Environmental Defense Institute

News on Environmental Health and Safety Issues

January 2024 **Volume 35** **Number 1**

Watch the movie about Oppenheimer - Then think about the WWII atomic bombings of Nagasaki and Hiroshima and the escalation of nuclear weapons

J. Robert Oppenheimer was the first director of the Los Alamos Scientific Laboratory and in charge of designing the first nuclear weapons. Oppenheimer is thought of as the "father of the atomic bomb." [1] There has been some criticism that the movie about J. Robert Oppenheimer did not give enough attention to the human loss and suffering that was caused by dropping two atomic bombs on Japan in 1945 during World War II. [2] [3] It is true that the movie does not dwell on the horrors of the two atomic bombs dropped on Japan during World War II in 1945. The movie does present the number of casualties, both immediate and within a few weeks and hints at the devastation. Importantly, the movie includes Oppenheimer's growing regrets and concerns about unleashing atomic weapons and the push to build more powerful nuclear weapons.

Oppenheimer's challenge was to lead the effort to design and built the atomic weapons, but it was not his choice to deploy the weapons on Japan — it was the U.S. president as prompted by the military that made that choice.

The times that led to the U.S. developing atomic weapons were extraordinary. During WWII, there was fear that the Nazi's would make an atomic bomb and the race to design and build atomic weapons was launched.

In the U.S., there were two competing atomic bomb designs: the plutonium bomb and the uranium-235 bomb. No one was certain which one could be produced the quickest or whether either of the weapons could be designed and built. The plutonium bomb was made from plutonium produced in new nuclear reactors at the Hanford site in Washington state. The uranium-235 bomb was made from uranium enrichment operations at the Oak Ridge National Laboratory. The program to create the first nuclear weapons was done secretly and caused the

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[1] Arjun Makhijani, Howard Hu, and Katherine Yih, *Nuclear Wastelands – A Global Guide for Nuclear Weapons Production and Its Health and Environmental Effects*, The MIT Press, 2000. ISBN 0-262-13307-5

[2] Movie Title: *Oppenheimer*, written for the screen and directed by Christopher Nolan, Oppenheimer is played by Cillian Murphy, Universal Studios, 2023.

[3] Breakfast Briefing, People Talk, *The Idaho Falls Post Register*, "'Oppenheimer' will get a theatrical release in Japan," December 8, 2023. There were criticisms in Japan for what many described as minimizing the Hiroshima and Nagasaki bombings. Ultimately the Japanese distributor Bitters End concluded that the movie should be seen.

U.S. military budget to mushroom from $1.9 billion in 1940 to $59.8 billion by 1945, a time when a billion dollars bought far more than it does today. [4]

The effort to make the first atomic weapons involved the most brilliant minds in physics. The achievement was marked by the first atomic bomb tested in the United States, in New Mexico. The test site selected was near Alamogordo which was not at or too near Los Alamos. Los Alamos was the remote bomb research location near Santa Fe, New Mexico, selected in 1942, where Oppenheimer led efforts to design and build the first atomic bombs.

Robert Oppenheimer named that first nuclear weapons test conducted July 1945, “Trinity.” Radioactive fallout and subsequent illness and death of citizens living near the Trinity test near Alamogordo is something the U.S. government has long sought to deny. With radioactive contamination, the dead bodies can take months and years to stack up and accurate counting these deaths is easily avoided. The monitoring of radioactivity in the environment, released from atomic weapons tests and other operations, is typically inadequate by design, now as it was in 1945, and also subject to coverup if unfavorable, now as it was in 1945.

The movie also presents the concern the physicists had — that an atomic explosion could end the world. This seems preposterous especially now after so many atomic bomb tests have been conducted by the United States, Russia, China, France and other countries. But the entire set of harms of atomic bomb explosions may not be immediately visible and still are not clear. Radioactive fallout is harmful to humans and all life. Other influences such as increased solar flares are less investigated. In any case, it was argued to be acceptable because the risk of destroying the world by detonating an atomic bomb “was close to zero.” A prime example of acceptance via mystification with implied sound rational and statistical basis.

The movie does display the enthusiasm for the successful explosion of the Trinity test in New Mexico and the weapon explosions on Hiroshima and Nagasaki as these explosions proved their effort to build the first atomic weapons was successful. This was during World War II and the belief was held by many that such powerful weapons would be a deterrent and would mean the end of wars.

The movie also shows the reservations and regrets that a few men, including Robert Oppenheimer would have about using atomic weapons. And the movie touches on how little tolerance there is in the U.S. government for those, including Oppenheimer, who voiced moral reservations as to developing larger, more powerful atomic bombs and escalation of nuclear weapons.

While the technical achievement of building the bomb is worthy of praise and the elation felt when the Trinity test proved the weapon worked is part of history, there were those people who questioned, even before the bombings, whether the atomic bombs should be dropped on Japan.

[4] Joshua Frank, *Atomic Days – The Untold Story of the Most Toxic Place in America*, Haymarket Books, Chicago, Illinois, 2022. ISBN: 978-1-64259-828-5, p. 75, Whiteman, “The Financial Facts You Never Learned About World War II.”

Americans have been told that the atomic bombings of Japan were needed in order to end the war with Japan — and therefore to reduce the loss of our troops. But there are many people who now believe that the surrender of Japan would have happened without the bombings. The atomic bombings of Japan, some assert, were a way to test the bombs and display the damage of these bombs. See considerable discussion by Arjun Makhijani at IEER.org. [5]

The uranium-235 atomic bomb nicknamed "Little Boy" was dropped on Hiroshima August 6, 1945, killing 70,000 people or more. The plutonium atomic bomb nicknamed "Fat Boy" (others say "Fat Man") was dropped on Nagasaki on August 9, 1945 and killed 35,000 people or more. [6]

After so much money and effort went into making the bombs, it seemed to some that the weapons were used on Japan in 1945 because the U.S. military had the weapons. Oppenheimer also feared that the larger hydrogen bombs would also be used.

The two atomic, just plain "fission" bombs dropped on cities in Japan were small in explosive power compared to hydrogen bombs later built. The larger hydrogen bombs are fission-fusion bombs and are also called thermonuclear bombs. These weapons use a special isotope of hydrogen called deuterium, with two neutrons instead of one. Oppenheimer opposed building these more powerful nuclear weapons.

Oppenheimer's regrets and concerns about the use of atomic weapons and continued building of more destructive nuclear weapons got him crosswise with the Atomic Energy Commission and others who championed the building the more-powerful-hydrogen nuclear bombs.

The movie "Oppenheimer" is hopefully, the beginning of the conversation, and not the end. The devastation brought to Japan, the harm to New Mexico citizens from the Trinity Test, the still-not-cleaned-up radioactive mess at Hanford, Oak Ridge and other Department of Energy and uranium mining or fuel-associated sites, the subsequent nuclear weapons testing in the Pacific Islands, at the Nevada Test Site, and elsewhere that brought cancers and other adverse health effects from the radioactive fallout – these are all issues the people need to understand.

Idaho Public Television presents a glowing depiction of the Naval Reactors Facility in 'Idaho Experience: Idaho's Nuclear Navy' - but there's a lot more to the story

In November 2023, Idaho Public Television's "Idaho Experience: Idaho's Nuclear Navy" was shown at the Colonial Theater in Idaho Falls, marking the 75th anniversary of the beginning

[5] Institute of Energy and Environment Research, https://ieer.org/news/from-pearl-harbor-to-hiroshima-2/ and https://ieer.org/news/the-nagaski-atomic-bombing-why-the-rush/

[6] Nuel Pharr Davis, *Lawrence and Oppenheimer*, Simon and Schuster New York, Library of Congress Catalog number: 68-19940, 1968.

of the development of the nuclear navy by the joint efforts of the Department of Navy and the Department of Energy. [7] The video of "Idaho Experience: Idaho's Nuclear Navy" became available in December and will remain available for viewing online but only until January 5, 2024. [8]

The documentary film amounts to a propaganda piece for the nuclear navy and the Idaho National Laboratory because it fully omits any honest discussion of the human health and environmental the harms Naval Reactors Facilities (NRF) has caused throughout its 75-year past. The documentary fully omits discussion of the extensive burial of long-lived radioactive waste over the Snake River Plain Aquifer from NFR and supporting operations at the INL. There was no discussion of the Idaho Settlement Agreement milestone to remove the still-accumulating naval spent nuclear fuel from the INL. [9] There was no discussion of the lack of a repository for the nuclear Navy's, Department of Energy's nuclear weapons production or materials testing spent fuel or the nation's spent nuclear fuel. There was no discussion of historical radiological releases from NRF and other INL supporting facilities.

The depiction of the State of Idaho's role and of the Naval Nuclear Propulsion Program in the documentary is glowing — as in flattery far beyond what is balanced. Far more humility would have been needed if more of the realities about the Navy's programs had been discussed — such as the Navy's radioactive waste that the Nany insists must be either injected into the Snake River Plain aquifer or set to trickle into it; past and ongoing radiological releases from NRF and supporting INL facilities such as INTEC; and its storage of spent nuclear fuel that, over time, cannot be prevented from poisoning the environment, and will poison the environment as inevitable container corrosion and dispersion will poison humans and the environment.

There was no discussion of the aging and unsafe spent fuel pool built in 1957 long used at NRF. And there was no discussion of the fact that workers at NRF, who are largely civilians, are ineligible for illness compensation that workers for other DOE contractors are eligible to apply for.

The photographs of the Naval Reactors Facilities (NRF) area at the Idaho National Laboratory site are worth seeing. Moving from diesel engine powered to nuclear powered submarines was one of the more logical uses for nuclear energy. Construction of the submarine prototype designed by Westinghouse, the S1W, began at NRF in 1950 and nearly 40,000 personnel received their 6-month training at NRF, using a prototype reactor in a pool inside a building rather than a submarine in an ocean. There were two other reactor prototypes built at

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[7] Post Register, *The Idaho Falls Post Register*, "Idaho Public Television to examine 'Idaho's Nuclear Navy,' November 28, 2023.

[8] *Idaho Public Television PBS*, "Idaho Experience: Idaho's Nuclear Navy," Aired 12/03/2023 and expires 01/05/2024. https://www.pbs.org/video/idahos-nuclear-navy-lpvivb/ or find it at https://www.idahoptv.org/shows/idahoexperience/

[9] 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

NRF: one for an aircraft carrier designed by Westinghouse, the A1W, and the other for a submarine designed by General Electric, the S5G. The prototypes operated between 1953 and 1995. The design of these prototypes did not take place in Idaho and only the prototype naval reactors were built in Idaho.

Naval Spent Nuclear Fuel

The Post Register article noted that "Over the decades the Navy has safely shipped 919 spent fuel containers to the facility where the fuel is examined to ensure it has operated as planned." The navy's spent nuclear fuel is removed at shipyards on both the Pacific and the Atlantic coasts, and then transported to Idaho by rail and most shipments are not excessive in size and weight. In contrast, some commercial spent nuclear fuel is heavier than ever before shipped by rail and the Department of Energy is designing new rail cars for the heavier loads.

The spent nuclear fuel remains radio-toxic for more than hundreds of thousands of years and longer than their containers or buildings will survive. The radioactivity that builds up inside the nuclear fuel as the fuel is used in nuclear reactors is far more radioactivity than is created by a nuclear weapons explosion. So, it has long been known that it was necessary to find a way to confine the spent fuels fission products and actinides needed to prevent the spread of this material to the environment for time frames far beyond hundreds of thousands of years.

The 1995 Idaho Settlement Agreement requires all but the most recently received naval spent nuclear fuel to leave Idaho by January 1, 2035; however, the Department of Energy has no repository and does not even have a repository program. The Navy has no place to dispose of the submarine and aircraft carrier spent fuel in Idaho. Naturally, there was no mention of this in the documentary.

It is worth noting that while the navy's spent nuclear fuel all comes to wet pools at NRF in Idaho, the submarine hulls and defueled core structural materials are sent to the Department of Energy's Hanford site in Washington. The Navy has packaged some of its spent fuel into dry storage that is kept inside a building at NRF.

The navy continues to ship its spent nuclear fuel to the Naval Reactors Facility at the Idaho National Laboratory. The navy's spent nuclear fuel is unloaded into an aging and unsafe spent fuel pool called the Expended Core Facility. The Navy and the Department of Energy announced in 2016 that they would replace the Expended Core Facility at the NRF. While $ 1.65 billion has been funded for the new spent fuel facility, the old ECF is, unfortunately, may still be in use.

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. [10] [11] The number of metric tons of spent fuel in the ECF pool isn't specified but is

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

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 **the Navy elected to shallowly bury this radioactive waste 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 Navy continues to shallowly bury its radioactive waste, waste than includes Greater-Than-Class-C radioactivity, over the Snake River 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. [12]

The Navy's Spent Fuel Handling Recapitalization Project [13] will incorporate the capabilities that currently exist in NRF's Expended Core Facility and its support facilities, but it will also 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. [14] 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. [15] After 2035, the Navy is allowed to continue receiving naval spent nuclear fuel from its nuclear-powered submarines and aircraft carriers.

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[11] 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

[12] 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.

[13] 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 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

[14] 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

[15] 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

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. [16]

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 remained 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. [17] [18] 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 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. [19] [20] [21]

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[16] 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

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

[18] 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.

[19] 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

[20] 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

[21] 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

Broader SNF Issues at INL

Unfortunately, the Department of Energy has not made similar progress for ensuring the capability for packaging non-Naval spent nuclear fuel at the INL — to make it road ready to a repository or repackage if a repository is delayed.

The mission need statement from 2007 stated that "The capability that is required to prepare Spent Nuclear Fuel for transportation and disposal outside the State of Idaho includes characterization, conditioning, packaging, onsite interim storage, and shipping cask loading to complete shipments by January 1,2035. These capabilities do not currently exist in Idaho." [22]

NRF Continues Burial of Radioactive Waste at INL

Analyses by the Department of Energy predict the eventual migration of radionuclide contamination into the soil and then aquifer from buried waste at the Radioactive Waste Management Complex (RWMC). [23] NRF waste buried at RWMC is not being removed. Future burial of NRF and other INL facility waste, some of which supports NRF operations, the replacement for RWMC, the Replacement Low-Level Waste Disposal facility provide significant and virtually unending contamination of the aquifer. [24]

Historically poor record keeping was conducted with regard to the amount and type of radionuclide material buried from NRF. For many years the Department of Energy placed no limits on curie content or radionuclide inventory in its burial grounds, the RWMC. NRF wastes included significant quantities of spent nuclear fuel material from experiments and from the Shippingport spent nuclear fuel examinations (from the 1960 and continuing into the 1980s) that were buried shallowly at the RWMC. Because of the CERCLA cleanup at RWMC, efforts have been made decades later to estimate radionuclides and curie amounts of material buried at RWMC in order to conduct waste migration studies. [25]

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[22] Department of Energy, Mission Need Statement: Idaho Spent Fuel Facility Project, DOE/ID-11344, September 2007. http://www5vip.inl.gov/technicalpublications/Documents/3867685.pdf

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

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

[25] Idaho Completion Project, Bechtel BWXT Idaho, LLC, for the US Department of Energy, Idaho Operations Office, "Supplement to Evaluation of Naval Reactors Facility Radioactive Waste Disposal at the Radioactive Waste Management Complex from 1953 to 1999," ICP/EXT-05-00833, April 2005.

It also is worth noting that significant aquifer contamination occurred due to fuel reprocessing at INTEC [26] in support of naval reactors programs.

The radionuclides buried at RWMC include the same radionuclides that pose the greatest concern for migration from a spent nuclear fuel repository. The radionuclides buried at RWMC include very long-lived and mobile radionuclides of carbon-14 (5,730-year half-life), iodine-129 (17-million-year half-life), technetium-99 (213,000-year half-life), nickel-59 (76,000-year half-life) and uranium-238 (4.4-billion-year half-life). The DOE's performance assessments for disposal of these radionuclides show that they will migrate to the aquifer in significant amounts for hundreds of thousands of years, see DOE/NE-ID-11243 — which DOE kept from public view until 2015 upon Freedom of Information Act request.

The CERLCA cleanup effort is focused on removing the most chemically contaminated waste because the Department of Energy asserts authority over radioactive contamination. [27] The amount of Rocky Flats weapons plant transuranic waste that is being cleaned up is unspecified. Less than 6 acres of the 35-acre burial ground are being exhumed. So, a small fraction of buried transuranic waste from Rocky Flats weapons plant is being exhumed, but none of the waste buried from NRF or the Advanced Test reactor or other facilities is being exhumed.

The performance assessment for RWMC predicts that the radiation ingestion dose for hundreds of thousands of years near the waste dump will reach the DOE limit of 100 mrem/yr unless the engineered soil cap over the dump is assumed to perform flawlessly, limiting infiltration to 0.1 cm/yr. In the case of perfect soil cap performance, the ingestion dose is about 30 mrem/yr. No other organization deems it reasonable to rely on maintenance of a soil cap forever and five-year-reviews forever; but it is an accepted tri-agency fiction among the DOE, Idaho Department of Environmental Quality, and the EPA for the RWMC burial ground at INL.

The population dose from the contamination due to migration of radionuclides to the aquifer is unspecified. For such expansive time frames because of the large amounts of very long-lived and mobile radioactive contamination, speculation of the number of affected people has not been provided as it is for other radiological releases.

The new replacement disposal facility use of metal canisters may alleviate some of the surface contamination and subsidence (soil erosion and uneven settling problems) that occur at RWMC, but it still is acknowledged that the radionuclides will eventually migrate into the soil and to the aquifer. The amount of radionuclides to be buried in the replacement for RWMC, the Replacement Remote-handled Low-Level Waste Disposal facility is significant and approaches or exceeds Greater-Than-Class C inventory limits for some of the contaminants.

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[26] Idaho Nuclear Technology and Engineering Center (INTEC), formerly the Chemical Processing Plant (CPP).

[27] See the CERCLA administrative record at www.ar.icp.doe.gov (previously at ar.inel.gov) and see also Parsons, Alva M., James M. McCarthy, M. Kay Adler Flitton, Renee Y. Bowser, and Dale A. Cresap, Annual Performance Assessment and Composite Analysis Review for the Active Low-Level Waste Disposal Facility at the RWMC FY 2013, RPT-1267, 2014, Idaho Cleanup Project.

In both the analysis of RWMC and of the new replacement for RWMC, the analysis assumptions of steady infiltration and leaching keep the doses artificially steady and low. Episodic flooding is known to occur and would increase migration rate and radiation doses but has been assumed not the occur for hundreds of thousands of years.

Inconsistencies in various buried waste studies at INL are not random — they result from pressure to lower the radiation ingestion doses from the most prevalent source of contamination. **Plutonium dose too high at RWMC? No problem, just raise the assumed soil sorbing coefficient.**

The various assumed parameters such at the soil coefficient for soil sorbing properties are adjusted by arguing whatever value selected is reasonable and conservative. **Yet the variability in the soil coefficients from study to study for the Department of Energy is quite large.** [28] The resulting analyses for predicted buried waste facility performance are inconsistent. The analysis results are not conservative but are based on best estimate (mean or median values) of radionuclide inventory and other factors and so the radiation ingestion doses may be significantly higher than stated for a variety of reasons. The analyses for the buried waste migration over millennia have assumed there will be no episodic flooding and there will be no geologic instability: these studies are scientifically indefensible, despite the mathematical modeling complexity involved in their derivation.

The Department of Energy has continued to obscure from public view the predicted future levels of contamination, the continual migration of these contaminants to Thousand Springs and beyond and the thousands of years that the waste will continue migration to the aquifer. It kept the performance assessment of RWMC from being publicly available until 2015 upon Freedom of Information Act request. The CERLCA cleanup documents made deceptive and misleading statements regarding the level of contamination after 10,000 years. The analysis gyrations and inconsistencies from study to study have been made in order to bias the results toward lower radiation ingestion results. Seemingly scientific, these studies show that radionuclide contaminants will migrate to the aquifer. But the assumptions built into the models regarding the rate and steadiness of this migration are a charade, a show made to provide studies that look scientific and protective of health when they are not.

The low-level waste from NRF and other INL facilities slated for burial over the Snake River Plain aquifer can be shipped out of Idaho to an operating low-level waste facility in

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[28] Idaho National Laboratory, "Explanation of Significant Differences Between Models Used to Assess Groundwater Impacts for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste and Greater-Than-Class-C-Like Waste Environmental Impact Statement (DOE/EIS-0375D) and the Environmental Assessment for the INL Remote-Handled Low-Level Waste Disposal Project (INL/EXT-10-19168)," INL/EXT-11-23102, August 2011. http://www.inl.gov/technicalpublications/documents/5144355.pdf and a report prepared for the US Department of Energy, DOE Idaho Operations Office, "Preliminary Review of Models, Assumptions, and Key Data Used in Performance Assessments and Composite Analysis at the Idaho National Laboratory," INL/EXT-09-16417, July 2009. See p. 11, Tables 3 and 4 for sorption coefficients.

Nevada. NRF needs to stop its burial practices over our aquifer especially in light of years of aquifer contamination it has caused and will cause with waste it has already buried.

NRF Radiological Air Emissions

The public was told that the historical radiological releases could not cause any health harm. But when asked which radionuclides and in what curie amounts had been released, the Department of Energy (and NRF) had no ideal. The historical air emissions from INL from 1952 to 1989 were then estimated in the 1991 *INEL Historical Dose Evaluation* (DOE/ID-12119). Emissions were often ambiguously documented as "unidentified beta and gamma" or "unidentified alpha." Because of the inadequate monitoring from the 1950s to the 1970s and beyond, and inadequate technical estimation of the air emissions, extensive efforts were made to try to characterize the identity of the radionuclides released and their curie amounts based on assumed fuel composition and release mechanism.

The *INEL Historical Dose Evaluation* not only low-balled the radiological releases, it omitted important radionuclides from the dose evaluation, like americium-241. The contribution of actinides, including americium-241, was later found to be far higher than assumed in the *INEL Historical Dose Evaluation*. [29] The dispersion of radionuclides was not based on wind speed and direction at the time of the releases, nor was the occurrence of rain modeled. The radiological doses to the public were underestimated by DOE but the reported low doses were used as rationale to not conduct epidemiology of the public.

Only the large NRF release from destructive fuel tests of the S1W reactor were included as episodic releases in the 1991 HDE. The fact is that its reactor operations and its spent fuel handling operations release airborne radioactivity. Opening spent fuel casks appears to release tritium and other radionuclides to the region. These 1991 HDE estimates which focused on the off-site public remain flawed and are not adequate to address historical worker exposures. The primitive nature of INL monitoring and reporting of emissions for years should re-emphasize the false argument for excluding NRF workers from EEOICPA compensation act coverage.

Radiological airborne emissions from materials testing reactors that supported the Navy's nuclear programs included the Materials Test Reactor and the Advanced Test Reactor. Radiological airborne emissions from spent fuel reprocessing at INTEC supported nuclear weapons programs in general and also NRF in particular. The recovered uranium-235 from spent fuel reprocessing of highly enriched spent fuel was used only to power a Department of Energy plutonium production reactor at the Savannah River Site, as the recovered uranium was too contaminated to fabricate into any other nuclear reactor fuel.

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[29] 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

Snake River Aquifer Contamination

The description of drinking water standards omits the fact that due to the non-community well loop-hole for drinking water regulations, the State of Idaho, per the Department of Energy's request, does not provide radionuclide sample results by independent certified laboratory to the State of Idaho and the State of Idaho does not make the INL's nor the NRF's radionuclide monitoring results publicly available. **Only chemical monitoring, not radiological monitoring, of INL drinking water is overseen by the State of Idaho Department of Environmental Quality.**

The Department of Energy has historically adopted its own far more lax contaminant level guidelines for its facilities and has not disclosed to workers the monitored contaminant levels. There is a lack of public disclosure of the current and historical radionuclide contaminant levels in INL drinking water including the drinking water at NRF. Workers remain uninformed of the level of contaminants in their drinking water at the INL and the NRF even for years when federal maximum contaminant levels have been exceeded. Other state environmental departments recognize that federal maximum contaminant levels are not necessarily protective of health and even the Department of Energy recognized this in the early years until they came to realize that they were exceeding them. Since then, the posture is to act as though any combination of chemical and radionuclide contaminants in drinking water is of no concern as long as individually, they are under the federal maximum contaminant level. The chemical and radionuclide contamination of INL drinking water has exceeded MCL levels historically, especially prior to chemicals being monitored in the last 1980s. Radionuclide monitoring has been spotty and has not covered all of the years that contamination was present. Contaminated drinking water may explain the epidemiology reports for the INL that found specific cancers to be elevated at INL for radiation and non-radiation workers.

Historical contamination of INL drinking water commenced in the early 1950s and monitoring of contaminants often lagged by decades. When nuclear operations were releasing large amounts of airborne contamination, the US Geological Survey ceased aquifer monitoring at INL from NRF to TAN between roughly 1965 and 1975. The EIS has obscured this by presenting only an average contamination level from past operations.

It is a reminder that the US Geological Survey monitors what wells it chooses and what contaminants it chooses to monitor and this does not necessarily serve for trending or public protection. Contamination levels off site at Mud Lake that exceeded federal drinking water standards were included in reports that the USGS now says were in error. Tritium levels in the Mud Lake well in 1966 clearly exceeded the MCL at 93,000 pCi/L and yet it appears the public was never told. Publication in a report 20 years later, in 1984, also does not seem adequate (USGS Report 84-714) [30] It does appear that the levels of tritium occurred but not for a different

[30] US Geological Survey, *Water-Quality Data for Selected Wells On or Near the Idaho National Engineering Laboratory, 1949 through 1982*, Report 84-714, June 1985. http://pubs.usgs.gov/of/1984/0714/report.pdf See

well in the Mud Lake area. Tritium levels offsite the exceeded the federal maximum contaminant level for tritium went unexplained by the USGS for decades.

The monitoring performed and the contaminant levels measured need to be provided for NRF even though it was comparatively low to other INL facilities. NRF has used averaging of well water contamination levels to obscure the peak values and the years when monitoring was absent or addressed an incomplete set of contaminants. Unexplained lapses of USGS monitoring have occurred at NRF. USGS monitoring for radionuclides has been spotty at best. Many long-lived radionuclides present in the aquifer were not monitored until the 1990s and then not reported by USGS. [31] And USGS monitoring of chemical contaminants was non-existent until the late 1980s. In the perennial effort to give the impression of rigorous monitoring, the Department of Energy and Naval Reactors are self-serving in the lack of clarity concerning past monitoring program deficiencies and actual contaminant levels present, monitored or not.

Radiation Workers Especially Harmed By NRF

In 2000, Congress passed the Energy Employees Occupational Illness Compensation Program Act (EEOICPA) to provide an alternative Federal compensation program for workers whose health was impacted as a result of nuclear weapons related work for Department of Energy contractors. [32] The EEOICPA generally covers contractors and Department of Energy employees, as designated by the Secretary of Energy, who worked in facilities that processed or produced radioactive material for use in the production of atomic weapons. But NRF workers, predominantly non-military workers, have been excluded from this compensation.

Facilities at NRF had conducted diverse operations with the large potential for inadequately monitored overexposure. The operations have included reactor operation and fuel dissolution, and will still include spent fuel pool operation, transfers of spent fuel to pool and examination areas and airborne contamination from resizing or cutting of irradiation material. The potential for elevated airborne contamination or unplanned loss of shielding has created inadequately monitored and controlled radiation exposures at Department of Energy facilities including those at INL.

The intent to protect workers has not always coincided with effective radiological protection of workers or adequate understanding of health effects. Experience at similar INL facilities, often with management personnel having extensive naval nuclear background, has shown a multitude

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USGS well 14 and the Mud Lake well for tritium (H-3) spikes. Multiply picocurie/milliliter (pCi/mL) by 1000 to convert to picocurie/Liter (pCi/L). The MCL for tritium is 20,000 pCi/L.

[31] T. M. Beasley, P. R. Dixon, and L. J. Mann, ^{99}Tc, ^{236}U, and ^{237}Np in the Snake River Plain Aquifer at the Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho, Environ. Sci. Technol., 1998, 32, 8375-3881.

[32] 42 USC 7384, The Act--Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA), as Amended and see the website for the Center for Disease Control, National Institute of Occupational Safety and Health, Division of Compensation Analysis and Support at http://www.cdc.gov/niosh/ocas/ and U.S. Department of Labor, Office of Workers' Compensation Programs, EEIOCPA Program Statistics, http://www.dol.gov/owcp/energy/regs/compliance/weeklystats.htm

of issues and new issues continue to arise. Transient conditions within hot cells and transfers of material to and from hot cells, undetected penetrations of hot cells or casks, inadequate lineup of shielding during transfers, and inadequately shielded filters have occurred at INL Department of Energy facilities: why would they not have occurred at NRF through its historical operations?

Inadequate internal monitoring programs at INL historically have been found in 2015 by investigations conducted by the National Institute of Occupational Safety and Health because of the most recent INL Special Exposure Cohort petition. Inadequate radiological protection has been found from 1963 to 1975 at the Chemical Processing Plant (now INTEC) and other facilities are being reviewed.

Section 4.13.2.1 of the EIS states: “No one in the NNPP [includes NRF] has exceeded 0.02 Sievert (2 rem) of radiation exposure in 1 year (less than half the annual limit of 5 rem) since 1979.” That the radiation levels prior to 1979 exceeded this, and the fact that Department of Energy employee studies have found increased levels of certain cancers for workers exposures generally below 2 rem per year is relevant. The Energy worker compensation act (EEOICPA) points out that "studies indicate than 98 percent of radiation-induced cancers within the nuclear weapons complex have occurred at dose levels below existing maximum safe thresholds." (See 42 USC 7384, The Act-Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA), as Amended.)

NRF workers are excluded from EEOICPA compensation “because of the effectiveness of Naval Reactors’ worker protection, worker training, and workplace monitoring programs, employees who performed Naval Reactors’ related work at Naval Reactors’ Department of Energy facilities . . . As discussed earlier, the GAO reported to Congress in 1991 that ‘Naval Reactors Laboratories are accurately measuring, recording, and reporting radiation exposures,’ and ‘exposures have been minimal and overall are lower than commercial nuclear facilities and other Department of Energy facilities.’ This longstanding record of effectiveness supports the conclusion by Congress that workers at Naval Reactors’ Department of Energy facilities did not need the compensation alternatives created for workers in the nuclear weapons complex by the EEOICPA.” [33]

The historically high allowable doses at NRF, the variety and complexity of operations at NRF, the problems of adequately monitoring internal dose and transient conditions, and the evolving science of radiation health [34]and epidemiology of radiation workers [35] showing elevated

[33] Naval Nuclear Propulsion Program, Office of Naval Reactors, “Occupational Radiation Exposure from Naval Reactors’ Exposure from Naval Reactors’ Department of Energy Facilities,” Report NT-113, Mary 2011. http://nnsa.energy.gov/sites/default/files/nnsa/02-12-multiplefiles/NT-11-3%20FINAL.pdf

[34] Kohnlein,W, PhD., and Nussbaum, R. H., Ph.D., “False Alarm or Public Health Hazard?: Chronic Low-Dose External Radiation Exposure, Medicine & Global Survival, January 1998, Vol. 5, No. 1. http://www.ippnw.org/pdf/mgs/5-1-kohnlein-nussbaum.pdf

[35] “An Epidemiology Study of Mortality and Radiation-Related Risk of Cancer Among Workers at the Idaho National Engineering and Environmental Laboratory, a U.S. Department of Energy Facility, January 2005. http://www.cdc.gov/niosh/docs/2005-131/pdfs/2005-131.pdf and http://www.cdc.gov/niosh/oerp/ineel.htm and Savannah River Site Mortality Study, 2007. http://www.cdc.gov/niosh/oerp/savannah-mortality/

cancer risks at annual doses less than 2 rem per year point to the unsupportable rationale for excluding NRF workers from compensation. Although it would in many cases be decades late, and the compensation will never compensate for the early deaths of fine people, this exclusion must be removed. **By any measure of fairness and honest assessment, the exclusion of NRF workers from EEOICPA act compensation must be removed.**

Summary

The Naval Reactors Facilities (NRF) area that supported the nuclear navy does have a long history in Idaho. NRF has continued using an unsafe and leak-prone spent fuel pool built in 1957.

Historical shallow radioactive waste disposal at the Idaho National Laboratory included radioactive waste from naval spent fuel end-caps, fueled experiment samples and other long-lived radioactive waste. NRF chose to continue polluting Idaho by burying long-lived radioactive waste from the end caps of its spent fuel by choosing to continue shallow waste burial over the Snake River Plain Aquifer at the INL when it could have gone to out-of-state to a Department of Energy disposal site in Nevada.

NRF uses its influence to jockey for space in disposal facilities that were designated for CERCLA waste, not NRF waste, as the Department of Energy admits that there is no end in sight to the need for disposal of decommissioning and demolishing of other nuclear facilities at INL.

NRF has been successful at many things and one of them is covering up just how much contamination it has caused or was caused by facilities at the INL that support NRF's missions. NRF operations have caused the early cancer death of many people but makes it its policy to not allow its workers or their families to be eligible for illness compensation under the Energy Employee Illness Compensation Program assistance, despite obviously high cancer rates for NRF workers.

Nuclear energy is not the answer to combatting climate change and the silliness of the new nuclear energy goals by COP23

Warnings about climate change are frightening. A new climate report warns of increased wildfires, extreme heat-waves and drought. [36] The climate report was the Fifth National Climate Assessment (NC5), a series of reports mandated by Congress through the Global Change Research Act of 1990. Another report by the International Energy Agency states that oil and gas are major emitters of planet-warming gases, and will need a rapid and substantial overhaul for the world to avoid even worse extreme weather. [37]

[36] Clark Corbin, *Idaho Capital Sun*, "New climate report warns of increased wildfires, heat and flooding for Idaho and Northwest region," Printed also in *The Idaho Falls Post Register*, November 25, 2023.

[37] Associated Press, *The Idaho Falls Post Register*, "To save the climate, the oil and gas sector must slash planet-warming operations," November 25, 2023.

On December 2, a pledge to ramp up nuclear energy was made during the United Nations climate conference [UN climate summit of the 28th Conference of the Parties in Dubai, United Arab Emirates] or COP23. **The COP23 pledge was made by the United States and 21 other countries to triple the global nuclear energy capacity by 2050.**

The pledge to ramp up nuclear energy is basically a shameless ploy to extort money and free up funds for this loser option. The Department of Energy admits that the pledge is really about the importance of financing for the additional nuclear power capacity and pressuring for high-level political engagement to spur further action on nuclear power. [38]

Will ramping up nuclear energy by 2050 help combat climate change now or any time soon?

The answer is no. The pledge to triple today's global nuclear energy capacity not realistic, particularly with existing nuclear plants are aging and can be expected to be shutdown.

Calling out the problems of increases in nuclear energy is Francois Diaz-Maurin who interviewed Mycle Schneider in the *Bulletin of the Atomic Scientists*. [39] **Mycle Schneider finds that the pledge to triple nuclear energy capacity is utterly unrealistic**. And the shutdown of existing nuclear power plants approaching end of life will add to the nuclear energy capacity that would need to added. **What the COP23 pledge to increase nuclear energy does do, is take money and attention away from urgently needed solutions that work.** According the Schneider, solutions start with sufficiency, efficiency, storage and demand response and only later, renewable energy. Nuclear energy has been too slow to deploy and far too costly.

The share of nuclear power in the world commercial electricity mix has been dropping by almost half since the middle of the 1990s, according to a report by a group of independent energy consultants and analysts, the World Nuclear Industry Status Report 2023 (WNISR). [40]

The problems with escalating cost, decade-low schedule delays and high risk of project cancellation continues to plague new nuclear energy. The two AP1000 nuclear plants in Georgia, with at least one of them operating in 2022, were promised to be online years earlier.

The Department of Energy began promoting small modular reactors because climate change required urgent action. One SMR, NuScale was promoted by the Department of Energy and NuScale had promised in 2008 that it would start generating power by 2015. Now in 2023, with

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[38] Department of Energy website, "At COP28, Countries Launch Declaration to Triple Nuclear Energy Capacity by 2050, Recognizing the Key Role of Nuclear Energy in Reaching Net Zero," December 1, 2023. https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key

[39] Francois Diaz-Maurin, Bulletin of the Atomic Scientists, "Nuclear expert Mycle Schneider on the COP28 pledge to triple nuclear energy production: 'Trumpism enters energy policy,'" December 18, 2023. https://thebulletin.org/2023/12/nuclear-expert-mycle-schneider-on-the-cop28-pledge-to-triple-nuclear-energy-production-trumpism-enters-energy-policy/?utm_source=Newsletter&utm_medium=Email&utm_campaign=MondayNewsletter12182023&utm_content=NuclearRisk_TripleNuclear_11182023

[40] A Mycle Schneider Consulting Project, Paris, World Nuclear Industry Status Report 2023, (WNISR), December 2023. www.worldnucleareport.org/-World-Nuclear-Industry-Status-Report-2023-.html.

no construction started, no certification license from the U.S. Nuclear Regulatory Commission for the modified design and the cost increases to a level "almost twice as expensive as the most expensive [large-scale] EPR reactors in Europe." [41]

Nuclear energy poses serious contamination due to mining, milling, enrichment, fuel fabrication, nuclear reactor operation, accidents, routine low-level waste, decommissioning radioactive waste and spent nuclear fuel.

Idaho National Laboratory Director John Wagner says the time to embrace nuclear energy is now. [42] But he goes on to ask "how quickly can we develop and deploy new reactors" because his job is simply to get the money to go forward with nuclear research. It is not Wagner's job to seek feasible and realistic solutions and he isn't seeking feasible and realistic solutions. The Department of Energy and the Idaho National Laboratory stress in advertisements that the INL employees 6,000 employees and is Idaho's sixth largest public and private employer, and pumped $3.38 billion into Idaho's economy in 2022. [43]

With untold dollars in advertising by the Department of Energy and mainstream media engaged in avoiding any negative press about nuclear energy, polls for public support are not meaningful. Department of Energy and nuclear industry Power Point presentations often claim that nuclear energy is Safe, Clean, Affordable, Reliable — generally without these claims being supportable. Bipartisan support for nuclear energy isn't meaningful either, given how uninformed leaders in government are with regard to the realities of cost, spent fuel management and disposal costs and risks and accident risks. Even Government Accountability Office (GAO) reports downplay the dangers and overlook the unstated costs of management and disposal of spent nuclear fuel.

The nuclear industry fights against renewable energy that is actually affordable and clean. China, which in 2022 generated more nuclear electricity that France, now for the first time, has in 2022 generated more power with solar than with nuclear. And while globally, nuclear accounted for 9.2 percent of the power mix in 2022, wind and solar generated 28 percent more electricity than nuclear plants, see the WNISR report.

By mid-2023, world-wide nuclear energy electricity generation was 364.9 giga-watts (GW). The peak electricity generation was 438 GW in 2002.

"Nuclear energy remains the most expensive and dangerous proposition financially, environmentally and now militarily, with insufficient liability protection and prospects of future Black Swan events that destroy whole regions, uproot populations, increase cancer occurrence, and threaten even distant ecosystems," writes Stephanie Cooke in the WNISR report.

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[41] Francois Diaz-Maurin, Bulletin of the Atomic Scientists, "Nuclear expert Mycle Schneider on the COP28 pledge to triple nuclear energy production: 'Trumpism enters energy policy,'" December 18, 2023.

[42] David Pace, *The Idaho Falls Post Register*, "INL Director John Wagner testifies on advanced reactors to U.S. Senate committee," December 19, 2023.

[43] *The Idaho Falls Post Register* advertisement included in in the *East Idaho Business Journal*, "INL and Idaho" January 16, 2024.

Tracking the tardy, cancelled or otherwise irrelevant to combatting climate change nuclear reactor projects promoted by the Department of Energy

With the Department of Energy throwing taxpayer money at a plethora of proposed reactors, a summary, though incomplete, is provided in Table 1, updated for January 2024.

An independent nuclear industry report, the World Nuclear Industry Status Report (WNISR), for 2023 forward by Stephanie Cooke states: "Bizarrely, nuclear energy is riding a new wave of popularity, and is seen by many policy planners and energy experts as part of the solution to reducing carbon emissions based on industry claims that it is both "clean" and "reliable". However, given its long lead times and exorbitant costs the prospects of this happening are virtually zero. Moreover, climate impacts, such as cooling water availability, heat sink capacity and storms, also threaten the performance and safety of nuclear reactors." [44]

The 2023 WNISR also noted in its review of small modular reactors that "more generally, there is a significant gap between the reality on the ground and what such agencies, and the general media, report about [small modular reactors] SMRs." The only SMRs deployed during the past two years are two 100 MW high-temperature gas cooled reactor units in China, and little is known about their operational experience.

An announcement in December 2023 was made regarding building a non-power test reactor of the Kairos Power, LLC, Hermes reactor at the Oak Ridge National Laboratory. The U.S. Nuclear Regulatory Commission gave a construction license for a 35 megawatt-thermal (and zero megawatt-electric) demonstration test reactor for the fluoride salt cooled high temperature reactor small scale demonstration plant. The source of the high-assay low-enriched fuel (HALEU) for the TRISO fuel has not been finalized. [45] **It is hoped that this may lead someday to a possible commercial power deployment.** What can be certain is that if operated, radioactive waste will be require cleanup, storage and disposal that no one wants to pay for. The NRC's approval is given despite admitting the absence of any spent fuel storage or disposal after the planned four-year research program is conducted. The NRC approval for the construction permit is being heralded and the fact the no design review for safety such as a design certification has been conducted by the NRC. As usual, the NRC ignores the spent fuel waste storage and disposition issues and associated costs as well as long-term risks.

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[44] A Mycle Schneider Consulting Project, World Nuclear Industry Status Report 2023, (WNISR), Paris, December 2023. www.worldnucleareport.org/-World-Nuclear-Industry-Status-Report-2023-.html.

[45] For the Kairos test reactor proposed at Oak Ridge, see https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2263/index.html and Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor, NUREG-2263, August 2023 at https://www.nrc.gov/docs/ML2321/ML23214A269.pdf

There has been no announcement regarding the small modular reactor proposed by GE Hitachi, the BWRX-300, that is an advanced boiling water reactor design. They have had plans to submit a license application to the NRC later in 2024 (see nrc.gov).

Note that the NuScale small modular reactor project had received partial approval for an earlier design but the project slated for Utah Associated Municipal Power Systems (UAMPS) was cancelled in November. Also, this November, the U.S. Air Force pulled back on a contract to build the Oklo micro-reactor. Oklo was denied an NRC license due to insufficient design information in January 2022.

Table 1. Partial list of nuclear reactors currently receiving U.S. research dollars, including the Versatile Test Reactor, Natrium, X-energy's Xe-100, NuScale and other reactors.

Reactor Category ***Reactor name***	**Reactor type/ Fuel type**	**MW-thermal**	**MW-electric**	**Fissile Material**	**Special notes**
Materials Testing					
Versatile Test Reactor (DOE/EIS-0542)	Fast neutron, sodium-cooled, U-Pu-Zr	300 MWth	None	Uranium-plutonium-zirconium metal	Uses but does not generate electricity. Very high accident consequences.
Commercial electrical power					
TerraPower & GE Hitachi *Natrium*	Fast neutron, sodium-cooled, U-Zr	840 MWth	345 MWe	Uranium-zirconium-hydride using HALEU	High project risk. High accident risk. High risk of frequent repairs. High risk of premature shutdown like other similar reactors.
GE Hitachi BWRX-300	10th evolution of GE's boiling water reactor (BWR)	870 MWth (2019 IAEA status report)	300 MWe	Uranium enrichment 3.4 percent average	**Clinch River site proposed. Plans to submit an NRC license application 4Q 2024.**
X-energy's *Xe-100*	High-temperature gas cooled, TRISO "pebble bed"	200 MWth times 4	Xe-100, 80 MWe; 4-pack is 320 MWe	TRISO (tristructural isotropic) uranium fuel from HALEU	High risk of frequent repairs. TRISO fuel used in Fort St. Vrain reactor. No containment. No

Reactor Category ***Reactor name***	**Reactor type/ Fuel type**	**MW-thermal**	**MW-electric**	**Fissile Material**	**Special notes**
				DOE Advanced Reactor Demonstration Program, 2020, promised up to $ 1.2 Billion.	existing technology for reprocessing.
	Kairos Power LLC, Hermes Fluoride salt cooled high-temperature reactor	320 MWth or reduced scale	140 MWe, Or reduced scale	TRISO fuel	Received DOE Advanced Reactor Demonstration Program money.
	Kairos Power LLC, Hermes Test Reactor	**35 MWth**	**0 MWe**	**TRISO fuel**	**August 2023, NRC approved construction permit a demonstration project for possible commercial deployment**
(Small Modular Reactor) *NuScale*	Light-water pressurized reactor, standard PWR fuel with MOX and other fuels envisioned The reactor modules are submerged in a common pool and lifted modules pose a risk to entire facility.	?	NuScale 50 MWe Various uprating to 60 MWe and even higher. For 60 MW per module, a 12-pack plant is 720 MWe	<4.95 percent enriched standard PWR fuel, hope to use plutonium mixed oxide fuel (MOX) and/or higher enrichment fuels. Zirconium-clad fuel poses hydrogen generation when overheated, like all PWRs.	High risk of frequent and costly repairs. Hot risk of premature shutdown due to materials reliability and novel design. Accident risks not better than conventional PWRs. **(UAMPs project cancelled November 2023.)**

Reactor Category *Reactor name*	Reactor type/ Fuel type	MW-thermal	MW-electric	Fissile Material	Special notes
Mobile reactors	Variety Generally sized for cargo container shipment.	?	< 20 MWe	variety	Wide range of sizes and accident consequences.
	Project Pele, BWXT Advanced Technologies, LLC, X-energy, LLC, high temperature gas cooled		1 to 5 MWe	TRISO fuel	Department of Defense High target risk at deployed at military bases. Likely to become permanent stranded fuel site where ever deployed.
	Oklo, a $25-million startup company (Aurora Powerhouse)	4 MWth	1.5 MWe	HALEU	Creates spent nuclear fuel problems without any significant benefit. **(Design application denied by NRC due to insufficient information)**
	Ultra Safe Nuclear Corporation (USNC), gas-cooled reactor demonstration project		5 MWe	TRISO fuel	Canada at Ontario's Chalk River site

Reactor Category ***Reactor name***	**Reactor type/ Fuel type**	**MW-thermal**	**MW-electric**	**Fissile Material**	**Special notes**
	Westinghouse Canada eVinci Micro Reactor		1 MWe to 5 MWe		
Micro *MARVEL*	Sodium-potassium-cooled, HALEU	100 kWth	"less than 100 kWe" Expect 20 kWe (0.02 MWe)	150 kg of 20 percent enriched U-235 (U-Zr-Hydride fuel in stainless-steel cladding	Testing planned at INL's TREAT facility
Molten Salt or Chloride Reactor	Molten Chloride Reactor Experiment (MCRE) DOE/EA-2209.	200 kWth	None for the research experiment	Not enough information. Note that the fuel is in the reactor coolant. Any significantly scaled-up reactor would be many decades away.	Preliminary research with no reprocessing capability and hold up of gaseous radiological releases.

Table notes: MWth is megawatts-thermal energy, MWe or simply MW is megawatts-electric energy. HALEU is high assay low-enriched uranium, produced by the Idaho National Laboratory in a highly environmentally airborne polluting pyroprocessing operation. Note regarding past, current or under construction reactors: the nominally 1000 MWe Westinghouse AP1000 under construction is a light-water pressurized reactor, 1000 MWe, fuel of uranium oxide of 4.55 percent uranium-235 enrichment; existing Advanced Test Reactor, 250 MW-thermal, 93 percent enriched uranium-235; formerly operated Fort St. Vrain high-temperature gas-cooled reactor, 330 MWe, used TRISO fuel; formerly operated Peach Bottom reactor, 40 MWe; formerly operated Hanford's Fast Flux Test Facility reactor was a 400 MW-thermal fast neutron sodium-cooled reactor; formerly operated INL's Experimental Breeder Reactor II (EBR-II) was a fast neutron sodium-cooled pool-type reactor of 62.5 MW-thermal (19 MWe), see Perry et al., Seventeen Years of LMFBR Experience: Experimental Breeder Reactor II (EBR-II), CONF-820465—2, April 1982 at https://www.osti.gov/servlets/purl/6534205 . Some MWth information added from Edwin Lyman, Union of Concerned Scientists, *"Advanced" isn't always better – Assessing the Safety, Security, and Environmental Impacts of Non-Light-Water Nuclear Reactors*, March 2021. See BWRX-300 at https://www.nrc.gov/reactors/new-reactors/smr/licensing-activities/pre-application-activities/bwrx-300.html . For the Kairos test reactor proposed at Oak Ridge, see https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2263/index.html and NUREG-2263 at https://www.nrc.gov/docs/ML2321/ML23214A269.pdf

Peace on Earth hoped for, as U.S. gives $ billions in weapons funding, nuclear power plants remain targets of war, and the U.S. denies the long-lasting problem of depleted uranium artillery

It was likely a very Merry Christmas for the major military firms such as Boeing, Lockheed Martin, General Dynamics, Northrop Grumman, and Raytheon. [46] The U.S. has already sent Ukraine $111 billion in aid, much of it for military weapons. The weapons given to the Ukraine from the U.S. Pentagon stocks will have to be replaced. To encourage Congress to pass more aid to the Ukraine, it was emphasized that the contracts for military weapons manufacturing benefit industries and companies in more than 35 different states in the U.S. [47]

A group of independent energy consultants and analysts, the World Nuclear Industry Status Report (WNISR), in 2022, describe at length issues of vulnerability of nuclear plants to war. [48] But not much is said of the possible human toll in terms of shortened life span, cancer and other illnesses, birth defects and increased infant mortality.

In addition to nuclear power plant terrorism, radiological contamination can also be spread by the use of depleted uranium artillery. On September 6, 2023, the U.S. announced it was sending thirty-one M1A1 Abrams tanks and depleted uranium armor-piercing tank rounds to Ukraine. [49]

Depleted uranium is uranium that is left over after extraction of uranium-235 and the composition of depleted uranium varies but typically includes between 0.2 and 0.4 percent uranium-235. Commercial nuclear power reactors typically use 3 to 5 percent enrichment in uranium-235. Reactors using high-enriched low-assay uranium will use nearly 20 percent enrichment in uranium-235. Some reactors use up to about 93 percent enrichment in uranium-235. But the uranium-235 does not contribute much of the radioactivity of natural uranium, enriched uranium or depleted uranium.

Depleted uranium includes of course uranium-238 and uranium-234. Depleted uranium composition can vary and can include various contaminant radionuclides. uranium-236 and other contaminant radionuclides such as technetium-99, and americium-241 if it resulted from reactor fuel reprocessing or a contaminated fuel enrichment facility. In natural uranium, about half of the radioactivity occurs from the uranium-238 and half from the seldom mentioned uranium-234. The uranium-235 does not contribute much to the radioactivity of natural uranium or depleted uranium, see Table 2.

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[46] Jeffrey D. Sachs, *Common Dreams*, "US Foreign Policy Is a Scam Built on Corruption," December 26, 2023.

[47] Washington (AP), *The Idaho Falls Post Register*, "How the US keeps funding Ukraine's military – even as it says it's out of money," December 16, 2023.

[48] A Mycle Schneider Consulting Project, Paris, World Nuclear Industry Status Report 2022, (WNISR), December 2022. www.worldnucleareport.org/-World-Nuclear-Industry-Status-Report-2022-.html.

[49] Michael N. Schmitt, Kevin S. Coble, *Lieber Institute West Point*, "United States transfers depleted uranium rounds to Ukraine: The legal issues," September 18, 2023. https://lieber.westpoint.edu/united-states-transfers-depleted-uranium-rounds-ukraine-legal-issues/

Table 2. Natural uranium composition.

Nuclide	Mass percent	Kg	Curie
U-234	0.005	38	23.4
U-235	0.714	5045	1.1
U-238	99.279	70,063.9	23.4
	100 %	70,572,2	47.9

Kg (kilogram) and curie amounts assumed for 1000 Megawatt reactor. Anthony V. Nero, Jr, *A Guidebook to Nuclear Reactors*, University of California Press, 1979.

The health harms related to depleted uranium may depend on the other radionuclide contaminants (such as americium-241) and also the chemical form and the particle size. Small particle size affects the distribution and clearance of the radionuclides from the body. Chemical and manufacturing processes affect the depleted uranium prior to use, and the conditions of use or fire may affect the particle size and dispersion of the depleted uranium.

I think that it bears repeating the long decay series of uranium-234, uranium-238 (see Table 3) and also of contaminant uranium-236 (see Table 4). Elevated radium, radon, and other radionuclides if monitored may be called "naturally occurring" radionuclides but they will be in elevated amounts.

Table 3. Uranium-238 decay series.

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

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

Table 4. Thorium-232 decay series.

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

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

The health harm caused by inhalation or ingestion of depleted uranium includes illness and increased risk of birth defects. [50] [51]

While officialdom continues to assert that depleted uranium does not cause adverse health effects, the truth is far different. In Fallujah, Iraq, where the U.S. used tons of depleted uranium munitions, the fallout from the 2003 invasion is ongoing, with Iraqi babies still experiencing congenital abnormalities at staggeringly high rates.” [52]

Uranium inhalation or ingestion can cause leukemia. A study in 2010 found a 14-fold excess in childhood cancers and a 38-fold excess in leukemias in people ages 0 to 34 from exposures to depleted uranium from weapons used in Fallujah, Iraq. [53] The other location noted by Chris Busby where childhood leukemia rates are unusually high is Fallon, Nevada. [54]

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

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

[52] Danaka Katovich, *Truthout*, “Op-Ed: By Sending Depleted Uranium to Ukraine, Biden Ensures Suffering Past War’s End,” September 26, 2023. https://truthout.org/articles/by-sending-depleted-uranium-to-ukraine-biden-ensures-suffering-past-wars-end/

[53] Chris Busby, Malak Hamdan, Entesar Ariabi, *Int J Environ Res Public Health, PubMed*, “Cancer, infant mortality and birth-sex ratio in Fallujah, Iraq 2005-2009., July 2010. https://pubmed.ncbi.nlm.nih.gov/20717542/

[54] Chris Busby, *Counterpunch*, Article appeared in *The Ecologist*, “Power Lines, Fallout and Childhood Leukemia,” May 9, 2014. https://www.counterpunch.org/2014/05/09/power-lines-fallout-and-childhood-leukemia/

Despite the realities of adverse health harm from depleted uranium artillery, the U.S. Center for Disease Control, the World Health Organization, and International Atomic Energy Agency "has stated unequivocally that there is no proven link between [depleted uranium] exposure and increases in cancers or significant health or environmental impacts." [55] The reality is that the truth is suppressed if the nuclear industry or the military weapons industry finds the information unfavorable. Adequate official government studies are not undertaken and often non-governmental studies are ignored.

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[55] Michael N. Schmitt, Kevin S. Coble, *Lieber Institute West Point*, "United States transfers depleted uranium rounds to Ukraine: The legal issues," September 18, 2023. https://lieber.westpoint.edu/united-states-transfers-depleted-uranium-rounds-ukraine-legal-issues/