust DOE to make decisions that will provide reasonable assurance of the protection of human health and the environment, both because of its regulatory ambiguity and because of the DOE's long history of creating contamination that cannot be remediated at its DOE sites and also at sites for mining, milling and processing uranium.

Even if the DOE were to improve its Radioactive Waste Manual, the DOE generously applies interpretation of how to meet its Orders, Standards and Manuals and allows removal of any inconvenient requirement via Secretary approval. The DOE's Radioactive Waste Manual and DOE Order 435.1 was blatantly violated in 2018, without DOE Secretary approval, with regard to waste acceptance criteria for allowing waste to be brought into a DOE facility at the Idaho National Laboratory as reported in a causal analysis conducted for four transuranic waste drums that overpressurized, ejecting their contents. It was business as usual for the DOE.

The evidence shows that DOE doesn't comply with its regulations or state regulations. The Department of Energy claims it follows its own regulations and for example, "Activities that affect, or may affect, the safety of DOE nuclear facilities must also comply with the requirements of 10 CFR 830, Nuclear Safety Management."

Anyone familiar with the two accidents at the Waste Isolation Pilot Plant (WIPP) in New Mexico in 2014 knows that DOE was failing in nearly all programs for safety at WIPP, including 10 CFR 830 requirements.

WIPP's original safety basis under 10 CFR 830 had been extensively reviewed, more than any other DOE facility. Reviews by the Environmental Protection Agency and by the Defense Nuclear Facility Safety Board had been conducted. But subsequent changes to the WIPP safety

[10] Department of Energy Radioactive Waste Manual 435.1-1 https://www.directives.doe.gov/directives-documents/400-series/0435.1-DManual-1/@@images/file

basis, approved by DOE had reduced safety significantly. They made the assumption that a roof fall would never occur in an open panel and had no accident analysis for this. WIPP experienced a roof fall within a couple months of not bolting the ceiling in the underground mine. The accident investigation report also discovered that far more plutonium/americium was released from a single drum in the February 12, 2014 event than the safety analysis predicted was possible. [11]

Anyone familiar with the numerous workers exposed to inhalation of plutonium and americium from ZPPR fuel plates for several minutes from the 2011 accident at the Materials and Fuels Complex knows that the DOE was not conducting and implementing adequate nuclear safety analysis or other safety programs to protect workers. In the 2011 ZPPR facility management refused to address\ any of the safety oversight chairman's stated worker safety concerns when performing ZPPR plate inspections and directed workers to examine the plates in unsafe conditions caused multiple workers to inhale radionuclides that were still at detectable levels, based on urine and fecal bioassay, months after the event. [12]

According to The Center for Public Integrity investigation in 2017 titled "Nuclear Negligence" [13] that covered bad behavior around the Department of Energy Complex, INL's MFC managers overseeing the ZPPR facility were warned 19 times by the Safety Oversight Chairman about worker safety issues concerning plutonium plate inspections but no action was taken. And Public Integrity reported that three legal settlements have resulted from the plutonium plate accident.

And anyone familiar with the cause of the four drums that blew their lids off at the INL's Radioactive Waste Management Complex in April 2018 understands that the Department of Energy took egregious shortcuts in each of these accidents, including failure to conduct nuclear safety analysis for a waste stream that they actually knew contained a very reactive form of uranium along with beryllium carbide. The DOE was actively involved with not meeting

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[11] Department of Energy Office of Environmental Management, Accident Investigation Report, "Phase 2 Radiological Releases Event at the Waste Isolation Pilot Plant February 14,2014," April 2015. http://wipp.energy.gov/Special/AIB_WIPP%20Rad_Event%20Report_Phase%20II.pdf See Sections 7.1 and 7.2. The release was found to have been from a single drum with stated inventory in plutonium-239 equivalent curies of 2.84 PE-Ci. But based on contamination on filters at Station A of 0.1 curies PE-ci far from the exploded drum in Panel 7, using conventional safety analysis assumptions the expected amount of material released to Panel 7 would not have exceeded 2.84E-4 PE-Ci — far less than what was measured downstream at Station A. The inventory in the drum appears to have been much higher than stated for WIPP drum and the release fractions may also be incorrect. This discrepancy in the transuranic inventory of the drum is in addition to the fact that forbidden inorganic "kitty litter" absorbent was placed in the drum which allowed an explosive combination of nitrates and organics. In my view, the extent to which the stated transuranic inventory was understated and actually not known does not appear to be adequately addressed by corrective actions recommended in the report. Alpha is difficult to monitor and easily shielded: DOE does not want you to know the degree that they say is in the drums may not conservatively bound what is actually in the drums.

[12] Department of Energy, Office of Health, Safety and Security (HSS), Accident Investigation Report, "Plutonium Contamination in Zero Power Physics Reactor Facility (ZPPR) at the Idaho National Laboratory" accident 11/8/11 at the Materials and Fuels Complex (MFC). http://energy.gov/hss/downloads/investigation-november-8-2011-plutonium-contamination-zero-power-physics-reactor.

[13] Patrick Malone, Peter Cary, *The Center for Public Integrity*, "Nuclear Negligence – Part Five: The inhalation of plutonium by 16 workers is preceded and followed by other contamination incidents but the private contractor in charge suffers only a light penalty," June 28, 2017 https://apps.publicintegrity.org/nuclear-negligence/repeated-warnings/

hazardous waste RCRA requirements required by the State of Idaho and also no conducting required nuclear safety analysis per 10 CFR 830. A causal analysis [14] has been issued for the four transuranic waste drums that blew off their lids last April at the U.S. Department of Energy's Radioactive Waste Management Complex. The causal analysis states that "Management failed to fully understand, characterize, establish and implement adequate process controls for treating waste which lacked documented origin or process information." Specifically, the requirements for meeting 10 CFR 830 were not met.

A 2014 event at the Idaho National Laboratory's FMF facility internally contaminated workers but this was not discovered until weeks had elapsed and workers had been exposed again to elevated airborne contamination during special processing in a leaking glovebox. [15] Battelle Energy Alliance failed to discuss why contamination swipes, hand-held alpha monitoring and step-in portal alpha monitors failed to identify the elevated contamination when the inadequately configured constant air monitor failed to identify the contamination. That curious lack of curiosity about why the elevated levels of airborne contamination was not identified until weeks later when contamination was found on constant air monitor filters and the DOE contractor inexplicably decided that no causal analysis was needed.

9. The DOE's Proposed Reclassification of HLW Is Mainly About Gutting State and Citizen Rights to Question and Legally Challenge DOE's Disposal Decisions

There must be the opportunity for independent scientific bodies to review each of DOE's reclassification decisions and the DOE must provide for review its the technical and scientific rationale for its decisions.

There must be an opportunity for review and concurrence by independent regulatory authorities such as the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Environmental Protection Agency (EPA).

There must be oversight by NRC or EPA in compliance monitoring in all aspects of the analysis and disposal of the waste.

There must be opportunity for judicial review of DOE's decisions.

And very importantly, there must be a state-issued permit allowing or rejecting the HLW reclassification decision, coupled with full public disclosure of DOE's studies and basis for

[14] Idaho Cleanup Project Core, "Formal Cause Analysis for the ARP V (WFM-1617) Drum Event at the RWMC," October 2018. https://fluor-idaho.com/Portals/0/Documents/04_%20Community/8283498_RPT-1659.pdf

[15] Department of Energy Occurrence Report NE-ID-BEA - - FMF – 2014- 0001. "MFC-704 FMF Suspect Contamination Found on CAM Filters," Sept 24, 2014. "On October 9, 2014, it was reported that low levels of transuranic contamination were detected on four separate filters, two each taken from a Continuous Air Monitor (CAM) and a Portable Low Volume Air Sampler operating in the Fuel Manufacturing Facility between August 25 through September 2. Multiple workers were found, weeks later, to have internal contamination as determined by bioassay. Battelle Energy Alliance wrote in the occurrence report that no cause analysis of the undetected elevated levels of airborne contamination was needed.

waste decision and the planned disposal method, with opportunity for public comment prior to the state's decision.

10. DOE's RCRA Waste and Its Efforts to Undermine State RCRA Regulations

DOE must explain any RCRA compliance implications for the proposed HLW waste reclassification. States need firm commitments regarding RCRA authority of any HLW or non-HLW waste and need firm commitments that these laws will not be undermined.

After decades of DOE dumping chemically (and radiologically) hazardous waste at its sites, the 1987 Superfund Amendments and Reauthorization Act (SARA) Amendments to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) applied hazardous substance cleanup liabilities and requirements to DOE and other federal facilities. The 1992 Federal Facilities Compliance Act (FFCA) amended RCRA to subject DOE and other federal facilities to the requirements of RCRA and to state and local hazardous waste regulations, enforcement actions and sanctions.

Nuclear wastes, including HLW, are often both chemically hazardous and radioactive. DOE's RCRA waste requires state permitting under federal and state RCRA laws. But RCRA excludes "source, special nuclear, [and] byproduct materials" from regulation of solid waste. The DOE is the nation's largest generator of mixed waste, waste which contains both chemical and radiological constituents.

The Federal Facilities Compliance Act, while subjecting DOE to state and local waste regulations effectively exempts DOE facilities from RCRA's prohibition of generator storage of hazardous wastes for more than ninety days by waiving liability for federal facility storage of mixed wastes when in accordance with an approved mixed waste management plan. At the Idaho National Laboratory, this is called the Site Treatment Plan and is updated annually. DOE can store, indefinitely, its low-level mixed waste.

Not only that, Under Subpart V of EPA's 40 CFR 266, the mixed waste rule, low-level mixed waste may be exempt from RCRA's transportation and disposal requirements. However, state's that have RCRA authority can require more restrictive practices than 40 CFR 266 would allow. Determining which RCRA laws apply to mixed waste transportation, storage and disposal can be quite difficult and DOE needs to explain the implications of its proposed HLW reclassification.

In 2006, three bills were introduced in Congress for Nuclear Fuel Management and Disposal that would have eliminated state authority under RCRA in regard to disposal of mixed waste. While these laws were not passed, in Idaho, our congressmen and our Governor cannot be counted on to be vigilant to oppose such bills that may weaken environmental protection of Idaho. Behind the scenes, the DOE is constantly at work to change laws to undermine state RCRA authority and any other state or federal oversight.

11. DOE Wants to Treat All HLW As Waste Incidental to Reprocessing AND Ditch the Restrictions of the Section 3116 Law Created for Some Waste Incidental to Reprocessing

When legal objections were raised concerning the DOE's efforts to leave behind thousands of curies of radioactive waste behind in tanks, DOE sought legislative relief. At INL and the SRS, this was provided by Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Public Law 108-375-OCT. 28, 2004, 118 STAT. 1811.
https://www.gpo.gov/fdsys/pkg/PLAW-108publ375/pdf/PLAW-108publ375.pdf

Section 3116 of the National Defense Authorization Act for fiscal year 2005 (2005 NDAA) authorizes the Secretary of Energy, in consultation with NRC, to determine that certain waste from reprocessing is not HLW (at INL and SRS, but not Hanford) if it meets the criteria set forth in that section: that it does not require disposal in a deep geologic repository, has had highly radioactive radionuclides removed to the maximum extent practical, meets concentration limits and/or dose-based performance objectives for near-surface disposal of radioactive waste set out in 10 CFR 61 subpart C and will be disposed of pursuant to a state-issued permit or state-approved closure plan. However, this law only applied to Idaho and South Carolina because of objection the state of Washington and New York congressional leadership to the law. The state of New York is where HLW at the failed West Valley Demonstration Project from commercial fuel reprocessing is stored.

DOE wants to remove the restrictions of the already very permissive Section 3116 2005 NDAA law and be able to reclassify any amount of its HLW, anywhere, to low-level waste. HLW that is reclassified as transuranic waste that isn't accepted at WIPP will be classified as low-level waste that DOE can dispose of onsite in shallow burial that it will argue is reasonably protection of human health and the environment.

Unlike Section 3116 of the 2005 NDAA, DOE's proposal removes the need for state agreement on its waste plans, removes the need to consult with the NRC, removes the NRC from monitoring compliance, removes the need to consider removal of radionuclides from the waste when economically and technically practical, and removes any limit to the total amount and the concentrations of long-lived radionuclides.

Section 3116 in the 2005 NDAA states:

SEC. 3116. DEFENSE SITE ACCELERATION COMPLETION.
(a) IN GENERAL.—Notwithstanding the provisions of the Nuclear Waste Policy Act of 1982, the requirements of section 202 of the Energy Reorganization Act of 1974, and other laws that define classes of radioactive waste, with respect to material stored at a Department of Energy site at which activities are regulated by a covered State pursuant to approved closure plans or permits issued by the State, the term ''high-level radioactive waste'' does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy (in this section referred to as the ''Secretary''), in consultation with the Nuclear Regulatory Commission (in this section referred to as the ''Commission''), determines—

(1) does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste;
(2) has had highly radioactive radionuclides removed to the maximum extent practical; and
(3)(A) does not exceed concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, and will be disposed of—

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; or

(B) exceeds concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, but will be disposed of—

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations;

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; and

(iii) pursuant to plans developed by the Secretary in consultation with the Commission.

(b) MONITORING BY NUCLEAR REGULATORY COMMISSION.—(1) The Commission shall, in coordination with the covered State, monitor disposal actions taken by the Department of Energy pursuant to subparagraphs (A) and (B) of subsection (a)(3) for the purpose of assessing compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations.
(2) If the Commission considers any disposal actions taken by the Department of Energy pursuant to those subparagraphs to be not in compliance with those performance objectives, the Commission shall, as soon as practicable after discovery of the noncompliant conditions, inform the Department of Energy, the covered State, and the following congressional committees:

(A) The Committee on Armed Services, the Committee on Energy and Commerce, and the Committee on Appropriations of the House of Representatives.

(B) The Committee on Armed Services, the Committee on Energy and Natural Resources, the Committee on Environment and Public Works, and the Committee on Appropriations of the Senate.

By eliminating the restrictions in the Section 3116 law, states no longer have any say about the radioactive waste disposal on DOE sites. And what the DOE has doing is using "dilution as the solution" prior to waste classification in order to claim, in some cases, that the HLW left in tanks did not exceed Class C low-level waste.

But even this "concentration averaging" cheat isn't enough for some of the HLW, including some of the tanks at the Savannah River Site where HLW is blended with grout and the diluted mixture's radioactive concentration when compared to 10 CFR 61.55 radioactivity concentrations for Class C, still exceeded Class C concentrations for long-lived transuranics. The

Class C concentration limits on alpha-emitters weren't based on protecting groundwater, it is based on limiting intruder doses at 500 years. How groundwater contamination is to be evaluated, which is the biggest concern, isn't actually spelled out in regulations and performance assessment analyses, which heretofore are wildly inconsistent and technically indefensible over the extremely long time-frames that the waste is a radiological hazard, over a million years.

So, the DOE is disposing of and apparently intends to save money by disposal of vast amounts of extremely long-lived radioactive waste that may be Greater-Than-Class C on the Savannah River Site as well as Hanford and the Idaho site. [16] [17] [18] [19] [20] [21] [22] [23] [24]

This isn't about scrapping a fine layer of radioactive waste off tank walls — this is about the bulk of HLW being diluted, then it's concentration of radioactivity evaluated to "alternate criteria" that allow exceeding Class C concentrations for long-lived radionuclides and then enormous quantities of HLW being shallow buried onsite using Performance Assessments full of inadequately evaluated assumptions and inadequate technical basis.

The approach by the DOE at the Savannah River Site was to ignore the long-lived and highly mobile fission products technetium-99 and iodine-129. But the U.S. Nuclear Regulatory Commission pointed out that this wasn't sound. Later it was determined that these ignored fission products dominate the projected radiation doses. [25]

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[16] B. Jennifer Davis, John S. Contardi, and Lawrence T. Ling, "A Regulatory Analysis of Incidental Waste," January 19, 2001, Available on adams.nrc.gov ML010120200.

[17] Gregory Suber Nuclear Regulatory Commission, NRC Waste Incidental to Reprocessing Program: Overview of Consultation and Monitoring Activities at the Idaho National Laboratory and the Savannah River Site – What We Have Learned – 12470, undated, on NRC Adams database.

[18] Department of Energy, Nuclear Energy, Idaho Field Office, "Basis for Section 3116 Determination for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility," DOE/NE-ID-11226, November 2006. https://www.energy.gov/sites/prod/files/em/FinalINTECTFFWDBasisDocument.pdf

[19] U.S. Nuclear Regulatory Commission Technical Evaluation Report for the U.S. Department of Energy Idaho National Laboratory Site Draft Section 3116 Waste Determination for Idaho Nuclear Technology and Engineering Center Tank Farm Facility," October 2006. ML062490142 at https://www.nrc.gov/docs/ML0624/ML062490142.pdf

[20] DOE-ID, 2003b, Performance Assessment for the Tank Farm Facility at the Idaho National Engineering and Environmental Laboratory, DOE/ID-10966, Rev. 1, April 2003 (Errata December 2, 2003).

[21] C. M. Barnes et al., "Feed Composition for the Sodium-Bearing Waste Treatment Process," INEEL/EXT-2000-01378, Rev. 3, September 2003. https://inldigitallibrary.inl.gov/sites/STI/STI/3156999.pdf#search=INEEL%2FEXT%2D2000%2D01378

[22] U.S. Nuclear Regulatory Commission Review of the Idaho National Engineering and Environmental Laboratory Draft Waste Incidental to Reprocessing Determination for Sodium-Bear Waste. (2002) on Adams database, no author and no date.

[23] "Tank Waste retrieval, processing, and On-site Disposal at Three Department of Energy Sites: Final Report, The National Academies Press, 2006. https://www.nap.edu/read/11618/chapter/14

[24] Victor Stello, Jr., U.S. NRC, "NRC Licensing of the Disposal of High-Level Hanford Defense Wastes," SECY-88-238, August 19, 1988. On NRC's Adams database. This policy letter highlights the disagreement between the Department of Energy and the Nuclear Regulatory Commission over what is and is not high level waste. The NRC has regulatory oversight of long-term storage and disposal of HLW. The DOE denied that reprocessing water at Hanford was HLW.

[25] Dr. Christianne Ridge, U.S. Nuclear Regulatory Commission, "NRC Perspective on Science and Technology for the Department of Energy's Defense Environmental Cleanup Program," December 5, 2017. On NRC's Adams Database.

What the Department of Energy was doing, with the U.S. NRC's approval at the INL and SRS, when using the Section 3116 law, is poised to further poison humans and the environment at those DOE sites and others. The NRC's involvement will be removed if DOE's proposed reclassification of HLW is allowed. The NRC contorted requirements for the DOE's wishes but at least it provided some transparency and questioning of DOE's approach, as well as monitoring of compliance.

12. HLW, Low-Level GTCC and TRU Waste Have All Long Been Recognized as a Hazard of Such a Magnitude That Deep Geologic Disposal Was Deemed Necessary

The DOE wants citizens to think that its low-level waste that exceeds NRC's Class C concentration levels is something they shouldn't worry about. But just because the regulations are complex and convoluted doesn't mean that the so-called "low-level" waste isn't hazardous.

If you understand the long-lived radionuclides in the waste and the hazard posed from HLW. you would then understand why for many decades, experts have sought and Congress has passed laws to support permanent disposal for HLW and to stop DOE from its ocean dumping of HLW. Similarly, regulations and laws have sought to protect the biosphere from the long-lived radionuclides in Greater-Than-Class C (GTCC) low-level waste. And a deep geologic repository was deemed necessary for the extremely large quantities of low activity waste called TRU which is disposed of at WIPP.

The Blue Ribbon Commission Subcommittee tasked with nuclear waste disposal issues concluded that "geologic disposal in a mined repository is the most promising and technically accepted option available for safely isolating high-level nuclear wastes for very long periods of time. This view is supported by decades of expert judgment and by a broad international consensus." [26]

The DOE's defense generated transuranic waste called TRU has alpha emitters in concentrations exceeding 100 nanocuries per gram. This waste has been correctly deemed needing deep geologic disposal.

The "low-level" radioactive waste known as Greater-Than-Class C or Greater-Than-Class C-like waste has long been deemed by the NRC to need deep geologic disposal. Alpha-emitters in GTCC waste can exceed 100 nanocuries per gram.

The vast amount of nuclear weapons-related transuranic waste, known as "defense TRU" is being disposed of at WIPP because of the large quantity of this waste and because of the very long half-life of the radionuclides. The waste could be deemed "low activity" as related to fresh spent nuclear fuel (SNF) or HLW that results from reprocessing of SNF. But it has long been recognized that transuranic waste was inappropriate to shallowly bury or even to store at the

[26] Blue Ribbon Commission of America's Nuclear Future (BRC), Disposal Subcommittee, draft, June 1, 2011. https://www.nrc.gov/docs/ML1209/ML120970323.pdf

Idaho National Laboratory, as the Atomic Energy Commission (AEC), later the Department of Energy had done throughout the 1950s, 1960s and early 1970s.

DOE would have citizens believe that when HLW becomes low-level waste, no matter the quantity, that it doesn't need deep geologic disposal. But low-level Greater-Than-Class C waste and TRU waste have long been recognized to need the kind of isolation from the biosphere provided by deep geologic disposal.

High-level waste is waste from reprocessing spent nuclear fuel and uranium targets for producing plutonium. It contains fission products such as cesium-137 and strontium-90 that cause about half of the radioactivity of recently reprocessed HLW. The waste from uranium targets may have fewer fission products. However, DOE SNF reprocessing and its target material may include more transuranic radionuclides.

Fission products such as iodine-129 and technetium-99 are a small fraction of the activity in the HLW, yet due to their very long half-life and their high mobility, they can dominate the radiological hazard to groundwater by leaching from the disposal site. The radioactive half-life of iodine-129 is 15.7 million years and the half-life of technetium-99 is 213,000 years. What appears to be a small curie level for I-129 and Tc-99 can pose a large hazard to groundwater from leaching radioactive waste.

In addition to fission products that are created in an operating nuclear reactor, transuranic radionuclides are created in a reactor by the successive absorption of neutrons. The transuranic radionuclides, those having more than the 92 protons that uranium has, include various isotopes of plutonium, americium, curium, neptunium, and others. These transuranic radionuclides either have very long a half-life or decay into progeny that have long half-lives. And they must decay through a long series of radionuclides before finally becoming a stable isotope of lead. For example, plutonium-241 decays to americium-241 that has a 430 year half life but it decays to neptunium-237, then to protactinium-233 then to uranium-233 with a 160,000 year half life and so forth. Plutonium-241 is a beta emitter rather than an alpha emitter is so the DOE doesn't count Pu-241 as an alpha emitter when it classifies transuranic waste. The transuranic radionuclides emit not only alpha particles but beta and gamma radiation. The actinides, which are uranium and transuranic radionuclides, pose serious health hazards from exceeding small curie amounts when inhaled or ingested. While DOE argues that the transuranics are easily bound to soil, other experts know that the chemistry of the waste, water and soil can allow leaching of transuranics from the buried waste at higher rates than assumed by the DOE.

Uranium-233 is an entirely man-made fissile material also used to make nuclear weapons. Plutonium-241 decays to Am-241 which decays to Np-237 which decays to U-233. Man-made U-233 has a decay series is similar to that of U-238 and U-235. Radium-225 results from U-233 decay series, while radium-223 results from U-235 decay series, radium-226 results from U-238 decay series, and radium-224 and radium-228 result from thorium-232 decay series. Drinking water monitoring typically only assesses radium-226 and radium-228.

The length of time that some of the radionuclides in the DOE's radioactive waste will be a hazard to human health isn't just 500 years, or 10,000 years. As decay progeny are produced by

radioactive decay, radionuclides like plutonium, americium, curium and neptunium as well as uranium and thorium become more radioactive over time, over hundreds of thousands of years and beyond one million years.

The lowest concentration limits for low-level radioactive waste is Class A. When the concentration of a radionuclide's activity per volume or per gram exceeds the U.S. Nuclear Regulatory Commission's Class C as specified in 10 CFR 61.55, the low-level waste is referred to as Greater-Than-Class C (or GTCC). GTCC waste can be as radioactive or more radioactive than spent nuclear fuel. GTCC waste includes no limit to the concentration of radioactivity in the waste. GTCC waste includes very long-lived radionuclides including I-129, Tc-99, Pu-238, Pu-239, and others.

So, when the DOE wants to say HLW is now "low level waste" or "low activity waste" it is important to understand that this does not mean the waste does not pose a serious long-term hazard to human health and the environment. Levels of alpha-emitters above 100 nanocurie/gram were not expected to be produced by NRC licensees except in spent nuclear fuel and HLW and the NRC's regulations for surface disposal for Classes A, B and C radioactive waste were not created with Greater-Than-Class C levels of transuranic waste.

DOE's HLW, even waste it may refer to as "low activity waste" usually has levels of alpha-emitters above 100 nanocurie/gram. Under DOE's proposal, DOE provides no standards for how DOE will classify or reclassify waste. DOE can reclassify HLW and dispose of it how it chooses on its DOE sites despite the waste exceeding Class C levels of alpha-emitters. DOE provides in its manual for managing radioactive waste that DOE may authorize ***alternative requirements*** for waste classification and characterization.

Under Order 435.1, DOE manages waste incidental to reprocessing as either low-level waste or transuranic waste based on the waste's specific radioisotopic inventory. DOE defines *transuranic waste,* or TRU, as waste that is contaminated with alpha-emitting radionuclides (greater than uranium on the periodic table) with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram. If the TRU is not considered as originating from defense programs to make it eligible to be disposed of at the WIPP facility, then the waste is classified by DOE as ***low-level waste***.

According to the NRC's radioactive waste concentrations for defining classes of low-level waste, the DOE's transuranic waste would exceed Class C concentrations and be Greater-Than-Class C low-level radioactive waste. The NRC's definition for alpha-emitting radionuclides is slightly different and more restrictive than the DOE's. The NRC's definition in 10 CFR 61.55 includes alpha-emitting transuranics with half-lives greater than 5 years. The NRC also has limits for beta-emitting transuranics, plutonium-241 and curium-242, which decay through many decay progenies before a stable non-radioactive isotope results. The NRC's 10 CFR 61.55 applies to NRC licensees or NRC licensed facilities; therefore, the DOE does not use 10 CFR 61.55 unless it plans to dispose of its waste at an NRC-licensed disposal facility.

Whenever the DOE disposes of radioactive waste at the Nevada National Security Site, it means that the waste classification exceeded what was allowed at commercial nuclear disposal facilities such as the one in Clive, Utah.

The DOE has used undefined and imprecise terms such as "low activity" waste to try to diminish the appearance that the waste poses a serious hazard and must be isolated from the biosphere for the length of time that the waste is hazardous if in our air, soil or water.

The length of time that the waste is hazardous is usually thought of as at requiring at least 10 half-lives. But this only applies when the radioactive decay results in a stable isotope. When the radionuclide requires many decay progenies before reaching a stable nuclide, the half-life of each of the progeny must be considered and believe it or not, the DOE often ignores this.

13. The Nuclear Industry Continues to Pretend that the Technology for Confining Long-lived Radioactive Waste for Millenia Exists – It Doesn't

The DOE has been telling the public that the technology for confining radioactive waste is not a problem — but may be true for the short-term in some cases but it is not true for disposal of radioactive waste in the long term. Unfortunately, the DOE does not have the technology to isolate the radioactive waste past a few decades. DOE does not have the technology to isolate the waste for 500 years. And DOE definitely does not have the technology to isolate the waste adequately for over 1 million years. The waste the DOE wishes to dispose of in shallow land burial has long-lived, mobile and radiotoxic radionuclides that the DOE cannot confine over time and cannot ensure the contrived slow steady trickle out predicted by its technically unjustified performance assessment models.

14. DOE Must Describe the Radionuclides That Dominate Its Radioactive Waste Disposal Hazard and Use Technically Defensible and Conservative Kd Values

For light-water reactor (LWR) spent nuclear fuel disposal, a study found that the radiotoxicity of the radionuclides that leach out of buried waste is typically dominated by the actinides, which are the uranium, thorium and transuranic radionuclides. [27] [28] But studies of estimated groundwater contamination from the same repository, Yucca Mountain, have yielded radiation doses ranging from 1 rem/yr to 1000 rem/yr in studies prior to 1995 (dominant contributors have included C-14, Cs-135, Np-237, Tc-99, I-129, Pb-210, U-234, and Ra-226), [29] and doses below 1 rem/yr assuming perfect performance of titanium drip shields (dominated by Tc-99 and I-129). [30]

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[27] Peter Swift, Sandia National Laboratories, ASTM-26 Workshop on Spent Fuel Disposal, Avignon, France, June 18, 2013, "Impact of Waste Characteristics on Disposal Options for Used Nuclear Fuel and High-Level Radioactive Waste," SAND2013-4208C, 2013. https://www.osti.gov/servlets/purl/1080027

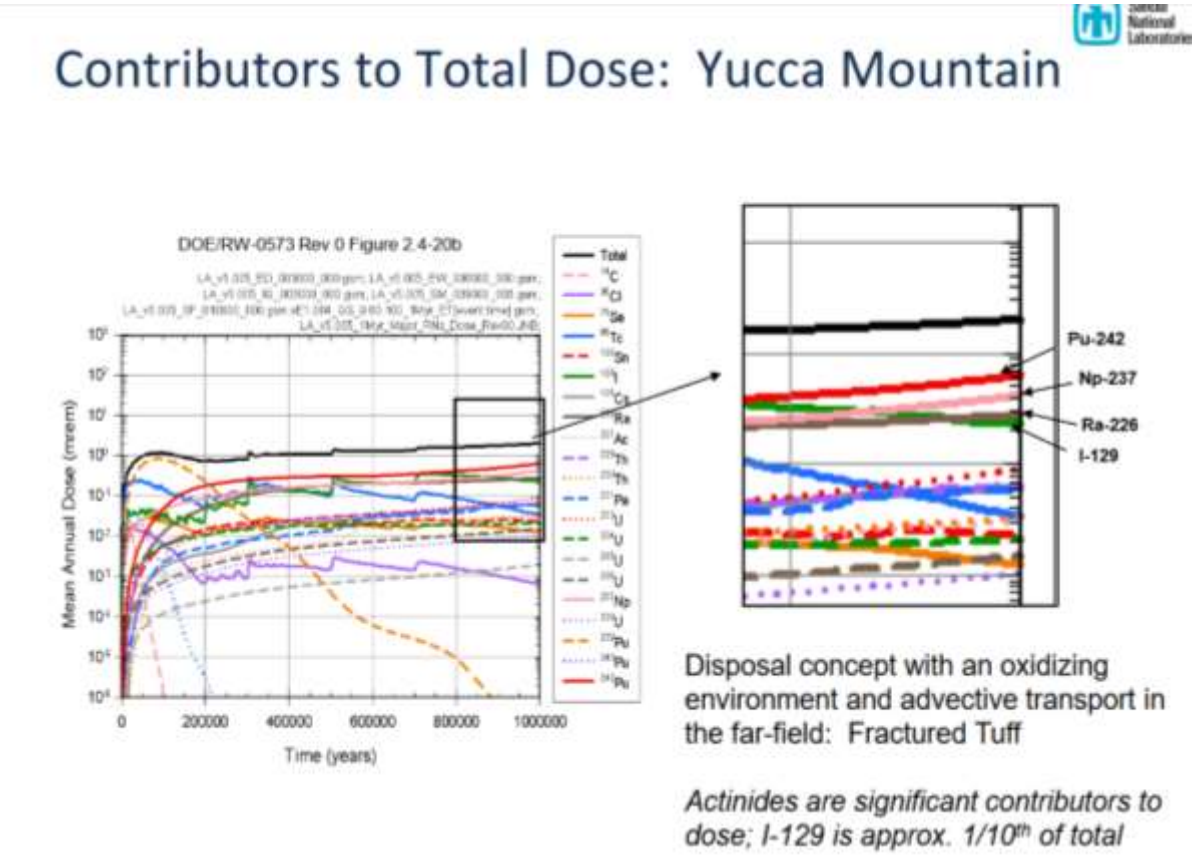
[28] Transuranics are radionuclides often having extremely long half-lives. Many decay progenies may be created before reaching a stable, non-radioactive state. See our factsheet at http://www.environmental-defense-institute.org/publications/decayfact.pdf. See also an ANL factsheet at https://www.remm.nlm.gov/ANL-ContaminationFactSheets-All-070418.pdf

[29] Institute for Energy and Environmental Research, Science for Democratic Action, "Centerfold for Technoweenies," Vol. 4. No. 4, Fall 1995, p. 8-9. https://ieer.org/wp/wp-content/uploads/2012/02/4-4.pdf

[30] U.S. Nuclear Regulatory Commission, "U.S. Department of Energy's 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 – Final Report," NUREG-2184, May 2016.

The radionuclides predicted to contribute to dose are given in this 2008 study of Yucca Mountain (DOE/RW-0573) shown in Figure 1. [31] The doses presented in Figure 1 are low but are average values of a very speculative assessment. Note the time scale of hundreds of thousands of years.

Figure 1. Contributors to Total Dose from 2008 Yucca Mountain study DOE/RW-0573.



https://www.nrc.gov/docs/ML1612/ML16125A032.pdf "The peak estimated annual individual radiological dose over the one-million-year period at any of the evaluated locations is 1.3 mrem [0.013 mSv]. This maximum dose is associated with pumping and irrigation at the Amargosa Farms area, and the estimated radiological dose at other potential surface discharge locations is lower. The NRC staff concludes that the estimated radiological doses are SMALL because they are a small fraction of the background radiation dose of 300 mrem/yr [3.0 mSv/yr] (including radon), and much less than the NRC annual dose standards for a Yucca Mountain repository in 10 CFR Part 63 {15 mrem [0.15 mSv] for the first 10,000 years, and 100 mrem [1 mSv] for one million years, after permanent closure}."

[31] U.S. Department of Energy, "Yucca Mountain Repository License Application," DOE/RW-0573, Rev. 1, 2008. (See slide presentation at https://www.energy.gov/sites/prod/files/2017/11/f46/Peter%20Swift%20PRACoP%202017%20final.pdf

The DOE's HLW composition can differ from that of light-water reactor fuel composition. The percentage of transuranic radionuclides resulting from DOE's fuel reprocessing and weapons production may differ. Likewise, the concentrations of certain fission products may differ. Long-lived fission products as well as transuranic radionuclides are in the HLW that the DOE wants to reclassify as non-HLW, and they are present in concentrations that typically exceed low-level waste Class C concentrations.

Nuclear fuel is typically made of uranium-238 and uranium-235 in varying enrichments of U-235. Commercial LWR fuel enrichment is typically 3 to 6 percent enriched in U-235; but reprocessed Naval fuel was highly enriched, over 90 percent enriched in U-235. Fission occurs when a uranium atom splits apart, creating fission products such as cesium-137. Transuranic radionuclides are created in a nuclear reactor by neutron absorption. Uranium-238 is bombarded with neutrons to produce plutonium-239 by neutron absorption. Fuels with higher uranium-235 enrichment produce more plutonium-238.

Fission products result when U-238 or U-235 split apart upon neutron bombardment in a nuclear reactor. Important fission products, especially for the first few hundred years are cesium-137 and strontium-90. Over the long term, the fission products that dominate radioactive waste disposal hazard are the highly mobile technetium-99 and iodine-129.

Activation products result in a nuclear reactor when metals, air or water become radioactive. Tritium is an activation product that results from the coolant water in the reactor. Carbon-14, nickel-59 and cobalt-60 are important activation products. Carbon-14 is produced through fast neutron reactions with nitrogen-14 and oxygen-17 in the coolant water and reactor components and by activation of oxygen in uranium-oxide. It can also be produced by activation of carbon-13 by thermal neutrons. Carbon-14 is also a fission product from the fuel. The main production of carbon-14 in reactor coolant in boiling water reactors (BWRs) occurs through neutron activation of oxygen-17, while nitrogen is negligible as a source for carbon-14. [32]

Some of the radionuclides that tend to dominate hazard from their leaching out of disposal facilities are presented in Table 4. The radionuclide's half-life and selected decay progeny are noted, as well as whether the radionuclide is a fission product, activation product, or actinide. The radionuclide's half-life and decay progeny half-life need to be understood in order to determine the importance over time. The radiotoxicity is indicated by the maximum contaminant level from federal drinking water standards.

Crucial in estimating waste disposal performance is the selection of Kd, a parameter that indicates the degree of mobility with water through soil, concrete or grout. A low value of Kd, such as 0 or 0.001 indicates high mobility of the radionuclide and therefore, a corresponding high level of contamination in groundwater. A high value of Kd, such as Kd of 90, indicates a very low mobility of the radionuclide. Estimates of possible Kd values can span several orders of magnitude — and this means the groundwater contamination might produce a 1 mrem/yr dose or

[32] Maria Lindgren et al., Swedish Nuclear Fuel and Waste Management Co, SKB, "Correlation factors for C-14, Cl-36, Ni-59, Ni-63, Mo-93, Tc-99, I-129 and Cs-135 In operation waste for SFR 1," ISSN 1402-3091, SKB Rapport R-07-05, January 2007. https://inis.iaea.org/collection/NCLCollectionStore/_Public/39/036/39036608.pdf

10 mrem/yr dose or a 100 mrem/yr dose and so on. But while natural radiation may be 300 mrem/yr, consuming an additional amount of radioactivity such as 100 mrem/yr would mean the difference between life and death. Early illness and death will result from the 100 mrem/yr exposure, despite nuclear industry propaganda to the contrary. And a pregnant mother consuming the 100 mrem/yr water is likely to have an unhealthy child, if the child survives at all.

The value of Kd selected is very important to estimating how contaminated groundwater may get and how far drinking water standards or other standards are exceeded through time. The Kd values are often estimated from artificial test tube conditions that may not reflect actual conditions at the disposal site over time. [33] [34] The analyst who doesn't work to come up with the Kd values favorable to DOE's wishes will likely be out of a job in the same way that geologists who find problems with geologic conditions associated with deep geologic disposal find themselves out of a job.

An NRC study of a study for HLW tank closure at the INL shows the tendency for analysts to select a Kd value from a literature search, and argue that their choice of a mid-range Kd value is reasonable, despite not having an adequate technical basis. [35] Pressure will always be put on selecting Kd values that will lower the predicted migration of contaminants so that disposal performance will artificially look acceptable.

A low Kd means the radionuclide is highly mobile. The Kd for plutonium at DOE sites with a large amount of plutonium is ratcheted up — but while plutonium can sorb to soil and be retained, it is also known that water chemistry conditions can change and the plutonium can de-sorb from soil and migrate with water. The de-sorbing of plutonium is ignored in state-of-the-art Performance Assessments. Assumptions made in order to bias the result toward optimistic performance are rationalized as being reasonable and in keeping with a best-estimate analysis that places the utmost importance on not being overly pessimistic — even if there is inadequate technical basis for the assumptions. The public barely notices the immorality of inflicting harm on future generations from underestimating the release of poison that will affect human health and the environment for geologic time frames.

[33] G.P. Flach and F.G. Smith III, Savannah River National Laboratory, for U.S. Department of Energy, "Degradation of Cementitious Materials Associated With Saltstone Disposal Units," SRNL-STI-2013-00118, Rev 0, March 2013. ML13189A205

[34] J.C. Seaman and F.M. Coutelot, The University of Georgia Savannah River Ecology Laboratory, "Contaminant Leaching from Saltstone," SREL Doc No. R-17-0005, September 29, 2017. This carefully worded report provides some clues as to the problems of determining Tc-99 and I-129 retention in grout based on test tube conditions.

[35] U.S. Nuclear Regulatory Commission Technical Evaluation Report for the U.S. Department of Energy Idaho National Laboratory Site Draft Section 3116 Waste Determination for Idaho Nuclear Technology and Engineering Center Tank Farm Facility, October 2006. https://www.nrc.gov/docs/ML0624/ML062490142.pdf

Table 4. A list of radionuclides that tend to dominate radioactive waste disposal hazard.

Radionuclide	Half-Life (Primary decay mode)	Typical Decay Progeny	Drinking Water Federal Maximum Contaminant Level (MCL)	Waste Leaching Parameter Kd (m^3/kg): (Possible radionuclide origin)
High activity fission products				
Cesium-137	30.2 year (beta)	Barium-137m	160 pCi/L	Kd: screening value 5 Rood for Hanford
Strontium-90	29.1 year (beta)	Yttrium-90	8 pCi/L	Kd: screening 0.1 by Rood Kd: 0.001 to 0.006 in an NRC review of an INL study
Long-lived fission products				
Iodine-129	17 million yr (beta, gamma)		1 pCi/L	Kd: 0.3 to 15 by Rood Kd: 0.002 to 0.03 NRC review Kd: 0 to 3 in INL study for RHLLW
Technetium-99	213,000 year (beta)		900 pCi/L	Kd: screening 78.1 Rood Kd: 0.001 to 5 depending on concrete or grout mixed with it, NRC Kd: 0 to .1 RHLLW
Selenium-79	65,000 year (beta)		? (Se-75 is 900 pCi/L)	Kd: ?
Cesium-135	2.3 million yr (beta)		900 pCi/L	Kd: ?
Activation Products				
Tritium	12.3 year (weak beta)		20,000 pCi/L	Kd: 0.0, firm
Carbon-14	5730 year (beta)		2,000 pCi/L	Kd: 0.25 to 5.0 NRC Kd: 0 to 2.0, RHLLW
Chlorine-36	301,000 year (beta, EC)		700 pCi/L	Kd: 0.0, firm

Radionuclide	Half-Life (Primary decay mode)	Typical Decay Progeny	Drinking Water Federal Maximum Contaminant Level (MCL)	Waste Leaching Parameter Kd (m^3/kg): (Possible radionuclide origin)
Niobium-94	20,000 year (beta)		?	(RHLLW disposal exceeds Class C for Nb-94)
Nickel-59	76,000 year (beta)		300 pCi/L	(RHLLW disposal exceeds Class C for Ni-59)
Nickel-63	96 year (beta)		50 pCi/L	(RHLLW disposal exceeds Class C for Ni-63)
Zirconium-93	1.5 million yr (beta)		2000 pCi/L	?
Actinides (include thorium, protactinium, uranium, neptunium, plutonium, americium, curium, californium and others)				
Thorium-230	77,000 year (alpha)	Radium-226 Many others	15 pCi/L	Kd: 40 to 2000 Rood (Pu-238 and U-238 parent decay progeny)
Protactinium-231	33,000 year (alpha)	Radium-223 Many others	15 pCi/L	Kd: screening 0.1 Rood (Pu-239 and U-235 parent decay progeny)
Uranium-238	4,470 million yr (alpha)	Uranium-234, Thorium-230, Radium-226 Many others	10 pCi/L Total U 30 microgram/L	Kd: 0.6 to 79 Rood Kd: 1.6 to 10 RHLLW (From ore, or enrichment or reprocessing. Primary constituent of depleted uranium.)
Uranium-234	240,000 year (alpha)	Thorium-230 Many others	Total U 30 microgram/L	Kd: (see U-238) (From ore or Pu-238 parent decay. Contributes significantly to activity despite

Radionuclide	Half-Life (Primary decay mode)	Typical Decay Progeny	Drinking Water Federal Maximum Contaminant Level (MCL)	Waste Leaching Parameter Kd (m^3/kg): (Possible radionuclide origin)
				low mass contribution)
Uranium-235 (Fissile material)	700 million yr (alpha)	Pa-231 Ra-223 Many others	Total U 30 microgram/L	Kd: (See U-238) (From ore or Pu-239 parent decay, or enrichment of fuel in fissile U-235)
Uranium-233 (Fissile material)	160,000 year (alpha)	Radium-225 Many others	Total U 30 microgram/L	Kd: (See U-238) (Reactor-made or from Pu-241, Am-241, or Np-237 parent decay)
Uranium-236	23 million yr (alpha)	Thorium-232 Many other	Total U 30 microgram/L	Kd: (See U-238) (Reactor-made or from Pu-244, Pu-240, Curium-244 (Cm-244) parent decay)
Neptunium-237	2,144 million yr (alpha)	Uranium-233 Radium-225 Many others	15 pCi/L	Kd: ? (Reactor-made or from Pu-241 or Am-241 parent decay)
Plutonium-238	88 year (alpha)	Uranium-234 Thorium-230 Radium-226 Many others	15 pCi/L	Kd: screening 0.1 Rood Kd: 22 to 1480 RHLLW (Reactor-made or from Pu-242, Am-242, Np-238 or Cm-242 parent decay)
Plutonium-239 (Fissile material)	24,000 year (alpha)	Uranium-235 Many others	15 pCi/L	Kd: screening 0.1 Rood Kd: 22 to 1480 RHLLW (Reactor-made or from Curium-237,

Radionuclide	Half-Life (Primary decay mode)	Typical Decay Progeny	Drinking Water Federal Maximum Contaminant Level (MCL)	Waste Leaching Parameter Kd (m^3/kg): (Possible radionuclide origin)
				Pu-243, Am-243, Np-239 or Cm-243 parent decay)
Plutonium-240	6,500 year (alpha)	Uranium-236 Many others	15 pCi/L	Kd: (See Pu-239) Reactor-made or from curium-248 or 244 parent decay)
Plutonium-241	14.4 year (beta)	Americium-241 Neptunium-237 Uranium-233 Many others	300 pCi/L	Kd: (See Pu-239) (Reactor-made) Erroneously ignored in classifying transuranics because it is a beta emitter rather than an alpha emitter.
Plutonium-242	380,000 year (alpha)	Uranium-238 Many others	15 pCi/L	Kd: (See Pu-239) (Reactor-made or from Cm-246 decay)
Curium-242	0.45 year (alpha)	Plutonium-238 Uranium-234 Many others	15 pCi/L	Kd: (See Pu-239) (Reactor-made, target irradiation) Short half-life has been erroneously used to ignore its transuranic decay product, Pu-238.
Curium-244	18 year (alpha)	Plutonium-240 Uranium-236 Many others	15 pCi/L	Kd: (See Pu-239) (Reactor-made, target irradiation) Short half-life has been erroneously used to ignore its transuranic decay product, Pu-240.
Americium-241	430 year (alpha)	Neptunium-237 Uranium-233 Many others	15 pCi/L	Kd: (See Pu-239) (Reactor-made or from Pu-241 parent decay)

Radionuclide	Half-Life (Primary decay mode)	Typical Decay Progeny	Drinking Water Federal Maximum Contaminant Level (MCL)	Waste Leaching Parameter Kd (m^3/kg): (Possible radionuclide origin)
Radium-226	1600 year (alpha)	Radon-222 Many others	5 pCi/L for radium-226 and radium-228 combined	Kd: 8 to 173 Rood (From Pu-238, U-238, U-234 parent decay)
Radium-228	5.75 year (beta)	Thorium-228 Radium-224 Many others	5 pCi/L for radium-226 and radium-228 combined	Kd: ? (From Pu-240, U-236, or Th-232 parent decay)

Table notes: Table only highlights the dominant decay mode, selected decay progeny, and selected parent progeny and is not exhaustive. Not all fission products, activation products or actinides have been included in the table. Dominant radionuclides highlighted are from spent nuclear fuel repository studies and from a few DOE low-level waste disposal studies and will differ according to the wastes disposed of and the characteristics that allow migration of radionuclides over time. Picocurie/liter (pCi/L), Kd in milliliter per gram.

The parameter Kd in cubic meters per kilogram strongly influences the prediction of waste migration into groundwater. A wide range of values have been used in various studies for the DOE. Kd values are often not only inconsistent, they are selected without adequate technical basis. Zero (0.0) is the most mobile with water infiltration to groundwater.

Arthur Rood, K-Spar Inc, Scientific Consulting, Submitted to Washington State Health Department, "Final Report Groundwater Concentrations and Drinking Water Doses with Uncertainty for the U.S. Ecology Low-Level Radioactive Waste Disposal Facility, Richland Washington," February 2004. https://www.doh.wa.gov/Portals/1/Documents/Pubs/320-031_appIV_w.pdf

U.S. Nuclear Regulatory Commission Technical Evaluation Report for the U.S. Department of Energy Idaho National Laboratory Site Draft Section 3116 Waste Determination for Idaho Nuclear Technology and Engineering Center Tank Farm Facility, October 2006. https://www.nrc.gov/docs/ML0624/ML062490142.pdf

Idaho National Laboratory, "Evaluation of Groundwater Impacts to Support the Natural Environmental Policy Act Environmental Assessment for the INL Remote-Handled Low-Level Waste Disposal Project," INL/EXT-10-19168, Rev. 3, August 2011. Tables 4 and 9.

Regarding waste classification errors for plutonium-241, curium-242 and curium-244, see IEER.ORG publication, *Science for Democratic Action*, "The Curious Case of Curium-242, Curium-244 and Plutonium-241," Volume 6, Number 1, May 1997.

Understanding the decay series of natural uranium and thorium, as well as for transuranic radionuclides is very important in understanding the hazard. The uranium-238 and uranium-235 decay series are commonly found, but the decay series for plutonium and for man-made uranium-233 are not so commonly found. So frequent are conceptions about these radionuclides that I am including simple tables to show the decay series.

Four decay series are presented in Tables 5 through 8 below:

the uranium-238 decay series known as the uranium series;

the thorium-232 decay series known as the thorium series;

the uranium-235 decay series known as the actinium series, and

the uranium-233 decay series which is man-made and remains officially nameless.

I have included these decay series tables here for three reasons: (1) unless you have a degree in radiochemistry, you need to have the names of the nuclides spelled out along with their short-hand symbol identifier (such as U, Pu, Np), (2) it is difficult to locate decay series that are complete with man-made decay chains feeding in, and (3) it is important to understand the specific decay series that a radionuclide belongs to as you study drinking water, lung count results and environmental radionuclide emissions data.

These decay series show the man-made actinides that may also decay through the same series in grey. The decay series depict alpha decay as progressing downward and reducing the atomic mass by 4. Beta decay by electron emission is depicted as progressing upward diagonally to the right. Beta decay flips a neutron into a proton and stays at the same atomic mass. Isotopes of the same chemical element have the same number of protons but can have variable numbers of neutrons and variable atomic mass. The half-lives of the various radionuclides range from millions or billions of years to milli-seconds.

Along with alpha and beta decays at various energy levels, gamma photon emissions of various energy levels can also occur which can be detected by gamma spectrometry.

So, while uranium, thorium and plutonium are thought of primarily as alpha particle emitters, gamma radiation is also emitted and decay progeny may emit beta particles rather than alpha particles along with gamma radiation at various energy levels measured in kiloelectron volts (keV).

Weak or low energy gamma emissions require less shielding than higher energy gamma emissions. Uranium decay progeny of Th-231, Th-234 and Pa-234, all beta emitters, have high specific activity in curies per gram that require some protection of workers.

Sources of uranium-238 include natural soil and rock sources, mill tailings, depleted uranium, reactor fuel melting from reactor accidents, and spent fuel reprocessing. Sources of uranium-234 decay progeny can include man-made plutonium-238 that is present in various materials and processes at the INL.

Sources of thorium-232 include natural thorium-232 in rock and soil. Sources of thorium-232 can also include man-made plutonium-240 and uranium-236 resulting from neutron capture in a reactor.

Sources of uranium-235 include natural uranium in rock and soil but are typically considered to be of small enough abundance to be ignored. But this decay series should not be ignored where large amounts of depleted, enriched or natural uranium are released to the environment. Sources

Table 5. Uranium-238 decay series.

Californium	Cf-250 *						
Curium	Cm-246 *		Cm-242				
Americium	↓	Am-242 /^	↓				
Plutonium	Pu-242	↓	Pu-238				
Neptunium	↓	Np-238 /^	↓				
Uranium	U-238		U-234				
Protactinium	↓	Pa-234 /^	↓				
Thorium	Th-234 /^		Th-230				
Radium			Ra-226				
Radon			Rn-222				
Polonium			Po-218		Po-214		Po-210
Bismuth			↓	Bi-214 /^	↓	Bi-210 /^	↓
Lead			Pb-214 /^		Pb-210 /^		Pb-206 (stable)

Table notes: Alpha decay downward reduces the atomic mass by 4; beta decay upward diagonally to the right flips a neutron to a proton and stays at the same atomic mass. In the table, arrow symbols downward are used to show the progression of some alpha decays if there was space to show the arrow. Movement upward and to the right is shown by /^ which is a lame keyboard attempt to look like an arrow. Man-made actinides are shown in grey.
* Decay series to Cf-250 and Cm-246 not shown which include Cm-250, Pu-246, Am-236 and Bk-250.
Sources of uranium-238 include natural soil and rock sources, depleted uranium, reactor fuel melting from reactor accidents, and spent fuel reprocessing. Sources of uranium-234 decay progeny can include plutonium-238.

Table 6. Thorium-232 decay series.

Californium	Cm-252		Cf-248				
Curium	Cm-248		Cm-244				
Americium	↓		↓				
Plutonium	Pu-244		Pu-240				
Neptunium	↓	Np-240/^	↓				
Uranium	U-240/^		U-236				
Protactinium			↓				
Thorium			Th-232		Th-228		
Actinium			↓	Ac-228/^	↓		
Radium			Ra-228/^		Ra-224		
Radon					Rn-220		
Polonium					Po-216		Po-212
Bismuth					↓	Bi-212/^	↓
Lead					Pb-212/^	↓	Pb-208 (stable)
Thallium						Tl-208/^	

See table notes for Table 5. Sources of thorium-232 include natural thorium-232 in rock and soil. Plutonium-240 and uranium-236 which results from neutron capture in a reactor also decay to thorium-232. Depleted uranium can include uranium-236. The higher actinides that decay to plutonium-240 are not shown but include californium-252 and -248, curium-248 and -244, plutonium-244, and neptunium-240.

Table 7. Uranium-235 decay series.

Californium	Cf-251						
Berkelium	↓	Bk-247					
Curium	Cm-247	↓	Cm-243				
Americium	↓	Am-243	↓				
Plutonium	Pu-243 /^	↓	Pu-239				
Neptunium		Np-239 /^	↓				
Uranium			U-235				
Protactinium			↓	Pa-231			
Thorium			Th-231 /^	↓	Th-227		
Actinium				Ac-227 /^	↓		
Radium				↓	Ra-223		
Francium				Fr-223 /^	↓		
Radon					Rn-219		
Polonium					Po-215		
Bismuth					↓	Bi-211 /^	
Lead					Pb-211 /^	↓	Pb-207 (stable)
Thallium						Tl-207 /^	

See table notes for Table 5. Sources of uranium-235 include natural uranium in rock and soil. It should not be ignored where enriched uranium is released to the environment. Plutonium-239 also decays to uranium-235 and higher actinides (californium, curium, americium and neptunium) are shown. Dispersion of reactor fuel from reactor accidents and spent fuel reprocessing can spread uranium-235 in the environment.

Table 8. Uranium-233 decay series.

Californium	Cf-241					
Curium	Cm-245					
Americium	↓	Am-241				
Plutonium	Pu-241 /^	↓				
Neptunium		Np-237				
Uranium		↓	U-233			
Protactinium		Pa-233 /^	↓			
Thorium			Th-229			
Actinium			↓	Ac-225		
Radium			Ra-225 /^	↓		
Francium				Fr-221		
Radon				↓		
Astatine				At-217		
Polonium				↓	Po-213	
Bismuth				Bi-213 /^	↓	Bi-209
Lead				↓	Pb-209 /^	↓
Thallium				Tl-209 /^		Tl-205

See table notes for Table 5. Uranium-233 is not naturally occurring. This weapons fissile material can only be produced in a reactor or by the higher actinide decays shown including plutonium-241 and americium-241 decay. Higher actinides (californium, curium, americium and neptunium) are shown. Uranium-233 can and has been used in nuclear weapons testing. Its dispersion can also result from various weapons production and separations processes. Disposal of americium-241 following plutonium purification may be a significant source. It can also result from spent fuel reprocessing particularly of high enriched uranium fuel because of the high buildup of neptunium-237 in HEU reactor operations.

of the U-235 decay series also include plutonium-239 which decays to uranium-235. Dispersion of reactor fuel from reactor accidents and spent fuel reprocessing can spread uranium-235 in the environment. Waste water disposal from HEU spent fuel reprocessing has put uranium-236 in the Snake River Plain Aquifer. Fuel reprocessing and calcining and reactor fuel melt tests or accidents spread various radionuclides present in nuclear fuels to air and soil.

Depleted uranium is uranium that is left over after extraction of uranium-235. Enriched uranium includes more than 0.72 percent up to 93.5 percent U-235 enrichment. Commercial nuclear power reactors typically use 3 to 5 percent enrichment. Enriched uranium also includes increased amounts of uranium-234 which cannot be separated from the uranium-235. Most depleted uranium includes between 0.2 and 0.4 percent uranium-235. Depleted uranium composition can vary and can include uranium-236 if it resulted from reactor fuel reprocessing. The health harm caused by inhalation or ingestion of depleted uranium includes illness and increased risk of birth defects. [36] [37]

Uranium-233 is not naturally occurring. This weapons fissile material can only be produced in a reactor or by the higher actinide decays shown including plutonium-241 and americium-241 decay. Uranium-233 has been dispersed by its production, separation and limited use in nuclear weapons testing. Disposal of americium-241 following plutonium purification may be a significant source. It can also result from spent fuel reprocessing particularly of high enriched uranium fuel because of the high buildup of neptunium-237 in HEU reactor operations.

Higher actinides such as californium, curium, americium and neptunium may be produced using target material in nuclear reactors in order to produce weapons related materials or to produce a heat source for radiothermal generators such as plutonium-238 which is used as a power supply in spacecraft. [38] These materials have been disposed of routinely to an open-air evaporation pond at the INL's ATR Complex. These materials have not necessarily been included in required federal reporting under the National Emissions Standards (NESHAPs) because they are not monitored but only estimated. Therefore, whenever unplanned releases are occurring via escaping resin beads, for example, the emissions would be underestimated. Frankly, the NESHAPs reporting by the INL appears to lack validation and may substantially understate INL's airborne emissions of transuranics and other radionuclides. And these very long-lived radionuclides are continuing to be released and to build up in our air, soil and water.

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[36] Rosalie Bertell, International Journal of Health Services, "Depleted Uranium: All the Questions About DU and Gulf War Syndrome Are Not Yet Answered," 2006. p. 514 https://ntp.niehs.nih.gov/ntp/roc/nominations/2012/publiccomm/bertellattachmentohw.pdf

[37] Depleted Uranium Education Project, *Depleted Uranium Metal of Dishonor How the Pentagon Radiates Soldiers & Civilians with DU Weapons*, 1997. ISBN:0-9656916-0-8

[38] Transuranics are radionuclides often having extremely long half-lives. Many decay progenies may be created before reaching a stable, non-radioactive state. See our factsheet at http://www.environmental-defense-institute.org/publications/decayfact.pdf. See also an ANL factsheet at https://www.remm.nlm.gov/ANL-ContaminationFactSheets-All-070418.pdf

15. The Buildup of Radionuclides in Our Water, Air and Soil is Being Neglected by the DOE — Idaho Already Has Public Drinking Water That Intermittently Doesn't Meet Current Federal Drinking Water Standards.

The DOE along with the Idaho Department of Environmental Quality are pretending they don't know the source of radiological contamination — even when they do know. The public drinking water laws require periodically monitoring for gross alpha levels in drinking water. If the levels of gross alpha are high enough, often even, then the evaluation of uranium and radium levels are required. But often, in Idaho's public drinking water, the intermittently elevated levels of gross alpha are not explained by naturally occurring uranium and thorium. The regulations actually make it impossible to answer what radionuclides are in the water because methods to use gamma spec analysis have not been delineated for public drinking water use. Public water drinking municipals lose profits when laboratory sampling requirements are increased.

The intermittently elevated levels of gross alpha in the southwestern portion of the state have been identified in public drinking water sampling and some studies have been conducted. But from what I see, no analysis has seriously tried to answer what the source of the radioactivity is. I say this because no trending over time of radionuclides has been conducted. No identification of all radionuclides in soil and water has been published. No assessment of the potential sources of the radioactivity have been identified. Basically, the Idaho DEQ actively fails to be curious about and seek the answers. Is it the airborne FUSRAP radionuclides? Is it from historical INL aquifer injection wells and percolation ponds that disposed of large amounts of "low-level" waste?

After contacting the Idaho Department of Environmental Quality to ask why the drinking water on the southwestern side of the state is so radioactive, the Idaho DEQ could not identify anyone at the agency who understood the issue. But the Idaho DEQ did say that there was a report on its website that looked at the issue. It was implied that the report solved the mystery.

The report "Isotopic and Geochemical Investigation into the Source of Elevated Uranium Concentrations in the Treasure Valley Aquifer, Idaho," in 2011 [39] does look at the issue — but does not identify the source of the elevated radioactivity. The report confirms the widespread occurrence of sometimes very high uranium concentrations, up to 100 micrograms/liter. The report does conclude that the source is not from agricultural fertilizer. The report suggests that the source is a near-surface source of contamination.

The mystery is not solved by the report and the report does not conclude that the source of the elevated uranium is natural. The report simply concluded that more work was needed — and there is no evidence that any work has continued since 2011.

[39] Brian Hanson, Dr. Shawn Benner, Dr. Mark Schmitz, Dr. Spencer Wood, Department of Geosciences, Boise State University., "Isotopic and Geochemical Investigation into the Source of Elevated Uranium Concentrations in the Treasure Valley Aquifer, Idaho," Submitted to the Idaho Department of Environmental Quality, April 2011. http://www.deq.idaho.gov/media/563327-uranium_treasure_valley_0411.pdf listed at http://www.deq.idaho.gov/regional-offices-issues/boise/water-quality-plans-reports/

There is another effort afoot to study the issue by Boise State University but so far it has not provided any answers. [40] It states that "The Treasure Valley Aquifer System (TVAS) in western Idaho contains documented uranium and arsenic concentrations, up to 110 microgram/liter and 120 micrograms/liter, respectively…" And "The contaminants historically show elevated concentrations with high spatial variability throughout the region."

See also our Environmental Defense Institute February newsletter article "What's Up With The Radionuclides in Drinking Water Around Boise, Idaho?" [41]

The CERCLA cleanup at the Idaho National Laboratory is leaving behind roughly 55 "forever" radioactively contaminated sites of various sizes, and about 30 "forever" asbestos, mercury or military ordnance sites. [42] [43] The areas contaminated with long-lived radioisotopes that are not being cleaned up will require institutional controls in order to claim that the "remediation" is protective of human health. People must be prevented from coming into contact with subsurface soil or drinking water near some of these sites — forever.

The Department of Energy downplays the mess and usually doesn't specify how long the controls are required when the time frame is over thousands of years: they just say "indefinite." In some cases, the DOE earlier had claimed that these sites would be available for human contact in a hundred or so years. [44] [45] You can find a summary that includes the "forever" sites at https://cleanup.icp.doe.gov/ics/ic_report.pdf

Institutional control of "forever" contamination means they put up a sign, maybe a fence or a soil cap — and assume it will be maintained for millennia. "Don't worry about the cost. And besides," they always add, "you and I won't be here." The DOE acknowledges that the soil cap they plan to put over the RWMC will require maintenance, basically annually, for millennia.

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[40] Gus Womeldorph and Shawn Benner, Boise State University, "A Study of Uranium and Arsenic in the Treasure Valley Aquifer System, Southwestern Idaho, Year 1, 2017-2018," 2018 at https://www.idwr.idaho.gov/files/publications/201807-GWQ-GW-Study-of-Uranium-in-TV-Aquifer-System.pdf

[41] Environmental Defense Institute February 2018 newsletter article by Tami Thatcher "What's Up With The Radionuclides in Drinking Water Around Boise, Idaho?"at http://environmental-defense-institute.org/publications/News.18.Feb.pdf

[42] INL Waste Area Group Institutional Controls Report. Dated March 25, 2016. https://cleanup.icp.doe.gov/ics/ic_report.pdf from the EPA page: https://cleanup.icp.doe.gov/ics/

[43] ibid. INL Waste Area Group Institutional Controls Report. I counted the "forever" radioactive sites as those with termination date for institutional controls stated as "indefinite" or as "not specified." I counted the chemical sites for asbestos, PCPs, mercury or ordnance similarly. The size of the mess actually ranges from some small number of curies to the huge waste inventory at the RWMC.

[44] Department of Energy Idaho Operations Office, *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory Site*, Fiscal Years 2010-2014, DOE/ID-11513, December 2015.

[45] Federal Facility Agreement and Consent Order New Site Identification (NSI), "TRA-04: TRA-712 Warm Waste Retention Basin System (TRA-712 and TRA-612), NSI-26002. Signed by the Department of Energy in August of 2015. See Idaho National Laboratory Federal CERCLA Cleanup documents at www.ar.icp.doe.gov

DOE continues to find more contaminated sites and expectations are not always met by remediation. [46] And the DOE has never stopped burying long-lived radioactive waste over the Snake River Plain aquifer.

Frequently cited stringent EPA standards such as 4 rem/yr in drinking water are emphasized. But cleanup efforts often won't come close to achieving the advertised standards.

16. DOE Continues Shallow Burial of Long-lived and Mobile Radionuclides Over the Aquifer

DOE argued against digging up meaningful amounts of transuranic and other long-lived radioactive waste at the Radioactive Waste Management Complex. Only the most egregious chemically laden waste is being removed. [47] [48] The DOE hasn't decided how much it will bury at the replacement for the RWMC, the Remote Handled Low-Level Waste disposal facility at the Idaho National Laboratory. The RHLLW facility allows disposal of Greater-Than-Class-C long-lived radionuclides that are expected to migrate into the Snake River Plain aquifer. The concentrations of Nickel-59, Nickel-63 and Niobium-94 are expected to exceed Class C and could not be disposed of at a commercial low-level waste disposal facility. The computations to provide the Performance Assessment for the rate at which the radionuclides will migrate into the aquifer are based on unsupported assumptions regarding optimistic selection of properties to slow the estimated rate of migration, assumption of uniform mixing in the aquifer while ignoring the known presence of "fast paths," the presumed lack of flooding, and stable geology for the need million and more years. The DOE hopes to increase the amount of radionuclides buried over the aquifer without so much as even the pretense of a soil cap to slow the migration of radionuclides into the aquifer. The DOE continues to bury radioactive waste over our Snake River Plain aquifer. [49] The DOE has failed to be truthful about past aquifer contamination

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[46] US Department of Energy, "Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site," Final, DOE/EA-1793, December 2011. http://energy.gov/sites/prod/files/EA-1793-FEA-2011.pdf

[47] U.S. Department of Energy, 2008. Composite Analysis for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site. DOE/NE-ID-11244. Idaho National Laboratory, Idaho Falls, ID and U.S. Department of Energy, 2007. Performance Assessment for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site. DOE/NE-ID-11243. Idaho National Laboratory, Idaho Falls, ID. Available at INL's DOE-ID Public Reading room electronic collection. (Newly released because of Environmental Defense Institute's Freedom of Information Act request.) See https://www.inl.gov/about-inl/general-information/doe-public-reading-room/

[48] See the CERCLA administrative record at www.ar.icp.doe.gov (previously at ar.inel.gov) and see also Parsons, Alva M., James M. McCarthy, M. Kay Adler Flitton, Renee Y. Bowser, and Dale A. Cresap, Annual Performance Assessment and Composite Analysis Review for the Active Low-Level Waste Disposal Facility at the RWMC FY 2013, RPT-1267, 2014, Idaho Cleanup Project. And see Prepared for Department of Energy Idaho Operations Office, Phase 1 Interim Remedial Action Report for Operable Unit 7-13/14 Targeted Waste Retrievals, DOE/ID-11396, Revision 3, October 2014 https://ar.inl.gov/images/pdf/201411/20141103009 60BRU.pdf

[49] US Department of Energy, "Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site," Final, DOE/EA-1793, December 2011. http://energy.gov/sites/prod/files/EA-1793-FEA-2011.pdf and see EDI's report "Unwarranted Confidence in DOE's Low-Level Waste Facility Performance Assessment – The INL Replacement

migration to the south of the Idaho National Laboratory, as I describe in *Tritium at 800 pCi/L in the Snake River Plain Aquifer in the Magic Valley at Kimama: Why This Matters*. [50]

The INL appears to being ignoring the transport of radionuclides from buried waste to the surface by upward diffusion through the unsaturated soils. In an Environmental Assessment (EA) for shallow burial of the nation's entire GTCC inventory at the Andrews, Texas WCS facility, [51] that EA found that burial of GTCC waste at the WCS facility, at the Andrews County, Texas waste site would be dominated by upward diffusion of volatile radionuclides. This means the estimates of air emissions may be omitting this contribution for INL air emissions.

17. Greater-Than-Class C Radioactive Waste Is Shallowly Buried of the Snake River Plain Aquifer by the Department of Energy

The DOE uses the excuse that it does not define a category of low-level waste in the way the NRC does — the DOE does not declare it has GTCC waste because it doesn't require that classification but the DOE admits it had "GTCC-like" waste.

According to the Environmental Assessment EA-2082 for disposal of the nation's GTCC waste at Andrews County, Texas, "GTCC-like waste refers to DOE-owned or generated LLW and non-defense transuranic (TRU) waste that is without a disposal path and has characteristics sufficiently similar to those of GTCC LLW such that a common disposal approach has been proposed."

The DOE, however, must determine whether its low-level waste exceeds Class C, and is GTCC, before sending waste to NRC-licensed disposal facilities.

Facility Will Contaminate Our Aquifer for Thousands of Years" at http://www.environmental-defense-institute.org/publications/rhllwFINALwithFigs4.pdf

[50] Thatcher, T.A., Environmental Defense Special Report, *Tritium at 800 pCi/L in the Snake River Plain Aquifer in the Magic Valley at Kimama: Why This Matters*, 2017. www.environmental-defense-institute.org/publications/kimamareport.pdf

[51] U.S. Department of Energy, Environmental Assessment for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste at Waste Control Specialists, Andrews County, Texas, DOE/EA-2082, October 2018. https://www.energy.gov/sites/prod/files/2018/11/f57/final-ea-2082-disposal-of-gtcc-llw-2018-10.pdf The inventory of GTCC and GTCC-like waste is about 12,000 cubic meters (420,000 cubic feet) in volume and contains about 160 million curies of radioactivity. "Since the site is in a semi-arid environment, most of the transport of radionuclides to the environment is expected to be through upward diffusion of volatile radionuclides, including helium-3, carbon-14, argon-39, krypton-85, iodine-129, and radon-222, to the surface rather than via groundwater." "The peak dose is dominated by upward diffusion of technetium-99." "Because of the geologic conditions at the site, as well as the license mitigation measures, releases would not be expected until well after most of the radionuclides had decayed away. Only very long-live [sic] radionuclides would be expected to remain…Transport of radionuclides from the waste to the surface or underlying groundwater would still be limited by diffusion through the unsaturated soils." The EA provides effective dose after loss of institutional control that increases over time, higher at 100,000 years after closure. Because the radionuclides ingested are not delineated, the effective dose which may appear low may in reality cause serious developmental problems or premature death to children.

What the DOE rely prefers to obscure is the fact that "up to 87 percent of the current and projected volume of 8800 cubic meters of GTCC wastes cited in DOE EIS [52] has TRU nuclides greater than 100 nanocuries/gram (nCi/gm)." [53]

Therefore, when the DOE proposes reclassification of HLW to low-level waste, which will often be GTCC low-level waste, and the DOE is only performing this reclassification because it does not have a deep geologic repository, it means that the DOE will be using shallow burial of the HLW at DOE sites.

Deep geologic disposal has long been advocated for the disposal of the nation's GTCC waste, and has been advocated in NRC regulations. The DOE's EIS for disposal of GTCC waste has long advocated disposal at WIPP; however, currently WIPP prohibits disposal of this GTCC waste.

Part of the reason the deep geologic disposal has long been advocated for HLW, GTCC and TRU waste is that it was hoped that geological features would isolate that waste and not require active institutional controls for geologic time frames, for over one million years. But what the Department of Energy has been saying at the Idaho National Laboratory is that they are relying on active institutional controls to perform basically annual maintenance on the soil cap that is placed over buried waste at the Radioactive Waste Management Complex. This type of silliness was sought to be avoided in the advocating for deep geologic disposal. But now we know that obtaining adequate isolation of waste, such as spent nuclear fuel and HLW, has turned out to be far more difficult that people hoped.

The DOE's Environmental Impact Statement of disposal of GTCC has recommended that it be disposed of at WIPP and found that disposal at DOE sites via shallow burial yielded excessive radiological releases. A single alternate to WIPP for disposal of GTCC has also been proposed at Andrews County, Texas, where arid climate and natural clay deposits are thought to limit the migration of contaminants. But there is a strong profit-motive for owners of the Andrews County waste disposal site to show a favorable disposal analysis.

The DOE has disposed of some of its GTCC "low-level" radioactive waste as well as spent fuel irradiation targets by shallow burial at the Idaho National Laboratory's Radioactive Waste Management Complex as well as at other its other DOE sites. The DOE continues to bury GTCC concentrations of INL wastes at the INL's remote-handled low-level waste disposal facility at the ATR Complex, claiming that the migration of contaminates will limit the groundwater contamination.

[52] Department of Energy, Environmental Impact Statement for Greater-Than-Class C Waste.
[53] U.S. Nuclear Regulatory Commission, Policy Issue Notation Vote, "Historical and Current Issues Related to Disposal of Greater-Than-Class C Low-Level Radioactive Waste," SECY-15-0094, July 17, 2015.

18. Health Harm of Radionuclides Including Uranium and Transuranics

While the penetrating power of an alpha particle is low, the energy imparted to tissue when in the body is very high. Many alpha emitters such as plutonium and uranium decay not only by alpha decay but also by beta and gamma emission. Beta particle monitoring is often particularly inaccurate. Gamma ray monitoring is based on badges worn on the collar but the source of radiation may be beneath the workers feet as is the case when workers work over spent nuclear fuel pools. Workers at INL have also had neutron dose from the Materials Test Reactor neutron beam and from concentrated fissile materials. Historical monitoring of neutron dose was inadequate.

The public as well as radiation workers need to keep in mind that, despite what they may have been taught:

- The cancer risk is not reduced when radiation doses are received in small increments, as the nuclear industry has long assumed. [54]
- Despite the repeated refrain that the harm from doses below 10 rem cannot be discerned, multiple and diverse studies from human epidemiology continue to find elevated cancer risks below 10 rem and from low-dose-rate exposure. [55]
- The adverse health effects of ionizing radiation are not limited to the increased risk of cancer and leukemia. Ionizing radiation is also a contributor to a wide range of chronic illnesses including heart disease and brain or neurological diseases.

The public and radiation workers take cues from their management that they should not be concerned about the tiny and easily shielded beta and alpha particles. DOE-funded fact sheets often spend more verbiage discussing natural sources of radiation than admitting the vast amounts of radioactive waste created by the DOE. The tone and the meta-message from the DOE, the nuclear industry, is that if you are educated about the risks, then you'll understand that the risks are low. Yet, these agencies continue to deny the continuing accumulation of compelling and diverse human epidemiological evidence that the harm of ingesting radionuclides is greater than they've been claiming.

The biological harm that ionizing radiation may cause to DNA is mentioned sometimes but it is emphasized that usually the DNA simply are repaired by the body. And the training to radiation workers will mention that fruit flies exposed to radiation passed genetic mutations to their

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[54] Richardson, David B., et al., "Risk of cancer from occupational exposure to ionizing radiation: retrospective cohort study of workers in France, the United Kingdom, and the United States (INWORKS), BMJ, v. 351 (October 15, 2015), at http://www.bmj.com/content/351/bmj.h5359 Richardson et al 2015 This cohort study included 308,297 workers in the nuclear industry.

[55] US EPA 2015 http://www.regulations.gov/#!documentDetail;D=NRC-2015-0057-0436 . For important low-dose radiation epidemiology see also John W. Gofman M.D., Ph.D. book and online summary of low dose human epidemiology in "Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis," Committee for Nuclear Responsibility, Inc., 1990, http://www.ratical.org/radiation/CNR/RIC/chp21.txt And see EDI's April 2016 newsletter for Ian Goddard's summary and listing of important human epidemiology concerning low dose radiation exposure.

offspring but workers are told that this phenomenon has never been seen in humans even though, sadly, the human evidence of genetic effects has continued to accumulate. Birth defects and children more susceptible to cancer are the result.

Gulf War veterans who inhaled depleted uranium have children with birth defects at much higher than normal rate. The same kinds of birth defects also became prevalent in the countries were citizens were exposed to DU. There are accounts to suggest that the actual number of birth defects resulting from the World War II atomic bombs dropped on Japan and by weapons testing over the Marshall Islands have been underreported. The Department of Energy early on made the decision not to track birth defects resulting from its workers or exposed populations. But people living near Hanford and near Oak Ridge know of increased birth defects in those communities.

In radworker training, there may be discussion of the fact that international radiation worker protection recommends only 2 rem per year, not 5 rem per year. There is no mention of recent human epidemiology showing the harm of radiation is higher than previously thought and at low doses, below 400 mrem annually to adult workers, increased cancer risk occurs.

There is no mention of the oxidative stress caused as ionizing radiation strips electrons off atoms or molecules in the body at energies far exceeding normal biological energy levels. And there is no discussion explaining the harm of inhaling or ingesting radioactive particles of fission products such as cesium-137, strontium-90, or iodine-131; of activation products such as cobalt-60; or transuranics such as plutonium and americium; or of the uranium itself.

The volatile or gaseous radionuclides, some of which can't be contained even with air filters — include technetium-99, tritium, carbon-14, iodine-129, argon-39, krypton-85, and radon-222 as the volatile radionuclides dominating the proposed Greater-Than-Class C radioactive waste disposal for the Andrews County, Texas facility. Often radionuclides with low curie levels dominate the disposal harm. **So, when DOE states an overall curie level without stating which radionuclides and their specific curie levels, neither the radiotoxicity nor the longevity of the radioactive waste has been indicated.**

Uranium and thorium and their decay products may be natural but in concentrated form in drinking water, soil or air, they are harmful. Radioactive waste disposal classification has often left out concentration limits for these radionuclides. Massive amounts of depleted uranium are considered Class A radioactive waste but won't be safe at the end of 100 years but will actually be more radioactive through decay progeny.

Plutonium-238, plutonium-239, and other transuranic radionuclides in radioactive waste in what appear to be low curie amounts can pose health harm and often dominant radionuclide ingestion doses from migration of the waste to groundwater. GTCC waste includes large amounts of transuranic waste. Only defense-generated transuranic waste approved for acceptance at WIPP can be shipped to WIPP for disposal.

Cancer rates for uranium are typically based on natural forms for uranium and not chemically altered forms that may be more soluble in the human body. The internal radiation cancer harm is not based on solid epidemiological evidence and there are experts from Karl Z. Morgan to Chris Busby to Jack Valentine that understand that the accepted models may understate the cancer

harm by a factor of 10, 100 or more. The nuclear industry continues to ignore the epidemiological evidence that implies tighter restrictions are needed. As you see the cancer mortality risk per picocurie in Table 9, you have to wonder why the disposal of uranium was unregulated and later inadequately regulated for many decades.

Table 9. Survey of selected radionuclide inhalation and ingestion lifetime cancer mortality risk.

Radionuclide	Lifetime Cancer Mortality Risk per pCi Inhalation	Lifetime Cancer Mortality Risk per pCi Ingestion	Notes
Cesium-137	8.1E-12	2.5E-11	Strong gamma emission used in aerial surveys. Mimics potassium in the body. Studies of the Chernobyl accident indicate that it is associated with increased risk of blood disorders, cardiac arrhythmias, autoimmune diseases, neuromuscular diseases, reproductive problems and cancer.
Stronium-90	1.0E-10	7.5E-11	Mimics calcium in the body and is a tooth and bone seeker.
Iodine-129	6.2E-12	3.3E-11	Long-lived and mobile fission product found to dominate long-term harm when inhaled or ingested. Collects in thyroid
Technetium-99	1.3E-11	2.3E-12	Long-lived and mobile fission product found to dominate long-term harm when inhaled or ingested. Tc-99 collects in thyroid
Americium-241	2.4E-8	9.5E-11	Bone seeker, see plutonium-239. Don't be misled by the 432 year half-life because it has many longer lived decay progeny.
Curium-242	1.4E-8	3.2E-11	See plutonium-239
Curium-242	2.3E-8	7.5E-11	See plutonium-239
Neptunium-237	1.5E-8	5.8E-11	See plutonium-239
Plutonium-238	3.0E-8	1.3E-10	See plutonium-239
Plutonium-239	2.9E-8	1.3E-10	ANL fact sheet says laboratory studies with experimental animals exposed to high levels of plutonium can cause

Radionuclide	Lifetime Cancer Mortality Risk per pCi Inhalation	Lifetime Cancer Mortality Risk per pCi Ingestion	Notes
			decreased life spans, diseases of the respiratory tract, and cancer. Once in the blood stream, plutonium is highly retained in the body, especially in bone and the liver. Plutonium is associated with cardiovascular disease, leukemia, lung cancer, breast cancer, childhood cancers, infant mortality and transgenerational mutations. Uranium, plutonium, americium decay progeny ultimately result in an isotope of lead.
Uranium-234	1.1E-8	6.1E-11	See uranium-238. Uranium-234 is a decay product of uranium-238 and has a much higher specific activity, in curie per gram, than either U-235 or U-238.
Uranium-235	9.5E-9	6.2E-11	See uranium-238
Uranium-236	9.9E-9	5.8E-11	See uranium-238
Uranium-238	8.8E-9	7.5-E-11	Bone, kidney. ANL Fact Sheet states: "reproductive effects in laboratory animals and developmental effects in young animals…" Uranium is associated with cancer, miscarriage, still births, childhood cancers, birth defects, infertility, brain disorders, kidney disease and trans-generational mutations. Spent nuclear fuel is usually over 90 percent unfissioned uranium. Uranium is released in reactor accidents and nuclear weapons testing, yet is rarely mentioned or monitored.
Radium-226	2.4E-8	2.9E-9	Radium-226 is a decay product of uranium-238 or plutonium-238 or uranium-234 or thorium-230.

Radionuclide	Lifetime Cancer Mortality Risk per pCi Inhalation	Lifetime Cancer Mortality Risk per pCi Ingestion	Notes
			Mimics calcium in the body and is stored in bone and teeth

Table source of information: Argonne National Laboratory, EVS, Human Health Fact Sheet, August 2005 at https://www.remm.nlm.gov/ANL-ContaminationFactSheets-All-070418.pdf Source used by ANL was Federal Guidance Report 13, U.S. Environmental Protection Agency, 402-R-99-001, September 1999.

Picocurie is 1.0E-12 curies. Lifetime cancer mortality risk ignores cancers that were caused but not the cause of death, ignores non-cancer illnesses such as increased risk of heart disease, and ignores genetic effects.

Alpha emitters (from most uranium, plutonium and curium radionuclides) are more able to cause double-strand DNA breaks that are misrepaired.

19. Disposal of Uranium in HLW Not Adequately Protected by NRC Regulations

Particularly for DOE's proposal to allow reclassification of HLW to Class C waste, the disposal of uranium at DOE sites is likely to not be protective of human health and the environment. The DOE's uranium wastes are not like natural uranium bound up in rock. The DOE's uranium wastes would have chemical form, concentrations and total quantities that make the waste a serious hazard for allowing the DOE discretion in its disposal of uranium in its reclassified HLW waste.

20. NRC and DOE Failure to Protect Human Health and the Environment Illustrated by FUSRAP Disposal

A program called the "Formerly Utilized Sites Remedial Action Program" (FUSRAP) and others have been dumping radioactive waste in Idaho for the financial benefit of a few owners. The Idaho legislature and Idaho Department of Environmental Quality have greased the laws and environmental protections to allow this to happen. The radiation active waste dumping is called the "storage" of "non-hazardous" waste. [56] [57] The US Ecology Site B Grandview site has made millions of dollars for the sites owners and has rewarded Idaho's politicians.

According to a 2010 article by The Idaho Statesman, "The waste from these sites contains radioactive contamination above current federal guidelines but is not regulated by the Nuclear Regulatory Commission or the Atomic Energy Act. The Idaho Department of Environmental Quality, which through passage of this legislation now regulates such material, classifies it as non-hazardous."

"In 2001, with passage of this legislation allowing radioactive FUSRAP waste to be stored in Idaho (including contracts in existence on July 1), American Ecology was awarded $4.4 million in federal contracts."

[56] FUSRAP "Formerly Utilized Sites Remedial Action Program" by the U.S. Army Corps of Engineers at http://www.mvs.usace.army.mil/Missions/FUSRAP/What-is-FUSRAP/

[57] *Mountain Goat Report*, from *The Idaho Statesman*, "It's More Than Contaminated Sand," July 28, 2010. http://mountaingoatreport.typepad.com/the_mountaingoat_report/environment/

"The dollar amount of the contracts grew in 2002 by over 200 percent to $13.8 million, with American Ecology having been awarded an average of $16.6 million in federal contracts per year from 2002 through 2007. The majority of these are radioactive FUSRAP waste storage contracts for the company's Grandview facility."

The radioactively contaminated soils are trucked to Idaho and then dumped. Is the air blown radioactive material partially at least an explanation for the gyrating levels of public drinking water contamination in the Boise area? [58] [59] [60]

Disposal of FUSRAP uranium byproduct waste has been trucked to Idaho for disposal at the western Idaho U.S. Ecology site in Owyhee County, near Grand View.[61] Depleted uranium from Kuwait, 6700 tons of radioactively contaminated sand, have been shipped to Idaho's US Ecology Grandview facility that opened in 2001. [62] The US Ecology Site A RCRA dump at Bruneau closed in 2001, formerly owned by Envirosafe. [63] It accepted unlicensed radioactive waste from FUSRAP programs. [64]

In June 2018, the Agency for Toxic Substances and Disease Registry (ATSDR), the federal public health agency of the U.S. Department of Health and Human Services, published a report evaluating the exposures to people living near Coldwater Creek where uranium processing wastes were improperly stored and disposed of in St. Louis, Missouri. [65] The radioactive contamination included uranium-238 and higher amounts of thorium-230 and its daughter product radium-226 than from unprocessed uranium ore because of the uranium extraction processing.

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[58] Idaho Department of Environmental Quality, http://www.deq.idaho.gov/water-quality/drinking-water/pws-monitoring-reporting/ and http://www.deq.idaho.gov/water-quality/drinking-water/pws-switchboard/ and find sample results for all counties at http://dww.deq.idaho.gov/IDPDWW/ where you select your county or drinking water system, select the specific water system. For the specific water system, it may be helpful to select the link at the left called "Chem/Rad Sample/Result by Analyte." Then select the analyte of interest that the well has data for by clicking on its code. This brings up the applicable lab samples that included that contaminant. Note that non-community wells typically sample fewer contaminants.

[59] Environmental Defense Institute newsletter for December 2017 "Where to Find Out More About Your Drinking Water." http://www.environmental-defense-institute.org/publications/News.17.Dec.pdf

[60] Environmental Defense Institute newsletter for February 2018 that contains several articles about drinking water: "What's Up With the Radionuclides in Drinking Water Around Boise, Idaho?" "Radionuclides in Drinking Water in Ammon, Idaho," "Understanding the Radionuclide MCLs in Drinking Water in Idaho," and "Understanding the Man-Made Radionuclides in Drinking Water in Idaho (with helpful decay chain information for uranium-238, thorium-232, uranium-235 and uranium-233 and the man-made actinides that can feed these decay series)" http://www.environmental-defense-institute.org/publications/News.18.Feb.pdf

[61] Hazardous Waste Management in Idaho, 2016 includes FUSRAP waste, see http://www.deq.idaho.gov/media/60179710/hw-management-idaho-2016.pdf

[62] *Mountain Goat Report*, from *New West*, "Idaho to get Giant Kuwaiti Litter Box," May 8, 2008. http://mountaingoatreport.typepad.com/the_mountaingoat_report/environment/

[63] US Ecology Annual Report, Form 10-K, February 25, 2014. https://seekingalpha.com/filing/2033622

[64] US Senate Haring 106-959, "Disposal of Low-Level Radioactive Waste," July 25, 2000. https://www.gpo.gov/fdsys/pkg/CHRG-106shrg71521/html/CHRG-106shrg71521.htm

[65] Agency for Toxic Substances and Disease Registry, Public Health Assessment for Evaluation of Community Exposures Related to Coldwater Creek St Louis Airport/Hazelwood Interim Storage Site (HISS)/Futura Coatings NPL Site North St Louis County Missouri, EPA Facility ID MOD980633176, June 18, 2018. https://www.atsdr.cdc.gov/sites/coldwater_creek/docs/ColdwaterCreek-508.pdf

The ATSDR agency found that the Army Corps of Engineers' Formerly Utilized Site Remedial Action Program (FUSRAP) has been characterizing and cleaning up contaminated area since 1998. But soil concentrations of radiological contaminants still remain higher than remedial goals. Background levels of thorium-230 should have been about 1 to 3 picocuries/gram (pCi/g) but were frequently detected above FUSRAP's remedial goal of 14-15 pCi/g. Thorium-230 levels have been as high as 54.5 pCi/g and recently as high as 27.3 pCi/g.

The ATSDR concluded that there was not enough sampling data to actually evaluate pathways of exposure.

The Missouri Department of Health (MDOH), now known as the Missouri Department of Health and Senior Services (MDHSS) had reviewed cancer incidence and mortality data from August 1984 to September 1988 around several sites, but at that time did not calculate the observed and expected cancer rates because about 15 percent of hospitals were not yet in compliance with new cancer reporting laws. Subsequently, in a later review, MDOH concluded that radiation induction could not be ruled out. Then in March 2013, MDHSS reviewed 1996-2004 cancer incidence data from six ZIP codes adjacent to Coldwater Creek and **they found statistically significantly elevated rates of incidence of several types of cancer** including female breast, colon, prostate, and kidney cancer, compared to the Missouri state rates. Then an updated analysis **found that childhood brain and other nervous system cancers were statistically significantly elevated** compared to the Missouri state rates. And they found that the incidence of leukemia, female breast, colon, kidney, and bladder cancer were statistically significantly elevated compared to the Missouri state rates.

It is interesting to note that the Center for Disease Control's National Program of Cancer Registries provide cancer statistics only on a state-wide basis since 1994 and not on a county basis, making contamination areas nearly impossible to trend by readily available cancer data in the U.S. available to the public. (See https://www.cdc.gov/cancer/npcr/public-use/index.htm).

In light of the elevated cancer rates, the ATSDR then applied radiation health models based on the International Commission of Radiological Protection (ICRP) that are known to underestimate the health risk. Combined with inadequate monitoring of the radiation levels, it is almost a miracle that ATSDR concluded that the elevated cancers *COULD* have been caused by the radioactive contamination.

The ATSDR folks don't seem to know that their radiation models are inadequate especially for inhaled and ingested radionuclides and underestimate the cancer risk by a factor of 100 or more. It is amazing that the ATSDR didn't state that the cancers could not have been caused by the radiation, as it so often case because of the understated harm from official radiation health modeling. For more about the inadequacy of radiation health harm estimates as currently estimated in the U.S., see our Environmental Defense Institute newsletter article from

September, "Just Two Problems with U.S. Radiation Protection: Radiation Dose Underestimated and the Harm Underestimated." [66]

The entire charade by the U.S. agencies from the Department of Energy, to the Environmental Protection Agency, to ATSDR would be hilarious if it were not so much illness and so many lives lost.

Let's recap the St Louis uranium waste debacle: The Department of Energy (known as the Atomic Energy Commission) processed uranium and the waste was improperly stored and disposed of and for decades. No federal or state agency saw to it that proper monitoring was conducted, even after citizens were begging them to address the issue. Elevated cancers are happening but denied for years. Elevated cancer rates are now recognized by the state of Missouri. And ATSDR applied their inadequate radiation model with inadequate data and actually says the elevated cancer rates *COULD* have been caused by the years of living with the radioactive contamination.

Now let's remember that the NRC created a loop hole that allowed sending FUSRAP radioactive waste to the RCRA disposal site in Idaho. The US Ecology site at Grand View, Idaho is not a low-level radioactive waste dump — but loop holes in the law allow radioactive waste from around the country and the world to be sent there.

An explosion occurred in November 2018 but details of why the explosion occurred remain to be revealed. But the safe processing of RCRA hazardous waste is supposed to be assured by the stringent RCRA permitting approval process by the Idaho Department of Environmental Quality. Recent reporting of the explosion included the fact that radiation monitoring was conducted [67] and citizens really have limited access to this information or any assurance that radiation monitoring is adequately conducted.

21. DOE's Performance Assessments Credit Active Institutional Controls for Millenia, Something Long Deemed Invalid

Assuming soil cap maintenance every year or every few years for millennia in order to preserve performance assessment modeling of perfect soil cap performance isn't anything but deceptive. The deceptive and unreasonable assumptions mean that human health and the environment won't be protected. Similarly, assuming no flooding, constant precipitation levels, no significant erosion are invalid assumptions and their use means the performance assessment is simply a work of deceptive fiction to give the impression that radionuclides will be confined.

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[66] Environmental Defense Institute September 2018 newsletter article by Tami Thatcher "Just Two Problems with U.S. Radiation Protection: Radiation Dose Underestimated and the Harm Underestimated" at http://environmental-defense-institute.org/publications/News.18.September.pdf

[67] Keith Ridler, Associated Press, *Star Tribune*, "Monitors check for radiation release after waste site blast," November 20, 2018. http://www.startribune.com/monitors-check-for-radiation-release-after-waste-site-blast/500943471/

22. DOE's Technically Invalid Credit for Grouting Must Not Be Allowed

The DOE likes to claim that grout will solidify, stabilize, reduce radionuclide migration from HLW remaining in HLW tanks (thousands of gallons of HLW). The ability of grout to reduce radionuclide migration has already failed in some cases and is oversold by DOE to convince stakeholders that technology is being applied that will protect human health and the environment — when actually it won't.

The DOE has grouted about 4 million gallons of so-called "low-activity waste" at the Savannah River Site, according to a 2017 Government Accountability Office report. [68]

23. DOE's Performance Assessment Compliance Period Must Be Defined for the Duration of Time the Waste Remains Hazardous

Historically, arbitrary and inadequate compliance periods have been used on performance assessments and/or public meetings. Long after the courts determined that 10,000 years was inadequate for Yucca Mountain repository compliance period, the DOE in Idaho was saying that the waste buried in Idaho (and staying buried) would remain low for 10,000 years. But DOE failed to mention in public meetings and public announcements for CERCLA cleanup that after 10,000 years, the radiation doses rapidly rose and remained elevated for thousands of years. And the relatively low radiation doses within 10,000 years are actually an artifact of modeling assumptions that delay the migration of radionuclides from the buried waste.

24. DOE's Performance Assessment of Shallow Burial of Reclassified HLW is a Smoke Screen and Migration of Radionuclides into Groundwater, Air and Soil will not be Protective of Human Health and the Environment

The DOE must not be allowed to conduct its own performance assessments to its own performance critieria (dose and contaminant air and water concentrations) and the DOE must not be allowed to make unsubstantiated claims about the performance of grout, soil caps, and waste migration characteristics such as the Kd for adsorbing to soil that are sometimes based on short-term test tube experiments not representing the chemistry of the waste.

The public needs to understand that the DOE's performance assessments are biased to achieve whatever result the DOE wishes. The DOE's performance assessments are cloaked in scientific jargon but the selection of various assumptions have been used to delay (on paper) the migration of radionuclides from the waste into air and groundwater. This tactic was used as the EPA had focused on disposal facility performance for the first 10,000 years, arguing that after that, everything was too uncertain to model. For this reason, the DOE biased the models to delay radionuclide migration to past 10,000 years which stayed elevated for thousands of years, but

[68] U.S. Government Accountability Office, "Nuclear Waste — Opportunities Exist to Reduce Risks and Costs by Evaluating Different Waste Treatment Approaches at Hanford," GAO-17-306, May 2017. https://www.gao.gov/assets/690/684468.pdf This report demonstrates a complete lack of understanding of the biological hazard of the so-called "low-activity wastes" and ignore the difficulty of confining the waste using grout.

never told the public about the contamination levels after 10,000 years, with regard to CERCLA cleanup at the RWMC at the Idaho National Laboratory.

The inability to adequately predict the rate of movement of radionuclides from buried waste over hundreds of thousands of years should not be used as an excuse to argue the waste is safely disposed of when, in fact, reasonable assurance has not been provided.

25. DOE's Performance Assessment Must Provide Specifics on Performance Assessment Objectives and Performance Criteria

The DOE's interpretation of its HLW reclassification scheme does not specify any set of performance criteria (radiation dose limits, water contaminant concentrations and air contaminant concentrations) for accepting or rejecting its performance assessment result.

Historically and currently, the DOE's water and air contamination limits have been far looser than needed to protect human health and looser than EPA or NRC standards. The DOE has historically loosened its standards further when contamination was occurring. Giving the DOE permission to reclassify its HLW while allowing it to select and/or modify the performance criteria thus provides no assurance of protection of human health and the environment. The DOE must not be allowed to use performance criteria (radiation dose limits, air and water contaminant concentrations) that it can modify at will.

Currently, the Department of Energy Idaho Field Office accepts the fiction that it is reasonable to assume that a soil cap over buried radioactive waste at the Radioactive Waste Management Complex at the Idaho National Laboratory will perform flawlessly for millennia while acknowledging that soil caps require active maintenance, basically annual maintenance to stabilize the soil caps. With a cracked leaking soil cap from erosion or animal/plant damage, water ingestion radiation doses will be higher than the performance assessment predicts.

26. DOE's Performance Assessments Based on Best Estimate Predicted Radiation Doses Are Not Protective of Biological Organisms Like Humans

It is currently accepted by the NRC that performance assessments reflect only the best estimate radiation doses and that actual radiation doses may be far higher or lower in any given year. High radiation doses can occur for many years on end. This may be convenient — but it doesn't protect human health.

The guidelines for conducting performance assessments, even the guidelines prescribed by the NRC, do not protect people in the future who will be harmed and especially their children will be harmed. Ideally performance assessments would be realistic but when this isn't possible, they must be conservative, meaning there is ample margin for some error in the estimate. The performance goals used by the NRC for limiting radiation dose are barely protective of adults and exceeding these radiation doses will devastate children and the unborn developing child.

Given how inaccurate and non-conservative disposal facility performance assessments currently are, people need to understand that the performance assessments conducted by the DOE will not

be protective of human health and the environment, over the long time-frames that the radioactive waste remains hazardous.

27. The DOE Must Not Be Allowed to Set Its Own Radiation Performance Criteria for Disposal Performance Assessments

The DOE must not be allowed to set its own radiation performance criteria for disposal of reclassified HLW evaluated in performance assessments. The criteria must be at least as stringent as EPA standards, 15 millirem/yr (which really is not adequately protective for internally ingested or inhaled radionuclide exposure).

28. The DOE Must Not Be Allowed to Approve the Performance Assessment

The DOE must not be allowed to approve the performance assessment. The performance assessments conducted by the DOE so far have been inconsistent and not technically valid. The performance assessment conducted by the NRC for Yucca Mountain is predicated on numerous invalid assumptions and vastly underpredicts the radionuclide migration from the waste. DOE's tendency to pressure analysts to yield the desired result — the result that is cheapest, typically — means that at other DOE facilities like WIPP, the RWMC ARP V, and ZPPR, technically invalid arguments or blatant violations of DOE Orders were required of DOE contractors in order to save money. Analysts who disagree tend to be removed.

29. DOE's Performance Assessments Must Not Redefine the Point of Compliance on Whim

The distance for the waste that the performance assessment criteria must be applied must be stipulated. Otherwise the DOE could select 50 miles or 500 miles or whatever distance it takes for their analysis to dilute the contamination to meet the selected contamination standard.

30. Monitoring of Reclassified HLW Must Have Adequate Monitoring and Reporting

The DOE must not be allowed to solely conduct radiological monitoring of its waste disposal sites. DOE's past and ongoing coverup of radiological contamination is not protective of human health and the environment.

DOE has failed to disclose past radiological releases and the DOE continues to coverup ongoing intentional and accidental releases. Extensive americium-241 contamination at the ATR Complex was known long ago but the DOE and the U.S. Geological Survey deliberately withheld the information. The DOE has long given presentations to the public that deliberately withheld information about long-lived radionuclide contamination. Even now, when filters are evaluated and found to have americium-241, plutonium-238 and plutonium-239, for example, the DOE and state pretend to not know the source of the radionuclides.

Monitoring of waste burial sites for CERCLA at INL has often been inadequate and biased to hide contamination findings by reduced monitoring and reduced reporting. Spotty monitoring means "no discernable trend could be found."

At the Idaho National Laboratory, formerly the Idaho National Engineering and Environmental Laboratory, the Idaho National Engineering Laboratory, and the National Reactor Testing Station, historical releases were monitored yet not actually characterized as to what and how many curies were released. When asked by the governor in 1989 to provide an estimate of the radionuclides released from routine operations and accidents, the Department of Energy issued the "INEL Historical Dose Evaluation." [69] [70] It has been found to have underestimated serious releases by sometimes 10-fold. Furthermore, the past environmental monitoring used all along to claim no significant releases had occurred were not used in the INEL Historical Dose Evaluation. The environmental records that could have been used against the Department of Energy were destroyed.

The waste incidental to reprocessing requirements under the Section 3116 law required U.S. Nuclear Regulatory Commission oversight to some degree for closure of DOE's HLW tanks at INL and SRS. The NRC oversight was publicly available such as a NRC monitoring report from 2007. [71]

31. The DOE Misinforms ICP Citizens Advisory Board and Actively Biases Endorsement Voting

The DOE uses citizens advisory boards (CABs), that the DOE hand selects and then presents a self-serving version of information that glosses over or omits discussion of even current DOE failure to comply with regulations and other serious performance failures. The DOE encourages lack of normal rules for conducting meeting CAB meetings, such as lack of notification for voting on issues important to citizens and unannounced re-voting if the citizens advisory board doesn't vote as leaders wish. The Idaho Cleanup Project CAB was asked for an unannounced vote on DOE waste reclassification and no presentation on the issue was provided. In the discussion that proceeded the unannounced vote to endorse DOE reclassification of waste efforts, there was not mention of high-level waste — only discussion of low-level waste. **Any so-called endorsement by the Idaho Cleanup Project Citizens Advisory Board must not be taken as reflecting views of thoughtful citizens of Idaho.**

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[69] US Department of Energy Idaho Operations Office, "Idaho National Engineering Laboratory Historical Dose Evaluation," DOE-ID-12119, August 1991. Volumes 1 and 2 can be found at https://www.iaea.org/inis/inis-collection/index.html

[70] Environmental Defense Institute's comment submittal on the Consent-based Approach for Siting Storage for the nation's Nuclear Waste, July 31, 2016. http://www.environmental-defense-institute.org/publications/EDIXConsentFinal.pdf

[71] "U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken By The U.S. Department of Energy at the Idaho National Laboratory Idaho Nuclear Technology and Engineering Center Tank Farm Facility in Accordance with the National Defense Authorization Act of Fiscal Year 2005," April 13, 2007. On NRC's Adams Database.

32. Department of Energy Long-standing Conflicts of Interest in Avoiding Adequate Cleanup

The DOE is self-regulating and has serious conflicts of interest in wanting to save money on cleanup of its radioactive waste, all while promoting nuclear energy and research which requires it to continually avoid the truth about the actual harms of radionuclides it releases to the environment, now and in the future. The Department of Energy has proven many times throughout its history, including predecessor agency the Atomic Energy Agency, that it puts weapons and research above protection of workers, the public and the environment. Try to count how many toxic waste sites around the U.S. the DOE has created. It's hundreds. Try to count the workers it had made ill. Billions of dollars have been paid to workers through the Energy Employee Occupational Illness Compensation Program Act, despite a high percentage of denied claims — denials that we continue to learn were not justified, as more information is revealed about actual practices at DOE sites, including the Idaho National Laboratory (formerly the National Testing Station, the Idaho Engineering Laboratory, and the Idaho Engineering and Environmental Laboratory).

33. The Department of Energy Is Not Trustworthy

From the DOE's nuclear weapons testing at the Nevada Testing Station, in the Pacific islands, and elsewhere, the DOE told people they were safe and then covered up epidemiology that showed people had increased rates of leukemia and cancer from the fallout. The DOE claimed its releases from the INL were too low to cause harm, but when asked to state what it had released to the Idaho skies, the DOE didn't know. Then when the DOE issued a report of estimated releases through its history to 1989, reviews by the Center for Disease Control found the releases had been significantly underestimated. It is also documented that many environmental monitoring records were subsequently destroyed, which would have indicated more contamination that the DOE wanted others to know about. The DOE has lost or destroyed worker radiation dose records throughout its history when the records would show elevated doses. The DOE uses secrecy, document destruction, omission of key information during public presentations, and adherence to providing false information about its plans, and breaks its commitments. The DOE would not have conducted any cleanup at all if other federal agencies had not been able to say that hazardous chemical laws needed to apply to DOE sites, allowing CERCLA cleanup investigations. The DOE has systematically lied about the pervasive long-lived radionuclides at sites likes the INL, omitting what it well knew, that uranium, plutonium and americium were included in soil and perched water. It omitted this information so well that the DOE and the U.S. Geological Survey have often, without justification, omitted the reporting of extensive radiological contamination at the INL, later found by CERCLA investigations.

DOE lied about its radiological releases decades ago from nuclear weapons testing, reactor testing, and reactor accidents and other operations and it continues to misinform the public about its past and about current contamination.

The Department of Energy has a long history of telling workers they are protected from radiological hazards — but workers got illnesses. Nationwide, billions of dollars of illness

compensation have been paid out under the Energy Employee Illness Compensation Program Act (EEICOPA) even with two-thirds of INL claims denied.

The Department of Energy has a long history of saying its radiological releases were too small to affect the public — but studies found that the public had higher infant mortality and certain cancers and leukemia.

The Department of Energy has rightfully earned and continues to earn the public's distrust. The Department of Energy must not be allowed to unilaterally reclassify HLW waste because the DOE cannot be trusted to comply with its own regulations should its regulations or DOE Orders be deemed inconvenient or costly.

34. The DOE Has A Record of Not Being Transparent

The DOE has also conducted numerous public comment opportunities, only to refuse to publish those public comments such as the consent-based interim spent nuclear fuel storage meetings conducted a few years ago. [72] [73] [74]

[72] The Department of Energy was planning to use a consent-based approach for siting spent nuclear fuel and high-level waste storage and disposal facilities including: (1) a pilot interim storage facility, (2) consolidated interim storage facilities, and (3) permanent geologic disposal facilities, one for commercial spent nuclear fuel and the other for defense spent nuclear fuel and high-level waste.

A consent-based approach was recommended in the 2012 Blue Ribbon Commission report on the nation's problem of spent nuclear fuel disposal, but no one knows what a consent-based approach entails. What we do know that even with local support, state opposition effectively stymied efforts to obtain authorization to construct the geologic waste disposal at Yucca Mountain at Nevada and prevented a proposed interim storage site at Skull Valley, Utah. The DOE held meetings in 2016 around the country seeking public input on the consent-based process, including one in Boise, Idaho. The Department of Energy successfully disposed of the consent-based approach and the public comments collected following the appointment of Rick Perry as the Secretary of Energy in 2017.

The majority of the spent nuclear fuel is from commercial electricity generation from US nuclear power plants. As of 2013, there was 70,000 metric tons heavy metal, enough for the stymied Yucca Mountain repository. The inventory is expected to roughly double as the existing fleet of US nuclear reactors operates for its expected life. Utilities are winning billions in compensation from the DOE over the continuing costs of storing the spent nuclear fuel because of the DOE's failure to provide a disposal facility.

The rest of the spent nuclear fuel is from DOE research and defense reactors, including nuclear submarines and carriers. The DOE's high-level waste is in various forms ranging from liquid waste at Hanford awaiting vitrification, highly soluble powder-like calcine at Idaho and vitrified waste as other sites.

[73] Before ending the consent-based siting effort, information found about the Department of Energy's consent-based siting at www.energy.gov/consentbasedsiting and its Integrated Waste Management and Consent-based Siting booklet at http://energy.gov/ne/downloads/integrated-waste-management-and-consent-based-siting-booklet

[74] Environmental Defense Institute's comment submittal on the Consent-based Approach for Siting Storage for the nation's Nuclear Waste, July 31, 2016. http://www.environmental-defense-institute.org/publications/EDIXConsentFinal.pdf

35. The DOE Knows if the Public Understands the Hazards of the Radioactive Waste, the Public Will Oppose Building More Nuclear Reactors and Fuel Reprocessing

The DOE is using the lack of a deep geologic repository for HLW as an excuse for the need to lower the waste classification of HLW — and yet the DOE actively promotes making more waste, more spent nuclear fuel and more HLW, to send to a repository that it assures us, in National Environmental Policy Act environmental impact statements, are soon going to accept waste. New nuclear reactors for electric energy are being promoted despite the lack of a repository while DOE is telling us we have to reclassify (and shallow bury) HLW because there isn't a deep geologic repository.