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When will the Navy replace the 1957 crumbling spent fuel pool?

The Navy and the Department of Energy announced in 2016 that they would replace the aging, leaking spent fuel pool called the Expended Core Facility at the Naval Reactors Facility (NRF) area at the Idaho National Laboratory. While $ 1.65 billion has been funded for the new spent fuel facility, the old ECF is, unfortunately, still being used.

About 32 metric tons of spent fuel were stored at NRF at the end of 2016, with expected shipments to Idaho of between 0.5 and 2 tons added each year. The spent fuel at NRF is now mainly stored in dry storage at the NRF Overpack Storage Pack Storage Building and expansions, according to the 2017 U.S. Nuclear Technical Review Board report and the NWTRB 2020 factsheet. [1] [2] The number of metric tons of spent fuel in the ECF pool isn't specified but is unlimited and is probably over several metric tons, enough for serious radiological consequences.

The naval spent nuclear fuel shipped to Idaho is unloaded into the ECF pool, examined and prepared for packaging by sawing off endcaps which are radioactive and shallowly buried at the INL at either the Radioactive Waste Management Complex or its replacement at the ATR Complex to forever trickle radioactive waste into the Snake River Plain aquifer.

The fuel at ECF is then placed in a canister and then the canister is loaded into a concrete overpack for dry storage until someday an interim storage facility or geological repository becomes available. Dry storage in metal canisters of Three Mile Island spent nuclear fuel stored at the Idaho National Laboratory's Idaho Nuclear Engineering and Technology Center (INTEC) have been leaking and releasing airborne radionuclides to the environment for years. [3]

The Navy's Spent Fuel Handling Recapitalization Project [4] will incorporate the capabilities that currently exist in NRF's Expended Core Facility and its support facilities, but it will also

[1] U.S. Nuclear Waste Technical Review Board (NWTRB), Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel. Arlington, December 2017.

[2] U.S. Nuclear Waste Technical Review Board (NWTRB), Department of Energy-Managed Spent Nuclear Fuel at the Idaho National Laboratory, Factsheet, Revision 1, June 2020. https://www.nwtrb.gov/docs/default-source/facts-sheets/doe-snf-fact-sheet---idaho-rev-1.pdf?sfvrsn=8 NWTRB factsheets for DOE-managed spent nuclear fuel at the Idaho National Laboratory, Hanford Site, Savannah River Site and Fort St. Vrain can be found at the NWTRB website at https://www.nwtrb.gov/our-work/fact-sheets

[3] Department of Energy annual environmental report for 2004 admitted that the Three Mile Island dry spent fuel storage was a significant source of INTEC's estimated airborne radiological releases in its table of radionuclide composition of INEEL airborne effluents, Table 4-2. See Idahoeser.com.

[4] Department of Energy, Naval Nuclear Propulsion Program, Draft Environmental Impact Statement for the Recapitalization of Infrastructure Supporting Naval Spent Nuclear Fuel Handling, DOE/EIS-0453D, June 2015 at

provide the new capability to handle full-length aircraft carrier spent nuclear fuel that has been arriving in M-290 shipping containers at NRF's Cask Shipping and Receiving Facility. [5] The M-290 shipping containers are being used for defueling the eight reactors on the USS Enterprise aircraft carrier.

The 1995 Idaho Settlement Agreement requires spent fuel at the INL to be placed in dry storage by December 31, 2023. The spent fuel, except for new shipments of Navy fuel and newly generated spent fuel, are required to be removed from Idaho by 2035. [6] The Navy is allowed to continue receiving naval spent nuclear fuel from its nuclear-powered submarines and aircraft carriers.

The 2008 addendum to the 1995 Idaho Settlement Agreement requires all legacy naval spent nuclear fuel received prior to 2017 to be out of water pool storage by 2023; requires spent nuclear fuel after 2017 to be in water pool storage no longer than 6 years; limits the total volume of spent nuclear fuel allowed in storage after 2035 to be 9 metric tons heavy metal; continues to limit the annual shipment amounts of spent nuclear fuel to INL after 2035; and others. [7]

The Navy has been placing its spent nuclear fuel into dry storage canisters since 2003 and is on track to meet the 2023 milestone of the Idaho Settlement Agreement and Consent Order that requires transition from wet to dry spent nuclear fuel storage. Over 70 percent of the Navy spent fuel canisters already received at NRF had been loaded as of 2018, according to the 2018 NRF presentation to the Idaho LINE commission. Neither the Navy nor the Department of Energy's research and commercial spent nuclear fuel are on track to meet the 2035 milestone to leave the state: there's currently no repository to send the spent nuclear fuel to.

But despite the progress on transitioning to dry fuel storage, the 1957-vintage unlined spent fuel pool in the Expended Core Facility is still in use despite a long history of leakage, degradation and inadequate seismic design. The ECF has been subjected to very high radiation fields for decades which can cause a serious reduction in concrete compressive strength. [8] [9] The reduction in concrete strength further reduces seismic safety margin in structural design.

At a Hanford spent fuel facility, the concrete strength was estimated to have been reduced over 90 percent from its original strength because of years of high radiation gamma fields. Even

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https://www.energy.gov/nepa/downloads/eis-0453-final-environmental-impact-statement or http://www.ecfrecapitalization.us/ or https://www.energy.gov/sites/prod/files/2016/08/f33/EIS-0453-DEIS_Volume_I.pdf

[5] Idaho Leadership in Nuclear Energy (LINE) May 2018 meeting presentation by Naval Nuclear Propulsion Program https://line.idaho.gov/wp-content/uploads/sites/12/2019/01/2018-05-us-naval-nuclear-propulsion-program-slides.pdf

[6] 1995 Settlement Agreement and many addendums and memorandums can be found at https://www.deq.idaho.gov/inl-oversight/oversight-agreements/1995-settlement-agreement.aspx

[7] 1995 Idaho Settlement Agreement 2008 addendum for the Navy https://www.deq.idaho.gov/inl-oversight/oversight-agreements/2008-navy-addendum/ and see the Settlement Agreement and the list of addendums at https://www.deq.idaho.gov/inl-oversight/oversight-agreements/1995-settlement-agreement.aspx

[8] Dirk Dunning, PE, Oregon Department of Energy, Waste Encapsulation Storage Facility (WESF) [Hanford] – concrete gamma dose damage, February 13, 2018.

[9] D. L. Fillmore, Ph.D., Literature Review of the Effects of Radiation and Temperature on the Aging of Concrete, INEEL/EXT-04-02319, September 2004.

though the ECF is not densely packed the way commercial spent fuel pools are, a few metric tons of highly enriched high burn-up naval spent nuclear fuel still pose a significant hazard from spent fuel pool accident risks. Read Environmental Defense Institute comment submittals on our website. [10] [11] [12]

The Navy manages to create the impression of a responsible organization. Well, the Navy is *responsible*, specifically, for continuing to put Idaho at risk by continuing to use a leak-prone spent fuel pool built in 1957 to far less stringent seismic hazard requirements than are recognized as necessary today.

And the Navy is responsible for decades of significant airborne emissions from its operations including the airborne effluents from outdoor leaching ponds and its "industrial ditch"; radioactive liquid waste disposal into the Snake River Plain aquifer from the NRF facility leaching ponds and "industrial ditch," and also likely from liquid NRF waste transported to INTEC for deepwell injection; for the extensive airborne and aquifer radiological wastes from naval spent fuel reprocessing at the INL's Idaho Nuclear Engineering and Technology Center (INTEC); and for denying its workers access to Energy Employee Illness Compensation Program assistance, despite obviously high cancer rates for NRF workers and known extensive radionuclide contamination at the NRF facilities, inside and out.

Rising radiation-induced cancer mortality rates, all largely based on the studies of external radiation doses to World War II atomic bombing survivors

The study of radiation harm by the nuclear industry has historically focused on excess cancer mortality (death) risk. While the study of the survivors of the World War II bombing of Nagasaki and Hiroshima in 1945 is widely considered "the gold standard" for radiation-induced cancer studies, there's a wide range of estimated lifetime cancer mortality risk per radiation dose cited in Department of Energy documents, from 1.2 in 10,000 persons per rem to 5.5 in 10,000 persons per rem. See Table 1 for examples of radiation-induced cancer mortality risks in Department of Energy documents from 1985 to 2015.

These radiation-induced cancer excess rates have applied a low dose or low dose rate risk reduction factor known as the "DREF" to lower the results, usually dividing the acute dose risk

[10] Tami Thatcher, Environmental Defense Institute, Comments on the Recapitalization of Infrastructure Supporting Naval Spent Nuclear Fuel Handling at the Idaho National Laboratory, DOE/EIS-04553D, August 10 2015. http://www.environmental-defense-institute.org/publications/CommentsECF.pdf

[11] Chuck Broscious, Environmental Defense Institute, Comments on the Recapitalization of Infrastructure Supporting Naval Spent Nuclear Fuel Handling at the Idaho National Laboratory, DOE/EIS-04553D, August 17, 2015. http://www.environmental-defense-institute.org/publications/EDINRFcomments.pdf and http://www.environmental-defense-institute.org/publications/EDINRFcommentsAT.pdf

[12] Chuck Broscious, Environmental Defense Institute, Review of Naval Nuclear Propulsion Program NRF Spent Nuclear Fuel Handling and CERCLA Cleanup Radioactive Waste Management at INL, 2015 http://www.environmental-defense-institute.org/publications/NNPP-Report.pdf and http://www.environmental-defense-institute.org/publications/NNPP-ATTACH.pdf

predicted by the study of bombing survivors by a factor of 2. So, the acute dose cancer mortality risk per rem from the study of bombing survivors is actually from 2.2 in 10,000 persons per rem to 11 in 10,000 persons per rem.

Table 1. Comparison of various radiation-induced cancer fatality risk per rem levels cited in Department of Energy reports and other reports.

Study	**Radiation-induced cancer mortality (death) risk per rem**
1985 Chupadera Mesa and Near-by Areas Summary Review to Support the DOE Designation/Elimination Decision, November 1985	1.2E-4 fatal cancers per rem
2005 Type B Accident Investigation of the Americium Contamination Accident at the Sigma Facility, Los Alamos National Laboratory https://www.energy.gov/sites/prod/files/2014/04/f15/LANL_Am_Type_B.pdf	3.0E-4 fatal cancers per rem
2015 Department of Energy, Naval Nuclear Propulsion Program, Draft Environmental Impact Statement for the Recapitalization of Infrastructure Supporting Naval Spent Nuclear Fuel Handling, DOE/EIS-0453D, June 2015	5.5E-4 fatal cancers per rem
2006 National Academy of Sciences BEIR VII, 2006 4.8E-4 fatal cancers per rem for adult men; 6.6E-4 fatal cancers per rem for adult women	5.7E-4 fatal cancers per rem
1990 John W. Gofman's review of the atomic bomb study, both the original 1965 estimated doses and the 1986 modified doses and includes neutron dose corrections	26E-4 fatal cancers per rem

Table notes: All the estimates of radiation-induced cancer mortality risk are largely based on the study of World War II atomic bombing survivors. All the studies except Gofman's [13] have applied a dose reduction factor for slow dose or low dose, known as the "DREF" effectively cutting the mortality risk in half. The DREF is 2.0 except for the BEIR VII study, [14] which used a DREF of 1.5. The lifetime dose in rem is used with the cancer mortality risk. For 1.2 radiation-induced cancer deaths in 10,000 people per rem, 1.2E-4 fatal cancers per rem is indicated. In many cases, the Department of Energy report does not identify the source of the estimated radiation-induced cancer rate.

The problem with the reducing of fatal cancer risk by using the DREF is that strong and diverse human epidemiology continues to show that no reduction in the risk should be applied for doses below 10 rem or obtained slowly over time. The 2015 nuclear-industry funded study of

[13] John W. Gofman, M.D., Ph.D., Committee for Nuclear Responsibility, Inc., "Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis," 1990.

[14] "Health Risks from Exposure to Low Levels of Ionizing Radiation BEIR VII – Phase 2, The National Academies Press, 2006, http://www.nap.edu/catalog.php?record_id=11340 The BEIR VII report reaffirmed the conclusion of the prior report that every exposure to radiation produces a corresponding increase in cancer risk. The BEIR VII report found increased sensitivity to radiation in children and women. Cancer risk incidence figures for solid tumors for women are about double those for men. And the same radiation in the first year of life for boys produces three to four times the cancer risk as exposure between the ages of 20 and 50. Female infants have almost double the risk as male infants.

radiation workers by Richardson included low doses and doses obtained slowly over time and indicated no risk reduction factor should be applied. [15]

I have included John W. Gofman's higher estimate of cancer mortality risk per rem in the table as an independent analysis. [16] But all of the studies of the atomic bomb survivors are based on external radiation and may underestimate internal exposure from inhalation and ingestion of radionuclides and were limited to cancer risk.

Scientists at Los Alamos tested a plutonium nuclear weapon in New Mexico, without warning people who lived and ranched nearby, on July 16, 1945. This test is known as the Trinity Test, and it spread radioactive fallout that would still be prominent decades later. The elevated levels of plutonium, strontium-90 and cesium-137 are acknowledged by the Department of Energy, but DOE estimated in 1985 that living in the contamination would yield radiation doses less than the Department of Energy's acceptable level for the public of 100 mrem/yr.

In a summary of the DOE's 1985 report regarding the Trinity Test fallout in New Mexico, the report states: "The National Academy of Sciences has recommended use of the following risk factors:

For uniform whole-body dose

- 0.00012 fatal cancers per rem [or 1.2E-4 fatal cancers per rem]." [17]

Then, as always, the radioactive contamination from the Department of Energy polluting is compared to the risk of living with natural background radiation.

For Chupadera Mesa, the fallout from the 1945 Trinity test of a plutonium nuclear weapon, the 1985 Department of Energy study estimated that the added external radiation from the fallout from a 1-year occupancy would be 13 mrem/y whole body and 39 mrem bone dose – from just a 1-year occupancy. The report estimated the inhalation from resuspension, from foods and from gardening in radioactive dirt would not be much over 2 mrem/yr, whole body dose. Then they said the overall cancer mortality risk at Chupadera Mesa from the radioactive fallout would be low, a mere 1.8E-6 for each year lived there.

But the risk, just from external radiation is easily 10 times higher. And the risk from the inhalation and ingestion of radionuclides is thought by many independent experts to be considerably higher per rem of internal radiation.

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[15] 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 epidemiology study that included a cohort of over 300,000 nuclear industry workers has found clear evidence of solid cancer risk increases despite the average exposure to workers being about 2 rem and the median exposure was just 410 millirem. Also see December 2015 EDI newsletter.

[16] John W. Gofman, M.D., Ph.D., Committee for Nuclear Responsibility, Inc., "Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis," 1990.

[17] Wayne R. Hansen and John C. Rodgers, Radiological Survey and Evaluation of the Fallout Area from the Trinity Test: Chupadera Mesa and White Sands Missile Range, New Mexico, LA-10256-MS, UC-11, Issued June 1985. And Chupadera Mesa and Near-by Areas Summary to Support the DOE Designation/Elimination Decision, November 1985, p. 13.

The 1985 DOE report [18] is neat, tidy, organized and dead wrong about the actual health risks from breathing radioactive air, eating radioactive food and living in radioactive soil. Yet, the meticulous report is brimming with confidence, detailed accounting of radiation dose and risk and was officially U.S. government endorsed. The message is that if you have any sense, you can see that the risk of radioactive fallout on your land simply is not going to appreciably increase your cancer risk.

The 1985 Trinity report states that mortality from cancer in the U.S. is 20 percent lifetime cancer mortality (death) risk. This is consistent with what the American Cancer Society website states, that for 1991, the US cancer death rate was 21.5 in 10,000 people, each year. [19] If you live to be 100, this is roughly a 20 percent lifetime cancer risk.

The 2005 accident investigation of a Department of Energy facility in New Mexico, the Sigma facility at the Los Alamos National Laboratory (LANL), states that the cancer death rate is 25 percent. Yet, the American Cancer Society website says that the US cancer death rate in 2017 is 15.2 per 10,000 people, each year. If you live to be 100, that is only about a 15 percent lifetime cancer death rate, not 25 percent. The 2005 accident investigation report does not cite the source of its radiation-induced cancer rate estimates. The 2005 report is for a male worker, and so neglecting to mention the higher cancer risk to women and children might be forgiven.

But in the 1985 DOE report downplaying the risk to the public living on radioactively contaminated land from the Trinity nuclear bomb detonation in 1945 in New Mexico, neglecting the higher risks to women, to children and to the child developing in utero is a very serious problem, as studies conducted by the International Commission on Radiation Protection, the U.S. Environmental Protection Agency and the National Academy of Sciences would later find. The people living in the radioactive contamination would have also been interested in the radiation-induced risk of infertility, birth defects, lowered intelligence and other health risks.

One more thing about the 1985 DOE report about the contamination monitoring of areas near the 1945 Trinity test — Environmental monitoring was conducted by the Department of Energy in 1985 of fallout from the Trinity test and they found plenty of plutonium and other radionuclides. And they also detected some rather short-lived fission and activation products decades after the Trinity test, including cobalt-60 and zirconium-95, which DOE claimed was due to nuclear weapons testing by the Chinese. That cover story is commonly used in Idaho too. The fallout could have been from U.S. weapons testing in Nevada or tests by other countries, but I suspect that the cobalt-60 and zirconium-95 could have been from more recent DOE releases from separating higher actinides in New Mexico from 1970s or 1980s Department of Energy activities at Los Alamos National Laboratory or other military installations within 50 miles of the Trinity test site. [20]

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[18] Wayne R. Hansen and John C. Rodgers, Radiological Survey and Evaluation of the Fallout Area from the Trinity Test: Chupadera Mesa and White Sands Missile Range, New Mexico, LA-10256-MS, UC-11, Issued June 1985.

[19] American Cancer Society website, accessed July 27, 2020. https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2020/cancer-facts-and-figures-2020.pdf

[20] W. Muller et al., European Atomic Energy Community Euratom, *The Isolation of Americium and Curium from Irradiated Am-241 Targets*, EUR 4232 e, 1969. http://aei.pitt.edu/91432/1/4232.pdf See the gamma spectrometry chart for americium targets at Americium targets.

Rising radiation-induced cancer incidence rates and higher risks to women and children

Cancer mortality had once been the main focus in radiation protection, but by the late 1990s, there was growing awareness of increasing **cancer incidence risk** per unit dose of radiation documented in various studies. [21] [22] [23] In the early 1990s, International Commission on Radiation Protection report ICRP 60 estimated the rate of non-fatal cancer incidence to be roughly one fifth of the rate of fatal cancers.

By 1999 and further amplified in 2006, the radiation-induced cancer incidence risk from radiation would be recognized to be far higher. The 2006 National Academy of Sciences report known as BEIR VII estimated that the average fatal cancer risk was 5.7E-4 per rem and the cancer incidence risk from radiation for males was estimated at 9.0E-4 per rem and for women was 13.7E-4 per rem lifetime exposure for solid cancers and leukemia combined. Table 2 shows cancer incidence and cancer mortality from the 2006 BEIR VII report. [24]

Table 2. Radiation-induced cancer incidence and fatality estimates per rem, lifetime dose, BEIR VII report.

	Males, solid cancers	Females, solid cancers	Males, leukemia	Females, leukemia	Males, all cancers	Females, all cancers
Cancer incidence (fatal and non-fatal)	8E-4	13E-4	1.0E-4	0.7E-4	9E-4	13.7E-4
Fatal cancer only	4.1E-4	6.1E-4	0.7E-4	0.5E-4	4.8E-4	6.6E-4
Average fatal cancer only					5.7E-4	

Table notes: National Research Council, National Academy of Sciences, BEIR VII report, 2006. The average fatal cancer rate per rem, of 5.7 per 10,000 persons per rem is equivalent to 5.7E-4 fatal cancers per rem. The cancer estimates include a dose reduction factor of 1.5.

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[21] Keith F. Eckerman, Richard W. Leggett, Christopher B. Nelson, Jerome S. Puskin, Allan C. B. Richardson, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides: Radionuclides-Specific Lifetime Radiogenic Cancer Risk Coefficients for the U.S. Population, Based on Age-Dependent Intake, Dosimetry, and Risk Models*, Federal Guidance Report No. 13. EPA-402-R-99-001. Oak Ridge, TN, Oak Ridge National Laboratory, U.S. Environmental Protection Agency, September 1999. Known as "FGR 13."

[22] U.S. Environmental Protection Agency, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides: CD Supplement*. Federal Guidance Report 13. EPA-402-C-99-001, Rev. 1 2002. Known as "FGR 13 CD."

[23] U.S. Environmental Protection Agency, *EPA Radiogenic Cancer Risk Models and Projections for the U.S. Population*, EPA 402-R-11-001, April 2011. Known as the "Blue Book."

[24] Richard R. Monson (Chair) et al., *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII – Phase 2*, Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, Board on Radiation Effects Research, National Research Council of the National Academies, Washington, DC: National Academies Press, 2006. Known as "BEIR VII."

Before the late 1990s, radiation risks to females was generally treated as roughly equal to the radiation risks to males. But by the late 1990s, studies of the survivors of the atomic bombing of Japan in 1945 by the International Commission on Radiation Protection (ICRP) had higher radiation risk harm to women than men, for the same dose. And the studies showed higher cancer risk to children, especially female children, than to adults for the same dose. The National Research Council BEIR VII report issued in 2006 found even higher risks to women and children. See Institute for Energy and Environmental Research (IEER.org) report, *Science for the Vulnerable*, for additional insight. [25]

Table 3. Radiation-induced cancer (incidence) per rem, by age at exposure and gender, for some cancer types, 2006 BEIR VII report.

	Infant		Age 5 years		Age 30 years	
	Male	Female	Male	Female	Male	Female
Colon	3.36E-4	2.2E-4	2.85E-4	1.87E-4	1.25E-4	0.82E-4
Lung	3.14E-4	7.33E-4	2.61E-4	6.08E-4	1.05E-4	2.42E-4
Breast	N/A	11.71E-4	N/A	9.14E-4	N/A	2.53E-4
Thyroid	1.15E-4	6.34E-4	0.76E-4	4.19E-4	0.09E-4	0.41E-4
Leukemia	2.37E-4	1.85E-4	1.49E-4	1.12E-4	0.84E-4	0.63E-4
All solid cancers	23.26E-4	45.92E-4	16.67E-4	32.65E-4	6.02E-4	10.02E-4
All cancers	25.63E-4	47.77E-4	18.16E-4	22.77E-4	6.86E-4	10.65E-4

Source: BEIR VII, 2006.

The American Cancer Society website states that in the U.S. the annual cancer incidence (all causes) for 2012 to 2016 for males is 48.9 in 10,000 people (48.9E-4) and for women is 42.1 in 10,000 (42.1E-4) people, but there was no trend information on cancer incidence overall. [26]

Studies by the International Commission on Radiation Protection (ICRP) have been adapted into U.S. Environmental Protection Agency reports including Federal Guidance Report 13. The incorporation of the higher radiation-induced risks to women and children for cleanup standards for radioactively contaminated sites sounds beneficial. But in reality, the high costs of cleanup mean that EPA cleanup standards are not feasible to meet and are not met.

The ICRP, EPA's reports and BEIR VII are not independent of each other. And there is good reason to believe that external radiation cancer risk is still underestimated a few-fold and that

[25] Arjun Makhijani, Ph.D., Brice Smith, Ph.D., Michael C. Thorne, Ph.D., Institute for Energy and Environmental Research, *Science for the Vulnerable Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk*, October 19, 2006.

[26] American Cancer Society website, accessed July 27, 2020. https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2020/cancer-facts-and-figures-2020.pdf

internal radiation risk from breathing radiatively contaminated air and from ingesting radioactively contaminated food and water is still underestimated by a far larger amount.

And there is plenty of reason to be concerned about the nearly exclusive focus on cancer and the exclusion of other illnesses such as heart disease and also infertility, birth defects, lowered intelligence and multigeneration effects.

Department of Energy Issues Revised Dose Concentration Guidelines in 2011, loosening air and water contamination levels, ignoring elevated cancer risks

The Department of Energy issued a new Derived Concentration Technical Standard, DOE-STD-1196-2011 in 2011. [27] The Department of Energy did this while ignoring the higher cancer incidence and mortality risks estimated by the ICRP, the EPA and also in the BEIR VII 2006 report.

The Department of Energy is sticking to its assertion that 100 mrem/yr is acceptable, no matter what the health risk per rem is and no matter what the risk to women, children and the unborn are. I believe that the DOE will continue to assault current EPA drinking water limits that are generally based on 4 mrem/yr in order to allow DOE unfettered polluting ability. [28]

The Department of Energy's allowance of environmental contamination providing100 mrem/yr also ignores the fact that for some of these radionuclides have such long radioactive half-lives, that land and water will remain contaminated, essentially, forever.

The DOE's 2011 revised water and air concentration standards used more recent gender-specific physiological parameters and "the latest information on the energies and intensities of radiation emitted by radionuclides from a 2008 ICRP report." While the Department of Energy's 2011 update of its "derived concentration guidelines" for air and water radionuclide contamination uses the Environmental Protection Agency's 1999 Federal Guidance Report 13, the changes to the DOE Standard reflect different ingestion and inhalation rates, different distribution to organs and different biological clearance to estimate the dose. But no adjustment was made based in Federal Guidance Report 13 for the predicted higher cancer incidence and cancer mortality rates that will result from the 100 mrem/yr dose.

The Department of Energy is using the lower intakes of air, water and food than it had for "reference man" because of smaller expected intakes by women and children, and creating the

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[27] U.S. Department of Energy, DOE Standard, Derived Concentration Technical Standard, DOE-STD-1196-2011, April 2011. https://www.nrc.gov/docs/ML1332/ML13323B598.pdf or http://www.hss.doe.gov/nuclearsafety/ns/techstds/standard/standard.html Tissue weighting factor for thyroid is 0.05, although the format of its Table 2 is misaligned.

[28] U.S. Environmental Protection Agency drinking water standards for beta-emitting radionuclide limits were based on 4 mrem/yr. Alpha radiation of exceeding 15 picocuries/liter triggers uranium and radium analysis in public drinking water supplies. The uranium maximum contaminant level (MCL) is 30 micocuries/liter (which would be about 20 pCi/L for natural uranium) and radium-226 and radium-228, combined MCL is 5 pCi/L. With 1990's era methods, 10 pCi/L of uranium-238, 1.7 pCi/L plutonium-238 or 1.5 pCi/L of americium-241 would equate to 4 mrem/yr.

new "derived concentration guideline" that still results in a 100 mrem/yr dose this this gender-averaged, age-averaged recipient.

The Department of Energy never explained how the new air and water contamination values had changed. Neither did the Department of Energy explain how thyroid cancer incidence risk had greatly increased for many long-lived alpha emitters such as americium and plutonium based on the ICRP studies. The low tissue weighting factors for thyroid and breast mean that the whole body dose estimation isn't affected much by their increased dose conversion factors (seivert per becquerel or rem per microcurie).

The Department of Energy continues to pretend that delivering 100 mrem/yr to the general public would not be a health catastrophe. Even the 0.001 mrem/yr (whole body dose) they say they are delivering annually from the Idaho National Laboratory has doubled the thyroid cancer incidence rate in the counties surrounding the Idaho National Laboratory.

The Department of Energy's estimated releases and monitored radionuclide concentrations in air and water are compared to the Department Energy's "derived concentration guidelines." The DOE's "derived concentration guidelines" are intended to limit annual doses from breathing air or drinking water of 100 mrem/yr. Prior to the revision in 2011, the DOE's DCGs were based on DOE's different models and assumptions documented in in 1988 in DOE/EH-0070 and DOE/EH-0071. [29] [30]

The DOE derived concentration guideline for americium-241 in drinking water had been 30 pCi/L in the 1988 version but was raised to 170 pCi/L in the 2011 using DOE STD-1196-2011, see Table 4.

Table 4. Comparison of Department of Energy Radionuclide Derived Concentration Guidelines (DCG) for americium-241.

Air contamination guideline before 2011	Air contamination guideline of STD-1196-2011	Water contamination guideline before 2011	Water contamination guideline of STD-1196-2011
2.0E-14 uCi/ml Equivalent to 20,000 E-18 uCi/ml	4.1E-14 uCi/ml Equivalent to 40,000 E-18 uCi/ml Allows 2 times the contamination	3.0E-8 uCi/ml Equivalent to 30 pCi/L	1.7E-7 uCi/ml Equivalent to 170 pCi/L Allows over 5.6 times the contamination

Table notes: The Department of Energy's derived concentration guidelines changed with the 2011 STD-1196-2011 and for americium-241 allow more contamination following the 2011 changes. uCi/ml is microcurie/milliliter or E-6curie/E-3liters; pCi/L is picocurie/liter or E-12curie/liter. Actinides such as uranium, plutonium and americium are often reported in INL environmental monitoring reports using E-18 uCi/ml. The U.S. EPA air contamination limit for 10 mrem/yr is 4000E-18 uCi/ml and the EPA limit for drinking water is 15 pCi/L for total alpha, excluding uranium.

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[29] Department of Energy, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, July 1988.

[30] Department of Energy, *External Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0070, July 1988.

In 2005, the report for Hanford regarding how to understand radionuclide and chemical hazards, written by Argonne National Laboratory, [31] recognized that 1.5 pCi/L of Am-241 in water would yield a 4 mrem/yr dose; this equates to 37.5 pCi/L for a 100 mrem/yr dose (depending on solubility class).

The change from 30 pCi/L to 170 pCi/L for americium-241 in water is enormous. And given the long half-life of americium-241 and its decay progeny, this contamination would be forever.

DOE similarly raised the contamination allowed in water for other alpha emitters including curium, plutonium and uranium. The DOE's derived concentration guidelines average men with women and average children with adults to arrive at a single average value of lower inhalation and lowered ingestion. Although the derived concentrations for a few radionuclides such as carbon-14 became more restrictive, the Department of Energy's 2011 dose concentration guidelines are generally far less protective of everyone, and its new generally more permission air and water contamination levels are especially harmful to women, children, infants and the unborn.

Elevated radiation-induced thyroid cancer incidence in women ignored by Department of Energy regulations

Thyroid cancer has been recognized as a concern in communities near Department of Energy facilities, including Hanford. The Hanford Thyroid Disease Study was steered into finding no evidence of harm from Hanford releases, yet ignored the higher thyroid risks from americium and plutonium. [32]

The Federal Guidance Report No. 13 and the BEIR VII (2006) findings reveal that thyroid cancer incidence, especially in women, is higher than the former ICRP 30 prediction. The Hanford Thyroid Disease Study completed in 2002, focused exclusively on iodine-131 in its estimated dose and concluded that Hanford's iodine-131 releases had not increased thyroid incidence cancer rates because it did not find higher thyroid cancer rates where the iodine-131 doses were believed to be higher. The Hanford Thyroid Disease study ignored thyroid cancer incidence risk increases from other radionuclides including iodine-129 and others such as americium-241 and plutonium which were known by 1999 to pose a high thyroid cancer incidence risk.

In New Mexico, the recognized elevated incidence of thyroid cancer in Los Alamos County, especially in men who worked at Los Alamos National Laboratory, was steered to conclude that there was no problem due to LANL. In the Idaho National Engineering Laboratory Historical Dose Assessment, [33] the estimated thyroid and whole-body radiation doses omitted

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[31] ANL factsheet for Hanford, 2005 at https://www.remm.nlm.gov/ANL-ContaminationFactSheets-All-070418.pdf

[32] Center for Disease Control, Hanford Thyroid Disease Study webpage, accessed July 6, 2020. https://www.cdc.gov/nceh/radiation/hanford/htdsweb/library.htm

[33] 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

radionuclides, including americium-241 and underestimated radiological releases from the INL, finding the radiation doses were deemed too small to cause any concern.

The Department of Energy, while accepting lower tabulated radiation doses and focusing on whole-body doses exclusively, has remained silent on the increased thyroid cancer incidence rates from various alpha emitters, and especially americium-241. Due to the low tissue weighting value, whole body dose estimates are not affected much by the elevated thyroid doses.

A 2013 Pacific Northwest National Laboratory (PNNL) report incorporating Federal Guidance Report 13 tabulated whole body and organ specific dose conversion factors for an average half-male and half-female at various ages. [34] The 2013 PNNL report is to be used for calculating radiation dose but not the risk of higher radiation risks recognized in the EPA's 1999 Federal Guidance Report 13. Buried near the end of the PNNL report is a chart of how wildly increased the thyroid cancer incidence was for various radionuclides, by a factor of 10, of 100, of 1000, of 10,000 and of 100,000! See Figure 1.

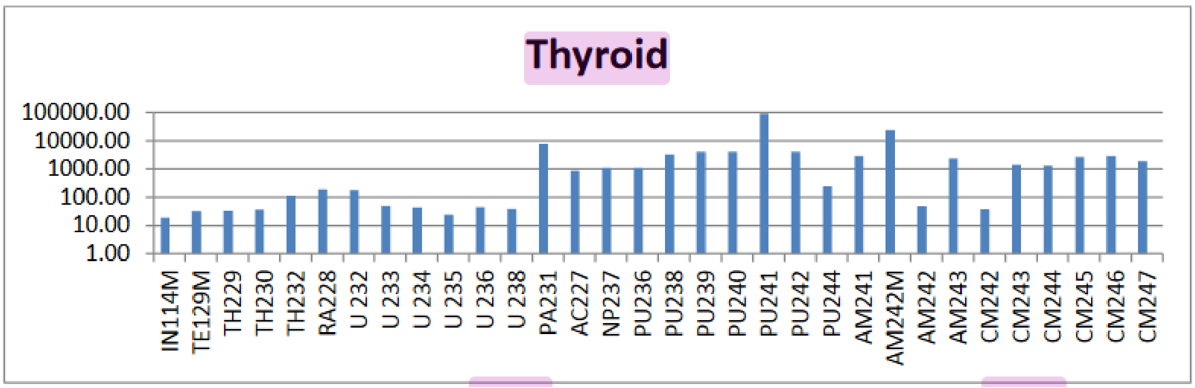

Figure 1. Ratio of the revised Federal Guidance Report (FGR) 13 thyroid dose conversion factors (DCFs) to the original Department of Energy (HUDUFACT.dat) thyroid DCF for radionuclides having the largest increases. (PNNL-22827)

The radionuclides in Figure 1 include thorium, uranium and uranium decay progeny, plutonium, curium and americium. The thyroid cancer incidence rate increase for plutonium-238, plutonium-239, plutonium-240, plutonium-241 and americium-241 is over 1000.

It is important to understand that for many years, releases of these various americium, curium and plutonium radionuclides were not stated or were understated by the Department of Energy in its environmental monitoring reports. The 1989 INEL Historical Dose Evaluation does not list americium-241 as a radionuclide that it released. Yet, there is evidence of extensive americium-241 contamination at INL facilities when CERCLA cleanup investigations were conducted in the early 1990s. I expect that Hanford, INL and Los Alamos all were releasing curium, americium,

[34] T.R. Hay and J.P. Rishel, Pacific Northwest National Laboratory, Department of Energy, *Revision of the APGEMS Dose Conversion Factor File Using Revised Factor from Federal Guidance Report 12 and 13*, PNNL-22827, September 2013. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22827.pdf

and plutonium radionuclides, even beyond what would be released by dissolving spent fuel, because of additional radiation target dissolution to obtain higher actinides for research and power sources.

In 1991, concern over perceived excess brain tumors in Los Alamos County led to a study which appears to have parsed the brain tumors into oblivion but did find a fourfold excess of thyroid cancer occurring during the late-1980s and continuing into 1993. [35]

While elevated levels of zirconium-95 and americium-241 could occur from nuclear weapons testing fallout or nuclear reactor fuel dissolution (intentionally or unintentionally), the elevated levels of these radionuclides can also result from irradiation target dissolution for plutonium-238 production or production of other higher actinides such as curium-244. These releases were usually considered "classified" and not reported.

At the Idaho National Laboratory, such releases have been extensive since at least the 1960s and are continuing. For many decades, the air monitoring that was conducted included only gross beta and did not monitor gross alpha in air.

Iodine-131 was the dominant focus for thyroid cancer studies and alpha emitters such as uranium, plutonium and americium were not considered relevant to thyroid cancer incidence. And for many years, cancer mortality (death) was the main focus and thyroid cancer often can be resolved with medical treatment and does not result in death.

Thyroid health issues are still very serious especially for the unborn child in terms of health and development. In addition, radiation doses affecting the thyroid of a child are far more carcinogenic for the same dose if received by an adult and this was apparent by 1999 even though the Department of Energy was delaying its implementation of this information.

Such releases are likely to have been occurring and in amounts higher than indicated by the Department of Energy, not only at the INL, but also from Hanford and from operations in New Mexico. In the thyroid cancer study in New Mexico, the thyroid cancers increased in the 1980s.

The thyroid cancer excess in New Mexico was found to be localized to Los Alamos County where the Los Alamos National Laboratory is located. Thyroid cancer incidence was found to be an unprecedented fivefold excess for men during 1988-1995 which "was distinguished not only by its magnitude and rapidity of onset, but also by a broad age distribution and a heterogenous mix of cell types, including two rarely diagnosed histologic forms." The men worked for LANL but typically had not grown up in Los Alamos County. The women experienced a 3-fold excess and included ages 30 to 59 years. The women's thyroid cancer was nearly all of one type, papillary carcinoma, which is associated with radiation exposure.

Had contamination from Los Alamos caused the excess thyroid cancers? The Department of Energy provided no environmental monitoring or environmental release information for the Los Alamos thyroid study. The Los Alamos thyroid study found that while many of the men were

[35] William F. Athas, Ph.D., New Mexico Department of Health, Investigation of Excess Thyroid Cancer Incidence in Los Alamos County, DOE/AL/75237—T1, Funded by the Department of Energy, April 1996. William F. Semantic Scholar, DOI: 10.2172/578910 https://www.semanticscholar.org/paper/Investigation-of-excess-thyroid-cancer-incidence-in-Athas/f477eef9d4f91697e0360eb2ab3f308dd1b35643

employed at the LANL, many had worked there for less than 2 years. The study said the men must have moved to LANL with their cancer. It also said the prevalence of overweight in the women meant some tendency to develop thyroid cancer. No stone was left unturned to discount the possibility that radiological releases from LANL had caused the cancers. And there was no recognition at that time of the far higher thyroid cancer risk from americium and plutonium contamination in air.

It is important to note that for the Hanford Thyroid Disease Study, there does not appear to be any recognition of the far higher thyroid cancer risk from americium and plutonium contamination in air. Total accumulated dose matters. This may explain why the exclusive focus on iodine-131 releases and their timing did not produce a dose response curve of higher disease rate in regions expected to have higher doses.

The counties near the INL have a 2-fold excess thyroid cancer rate. The counties also have blowing in the wind high levels of all manner of radionuclides, including iodine-131, iodine-129, (and a lot of airborne iodine-129 from the leaking Three Mile Island dry spent fuel canister), americium and plutonium.

Counties near the INL have double the thyroid cancer incidence while other counties in Idaho did not approach these high thyroid cancer incidence rates. The counties near the INL listed in the table are Butte, Bonneville, Madison, Jefferson, Bingham and Fremont counties, which ranged from 42.8 per 100,000 for Butte to 27.9 per 100,000 for Fremont. These cancer incidence rates are double, or more, the US and the Idaho state average for incidence of thyroid cancer which are 15.7 per 100,000 and 14.2 per 100,000. [36]

The Department of Energy's failure to discuss the new thyroid cancer incidence data shows how little they care about human health. And the change for acceptable contamination levels in water from 30 pCi/L to 170 pCi/L for americium-241 and raising the contamination concentrations allowed for other radionuclides is proof that the Department of Energy has no regard to human health.

Cancer Latent Period, Not Accurately Known

For ionizing radiation exposure, the time between exposure and appearance of cancer is known as the latent period. The latent period is usually defined as the time that an excess of cancers can be determined to be higher than the spontaneous rate of occurrence.

The latent period for solid cancers is often 10 years or longer; yet, shorter latent periods may occur. Often, radiation doses, even in medical radiation, are not accurately known.

[36] See Environmental Defense Institute newsletter for July 2020 article "Troubling Increases in U.S. Thyroid Cancer Incidence Rates; and Counties Around the Idaho National Laboratory Roughly Double State and National Cancer Rates," and chart of increasing americium-241 and plutonium releases from the INL.

The Center for Disease Controls National Institute of Occupational Safety and Health website for radiation-induced cancers website implies that generally that the latency period for most solid cancers was 20 years but was shorter, 10 years, for leukemia, bone or thyroid cancer. [37]

The NIOSH website states that for a radiation worker to be eligible for energy worker illness compensation, the minimum period that must have elapsed between the exposure and the disease for leukemia is at least 2 years from the first exposure. [38] While leukemia is more rare than solid cancer, leukemia is known to have a shorter latent period of only 3 to 5 years.

For irradiation of the unborn, however, the leukemia latent period can be even shorter.

The NIOSH website states that the minimum latency period for most other cancers, including thyroid cancer, is at least 5 years.

But a study conducted by Korea discusses a far shorter latency period for thyroid cancer, and considers the minimum latency period for thyroid cancer to be a mere 2 years. [39] This means that a worker with radiation-induced thyroid cancer may be denied compensation if the cancer developed in under 5 years. There is a worker illness compensation program for workers at Department of Energy facilities, under the Energy Employee Occupational Illness Compensation Program. But there is no similar program for other radiation workers at U.S. Nuclear Regulatory Commission (NRC) facilities or nuclear facilities not licensed by the NRC such as the US Ecology Idaho radioactive and hazardous waste dump at Grandview, Idaho. Nor is there compensation for the people living near (within 50 miles) of nuclear facilities.

Some studies of patients exposed to medical radiation would conclude that cancer risks had not increased, but they had followed a small number of patients for only a short time, less than a decade following irradiation.

In other cases, troops exposed to nuclear weapons testing in the 1950s and 1960s would be denied compensation or struggle to win compensation because their cancer did not appear soon enough. Their compensation would be denied because their cancer did not occur until 2 or more decades later.

The estimate of an appropriate latent period is often hampered by the lack of a reliable radiation dose estimate as well as the effort required to follow-up for many years. And deaths are not always recorded with the cause attributed to cancer.

When a cancer occurs years after exposure, and is a rare cancer type or location, then the radiation exposure can be attributed to the radiation exposure.

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[37] Center for Disease Control NIOSH-IREP Cancer Model https://www.cdc.gov/niosh/ocas/pccalc.html

[38] Center for Disease Control, National Institute for Occupational Safety and Health at https://www.cdc.gov/niosh/ocas/ocassec.html#cancers

[39] Eun-A Kim et al., *Annual Occupational Environmental Medicine*, "Probability of causation for occupational cancer after exposure to ionizing radiation," 2018. Doi: 10.1186/s40557-018-0220-5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5791729/ (This study was for the Korean Probability of Causation program.)

According the John W. Gofman, M.D., a cancer occurring within 5 years or after 40 years may be due to the damage caused to a single cell, repaired imperfectly, following radiation exposure. Within the first five years after the atomic bombing of Japan in World War II, no excess solid cancers occurred but leukemia excess did occur. Initially, there was hope that no excess solid (non-leukemia) cancer would occur in the A-bomb survivors, but that was not the case. The exposure from the bombing was acute and delivered all-at-once, yet most of the survivors had organ doses below an 11-rem organ dose. As the years went by, excess cancers did occur in the A-bomb survivors. [40] The study of the bombing survivors did not start until 5 years after the bombing.

There are many studies of the A-bomb survivors that have been published and the finding in each study can vary according to the years after the bombing as well as how the doses were estimated and what survivors were omitted from the study. John W. Gofman was aware that certain errors did require correction to original radiation dose estimates, yet he was dismayed at the large amount of unwarranted changes that were made which had the effect of knowingly lowering the radiation-induced cancer risk per unit dose due to driving interests by the Department of Energy. [41]

Articles by Tami Thatcher for August 2020.

[40] John W. Gofman, M.D., Ph.D.: *Radiation and Human Health*, Sierra Club Books, 1981.
[41] John W. Gofman, M.D., Ph.D., Committee for Nuclear Responsibility, Inc., "Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis," 1990.