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Tritium at 800 pCi/L in the Snake River Plain Aquifer in the Magic Valley at Kimama: Why it matters

When the deep well monitoring at Kimama performed by the US Geological Survey discovered elevated levels of tritium, about 10 times higher than they had reported for over two decades in the Magic Valley groundwater monitoring, the USGS did not try to identify the source of the contamination. [1] Nor did it get news coverage.

Kimama is located in Lincoln county roughly 60 miles southwest of the INL, about 20 miles northwest of Acequia in Minidoka county, in the Magic Valley, roughly near MV-07 in Figure 1 below. Monitoring in the Magic Valley actually began in the 1950s, although much of the data is difficult to obtain. There are dozens of reports beginning in 1989, however, all stating tritium concentrations in groundwater in the Magic Valley are less than 150 pico-Curie/liter (pCi/L) often far less. By 1999, the levels of tritium in the Magic Valley were reported by the USGS as generally less than 65 pCi/L. And a USGS 2003 study found 38.1 pCi/L to be the maximum tritium concentration in the Magic Valley. [2] **So, why isn't it news when the tritium concentration far south of the INL is found in a deep borehole to exceed 800 pCi/L? What is the source of the elevated tritium and other radionuclides?**

See our Environmental Defense Institute special report on the contamination at Kimama [3] for a detailed look at the radionuclides and other constituents found in the deep Kimama borehole in the Snake River Plain Aquifer and the contaminants that were prominent in historical waste water from the Idaho National Laboratory, originally called the National Reactor Testing Station.

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[1] USGS "Geophysical Logs and Water Quality Data for Boreholes Kimama-1A and -1B, and a Kimama Water Supply Well near Kimama, Idaho," Data Series 622,DOE/ID-22215, 2011.

[2] Rattray, G.W. and Wehnke, A.J., "Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Laboratory to the Hagerman Area, Idaho, 2003.," US Geological Survey Report 2005-1125 version2, 2005.

[3] 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 Matter," 2017. www.environmental-defense-institute.org/publications/kimamareport.pdf

Our EDI report also compares normal background levels of radionuclides and other constituents in the aquifer to groundwater flowing to the aquifer from neighboring mountain ranges, the levels in the aquifer beneath polluting facilities at the INL and the levels downgradient in the Magic Valley.

Our report compares weapons fallout to the Kimama deep borehole in regard to ratios of americium-241 to plutonium-239 (and Pu-240), and also of cesium-137 to plutonium-239 (and – Pu-240). These ratios show that that the deep aquifer contamination at Kimama is not from weapons fallout but may be from INL wastes.

Various tell-tale non-radiological constituents from INL waste water are not present in weapons fallout — such as elevated levels of sodium, chloride, nitrate, hexavalent chromium and volatile organic chemicals — have been found to go hand in hand in the Magic Valley wells that are the most contaminated with radionuclides.

Figure 1 below shows some of the wells south of the INL that existed by the 1960s, although many of them are no longer actively monitored by the USGS.

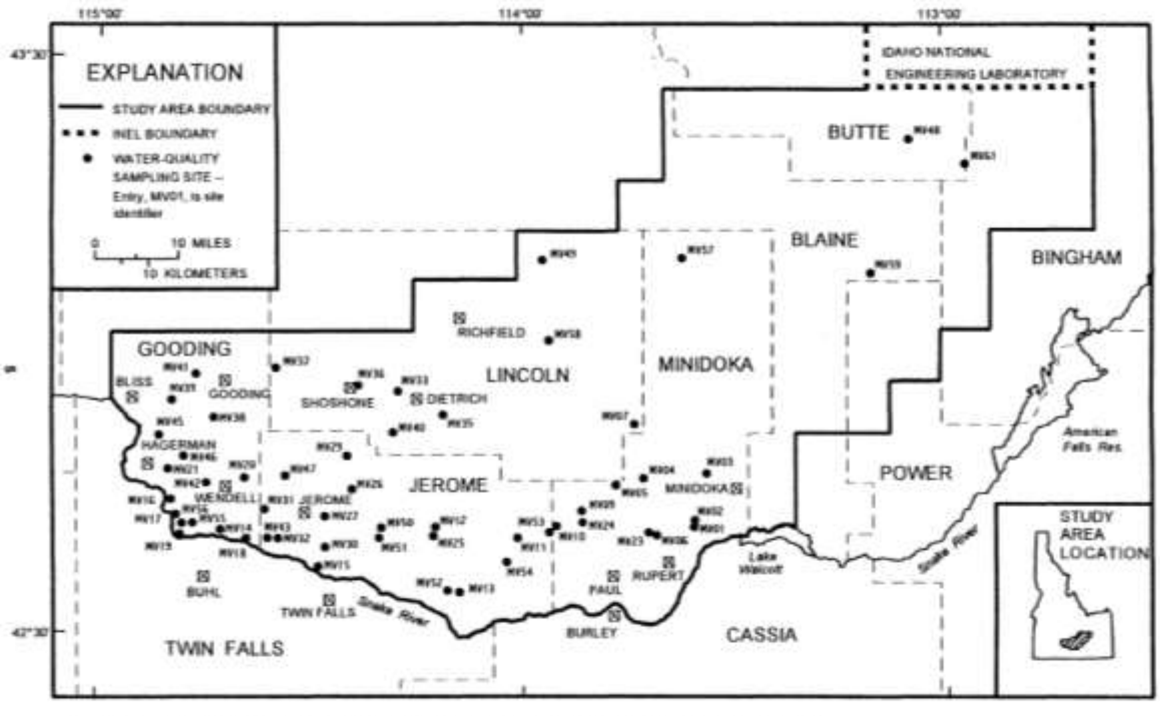

Figure 2. – Location of selected water-quality sampling sites on the eastern Snake River Plain.

Figure 1. Figure is from 97-4007 (DOE/ID-22133) from https://pubs.usgs.gov/wri/1997/4007/report.pdf

While it is true that global weapons testing radiological fallout and local weapons testing fallout from the Nevada Test Site did spread vast amounts of radioactive tritium over Idaho and much of the US, a close examination of the INL waste water contaminants and the differences between INL waste water and weapons fallout will prove that the aquifer contamination downgradient from the INL is from historical INL waste water and perhaps from buried waste. Waste water from nuclear fuel reprocessing, other fuel separations processes and reactor operations from the historical operations at the Idaho National Laboratory included 31,000 curies of tritium between 1952 and 1990.

The fact that INL contamination tends to go deeper in the aquifer as it flows downstream from INL, deeper than was historically sampled by the USGS — and the enormous levels of tritium disposed of into the Snake River Plain aquifer by the INL — does provide a reasonable explanation for the elevated levels of tritium contamination in the Magic Valley.

Figure 2 below shows in deeper red the portion of the Snake River Plain Aquifer having greater depth. As the aquifer flows from deeper to shallower sections, in the general southwesterly downgradient flow, the frequently unmeasured levels of higher contamination deep in the aquifer then mix with more less contaminated monitored aquifer contamination closer to ground level. This may explain why contamination levels often bump up in the regions to the south where the aquifer is more shallow, in the lighter pink areas on the figure.

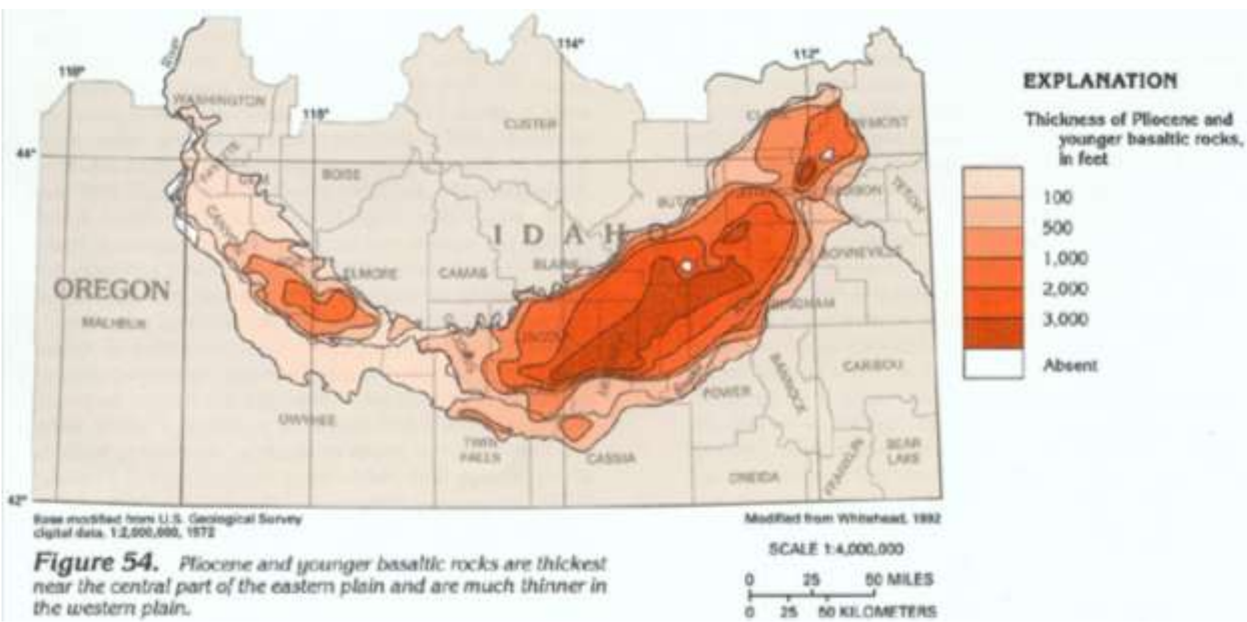

Figure 2. Snake River Plain Aquifer thickness from US Geological Survey at http://pubs.usgs.gov/ha/ha730/ch_h/jpeg/H054.jpeg

Once a contaminant is in the aquifer, it flows downgradient, generally to the south or southwest of the INL. A portion of the flow will arrive very rapidly while the rest of the contamination may continue to arrive for years. Soil may slow the migration of contaminants buried below grade in waste or in percolation ponds. Ongoing precipitation and waste water from percolation ponds/ditches flush contaminants in the soil or perched water layers into the aquifer. But once that contamination is in the aquifer, it flows downgradient, generally flowing deeper as it flows from the source of the contamination.

Along with radiological contaminants, historical operations at the INL disposed of a multitude of chemical contaminants into the aquifer. The chemical wastes were often used in nuclear fuel reprocessing or other separations processes, then disposed of via deep injection wells at Idaho Nuclear Technology and Engineering Center (INTEC), ATR Complex (formerly the Test Reactor Area), the Naval Reactors Facility (NRF), Test Area North (TAN) and other facilities. [4] Chemical contaminants have also reached the aquifer from burial of wastes at the Radioactive Waste Management Complex (RWMC). See Figure 3 for the location of various INL facilities.

Chemical contamination of the aquifer from the INL

It is generally recognized that in addition to radionuclides and highly acidic wastes for dissolving metal fuels, organic compounds, in large quantities, such as toluene, carbon tetrachloride, benzene, acetone, methyl ethyl ketone, EDTA, HEDTA, and tributyl phosphate have frequently been used in nuclear fuel separations processes. [5]

Despite the chemical disposal via injection wells, percolation ponds and waste burial, commencing in the early 1950s, the US Geological Survey did not monitor chemical contamination until the late 1980s.

And despite over two decades of CERCLA cleanup and remediation activities at the INL including vapor extraction at the RWMC and TAN for CERCLA cleanup, the levels of chemical contamination in the aquifer at both locations have been increasing. Carbon tetrachloride levels continue to increase at RWMC; 821,000,000 grams disposed of there between 1952 and 1978. Trichloroethylene (TCE) was disposed of via injection well at TAN but the quantity is unknown — but it may have been as much as 35,000 gal. [6] [7]

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[4] The Administrative Record for the Idaho National Laboratory CERCLA cleanup investigations can be found at https://ar.icp.doe.gov and it includes other facilities such as the Power Burst Reactor and its aquifer disposal well and ponds.

[5] Makhijani, A., Hu, H. and Yin K., *Nuclear Wastelands – A Global Guide to Nuclear Weapons Production and Its Health and Environmental Effect*," By a special commission of International Physicians for the Prevention of Nuclear War and the Institute for Energy and Environmental Research. The MIT Press, Cambridge, Massachusetts, 2000.

[6] Department of Energy, "Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report," INEEL/EXT—03-01169, Rev. 2, September 2003. p. 4-2, 4-23 to 4-26.

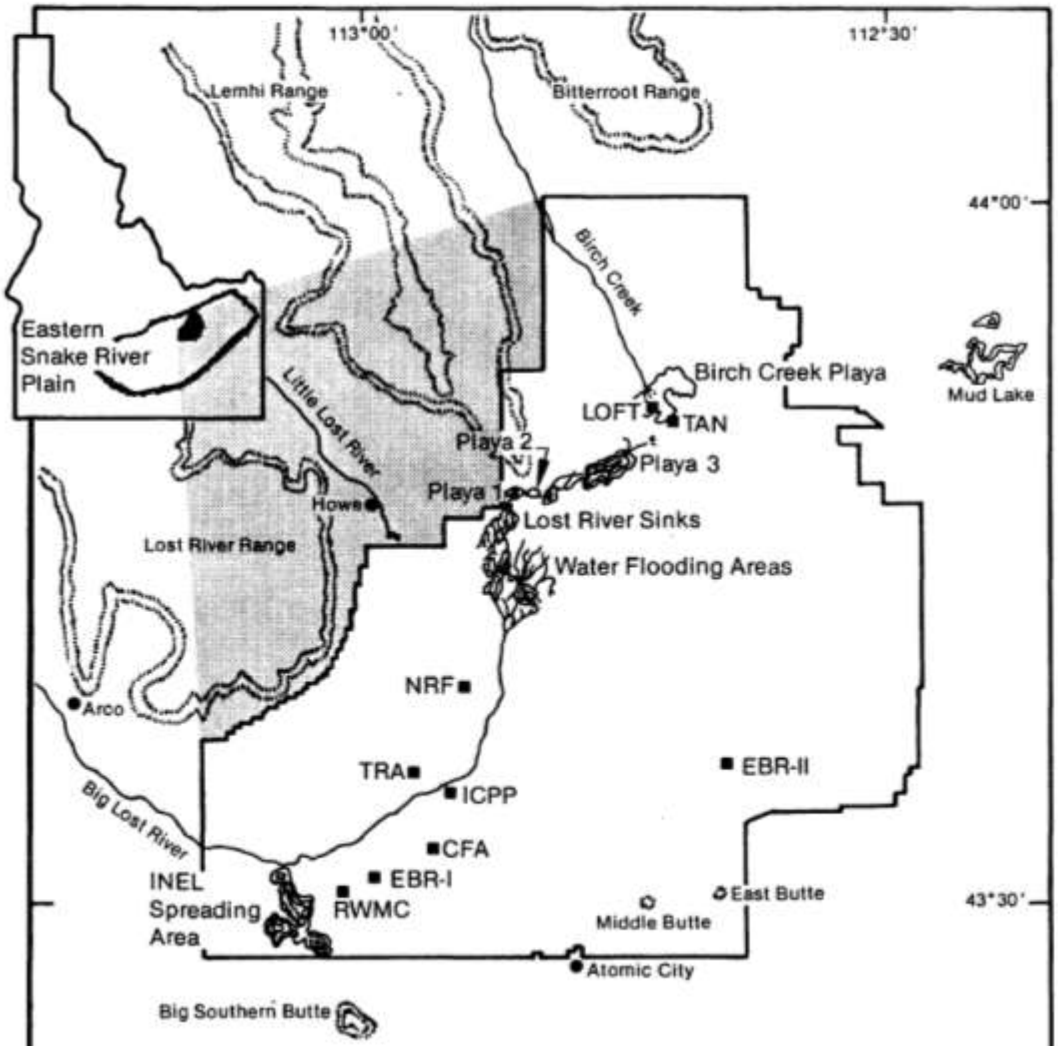

Figure 3. Idaho National Laboratory facilities.

Tetrachloroethylene, PCE, was disposed of at TAN but the amount is unknown. PCE was also disposed of at RWMC and NRF. Recent detections of PCE north of RWMC are being investigated by the US Geological Survey. You might not be surprised at the amount of chemicals from the INTEC, the chemical processing plant for spent nuclear fuel reprocessing — but you might be surprised that actually the Naval Reactors Facility disposed of almost as many chemicals as INTEC. Both INTEC and NRF are upgradient of the recently found PCE contamination where the contamination plumes from INTEC, NRF and TRA have long commingled.

[7] 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.

The Advanced Test Reactor Complex, formerly called the Test Reactor Area (TRA) disposed of unknown levels of contaminants that the CERLA cleanup has never attempted to investigate. Primarily, this is because the materials involved nuclear fuels and weapons material separations. But we do know that over 31,000 lb of hexavalent chromium was injected into the aquifer.

The chemical soup from INL waste water disposal has been flowing downgradient for decades. Let's take a look at some of these chemicals and what facilities they came from. The finding of various chemicals downgradient will take on a whole new meaning — meaning that the USGS has tended to downplay. Because so many reports present only a fragmented look at the chemical contaminants, I have compiled a table of chemical contaminants most prevalent at the INL **in the aquifer** from various CERLCA cleanup, USGS and other reports. [8] [9] [10] [11] [12]

Table 1. Facilities that disposed of chemical contaminants at the Idaho National Laboratory that have been **found in the aquifer in significant concentrations**.[a]

Chemical	RWMC	TAN[d]	INTEC	TRA[b]	NRF[c]
Carbon tetrachloride	G				
Chloroform	G		G		G
Dichloro-difluoromethane	G	G			
Methylene chloride	G		G		x
1,1,-Dichloroethane		G	G		
Cis-1,2-Dichloroethene		G			
Trans-1,2,-Dichloroethene		G			
Tetrachloroethylene, PCE	G	G			G
Trichloroethylene, TCE	G	G	G		G
1,1,1-Trichloroethane	G	G	G	G	G
Toluene	G	G	G	G	G
Hexavalent chromium				G	

a. The facilities are the Radioactive Waste Management Complex (RWMC), Test Area North (TAN) and vicinity, Idaho Nuclear Technology and Engineering Center (INTEC) — formerly the Chemical Processing Plant and vicinity including Central Facilities Area that received contaminated drinking water from INTEC, Test Reactor Area, now called the Advanced Test Reactor Complex, and the Naval Reactors Facility (NRF). The letter "G" denotes contamination of concern in the aquifer.
b. Acrylonitrile was found in soil and waste water disposal entrances at TRA.

[8] Department of Energy, "Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report," INEEL/EXT—03-01169, Rev. 2, September 2003. p. 4-2, 4-23 to 4-26.

[9] Greene, M.R., Tucker, B.J., "Purgeable Organic Compounds in water at or near the Idaho National Engineeing Laboratory, Idaho, 1992-95," US Geological Survey Report 98-51, June 1998.

[10] Liszewski, M.J. and Mann, L.J., Purgeable organic compounds in ground water at the Idaho National Engineering Laboratory, Idaho – 1990 and 1991," US Geological Survey Report 92-174 (DOE/ID-22104), 1992.

[11] Mann, L.J.and Knobel, L.L., "Purgeable organic compounds in ground water at the Idaho National Engineering Laboratory, Idaho ," US Geological Survey Report 87-766, December 1987. https://pubs.usgs.gov/of/1987/0766/report.pdf

[12] See the Naval Reactor Facility final environmental impact statement at www.ecfrecapitalization.us and the summary at http://www.ecfrecapitalization.us/EIS-0453-FEIS_Summary.pdf See Chapter 3.

c. Aroclor-1254, Aroclor-1260, Bis-2-Ethylhexl-phthalate, Din-Octylphalate, Di-n-Octylphalate and benzene were found is disposal ditch soil at NRF.
d. At Test Area North, Trans-1,2,Dichloroethene levels of 22,000 microgram per liter (ug/L) and Trichloroethylene of 35,000 ug/L were measured in 1987. Typical limits for drinking water are 5 ug/L. Source USGS report: 87-766.

Radionuclide contamination of the aquifer from the INL

Uranium and thorium fuel separations waste from INL disposed of into the aquifer is the likely source of much of the elevated gross alpha contamination present in downgradient community drinking wells in the Magic Valley that began increasing by the early 1960s. See our EDI special report for 1960s gross alpha trends as the levels began to exceed natural background levels in the aquifer.

Along with plutonium and many uranium isotopes, the INL CERLCA cleanup found contaminants of concern that included thorium isotopes, uranium-233 fissile material bred from thorium, and europium-152, a contaminant of U-233 production. [13]

Table 2. Radionuclide levels monitored in 2010 at Kimama. [a]

Constituent (pCi/L)	300 ft supply well	830 ft	460 ft borehole	830 ft borehole
Tritium	**50**	**810**	**240**	**70**
Strontium-90	**0.5**	**1.5**	**0.3**	**NA**
Cesium-137	**15**	**8**	**12**	**NA**
Gross alpha	**0**	**18**	**-1**	**NA**
Gross beta	**3.8**	**14.4**	**4.3**	**NA**
Americium-241	**-0.01**	**0.003**	**0.006**	**NA**
Plutonium-238	**-0.005**	**-0.003**	**0.006**	**NA**
Plutonium-239+240	**-0.005**	**0.003**	**0.009**	**NA**

a. USGS Data Series 622, DOE/ID-22215, 2011.
b. Uncertainties not listed here are in Table 4 of the DOE/ID-22215 report.

The USGS was intimately involved in hiding information about nuclear weapons fallout, the INL's weapons material separation techniques, and various chemical and radionuclide contamination at the INL at the request of the Atomic Energy Commission, now called the Department of Energy. The USGS monitoring has tended to be decades late and aimed more at hiding DOE's aquifer contamination than disclosing it.

[13] See INL CERCLA Cleanup Administrative Record at https://ar.icp.doe.gov and See one report for an idea of contaminants in Department of Energy Idaho Operations Office, "Final Removal Action Report for CPP-601, CPP-602, CPP-627, CPP-630, and CPP-640," DOE/ID-11453, February 2012. See Table 3, p. 19 and 20. *https://ar.icp.doe.gov/images/pdf/201202/2012022800768BRU.pdf*

The high levels of gross alpha from uranium and thorium radioactive wastes, other radionuclides, hexavalent chromium and other waste constituents have long reached Idaho's Magic Valley. [14] And there is evidence to suggest that the contaminants have adversely affected the health of people drinking the water (see EDI's June 2016 newsletter).

State Continues to Fine the Department of Energy Over Integrated Waste Treatment Unit Delays:

Fluor Says Treatment is Many Months Away

The Idaho Falls Post Register reported that Department of Energy continues to accrue fines after missing the October 2016 treatment date that DOE negotiated with the State of Idaho the year before. [15] State fines now exceed $300,000 and daily penalties will increase next April. Total federal costs related to the facility construction and testing and modifications stand at about $785 million, over $200 million over budget — and over 4 years behind schedule for treating the liquid waste at the Idaho National Laboratory.

The previous cleanup contractor, CH2M-WG Idaho paid at least another $90 million out of its own pocket related to the cost overruns. Fluor took over the cleanup contract in June.

The DOE's Idaho Cleanup Project Deputy Director Jack Zimmerman asked the Idaho Department of Environmental Quality to consider not assessing the fines, due to provisions in the agreement that said the DOE wouldn't be fined if an "upset or breakdown" required treatment to be stopped. But IDEQ Director John Tippets replied in a September 28 letter that the waste treatment never started, and current issues with the facility are mostly the same as previous ones that caused the missed 2014 deadline.

Zimmerman again appealed to the DEQ to reconsider the fines — but Tippets reaffirmed in an October 31 letter the DEQ's intention to keep them in place.

Problems continue with the build up of a "wall scale" that looks like tree bark when test runs have been conducted. There is a problem with a faulty component associated with replacing the "ring header." And also problems with an "auger/grinder."

[14] Department of Energy, Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report, INEEL/EXT-03-01169, Rev. 2, September 2003. p. 4-2. at https://inldigitallibrary.inl.gov/sti/3562854.pdf

[15] Reporter Luke Ramseth, Idaho Falls Post Register, "DOE fines stack up over nuke waste plant – The DOE accures fines of $300K, as Fluor makes progress.

Fluor has been enlisting experts from private industry and national laboratories and have been testing at a smaller-scale facility in Colorado.

Antitrust Lawsuit preventing Utah's radioactive waste company EnergySolutions from buying Texas Waste Control Specialists

When Utah's low-level radioactive waste disposal company EnergySolutions tried to buy Waste Control Specialists, with its radioactive waste facility in Andrews, Texas, the US Department of Justice filed an antitrust lawsuit.

Through political pressure and denial any and all science regarding protection of the aquifer near the Texas facility, Texas gave Waste Control Specialists approval for the radioactive waste dump despite not having a completed analysis. The Andrews, Texas facility is also licensed to dispose of depleted uranium, [16] never mind the fact that in 2007 a team of geologists and engineers at the Texas Commission of Environmental Quality unanimously recommended denying any license for radioactive waste at the Andrews site because of two water tables in the "immediate vicinity." [17] [18] WCS denies that the waste will enter the Ogallala aquifer.

The Department of Energy has about 700,000 metric tons of depleted uranium they must first process through conversion of depleted uranium hexafluoride (DU6) to a more stable form. The DU6 is the from uranium enrichment to obtain uranium enriched in uranium-235 for nuclear reactor fuel. Three disposal sites have been considered by the Department of Energy for disposal of the converted depleted uranium: Clive, Utah; Nye County, Nevada; and Andrews, Texas. [19]

If the acquisition is blocked, EnergySolutions is more likely to pursue its plan to dispose of the DOE's depleted uranium at the Clive, Utah facility located 80 miles west of Salt Lake City. [20]

Utah state officials have not been satisfied with EnergySolutions performance assessment of the depleted uranium waste disposal at its Clive, Utah facility.

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[16] Waste Control Specialists, press release August 22, 2014 stating that the Texas Commission for Environmental Quality voted accept an amendment to allow disposal of more than 700,000 metric tons of converted depleted uranium. http://www.wcstexas.com/wp-content/uploads/2015/04/Aug_22_2014-2.pdf

[17] Forrest Wilder, *Texas Observer*, "Radioactive Waste Dump Over Agallala Aquifer?," June 10, 2010 https://www.texasobserver.org/radioactive-waste-dump-over-ogallala-aquifer/

[18] Paul Derienzo, Counterpunch, "Radioactive Texas Waste Dump Threatens Key US Water Resources," September 7, 2015. http://www.counterpunch.org/2015/09/07/radioactive-texas-waste-dump-threatens-key-us-water-resource/

[19] See Wise Uranium Project, "Current Issues: Waste Management of Deplete Uranium," http://www.wise-uranium.org/edissdp.html

[20] Salt Lake City (AP), *Idaho Falls Post Register*, "Lawsuit reopens issue of uranium disposal in Utah," December 4, 2016.

While uranium is a naturally occurring radionuclide, when bound in rock naturally, it is much less concentrated that it would be as disposed of at the “low-level” radioactive waste facilities. Large concentrations of depleted uranium should be disposed of in deep geologic disposal facilities — not shallow land burial as proposed by EnergySolutions at Clive, Utah. The uranium grows more radioactive over millions of years by its decay products.

See Table 3 for a comparison of uranium and transuranic wastes, and Table 4 for a comparison of natural uranium to depleted uranium by mass and by activity composition. Transuranic wastes are required to be disposed of in deep geologic repositories such as the Waste Isolation Pilot Plant, WIPP, in New Mexico. Why aren’t concentrated uranium wastes required to have deep geological disposal?

Table 3. Properties of Uranium Isotopes and Selected Transuranium Elements [a]

Isotope	Main decay mode	Alpha particle energy, MeV	Half-life, years	Comments
Uranium Isotopes:				
uranium-238	alpha	4.1	4.46 billion	
uranium-234	alpha	4.8	245,000	
Transuranics:				
neptunium-237	alpha	4.8	2.14 million	
plutonium-238	alpha	5.5	87.7	
plutonium-239	alpha	5.1	24,110	
plutonium-240	alpha	5.1	6,537	
plutonium-241	beta	see note 2	14.4	not included in TRU waste definition
americium-241	alpha	5.5	432	strong gamma emitter

Table from Institute for Energy and Environmental Research http://www.ieer.org/latest/duf6-96.html

Notes 1. All energies rounded to two significant figures. The alpha emitting radionuclides emit alpha particles with more than one characteristic energy, with each energy level being produced with a known probability. The alpha particle energy shown is an approximate average of these particles energies, weighted by the emission probability.

2. Plutonium-241 is not included in the definition of TRU waste since it has a half-life of less than 20 years. Its beta particle energy is 0.021 MeV.

Table 4. Natural uranium and depleted uranium mass contribution and radioactivity.

Composition	By mass (%)			By activity (%)			Specific activity of mixture
	U-234	U-235	U-238	U-234	U-235	U-238	Bq/mg
Natural Uranium	0.5E-3	0.72	99.3	48.9	2.2	48.9	25.2
Depleted Uranium	1.0E-3	2.0E-1	99.8	15.5	1.1	83.4	14.8

The reader should note that the uranium-234 content of natural uranium while very low in mass percent is almost 50 percent of the radioactivity of natural uranium. Uranium-234 contributes over 15 percent of the radioactivity of depleted uranium. Depleted uranium is roughly two thirds the specific activity of natural uranium but what will be disposed of is much more highly concentrated and not bound to rock as it was in its natural state.

WIPP Reopening After Two Accidents That Were Never Supposed to Happen

The Waste Isolation Pilot Plant (WIPP) located in New Mexico is reopening [21] after two back-to-back accidents that the Department of Energy said would never happen. In 2012, two accidents, (1) a salt truck fire that could have been prevented and resulted due to lax vehicle maintenance and ignoring safety audit finding, and (2) an accident resulting from loading waste drums, *actually hundreds of them*, with materials strictly forbidden by regulations to be combined in the waste drums. One of the improperly loaded waste drums exploded in the underground WIPP facility in 2012, causing a release of an amount of plutonium and americium that exceeded the amount assumed to be releasable from a single drum. (See our March 2016 Newsletter and others for more information about the accidents at WIPP.)

The environmental impact statements had assured the public that the risks of any release were extremely low and would never happen in our lifetimes — but then happened only fifteen years later. Now some people are asking whether the NEPA process was adequate. [22]

[21] Susan Montoya Bryan, AP, *ABC news*, "US Allowing Work to Restart at Nuke Sump 3 Years After Leak," Albuquerque, NM, December 23, 2016, http://abcnews.go.com/Technology/wireStory/us-allowing-work-restart-nuke-dump-years-leak-44373826

[22] Concerned Citizens for Nuclear Safety (CCNS), "SRIC and NRCD Address NEPA requirements for Reopening WIPP," November 23, 2016, http://nuclearactive.org/sric-and-nrdc-address-nepa-requirements-for-reopening-wipp/

During the Town Hall, Don Hancock, of Southwest Research and Information Center, asked how ceiling collapses would be avoided when waste emplacement begins and continues for three years. The question was not answered. http://www.sric.org/

When asked whether Nuclear Waste Partnership, the management contractor and operator at WIPP, would receive a bonus if a container of waste was emplaced in the WIPP underground before the end of the year, Phil Breidenbach, President and Project Manager of Nuclear Waste Partnership, conducting work for WIPP, responded, “No.” However, the Performance Evaluation and Measurement Plan clearly states that Nuclear Waste Partnership would receive a $2.1 million bonus. [23]

Articles by Tami Thatcher, for January 2017.

[23] Concerned Citizens for Nuclear Safety (CCNS), “DOE denies expedited FOIA request by Citizen Action NM and CCNS for Critical WIPP documents,” December 23, 2016. http://nuclearactive.org/