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NuScale scales down SMR project planned for Utah Associated Municipal Power Systems (UAMPS) slated to be constructed at the Idaho National Laboratory

The NuScale small modular reactor project slated to be built at the Idaho National Laboratory has been cut in half, from 12 reactor modules to 6 reactor modules. [1] The electric energy per module in the design application is 50 MW per module but NuScale hopes to increase the allowable generation per module to 77 MW per module, and therefore expects the 6-module facility to generate 462 MW-electric. Subscribers have been found for only 103 MW. [2]

Last October, the City of Idaho Falls cut it commitment to the project in half, from 10 MW to 5 MW. NuScale received a commitment from the Department of Energy last year of $1.4 billion dollars.

NuScales's design application was approved by the U.S. Nuclear Regulatory Commission which didn't actually complete its review and left open important unresolved issues like the very unique heat exchangers. NuScale must also apply to the NRC for a license to construct and operate the facility and the NRC has stated that it is not a given that it will be approved.

When the Department of Energy issued its press release in August 2020 that said the U.S. Nuclear Regulatory Commission had approved the NuScale design, DOE's website stated "The final safety evaluation report [FSER] issued by the NRC is the first of its kind for a SMR and represents the technical review and NRC staff's approval of the NuScale SMR design." [3]

But the U.S. NRC's communications to the Idaho Leadership in Nuclear Energy Commission at its October meeting[4] and to NuScale in writing state that "… this SDA [standard design approval] does not constitute a commitment to issue a permit, design certification (DC), or license…." [5] [6]

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[1] *World Nuclear News* "Scaled down SMR pilot project remains on course," July 23, 2021. https://world-nuclear-news.org/Articles/Scaled-down-SMR-pilot-project-remains-on-course

[2] Kyle Pfannenstiel, *The Idaho Falls Post Register*, "Eastern Idaho reactor project downsized," July 18, 2021.

[3] U.S. Department of Energy, Office of Nuclear Energy, NRC Approves First U.S. Small Modular Reactor Design at https://www.energy.gov/ne/articles/nrc-approves-first-us-small-modular-reactor-design

[4] Doug Hunter, CEO and General Manager of Utah Association of Municipal Power Systems (UAMPS), presentation to the Idaho Line Commission CFPP [Carbon Free Power Project] October 14, 2020. https://line.idaho.gov/wp-content/uploads/sites/84/2020/10/2020-1014-cfpp.pdf

[5] U.S. Nuclear Regulatory Commission, Letter from Anna H. Bradford, NRC to Zackary W. Rad, NuScale Power LLC, Subject: Final Safety Evaluation Report for the NuScale Standard Plant Design, August 28, 2020 at https://www.nrc.gov/docs/ML2023/ML20231A804.pdf

Among the NuScale problems and NuScale's numerous exclusions to safety standards, the NRC was provided insufficient information from NuScale's design certification application [7] regarding: (1) the shielding wall design in certain areas of the plant; (2) the potential for containment leakage from the combustible gas monitoring system; and (3) the ability of the steam generator tubes to maintain structural and leakage integrity during density wave oscillations in the secondary fluid system…" [8] See a list of unresolved NuScale safety problems in the Environmental Defense Institute's November 2020 newsletter.

The projected date for the facility to operate is an optimistic 2029, but the project may be years away from submitting its application to NRC for a license to construct and operate the facility.

In addition to the NuScale SMR project with the Utah Associated Municipal Power Systems (UAMPS), which has no nuclear energy experience, NuScale is seeking potential opportunities around the globe — all in places which, like the U.S., have no spent nuclear fuel disposal capability and therefore will be trapped in the risky and expensive problem of storing the spent fuel indefinitely.

Fluor is NuScale's tapped out majority investor on the deployment of NuScale but Fluor has found a partner in Japan's JGC Holdings Corporation which will invest $40 million dollars. [9]

Many Radiation Workers and Nuclear Industry Professionals Don't Even Know How Much More Vulnerable Women and Children are to Ionizing Radiation

Nuclear reactors, nuclear fuel production and radioactive waste can release radionuclides to the environment from routine operations and from accidents. The health harm from nuclear reactors, other nuclear operations and from radiation material storage and disposal need an adequate radiation projection model. But are the radiation protection models and standards being used in the U.S. protective of human health?

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[6] U.S. Nuclear Regulatory Commission, Letter from Anna H. Bradford, NRC to Zackary W. Rad, NuScale Power LLC, Subject: Final Safety Evaluation Report for the NuScale Standard Plant Design, September 11, 2020 at https://www.nrc.gov/docs/ML2024/ML20247J564.pdf

[7] NuScale's Standard Plant Design Certification Application to apply for standard design approval can be found at https://www.nrc.gov/reactors/new-reactors/smr/nuscale/documents.html

[8] U.S. Nuclear Regulatory Commission, Letter from Anna H. Bradford, NRC to Zackary W. Rad, NuScale Power LLC, Subject: Final Safety Evaluation Report for the NuScale Standard Plant Design, September 11, 2020 at https://www.nrc.gov/docs/ML2024/ML20247J564.pdf (Don't bother looking at the letter NRC made easily accessible from its webpages for NuScale at https://www.nrc.gov/docs/ML2023/ML20231A804.pdf)

[9] *World Nuclear News*, "Japan's JGC invests in NuScale Power," April 6, 2021. https://world-nuclear-news.org/Articles/Japans-JGC-invests-in-NuScale-Power

The tighter the radiation standards, the less viable nuclear energy and radioactive material disposal options are. That is why the nuclear industry has always tried to keep control of the organizations that set radiation dose standards.

For federal projects involving large monetary expenditures, the Department of Energy is required to prepare a National Environmental Policy Act (NEPA) environmental impact statement which among other things, involves assessing the radiological impacts to the public and to workers. In the past, these assessments included health harm from cancer and leukemia risks and also from hereditary effects from exposure to radiation. In recent Department of Energy NEPA assessments, hereditary effects have not been included. (And I will discuss more about this in the next article.)

Mary Olsen of Gender and Radiation Impact Project and David Lochbaum are seeking to provide needed emphasis on the greater harm to females from radiation exposure in the July Nuclear Hotseat program, episode #525. [10] [11]

It needs to be understood that the use of Reference Man for radiation workers that allows 5 rem to an adult male or female worker and often has been implied as being protective to women, children and the unborn — but is not protective.

Young females, as Mary Olsen points out, are not just a subpopulation of the human race. The human race relies on healthy young females and they suggest the need for Reference Girl, because of the greater harm for the same exposure to radiation. On their website, it is also acknowledged that current protections for the unborn are inadequate.

Before the late 1990s, radiation risks to females were 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 found 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. [12]

No matter what the radiation standard, the adult male will be more protected than adult women, children or the unborn because women and children and especially the embryo or fetus

[10] Libbe HaLevy, *Nuclear Hotseat*, " 'Reference Man' Inadequate Radiation Model for Exposure of Girls, Women, Boys, by Mary Olsen of Gender and Radiation Impact Project, Dave Lochbaum, formerly of Union of Concerned Scientists," NH Episode #525, July 14, 2021. http://nuclearhotseat.com/2021/07/14/reference-man-standard-inadequate-for-women-girls/

[11] Mary Olsen, Gender and Radiation Impact Project and Beyond Nuclear, webpage "Reference Girl – We need a new definition for better protection," May 10, 2021 webpage. https://www.genderandradiation.org/reference-girl

[12] 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.

are more vulnerable to radiation exposure. [13] The 2006 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. So, female children are roughly 10 times more vulnerable to the cancer-causing effects of radiation than adult men.

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. [14] [15] [16] 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. But 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 1 shows cancer incidence and cancer mortality from the 2006 BEIR VII report for males and females. [17] Table 2 shows the 2006 BEIR VII report radiation-induced cancer incidence rate per rem, by age at exposure and gender, for some cancer types.

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[13] "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.

[14] 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."

[15] 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."

[16] 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."

[17] 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."

Table 1. 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. Fatal cancer rate is the cancer mortality rate. The incidence of cancer rate is the cancer morbidity rate. The BEIR VII cancer estimates include a dose reduction factor of 1.5.

Table 2. 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. [18]

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 the agencies will simply agree that the cleanup standards cannot 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 internal radiation risk from breathing radiatively contaminated air and from ingesting radioactively contaminated food and water is still underestimated by a far larger amount.

Despite the high rate of radiation-induced cancer incidence, 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 6.0 in 10,000 persons per rem. See Table 3 for examples of radiation-induced cancer mortality risks in Department of Energy documents from 1985 to 2020.

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 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.

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 radiation workers by Richardson included low doses and doses obtained slowly over time and indicated no risk reduction factor should be applied. [19]**

[18] 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

[19] 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.

Table 3. 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 [20]	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
2020 U.S. Department of Energy Versatile Test Reactor Draft Environmental Impact Statement (DOE/EIS-0542) at https://www.energy.gov/nepa	6.0E-4 fatal cancers per rem below 20 rem and 12.0E-4 fatal cancers at or above 20 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 [21] 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, [22] 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.

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[20] 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.

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

[22] "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.

The studies of the Japanese World War II bombing survivors of Hiroshima and Nagasaki are considered the "Gold Standard," however, the way the studies were conducted and manipulated has led to the underestimate of cancer mortality. I have included John W. Gofman's higher estimate of cancer mortality risk per rem in Table 3 as an independent analysis. [23]

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.

The nearly exclusive focus on cancer by the nuclear industry has meant actively ignoring the increase in other illnesses such as heart disease, compromised immune system, [24] shortened life span and also infertility, infant mortality, birth defects, lowered intelligence and multigeneration effects, due to radiation exposure.

The "International Commission on Radiation Protection" (ICRP) which has always underestimated the genetic harm of radiation exposure further reduced its estimates 6-fold in 2007 largely facilitated by ignoring relevant congenital malformations studies during the last several decades that would provide strong evidence to the contrary. (More about this in the next article.)

The Department of Energy is assessing the MARVEL nuclear reactor project [25] (see my comments to the draft and final environmental assessment [26] and an opinion piece by Ian Cotton of Snake River Alliance [27]) and the Versatile Test Reactor project [28] [29] [30] by ignoring the true

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

[24] See the April 2021 Environmental Defense Institute newsletter article by Tami Thatcher "With Southeast Idaho COVID-19 Hotspots, It's Time to Review the Effect of Radiation on the Immune System," http://www.environmental-defense-institute.org/publications/News.21.April.pdf

[25] Department of Energy, Final Environmental Assessment for the Microreactor Applications Research, Validation, and Evaluation (MARVEL) Project at Idaho National Laboratory, DOE/EA-2146, June 2021. https://www.id.energy.gov/insideNEID/PDF/DOE%20EA-2146%20Final%20Environmental%20Assessment%20for%20the%20MARVEL%20Project%20at%20INL.pdf and https://www.id.energy.gov/insideNEID/PDF/CLN211013%20signed%20final.pdf

[26] Public Comment Submittal from Tami Thatcher on the U.S. Department of Energy Draft and Final Environmental Assessment for the Microreactor Applications Research, Validation, and Evaluation (MARVEL) Project at Idaho National Laboratory, DOE/EA-2146, January 2021 at http://www.environmental-defense-institute.org/publications/CommentDOEMARVELdea.pdf and June 2021 at http://www.environmental-defense-institute.org/publications/CommentDOEMARVELfinalea.pdf

[27] Ian Cotton, Snake River Alliance, *The Idaho Falls Post Register*, "Opinion: Concerns with nuclear energy must be taken seriously," July 16, 2021.

[28] U.S. Department of Energy's Versatile Test Reactor Draft Environmental Impact Statement (VTR EIS) (DOE/EIS-0542) at https://www.energy.gov/ne/downloads/public-draft-versatile-test-reactor-environmental-impact-statement-doeeis-0542 (Announced December 21, 2020). A copy of the Draft VTR EIS can be downloaded at https://www.energy.gov/nepa or https://www.energy.gov/ne/nuclear-reactor-technologies/versatile-test-reactor.

[29] Public Comment Submittal from Tami Thatcher on the U.S. Department of Energy's Versatile Test Reactor Draft Environmental Impact Statement (DOE/EIS-0542), February 2021 at http://www.environmental-defense-institute.org/publications/CommentVTRdEIS.pdf and March 2021 with an emphasis on accidents at http://www.environmental-defense-institute.org/publications/CommentVTRdEIS2.pdf

radiation harm from chronic environmental radiological exposure harm in cancer and leukemia risks; heart disease, immune system and other life shortening diseases adversely influenced by radiation exposure; and by ignoring genetic risks and genomic instability.

While the annual dose limit to radiation workers in the U.S. is 5 rem and the Department of Energy claims to administratively require approval for annual doses above 2 rem per year, the annual dose and the cumulative lifetime dose must be considered.

The epidemiology study by Richardson 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. [31]

Doses to radiation workers have historically not been accurate and the doses less than 100 millirem per year to employees are basically considered nil and are not reported. Non-radiation workers such as secretaries working in the elevated background due to spent nuclear fuel facilities, breathing in radionuclides and drinking radioactively contaminated water may not even be monitored as DOE sought to cut costs on radiation badges at its INL facilities around 2005.

The annual dose limits to the public are typically 100 millirem per year but by eating a few ducks that have visited INL evaporation ponds laden with americium-241 and other radionuclides, a member of the public can easily exceed the 100 mrem/yr limit. Being near a radioactive shipment of spent nuclear fuel in a traffic jam will give you and your baby an unmonitored radiation dose for which there is actually no specific limit.

The point I want to make here is that you have to consider the annual dose, the age and gender of the person receiving the dose, and the cumulative dose over time, in order to begin to estimate the harm of the radiation to the human body.

In any release of radioactive material, there really is no thorough environmental monitoring to determine the inhalation, ingestion (food and water), cloud shine, or ground shine that a human being is actually exposed to.

The Department of Energy's Versatile Test Reactor draft Environmental Impact Statement provided a table of radiation exposure limits to members of the public and to radiation workers, which I provide below in Table 4a. But the reality is that the radiation limits are far more complicated and far less protective than they seem from the VTR EIS Table C-1. I provide a more comprehensive table of the patchwork of radiation standards in Table 4b below.

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[30] Public Comment Submittal from Chuck Broscious on the U.S. Department of Energy's Versatile Test Reactor Draft Environmental Impact Statement (DOE/EIS-0542), March 2021 at http://www.environmental-defense-institute.org/publications/EDI.Com.VTR.6.pdf

[31] 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.

Table 4a. Radiation exposure limits for members of the public and radiation workers (source for this table is the DOE Versatile Test Reactor draft Environmental Impact Statement, Table C-1)

Regulation or standard	Public Exposure Limit at the Site Boundary	Worker Exposure Limit
10 CFR Part 835 (DOE)	-	5,000 mrem per year (Note a)
DOE-STD-1098-2017 (DOE)		2,000 mrem per year (Note b)
DOE Order 458.1 (DOE) (Note c)	100 mrem per year (all pathways) 10 mrem per year (all air pathways) 4 mrem per year (drinking water pathway)	-
40 CFR Part 61, Subpart H (EPA)	10 mrem per year (all air pathways)	-
40 CFR Part 141 (EPA)	4 mrem per year (drinking water pathway)	-

Table notes: DOE, Department of Energy; EPA, Environmental Protection Agency; CFR, Code of Federal Regulations; mrem, millirem. Note a: "Although this measurement is a limit (or level) that is enforced by DOE, worker doses must be managed in accordance with as low as reasonably achievable principles. Refer to footnote b. Note b: This is an administrative control level; exceeding this level generally requires approval of senior management. DOE established this level to assist in achieving its goal of maintaining radiation doses as low as reasonably achievable. DOE recommends that facilities adopt a more limiting Administrative Control Level (DOE 2017). Facility operators must make reasonable attempts to maintain individual worker doses below these levels. Note c: Consistent with 10 CFR Part 20." Notes a, b and c are those stated in the VTR EIS.

The Department of Energy stating that it limits the drinking water radiation limit to 4 mrem per year to the public does not appear credible because this would imply a more stringent standard than the state and federal drinking water programs. The INL historically released to the Snake River Aquifer, often via deepwell injection, plutonium and uranium alpha emitters, tritium, iodine-129, strontium-90, cobalt-60, niobium-95 and other radionuclides which workers were drinking and which flowed downgradient in the aquifer to communities south of the INL including Atomic City.

Table 4b highlights the patchwork of radiation standards for the nuclear fuel cycle, for nuclear power plants, for radioactive waste disposal, and for radioactivity in air and water. It is sometimes a "bait and switch" situation as in U.S. Environmental Protection Agency legacy waste sites addressed under CERCLA cleanup laws. The EPA will emphasize that cancer incidence is considered, not just cancer mortality. And the EPA will emphasize that the goal is to remain at a very low lifetime risk level, below 10^{-4}. But in reality, the high cost of cleanup will mean that the cancer incidence risk is higher and often the EPA will say that the cleanup remedy was effective because humans will be prohibited from living at the toxic site. This is the situation for dozens of CERCLA cleanup sites at the Idaho National Laboratory.

Table 4b. Radiation exposure limits for members of the public and radiation workers in the U.S. (expanded but still only a partial listing).

Regulation or standard	Public Exposure Limit at the Site Boundary	Worker Exposure Limit	Lifetime Limit or Dose
10 CFR Part 835 (DOE)	-	5,000 mrem per year	Working from age 18 to 65, 65 rem lifetime, due to NCRP lifetime cumulative limit. (See note aa.)
DOE-STD-1098-2017 (DOE)		2,000 mrem per year (See note bb)	Working from age 18 to 65, if 2 rem/yr, 94 rem lifetime
DOE Order 458.1 (DOE) (Source: VTR EIS, Appendix C, page C-3.)	100 mrem per year (all pathways) 10 mrem per year (all air pathways) 4 mrem per year (drinking water)	-	Unlimited, but the dose at age 100 would be10 rem lifetime dose from all pathways. Eating water fowl that have visited Idaho National Laboratory evaporation ponds and you may have exceeded this annual limit. The drinking water on Department of Energy sites historically was not adequately monitored for chemicals or radionuclides. The INL and other sites are not required to monitor and report radionuclides in the drinking water because workers are not living there full time.
NRC	100 mrem/yr		Unlimited, but the dose at age 100 would be10 rem lifetime dose
40 CFR Part 61, Subpart H (EPA)	10 mrem per year (all air pathways)	-	At age 100, for air pathway of 10 mrem/yr, 1 rem lifetime. But the monitoring of emissions is not adequate to assure this, nor does it apply to accident conditions
EPA CERCLA cleanup	Formerly, 15 mrem per year for the assumed land use (farmer or rancher or resident, for example) has been used but lifetime cancer risk is preferred over a dose limit.		1 in 10,000 to 1 in 1,000,000 (10^{-4} to 10^{-6}) increased lifetime risk of getting cancer. The cancer incidence risk of 10^{-4} for the combination of radionuclides and toxic chemical remaining after

Regulation or standard	Public Exposure Limit at the Site Boundary	Worker Exposure Limit	Lifetime Limit or Dose
			cleanup is often not met. (See Note cc.)
40 CFR Part 141 (EPA)	Public drinking water 4 mrem per year beta/photon (drinking water pathway) Ra-226/228; 5 pCi/liter Uranium: 30 micrograms/liter Gross alpha: 15 pCi/L 50 picocuries per liter for beta radiation, 40 CFR 191.03(a)	-	At age 100, for drinking water pathway of 4 mrem/yr, would be 400 mrem lifetime but the radium, uranium, gross alpha doses must also be added to this.
EPA Spent Nuclear Fuel and High-Level Waste and TRU Waste See Yucca 40 CFR 197, 10 CFR 63 and others	In 2001, EPA created a 15 mrem/yr limit over 10,000 year compliance period. When the compliance period for Yucca Mountain was extended because of the millennia that the radioactive waste is toxic, the EPA set the limit after 10,000 years at 350 mrem/yr because the experts were convinced that the contaminant migration from Yucca Mountain would not stay below 15 mrem/yr. The EPA later reduced the 350 mrem/yr limit to 100 mrem/yr for the post-10,000 year compliance period. Subsequently, unrealistic models were used to lower the predicted doses from Yucca Mountain to make it appear that stringent dose limits would be met.		The EPA's radiation protection standards have been reduced at times because of nuclear industry pressure. Average doses from repositories have been used, leaving untold years of higher contamination and doses exceeding the annual limit. There is no EPA limit for the buried waste at the Idaho National Laboratory after 10,000 years. DOE allows 30 mrem/yr dose from water ingestion near the Radioactive Waste Management Complex burial grounds after 10,000 years. But the dose will be significantly higher if the soil cap over the waste is not perfectly maintained for millennia.
EPA Uranium Fuel Cycle 40 CFR 191.03 (a)	25 mrem/yr (whole body), 75 mrem/yr thyroid, 25 mrem/yr per other critical organ.		

Regulation or standard	Public Exposure Limit at the Site Boundary	Worker Exposure Limit	Lifetime Limit or Dose
NRC Decommissioning	25 mrem/yr or 100 mrem/yr		Unlimited, but for 100 mrem/yr, the dose at age 100 would be10 rem lifetime dose
None	Unmonitored dose from transportation of radioactive materials by trucks, trains, etc.	-	Unlimited
None	Unlimited and unmonitored dose from accidents	-	Unlimited until evacuation or forced relocation
None	Medical radiation cumulative dose is not tracked, even for irradiation of highly radiosensitive breast tissue	-	Estimates of lifetime medical radiation dose can easily be above 10 rem lifetime

Table notes: DOE, Department of Energy; EPA, Environmental Protection Agency; CFR, Code of Federal Regulations; mrem is millirem; 1000 mrem is equal to 1 rem. DOE Orders and Standards are not considered mandatory by DOE and the Secretary of Energy can choose whether or not to meet them. Monitoring programs are generally inadequate to show that worker and public exposure limits are met. Note aa: Using the cancer mortality rate of 6.0E-4 per rem, a person with 65 rem lifetime, (not using the low dose rate increase factor of 2) would have a cancer mortality risk of 65 rem multiplied by 6E-4/rem equal to 0.039 or roughly 4 percent. Using Gofman's 26E-4 per rem, the cancer mortality risk is almost 17 percent. Note b: The DOE allows this administrative control level of 2 rem to be exceeded whenever inconvenient to stay below 2 rem or if an exposure above 2 rem has occurred. Note cc: EPA CERCLA cleanup standards are highly variable and depend on the evaluation methods, the land use assumptions and the cost of cleanup. To get an idea of how convoluted the EPA cleanup standards, in practice, see this 2007 *Radiation Site Cleanup: CERCLA Requirements and Guidance* presentation at https://semspub.epa.gov/work/HQ/190132.pdf . This presentation also lists uranium mill tailing EPA, radon, and building habitability standards yet is only a partial listing of the patchwork of regulatory standards for radiation.

The general focus of the radiation standards is on cancer mortality or cancer incidence. The lifetime cancer risk depends on the cumulative dose and often the worker and public radiation "protection" standards allow excessive cancer risk over a lifetime. The standards also allow harmful doses of radiation to children and the unborn child *in utero*.

The Department of Energy released millions of curies of radionuclides to the skies especially in the early years of the operation of the Idaho National Laboratory. People suspected excess cancers were occurring, especially as children were dying of cancer. But the Department of Energy was successful in preventing the Center for Disease Control from conducting meaningful epidemiology in southeast Idaho. In one study comparing workers to the general population, cancer excesses were left unexplained.

It is not just the Department of Energy that has sought to avoid adequate epidemiological studies near its nuclear facilities. The US Nuclear Regulatory Commission refuses to fund epidemiology studies near US nuclear power plants. It is obvious to me that the NRC understood that valid, well-designed epidemiological studies would make it harder or impossible to build new nuclear plants.

The framework for a proposed study was reported in "Analysis of Cancer Risks in Populations Near Nuclear Facilities; Phase I (2012). [32] After 5 years in planning for the study, the NRC has now decided it would take too long and cost too much.

The NRC issued a statement [33] explaining their decision which included this excuse: "For example, the German study initially found an association of increased childhood leukemia risk within 5 kilometers of the facilities. However, upon examination of the offsite exposures, the authors concluded the increased risk could not be explained by the releases from the facilities." In other words, it couldn't happen, so it didn't.

Epidemiology conducted in Europe includes the study known by its German acronym KiKK (Kinderkrebs in der Umgebung von Kernkraftwerken). The KiKK study on Childhood Cancer in the Vicinity of Nuclear Power Plants, completed in 2007 is scientifically rigorous and statistically sound and its peer reviewed results show significantly elevated cancer risk for children under five years of age living within 5 km of a nuclear power plant. The study looked at childhood leukemia and cancer near nuclear plants from 1980 to 2003.

In Illinois, near the Braidwood and Dresden nuclear power plants, one family learned that many children in the area had cancer, brain cancer, and leukemia, after their daughter Sarah was diagnosed with brain cancer when she was seven. [34] Cindy and Joe Sauer lived in the area of these reactors from 1998-2004. Joe Sauer, a medical doctor, conducted his own epidemiology study which showed clear increases in childhood cancers near the plants. Read his findings of elevated brain and other cancers near these plants and other studies. [35] [36]

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[32] See cancer risk study at nap.edu.

[33] NRC Policy Issue Information SECY-15-0104, August 21, 2015 "Analysis of Cancer Risks in populations Near Nuclear Facilities Study," http://pbadupws.nrc.gov/docs/ml1514/ML15141A404.pdf

[34] Read about Cindy and Joe Sauer and what they learned about childhood cancer near nuclear power plants: http://ieer.org/resource/commentary/on-life-near-two-nuclear-power-plants-in-illinois/ and read Joe Sauer, MD, presentation on elevated cancer rates near the Dresden and Braidwood nuclear plants at http://ieer.org/wp/wp-content/uploads/2013/06/Health-Concerns-and-Data-Around-Illinois-Nuclear-Plants-slides-for-SDA-2013.pdf

[35] Dr. Paul Dorman, "Why UK nuclear power plants may cause childhood cancer and leukaemia," May 16, 2011, https://www.escosubs.co.uk/theecologist/promotion.asp?code=RF2011ROW

[36] Steve Wing, David B. Richardson, Wolfgang Hoffman, "Cancer Risks Near Nuclear Facilities," Environ Health Perspect. 2011;119(4):417-421.

Department of Energy's Ridiculous Statements About VTR Radiation Harm

The Department of Energy's Versatile Test Reactor Environmental Impact Statement actually implies radiation doses below 1000 rem are not harmful.

The VTR EIS doubles down on general Department of Energy ignorance of radiation health by saying, for an individual, that **"Unless the exposure is quite high (~ 1000 rem), the expected LCF [latent cancer fatalities] would be 0."** (See Appendix D, pages D-66 and D-67)

But the VTR EIS statement is ridiculous as well as false because a radiation dose received in an acute dose is known to have an LD50 of 300 to 400 rad, meaning 50 percent of adults receiving this dose would die within 30 days. The VTR EIS has made quite a remarkable error and exaggeration as to the nature of a 1000 rem whole body dose. See many sources, including *Radiobiology for the Radiologist*, by Eric J. Hall, 5th ed., 2000, p. 134.

With the predicted 790 rem dose to a hypothetical member of the public 3.1 miles from the reactor, to the MEI, from a VTR accident being so high, the Department of Energy tried to try to give the impression that doses up to 1000 rem have negligible harm and negligible latent cancer fatality risk. But it is true that a person standing at 3.1 miles (or closer) to the VTR for plume passage from the destroyed reactor, dead within weeks of the accident, is not going to develop cancer.

With the VTR EIS assumed latent cancer fatality risk of 0.0006 LCF per rem, a person (who is an average of male and female and an average of young and old age) if exposed to 1000 rem would have a cancer mortality risk greater than a probability of 1.0.

The latent cancer probability for one person exposed to 1000 rem (whole body), the dose in rem is multiplied by 0.0006 LCF/rem and also multiplied by 2 for exposures over 20 rem (see VTR EIS Appendix C, page C-4), which would equal 1.2 LCF.

1 person x 1000 rem x 6.0E-4 LCF/rem x 2 $_{\text{for exposures over 20 rem}}$ = 1.2 cancer fatalities

This is the cancer mortality probability, greater than 1, that the Department of Energy has called out in the Versatile Test Reactor EIS as being "0".

And while Idaho is relatively low in population, more than one person is going to be receiving the very high Versatile Test Reactor accident doses: the acute fatalities and the latent cancer fatalities will be numerous, something not acknowledged by the VTR EIS when it proclaims than doses, unless above 1000 rem, will create "0" latent cancer fatalities.

Even if the current nuclear industry promoted radiation protection models were adequate, the statements in the Department of Energy's Versatile Test Reactor Environmental Impact Statement that try to say any dose below 1000 rem would not be a health catastrophe are false.

Well known acute radiation syndrome conditions that often cause death are described in Table 5.

Table 5. Acute radiation syndrome.

Radiation Dose	Condition
Dose above 10,000 rad	Death within 24 to 48 hours from neurologic and cardiovascular breakdown, or "cerebrovascular syndrome" or "vascular syndrome"
Dose 500 to 1200 rad	Death within days, extensive bloody diarrhea and destruction of the gastrointestinal mucosa, or "gastrointestinal syndrome"
Dose 250 to 500 rad	Death may occur within several weeks and is caused by effects on the blood forming organs and this is known as bone-marrow death or "hematopoietic syndrome"

Table source: *Radiobiology for the Radiologist*, by Eric J. Hall, 5th ed., 2000. Many other information sources are similar and radiation absorbed dose (rad) rather than rem is used. For gamma-rays or x-rays and evenly distributed dose over the whole body, rad may be considered roughly equivalent to rem. Relating the rad to the rem (or Sievert), however, is problematic. The rem dose considers the radiation quality of neutrons, alpha particles, etc. and the distribution throughout the body. The rem, for internal radiation, also considers the biological clearance times of the radionuclide from the body. The rem also includes subjective numerical watering-down factors based on opinions about the cancer fatality producing experience of the radionuclide in the conversion factors for curie per rem and erroneous organ or tissue weighting factors used to determine whole body rem dose.

And as for the genetic harm, which the VTR EIS assumes is far lower than the latent cancer fatality risk, the VTR EIS ignores genetic effects of radiation exposure except to say on page C-2 of Appendix C states that radiation is more likely to produce somatic effects such as cancer than genetic effects which affect descendants of the exposed individual.

Human Evidence That Genetic Effects of Radiation Are Far More Likely Than ICRP Predicts

Anyone who has ever been a radiation worker in the US has been told repeatedly that, despite the known genetic damage to fruit flies from radiation exposure, no genetic consequences have ever been documented in humans.

Concern over genetic harm from radiation exposure was basically alleviated by the studies of World War II nuclear bomb survivors of the bombing of Nagasaki and Hiroshima in August 1945 which would proclaim that genetic effects were not found. It was thought by experts that perhaps the doubling dose for genetic effects was near 200 rem but the average radiation dose to bombing survivors was about 40 rem. [37]

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[37] James N. Yamazaki with Louis B. Fleming, *Children of the Atomic Bomb – An American Physician's Memoir of Nagasaki, Hiroshima, and the Marshall Islands*, Duke University Press, 1995. p. 124 and 132. This book tells the important story of the human dimension of the bombing, but does echo the unreliable claims of no genetic harm.

From the World War II nuclear bombing of Japan's cities of Nagasaki and Hiroshima, the studies of survivors who were in the womb at the time of the bombing, some had received fetal exposures that caused microcephaly and sometimes also mental retardation. For children conceived after the bombing, it should be noted that about 150,000 children of the survivors never came to the clinics to be examined (Yamazaki, p. 122).

It has been known now for a few decades that radiation exposure to the developing embryo and fetus "can cause growth retardation; embryonic, neonatal, or fetal death; congenital malformations; and functional impairment such as mental retardation." [38]

In 2007, the International Commission of Radiological Protection (ICRP) lowered its estimate of the risk of genetic harm of congenital malformations by 6-fold, from 1.3E-4/rem to 0.2E-4/rem. Based on the belief that the study of the Japanese bomb survivors did not detect genetic effects, **the ICRP genetic effect estimate for humans is based on studies of external radiation of mice.**

The ICRP estimate of risk of congenital malformations is a fraction of its predicted cancer risk for cancer mortality (or latent cancer fatality). The ICRP latent cancer fatality risk was 5.0E-4 LCF/rem (1991 estimate), close to the cancer mortality rate used in the Department of Energy's Versatile Test Reactor EIS of 6.0E-4 LCF/rem. [39]

While the studies of genetic injury to the Japan bombing survivors declared that they found no evidence of genetic damage, other researchers have found those studies to have been highly flawed. A report published in 2016 by Schmitz-Feuerhake, Busby and Pfugbeil summarizes numerous human epidemiology studies of congenital malformations due to radiation exposure. [40]

The 2016 report disputes the ICRP genetic risk estimate and finds that diverse human epidemiological evidence supports a far higher genetic risk for congenital malformations. **Nearly all types of hereditary defects were found at doses as low as 100 mrem.** The pregnancies are less viable at higher doses and so the rate of birth defects appears to stay steady or falls off at doses above 1000 mrem or 1 rem. The 2016 report found the excess relative risk for congenital malformations of 0.5 per 100 mrem at 100 mrem falling to 0.1 per 100 mrem at 1000 mrem.

The 2016 report's result for excess relative risk of congenital malformations of 5.0/rem is 250,000-fold higher than the ICRP estimate of 0.2E-4/rem which ICRP appears to assume has a linear dose response. See Table 6 for a comparison of the risk of congenital malformations.

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[38] Eric J. Hall, *Radiobiology for the Radiologist*, 5th ed., 2000, p. 190.

[39] U.S. Department of Energy's Versatile Test Reactor Draft Environmental Impact Statement (VTR EIS) (DOE/EIS-0542) (Announced December 21, 2020). A copy of the Draft VTR EIS can be downloaded at https://www.energy.gov/nepa or https://www.energy.gov/ne/nuclear-reactor-technologies/versatile-test-reactor. (See discussion in VTR EIS Appendix C, page C-4).

[40] Inge Schmitz-Feurerhake, Christopher Busby, and Sebastian Pflugbeil, *Environmental Health and Toxicology, Genetic radiation risks: a neglected topic in the low dose debate*, January 20, 2016. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4870760/ The 2016 report found the "excess relative risk for congenital malformations of 0.5 per mSv at 1 mSv falling to 0.1 per mSv at 10 mSv exposure and thereafter remaining roughly constant."

Table 6. Excess relative risk of congenital malformations (CM).

Source	CM Risk/Sievert	CM Risk/mSv	CM Risk/mrem	CM Risk/rem
ICRP 1990 based on mice	1.3E-2/Sv	1.3E-5/mSv	1.3E-7/mrem	1.3E-4/rem
ICRP 2007 based on mice	0.2E-2/Sv	0.2E-5/mSv	0.2E-7/mrem	0.2E-4/rem
2016 report by Schmitz-Feurerhake, Busby, and Pflugbeil based on human epidemiology At 100 mrem	500/Sv	0.5/mSv	0.5E-2/mrem	5.0/rem
2016 report by Schmitz-Feurerhake, Busby, and Pflugbeil based on human epidemiology At 1000 mrem	100/Sv	0.1/mSv	0.1E-2/mrem	1.0/rem

Table source: Inge Schmitz-Feurerhake, Christopher Busby, and Sebastian Pflugbeil, *Environmental Health and Toxicology*, *Genetic radiation risks: a neglected topic in the low dose debate*, January 20, 2016. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4870760/ The 2016 report found the "excess relative risk for congenital malformations of 0.5 per mSv at 1 mSv falling to 0.1 per mSv at 10 mSv exposure and thereafter remaining roughly constant." Table notes: Sievert (Sv), millisievert (mSv); millirem (mrem); International Commission on Radiological Protection (ICRP). 1000 milliSievert equals 1 Sievert which equals 100 rem which equals 100,000 millirem. 1 mSv equals 100 mrem.

Now if this sounds impossible, remember that the birth effects were known to be elevated near the Department of Energy's Hanford site and those workers annual doses were typically not above 5 rem per year.

Plutopia [41] documents the elevated percentage of deaths among infants in the Richland population in the 1950s. Elevated fetal deaths and birth defects in Richland were documented by the state health reports, yet Hanford's General Electric doctors and the Atomic Energy Commission that later became the Department of Energy failed to point these statistics out. The local newspapers failed to write of it. The Department of Energy has continued to fail to tell radiation workers and the public of the known risk of increased infant mortality and increased risk of birth defects that result from radiation exposure.

It must be remembered that, in addition to genetic effects, there is also harm to the unborn exposed to radiation in the womb including infant death, microcephaly, retardation, Down's syndrome, cancer and leukemia. Intake of radioactive iodine also damages the embryo/fetus thyroid and causes failure to thrive.

The finding of excess infant deaths near the Department of Energy Savannah River site around the 1970s and near the 1979 Three Mile Island nuclear accident are described in Jay Gould's book *Deadly Deceit*. [42]

The Department of Energy support for and subsequent squelching of Hanford radiation worker epidemiology studies are described in Gayle Greene's *The Woman Who Knew Too Much – Alice Stewart and the Secrets of Radiation*. [43] Alice Stewart is famous for the unexpected finding that very small external x-ray medical radiation doses to pregnant woman in the 1950s increased the risk of childhood cancer and leukemia.

The importance of chronic internal radiation from inhaling and ingesting radionuclides in the environment from contaminated cannot be overstated because many radionuclides such as uranium and strontium-90 are known to bind to DNA.

Time magazine recently mentioned Julian Aguon's book *What We Bury At Night*, a chronicle of how irradiated Marshallese mothers had borne "jellyfish babies" with translucent skin and no bones. From 1946 to 1958, the U.S. tested 67 nuclear weapons in the Marshall Islands near Guam. Official reports omitted the truth of the birth defects.

For more information about the health effects and after math from the U.S. bomb tests over the Pacific islands and the repeated deceptions about the consequences, read Giff Johnson, *Don't Ever Whisper —Darlene Keju, Pacific Health Pioneer, Champion for Nuclear Survivors*. [44] Sadly, the problems for the Marshallese continue to this day, even as some Marshallese have

[41] Kate Brown, *Plutopia – Nuclear Families, Atomic cities, and the Great Soviet and American Plutonium Disasters,* Oxford University Press, 2013. ISBN 978-0-19-985576-6. Note that many publications use spelling variation Mayak instead of Maiak.

[42] Jay M. Gould and Benjamin A. Goldman, *Deadly Deceit – Low Level Radiation High Level Cover-Up,* Four Walls Eight Windows New York, 1990. ISBN 0-941423-35-2.

[43] Gayle Greene, *The Woman Who Knew Too Much – Alice Stewart and the Secrets of Radiation,* University of Michigan, 1999. ISBN 0-472-08783-5.

[44] Giff Johnson, *Don't Ever Whisper – Pacific Health Pioneer, Darlene Keju, Champion for Nuclear Survivors*, 2013. ISBN-10: 1489509062.

been brought to live in Arkansas because their islands remain too contaminated and environmental remediation was ineffective and becoming more so with rising sea levels. [45] [46]

Articles by Tami Thatcher for August 2021.

[45] Olivia Paschal, *FacingSouth.org*, "The long road to nuclear justice for the Marshallese people," April 2, 2021. https://www.facingsouth.org/2021/04/long-road-nuclear-justice-marshallese-people The U.S. conducted 67 nuclear weapons tests near the Marshall Islands from 1946 to 1958. The largest test was the Castle Bravo conducted on March 1, 1954.

[46] Olivia Paschal, *FacingSouth.org*, "Arkansas Marshallese commemorate 75th anniversary of U.S. nuclear testing," July 13, 2021. https://www.facingsouth.org/2021/07/arkansas-marshallese-commemorate-75th-anniversary-us-nuclear-testing