Airborne Radiological Releases from the Idaho National Laboratory and the Increasing Radioactive Contamination in Southeast Idaho

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By Tami Thatcher

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Brief Summary: This report takes a closer look at the radiological releases from the Idaho National Laboratory (INL) from 1990 to 2019 and at the trends in environmental contamination in southeast Idaho from the INL.

Stated radiological releases from the Idaho National Laboratory since 1952 had decreased by the early 1990s due to cessation of spent nuclear fuel processing of Department of Energy research reactor and naval spent fuel. The calcining of liquid high-level waste had ceased by mid-2000.

Since 2000, however, the radiological releases from the INL have been increasing and so have the maximum concentrations in radiological detections for environmental surveillance.

While official environmental monitoring programs continue to assert that all of the detected radioactive contamination is due to past nuclear weapons testing or naturally occurring radioactivity, the evidence of INL contamination can be seen.

With an emphasis on airborne releases, this review presents selected highlights of the radiological monitoring program results of the Department of Energy environmental surveillance program and also of the Idaho Department of Environmental Quality surveillance program. Gyrating levels of radionuclides (such as iodine-131, strontium-90 and cesium-137) detected in milk, and radionuclides such as strontium-90 and cesium-137 in lettuce and wheat are presented. Gyrating and elevated levels of tritium in milk, atmospheric vapor and precipitation are also presented. Significantly elevated concentrations of radionuclides in milk and in atmospheric tritium occur between 2000 and 2003.

The improper and technically indefensible omission of the airborne releases of evaporation pond radionuclide effluents until 2001 is discussed. Only the radionuclides listed in airborne radiological releases are used by the Department of Energy in estimating annual radiation dose to the public.

The cancer rates in the counties surrounding the INL show that the current levels are anything but benign, despite the low estimated radiation doses. The incidence of thyroid cancer in the communities surrounding the INL is roughly double the rate of the rest of the state and country.

The projected INL radiological airborne releases are expected to increase 170-fold from more recent levels.

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Executive Summary

After taking time to try to interpret Department of Energy [1] and the State of Idaho radiological environmental monitoring programs at the Idaho National Laboratory (INL) [2] and in the surrounding communities, I was surprised to learn how the radiological releases had ramped up after the year 2000.

Spent nuclear fuel reprocessing had largely ceased years before for program officially ended in 1991. Calcining of liquid high-level waste resulting from spent fuel reprocessing ceased by mid-2000.

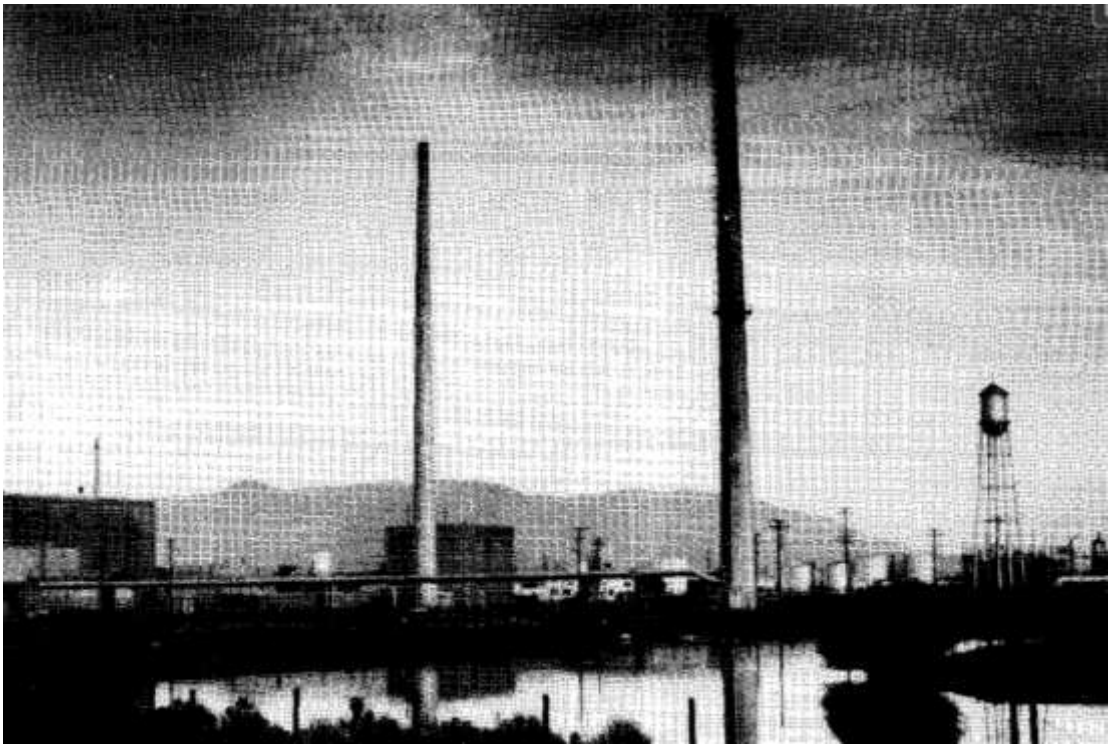
The official environmental monitoring programs have asserted for many years and continue to assert that the radioactivity that they detect cannot be attributed to the INL.

This report focuses on the airborne releases of radiological effluents from 1990 to 2019 and the radiation monitoring program data from Department of Energy and State of Idaho monitoring programs, when available. The following are examined: the maximum levels detected in ambient air of gross alpha and gross beta radioactivity, of tritium in atmospheric vapor and in precipitation, of iodine-131, strontium-90, cesium-137 and tritium in milk, of strontium-90 and cesium-137 in wheat and lettuce, of radionuclide detections in air filters, of radionuclide detections in waterfowl and yellow-bellied marmots, and of detections in soil.

The releases to the Snake River Plain Aquifer from deepwell injection of liquid waste resulting from spent nuclear fuel reprocessing were no longer routine by 1984. Yet, there was a shift from deepwell injection to percolation ponds at INTEC in 1984. And there was a shift from percolation ponds in use since 1952 to open-air evaporation ponds at the ATR Complex in 1993. There were also other percolation ponds put into service at the Idaho National Laboratory. These changes resulted in increased airborne radiological releases that were not included in airborne effluent releases or the estimation of radiation dose to the public before 2001.

[1] Department of Energy's contractor for Environmental Monitoring for the Idaho National Laboratory and surrounding areas at http://idahoeser.com/Publications.html prior to late 2021 and now moved.

[2] See Idaho Department of Environmental Qualities INL Oversight Program monitoring annual and quarterly reports online at https://www.deq.idaho.gov/idaho-national-laboratory-oversight/inl-oversight-program/monitoring-activities/



(Picture from Department of Energy 1984 picture of the Test Reactor Area radioactive waste disposal pond. The Test Reactor Area would later be renamed the ATR Complex.)

Here are some key points to understand about the radiological airborne effluents from the INL:

(1) Cancer rates in the counties surrounding the Idaho National Laboratory are elevated. In particular, the thyroid cancers remain elevated in Bonneville County and all of the counties surrounding the INL and are about twice the rate of the remainder of the counties in Idaho and the rest of the country

(2) Soil as well as crop contamination is usually from airborne releases of radionuclides. The leafy, growing plants readily incorporate airborne radionuclides into the plant and create a significant portion of the radiation dose from airborne radioactive effluents.

(3) The radionuclide contamination in soil off of the INL site, the cesium-137 and strontium-90 levels do seem lower since 2006 than from the 1970s and 1980s. But the level of strontium-90 in garden lettuce and wheat does not seem to be trending downward and this appears to be due to continued radiological airborne releases from the INL. The releases of strontium-90 have remained high and the release of cesium-137 in 2019 was 10 times higher than the previous decade.

(4) The level of plutonium-238 in soil in southeast Idaho is elevated and rising. The proportion of plutonium-238 to plutonium-239/240 is much higher than would be the case for contamination from past nuclear weapons testing. The significant rise in plutonium-238 contamination is due to the INL, despite no official admittance of this fact.

(5) The level of americium-241 in soil in southeast Idaho is rising. The rise in americium-241 contamination, a decay product of plutonium-241, near the INL is not likely to be

from to historical weapons testing but is from continued releases from the special programs at the INL, despite no official admittance of this fact.

(6) The trending of average concentrations of plutonium-239 in soil is less clear, but the maximum contamination levels found in some biennial soil samples in recent years is often higher than the maximums found from 1970 to 1994. The plutonium-239 from nuclear weapons testing that largely ceased by 1980 would be steady or decreasing, not increasing.

(7) Fission product iodine-131, with its 8-day half-life, results from recent reactor operation or nuclear weapons testing. Iodine-131 has a large gamma emission of 380 kilo-electron volts (keV). Iodine-129, with a low energy gamma of 25 keV, is also a fission product and is not naturally occurring, but I-129 has a 16-million-year half-life. The INL releases of I-129 ramped way up due to the dry storage of Three Mile Island Unit 2 (TMI-2) nuclear accident fuel debris. The TMI-2 accident occurred in 1979 and fuel debris was brought to Idaho and stored in a Test Area North fuel storage pool. Later the fuel was transferred to dry storage in the late 1990s and the seals on the canisters were found to have been damaged by the drying process used. The TMI-2 spent fuel canisters are rather unique and are not sealed, which allows the continued release of fission products from the dry fuel debris storage at the INL. Hydrogen along with various radionuclides are released from the TMI-I canisters, but the releases are estimated rather than measured. Radioactive iodine-129 is particularly difficult to detect in current environmental monitoring programs and the deficiencies in the ability to detect the radioactive iodine are not adequately explained.

(8) Airborne tritium levels gyrate up and down in southeast Idaho and this is due to intermittent airborne releases of tritium from INL operations involving reactor operations or spent nuclear fuel. The Department of Energy's environmental contractor has continued claiming that the levels of tritium in precipitation are naturally occurring or are due to past nuclear weapons testing. But naturally occurring levels would not exceed 30 picocurie per liter (pCi/L) and former weapons testing tritium would be decreasing and would not be gyrating upward in such large amounts.

(9) Some of the radionuclides released from the INL are called nuclear activation products. While fission products result from the fissioning of uranium-235 or other fissile or fissionable nuclides, activation products result from air, water, or cladding materials being bombarded with neutrons. Activation products also tend to have moderately short radioactive decay half-lives. A radioactive half-life of one year or less, when there is no long-lived parent radionuclide, means that these radionuclides are not from historical weapons testing. And it allows the determination of the source of the contamination. Several important activation products typical of INL releases include chromium-51, iron-59, zinc-65, manganese-54, cobalt-60. And due to their relatively short half-lives of less than one year, they would not be from past nuclear weapons testing. Fission products such as zirconium-95 and niobium-95 and also cerium-141 and 144 also have short radioactive half-lives would not be from past nuclear weapons testing.

(10) When the tissue from yellow-bellied marmots in Pocatello, Idaho, have numerous fission products and especially numerous nuclear activation products, formed by neutron capture reactions in a nuclear reactor, as found in the second quarter of 2002 and these

activation products or fission products have short radioactive decay half-lives, it calls for admitting that the source of these radionuclides is the INL. That the source is the INL and that the source is not being admitted should concern everyone living within 50 miles of the INL. **The approach currently taken by the Department of Energy's environmental monitoring program is to assure that the detections are not analyzed adequately and can then be characterized as "not detected."** Thus, the annual report stated only strontium and cesium being detected in the marmot tissues because the cesium and strontium could be attributed to past nuclear weapons testing. The bar the Department of Energy's environmental surveillance contractor has been selected assure a high confidence that it is not a false detection. In 2003, this is done by deeming only those results meeting three standard deviations (3s), for example, 30 pCi/L ± 10 pCi/L when the uncertainty is reported as one standard deviation (1s), which ensures that the results provide 95 percent confidence that it is not a false detection. The problem is the very high probability of false negatives may be 50 percent. The sample that is near detection limits may have a 50 percent chance of containing the radionuclide higher than background although the monitoring program falsely concludes that the sample does not contain the radionuclide when in fact it does.

(11) The Department of Energy's environmental contractor has taken to selecting analytical techniques that have resulted in results that are not physically possible and reflect inappropriate handling of the blanks used to compare to the sample. Fifty percent of a sample's distribution could be a negative value, as the blank's counts are subtracted from the sample's counts. But when nearly the entire distribution is a negative value, it reflects that the contractor used a "hot" blank to compare to the sample. For example, a radioactive concentration that is stated to be -30 pCi/L ± 10 pCi/L would have nearly the entire distribution for the sample being a negative radioactivity and this is not physically possible. The larger the negative number, is indicative that the blank used to compare to the sample was to that amount, more radioactive than the sample. This needs to be acknowledged by the monitoring program. But in reality, they are embracing the negative values as they compute the average values, as the large negative values offset valid positive value detections.

About the Author

Tami Thatcher is an Idahoan with roots in the Little Lost Valley. Her grandparent's ranch was located at the boundary of the INL between INTEC and Test Area North. There were radiation monitoring film badges hung on grandma's white picket fence — and she died of cancer. And so did her great grandmother who had lived on the ranch during the 1950s and 60s when radiological airborne releases from the INL were very large. She has witnessed numerous friends and colleagues who worked at the Idaho National Laboratory die of cancer. So understanding historical radioactive contamination, both airborne and in groundwater, has become a deeply personal interest. She has a Bachelor of Science degree in Mechanical Engineering from the University of Idaho and worked as a nuclear safety analyst at the Idaho National Laboratory.

Airborne Radiological Releases from the Idaho National Laboratory and the Increasing Radioactive Contamination in Southeast Idaho

At the Idaho National Laboratory (formerly called the National Reactor Testing Station) radiological and chemical processes largely commenced in 1952 including the operation of nuclear reactors, spent nuclear fuel reprocessing and other nuclear fuel separations processes. These operations, open air destructive nuclear fuel tests, and accidents released airborne radiological contamination to blow in the wind and have often been underestimated.

Airborne releases that have been omitted from Department of Energy's stated annual estimates of Idaho National Laboratory airborne effluents (waste) include radioactive waste drum mishaps at the Radioactive Waste Management Complex (RWMC) that have caused airborne releases when barrels of transuranic waste, would be damaged during waste burial operations. These occurrences were considered routine and did not trigger bioassay for workers, and the releases were ignored. Airborne releases also increased as cleanup work of contaminated soils were released as heavy equipment was used to scrape contaminated soils and haul contaminated soils from various locations at INL to other locations at INL in the name of "cleanup" through the years.

Enormous quantities of radiological and chemical contaminants were also injected into the Snake River Plain aquifer and were also released via percolation ponds to flow downgradient to other INL facilities as well as offsite communities. The percolation ponds and the lined evaporation ponds also contributed to airborne effluents but this was ignored until 2001.

This report focuses on airborne radiological effluents, particularly from the INL from 1990 to 2019. The primary sources of environmental monitoring data are from Department of Energy environmental monitoring reports [3] and State of Idaho Department of Environmental Quality INL Oversight Program reports. [4] The State of Idaho began environmental monitoring in 1989 but has removed from public online access decades of reports, leaving only the most recent years of environmental quarterly and annual reports available without expensive and cumbersome information requests. The State of Idaho DEQ went from displaying all of their environmental monitoring reports to displaying ten years of the reports, to know displaying only six years of annual reports and only 4 years of quarterly data reports. Documents in the State of Idaho Department of Environmental Quality office were sometimes only available printed in the tiniest font possible and nearly illegible, so even an approved office visit may not result in meaningful

[3] Department of Energy's environmental monitoring reports, see idahoeser.com and inldigitallibrary.inl.gov.
[4] Idaho Department of Environmental Quality, INL Oversight Program Monitoring Reports, accessed July 7, 2020 at https://www.deq.idaho.gov/inl-oversight/monitoring/reports/ .

access to the information. The Idaho DEQ INL environmental monitoring program appears to be under the influence of the Department of Energy as DEQ's reports downplay detected radiological contamination.

The impression has been that the bad old days are over, that those days of millions of curies being released from the INL to the skies and to the communities surrounding the INL was largely in the past and prior to 1989. I will discuss how the official accounting of the releases documented in the *INEL Historical Dose Evaluation* [5] from 1952 to 1989 has underestimated the releases, omitted certain radionuclides important to human health, and underestimated the harm from airborne releases.

In this review of 1990 to 2019, I will present the airborne radiological effluents stated to have been released from the INL and why these estimates of stated releases are likely to be low. I present some of the trends in the environmental monitoring results. The radiological contamination is detected in ambient air monitoring stations and analysis of air filter particulate. The radiological monitoring related to airborne releases also includes the sampling of soil, of lettuce, wheat, and milk. I include the sampling of animal tissues: waterfowl and yellow-bellied marmots. The sampling of waterfowl (ducks) can include access to radiological contamination from open-air evaporation ponds but animals off of the INL site, such as yellow-bellied marmots collected from off of the INL site, would not have access to those open-air liquid radioactive waste ponds.

I will discuss the radionuclides most prevalent to the Department of Energy's estimated radiation dose to people offsite that are presented in its annual environmental surveillance reports. The radiation doses from airborne effluents includes plume shine, inhalation and contaminated crop ingestion.

And I will discuss how certain radionuclides released from the INL can be distinguished from former nuclear weapons testing at the Nevada Test Site and from global nuclear weapons fallout from nuclear weapons testing conducted by the United States (outside the continental U.S), France, China and others.

The ingestion as well as the inhalation of radionuclides is more harmful than external radiation. This is a fact that is not included in the current estimation of effective whole-body dose, even though at least one former member of the International Commission on Radiological Protection (ICRP) has acknowledged that the effective dose from internal radiation is probably at least 100 times greater than currently modeled. Radiation is also many times more harmful to children, especially female children, and to developing the child in utero than to an adult male.

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

I reviewed cancer registry reports for counties surrounding the INL and I found that for over a decade, the incidence of thyroid cancer in these communities is roughly double to rate in the rests of the state and the rest of the country. [6]

To a very large extent, the Department of Energy, the State of Idaho and the Center for Disease Control have failed the citizens of Idaho and have ignored the adverse health effects from INL's continuing airborne radiological releases.

The official estimated annual doses from INL airborne radiological effluents remain below the Environmental Protection Agency limit of 10 millirem per year and are stated to be a fraction of a mrem/yr in Department of Energy annual environmental surveillance reports. But the INL's stated airborne releases have often been underestimated. For example, the radiological releases from the evaporation ponds installed at the ATR Complex in 1993 were not included in the airborne effluents until 2001. Also, only the estimated releases for the year are included in the radiation dose estimates. The doses received from past INL releases and also from former nuclear weapons testing from long-lived radionuclides are ignored.

Radiation Worker and Citizen Compensation Programs

Like the rest of the country, southeast Idaho received nuclear weapons testing fallout from the Department of Energy's Nevada Test Site and also from the nuclear weapons testing conducted by other countries. While a compensation program for citizens exposed to Nevada Test Site nuclear weapons tests was created by Congress, the Radiation Exposure Compensation Act, it does not cover southeast Idaho where the Department of Energy showered citizens with both nuclear weapons testing fallout and radiological releases from the Idaho National Laboratory.

Many former INL workers may suspect that they have been exposed to radiation or chemicals and following illness may have applied to the Energy Employee Occupational Illness Compensation Program Act (EEOICPA) only to be denied. [7] The National Institute of Occupational Safety and Health (NIOSH) that administers the energy employee illness program, the EEOICPA, emphasizes that it uses claimant favorable modeling to determine whether working at INL likely caused the illness. But they have denied two-thirds of the claims by INL workers. Fortunately, there are now several radiation exposure cohorts that provide

[6] Environmental Defense Institute February/March 2020 newsletter article "Rate of cancer in Idaho continues to increase, according to Cancer Data Registry of Idaho" and the July newsletter article "Troubling Increases in U.S. Thyroid Cancer Incidence Rates: And Counties Around the Idaho National Laboratory Roughly Double State and National Thyroid Cancer Rates."

[7] 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

compensation for INL and ANL-W employees for certain years of employment without requiring radiation dose reconstruction to determine eligibility. [8]

Reporting of drinking water contamination at various INL sites has rarely been comprehensive and for many years was not conducted. Environmental Defense Institute has prepared two reports, however, that highlight some of the recorded levels of contamination in drinking water at INL that workers were drinking and also downgradient of the INL. [9] [10]

NIOSH did conduct epidemiology comparing the health of INL workers to that of surrounding communities and they found that both radiation workers and non-radiation workers at the INL site had elevated illnesses. [11] NIOSH never sought to answer why. And this is despite the growing body of human epidemiological evidence that shows that the officially accepted models of radiation cancer risk underestimate the harm of ionizing radiation. [12] [13]

Radiological Releases From the INL

Beginning in 1952, millions of curies of radioactive effluents were released from stacks, open-air destructive nuclear fuel testing, fuel reprocessing, calcining, other operations and accidents. When then State Governor Cecil Andrus asked what had been released, the Department of Energy had to begin a review of the accidents, tests and various operations they had conducted to try to estimate what they had released. DOE had long been assuring people that no serious radiological releases had taken place based on various environment samples of sage, soil, rabbit

[8] See the Idaho National Laboratory status at http://www.cdc.gov/niosh/ocas/ineel.html and see the portion of INL formerly ANL-W at http://www.cdc.gov/niosh/ocas/anlw.html

[9] Environmental Defense Institute report by Tami Thatcher, *The Hidden Truth About INL Drinking Water*, June 2015, http://environmental-defense-institute.org/publications/INLdrinkwaterR1.pdf

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

[11] "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/

[12] 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] (And please note that studies of high leukemia risk in radiation workers and of ongoing studies to assess health effects of high and low-linear energy transfer internal radiation must also be studied in addition to this one on external radiation.)

[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.

thyroids, and by film badge. But, the Department of Energy didn't actually know how many curies they had released of the various radionuclides.

Estimates of the airborne radiological releases for 1952 through 1989 were prepared by the Department of Energy in the *INEL Historical Dose Evaluation* [14] (or INEL HDE) but significantly underestimated the radiological releases (see more discussion later in this report).

INL airborne releases included a long list of every fission product that exists but few were monitored. The radionuclides that were released to the air, often completely unfiltered, blew with the prevailing winds. The winds that carry radioactive effluent toward the northeast by day and often reverse, carrying the effluent toward the southwest at night. The shifting winds ensure a generous offering of airborne effluent as far south as Rupert and as far north as Dubois, as far west as Craters of the Moon and as far east as Idaho Falls, see Figure 1.

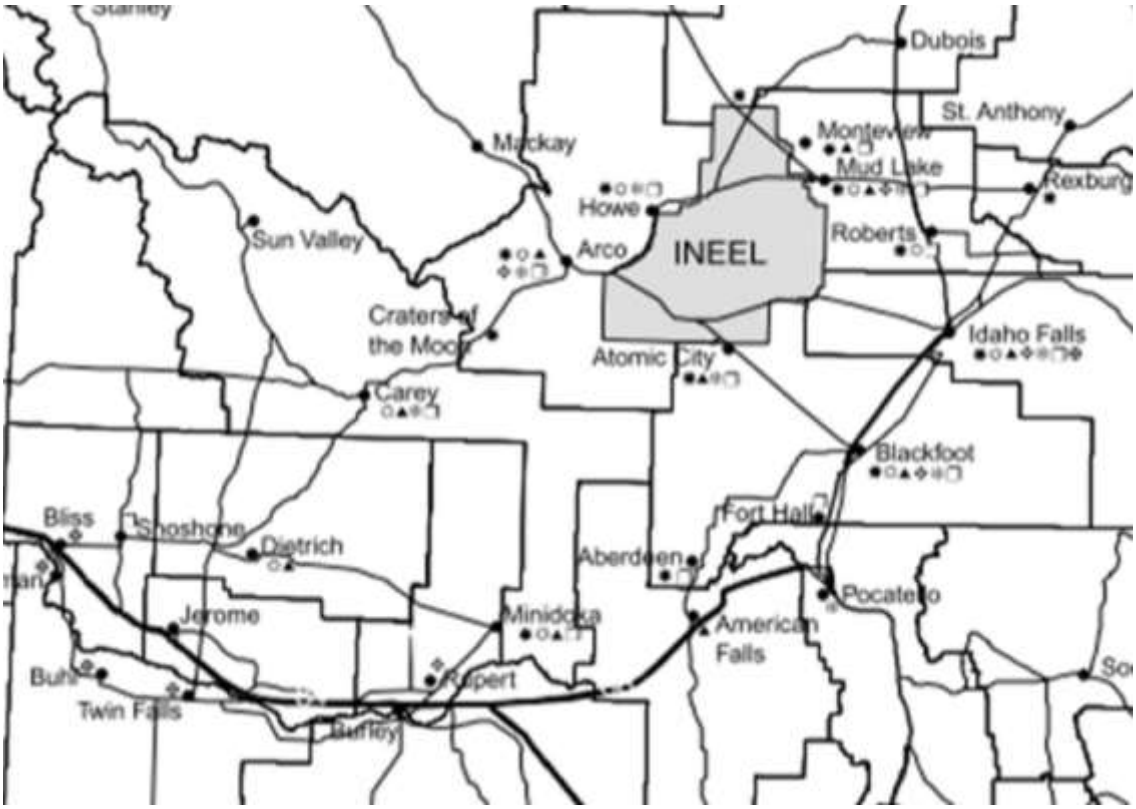


Figure 1. Communities near the Idaho National Laboratory in southeast Idaho.

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

Wind isopleths provided in Department of Energy environmental surveillance reports to indicate possible the radionuclide concentrations from the Idaho Chemical Processing Plant stack [later renamed the Idaho Nuclear Engineering and Technology Center (INTEC)] are often lopped off south of the INL despite the air concentrations remaining high (see Figure 2). Long-lived particles land in the soil and then can be resuspended to blow another day.

In the wind isopleth in 1985, the annual average contamination concentration in Idaho Falls relative to the INTEC stack are 3 percent. Of course, not all INL releases are from the INTEC stack. Radiological releases are also from the Test Reactor Area (TRA) renamed the ATR Complex, the burial ground at the Radioactive Waste Management Complex (RWMC), from Test Area North (TAN), from the Materials and Fuels Complex that was the location of the Experimental Breeder Reactor II (EBR-II), and from other INL site operations. See Figure 3. And many releases are intermittent rather than constant.

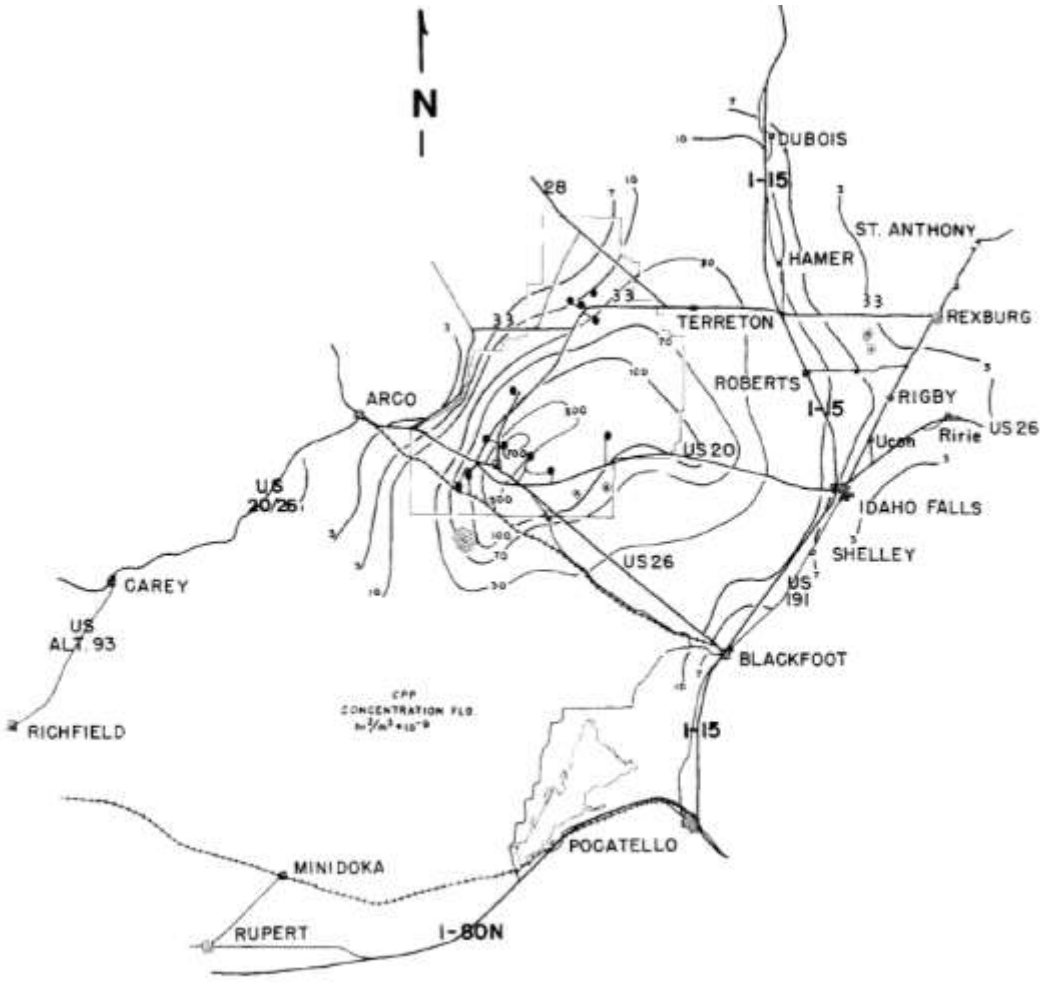


Figure 10. 1985 average of mesoscale dispersion isopleths of air concentrations at ground level, normalized to unit release rate.

Figure 2. Wind isopleth for INTEC stack releases for 1985.

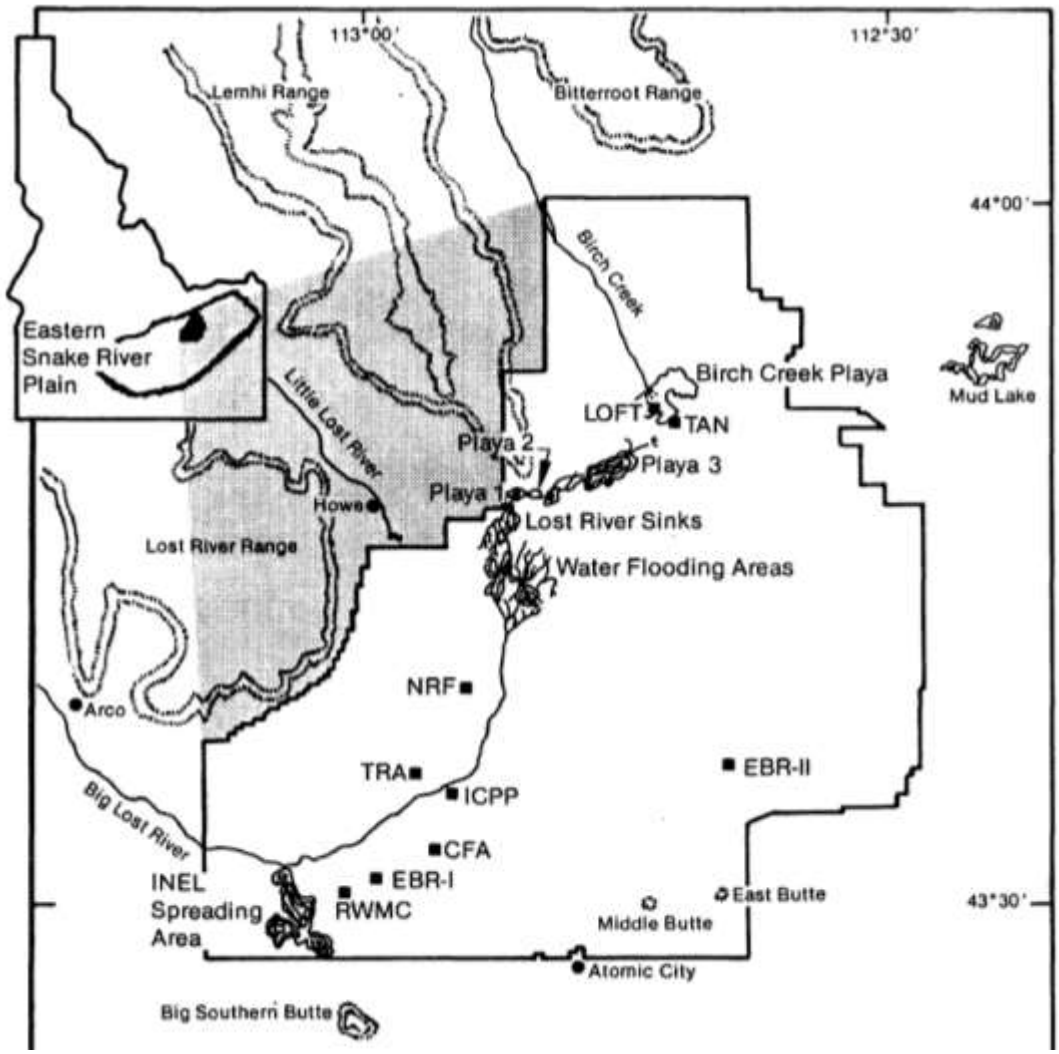


Figure 3. General location of Idaho National Laboratory facilities. (Note that TRA was renamed the ATR Complex; ICPP was renamed INTEC; and EBR-II was renamed MFC.)

The Department of Energy environmental surveillance reports provide an estimate of the radiological airborne releases of the radionuclides released from its facilities at the Idaho National Laboratory. The stated airborne releases, (curies of each radionuclide) are used by the Department of Energy to provide an estimate of the effective whole-body radiation dose.

The actual radiological releases from the Idaho National Laboratory have often been underestimated, both before 1989 and also after 1989. The curie amounts of INL airborne effluents are estimated by Battelle Energy Alliance and the Idaho Cleanup Project. Most of the releases are unmonitored or intermittently monitored. The methodology of how the releases were estimated is typically not publicly available. The omission of certain radionuclides, is one way that the releases have been understated. The omission of radioactive liquid effluents in open-air ponds is another way that airborne effluents were significantly underestimated until 2001 (more about this later in this report).

There is a general downward trend in the curie amounts of radionuclides over the last ten years; however, **the releases over the last twenty years have generally been higher than the releases from 1993 through 1996**, see Figure 4. With the end of spent fuel reprocessing by 1991 and the end of calcining by mid-2000 (both operations conducted at INTEC), it may come as a surprise to see the escalating radionuclide releases starting by 2001.

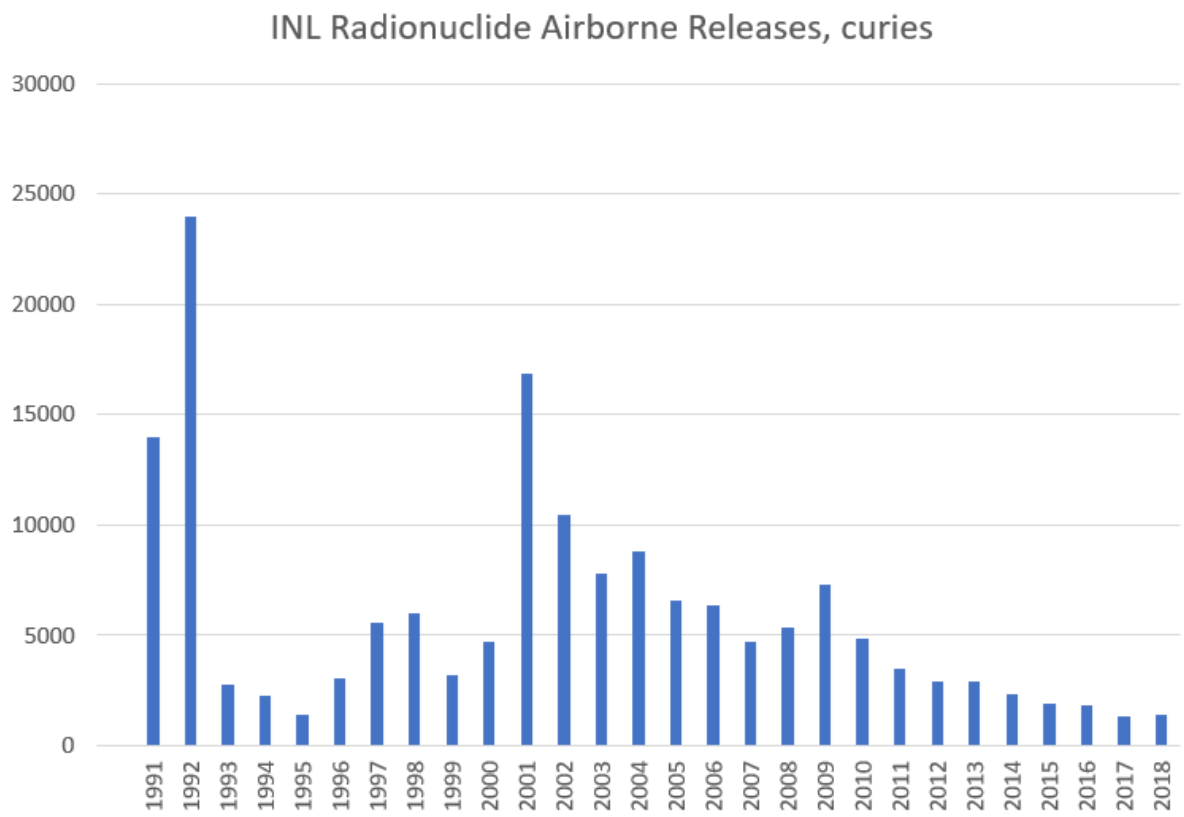


Figure 4. INL Radionuclide Airborne Releases, curies, from 1991 to 2018.

It is important to know that regarding the curie amount for some radionuclides like krypton-85, very large curie amounts yield small radiation doses. And **for other radionuclides like iodine-129, plutonium-239 and americium-241, very small curie amount releases yield large contributions to radiation dose.** The trend in annual estimated effective dose is provided in Figure 5.

As you can see in Figure 5 below, the radiation doses from the Idaho National Laboratory from 2000 to 2019 are generally higher than for the 1990s. **And the radiation dose trend over the last few years is increasing, not decreasing**. This is without accounting for ingestion of radioactive animal tissue, which I have not included here.

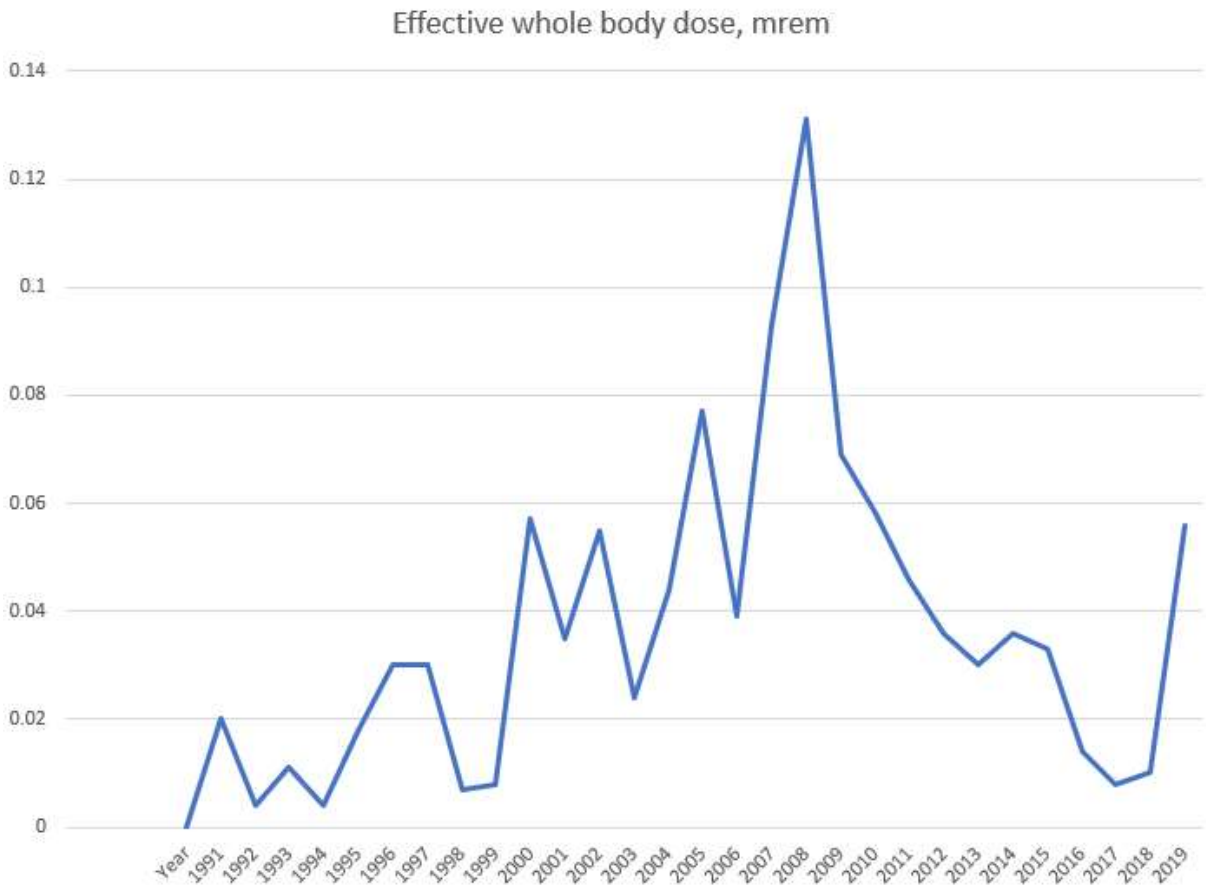


Figure 5. Department of Energy estimated annual effective whole-body dose in millirem from INL airborne releases, 1991 through 2019.

There are a few things to keep in mind whenever these seemingly negligible doses are discussed. First, they are using the effective whole-body dose which waters down the dose and does not reflect the far higher organ absorbed doses and in no way provides a reliable indicator of health risk, not even fatal cancer risk (more about this in the next article). Second, the organ doses, absorbed doses, need to be presented but are not. The thyroid doses in particular need to be displayed. The thyroid doses are far above natural background levels. And third, the 100 millirem per year that the Department of Energy keeps emphasizing as their allowable and safe level was based on faulty models limited almost exclusively to cancer mortality risk and the incorrect presumption by the ICRP that the risk was 0.0001 fatal cancers per year. This risk was the basis for various regulations selecting 100 mrem per year. But the fatal cancer risk is now admitted by the Department of Energy to be at least 0.0006 fatal cancers per year.

Often forgotten is the fact that the effective whole-body dose is applicable only to late stochastic effects, basically only cancer mortality (fatal cancers) and not to immediate deterministic effects. This fact was forgotten when the Department of Energy misused effective dose and the cancer mortality rate to incorrectly state that doses as high as 1000 rem, yes, 1000 rem, caused no harm, despite the long-known fact that 50 percent of people exposed to 500 rem

would die within weeks. (Read more in the August 2021 Environmental Defense Institute newsletter about errors in the Department of Energy's Versatile Test Reactor Environmental Impact Statement.)

The specific radionuclides released from the INL and from each facility each year vary, as do their curie amounts. The radionuclides that tend to dominate the radiation effective whole-body dose include tritium, argon-41, strontium-90, cesium-137, iodine-129, plutonium-239 and americium-241. **In 2015, 561 curies of argon-41 yielded a 0.0025 mrem dose, while 0.000673 curies of plutonium-239 yielded a comparable dose contribution of 0.0019 mrem.**

In 1998, most of the radiation dose came from iodine-129 (6.3E-3 mrem) and argon-41 (1.8E-3 mrem), while in 2008 most of the dose came from strontium-90 (0.03 mrem), americium-241 (0.011397 mrem) and plutonium-239 (0.011528 mrem).

The dilution of the radionuclides in air is not based on the reality of actual plume movement and rain-out. Nothing about the radiation dose is nearly as precise or conservative as the Department of Energy would like it to appear. The Department of Energy's environmental surveillance reports (Idahoeser) continually compare the radiation dose to what it deems the limit on exposure to the public, 100 mrem/yr. In fact, the limit on airborne radionuclide from Department of Energy facilities is by federal Environmental Protection Agency regulations, limited to a dose to the public of 10 mrem/yr.

The Department of Energy's all-pathways allowable dose to the public of 100 mrem/yr is not a benign value that could be exceeded year after year without causing a health catastrophe especially for mothers, children and the unborn. The reason is that the harm from internal radionuclides is greater than currently represented by the models adopted by the Department of Energy. The harm from chronic radiation exposure from internal radiation is not well represented by the study of Japan's World War II bombing survivors. The exposure from the bombings were large gamma (with neutron) doses delivered at one time. The effects of living in the fallout were largely removed by the selection of the control population versus that bombing survivors.

The radiation dose estimates stated in the Department of Energy's annual environmental surveillance reports are based on stated radiological airborne effluents (waste) and the estimated maximum radiation dose considers the dose from air immersion, air inhalation and from ingestion based on expected wind pattern dilution. The location of the hypothetical individual who is referred to as the "maximally exposed individual" called the MEI, is off of the INL site.

The variety of radionuclides released from INL's nuclear facilities includes many dozens of radionuclides, but there are 20 radionuclides that have been the main contributors to the estimated dose, see Table 1. These are tritium, carbon-14, chlorine-36, argon-41, chromium-51, cobalt-60, zinc-65, krypton-85, strontium-90, antimony-125, iodine-129, iodine-131, cesium-137, plutonium-238, plutonium-239, plutonium-240, plutonium-241, americium-241, uranium-234 and uranium-238.

Table 1. Top twenty radionuclides that tend to be the main contributors to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory.

Radionuclide	Half-life	100 mrem per year "Derived Concentration Guide" inhalation of air, uCi/mL	100 mrem per year "Derived Concentration Guide" in water, uCi/mL	Common source of the contaminant
Tritium (H-3)	12.3 year	2.1E-7 (water vapor)	1.9E-3	Advanced Test Reactor, INTEC. A 10 year high of 1600 curies in 2008.
Carbon-14	5,700 year	6.6E-10	6.2E-5	Spent fuel, cladding and reactor coolant
Chlorine-36	301,000 year	1.0E-10	3.2E-5	
Argon-41	1.83 hour	1.4E-8 for cloud immersion	-	Advanced Test Reactor
Chromium-51	27.7 day	9.4E-8	7.9E-4	Advanced Test Reactor
Cobalt-60	5.27 year	1.2E-10	7.2E-6	Irradiation target cladding
Zinc-65	244 days	1.6E-9	8.3E-6	Irradiation target cladding
Krypton-85	10.7 year	3.6E-6 for cloud immersion	-	Spent fuel dissolution
Strontium-90	28.6 year	2.5E-11	1.1E-6	Various
Antimony-125	2.73 year	3.1E-10	2.7E-5	INTEC
Iodine-129	16,000,000 year	1.0E-10	3.3E-7	Rather steady and continuing releases from INTEC TMI-2 fuel and stack
Iodine-131	8.04 day	4.1E-10	1.3E-6	Advanced Test Reactor
Cesium-137	30.2 year	9.8E-11	3.0E-6	Various and now especially MFC
Plutonium-238	87.7 year	3.7E-14	1.5E-7	Various
Plutonium-239	24000 year	3.4E-14	1.4E-7	
Plutonium-240	6580 year	3.4E-14	1.4E-7	Decays to radium-228
Plutonium-241	14.35 year	1.8E-12	7.6E-6	Decays to Am-241
Americium-241	458 year	4.1E-14	1.7E-7	
Uranium-234	246,000 year	4.0E-13	6.8E-7	MFC
Uranium-238	4.47E9 year	4.7E-13	7.5E-7	MFC

Table notes: For the 100 mrem/yr "Derived Concentration Guide" values for air and water, see Department of Energy DOE-STD-1196. But note that the limit on radiation dose from airborne emissions is actually 10 mrem/yr under EPA regulations. The unit uCi/mL stands for microcurie/milliliter, or 1.0E-6 curie/liter. Note that all plutonium, americium and uranium isotopes decay through a long series of radioactive decay products. The Department of Energy's Idahoeser report for 2019 did not include chlorine-36 or uranium derived dose concentration data.

In Table 2, the dominant radionuclides contributing to radiation dose from INL airborne effluents for 2015 and 2019 are listed.

Extremely long-lived radionuclide iodine-129, with a 16-million-year half-life, continues to be steadily released from spent fuel at INTEC, primarily from Three Mile Island Unit II spent nuclear fuel debris that the Department of Energy brought to Idaho, graciously sparing people living around the failed reactor in Pennsylvania. The low energy beta emitter is difficult to detect in the environment, but finds its way into living tissue.

High energy gamma emitter iodine-131 has a short half-life of about 8 days, but it is pervasively released from Advanced Test Reactor operations not only from its reactor fuel but also from its target materials.

Since 2000, the total curies released from the INL has ranged from 1330 curies to 16,833 curies. The estimated radiation dose to the MEI has ranged from 0.008 mrem to 0.131 mrem. Reactor operations release tritium, argon-41, iodine-131, chromium-51 and other radionuclides; irradiated material processing releases actinides, fission products and cladding activation products; fuel processing releases krpton-85 and other radionuclides; cleaning up nuclear weapons production waste from Rocky Flats involves actinides such as americium, plutonium and uranium, and we are discovering what the recovery of enriched uranium from Experimental Breeder Reactor II (EBR-II) fuel involves releasing as the high-assay low-enriched uranium fuel process ramps up at the Materials and Fuels Complex.

In 2019, INL's releases of uranium-234 and uranium-238 releases skyrocketed, as did the release of zinc-65 and chlorine-36. The release of cesium-137 was about 10 times higher than previous recent years and strontium-90 releases remained high. INL's Materials and Fuels Complex was the primary source of these radionuclides, and the MFC is located far closer to Idaho Falls than the Advanced Test Reactor, Idaho Nuclear Technology and Engineering Center (INTEC) or the Radioactive Waste Management Complex. (That is why it is especially concerning when the Idaho DEQ collected no air monitoring data in Idaho Falls from July to September in 2020 but the complete annual reports for 2020 are not yet available.)

Table 2. Estimated radiation dose from specific radionuclides from airborne radionuclide effluents at the Idaho National Laboratory for 2015 and 2019.

Radionuclide (Half Life)	Curies released by INL in 2015	2015 MEI mrem due to INL air effluents	Curies released by INL in 2019	2019 MEI mrem due to INL air effluents
Tritium (H-3) (12.3 year)	532	0.0111	450	0.0011
Carbon-14 (5,700 year)	0.988		0.683	
Chlorine-36 (301,000 year)	-		7.19E-3	0.0035
Argon-41 (1.83 hour)	561	0.0025	884	
Chromium-51 (27.7 day)	-		-	
Cobalt-60 (5.27 year)	1.30E-2		8.22E-3	
Zinc-65 (244 day)	3.26E-5		0.16	0.0019
Krypton-85 (10.7 year)	733		51.1	
Strontium-90 (28.6 year)	3.05E-2	0.0020	2.36E-2	
Antimony-125 (2.73 year)	7.33E-4		-	
Iodine-129 (16,000,000 year)	2.15E-2	0.0037	1.31E-3	
Iodine-131 (8.04 day)	1.1E-2		9.0E-2	
Cesium-137 (30.2 year)	0.0239	0.0010	0.267	0.0314
Plutonium-238 (87.7 year)	1.33E-4		-	
Plutonium-239 (24,000 year)	6.73E-4	0.0019	1.94E-5	
Plutonium-240 (6580 year)	1.90E-4	0.0004	1.88E-6	
Plutonium-241 (14.35 year)	4.19E-3		-	
Americium-241 (458 year)	3.36E-3	0.0093	7.19E-5	
Uranium-234 (246,000 year)	-		5.88E-2	0.0430
Uranium-238 (4.47E9 year)	-		1.29E-1	0.1124
		Total 0.033 mrem, 2015		Total 0.0588 mrem, 2019

Table notes: MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Table

notes (continued) Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead.

The DOE's environmental surveillance reporting has unexplained gaps, omissions and technically unsupportable explanations that deny radionuclides are from the INL. The DOE's environmental surveillance reports historically omitted americium-241 from stated radiological airborne effluent estimates and omitted monitoring of Am-241. More recent years have routinely explained the Am-241 as being from past nuclear weapons testing, when in fact, numerous CERCLA cleanup reports have found extensive at-facility radiological contamination, including Am-241, that cannot be attributed to past weapons testing.

Plutonium-241 is made by neutron capture in a reactor and Pu-241 decays to amercicium-241. Neither the Pu-241 nor Am-241 releases from the INL were adequately reported in past years. Americium-241 builds up over about 70 years as the Pu-241 decays into Am-241. In contrast, plutonium-239 decays slowly into uranium-235 and other decay products.

The Department of Energy has often lumped the reporting of plutonium-239 and plutonium-241 together and omitted mention of plutonium-241 or its decay product americium-241. Natural as well as manmade isotopes of uranium have usually not been reported. But plutonium-240, uranium-232, and uranium-236 feed the thorium-232 decay series and the elevated levels of decay products such as thallium-208 are attributed to naturally occurring thorium-232 decay when it is actually due to the release of radionuclides from the INL. The levels of radium-228 are elevated in our region not by naturally occurring thorium but from weapons testing fallout and by the release of plutonium-240 and uranium-236.

The Department of Energy's environmental monitoring programs are often wrong about the source of contamination as it attributes elevated levels of airborne americium-241 to past nuclear weapons testing. There is no independent oversight and no error reporting or review of the DOE's highly biased and inadequate environmental monitoring program.

The DOE's environmental monitoring contractor routinely does not provide quarterly monitoring reports, incorrectly attributes INL radiological releases to historical weapons testing, fails to provide trending information, when it provides trending, fails to explain the large gaps in data availability. There is no independent or honest assessment and oversight of the lapses common to the DOE's environmental monitoring program.

The various environmental impact statements created by the Department of Energy for large, new projects fail to address the inadequate environmental monitoring by DOE contractors, including the annual environmental surveillance report contractor, which incorrectly attributes americium-241 from the INL to past nuclear weapons testing.

DOE's environmental monitoring program is inadequate and the program is designed more around hiding the INL's contamination than revealing it. When INL's airborne releases were

increased, in 2003 the program raised the bar for what would be considered a detection of radioactivity. When that wasn't enough, the program would raise the concentration level that could be detected, the "minimum detectable concentration" selected prior to monitoring and analytical laboratory selection. So, when the technology had easily allowed 1 picocurie/liter to be detected, the specified sampling program minimum detectable concentration would be raised to 3 pCi/L in milk, for example. Taking air monitors offline, destruction of samples and similar approaches have been taken in order to keep a lid of the growing radiological contamination in southeast Idaho.

Even now, when ambient air filters are evaluated and found to have americium-241, plutonium-238 and plutonium-239, for example, the DOE and State of Idaho assert that the source of the radionuclides is most likely due to former weapons testing, even though the ratios of the material and the historical levels of the material do not support this assertion.

Monitoring of waste burial sites for CERCLA at INL and the Snake River Plain Aquifer has often been inadequate and biased to hide contamination findings by reduced monitoring and reduced reporting. The ease with which strong detections can be discounted and the deliberate practice of conducting spotty, infrequent monitoring of land and the aquifer often means "no discernable trend could be found."

The plutonium and americium-241 releases from the Idaho National Laboratory between 2001 and 2017 shown in Figure 6 are based on Department of Energy environmental monitoring reports. [15]

Plutonium-238 concentrations in soil in areas at or surrounding the INL are shown in Figure 7. Any plutonium-238 from weapons testing conducted prior to 1980 would have been decreasing. Instead, the concentrations detected in soil have increased, especially after 2000. [16]

[15] Department of Energy's environmental monitoring reports, see idahoeser.com and inldigitallibrary.inl.gov.

[16] See Environmental Defense Institute June 2020 newsletter article "Digging into the Radiological Soil Contamination Levels in counties around the Idaho National Laboratory" which looks at trends from 1975 through 2018.

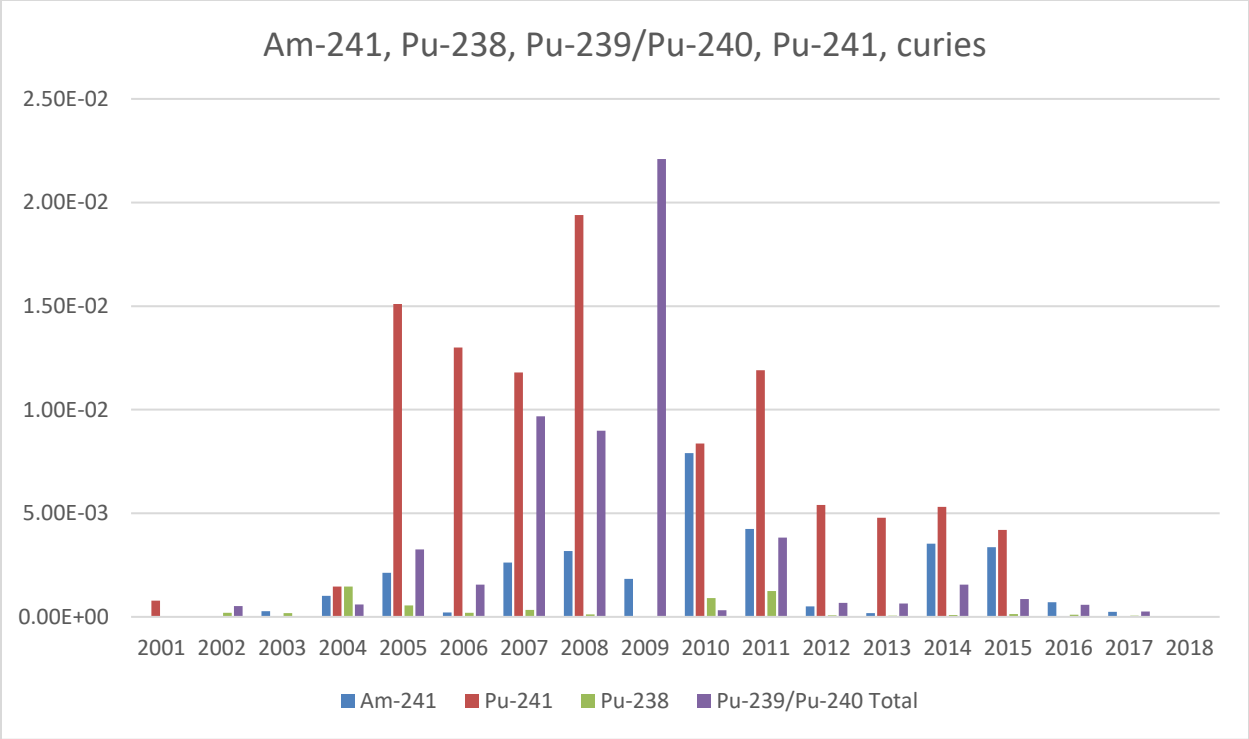


Figure 6. Americium-241, plutonium-238 and other actinides released by the INL between 2001 and 2018.

Year	Mean	Min	Max
1975	0.0028	0.0023	0.0034
1978	0.001	0.0005	0.002
1980	0.0007	0.0005	0.0009
1982	0.0011	0.0007	0.0017
1984	0.0015	0.0008	0.0027
1986	0.0021	0.001	0.0027
1988	0.0014	0.0009	0.0024
1990	0.0006	0.0003	0.0012
1992	0.0013	0.0009	0.0019
1994	0.0013	0.0009	0.0019
1996	0.0011		
1998	0.004		
2000	0.0016	0.0005	0.004
2002	0.0129	0.002	0.027
2006	0.103	0.052	0.154
2008	0.034	0.034	0.034
2010	0.0878	0.0657	0.11
2012	0.0107	0.0075	0.0147
2014	0.0111	0.0074	0.0156
2016	0.0073	0.0041	0.013
2018	0.0067	0.004	0.0109

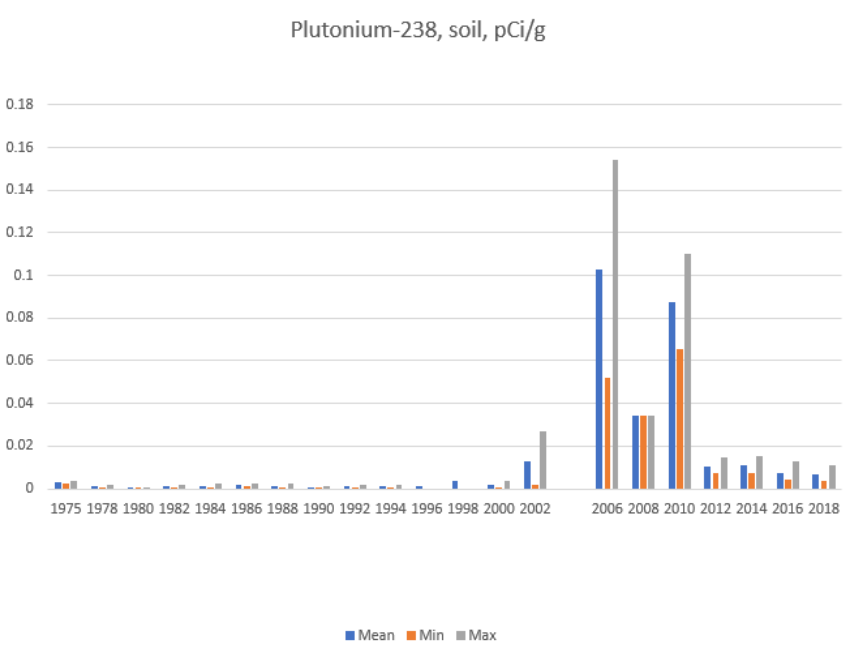


Figure 7. Plutonium-238 detected in soil between 1975 and 2018.

Iodine-129 and iodine-131 releases between 1973 and 2017, in curies, are shown in Figure 8.

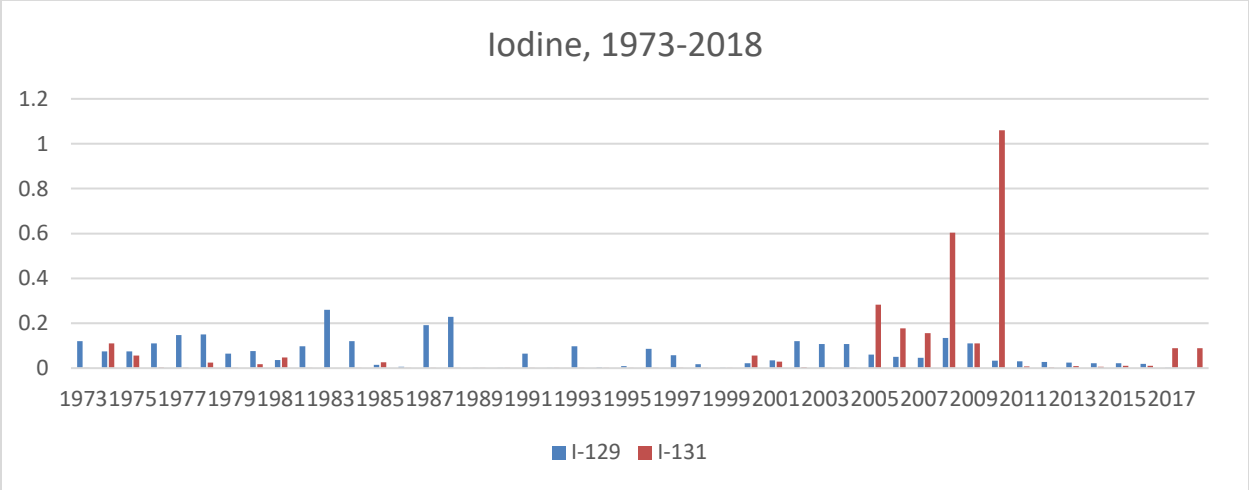


Figure 8. Iodine-129 and iodine-131 released from the INL between 1973 and 2018.

The plutonium and americium-241 and the iodine-129 and iodine-131 are not the only radionuclides with elevated releases from the INL. But these radionuclides might have influenced the elevated thyroid cancers in Bonneville County reported for 2013 to 2017.

Iodine-129 with its 16-million-year half-life has higher inhalation and ingestion dose conversion factors than iodine-131 with its 8-day half-life. While iodine-131 does give a higher air emersion and ground shine dose, the iodine-129 dose often is a dominant dose contributor for INL airborne releases.

A condensed timeline of important INL operations and radiological events is provided in Table 3. Expanded timelines of INL operations, accidents and non-INL radiological events are provided in Appendix A.

Table 3. Condensed timeline of Idaho National Laboratory operations and key non-INL radiological events of interest.

Date	Operations or Event
1949	Inception of the National Reactor Testing Station (NRTS) later renamed the Idaho National Engineering Laboratory (INEL), the Idaho National Engineering and Environmental Laboratory (INEEL), and finally renamed the Idaho National Laboratory (INL)
1952 to present	Inception of the burial ground at the Radioactive Waste Management Complex (RWMC) where radioactive waste from INL operations, from Rocky Flats nuclear weapons plant, and radioactive waste from around the country would be buried over the Snake River Plain Aquifer without a liner. Airborne releases from broken containers and extensive flooding at the facility would generally be ignored and not included in stated airborne effluents used to estimate radiation dose.
1952 – 1970	Operation of the Materials Test Reactor at the Test Reactor Area
1953 – 1988	Spent nuclear fuel reprocessing at the Idaho Chemical Processing Plant that would later be renamed the Idaho Nuclear Engineering and Technology Center (INTEC). Reprocessing did not officially end until 1991.
1957 – 1981	Engineering Test Reactor operations at the Test Reactor Area
1961	Stationary Low-Power 1 (SL-1) reactor accident on January 3, 1961
1963-1981; 1982-1993; June 1997 to May 2000	Calcining of liquid high-level radioactive waste at ICPP renamed INTEC, at the Waste Calcining Facility (WCF) from 1963 to 1981. The New Waste Calcining Facility (NWCF) begins operating in 1982 and ceases operation in 2000. The Idaho DEQ allows NWCF operations despite knowing by 1989 that the facility violated permit requirements.
1967-present	Advanced Test Reactor (ATR) operations at the Test Reactor Area, renamed the Reactor Technology Center (RTC) in 2005 and then later renamed the ATR Complex
March 28, 1979	Three Mile Island Unit 2 meltdown in Harrisburg, Pennsylvania. The TMI-2 fuel debris is later brought to the Test Area North (TAN) pool and then packaged for dry storage and placed at INTEC. The dry storage must remain unsealed due to hydrogen offgassing and leaks radionuclides including iodine-129. The TMI-2 spent fuel and fuel debris was transported to the INL from 1986 through 1990 and stored in the Test Area North pool from 1986 through 2001. The transition from wet storage to dry storage was conducted from 1998 through 2001.
1980	China conducts a very large atomic weapons test (1000 kT) on October 16, 1980. Far higher levels of gross beta activity charted in air monitoring in southeast Idaho, exceeding 1000 E-15 microcurie/milliliter and far more than 10 times higher than typical maximum concentrations.
1984	Percolation ponds are installed to replace “routine” deepwell injection of liquid radioactive waste at INTEC
1986	Chernobyl Accident on April 26, 1986 in the Ukraine. Far higher levels of gross beta activity charted in air monitoring in southeast Idaho, exceeding 1000 E-15 microcurie/milliliter and far more than 10 times higher than typical maximum concentrations.

Date	Operations or Event
1987	Extensive chemical contamination to the aquifer would be ignored until around 1987 when pressure from the U.S. Environmental Protection Agency dispelled DOE's belief that the chemical contamination in the radioactive waste that it had authority over could be ignored.
1991	The DOE issues the *INEL Historical Dose Assessment* (INEL HDE) of operations and accidents from 1952 through 1989) at the request of the State of Idaho.
1993	ATR Complex (or Test Reactor Area) transition from percolation ponds for liquid radioactive waste to two lined radioactive waste evaporation ponds in 1993. Unlined ponds had been used from 1952 to 1993. The retention basin was found to continue to leak after 1993 even though it was thought to have been taken out of service in 1993 so perched water levels remained high. Reporting of liquid effluents to the evaporation ponds were omitted from airborne effluents and excluded from radiation dose estimates until 2001.
1995	The 1995 Idaho Settlement Agreement between the State of Idaho and the Department of Energy which contains milestones for the Department of Energy to remove spent nuclear fuel and transuranic waste.
1995	EPA contamination investigations commence at the INEL (now the INL). Extensive contamination is found at the INL which becomes a federal CERCLA site. Cleanup activities often involve bulldozing and moving soils, generally not reported as creating airborne contamination and not included in radiation dose estimates.
2008	Idaho signs tri-party agreement with the Department of Energy and the Environmental Protection Agency agreeing that only the small amount of "targeted" waste would be exhumed from the burial grounds at the Radioactive Waste Management Complex. Statements that 100 percent of the waste was exhumed often omit the explanation that this means 100 percent of the "targeted" waste and that nearly all of the radioactive waste will remain buried.

Elevated Cancers in Communities Near the INL

There are elevated rates of certain cancers in the communities affected by the INL. For the communities within 50 miles of the INL, airborne releases are particularly significant.

The news headline for the Idaho cancer register report issued in 2018 read that "cancer trends for Idaho are stable." [17] That is what citizens were supposed to take away from the 2017 cancer rate study in Idaho. Why were citizens not told about any of the cancers in the counties in Idaho that significantly exceeded state average cancer rates and exceeded the rest of the US? [18]

The Department of Energy and the State of Idaho are actively ignoring the likely environmental causes of elevated rates of cancer in the communities surrounding the INL and especially the elevated rates of childhood cancer.

The forty-first annual report of the Cancer Data Registry of Idaho (CDRI) was issued in December 2019 for the year 2017. [19] While the rate of some cancers decreased, the bad news for the State of Idaho is that the overall rate of cancer incidence continues to increase.

And, very importantly, childhood cancers in Idaho continue to increase. Pediatric (age 1 to 19) cancer increased at a rate of about 0.6 percent per year in Idaho from 1975 to 2017, see https://www.idcancer.org/pediatriccancer.

The rate of childhood cancer incidence in Bonneville County exceeded the remainder of the state for boys, based on the adjusted rate of cancer incidence. For girls the rate was high, but not above the remainder of the state, see Table 4.

Table 4. Bonneville County childhood cancer incidence rate compared to the rest of Idaho, 2017.

Cancer type	Sex	Rate in Bonneville County	Adjusted Rate in Bonneville County	Rate for remainder of Idaho
Pediatric Age 0 to 19	Total	17.8	17.9	18.2
	Male	19.0	**19.3**	19.1
	Female	16.5	16.5	17.2

Table notes: Rates are expressed as the number of cases per 100,000 persons per year (person-years).

The INL has continued to release radionuclides to the air within 50 miles of the lab with radionuclides including iodine-131, iodine-129, americium-241, strontium-90, cobalt-60, plutonium-238, plutonium-239, ruthenium-103, cesium-134 and cesium-137 and many others. And while doing so, has continued to insinuate that all the radionuclides are from former nuclear

[17] Brennen Kauffman, *The Idaho Falls Post Register*, "New cancer report on 2017 shows stable cancer trends for Idaho," December 13, 2018.
[18] https://statecancerprofiles.cancer.gov/
[19] C. J. Johnson, B. M. Morawski, R. K., Rycroft, Cancer Data Registry of Idaho (CDRI), Boise Idaho, Annual Report of the Cancer Data Registry of Idaho, *Cancer in Idaho – 2017*, December 2019. https://www.idcancer.org/ContentFiles/AnnualReports/Cancer%20in%20Idaho%202017.pdf

weapons testing or some other mysterious source. A study published in 1988 found the mallard ducks near the ATR Complex percolation ponds at the Idaho National Laboratory to be full of transuranic radionuclides including plutonium-238, plutonium-239, plutonium-240, americium-241, curium-242 and curium-244. [20] An employee who I knew had the habit of jogging around the radioactive waste ponds at lunchtime. He died of liver cancer in his 50s. This health-conscious non-smoker was told, like the rest of us, that the radioactivity in the ponds was mainly tritium and was of no health concern what-so-ever.

The stated radionuclide releases from the Idaho National Laboratory to air have often been incomplete or underestimated the releases. The stated "effective dose equivalent" whole body dose has been a *fictional* fraction of a millirem.

The INL releases tons of volatile organic compounds with chlorine compounds to the air, such as the vapor extraction of carbon tetrachloride from buried Rocky Flats waste at the INL's Radioactive Waste Management Complex. A few years ago, EPA monitoring found high levels of carbon tetrachloride in Idaho Falls air. This emission is said to be within federal guidelines, but because chlorine compounds are so unhealthy for the thyroid, the prevalent chemical toxins that are released by the INL that are not even discussed in its environmental monitoring reports may need to be considered in light of elevated thyroid cancer incidence rates near the INL.

The radiation dose reconstruction analysts for the Center for Disease Control, who determine eligibility for the Energy Employee Occupational Illness Compensation Program (EEOICP) continue to ignore what went on and what is still going on at INL facilities, particularly the ATR Complex formerly known as the Test Reactor Area. The radiation dose reconstruction has continued to pretend that the fuel composition of the operating reactors and lack of fuel melt in these reactors means that workers were not exposed to airborne contamination. The CDC need only look at the radionuclides in the ducks. The levels of transuranics including americium-241 and curium in the air at the ATR Complex and other facilities at the INL are sometimes extensive. [21] [22]

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[20] O. D. Markham et al., Health Physics, "Plutonium, Am, Cm and Sr in Ducks Maintained on Radioactive Leaching Ponds in Southeaster Idaho," September 1988. https://pubmed.ncbi.nlm.nih.gov/3170205/ (This study evaluated the concentrations of strontium-90, plutonium-238, plutonium-239, plutonium-240, americium-241, curium-242 and curium-244 in the tissues of mallard ducks near the ATR Complex reactive leaching ponds at the Idaho National Laboratory. It found the highest concentrations of transuranics occurred in the gastrointestinal tract, followed closely by feathers. Approximately 75%, 18%, 6% and 1% of the total transuranic activity in tissues analyzed were associated with the bone, feathers, GI tract and liver, respectively. Concentrations in the GI tracts were similar to concentrations in vegetation and insects near the ponds. The estimated total dose rate to the ducks from the Sr-90 and the transuranic nuclides was 69 millrad per day, of which 99 percent was to the bone. The estimated dose to a person eating one duck was 0.045 mrem. The ducks were estimated to contain 305 nanoCuries of transuranic activity and 68.7 microCuries of strontium-90.)

[21] F. Menetrier at al., *Applied Radiation Isot*., "The Biokinetics and Radiotoxicology of Curium: A Comparison With Americium," December 2007. https://pubmed.ncbi.nlm.nih.gov/18222696/ (This study found that the biokinetics of curium are very similar to those of americium-241. Lung and bone tumor induction appear to be the major hazards. Retention in the liver appears to be species dependent.)

[22] R. L. Kathren, Occupational Medicine, "Tissue Studies of Persons With Intakes of the Actinide Elements: The U.S. Transuranium and Uranium Registries," April-June 2001. https://pubmed.ncbi.nlm.nih.gov/11319054/ (This

The extensive airborne concentrations of americium-241 at the INL may be important to the underestimation of thyroid doses and risks of thyroid cancer incidence. A 1993 study estimated that the dose to the thyroid from americium-241 to be about 1.42 times that delivered to bone. They concluded that the thyroid dose is much higher from americium-241 than has been reported in people. [23]

Americium-241 is an alpha emitter but also has a gamma ray that penetrates into tissue by 1 centimeter.

On the potential health harm of americium-241, the Agency for Toxic Substances and Disease Registry has stated that: "The radiation from americium is the primary cause of adverse health effects from absorbed americium. Upon entering the body by any route of exposure, americium moves relatively rapidly through the body and is deposited on the surfaces of the bones where it remains for a long time. As americium undergoes radioactive decay in the bone, alpha particles collide with nearby cell matter and give all of their energy to this cell matter. The gamma rays released by decaying americium can travel much farther before hitting cellular material, and many of these gamma rays leave the body without hitting or damaging any cell matter. The dose from this alpha and gamma radiation can cause changes in the genetic material of these cells that could result in health effects such as bone cancers. Exposure to extremely high levels of americium, as has been reported in some animal studies, has resulted in damage to organs.

The Department of Energy's accepted modeling of health risk from radionuclide emissions (routine or from accidents) actively ignores diverse, compelling human epidemiology. I have been told that the reason is "that somebody high up has decided that the benefit of changing the radiation protection standards isn't worth the cost." This basic description comes from university professors and INL lab directors. Basically, the Department of Energy has decided that protecting your health, or your child's health or protecting human beings in the future from its growing inventory of radioactive waste just isn't worth the cost. It would, after all, increase the cost of nuclear waste disposal and it would require reducing airborne emissions from its facilities.

The rates of cancer for children continue to be elevated, especially in counties surrounding the Idaho National Laboratory. The incidence of thyroid cancer is double in the counties surrounding the INL and double that of all other counties in Idaho and double the rates for the country from the SEER database. This is a consistent result for over a decade. As thyroid cancer incidence was climbing everywhere, is has been consistently double in the counties surrounding the INL. Recent environmental impact statements by the Department of Energy including the Versatile Test Reactor EIS present some of the cancer data but remain silent on the trends. The DOE's

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study finds that the dose coefficients for alpha radiation induction of bone sarcoma may be too high while those for leukemia are a factor six too low.

[23] G. N. Taylor et al., Health Physics, "241Am-induced Thyroid Lesions in the Beagle," June 1993. https://pubmed.ncbi.nlm.nih.gov/8491622/

EISs are also silent on many radiogenic cancers such as male breast cancer. And they are silent on the rates of childhood cancer which are elevated.

Elevated Rates of Thyroid Cancer Incidence in Counties Surrounding the INL

The wide-spread thyroid cancer incidence increases in the US do not appear to be due to radiation exposure. I suspect other governmentally permitted and highly profitable environmental toxins related to our food and perhaps also cell phone use. **But the rates that are double the rest of Idaho and the US in only counties near the Idaho National Laboratory are, I believe, due to the radiological releases from INL and are perhaps aggravated by airborne chemical releases from the INL.**

In 1975, the rate of thyroid cancer incidence for men and women combined was 4.8 per 100,000 in the US. In 2015, thyroid cancer incidence reached 15.7 per 100,000 according to the Surveillance, Epidemiology, and End Results Program (SEER) website. Thyroid cancer incidence and mortality in the US may have finally leveled off after years of increases, according to the National Cancer Institute, Surveillance, Epidemiology, and End Results Program (SEER). [24] However, several counties surrounding the Idaho National Laboratory have roughly double (or more) the thyroid cancer incidence than the Idaho state average and US average.

The SEER 9 region is roughly 10 percent of the US population and includes parts of California [San Francisco and Oakland], Connecticut, Georgia [Atlanta only], Hawaii, Iowa, Michigan [Detroit only], New Mexico, Utah, and Washington [Seattle and Puget Sound region]. [25]

Thyroid cancer incidence in the US increased, on average, 3.6 percent per year during 1974-2013, from 4.56 cases per 100,000 person-years in 1974-1977 to 14.42 cases per 100,000 person-years in 2010-2013. These thyroid cases were not trivial: the mortality also increased. Mortality increased 1.1 percent per year from 0.40 per 100,000 person-years in 1994-1997 to 0.46 per 100,000 person-years in 2010-1013 overall and increased 2.9 percent per year for SEER distant stage papillary thyroid cancer. [26] From 1974 to 2013, the SEER 9 region cancer data included 77,276 thyroid cancer patients and 2371 thyroid cancer deaths.

[24] National Cancer Institute, Surveillance, Epidemiology, and End Results Program, Cancer Stat Facts: Thyroid Cancer. https://seer.cancer.gov/statfacts/html/thyro.html

[25] National Cancer Institute, Surveillance, Epidemiology, and End Results Program, Cancer Query System. https://seer.cancer.gov/canques/incidence.html

[26] Hyeyeun Lim et al., JAMA, "Trends in Thyroid Cancer Incidence and Mortality in the United States, 1974-2013," April 4, 2017. https://pubmed.ncbi.nlm.nih.gov/28362912/ or https://jamanetwork.com/journals/jama/fullarticle/2613728

Bonneville County, where Idaho Falls is located, has double the thyroid cancer rate of the US and double the rate compared to the rest of Idaho, based on the Cancer Data Registry of Idaho (CDRI) for the year 2017. [27] See Table 5.

Table 5. Bonneville County thyroid cancer incidence rate compared to the rest of Idaho, 2017.

Cancer type	Sex	Rate in Bonneville County	Adjusted Rate in Bonneville County	Rate for remainder of Idaho
Thyroid	Total	28.2	30.7	14.2
	Male	16.0	17.8	7.4
	Female	40.3	43.5	21.0

Table notes: Rates are expressed as the number of cases per 100,000 persons per year (person-years). Rates are expressed as the number of cases per 100,000 persons per year (person-years). Adjusted rates are age and sex-adjusted incidence rates for the county using the remainder of the state as standard. Data from Factsheet for the Cancer Data Registry of Idaho, Idaho Hospital Association. Bonneville County Cancer Profile. Cancer Incidence 2013-2017. https://www.idcancer.org/ContentFiles/special/CountyProfiles/BONNEVILLE.pdf

Some people have wondered if the thyroid incidence rate is due to overdiagnosis of elderly patients — no, it is not. A study of pediatric thyroid cancer rates in the US found that in pediatric patients with thyroid cancer diagnosed from 1973 to 2013, the annual percent change in pediatric cancer incidence increased from 1.1 percent per year from 1973 to 2006 and markedly increased to 9.5 percent per year from 2006 to 2013. [28]

Some people have wondered if the increased rate of incidence is due to overdiagnosis of trivial nodules — no, it is not. The figures for the incidence rates for large tumors and advanced-stage disease suggest a true increase in the incident rates of thyroid cancer in the United States. I've seen this just from a handful of acquaintances in Idaho Falls.

For pediatric patients, the thyroid incidence rate was 0.48 cases per 100,000 person-years in 1973 to 1.14 cases per 100,000 person-years in 2013. The incidence rate for large tumors were not significantly different from incidence rates of small (1-20 mm) tumors.

Both thyroid cancer US trend studies (by Lim and by Qian) used the SEER cancer incidence file maintained by the National Cancer Institute and includes 9 high-quality, population-based registries.

[27] C. J. Johnson, B. M. Morawski, R. K., Rycroft, Cancer Data Registry of Idaho (CDRI), Boise Idaho, Annual Report of the Cancer Data Registry of Idaho, *Cancer in Idaho – 2017*, December 2019. https://www.idcancer.org/ContentFiles/AnnualReports/Cancer%20in%20Idaho%202017.pdf

[28] Z. Jason Qian et al., *JAMA*, "Pediatric Thyroid Cancer Incidence and Mortality Trends in the United States, 1973-2013," May 23, 2019. https://pubmed.ncbi.nlm.nih.gov/31120475/ or https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6547136/

As the SEER 9 region thyroid incidence peaked at 15.7 per 100,000, and the State of Idaho thyroid incidence average was 14.2 per 100,000, Bonneville County reached thyroid cancer rates of 30.9 per 100,000. [29] But other counties near the Idaho National Laboratory also have elevated thyroid cancer incidence rates: Madison (29.3 per 100,000), Fremont (27.9 per 100,000), Jefferson (28.9 per 100,000), and Bingham (28.6 per 100,000). But let's not forget Butte County. Butte county's thyroid cancer rate of 45.9 per 100,000 puts it in a class by itself. Much of Butte County is within 20 miles of the INL and nothing says radiation exposure like Butte's leukemia rate at 3 times the state rate and myeloma at 5 times the state average rate.

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

A 2013 Pacific Northwest National Laboratory (PNNL) report incorporating Federal Guidance Report 13 tabulated whole body and organ specific dose conversion factors for an average half-male and half-female at various ages. [30] The 2013 PNNL report is to be used for calculating radiation dose but not the risk of higher radiation risks recognized in the EPA's 1999 Federal Guidance Report 13. Buried near the end of the PNNL report is a chart of how wildly increased the thyroid cancer incidence was for various radionuclides, by a factor of 10, of 100, of 1000, of 10,000 and of 100,000! See Figure 9.

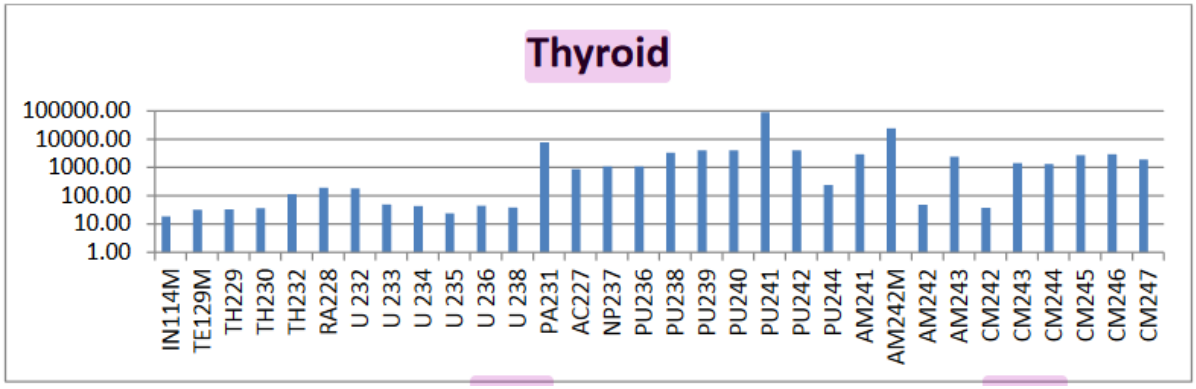

Figure 9. Ratio of the revised Federal Guidance Report (FGR) 13 thyroid dose conversion factors (DCFs) to the original Department of Energy (HUDUFACT.dat) thyroid DCF for radionuclides having the largest increases. (PNNL-22827)

[29] Environmental Defense Institute February/March 2020 newsletter article "Rate of cancer in Idaho continues to increase, according to Cancer Data Registry of Idaho."

[30] 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

The radionuclides in Figure 9 include thorium, uranium and uranium decay progeny, plutonium, curium and americium. The thyroid cancer incidence rate increase for plutonium-238, plutonium-239, plutonium-240, plutonium-241 and americium-241 is over 1000. For plutonium-241, the increase in thyroid dose is by a factor of 100,000. Plutonium-241 as well as americium-241 releases from the INL were often omitted from stated radiological releases.

It is important to understand that for many years, releases of these various americium, curium and plutonium radionuclides were not stated or were understated by the Department of Energy in its environmental monitoring reports. The *INEL Historical Dose Evaluation* which states the airborne release estimates for 1952 through 1989 does not list americium-241 as a radionuclide that the INL released. In fact, the Department of Energy did not state americium-241 in either airborne or liquid effluent radiological releases until 2001. Yet, there is evidence of extensive americium-241 contamination at INL facilities prior to the mid-1990s when CERCLA cleanup investigations were conducted.

The Department of Energy has largely thwarted efforts to have epidemiology conducted near the INL. Epidemiology that was conducted of INL workers found unexplained elevated levels of certain radiogenic cancers in both radiation and non-radiation workers.

Epidemiology of thousands of radiation workers found elevated cancer risk occurring at an average 200 mrem/yr. [31] An INL-specific study found radiation and nonradiation workers at the site had higher risk of certain cancers. [32] The US Nuclear Regulatory Commission and the Department of Energy maintain that their 5 rem/yr worker exposure limit is protective despite compelling scientific evidence to the contrary. [33]

The NRC cancelled funding of what would have been the first meaningful epidemiology study of health near US nuclear facilities. They claimed it would cost too much (at $8 million) and take too long. [34]

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[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] (And please note that studies of high leukemia risk in radiation workers and of ongoing studies to assess health effects of high and low-linear energy transfer internal radiation must also be studied in addition to this one on external radiation.)

[32] "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/

[33] "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.

[34] NRC (Nuclear Regulatory Commission) 2010. NRC Asks National Academy of Sciences to Study Cancer Risk in Populations Living near Nuclear Power Facilities. NRC News No. 10-060, 7 April 2010. Washington, DC: NRC.

The US NRC prefers reliance on the 1980s epidemiology study that mixed children and adults and populations near and far from nuclear plants and predictably found no harm. [35] The NRC actively ignores the irrefutable studies from Germany that found increased cancer and leukemia rates of children living near each of the plants. [36] [37] [38]

The U.S. NRC knows that if people knew the harm of living near nuclear power plants, just from routine radiological emissions, it would be the end of nuclear energy.

Understanding the Distortion of "Effective Whole-Body Doses"

Although not always delineated as "effective" whole-body radiation doses, the dose estimates in millirem (mrem) that are provided in Department of Energy environmental surveillance annual reports for the Idaho National Laboratory are given only in "effective" whole-body dose.

What this means, actually, is that the non-physical concept of "effective" whole body doses does not provide meaningful doses for estimating fatal cancer risk because the organ absorbed doses are unstated. In addition, the basis for assigning importance of various organs or tissues to the contribution to cancer mortality is based primarily on the external gamma dose received by survivors of the 1946 atomic bombing of Japan and it tells nothing about the cancer risks when radionuclides are inhaled or ingested and incorporated into the body. Cesium-137 mimics potassium, strontium-90 mimics calcium, plutonium-239 mimics iron, etc.

Even with accounting for the clearance of the radionuclide from the body and accounting for the tendency for the radionuclide to accumulate in certain organs such as the thyroid or in bone tissue — the harm from internal radiation is greater than from external radiation and is not accounted for by the nuclear industry's International Committee on Radiological Protection (ICRP) models because of their reliance on reviewing the radiation harm from external radiation.

Don't blame the ICRP. They are just nuclear weapons industry-funded folks who don't actually understand human biology. Anyone not sticking to the nuclear industry agenda would be booted out, sooner or later.

The framework for the study was reported in "Analysis of Cancer Risks in Populations Near Nuclear Facilities; Phase I (2012). See cancer risk study at nap.edu.

[35] NCI (National Cancer Institute) 1990. Cancer in Populations Living near Nuclear Facilities. 017-042-00276-1. Washington, DC: Superintendent of Documents, U.S. Government Printing Office.

[36] Kaatsch P, Kaletsch U, Meinert R, Michaelis J.. 1998. An extended study of childhood malignancies in the vicinity of German nuclear power plants. Cancer Causes Control 9(5):529–533.

[37] The study is known by its German acronym KiKK (Kinderkrebs in der Umgebung von Kernkraftwerken): Kaatsch P, Spix C, Schmiedel S, Schulze-Rath R, Mergenthaler A, Blettner M 2008b. Vorhaben StSch 4334: Epidemiologische Studie zu Kinderkrebs in der Umgebung von Kernkraftwerken (KiKK-Studie), Teil 2 (Fall-Kontroll-Studie mit Befragung). Salzgitter: Bundesamt für Strahlenschutz.

[38] Kaatsch P, Spix C, Schulze-Rath R, Schmiedel S, Blettner M.. 2008.. Leukemia in young children living in the vicinity of German nuclear power plants. Int J Cancer 122(4):721–726.

An "effective" dose in rem builds into the rem estimate various multipliers that lower the rem value based on nuclear promotor's opinions of the cancer mortality effect of radiation to various parts of your body. And this is in addition to the multipliers regarding the type of radiation, the *equivalent* dose, that increase the dose from alpha radiation and neutron exposure over that of gamma exposure.

The Department of Energy tries to tell people they really don't need a healthy thyroid because people don't often die of thyroid cancer. Never mind how important a healthy thyroid is to the developing fetus/embryo in utero. It reminds me of an old Monte Python comedy, when organ harvesters try to tell the patient that "you really don't need a liver" as they cut out the person's liver to sell the organ for profit.

I have never understood before now just how the "effective" rem dose is lowered before the ICRP's low-balled cancer mortality rate is even applied. I say this because in 1990, John W. Gofman's review of the atomic bomb effects on Japanese survivors predicted 0.0026 fatal cancers per rem, [39] which is over 4 times higher than the current Department of Energy fatal cancers per rem value of 0.0006. But even Gofman's prediction would underestimate the cancer risk from internal radiation, such as the iodine-129, strontium-90, cesium-137, americium-241, plutonium-239, and others, which make up most of the radiation dose from INL radiological releases.

The Department of Energy's estimated whole-body doses in millirem cannot readily be related to the actual absorbed organ dose. The absorbed organ doses are not provided and these cannot be scaled directly from the whole-body dose estimates because of the significant iodine accumulation in the thyroid and because of the way that effective dose diminishes the importance of the thyroid. The thyroid organ doses would be especially important considering the very high levels of certain radionuclides released by the INL that are particularly harmful to the thyroid including iodine-131, iodine-129, americium-241 and others, in regard to thyroid cancer incidence. But because few deaths occur due to thyroid cancer, the rem doses to the thyroid are diminished by reduction factors which focus on the endpoints of primarily cancer mortality.

Effective whole-body dose in rem (or millirem which is one thousandth of a rem) starts off with an estimate of absorbed dose but then keeps reducing and further reducing the estimated dose on the basis on ICRP opinion of the likelihood of that organ to cause cancer mortality based on external exposure. Then ICRP sums the reduced organ doses, again weights the organs to reduce their importance and thus the black box spits out an "effective" whole body dose.

This method for estimating the effective whole-body dose had actually originally been called **the doubly-weighted organ doses model** or construct, according to a 2017 article by Fisher and

[39] John W. Gofman, M.D., Ph.D., Committee for Nuclear Responsibility, Inc., "Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis," 1990. See more in the August 2021 Environmental Defense Institute newsletter.

Fahey on *Appropriate Use of Effective Dose in Radiation Protection and Risk Assessment*. [40] For additional information about how misleading the "effective dose" is, read *Burdens of Proof* by Tim Connor, Energy Research Foundation, 1997 regarding the multiple failures to attribute Hanford radiological releases to the thyroid cancers in the region.

As far back as 1977, the U.S. Environmental Protection Agency recognized that continued exposure over substantial portions of a lifetime near 100 mrem per year should be avoided, read more in the TENORM report. [41] In 1977, it was assumed by the ICRP that the risk of fatal cancers was 0.0001 per rem (or 1.0E-5 per millisievert in SI units). Various radiation regulations were based on this assumption. It was recognized by 1994 that the fatal cancer risk was higher, at 0.0005 per rem. Even the ICRP currently recognizes that the fatal cancer risk from ionizing radiation is now at least 0.0006 per rem.

The 100 millirem (mrem) per year all pathways radiation dose limit is greatly emphasized by the Department of Energy as the dose they consider allowable. Air permits may be regulated by the U.S. Environmental Protection Agency or by the states, but in either case, the EPA and the state, such as the State of Idaho, will often emphasize that the state cannot regulate Department of Energy radiological emissions. In Idaho, the State of Idaho Department of Environmental Quality will issue an air permit to the Department of Energy based entirely on the DOE's stated radiological release guesses or estimates, the Department of Energy contractors monitoring or lack thereof, and the State will agree to rapid records destruction of radiation monitoring of open-air radioactive waste evaporation ponds that is fully intended to cover up any radiological releases in excess of agreed to quantities. This was the situation at the Idaho National Laboratory's Advanced Test Reactor air permit with the State of Idaho but now the state air permit for the ATR Complex (TRA evaporation ponds) are deemed exempted from state permitting, see the recent change in Appendix D.

In the Department of Energy's environmental monitoring reports, it is greatly emphasized that the DOE's derived concentration standards (DCGs) are safe as they imply a dose of 100 mrem per year. By now, you may be starting to understand why 100 mrem per year would actually guarantee a health catastrophe to the health of people, especially children.

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 higher radiation risk harm to women than men, for the same dose. And the studies showed higher cancer

[40] Darrell R. Fisher and Frederic H. Fahey, *Health Phys*., "Appropriate Use of Effective Dose in Radiation Protection and Risk Assessment," August 2017, PMID: 28658055 and https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5878049/

[41] National Research Council, Committee on Evaluation of EPA Guidelines for Exposure to Naturally Occurring Radioactive Materials. Evaluation of Guidelines to Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials. Washington DC, National Academies Press, 1999. See page 108. https://www.nap.edu/catalog/6360/evaluation-of-guidelines-for-exposures-to-technologically-enhanced-naturally-occurring-radioactive-materials and chapters at https://www.nap.edu/catalog/6360/evaluation-of-guidelines-for-exposures-to-technologically-enhanced-naturally-occurring-radioactive-materials#toc

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. [42] (Read more in the August 2020 Environmental Defense Newsletter.)

The Department of Energy's DCG from gross alpha radioactivity in air for a 100 mrem per year dose are getting closer to the DCG for gross alpha radioactivity in air and are actually being exceeded from time to time in southeast Idaho. The most restrictive DCG is for americium-241 at 20 E-15 microcuries per milliliter (E-15 uCi/mL). With gross alpha radioactivity air usually below 4 E-15 uCi/mL, it is notable that values such as 7.2 E-15 uCi/mL occur (see Blackfoot monitoring in 2012). The increasing gross alpha radioactivity in air values are within a factor of three or four of the DCG.

There are large fluctuations in the concentrations of gross beta radioactivity in air in southeast Idaho and these fluctuations appear to be due to the INL's airborne radiological releases, despite statements to the contrary by the Department of Energy's environmental surveillance contractor. In 1998, the gross beta radioactivity in air concentrations ranged from 8 to 38 E-15 uCi/mL. In contrast, in 2002, gross beta concentrations ranged from 8 to 129.4 E-15 uCi/mL. The Department of Energy's environmental surveillance contractor continues to assert that no detected radioactivity could be attributed to the INL, stating: "In general, gross alpha and gross beta activities show levels and seasonal variations not attributable to INEEL releases. Seven of the weekly gross beta results showed statistical differences between boundary and distant locations. In all cases the differences were attributed to natural variation or to inversion conditions." And as typical of every INL annual environmental surveillance report no matter what they detect in their monitoring, they state: "In summary, the results of the monitoring programs for 2002 presented in this report indicate that radioactivity from current INEEL operations could not be distinguished from worldwide fallout and natural radioactivity in the region surrounding the INEEL."

The Department of Energy embraces only the effective whole-body dose while ignoring the far higher organ doses, such as the absorbed dose to the thyroid from Idaho National Laboratory releases of iodine-131, iodine-129, americium-241 and other radionuclides.

While the International Commission of Radiological Protection (ICRP) continues to say that "Radiation induced heritable disease has not been demonstrated in human populations," Chis Busby writes that evidence of genetic effects *has* been found in humans and at very low radiation doses. [43] [44]

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[42] 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.

[43] Chris Busby, *The Ecologist*, "It's not just cancer! Radiation, genomic instability and heritable genetic damage," March 17, 2016. https://theecologist.org/2016/mar/17/its-not-just-cancer-radiation-genomic-instability-and-heritable-genetic-damage

Robin Whyte wrote in the *British Medical Journal* in 1992 about the effect in neonatal (1 month) mortality and stillbirths in the United States and also in the United Kingdom. The rise in strontium-90 from nuclear weapons testing from 1950 to 1964 has been closely correlated, geographically, with excess fetal and infant deaths. The doses from strontium-90 due to atmospheric nuclear weapons testing were less than 50 millirem (or 0.5 millisievert), according the Chris Busby. Radioactive fallout from atmospheric nuclear weapons testing would not only include strontium-90, it would include iodine-131, tritium, cesium-137, and other radionuclides, including plutonium. [45] The extent of the nuclear weapons testing immorality continues to astound me and I applaud the work being done to reduce the risk of human extinction from nuclear weapons. [46]

The ICRP maintains that human evidence of genetic effects due to radiation does not exist. The ICRP then uses the study of external radiation on mice to estimate the heritable risks for humans. One study was conducted using internal radionuclides on mice and the study noted that "detailed research on internal radiation exposure has hardly ever been reported in the past." [47] **This limited study of microcephaly in mice found that far lower doses of internal radiation caused the same effect as higher doses of external radiation.**

The commonly accepted practice of expressing radiation dose in rem or Sieverts is focused on the biological endpoint of fatal cancer. The actual health harm may include infertility, increased infant mortality, birth defects, cancer incidence, increased heart disease, shortened life span and other adverse health effects, none of which are necessarily reflected in effective whole-body dose, in rem or one-thousandth of a rem, a millirem.

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[44] Chris Busby, Scientific Secretary, European Committee on Radiation Risk, Presentation, *Radioactive discharges from the proposed Forsmark nuclear waste disposal project in Sweden and European Law*, September 8, 2017. Online pdf 646_Nacka_TR_M1333-11_Aktbil_646_Christopher_Busby_presentation_170908

[45] R. K. Whyte, *British Medical Journal*, "First day neonatal mortality since 1935: re-examination of the Cross hypothesis," Volume 304, February 8, 1992. https://www.bmj.com/content/bmj/304/6823/343.full.pdf

[46] Jackie Abramian, ForbesWomen, "After Her Nuclear Disaster Dress Rehearsal, Cynthia Lazaroff Has A Wake-Up Call For Our World As We Sleepwalk Into Nuclear Extinction," September 21, 2021. https://www.forbes.com/sites/jackieabramian/2021/09/21/after-her-own-nuclear-disaster-dress-rehearsal-cynthia-lazaroff-has-a-wake-up-call-as-our-world-sleepwalks-into-nuclear-extinction/?sh=6a22151d62e2 Lazaroff has founded NuclearWakeupCall.Earth due to her concern over nuclear weapons. "There are nearly 13,500 nuclear warheads in current arsenals of nine nuclear-armed states. That the U.S. has more nuclear warheads than hospitals should be a wake-up call," says Lazaroff.

[47] Yukihisa Miyachi, J-STAGE, "Microcephaly Due to Low-dose Intrauterine Radiation Exposure Caused by 33P Beta Administration to Pregnant Mice," 2019 Volume 68 Issue 3 Pages 105-113. https://www.jstage.jst.go.jp/article/radioisotopes/68/3/68_680303/_article/-char/en

INL Releases Prior to 1990 and Former Weapons Testing Fallout

The estimates of the *INEL Historical Dose Evaluation* [48] continue to be found in error and to significantly underestimate what was released. [49] [50] [51] Theoretical and idealized modeling of the releases were used for estimating the releases for the INEL HDE without using environmental monitoring to confirm the estimates — except for the 1961 SL-1 accident in which the environmental monitoring showed that the **theoretical modeling had underestimated the release**. In fact, many of the environmental monitoring records were deliberately destroyed before the 1991 report was released. [52] INL airborne releases included a long list of every fission product that exists including iodine-131, long-lived I-129, tritium, strontium-90, cesium-37, plutonium, and uranium.

If the SL-1 accident radiological release estimates by the Department of Energy are correct, then that fuel was the best nuclear fuel ever designed because the vaporized fuel was said by the Department of Energy to have released only the iodine-131 to southeast Idaho, with the rest of the radionuclides claimed to have stayed within the local vicinity of the unconfined building where the reactor exploded, vaporizing much of the core.

The source documents for the INEL HDE are in fact part of the Human Radiation Experiments collection of DOE documents. Why? Because there was enough information available for the DOE to know that showering nearby communities and their farms and milk cows with radiation really was likely to be harmful to their health. The INL (formerly the NRTS, INEL and INEEL) takes up dozens of volumes of binders in the DOE's Human Radiation Experiments collection and that isn't including the boxes of documents no one can get access to or the records that were deliberately disposed of. [53]

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

[49] Risk Assessment Corporation, "Identification and Prioritization of Radionuclide Releases from the Idaho National Engineering and Environmental Laboratory," October 8, 2002, https://www.cdc.gov/nceh/radiation/ineel/to5finalreport.pdf See p. 117, 118 for SL-1.

[50] SENES Oak Ridge, "A Critical Review of Source Terms for Select Initial Engine Tests Associated with the Aircraft Nuclear Program at INEL," Contract No. 200-2002-00367, Final Report, July 2005. http://www.cdc.gov/nceh/radiation/ineel/anpsourceterms.pdf See p. 4-67 for Table 4-13 for I-131 estimate for IET's 10A and 10B and note the wrong values for I-131 are listed in the summary ES-7 table.

[51] CDC NIOSH, "NIOSH Investigation into the Issues Raised in Comment 2 for SCA-TR-TASK1-005," September 3, 2013. https://www.cdc.gov/niosh/ocas/pdfs/dps/dc-inlspcom2-r0.pdf See p. 3 stating various episodic releases underestimated by the INEL HDE: IET 3, IET 4 and IET 10.

[52] Chuck Broscious, Environmental Defense Institute Report, "Destruction and Inadequate Retrieval of INL Documents Worse than Previously Reported," Revised September 1, 2018. http://environmental-defense-institute.org/publications/DocDestruction.pdf

[53] February 1995, the Department of Energy's (DOE) Office of Human Radiation Experiments published *Human Radiation Experiments: The Department of Energy Roadmap to the Story and Records* ("The DOE Roadmap"). See also the INL site profile on Occupational Environmental Dose: http://www.cdc.gov/niosh/ocas/pdfs/tbd/inl-anlw4-r2.pdf) Most of the documents in the DOE's Human Radiation Experiments collection remain perversely out of public reach. Documents are said to be stored at the INL site, out of state in boxes, [Good luck with getting these documents via the Freedom of Information Act] and in the National Archives. I found that retrieving

Sources of iodine-131 other than the INL that were considered were regional weapons fallout (typically from the Nevada Test Site), global weapons fallout from US weapons testing outside the contiguous states, and global weapons tests conducted by foreign countries including the former Soviet Republic, China, France and others.

The INEL HDE reported various instances of elevated I-131 in milk including two instances in 1965 and sixteen instances in 1966 where neither known INL releases nor known weapons tests could explain the elevated iodine-131 in the milk near the INL. [54]

The partial test ban allowed underground tests but not atmospheric tests or underwater tests. [55] The 1993 UNSCEAR report lists atmospheric releases of iodine-131 from leakage of underground weapons tests at the Nevada Test site. [56] Iodine-131 was identified because of the significant health effect as I-131 is ingested via cows or goat's milk but tritium and other radionuclides were probably also released. But the UNSCEAR report does not mention the Plowshares program weapons testing—some of which was conducted underground—but some tests were above ground.

A compilation of known underground tests that released radioactivity and additional tests from the Plowshares above ground tests is provided in Appendix A. The underground test iodine-131 release data is from the UNSCEAR 93 report. [57] The Plowshares tests that were after the 1963 partial test ban and were "crater" type are from FAS.org website compilation of Department of Energy report DOE/NV-209.

Now that more than forty years have passed since the bulk of the US weapons testing took place, health studies are still not complete, and the data for regional US weapons testing are scattered around and currently cannot be accessed on Department of Energy websites. The need to hide the fact that the US was still releasing fallout after the 1963 partial test ban—accidentally they claimed on numerous occasions— meant that the Idaho Operations Office and the US Geological Survey were not to put too fine a point on any environmental monitoring that might disclose US DOE weapons fallout or INL fallout.

The same folks that put a film badge on my grandmother's white picket fence in the 1950s chose to act like they were not able to provide enough coherent environmental monitoring of air, water or milk through the 1980s to explain INL releases versus NTS releases or global fallout.

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documents from the National Archive would require extensive fees for searches and copying. Where is the transparency in creating a document collection that cannot be viewed by the public?

[54] *INEL Historical Dose Evaluation*, DOE/ID-12119, 1991. See Appendix E, Table E-5 for milk sampling.

[55] Pravalie, R. (2014). Nuclear Weapons Tests and Environmental Consequences: A Global Perspective. *Ambio*, *43*(6), 729–744. http://doi.org/10.1007/s13280-014-0491-1.

[56] UNSCEAR, Report to the general assembly, United Nations, "Annex B: Exposures from man-made sources of radiation," 1993. http://www.unscear.org/unscear/en/publications/1993.html See Table 13, p. 130 for atmospheric released of iodine-131 from underground tests at the Nevada test site.

[57] Federation of American Scientists, website containing United States Nuclear Tests July 1945 through September 1992, (DOE/NV-209 Rev. 14, December 1994) , https://fas.org/nuke/guide/usa/nuclear/usnuctests.htm United States Nuclear Tests by Date include date, yield, purpose, i.e., Plowshare, and type, i.e. crater, tower, or shaft.

The lapses, omissions, destroyed samples, lost data, general fuzziness, etc. appear to be deliberate.

Most of the radionuclides releases by former weapons testing, which had largely ended by 1981, would have already peaked and would be reduced by radioactive decay. Plutonium-239, plutonium-238, cesium-137, strontium-90 and tritium from former nuclear weapons testing would still be in the environment but the levels would not be increasing.

It is important to note here that former weapons testing released far more plutonium-239 than plutonium-238, by activity. [58] When more plutonium-238 than plutonium-239 is detected in the environment in southeast Idaho, the source is most likely the Idaho National Laboratory. Spent nuclear fuel reprocessed at the INL contained more plutonium-238 than plutoinium-239, by activity. Other INL operations can release plutonium-238.

It is also important to understand the decay of plutonium-241 into americium-241. The rather short-lived plutonium-241 decays into americium-241, causing Am-241 to build up during the first 70 years. So trending americium-241 becomes more complicated. But it is important to know that former weapons testing released far more plutonium-239 than plutonium-241. The activity levels of americium-241 should not exceed the activity levels of plutonium-239 when due to former weapons testing. Reactor accident fallout would have more plutonium-241 and subsequently more americium-241 over time than former nuclear weapons testing fallout. The INL releases americium-241 have been extensive and are ongoing. The americium-241 was not only released from the fugitive waste from the burial grounds and their waste treatment and exhumation. Other INL operations continue to release americium-241 as well as plutonium-238 and plutonium-239, intermittently.

Radiological Monitoring in Ambient Air

Ambient air radioactivity monitoring of gross alpha and gross beta radioactivity is summarized in Tables 6 and 7. The results for selected years are shown in Figures 10 and 11. Gross alpha monitoring of radioactivity in air was not reported prior to 1990. The average values stated in ESER reports are typically below 2.5 E-15uCi/mL. Gross alpha peak values for Blackfoot are over the average gross alpha values, at 6.3 E-15uCi/mL in 1990, 6.97 E-15 uCi/mL in 2002, and 7.2 E-15 uCi/mL in 2012. Peak values for Idaho Falls are 6.1 E-15 uCi/mL in 2000 and 6.16 E-15 uC/mL in 2004.

Notice the troublesome negative radioactivities stated as minimums for gross alpha radioactivity. Where a normal low would be probably at least 0.5, minimum values as low as -0.49 have been recorded for Idaho Falls. This reflects a laboratory blank that is more

[58] T. M. Beasley et al., Environmental Measurements Laboratory, *Heavy Element Radionuclides (Pu, Np, U) and Cs-137 in Soils Collected from the Idaho National Engineering and Environmental Laboratory and Other Sites in Idaho, Montana, and Wyoming*, EML-599, October 1998. See page 4 for expected activity ratios of americium-241 to plutonium-239 (0.4 in 1998) and for the expected activity ratio of plutonium-238 to plutonium-239 (below 0.05 in 1994) from former weapons testing and the non-INL 1964 Pu-238 radioactive thermal generator SNAP-9A accident.

contaminated than the sample. In reality, there is no such thing as negative values of radioactivity. Conceptually, these values reflect radioactive decay counting where the background counts subtracted from sample counts yield a negative number and this indicates that the background or blank was more radioactive than the sample. It also suggests that the peak values are low by the amount of the actual minimum plus the absolute value of the minimum negative value, for example, in Blackfoot in 2004, the peak gross alpha value was stated as 4.95 but in reality, may be closer to 5.86 E-5 (4.95 plus 0.5 (an estimate of the actual minimum) plus 0.41), because the results appear shifted downward. This downshifting also decreases the stated average values.

Likewise in Idaho Falls in 2004, the peak stated as 6.16 should probably be closer to 7.15, in units of E-15uCi/mL. You can imagine that the gross alpha values due to global weapons fallout and naturally-occurring uranium and thorium are not gyrating this much. The elevated levels of gross alpha radioactivity in air are in reality due to the Idaho National Laboratory, despite the repeated assertions that they are not. And in fact, the stated radionuclide releases from the INL in 2004 are significantly higher in alpha emitters of americium, plutonium and uranium.

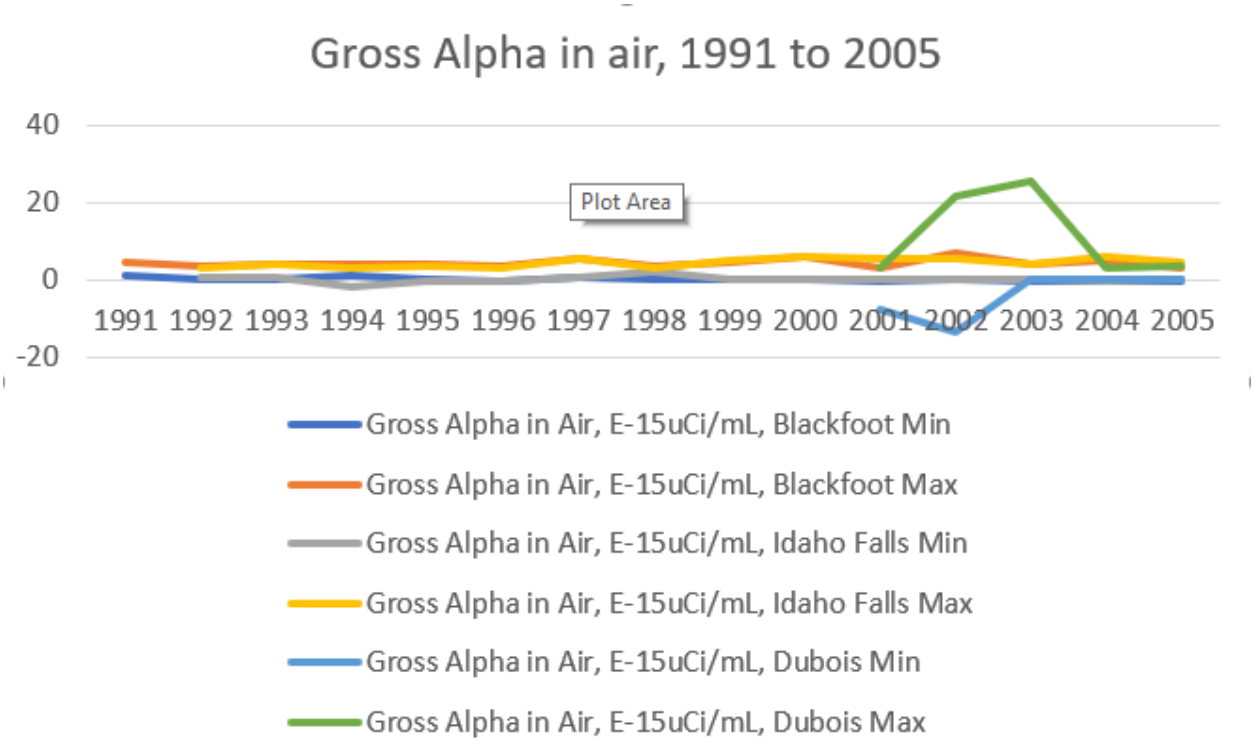

Figure 10. Gross alpha radioactivity in air for Blackfoot, Idaho Falls and Dubois from 1991 to 2005.

Table 6. Gross alpha radioactivity in air for Blackfoot, Idaho Falls and Dubois from 1990 to 2019.

Year	MDC, E-15 uCi/mL	Blackfoot, E-15 uCi/mL			Idaho Falls *, E-15 uCi/mL			Dubois, E-15 uCi/mL		
		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
1990	0.3	0.9	6.3	2.01	0.5	3.9	1.51			
1991	0.3	1.0	4.3	2.50	0.6	5.2	1.62			
1992	0.3	0.3	3.4	1.81	0.5	3.0	1.54			
1993	0.3	0.1	4.1	1.8	0.6	3.9	1.6			
1994	0.3	0.8	3.9	2.0	-1.7	3.0	0.6			
1995	2	-0.1	3.8	1.6	-0.5	3.3	1.5			
1996	2	-0.2	3.4	1.7	-0.3	3.2	1.4			
1997	1	0.7	5.6	2.1	0.5	5.6	2.0			
1998	1	0.2	3.4	1.7	1.8	2.9	1.5			
1999	1	0.2	4.5	2.0	0.3	4.7	1.8			
2000	1	0.03	5.8	2.0	0.3	6.1	2.0			
2001	1	-0.3	2.9	1.7	0.1	5.5	2.0	-7.8	2.9	1.4
2002	1	-0.05	6.97	1.46	0.18	5.34	1.91	-13.42	21.30	1.49
2003	1	-0.18	3.93	1.66	0.27	4.16	2.10	0.14	25.2	1.58
2004	1	-0.41	4.95	1.30	-0.49	6.16	1.50	0.26	3.0	1.51
2005	1	-0.23	3.01	1.30	0.25	4.53	1.72	-0.17	3.35	1.03
2006	1	0.23	4.63	1.40	0.36	4.53	2.13	-0.26	4.83	1.67
2007	1	0.69	3.5	1.7	0.49	4.0	1.9	0.00	4.1	1.4
2008	1	0.03	3.3	1.4	0.39	3.0	1.6	0.16	2.8	1.3
2009	1	0.65	2.8	1.3	0.70	3.0	1.4	0.25	2.1	1.2
2010	1	0.30	2.7	1.0	0.31	3.1	1.3	0.03	2.4	1.0
2011	1	0.37	4.1	1.2	0.11	2.9	1.3	0.31	3.8	1.0
2012	1	0.29	7.2	1.5	0.30	4.9	1.3	0.45	4.7	1.2
2013	1	0.55	2.0	0.9	0.30	2.5	1.2	0.09	3.0	1.1
2014	1	0.55	2.27	1.1	-0.26	2.04	1.0	0.41	2.16	1.1
2015	1	-0.18	5.3	1.2	-0.05	4.8	1.3	0.30	5.0	1.2
2016	1	-0.44	3.7	1.1	-0.08	4.0	1.1	0.29	3.0	1.0
2017	1	0.32	3.0	1.1	0.36	4.9	1.5	0.33	4.9	0.9
2018	1	0.10	3.1	1.2	-0.09	4.2	1.8	0.14	3.5	1.2
2019	1	0.61	3.0	1.3	0.14	2.9	1.9	0.26	2.3	1.1

Table notes: Data source is the Department of Energy annual environmental surveillance reports which had been at IdahoESER.com until moved by DOE. Units of gross alpha radioactivity in air are in E-15 microcuries/milliliter (E-15 uCi/mL). MDC is minimum detectable concentration stated in the annual program summary which may differ for actual samples. Detection capability is improved as the MDC is decreased; likewise, detection capability is reduced as the MDC is increased. For 1990 through 1993, ANL-W data are given because no Idaho Falls data was available. For 1994, the data were EG&G as stated in the ESER report because there was no ESER data for 1994 for Idaho Falls. No data were reported for gross alpha for Dubois prior to 2001.

There are some weird monitoring results for gross alpha, especially for Dubois. Yet, almost magically, the average values for Dubois are whipped into line.

The Department of Energy derived air concentration for gross alpha is 20 E-15 uCi/mL, which would correspond to a 100 mrem/yr dose if that concentration were sustained all year. Maximum gross alpha values have exceeded 20 E-15 uCi/mL in Dubois in 2002 and 2003.

Minimum detectable concentrations reported in ESER monitoring summary tables for gross alpha activity in air were 0.3 E-15uCi/mL in 1990, increased to 2E-15 uCi/mL in 1995 and 1996, then reduced to 1 E-15 uCi/mL all other years.

Gross beta radioactivity in air from 1990 to 2019, for Blackfoot and Idaho Falls, is shown in Table 6. Some very curious things happen in the monitoring program. The lower the minimum detectable concentration, the better the detection capability. In 2000 and 2001 and again in 2004, the minimum detectable concentration that had been as low as 3E-15uCi/mL is increased to 3000E-15uCi/mL. The wild changes in the selected minimum detectable concentration for gross beta, beginning in 2000, are not stated on the table where the gross beta results are presented. The minimum detectable concentrations are only stated on a program summary table elsewhere in the report.

In 2002, the ESER contractor downshifts the units for gross beta radioactivity so that 100 E-15uCi/mL is stated as 10 E-14uCi/mL. When the change in units happens, it is placed at the bottom of the table in a very tiny font.

The average value of gross beta radioactivity is typically below 30 E-15uCi/mL. The peak values for gross beta radioactivity in Blackfoot exceed 100 E-15uCi/mL four times, (2002, 2004, 2007 and 2010) and also exceed that level in Idaho Falls in three of those years (2002, 2004 and 2007).

Minimum detectable concentrations (MDCs) selected for environmental surveillance detection capability of gross beta activity in ambient air, which would decrease with state-of-the-art monitoring, are greatly increased in the year 2000. The selected MDCs vary by a factor of 1500, as reported in ESER monitoring summary tables for gross beta MDC. The MDCs are changed unpredictably and range between 2E-15uCi/mL and 3000E-15uCi/mL. The change from higher resolution (lower minimum detectable concentration values) to lower detection capability (higher minimum detectable concentration values) raises questions as to why this was done. When additional types of radionuclides are in the environment, this can cause interference with radioactivity detection. Yet, the Department of Energy's program maintained its claim throughout all years of monitoring that no radioactivity released by the Idaho National Laboratory that was detected offsite could be attributed to the INL. The one major offsite radiological release event was the Fukushima nuclear disaster in 2011, which does not explain the DOE's actions to reduce the radioactivity detection capability throughout the years 2000 through 2008.

See Figure 11 for gross beta radioactivity in air, for Blackfoot and Idaho Falls from 1991 to 2005.

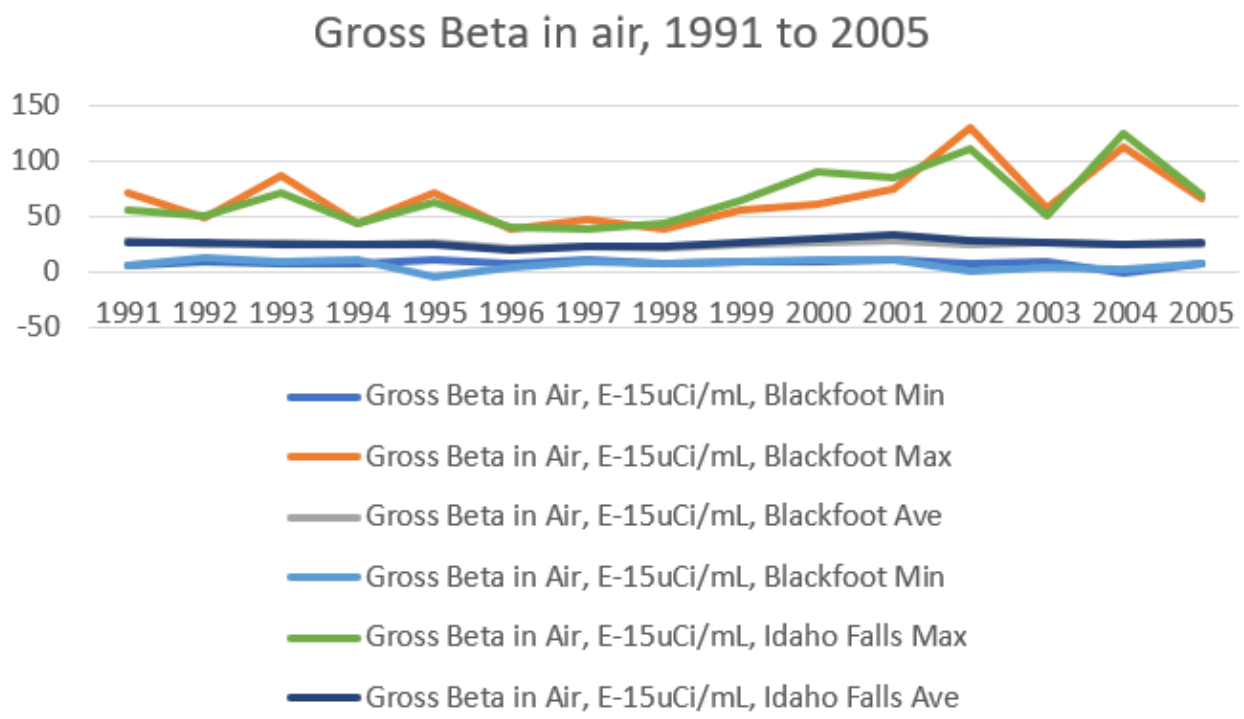

Figure 11. Gross beta radioactivity in air, for Blackfoot and Idaho Falls from 1991 to 2005.

The ambient air monitoring program includes the analysis of radionuclides collected in air filters. Some highlights of the air filter analyses are provided in Appendix C, Table C1 and C2. The specific radionuclides that were detected included cerium-141, cerium-144, cobalt-60, manganese-54, cesium-134, cesium-137, ruthenium-103, ruthenium-106, strontium-90, antimony-125, zirconium-95, zinc-65, americium-241, plutonium-238 and plutonium-239. Strontium-90, cesium-137, and plutonium-239 are present from former weapons testing. In the 1960s and even as late as 1980, attributing a variety of rather short-lived radionuclides to weapons testing is seen as plausible when actually, their detection was likely due to the INL. By the mid-1990s, because of their relatively short half-life (about one year or less), the levels of cerium-141, cerium-144, cobalt-60, cesium-134, ruthenium-103, ruthenium-106, antimony-125, zirconium-95 and zinc-65 are very likely to have come from the Idaho National Laboratory even if the radionuclide was not listed as an airborne effluent. The practice before 2001 was to not list the radionuclides in liquid effluents flushed to open-air ponds, even after the ponds with very high releases of liquid effluent transitioned from percolation ponds to lined evaporation ponds. For 1986 to 2000, even when liquid effluents are listed, the cutoff value is 1.0E-2 curies and the list of liquid effluents was incomplete. But without knowing the half-life of the radionuclide and with the radionuclide not acknowledged as being released from the INL, the detection of various radionuclides detected in air filters were simply attributed, incorrectly, to former nuclear weapons testing.

Table 7. Gross beta radioactivity in air, for Blackfoot and Idaho Falls from 1990 to 2019.

Year	MDC, E-15 uCi/mL	Blackfoot, E-15 uCi/mL			Idaho Falls, E-15 uCi/mL		
		Min	Max	Ave	Min	Max	Ave
1990	8	6	86	28	7	63	25
1991	8	6	71	29	6	56	26
1992	8	9	49	25	12	51	27
1993	8	7	87	27	9	72	24
1994	8	8	43	25	10	44	25
1995	5	10	72	27	-4	63	25
1996	5	8	39	21	4	40	20
1997	3	11	47	23	9	39	23
1998	3	8	38	21	7	44	23
1999	3	9	55	24	9	64	26
2000	3000	9.9	61.1	26.4	10.2	89.6	29.3
2001	3000	11.8	74.2	28.6	11.4	85.7	32.9
2002	2	8	129.41	25.2	1.2	110	28.2
2003	20	8.9	57.2	25.6	3.4	50.1	26.7
2004	2000	-0.6	112	23.8	2.9	124.0	24.7
2005	2000	7.1	66.6	25.3	7.3	69.2	26.1
2006	2000	5.9	49.0	23.9	5.3	45.1	24.9
2007	2000	11	110	29	12	110	31
2008	2000	9.3	47.0	27	11	28	28
2009	10	11	60	28	12	56	29
2010	10	9.5	52	24	9.4	51	25
2011	10	9.4	105	26	8.4	73	26
2012	10	9.0	59	27	6.9	42	22
2013	2	9.0	77	20	8.8	50	23
2014	2	9.1	47	20	9.2	40	20
2015	2	8.6	75	24	0.8	53	24
2016	2	5.1	61	18	4.6	62	19
2017	2	8.2	44	19	9.1	46	19
2018	2	11	42	24	10	46	24
2019	2	8.8	50	26	10	48	26

Table notes: Data source is the Department of Energy annual environmental surveillance reports which had been at IdahoESER.com until moved by DOE. Units of gross beta radioactivity in air are in E-15 microcuries/milliliter (E-15 uCi/mL). MDC is minimum detectable concentration stated in the annual program summary which may differ for actual samples. Detection capability is improved as the MDC is decreased; likewise, detection capability is reduced as the MDC is increased.

Radiological Monitoring of Milk, Lettuce and Wheat

The radiological airborne effluents released by the INL are stated in the annual environmental monitoring reports, at least since the 1970s. The radiological liquid effluents have been released since 1952 but were assumed to percolate or be injected directly into the aquifer and were not included in the estimates of the radiation dose to the public.

From 1986 through 2000, the curie amounts of radiological liquid effluents were listed separately from the airborne effluents. Yet, even when the main radioactive waste ponds at the Test Reactor Area (TRA), which would be renamed the ATR Complex, installed lined evaporation ponds in 1993, these liquid effluents were still not included in the airborne effluents and were not included in radiation dose estimates to the public.

After 2000, the liquid pond effluents at various facilities were included as airborne effluents and were included in radiation dose estimates to the public.

The radionuclides that are dominant dose contributors in the Department of Energy's estimates of radiation dose to the public are listed in Appendix B.

The annual curie amounts of strontium-90 released by the Idaho National Laboratory are shown in Figure 12 and listed in Appendix B.

From Figure 12, it can be seen that curies of strontium-90 released by the INL and used to estimate the radiation dose to the public was significantly understated prior to 2001. Strontium-90 is only one of many radionuclides flushed to open-air ponds, even evaporation ponds, but were ignored in radiation dose estimates to the public, significantly underestimating the effective whole-body radiation doses to the public.

The strontium-90 concentrations in wheat and lettuce are shown in Figures 13 and 14 and the data provided in Table 8. If you examine the data, you start to understand how important the specification of the minimum detectable concentration (MDC) is. There was no technical difficulty with obtaining an MDC of 4 pCi/kg in 1974 for wheat and the same MDC for lettuce in 1977. But then the MDC for lettuce is raised to 80. Really large increases in the strontium-90 concentrations in wheat occur by 2002. From 1974 to 2000, the values were typically below 16 pCi/kg in wheat, with the exception of 31 pCi/kg in 1983 and there is no nuclear weapons test or reactor accident in another part of the world to explain what happened in 1983. But after 2000, the strontium-90 values in wheat in Idaho Falls skyrocket to 240 pCi/kg in 2002. The detection is not a solid 3s result but it is nearly a 2s result and it indicates a far higher than previous concentration of strontium-90 in wheat.

For lettuce, in 2004 there is a solid detection of 328 pCi/kg of strontium-90.

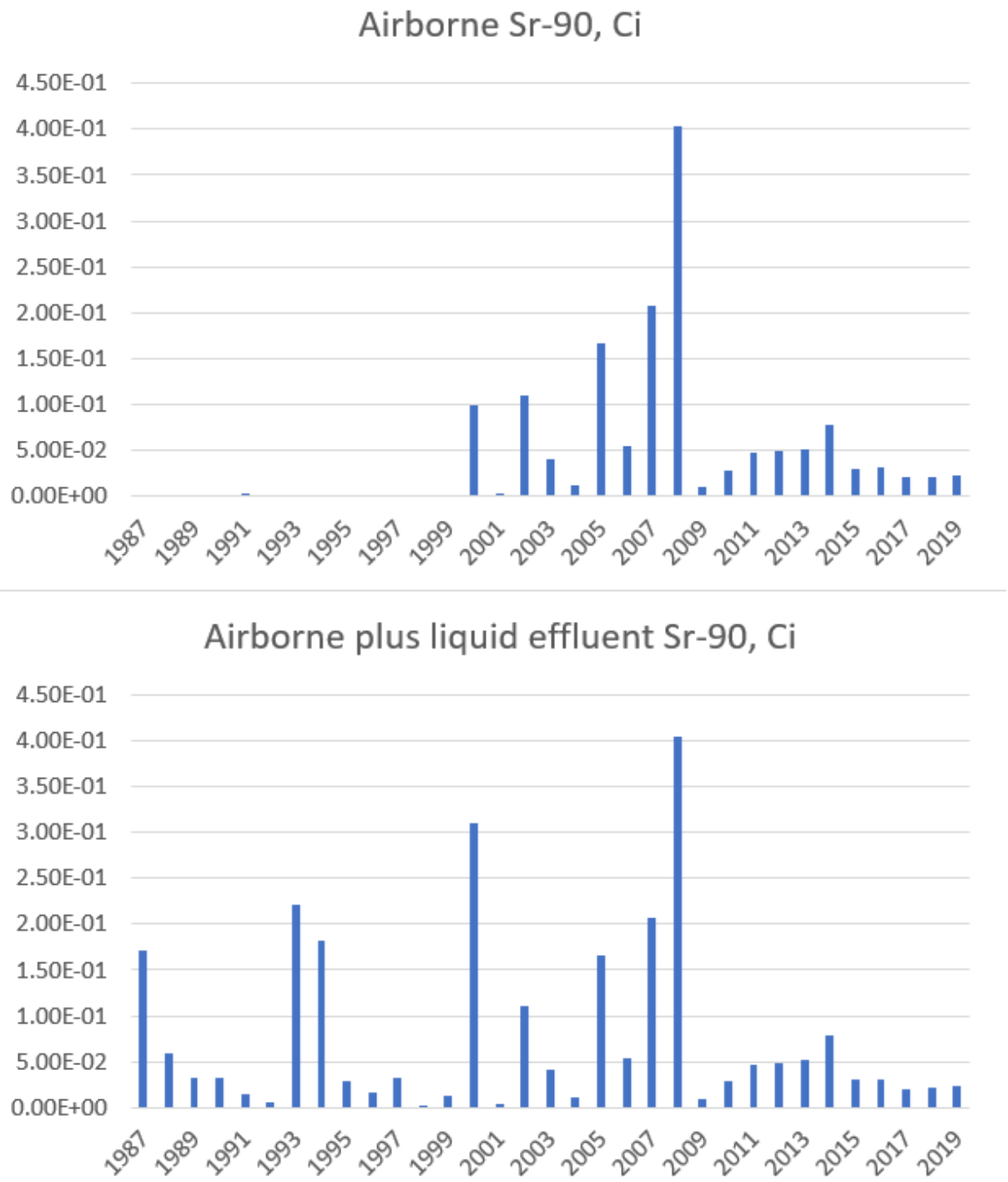

Figure 12. Strontium-90 released by the Department of Energy. Note that prior to 2001, the radiation doses were based only on the stated airborne releases and not the strontium released to the evaporation or percolation ponds.

The 2008 ESER annual report states that "Strontium-90 is present in soil as a residual of fallout from aboveground nuclear weapons testing, which occurred between 1945 and 1980." But note that the report does not acknowledge the past or continuing strontium-90 releases from the INL. The typical ESER conclusion in all annual reports is that any detection of strontium-90 is most likely from weapons testing fallout. It is only by closer examination of trends and of the presence of other radionuclides that it is clear that the source is the INL. In addition to radionuclides in soil, plants readily take up radionuclides that are in the air. The ESER reports for the recent decades ignore the elevated levels of strontium-90 in the air.

The ESER program maintains the fictional assertion that the radioactivity detected in communities surrounding the INL is due to former global nuclear weapons testing, which it says ended by 1980. Strontium-90 is not naturally occurring. Strontium-90 radioactivity decays over time and does not build up. The large increases in strontium-90 contamination can only be due to ongoing radiological releases from the Idaho National Laboratory.

With regard to the lack of integrity of the Department of Energy's environmental surveillance, look at the negative value for strontium-90 in wheat in 2019, in Table 8. The 2019 value is a negative value of -36.40 ± 25.4 pCi/kg with an MDC of 63.6 pCi/kg. In contrast, the value in 1979 is 10 ± 4 pCi/kg with an MDC of 4 pCi/kg. That negative value in 2019 should not make anyone feel comfortable. It is actually more likely that the level can only be considered something below its MDC of 63.6 pCi/kg. And keep in mind that ESER uses all the negative values to determine average values, thus lowering the stated average values.

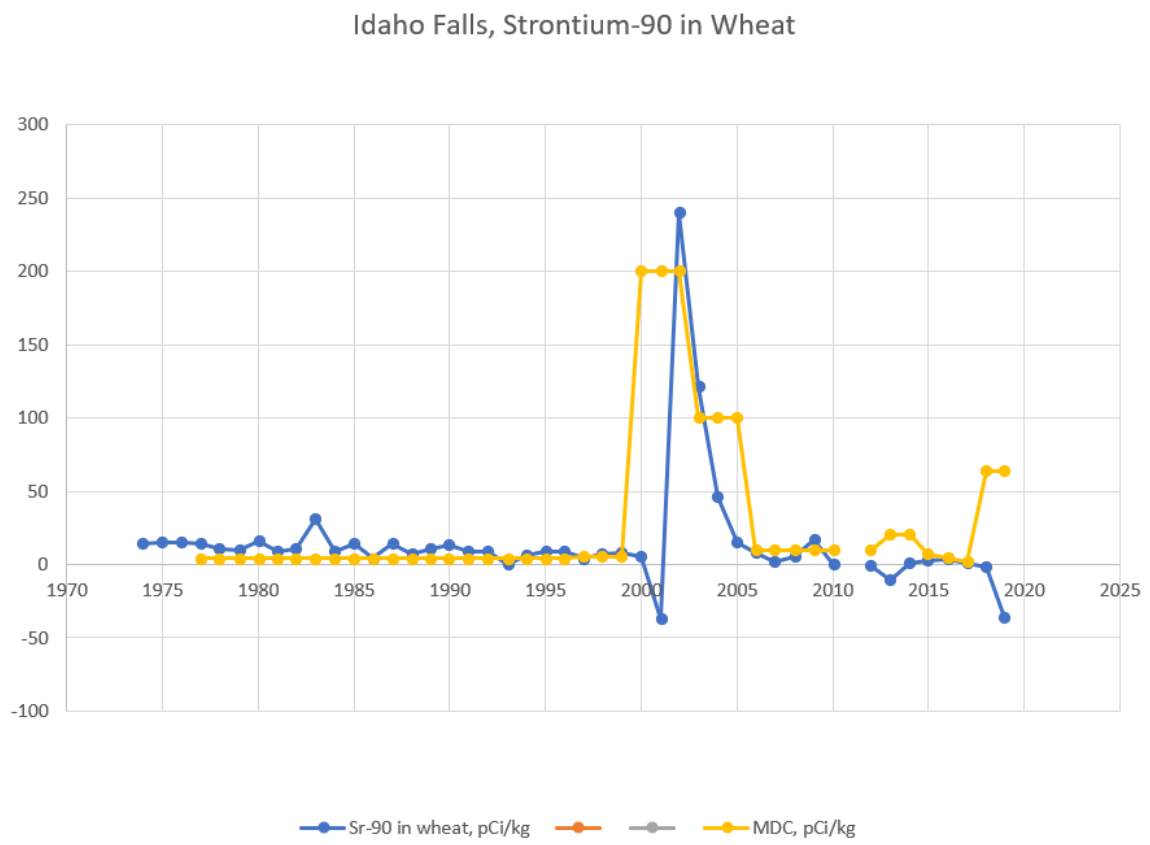

Figure 13. Strontium-90 concentrations in wheat in Idaho Falls, 1974 through 2019.

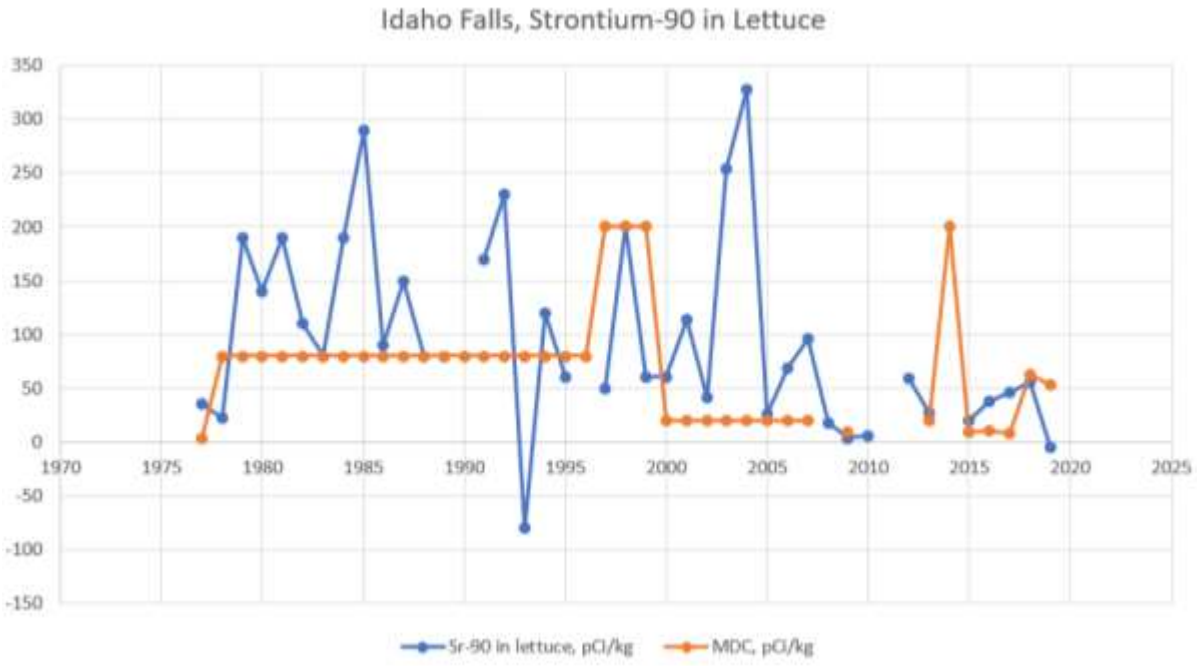

Figure 14. Strontium-90 concentrations in lettuce in Idaho Falls, 1977 through 2019.

Table 8. Strontium-90 concentrations in wheat and lettuce in Idaho Falls, from 1974 to 2019.

Year	Wheat, pCi/kg (±2s)	Minimum detectable concentration, pCi/kg	Lettuce, pCi/kg (2s)	Minimum detectable concentration, pCi/kg
1974	14 ± 4	Unstated	-	-
1975	15 ± 4	Unstated	-	-
1976	15 ± 6	Unstated	-	-
1977	14 ± 4	4	35 ± 6	4
1978	11 ± 4	4	22 ± 6	80
1979	10 ± 4	4	190 ± 8	80
1980	16 ± 6	4	140 ± 100	80
1981	9 ± 4	4	190 ± 80	80
1982	11 ± 4	4	140 ± 40	80
1983	31 ± 6	4	< MDC	80
1984	9 ± 4	4	190 ± 40	80
1985	14 ± 4	4	290 ± 6	80
1986	< MDC	4	90 ± 40	80
1987	14 ± 4	4	150 ± 80	80
1988	7 ± 3	4	< MDC	80
1989	11 ± 3	4	< MDC	80
1990	13 ± 4	4	"sample lost in analysis"	80
1991	9 ± 3	4	170 ± 100	80
1992	9 ± 2	4	230 ± 40	80
1993	0 ± 3	4	-80 ± 5	80
1994	6 ± 2	4	120 ± 40	80
1995	9 ± 5	4	60 ± 30	80
1996	9 ± 18	4	"sample destroyed"	80
1997	4 ± 4	5	50 ± 30	200
1998	7 ± 5	5	200 ± 30 70 ± 40	200
1999	8 ± 9	5	60 ± 40	200
2000	5 ± 3	200	61 ± 50	20 to 200
2001	-37 ± 88	200	114 ± 110	200
2002	240 ± 270	200	41 ± 50	20
2003	121 ± 128	20 to 100	254 ± 340	20
2004	46 ± 44	20 to 100	328 ± 220	200
2005	15 ± 48	20 to 100	26 ± 48	200
2006	7.8 ± 5.0	10	69 ± 16	200
2007	2.0 ± 7.2	10	96 ± 16	200
2008	5.5 ± 4	10	18 ± 12	200
2009	16.80 ± 3.88	200	5.65 ± 16.3	9
2010	0.11 ± 6.5	200	35 ± 6	

Year	Wheat, pCi/kg (±2s)	Minimum detectable concentration, pCi/kg	Lettuce, pCi/kg (2s)	Minimum detectable concentration, pCi/kg
2011	No data	-	No data	-
2012	-0.72 ± 41.80	200	59.60 ± 47.2	200
2013	-10.50 ± 15.48	20	26.60 ± 11.4	20
2014	0.86 ± 2.34	20	No data	200
2015	3.08 ± 3.66	6.82	20.60 ± 8.28	8.87
2016	3.63 ± 1.88	4.22	37.60 ± 6.9	10.9
2017	0.78 ± 2.20	2.22	46.30 ± 7.36	8.17
2018	-2.05 ± 34.4	63.6	55.60 ± 40.0	62.2
2019	-36.40 ± 25.4	63.6	-5.14 ± 34.8	53.8

Table notes. Units are picocurie per kilogram (pCi/kg). Uncertainty is stated in plus-or-minus 2 standard deviations denoted as "2s." Significant global nuclear weapons testing occurred in September 1977, March 1978, December 1978 and October 1980. The Chernobyl accident occurred in April 1986. Fukushima occurred in March 2011. When the ESER report stated "< MDC", meaning the sample result was below the minimum detectable concentration, that was the only result recorded.

The data source for the tables of specific radionuclide activity for various radionuclides are taken from ESER annual reports. Until 2003, the results had been presented in annual reports even if the sample result was between 2s and 3s. In 2003, only the detections that were 3s detections were listed in the annual summary tables. The high bar for qualifying a sample result as a detection means that the detection is not likely to be a false positive and less than 5 percent of the results would be a false positive. The problem, however, is that for samples near the minimum detectable concentration, there is likely to be a high probability of a false negative (as much as 50 percent).

The annual reports provide a perspective and the quarterly reports provide more information. The quarterly reports that discard many solid detections between 2s and 3s, indicate some very strange results. For example, in third quarter of 2019, the detection of americium-241 at 0.94 ± 0.34 E-18uCi/mL is discarded by is nearly a 3s detection in Blackfoot. The samples on the same date yield plutonium-239/240 at 0.15 ± 0.15 E-18uCi/mL. So, the activity ratio of Am-241 to Pu-239/240 is over 6 when it should not exceed a roughly 1:1 correspondence if from global fallout. And for global fallout, plutonium-238 activity should not exceed plutonium-239/240's activity. Yet, the Blackfoot radiological monitoring find plutonium-238 activity at 2.11 ± 0.59 E-18uCi/mL (a greater than 3s detection) with plutonium-239/240 at only 0.15 ± 0.15 E-18uCi/mL. These results actually provide strong proof that the INL is the source of the contamination and that the contamination is not from global nuclear weapons testing as the Department of Energy continues to claim.

Milk sampling is conducted by the Department of Energy's ESER program and also by the State of Idaho Department of Environmental Quality, see Appendices C and D. The Idaho DEQ's INL Oversight Program only analyzes milk samples for iodine-131. The DEQ's annual reports, created since 1991, are only available for the most recent 5 or 6 years. In the available reports, the DEQ reports state "The DEQ action level of 4.4 pCi/L is based upon the radioiodine concentration in milk necessary for an infant to receive an annual thyroid radiation dose of 5 millirem. The Food and Drug Administration (FDA) recommended maximum concentration of I-131 for food, including milk, is 4600 pCi/kg." This sounds rather thoughtful of the DEQ, but the DEQ neglects to mention that the minimum detectable concentration they have selected for I-131 in milk sampling analysis is stated in their quarterly reports as "approximately 4 pCi/L." So, the DEQ is perhaps only barely capable of detecting 4.4 pCi/L of I-131 in milk samples. And note, the FDA's allowable concentration would give over 5000 mrem/yr to an infant's thyroid. What is it giving to the developing fetus/embryo?

The Idaho DEQ did not detect I-131 in milk for years 2013 through 2019 and neither did the DOE's environmental surveillance contractor, reports that were previously at IdahoESER.com. However, the ESER contractor did detect I-131 in concentrations exceeding 4.4 pCi/L in 1995, 1996, 2001, 2002 and 2011. And the milk usually contained strontium-90 and tritium and sometimes cesium-137. The ESER milk sampling program is spotty and only conducted in the second and fourth quarter of the year.

What is remarkable about detections of I-131 in milk exceeding 4.4 pCi/L after 1995 is that for the years from 1974 through 1989, the INEL HDE recognized that aside from the 1986 Chernobyl accident and numerous nuclear weapons tests that they recognized between 1974 through 1980, there were only two detections of I-131 in milk that exceeded 2 pCi/L.

In the years from 1979 through 1989, the detections of I-131 in milk did not exceed 1.1 pCi/L with the exception of one sample in 1986 that the INEL HDE did not attribute to Chernobyl or weapons testing or known INL releases. It appears to me that this was iodine-131 from the ATR Complex liquid releases, although unstated in the liquid releases. In any case, with the possible exception of 2011 Fukushima accident, between 1989 to the present, any I-131 in milk would be from the INL operations. And detections after 1989 that exceed 1.1 pCi/L are higher than from the INL's releases from the 1970s and 1980s.

There are known high releases of both radioactive iodine-131 and iodine-129 from the INL. In spite of this, iodine-129 is not monitored in milk. Oddly, for many years, the Department of Energy's ESER program listed both I-131 and I-129 in their milk sampling program. There are MDC's listed for I-129 in milk from 1990 to 2001, and yet no discussion of I-129 sampling or results are ever presented. On several occasions, there are statements that the analysis for I-129 was not performed or that the results would be presented next year, but no I-129 in milk result are ever presented.

The DOE's ESER contractor apparently did not analyze for cesium-137 in milk prior to 2000. In 2000, cesium-137 in milk was analyzed and cesium-137 was detected in 20 samples.

Cesium-137 was also detected in 2001. There are old results for cesium-137 in milk, such as in 2015 when the result is -3.08 ± 1.94 (1s) pCi/L. The minimum detectable concentration is 1 pCi/L and the results indicate a hot blanks, high background or other laboratory radioactive decay counting problem.

The highest strontium-90 concentration in milk detected by ESER was 5.89 pCi/L in 2002. In 1991, the minimum detectable concentration MDC for Sr-90 in milk was 1 pCi/L. And in 1997, the MDC was 0.3 pCi/L. Yet, inexplicably, ESER selected the unusually coarse MDC of 5 for the years 2000 through 2012, as though they didn't want Sr-90 detections in those years. The MDC for Sr-90 in milk since 2013 (through 2019) has been below 0.24 pCi/L.

Iodine-131, strontium-90 and cesium-137 radioactivity in milk samples monitored by the Department of Energy from 1991 through 2019 are shown in Figure 15. The data for Figure 15 are provided in Appendix C.

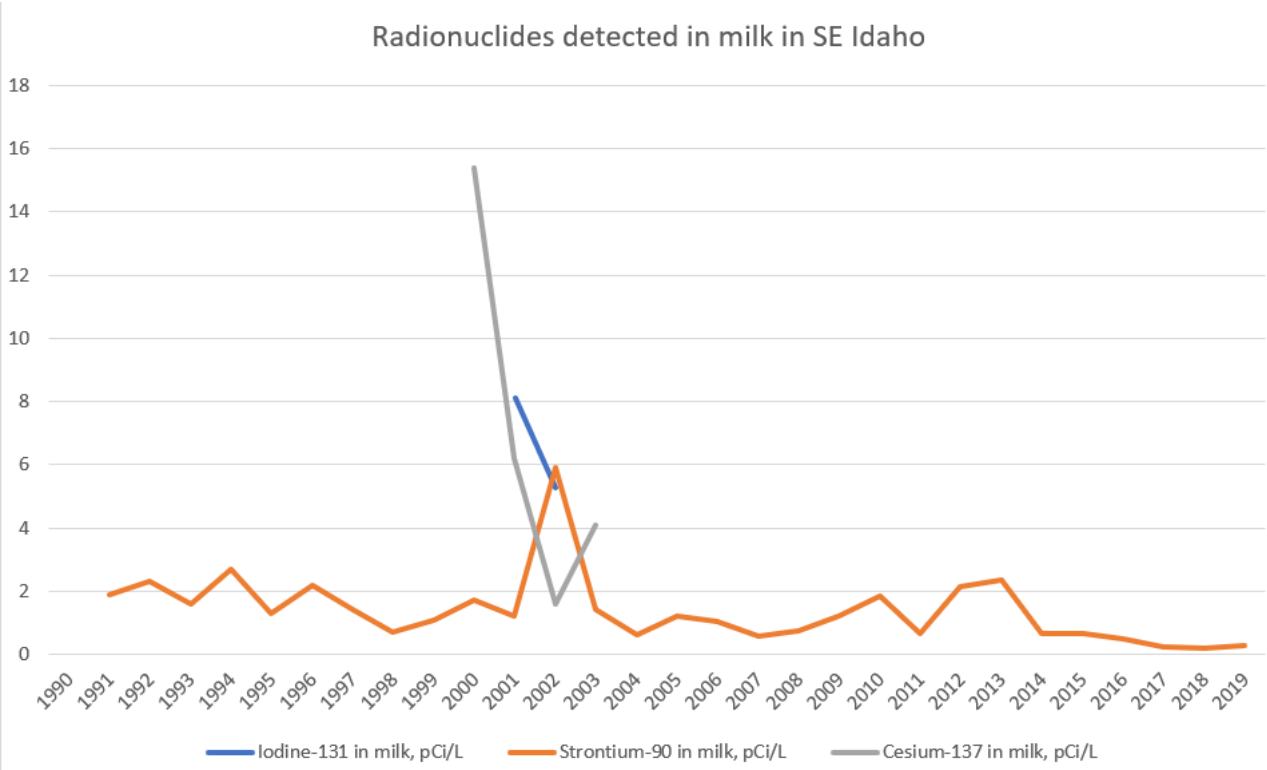

Figure 15. Iodine-131, strontium-90 and cesium-137 radioactivity in milk samples monitored by the Department of Energy, 1991 through 2019.

Radiological Monitoring of Tritium

Tritium in milk, tritium in atmospheric vapor and tritium in precipitation as monitored by the Department of Energy from 1990 to 2019 are shown in Figure 16. The data for Figure 16 are provided in Appendix C, Table C4. Figure 16 shows a large escalation in the concentration of tritium in atmospheric vapor in 2001 and especially in 2002 in Idaho Falls. (Please note that the peak of tritium in atmospheric vapor in 2002 is real but not to scale relative to the tritium in milk and precipitation which are in units of pCi/L.)

In 2002, the tritium detected in atmospheric vapor skyrocketed to 9340 E-15 uCi/mL in Idaho Falls even though the 1996 detection had been near 100 ± 81 (2s) in Idaho Falls in 1996 (see Table C4 in Appendix C).

In 2005, tritium detected in precipitation in Idaho Falls by the Department of Energy environmental surveillance program was 185 ± 31.3 (1s) yet the U.S. Environmental Protection Agency RadNet detection of tritium in precipitation was 1720 pCi/L on October 15, 2005 (see Table C4 in Appendix C). There has never been an explanation of the large discrepancy in the results from the two agencies. EPA RadNet receives samples from the Department of Energy and has RadNet surveillance in Idaho Falls and Boise.

From 1997 through 1999, tritium concentrations in milk had been monitored with the MDC of 100 pCi/L and was deemed below detection level. But from 2000 through 2008 the MDC was raised to 300 pCi/L, which diminishes the detection capability, (see Table C4 in Appendix C).

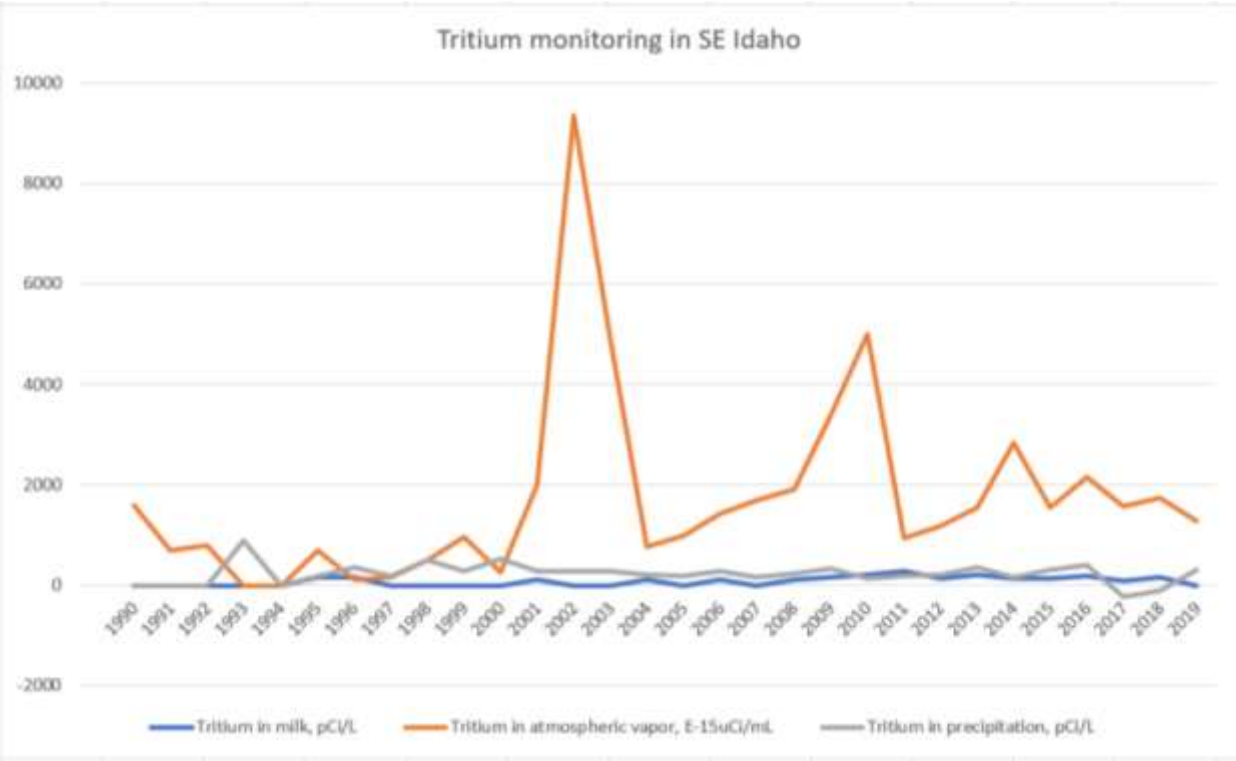

Figure 16. Tritium in milk, tritium in atmospheric vapor and tritium in precipitation as monitored by the Department of Energy, 1990 through 2019.

Liquid Effluent to Radioactive Waste Ponds Detected in Waterfowl and Yellow-bellied Marmots

The detection of specific radionuclides in muscle tissue and bone of waterfowl (ducks) and in yellow-bellied marmots in past years in southeast Idaho tell us some very interesting things.

A study of the radionuclides in ducks from 1993 to 1998 found fourteen different radionuclides, all of which were found in the Test Reactor Area (TRA) evaporation ponds. [59] The Test Reactor Area was renamed the ATR Complex in 2005. Some of these fourteen radionuclides have relatively short half-lives and could have only come to southeast Idaho from recent nuclear reactor operations at the Idaho National Laboratory.

I have listed the fourteen radionuclides in Table 9 below, arranged by highest concentration in either muscle or bone. Where the concentration was significantly higher in bone than in muscle, I have commented in the table that the radionuclide appears to act as a bone seeker. Strontium-90, americium and plutonium are well known bone seekers. Other radionuclides were less known to me to be **bone seekers** include chromium-51, ceium-144, hafnium-181, antimony-124, and manganese-54. The long-lived bone seekers like americium-241 and plutonium are retained in the bone, essentially for the rest of your life. And while the curie amounts of the americium and plutonium are lower, these alpha emitters are more adept at making imperfectly repaired DNA damage, compared to gamma radiation.

It is also important to note that even if a radionuclide is not a bone seeker, but is spread out in just muscle or in both muscle and bone rather evenly, or is external to the body, gamma ray energies above 200 keV penetrate bone to the red marrow where blood cells are formed. [60]

White blood cells make up an essential part of the body's immune system. If a person dies of infection, for example, the death will not be attributed to radiation (perhaps unless an acute dose over 300 rad occurred). Regarding bone or red marrow dose, the nuclear industry's fixation on only bone cancer or leukemia and this means that the "effective" dose is a watered-down dose which discounts non-cancerous illnesses including illnesses related to impaired immune system. Deaths other than from cancer or leukemia are not counted as being caused from radiation exposure.

While the study of ducks that landed at the Test Reactor Area ponds and are presumed to have been uniquely contaminated and only present a hazard to human health if consumed and in large number, I believe there is more to be learned. The ducks that were the "control" ducks, and 30 miles or so from TRA also had gamma spectrometry indicating the uniquely TRA radionuclides. The counting statistics, if less than 2 standard deviations were not reported and if less than 3 standard deviations were not considered "real."

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[59] Ronald W. Warren et al., *Waterfowl Uptake of Radionuclides from the TRA Evaporation Ponds and Potential Dose to Humans Consuming Them*, Stoller-ESER-01-40, October 2001. http://idahoeser.com/Surveillance/PDFs/TRADuckReport.pdf

[60] Department of Energy, External Dose-Rate Conversion Factors for Calculation of Dose to the Public, DOE/EH-0070, July 1988. https://www.osti.gov/servlets/purl/6953527 Released 2004.

Table 9. Radionuclides found in ducks in southeast Idaho from 1993 to 1998 from Stoller-ESER-01-40 report.

Radionuclide	Half-life	Gamma energy, keV (abundance)	Average, pCi/g	Max, pCi/g	Tissue/Bone and notes
Cr-51	27.8 day	320 keV (9%)	16.3	82.8	Bone seeker
Sr-90	29 year	All beta and cannot be detected by gamma spectrometry	2.9	11.5	Bone seeker
Co-60	5.26 year	1173.2 (100%) and 1332.5 (100%)	2.3	10.7	Found in muscle and bone
Ce-144	284 day	134 keV (11%)	0.5	5.2	Bone seeker
Cs-137	30 year	600 keV (from the Ba-137m, 95%)	0.35	1.95	Found in both muscle and bone
Hf-181	42.5 day	133 keV (48%)	0.3	2.1	Bone seeker
Zn-65	245 day	1114 keV (49%)	0.1	0.4	Bone and muscle
Co-58	71.3 day	810 keV (99%)	0.05	1.52	Muscle more than bone
Sb-124	60 day	1692 keV (50%)	(-0.002)	0.04	Bone seeker
Mn-54	303 day	834.8 keV (100%)	0.03	0.1	Bone seeker
Cs-134	2.05 year	605 keV (98%) and 796 keV (99%)	-0.1	0.21	Muscle
Am-241	430 year	59.6 keV (36%)	2.6E-3	7.7E-3	Bone seeker
Pu-238	88 year	1.8 keV	2.6E-4	7.3E-4	Bone seeker
Pu-239/240	24,000 year/ 6500 year	< 1 keV/ 1.7 keV	1.2E-4	4.6E-4	Bone seeker

Table notes: Gamma energy in kilo-electron-volts (keV), and percent abundance which refers to the percent of decays that also release the gamma photon from https://www1.physics.indiana.edu/~courses/p451/examples/Gamma_Energies_table.pdf ; radioactivity in tissue or bone in picocurie per gram, pCi/g where 1 picocurie is 1E-12 curies; when found strongly in bone the figures are for bone rather than muscle; chromium-51 is Cr-51; strontium-90 is Sr-90; cobalt-60 is Co-60, cerium-144 is Ce-144; cesium-137 is Cs-137; hafnium-181 is Hf-181; zinc-65 is zinc-65; cobalt-58 is Co-58; antimony-124 is Sb-124; manganese-54 is Mn-54; cesium-134 is Cs-134; americium-241 is Am-241; plutonium-238 is Pu-238; and plutonium-239 and/or plutonium-240 is Pu-239/240. See Table 4 of the Stoller-ESER-01-40 report for muscle and bone radionuclide concentrations and this table lists either the muscle or bone concentration, which ever was higher. Where the radionuclide concentration in bone was significantly higher than in muscle, I have commented that the radionuclide behaved as a bone seeker in my table.

The problem is that these statistics are intended to prevent false detections. This means that the error of a false negative, or failure to report an actual detection, is as high as 50 percent.

As I compare the radioactivity in duck tissue from the 2001 TRA duck report (Stoller-ESER-01-40) [61] to the 2002 Marmot tissue report, I also confirm my suspicion that the counting statistics for the Pocatello Zoo location marmots was faulty. In the 2001 TRA duck report, which covers duck tissues analyzed from 1993 through 1998, chromium-51 maximums were 20 ± 9 pCi/g in bone. In the 2002 marmot report, we have values like chromium-51 of -22.0 ± 450.0 pCi/g; 13.2 ± 460 pCi/g.

When the radioactivity in near zero, half of the sampled distribution may be negative. But in reality, there is no such thing as negative radioactivity; the overly large uncertainty values indicate serious problems. The negative results and the wide uncertainties indicate either the blanks, the background, or both are elevated. The radiological results are a net result between the sample and a blank, with all decay counting taking place with the presence of background radioactivity. High background radioactivity may widen the uncertainty range. Higher levels of radioactivity in the blank than in the sample will produce large negative results. Results for a sample are the net result obtained subtracting the blank counts from the sample counts.

Unusually large uncertainty ranges indicate a more sinister problem. Either the counting times should have been lengthened or hot blanks were being used or the gamma spectrometry software was not properly attuned to the unusual varieties of radionuclides present.

A very wide and ambiguous latitude is allowed in interpreting gamma spectroscopy results. And the general advise by the Department of Energy's environmental surveillance program is to ignore negative detection values and assume the result is "zero." Yet, these large negative results offset higher values being detected and maintain the annual averages. The higher maximum values and lower negative results are ignored as annual averages appear in line with previous years.

The gamma spectrometry identification of radionuclides in tissue may incorrectly estimate the concentration levels in the tissues, but the identification of radionuclides via gamma spectroscopy should not be dismissed. It appears that through the presence of hot blanks and contaminated background levels, that evidence of radiological contamination came from the INL is dismissed. In fact, the ATR Complex evaporation ponds always release large curie amounts of chromium-51 and this radionuclide activation product is not due to former nuclear weapons testing. There are other radionuclides from the evaporation ponds such as hafnium-181, zinc-65 and other radionuclides fission or activation products with less than one-year half-lives, that also cannot be attributed to former nuclear weapons testing. The Department of Energy's annual report for 2002 for the offsite marmots discarded all radionuclides except those that could plausibly be attributed to former nuclear weapons testing, retaining the strontium-90.

[61] Ronald W. Warren et al., *Waterfowl Uptake of Radionuclides from the TRA Evaporation Ponds and Potential Dose to Humans Consuming Them*, Stoller-ESER-01-40, October 2001. http://idahoeser.com/Surveillance/PDFs/TRADuckReport.pdf

Even in the "control" ducks, ducks not harvested at the ATR Complex, the ratio of plutonium-238 to plutoniuim-239 is too high to be from weapons testing fallout.

The intake of radionuclides from air or bioaccumulation in vegetation is not explored in the 2001 TRA duck report. When this report is viewed in light of the yellow-bellied marmot report from 2002 which found in the gamma spectrometry of marmot tissues, many of these same radionuclides, some of which can only be from the INL, I have to wonder how what human tissue (muscle and bone) include of the ongoing radiological releases from the reactor and isotope operations at the INL.

While strontium-90, cesium-137, and plutonium-239/240 are known to have been spread by the Department of Energy's nuclear weapons testing at the Nevada Test Site, with above ground testing ending in 1963, there are several radionuclides in the table that have rather short half-lives and cannot be from global weapons testing fallout, Nevada Test Site weapons testing falling, or Chernobyl. And in fact, all fourteen radionuclides were stated in the 2001 report as being found in duck tissues are released to the evaporation ponds.

The Department of Energy fails to address the rather short-lived radionuclides produced in nuclear reactors that were found in marmot tissue as far away as Pocatello Idaho which cannot have come from past weapons testing or radioactive disposal activities such as importation of radioactive waste via train car past Pocatello to US Ecology Grandview Idaho.

Based on the Department of Energy's 2002 annual surveillance report of marmot tissues, there appear to be radionuclides rather arbitrarily omitted that were likely present but not listed as detected in the 2001 TRA duck report. These radionuclides include zirconium-95 (gamma ray 756 keV, 49 percent abundance, 65 day half-life) which decays to niobium-95 (gamma ray 765 keV, 100 percent abundance, 35 day half-life), and ruthenium-106 (gamma ray 511.9 keV, 20.4 percent abundance, and 622 keV, 11 percent abundance, 1.02 year half-life), and cerium-141 (gamma ray 145 keV, 40 percent abundance and 33 day half-life) which were noted in marmot tissues but later excluded from final reporting by the Department of Energy's environmental surveillance with no explanation of the source of the gamma spectrometry identification of the presence of the these radionuclides.

If yellow-bellied marmots in Pocatello in 2002 had short-lived activation products in their tissues that cannot be from past weapons testing or from the phosphate industry, why weren't questions asked about where the short-lived radioactive manganese, zirconium, cerium and others came from? Why did gamma spectrometry detect these radionuclides both on and off the INL site? Why were the results of the marmot tissue sampling program white-washed? And why weren't additional follow-on studies conducted?

The Department of Energy annual environmental surveillance reports for many years, and including 1993 never included the amount of americium-241 released by the INL. Later reports would include the Am-241 releases. But this means that many decades of americium-241 releases were not included in dose estimates for the offsite public. The Department of Energy environmental surveillance reports also had presented the air effluents and the liquid effluents in a single table. And it appears that the liquid effluents, even after send to open-air lined evaporation ponds, were not included in the dose estimates for the offsite public. Later reports would include, it appears, at least some of the radionuclides sent to the evaporation ponds.

Unique radionuclides that could only come from the Advanced Test Reactor (ATR Complex) or associated operations include chromium-51, cerium-144, hafnium-181, zinc-65, cobalt-58, cobalt-60, manganese-54 and antimony-124. All of these radionuclides have a half-life of less than one year with the exception of cobalt-60, which has a 5.26-year half-life. The elevated evaporation pond and TRA duck levels of cesium-134 and -137, strontium-90, americium-241, plutonium-238 and plutonium-239/240 show these came from the Test Reactor Area although the Department of Energy's environmental surveillance reports frequently deny detected radionuclides came from the INL. Note also the rather short half-life of cesium-134, of 2.05 years.

The same ATR Complex radionuclides found in CERCLA cleanup reports, [62] and in ducks are still being found in animal tissue. Some of these radionuclides are found in the "controls" or the animals offsite that are not near the ATR Complex ponds. Could these be found in your tissue?

For a description of the use of gamma spectrometry analysis, see the October 2019 Environmental Protection Agency report. [63] This EPA report includes usual information about gamma energies and includes discussion of low abundance gamma rays that may be used in alpha spectrometry. It also includes a discussion of uncertainty calculations.

I also believe that the use of the ATR Complex evaporation pond as the dumping ground for highly radioactive resin beads discharged or escape from the Advanced Test Reactor continues to be covered up. The evaporation pond was not designed to receive the radioactively laden resin beads.

A 2016 Occurrence Report (OR) stated **that soil contamination levels were as high as 250,000 disintegrations per minute per 100 square centimeters near the ATR Complex evaporation pond.** The contractor admitted that radionuclides were being sent to the open-air

[62] For example, EG&G for the Department of Energy, *Perched Water System Remedial Investigation Feasibility Study for the Test Reactor Area of the Idaho National Engineering Laboratory*, EGG-WM-10002. March 1992.

[63] U.S. Environmental Protection Agency, *High Resolution Gamma-Ray Spectrometry Analyses for Normal Operations and Radiological Incident Response*, EPA 402-B-17-001, October 2019. https://www.epa.gov/sites/production/files/2020-07/documents/guide_for_high_resolution_gamma_spectrometry_analyses_camera_ready.pdf

lined evaporation ponds that the ponds were not designed for. And the DOE Occurrence Report stated that snow fence was erected to limit the spread of radioactivity among other actions. [64]

This is not the first time radioactively laden resins, intended to capture radionuclides and clean up the waste water, have escaped the resin beds. Resin beads were found near an underground piping leak in waste water lines headed for the evaporation pond. [65] Radiation monitors that should have detected the elevated radiation levels in the waste water going to the pond were either kept off or were otherwise ineffective in detecting the elevated radiation levels in the waste water. The damaged pipe and resins inside it were then left in the ground.

But in the 2016 OR, it was admitted that the resins escaped to the open-air evaporation pond and resulted in contaminating the ponds and soil near the ponds. The reality is that resins may have been sent to the ponds since the evaporation ponds was installed in 1993. The degree to which the release may have increased in recent years or months is not described.

When resins were previously found as described in DOE/NE-ID-11139 in the 2001, federal cleanup CERCLA Track 1 documentation was prepared. But apparently this has not occurred for the 2016 OR despite the radioactivity involved being above ground rather than occurring underground where a pipe was leaking.

The evaporation ponds were installed in 1993 to accept warm waste water that had been filtered through resin cleanup systems and the main radionuclide to be released was to be tritium. Based on DOE/NE-ID-11139, the normally accepted levels of radioactivity released to the evaporation ponds are not trivial and the tritium released to the evaporation pond is in concentrations far exceeding drinking water standards, over 9 million picocuries/liter. [66] But the Battelle Energy Alliance does not estimate its releases of tritium from the ATR Complex to the skies. This requires others to make rough estimates when creating air emissions reports for the INL.

The 2006 INL report (INL/EXT-06-11601) characterized potential ATR resins from experiment loops and the main primary coolant system in order to investigate waste disposal options. [67] The ATR resins require remote handling and are too radioactive to be accepted by most commercial low-level radioactive waste disposal facilities. The resins likely include cesium-137, strontium-90, and may include long-lived radionuclides significant for migration to

[64] Department of Energy Occurrence Report NE-ID—BEA-ATR-2016-0014. "Contaminated Soil Outside Warm Waste Evaporation Pond at the ATR Complex." a copy made available on our website www.environmental-defense-institute.org/publications/ATR-2016-0014.htm

[65] DOE/NE-ID-11139, "Track 1 Decision Documentation Package for TRA-605 Warm Waste Line," January 2005. http://ar.inel.gov/images/pdf/200503/2005030300231KAH.pdf

[66] DOE/NE-ID-11139, "Track 1 Decision Documentation Package for TRA-605 Warm Waste Line," January 2005. http://ar.inel.gov/images/pdf/200503/2005030300231KAH.pdf

[67] Timothy Carlson et al., Idaho National Laboratory for the Department of Energy Office of Nuclear Energy, "Low-level Waste Disposal Alternative Analysis Report," INL/EXT-06-11601 rev. 1, September 2006. Table B-2-4. https://inldigitallibrary.inl.gov/sites/sti/sti/3661678.pdf

the aquifer including americium-241, neptunium-239, plutonium-239, iodine-129, technetium-99 and others.

Yellow Bellied Marmots

In 2002, marmot tissues were analyzed for radionuclide content. The marmots were taken from the Idaho National Laboratory near the Radioactive Waste Management Complex and from near the Pocatello Zoo. There was also marmot data from 1998 also detecting cobalt-60, zinc-65, niobium-95, cesium-134, cerium-141 and also strontium-90, cesium-137 and plutonium-238.

Now you might expect the INL's marmots to have higher concentrations of radionuclides and you might expect that the marmots from Pocatello would only have radionuclides from weapons testing fallout. Well, yes, the INL's marmots did sometimes have higher concentrations of radionuclides. But the marmots from INL and from Pocatello had short-lived neutron activation products that would not be at concentrations this high from weapons testing fallout.

Nor would these activation products be from uranium refining processes such as the waste from Formerly Utilized Sites Remedial Action Program (FUSRAP), radioactive soil that is shipped, often by railway through Pocatello, to the US Ecology disposal site at Grandview on the Boise-side of the state.

Both the INL's RWMC and the Pocatello marmots had the mainstays: strontium-90 and cesium-137 in their tissues. And in 2002, both the INL's and the Pocatello marmots had these short-lived neutron activation products that can only be from the INL: cerium-141, cobalt-58 and cobalt-60, chromium-51, hafnium-181, manganese-54, niobium-95, zinc-65, and the fission product ruthenium (either Ru-103 or Ru-106, both of which are short-lived). See Table 10.

I found this data shocking, particularly since neither fuel reprocessing or calcining were being conducted at INL's INTEC. The Department of Energy's environmental monitoring narrative was simply to say that eating a marmot wouldn't be that harmful.

Table 10. Man-made radionuclides in marmots from Pocatello and from one INL sample from the 2002 environmental monitoring report data, selected results.

Location and Collect Date	Analyte	Result ± 2s uncertainty (pCi/g)	Result ± 2s uncertainty (pCi/g)
Pocatello Zoo area, March 1, 2002, analyzed June 5, 2002.			
	Americium	0.60 ± 0.90	1.60 ± 1.90
	Cerium-141	59.20 ± 45.00	42.40 ± 45.00
	Cesium-137	2.40 ± 3.50	-0.80 ± 2.60
	Cobalt-58	1.00 ± 10.00	-4.80 ± 9.20
	Cobalt-60	2.80 ± 4.00	2.40 ± 3.10
	Chromium-51	-22.00 ± 450.00	13.20 ± 460.00
	Hafnium-181	-11.10 ± 21.00	-13.30 ± 21.00
	Manganese (Mn-54)	5.70 ± 4.40	1.20 ± 3.60
	Niobium-95	8.00 ± 35.00	29.4 ± 34.00
	Plutonium-238	0.00 ± 0.80	0.00 ± 1.30
	Plutonium-239/240	0.30 ± 0.70	-0.30 ± 0.50
	Ruthenium (radioactive, unspecified nuclide)	6.50 ± 23.00	-12.50 ± 23.00
	Zinc-65	-16.70 ± 11.00	-13.70 ± 9.20
	Zirconium (radioactive, unspecified)	-15.40 ± 21.00	-9.80 ± 18.00
	Strontium-90	12.00 ± 21.00	8.40 ± 8.30
Idaho National Laboratory, March 17, 2002, analyzed May 17, 2002			
	Americium	4.3 ± 3.00	1.10 ± 1.30
	Cerium-141	12.20 ± 63.00	28.00 ± 96.00
	Cesium-137	-1.10 ± 2.80	4.20 ± 3.80
	Cobalt-58	-9.40 ± 11.00	-0.60 ± 15.0
	Cobalt-60	1.60 ± 3.50	1.50 ± 4.50
	Chromium-51	168.00 ± 670.00	-298.00 ± 1000.00
	Hafnium-181	4.30 ± 26.00	-33.20 ± 38.00
	Manganese (Mn-54)	-0.20 ± 3.90	5.00 ± 5.20
	Niobium-95	36.70 ± 46.00	41.50 ± 66.00
	Plutonium-238	-0.20 ± 0.40	0.00 ± 1.40
	Plutonium-239/240	0.70 ± 1.00	1.10 ± 1.60
	Ruthenium (radioactive, unspecified nuclide)	-24.9 ± 29.00	-45.90 ± 42.00

Location and Collect Date	Analyte	Result ± 2s uncertainty (pCi/g)	Result ± 2s uncertainty (pCi/g)
	Zinc-65	-13.00 ± 10.00	-3.90 ± 14.00
	Zirconium (radioactive, unspecified)	4.10 ± 22.00	-17.10 ± 30.00
	Strontium-90	13.20 ± 15.00	2640.00 ± 540.00

Source: Previously at the Department of Energy's environmental surveillance contractor's website Idahoeser.com, 2002.

It is important to note that in the early years of environmental monitoring, Pocatello was included. But in later years, usually Pocatello was excluded from the environmental monitoring program because it was deemed too far away from the INL. For many years, the wind isopleths were unscientifically loped off everything south of Blackfoot even though elevated concentration lines extended south of the Blackfoot. Wind isopleths would imply that the marmots in Pocatello would have minimal, if any, influence from the INL airborne contamination. And yet, the marmots in Pocatello had internal contamination levels near the levels of the INL RWMC marmots.

The environmental monitoring program narrative has been to avoid admitting when the radionuclides detected in environmental monitoring are due to INL releases. Vague denials of INL being the source of the radionuclide contamination have been common. And placing the blame on past weapons testing has been overused through the years. Then I came across data on radionuclide discharges to the open-air evaporation pond at the Advanced Test Reactor Complex. While alpha emitters were largely excluded, many of the short-lived radionuclides found in marmots are released by the INL, see Table 11. Americium-241 is an alpha emitter, but was included in the INL's table as it is also a gamma emitting radionuclide.

Table 11. Gamma-emitting radionuclides discharged to the ATR Complex Evaporation Pond from August 13, 1993 to January 20, 2012, estimated total decay-corrected activity (millicuries).

Analytes	Activity released (millicuries/year)	Analytes	Activity released (millicuries/year)
Silver-110m	1.76	Iodine-131	0.23
Americium-241	22.20	Iodine-133	0.02
Barium-140	0.27	**Manganese-54**	11.77
Cerium-141	0.96	Molybdenum-99	1.49
Cerium-144	54.37	Sodium-24	38.98
Cobalt-58	11.30	**Niobium-95**	0.57
Cobalt-60	4176.58	Neptunium-239	0.20
Chromium-51	1105.34	Rhenium-188	4.34
Cesium-134	12.99	**Ruthenium/Rh-106**	3.17
Cesium-137	6630.04	Antimony-122	0.04
Europium-152	135.94	Antimony-124	1.15
Europium-154	118.37	Scandium-46	1.23
Europium-155	23.10	Tantalum-182	2.04
Iron-59	1.20	Tungsten-187	0.06
Hafnium-175	1.80	**Zinc-65**	24.77
Hafnium-181	29.81	**Zirconium-95**	1.65
		Strontium-90 (beta)	396
		Tritium (weak beta)	124,500

Analytes in **bold** were detected in marmot tissue samples in 2002. Beta emitters such as strontium and tritium are not gamma emitters, but have been added to this table. The INL data excluded many known alpha emitters from the table such as plutonium-238, plutonium-239 and curium-244. Table source is *Technical Basis for Environmental Monitoring and Surveillance at the Idaho National Laboratory Site*, DOE/ID-11485, February 2014.

These marmot tissue samples did not address the elevated levels of tritium in air, precipitation and water and did not include thyroid tissue samples. But if the grass eating and air breathing marmots have these radionuclides in their bodies, what about people?

Underreporting of INL Radiological Airborne Effluents and Radiological Liquid Effluents to Waste Ponds

In the tables of airborne effluents from the Idaho National Laboratory for the years 1985 through 2019 provided in Appendix B, I have noted liquid effluents. For the all years of INL operation since 1952, there have been radioactive liquid waste effluents. But only in the years from 1986 through 2000 were estimated curie levels of various radionuclides provided in the Department of Energy annual surveillance reports. Very importantly, the DOE did not include the liquid effluents in its estimates of radiation dose to the public. Most of the liquid effluents were released to INTEC and ATR Complex ponds but there are other radioactive waste water ponds at the INL as well. After 2000, liquid effluents were included in airborne effluents and were included in the estimation of radiation dose. However, the cutoff limits in reporting of airborne effluents often left out radionuclides of less than 1.0E-3 curies and the liquid effluents often left out radionuclides of less than 1.0E-2 curies. And certain radionuclides were not disclosed as part of DOE policy for many years.

For example, americium-241 is not listed as an INL airborne effluent until 2001 and it has never been listed as a liquid effluent. Yet, the INL has been a generous emitter of americium-241 since at least the 1960s.

While some radionuclides that were released were not reported because of the curie level being below the stated cutoff value, there are various differences in how radionuclide airborne waste (or "effluents") are reported through the years. For some years, neither natural nor reactor-made uranium isotopes are reported whether or not these were released. The reporting of plutonium isotopes may separate Pu-238 or include it in one plutonium total value. Plutonium-239 is typically reported as the combination of plutonium-239 and plutonium-240. Plutonium-241 is typically not reported.

The Department of Energy, upon transitioning from percolation ponds to lined evaporation ponds in 1993 continued to exclude the liquid effluents from airborne effluent statements until 2001. The levels of radionuclides in the liquid effluent were often as high or higher than stated airborne effluents. The assumption that liquid effluents in an evaporation pond did not become airborne was not based on sound technical information. It did, however, artificially lower the estimated radiation doses to the public.

Lined ponds are installed at the ATR Complex in 1993 but there was excessive leakage of waste water at the ATR Complex due to retention basin and underground piping leakage for years after 1993 and so there was radioactive water leaching into perched groundwater. However, there was also evaporation which released radioactivity to the air which the Department of Energy did not include in its radiation dose estimates from airborne releases even after environmental monitoring in 1995 indicated excessive radiological detections in the region. The lined evaporation ponds at the ATR Complex have continued to receive high curie amounts of radioactive waste from operations in addition to those of operating the Advanced Test

Reactor. Thus, by failure to report various radionuclides, failure to include some portion of evaporation of liquid effluent discharges, the estimated annual radiation doses are clearly underestimating the dose to the public from airborne effluents.

The grouping of radionuclides in 2009 was an unprecedented lack of transparency to mystify the reader as to what radionuclides had actually been released.

In 1985, that annual report acknowledges that if a person ate one duck that had visited the ATR Complex, that person would receive 10 mrem. Contrast this to the estimated effective whole-body radiation dose estimates usually significantly below 0.1 mrem per year.

But in 1978, the Department of Energy annual surveillance report acknowledged that if a person ate a single duck that had visited the liquid waste disposal pond at the Test Reactor Area that would later become the ATR Complex, a dose of 90 mrem could be received, although the average dose was estimated as 32 mrem.

Radiological Monitoring Program Deficits

It is fundamental when planning the radiological monitoring program and selecting the analytical laboratory and how refined its capabilities are, to select the desired "minimum detectable concentration" or MDC for the monitoring of various radionuclides in air, water, milk, lettuce, wheat and so forth.

The actual MDC achieved will vary for each sample and will depend on things such as the counting time, the air monitor flow rate and hours operated, the sample size, and on the interference from the presence of other radionuclides.

When the readily achievable state-of-the-art has achieved a certain MDC, it is troubling when the planned for MDC is raised, thus reducing the detection capability. For example, from 1997 through 1999, the stated monitoring program MDC for detection of iodine-131 in milk was 100 pCi/L. But from 2000 through 2008, the MDC for detection of I-131 in milk was raised to 300 pCi/L. Similarly, the MDC for detection of tritium in atmospheric vapor was raised from 300 E-15 uCi/mL used from 1995 through 1997, to 4000 E-15 uCi/L for 1998 through 2001.

It should be noted that while it is common practice for the DOE's monitoring program to say the result was "less than the MDC" or "<MDC," actually, results of roughly one-half of the MDC are frequently expressed. And in reality, statistically significant differences from a blank that are less than the MDC by about one half are obtained. It is important for the environmental surveillance to state the MDC that was specified and the actual MDC achieved with the actual sample if it not higher than the 'a priori" specified MDC, in any case.

The reporting of radionuclide monitoring has been recognized for decades as requiring statement of the reported result, its analytical uncertainty, whether expressed as 1 standard deviation (1s), 2s or 3s, the approximate at least minimum detectable concentration (MDC) obtained, and a statement regarding the background level of the radionuclide.

When a tax payer funded radiological monitoring program simply states that a radionuclide was not detected and does not provide any indication of the MDC, perhaps its just sloppiness. But the tendency toward providing less information — not providing the MDC and not providing the uncertainty range — seems to coincide with increased contamination levels.

Typical explanations of the detection statistics in the Department of Energy radiological monitoring program have more often than not, been quite deficit.

In 2003, the Department of Energy's environmental surveillance program arbitrarily decided to ignore detections and deem the radiological detection as "not detected" if the mean result was less than 3 times the sample standard deviation (1s). For example, 2 pCi/L ± 1 pCi/L (1s) which would have been reported as a solid 2s result was now deemed "not detected." A sample with the result of 3 ± 1 pCi/L (1s) would be considered a detection; but the result of 2.9 ± 1 pCi/L (1s) would not. Thus, in 2003, amid growing radiological contamination, the bar for accepting the detection as valid was raised.

There is no doubt that a result that is 3 standard deviations or more is a strong detection. For a single-tailed distribution applicable to a radiation detection hypothesis testing, a 3.08 standard deviation has a 0.1 percent chance of being a false positive. The result that is at least 3 standard deviations or greater, for example, 3 pCi/L ± 1 pCi/L is a stronger detection than 2 pCi/L ± 1 pCi/L. But a result that is 1.65s would still have an acceptably low probability of a false positive: of 5 percent. But reducing the probability of false positives (saying the radionuclide was detected above background levels when in reality it was no different than background) is not the only concern.

The probability of false negative (saying no radioactivity was detected above background levels when in reality it was above background) is also a concern. as high as 50 percent for samples with a mean result less than 3s. When the mean result is equal to 1.65s, half of the sample distribution lies to the left of 1.65s, and half of it lies to the right of 1.65s. When the sample result is 1.65s, there is a 50 percent chance of a false negative; likewise, results between 1.65s and less than 3s suffer from rather high probabilities of false negatives and this is not remedied by tossing out all detections below 3s. Nor is the decision to discard all detections below 3s statistically sound or necessary. [68] [69]

When the Department of Energy choose to raise the bar on what it would consider valid detections of radioactivity in its sampling program, it did so with the apparent aim of discounting

[68] James D. Evans, *Straightforward Statistics for the Behavioral Sciences*, Brooks/Cole Publishing Company, 1996. See level of significance for single-tailed and two-tailed distributions, hypothesis testing and Type I and Type II errors. The statistical significance of a radioactivity detection is a single-tailed case because it is only the high levels of radiation and not the low levels of radiation that are of interest in determining whether radioactivity is detected.

[69] L.A. Currie, National Bureau of Standards, Prepared for the U.S. Nuclear Regulatory Commission, Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluents and Environmental Measurements, NUREG/CR-4007, 1984. (See NRC.gov ADAMS database ML16152A647)

the growing number of radionuclide detections in its radiological monitoring program. It did so while knowing the radioactivity levels were growing because of airborne effluents (waste to the air from stacks, ponds and other sources) from the Idaho National Laboratory. And at the same time claiming that no radioactivity detections in southeast Idaho could be attributed to the INL.

The inadequate monitoring and reporting of radionuclide emissions and inadequate environmental monitoring by the DOE's environmental surveillance contractor is largely by choice. The program intends to minimize the appearance of radiological releases from the Idaho National Laboratory and specifically, to hide releases associated with isotope production and irradiation test examinations. These releases include americium-241, which the environmental monitoring reports have attributed to past nuclear weapons testing.

Currently, public drinking water monitoring does not prescribe (or even allow) determining how much americium-241, plutonium-239 and other man-made radionuclides are in the water. The water supplies can and do become contaminated by the airborne radiological contamination. And even the Department of Energy's environmental monitoring program omits determination of the level of man-made contamination from elevated levels of uranium-235 from enriched nuclear fuel and from reactor-produced uranium isotopes such as uranium-232 and uranium-236. The presumption that uranium in our air, water and soil is naturally occurring is false and the monitoring programs are designed to prevent determining the level of radioactivity from Idaho National Laboratory emissions. Drinking water can become contaminated by airborne radiological effluents that enter wells and water tanks, dissolve and remain in the water.

Because I have needed to refer to this information so often, I believe it would be helpful to include here some basic information on significance testing.

Table 12. Conventional levels of significance for one-tailed and two-tailed significance testing.

Level of Significance	Two-tailed, Zcrit	One-tailed, Zcrit	Interpretation
0.05 or 5 percent	1.96	1.65	Conventional risk of a Type I error
0.01 or 1 percent	2.58	2.33	Low risk of a Type I error
0.001 or 0.1 percent	3.30	3.08	Negligible risk of a Type I error

Table notes: It is assumed here that the distribution uncertainty of the null hypothesis (or the blank) has the same uncertainty bands as the sample. If a sample result was 3 ± 1 (1s) pCi/L, we might assume that the null hypothesis with a mean centered at 0 pCi/L, the Zcrit value would be nearly 3.08, and nearly the 0.1 percent risk of a Type I error. But a result of 1.65 ± 1 (1s) pCi/L would have a reasonably low risk of a Type I error, at 5 percent. The result of 1.65 ± 1 (1s) pCi/L, however, has a 50 percent chance of a Type II error, a "false negative."

Table 13. Type I and Type II error decision matrix.

True State of Affairs	Fail to Reject Ho, the null hypothesis	Reject Ho, the null hypothesis
Ho is true	Correct decision probability = $1 - \alpha$	Type I error probability = α (known as the level of significance) (sometimes called a "false positive")
Ho is false	Type II error probability = β (sometimes called a "false negative")	Correct decision probability = 1 – β (known as the power of the test)

Table notes: In our case trying to detect radioactivity in a sample, Ho, the null hypothesis is that the sample radioactivity is no different than background. In actual testing, this can mean that the radioactivity is no different than the blanks prepared for comparison to the sample.

The increasingly prevalent occurrence of large negative results for radioactivity detections is not an indication that the level of radioactivity is insignificant. These large negative results, for example, -30 ± 10 pCi/L, would indicate that the entire sampling distribution were negative values. This is an indication of radioactive blanks, background, or both. The large negative values are used in averaging the data and to offset unusually high detections.

What Happens Next?

Many of the assertions put forth in the Department of Energy's annual environmental reports concerning radiation dose from INL releases should not be believed. The effective doses appear low but are underestimated. These doses are primarily from internally ingested radionuclides, inhaled radionuclides and least of all, from external radiation. The conversion of effective whole-body dose to a cancer risk is based on external radiation as estimated by nuclear promoting agencies studying the survivors of the 1945 atomic bombings of Japan. The additional harm from internally incorporated radionuclides is known by many but is not accounted for by official radiation models of the International Commission on Radiological Protection, even as their officials have publicly acknowledged that the harm from internal radiation is currently underestimated by perhaps more than a factor of 100. However even if we take the DOE's effective dose and multiply it by 100, it would still underestimate the cancer incidence for specific organs because of the way the effective whole-body dose "doubly multiplies" the reduction factors for organs deemed unlikely to cause cancer mortality.

The INL's EBR-II fuel is the feedstock for its high-assay low-enriched uranium (HALEU), DOE/EA-2087, being pyroprocessed at INL's Materials and Fuels Complex and increasing the radiological airborne emissions from the INL 170-fold, see Table 14.

The Department of Energy and the Idaho Department of Environmental Quality are failing to address the buildup of radionuclides in our air, water and soil. Both agencies are failing to acknowledge the inadequacy of the environmental surveillance programs. And no agency is attributing health issues such as elevated thyroid cancer incidence or elevated rates of birth defects to radionuclides in the environment.

People might eventually catch on that Idaho is getting more and more radiologically polluted — but with all the deliberate omissions and dis-information, probably not before it's too late.

Table 14. Estimated annual air pathway dose (mrem) to Idaho communities from normal operations to the maximally exposed offsite individual from proposed projects, including the estimated dose from expanding capabilities at the Ranges based on DOE/EA-2063.

Current and Reasonably Foreseeable Future Action	Estimated Annual Air Pathway Dose (mrem)
National Security Test Range	0.04[e]
Radiological Response Training Range (North Test Range)	0.048[d]
Radiological Response Training Range (South Test Range)	0.00034[a]
HALEU Fuel Production (DOE-ID, 2019)	1.6[a]
Integrated Waste Treatment Unit (ICP/EXT-05-01116)	0.0746[h]
New DOE Remote-Handled LLW Disposal Facility (DOE/ID 2018)	0.0074[a]
Recapitalization of Infrastructure Supporting Naval Spent Nuclear Fuel Handling (DOE/EIS 2016)	0.0006[c]
TREAT (DOE/EA 2014)	0.0011[a]
DOE Idaho Spent Fuel Facility (NRC, 2004)	0.000063[a]
Plutonium-238 Production for Radioisotope Power Systems (DOE/EIS 2013)	0.00000026[b]
Total of Reasonably Foreseeable Future Actions on the INL Site	1.77[g]
Current (2018) Annual Estimated INL Emissions (DOE2019a)	0.0102[f]
Total of Current and Reasonably Foreseeable Future Actions on the INL Site [**DOE WOULD INCREASE INL'S AIRBORNE RELEASES BY OVER 170 TIMES**]	1.78[g]

Table notes:

a. Dose calculated at Frenchman's Cabin, typically INL's MEI for annual NESHAP evaluation.

b. Receptor location is not clear. Conservatively assumed at Frenchman's Cabin.

c. Dose calculated at INL boundary northwest of Naval Reactor Facility. Dose at Frenchman' Cabin likely much lower.

d. Dose calculated at INL boundary northeast of Specific Manufacturing Capability. Dose at Frenchman's Cabin likely much lower.

e. Sum of doses from New Explosive Test Area and Radiological Training Pad calculated at separate locations northeast of MFC near Mud Lake. **Dose at Frenchman's Cabin likely much lower.**

PLEASE NOTE THAT THE PUBLIC AT MUD LAKE IS CLOSER TO THE RELEASE THAN TO FRENCHMAN'S CABIN.

f. Dose at MEI location (Frenchman's Cabin) from 2018 INL emissions (DOE 2019a). The 10-year (2008 through 2017) average dose is 0.05 mrem/year.

PLEASE NOTE THAT MANY RADIOLOGICAL RELEASES ARE IGNORED AND NOT INCLUDED IN THE RELEASE ESTIMATES IN NESHAPS REPORTING.

g. This total represents air impact from current and reasonably foreseeable future actions at INL. It conservatively assumes the dose from each facility was calculated at the same location (Frenchman's Cabin), which they were not.

h. Receptor location unknown, according to the Department of Energy, the agency that is supposed to know the receptor location.

Information Sources

The Department of Energy's Environmental Surveillance Education and Research (ESER) contractor conducts environmental surveillance in counties surrounding the Idaho National Laboratory. The DOE changes it environmental monitoring contractor frequently. The Department of Energy's contractor for environmental monitoring for the Idaho National Laboratory and surrounding areas were at http://www.idahoeser.com/ but the years of reports displayed and the website location are constantly changing. The reports generally use the report numbering DOE/ID-12082(87) for the year 1987, for example. The most recent website location for the ESER reports is https://idahoeser.inl.gov/publications.html.

Stoller environmental reports had been online for the years 1995 onward, for annual and quarterly reports. Then the years before 2000 were deleted from the website. The DOE's surveillance contractor's website had data trending tools, but these tools had long been disabled and then were removed. The trending tools made the gaps in monitoring data all too apparent. And the trending tools could make elevated contamination levels all too apparent.

The Department of Energy began releasing radionuclides to southeast Idaho in 1952 and created its first annual environmental surveillance report for 1958. The location of the Department of Energy annual (or quarterly) surveillance reports since 1958 is varied. There is no single location to locate these reports.

The Idaho Department of Environmental Quality's INL Oversight Program began monitoring counties near the INL site and at the INL in 1989. But the Idaho DEQ has removed all but the most recent handful of years of reports from its website. It has rendered its quarterly reports into an illegibly tiny font in documents that can be seen only via expensive copying and searches and a granted information request. See the shrinking database of radiological monitoring data by the Idaho DEQ at https://www.deq.idaho.gov/idaho-national-laboratory-oversight/inl-oversight-program/monitoring-activities/

APPENDIX A – Timelines

Table A1. Timeline of Idaho National Laboratory operations and events of interest.

Date	Operations or Event
1946	Atomic Energy Agency (AEC) agency creates to oversee nuclear weapons development and nuclear research. The AEC operated various federal laboratory sites including Hanford, Savannah River Site, Oak Ridge and the National Reactor Testing Station (NRTS) that would become the Idaho National Laboratory. The AEC conducted nuclear weapons testing and nuclear reactor oversight. In 1975, AEC briefly becomes Energy Research and Development (ERDA) but in 1977 is divided into the Department of Energy and the Nuclear Regulatory Commission. The Department of Energy would continue nuclear reactor research, oversight of DOE laboratories and nuclear weapons-related work. The NRC oversees commercial nuclear reactors, commercial fuels, and other nuclear materials such as medical isotopes that are not under the Department of Energy.
1949	Inception of the National Reactor Testing Station (NRTS) later renamed the Idaho National Engineering Laboratory (INEL), the Idaho National Engineering and Environmental Laboratory (INEEL), and finally renamed the Idaho National Laboratory (INL)
1949	Inception of the National Reactor Testing Station (NRTS) later renamed the Idaho National Engineering Laboratory (INEL) later renamed the Idaho National Engineering and Environmental Laboratory (INEEL) later renamed the Idaho National Laboratory (INL)
1952 - 1970	Operation of the Materials Test Reactor (MTR) begins at the Test Reactor Area (TRA). Tritium is especially high in the MTR due to the lithium in its nuclear fuel. TRA would be renamed the Reactor Technology Complex (RTC) and then renamed the ATR Complex, after the Advanced Test Reactor
1953 - 1988	Nuclear fuel/material reprocessing was conducted from February of 1953 through 1988 at the Idaho Chemical Processing Plant (ICPP), with the official end of reprocessing announced in 1991. The ICPP would later be renamed the Idaho Nuclear Technology and Engineering Center (INTEC). Primarily for uranium-235 recovery, nuclear fuels were reprocessed from various INL reactors (the Materials Test Reactor, Experimental Breeder Reactor's I and II, Borax, Engineering Test Reactor, SNAPTRAN 2/10A-2 and -3 debris, Advanced Test Reactor and others), various non-INL reactors, and naval nuclear spent fuel. Iodine releases would be reduced in 1958 due to filter improvements. RaLa runs to recover barium-140 in the radioactive lanthanum (RaLa) runs (1957 to 1963). Barium releases are higher in early years of reprocessing. Iodine-129 was not reported until 1979 but were estimated in the INEL HDE and are thought to have primarily been released during calcining. Generally, the radioactivity monitoring and reporting were deficit throughout the reprocessing and calcining

Date	Operations or Event
	operations as well as reactor operations.
1952 - present	INL's burial ground at the Radioactive Waste Management Complex (RWMC) is created, see July 2017 EDI newsletter. The Department of Energy would shallowly bury radioactive waste without a liner over the Snake River Plain Aquifer. The radioactive and chemical waste came from the INL operations, from the DOE's Rocky Flats nuclear weapons plant and also accepted radioactive waste from around the country for decades. Waste continued to be shipped the INL from Rocky Flats even though the DOE agreed to not bury the waste. Instead, the barrels of waste were stacked above ground at the RWMC, putting Idaho at risk of above ground airborne releases despite make-shift enclosures over the stored waste. The above-ground stored waste is being shipped to WIPP in New Mexico. The replacements for the burial ground are the Remote-Handled Low-Level Waste Facility near the ATR Complex and the ever expanding Idaho CERCLA Disposal Facility which accepts more than CERCLA cleanup waste.
1952-1981	Various reactor testing programs including the Power Burst Facility (1972-1985), SPERT-I (1955-1964), SPERT-II (1960-1964), SPERT-III (1958-1968), SPERT-IV (1962-1970), BORAX (1954 - 1958), Aircraft Engine Tests (1955 – 1961), Test Area North Low Power Test Facility (LPTF), Mobile Low-Power Reactor No. 1 (ML-1) at ATR-IV (1961-1964), Spherical Cavity Reactor Critical Experiment (SCRCE) (1972-1973), LOFT (1977 to 1985) and others.
1955	Experimental Breeder Reactor I reactor meltdown
1957-1981	Engineering Test Reactor operations at the Test Reactor Area
January 3, 1961	Stationary Low-Power 1 (SL-1) reactor accident
1963	Partial nuclear weapons ban goes into effect, the Atomic Energy Commission's Nevada Test Site nuclear weapons above ground testing is banned but below ground and certain above-ground testing continues
1963-1981; 1982-1993; June 1997 to May 2000	Calcining of liquid high-level radioactive waste at ICPP renamed INTEC, at the Waste Calcining Facility (WCF) from 1963 to 1981. The New Waste Calcining Facility (NWCF) begins operating in 1982 and ceases operation in 2000. The Idaho DEQ allows NWCF operations despite knowing by 1989 that the facility violated permit requirements.
April 1, 1964	SNAPTRAN-3 test (and various testing of SNAPTRAN-1 in the 1960s but no known whereabouts of the SNAPTRAN-1 reactor as the documents only state that the SNAPTRAN-2 and -3 reactors were reprocessed)
January 11, 1966	SNAPTRAN-2 destructive test
1967-present	Advanced Test Reactor (ATR) operations at the Test Reactor Area, renamed the Reactor Technology Center (RTC) in 2005 and then later renamed the ATR Complex
1977	The Atomic Energy Agency (AEC) splits into the Department of Energy and the Nuclear Regulatory Commission (NRC)
March 28, 1979	Three Mile Island Unit 2 meltdown in Harrisburg, Pennsylvania. The TMI-2 fuel debris is later brought to the Test Area North (TAN) pool and

Date	Operations or Event
	then packaged for dry storage and placed at INTEC. The dry storage must remain unsealed due to hydrogen offgassing and leaks radionuclides including iodine-129. The TMI-2 spent fuel and fuel debris was transported to the INL from 1986 through 1990 and stored in the Test Area North pool from 1986 through 2001. The transition from wet storage to dry storage was conducted from 1998 through 2001. (See L. Pincock et al., INMM 2012 Conference Preprint, "Lessons Learned From Three Mile Island Packaging, Transportation and Disposition that Apply to Fukushima Daiichi Recover," INL/CON-12-26246, July 2012.)
1984	The U.S. Geological Survey (USGS) concerns over the extensive radioactive and chemical dumping at the INL leads to increased concerns over the INL's injection wells, particularly at ICPP (now INTEC). The injection well at INTEC is later capped. The extent of chemical and radiological contaminants from INL waste water injection wells and percolation ponds is discussed in EDI reports *The Hidden Truth About INL Drinking Water* and *Tritium at 800 pCi/L in the Snake River Plain Aquifer in the Magic Valley at Kimama: Why This Matters*. [70] [71]
1984	Percolation ponds are installed to replace "routine" deepwell injection of liquid radioactive waste at INTEC
Late 1980s	The U.S. Environmental Protection Agency (EPA) and its hazardous waste laws begin to press the DOE to comply with hazardous waste laws, that the DOE had argued were not required to enforce because the materials were also radioactive. The EPA prevails and the DOE must comply with EPA hazardous waste laws even though DOE regulates its radioactive materials.
1987	For the first time, the U.S. Geological Survey includes monitoring chemical contaminants in its aquifer monitoring, despite its knowledge of extensive chemical dumping at the INL by the DOE. For the first time, carbon tetrachloride and other chemicals in the aquifer are being reported and workers are being brought bottled water at some INL facilities such as Test Area North.
Late 1980s	The Idaho Department of Environmental Quality is forming a public drinking water program. Initially, it includes the INL wells used by employees. The DOE later presses Idaho DEQ to stop monitoring the wells used for employee drinking water.
1988	The last fuel is reprocessed at ICPP in 1988, but operations are not terminated until 1991
1991	The DOE issues the *INEL Historical Dose Assessment* (INEL HDE) of

[70] Environmental Defense Institute report by Tami Thatcher, *The Hidden Truth About INL Drinking Water*, June 2015, http://environmental-defense-institute.org/publications/INLdrinkwaterR1.pdf

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

Date	Operations or Event
	operations and accidents from 1952 through 1989) at the request of the State of Idaho.
1993	ATR Complex (or Test Reactor Area) transition to two lined radioactive waste evaporation ponds in 1993. Unlined ponds had been used from 1952 to 1993. The retention basin was found to continue to leak after 1993 even though it was thought to have been taken out of service in 1993. Extensive underground piping leakage, including radioactively laden resin beads were found in contamination from the piping leaks. Apparently resin bead escape was considered business as usual, as the radiation detector alarms during resin bead escape was simply shut off. Battelle Energy Alliance has refused to answer any questions about the resin bead escapes to the open-air evaporation pond at the ATR Complex noted in a 2016 DOE Occurrence Report.
1995	EPA contamination investigations commence at the INEL (now the INL). Extensive contamination is found at the INL which becomes a federal CERCLA site. Cleanup activities often involve bulldozing and moving soils, generally not reported as creating airborne contamination and not included in radiation dose estimates. Some buildings, such as those near the site of the 1961 SL-1 accident are found so contaminated that the buildings cannot be remediated. The buildings had been in continued use by INL employees since the 1961 accident. The SL-1 burial ground is found to have extensive above ground contamination, as are other sites at the INL.
1995	The 1995 Idaho Settlement Agreement between the State of Idaho and the Department of Energy which contains milestones for the Department of Energy to remove spent nuclear fuel and transuranic waste.
2000	The Energy Employee Occupational Illness Compensation Program Act (EEOICPA) is passed by Congress. [72] The National Institute of Occupational Safety and Health (NIOSH) performs dose reconstruction to determine eligibility for compensation and roughly two-thirds of the INL worker illness compensation claims have been denied. [73]
2001	Although not related to the INL, in 2001, the phosphate operation of the FMC in Pocatello ceases operations that ran from 1949 to 2001, but Simplot operations continue. Radioactive uranium and thorium from phosphate mining is piled in phospho-gypsum stacks. It had previously been used in road bed and in concrete used for housing until the 70s.

[72] 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

[73] See the NIOSH Radiation Dose Reconstruction Program at http://www.cdc.gov/niosh/ocas. See the Idaho National Laboratory status at http://www.cdc.gov/niosh/ocas/ineel.html and see the portion of INL formerly ANL-W at http://www.cdc.gov/niosh/ocas/anlw.html

Date	Operations or Event
2004	US Court of Appeals rules [74] that the 10,000-year cutoff date for estimating consequences of waste migration from Yucca Mountain licensing is not consistent with recommendations of the National Academy of Sciences. The court noted that at massive levels, radiation exposure can cause sudden death. At lower doses, radiation can have devastating health effects, including increased cancer risks and serious birth defects such as mental retardation, eye malformation, and small brain or head size. Radioactive waste and its harmful consequences persist for times spans seemingly beyond human comprehension. The half-life of iodine-129 is 17 million years, and of neptunium-237 is 2 million years. Despite this 2004 ruling, the EPA, the State of Idaho and the Department of Energy continue to use 10,000 years as the time after which, they could disregard what happens to future earth inhabitants. The public was not told of the radiation doses from RWMC waste migration after 10,000 years, the time when the radiation ingestion doses start to ramp up and stay elevated for millennia, and that is with perfect soil cap performance.
2005	The INEEL becomes the INL. Battelle Energy Alliance becomes the prime contractor. Argonne National Laboratory-West, which had been overseen by the DOE Chicago Office comes under the INL umbrella and is now overseen by the DOE-Idaho Operations Field Office.
2008	Although Idaho wins the court battle of the question of whether "all means all" because the Department of Energy maintained that they never intended to exhume any of the buried transuranic waste, Idaho capitulates agreeing that only "targeted" chemically laden transuranic waste will be exhumed, roughly 6 of the 97 acres, and probably less than 10 percent of the buried transuranic waste. Uncertainty concerning how much was buried and inability to estimate how much is being exhumed mean we can't know for certain how much TRU waste has been exhumed. The Record of Decision for RWMC (WAG 7) is signed by the State of Idaho, the Department of Energy and the Environmental Protection Agency. [75] The State, EPA and DOE give the public information about remediation of the RWMC in terms of 100-, 1000- and 10,000-year time periods. At no time is the public informed of the escalating rates beyond 10,000 because of modeling coefficients selected to delay the estimated migration of the radioactive waste to the aquifer beyond 10,000 years. And that the migration of these wastes will continue essentially forever, beyond hundreds of thousands of years. The ingestion doses will

[74] US Court of Appeals July 9, 2004 court opinion at http://www.yuccamountain.org/pdf/opinion04.pdf

[75] Idaho Cleanup Project, Idaho National Laboratory, "Record of Decision – Radioactive Waste Management Complex Operable Unit 7-12/14, DOE/ID-11359, September 2008. https://ar.icp.doe.gov/images/pdf/200810/2008100100495TUA.pdf

Date	Operations or Event
	exceed 100 milli-rem per year without a soil cap, or will exceed 30 mrem/yr with perfect soil cap performance, forever. The studies assume steady infiltration of water and assume geologic stability forever, despite knowing these assumptions are contrived and non-conservative. Construction of Accelerated Retrieval Project (ARP) commences in 2008. The ARPs involve separate enclosures over the SDA for exhumation work of "targeted" chemically laden transuranic waste.
2011	The plutonium inhalation event at the Materials and Fuels Complex (MFC), formerly ANL-W, operated by Battelle Energy Alliance for the Department of Energy
February 2014	Two accidents at the DOE's Waste Isolation Pilot Plant (WIPP) and did not resume receiving INL waste shipments until April 2017. WIPP's original safety basis had been extensively reviewed, more than any other DOE facility. Reviews by the Environmental Protection Agency and by the Defense Nuclear Facility Safety Board had been conducted. But subsequent changes to the WIPP safety basis, approved by DOE had reduced safety significantly. They made the assumption that a roof fall would never occur in an open panel and had no accident analysis for this. WIPP experienced a roof fall within a couple months of not bolting the ceiling in the underground mine. The accident investigation report also discovered that far more plutonium/americium was released from a single drum in the February 12, 2014 event than the safety analysis predicted was possible. [76]
2017	EEOICPA cohort expanded, but still most INL workers' illness claims are denied. The Naval Reactors Facilities (NRF) civilian workers are denied compensation by NRF claims that no workers there were ever harmed, despite obviously elevated cancers for workers involved in spent nuclear fuel operations there and radiologically filthy operations at the NRF. The Energy Employee compensation program investigations have collected data and interviews concerning the burial ground at RWMC and finds that worker radiological protection programs were weak, historically. In addition to historical problems, illness claims from recent years of

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

Date	Operations or Event
	employment, particularly from the RMWC area, continue to come in. If radiation exposures cannot adequately be estimated, a formal special exposure cohort for RWMC workers may need to be designated. Details regarding the May 1, 2017 SC&A contractor review of the INL's burial ground can be found on the NIOSH website. [77]
2016	Fluor Idaho becomes the Idaho Cleanup Project contractor
2016	Radioactively-laden resin beads released to open-air evaporation ponds at ATR Complex. Improperly remediated. Idaho DEQ refuses to investigate. The U.S. EPA provides a sham response but forgets what it was supposed to investigate. Later air permitting requirements are modified so that neither the state nor the EPA will need to pretend to investigate DOE airborne releases.
2018	Four transuranic waste drums overpressurize and forcefully eject their lids and contents inside a fabric enclosure at the burial grounds, the Radioactive Waste Management Complex. The accident occurred after workers had left work for the day. Fire fighters responded to an alarm at the facility, yet had no knowledge that a radiological event had occurred. Fluor Idaho was allowed to get away with willful pretending that there was not excessive beryllium in the waste and also that extremely high amounts of uranium in the waste, which was not the typical "roaster oxide" uranium but rather was uranium metal that had not been roasted to form an oxide layer. This unroasted uranium had recently caught fire in a nearby facility, yet was deemed to not be a pyrophoric material or a chemically incompatible material, which was prohibited in its RCRA hazardous waste permit with the State of Idaho. The State of Idaho declined to take timely action against Fluor Idaho, but after the 2-year clock had run out for taking action against Fluor Idaho managers, Idaho DEQ issued notice that what Fluor Idaho did was not so good.
2019	Large range fire at the INL
2021	Fluor Idaho is replaced by Idaho Environmental Coalition at the end of the year.

Table A2. Timeline of international or non-INL radiological events.

Year	Event
1945	U.S. nuclear weapons test at Alamogordo, New Mexico [21 kilo-ton (kT) yield] on July 16, 1945
1945	U.S. atomic bombing of Hiroshima, Japan (15 kT) on August 5, 1945
1945	U.S. atomic bombing of Nagasaki, Japan (21 kT) on August 9, 1945
1946 and 1948	U.S. atomic weapons testing at Bikini and Enewetak (18 to 49 kT)
1951 – 1963	109 U.S. atomic weapons tests outside the U.S. at Enewetak, Bikini, off the

[77] See 2017 SC&A burial ground review at https://www.cdc.gov/niosh/ocas/pdfs/abrwh/scarpts/inlburgnd-r0.pdf

Year	Event
	U.S. west coast (Wigwam and Yucca), Johnston Islands, South Atlantic, and Christmas Islands. There are also atmospheric and underground tests by other countries. The number of atmospheric tests by other countries before the end of 1963 are: 21 by the U.K. in Australia, Malden Island, and Christmas Island; 219 atmospheric tests conducted by the USSR, the former Soviet Union; and 4 tests conducted by France.
1951	12 U.S. atomic weapons tests at the Nevada Test Site
1952	8 U.S. atomic weapons tests at the Nevada Test Site
1953	11 U.S. atomic weapons tests at the Nevada Test Site
1955	17 U.S. atomic weapons tests at the Nevada Test Site
1956	1 U.S. atomic weapons tests at the Nevada Test Site
1957	31 U.S. atomic weapons tests at the Nevada Test Site
1958	39 U.S. atomic weapons tests at the Nevada Test Site
1961	9 U.S. atomic weapons tests at the Nevada Test Site and 1 test in Carlsbad, New Mexico called shaft or tunnel tests
1962	61 U.S. atomic weapons tests at the Nevada Test Site, most shaft or tunnel, but 2 airdrop tests
1962	Nevada above-ground "plow shares" Sedan Test at the Nevada Test Site on July 6, 1962 is suspected of wide spread contamination that reached southeast Idaho but is not always counted as a "weapons test."
1963	42 U.S. atomic weapons tests at the Nevada Test Site, 1 at Fallon, Nevada that are shaft or tunnel and 4 surface tests at Nellis, Nevada
1963	Partial nuclear weapons testing ban (on above ground tests in the US) goes into effect late in the year of 1963. See additional Table below for testing at the Nevada Test Site after the partial test ban of 1963. Over 100 atmospheric tests were conducted at the Nevada Test Site by this time. Nuclear weapons testing was conducted by the U.S. in the Pacific islands; Amchitka, Alaska; Fallon Nevada; Rifle, Colorado and other places in addition to the Nevada Test Site. Contamination from other testing or related activities is not listed.
1964 - 1979	China ground blast (in 1964); China conducts 21 atmospheric nuclear weapons tests (1965-1979).
1964	46 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1965	38 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1966	47 U.S. atomic weapons tests at the Nevada Test Site and 1 test at Amchitka, Alaska (shaft or tunnel)
1966 – 1974	46 atmospheric atomic weapons tests conducted by France
1967	41 U.S. atomic weapons tests at the Nevada Test Site and 1 test at Farmington, New Mexico (shaft or tunnel)
1968	56 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1969	44 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1970	39 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1971	23 U.S. atomic weapons tests at the Nevada Test Site and 1 test at Amchitka, Alaska (shaft or tunnel)

Year	Event
1972	39 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1973	11 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1974	22 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1975	22 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1976	21 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1977	20 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1978	21 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1979	16 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1979	The first commercial nuclear power meltdown in the U.S., the Three Mile Island Unit 2 meltdown on March 28, 1979 at Harrisburg, Pennsylvania
1980	17 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1980	EPA designated as "Event A" China conducts a very large atomic weapons test (1000 kT) on October 16, 1980. Far higher levels of gross beta activity charted in air monitoring in southeast Idaho, exceeding 1000 E-15 microcurie/milliliter and far more than 10 times higher than typical maximum concentrations.
1981	16 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1982	18 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1983	19 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1984	20 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1985	18 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1986	15 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1986	EPA designated as "Event B" - Chernobyl Accident on April 26, 1986 in the Ukraine. Far higher levels of gross beta activity charted in air monitoring in southeast Idaho, exceeding 1000 E-15 microcurie/milliliter and far more than 10 times higher than typical maximum concentrations.
1987	15 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1988	15 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1989	12 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1990	9 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1991	7 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1992	6 U.S. atomic weapons tests at the Nevada Test Site (shaft or tunnel)
1999	EPA designated "Event C" – Tokaimura Japan criticality on September 30, 1999
2000	EPA designated "Event D" – Los Alamos (Santa Fe) fire on May 8, 2000
2000	EPA designated "Event E" – Hanford fire, June 27, 2000
2011	EPA designated "Event F" - Fukushima nuclear disaster in Japan on March 11, 2011
2011	EPA designated "Event G" - Los Alamos Concha's fire on June 26, 2011

Table notes: See Federation of American Scientists, FAS.org website for the compilation of nuclear tests containing United States Nuclear Tests July 1945 through September 1992, (DOE/NV-209 Rev. 14, December 1994) at https://fas.org/nuke/guide/usa/nuclear/usnuctests.htm Not all nuclear weapons tests noted in the table affected the INL. Not all weapons tests that affected the INL were necessarily identified as affecting southeast Idaho. The nuclear weapons testing at the Nevada Test Site was extensive in the 1950s through 1963 and below ground and

surface testing by the U.S. at the Nevada Test Site continued after the 1963 partial test ban. Atmospheric tests and above ground and below ground nuclear weapons testing by the U.S. are noted in the table, but only atmospheric tests outside the U.S. after 1963 are noted in the table. In addition to tests at the Nevada Test Site after 1963, the U.S. conducted weapons or weapons-related tests with at Fallon, Nevada; Nellis, Nevada, Farmington, New Mexico; Rifle, Colorado and Amchita, Alaska. The Atomic Energy Commission (AEC) that would become the Department of Energy was in control of the monitoring of both its nuclear weapons testing fallout and the radioactive fallout from the INL and sought to limit its liability and limit any opposition to its activities. In the 60s and 70s, it is often unclear what nuclear tests actually affect the INL or were actually due to the INL's extensive radiological releases. The October 1980 nuclear weapons test conducted by China and the 1986 Chernobyl accident were detected by the U.S. Environmental Protection Agency and by INL monitoring and dominated the ambient air gross beta measurements in southeast Idaho. Both the 1980 China test and the 1986 Chernobyl accident fallout are noted in the *INEL Historical Dose Evaluation* [78] as being "easily detected at the INL" (see page E-32). This is despite INL's recent statements at INL "Chernobyl Talks" that Chernobyl fallout could not be detected at the INL. Of note are a lack of nuclear weapons tests or accidents from 1981 to 1983, yet iodine-131 is detected in milk samples near the INL in those years that the *INEL Historical Dose Evaluation* which the report left as undetermined cause (page E-36) as the INL denied that INL releases were the source of iodine-131 in milk in those years. Some of the milk contamination also occurred in 1980 before the October weapons test and the source of the iodine-131 in milk was undetermined.

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

Table A3. Atmospheric releases of iodine-131 to the atmosphere from underground tests and above ground Plowshare program tests carried out at the Nevada Test Site before and after the 1963 partial testing ban.

Name of test	Year of test	Yield, kT	Iodine-131 released	
			TBq	Ci
Antler	9/151961	2.6	0.2	5.4
Feather	12/22/1961	150	0.04	1.08
Pampas	03/01/1962	9.5	0.0004	0.01
Platte	04/14/1962	1.85	0.4	10.8
Eel	06/19/1962	4.5	0.4	10.8
Des Moines	**06/13/1962**	**2.9**	**1200**	**32,400**
Sedan, Plowshare	07/06/1962	104	?	?
Bandicoot	**10/19/1962**	**12.5**	**330**	**8,910**
Yuba	06/05/1963	3.1	0.0008	0.0216
Eagle	12/12/1963	5.3	0.08	2.16
Pike	**03/13/1964**	**<20**	**13**	**351**
Alva	08/19/1964	4.4	0.001	0.027
Drill	12/05/1964	<23.4	0.5	13.5
Parrot	02/12/1964	1.3	0.2	5.4
Alpaca	02/12/1965	0.33	0.0009	0.0243
Palanquine, Plowshare	04/14/1965	4.3	?	?
Tee	05/07/1965	7	0.06	1.62
Diluted Waters	06/16/1965	<20	0.7	18.9
Red Hot	**03/05/1966**	**<20**	**7**	**189**
Pin Stripe	**04/25/1966**	**<20**	**7**	**189**
Double Play	**06/15/1966**	**<20**	**4**	**108**
Derringer	09/12/1966	7.8	0.009	0.243
Nash	01/19/1967	39	0.5	13.5
Midi Mist	06/26/1967	<20	0.01	0.27
Hupmobile	**01/18/1968**	**7.4**	**4**	**108**
Cabriolet, Plowshare	01/26/1968	2.3	?	?
Buggy, Plowshare	03/12/1968	5.4	?	?
Schooner, Plowshare	12/08/68	30	?	?
Pod	10/29/1969	16.7	0.03	0.81

Scuttle	11/13/1969	1.7	0.0001	0.0027
Snubber	04/21/1970	12.7	0.2	5.4
Mint Leaf	05/05/1970	<20	3	81
Carpetbag ?	**12/17/70**	**220**	**?**	**?**
Baneberry	**12/18/1970**	**10**	**3000**	**81,000**
Diagonal Line	11/24/1971	<20	0.05	1.35
Rio Blanco, Plowshare in Rifle, Colorado	05/17/1973	99	?	?
Riola	09/25/1980	1.07	0.02	0.54
			Total (Rounded) 5000 Bq	**Total (Rounded) 135,000 Ci**

Units: TBq = Tera (10^{12}) Becquerel, 1 Ci = 1 curie = 3.7E10 disintegrations/second = 3.7E10 Bq kT = kilotons, The only Plowshare tests listed were "crater" type. Carpetbag test on 12/17/70 added to table but not officially noted as causing an offsite release. The iodine-131 release for 12/18/70 Baneberry test seems disproportionately high for its yield.

Sources: http://www.unscear.org/unscear/en/publications/1993.html and FAS.org summary of DOE/NV-209.

APPENDIX B – INL Air Effluents Dominating the Estimated Airborne Radiation Doses (1986 through 2019)

Note that the Naval Reactors Facility (NRF) radiological releases were included in the Department of Energy radiological releases for many years but were no longer included after 2004.

Table B1-a. Radionuclides contributing to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory for 2015 to 2019.

Radionuclide (Half Life)	Curies released in 2015	Curies released in 2016	Curies released in 2017	Curies released in 2018	Curies released in 2019
Tritium (H-3) (12.3 year)	532	472	395	336	450
Carbon-14 (5,700 year)	0.988	1.04	0.625	1.64	0.683
Chlorine-36 (301,000 year)	-	-	1.86E-6	2.80E-5	7.19E-3
Argon-41 (1.83 hour)	561	705	862	904	884
Chromium-51 (27.7 day)	-	-	-	-	-
Cobalt-60 (5.27 year)	1.30E-2	9.74E-3	9.44E-3	8.93E-3	8.22E-3
Zinc-65 (244 day)	3.26E-5	-	-	-	0.16
Krypton-85 (10.7 year)	733	623	3.83	59.3	51.1
Strontium-90 (28.6 year)	3.05E-2	3.15E-2	2.06E-2	2.19E-2	2.36E-2
Antimony-125 (2.73 year)	7.33E-4	-	6.1E-5	-	-
Iodine-129 (16,000,000 year)	2.15E-2	1.96E-2	1.66E-3	1.67E-3	1.31E-3
Iodine-131 (8.04 day)	1.1E-2	1.06E-2	8.89E-2	8.88E-2	9.0E-2
Cesium-137 (30.2 year)	0.0239	2.19E-2	6.22E-3	6.78E-2	0.267
Plutonium-238 (87.7 year)	1.33E-4	1.07E-4	6.47E-5	1.24E-5	-
Plutonium-239 (24,000 year)	6.73E-4	4.17E-4	1.34E-4	4.22E-5	1.94E-5
Plutonium-240 (6580 year)	1.90E-4	1.13E-4	1.26E-5	7.10E-6	1.88E-6

Radionuclide (Half Life)	Curies released in 2015	Curies released in 2016	Curies released in 2017	Curies released in 2018	Curies released in 2019
Plutonium-241 (14.35 year)	4.19E-3	2.91E-3	-	3.87E-5	-
Americium-241 (458 year)	3.36E-3	7.02E-4	3.28E-4	4.44E-5	7.19E-5
Uranium-234 (246,000 year)	-	1.01E-6	2.82E-7	-	5.88E-2
Uranium-238 (4.47E9 year)	-	1.7E-7	2.41E-7	3.95E-5	1.29E-1
Total curies	1870	1860	1330	1370	1450
MEI effective whole-body dose, mrem	0.033	0.014	0.008	0.0102	0.0559

Table notes: MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead. Only the radionuclides that tended to be contributors to effective whole-body dose were listed; additional radionuclides may be listed in INL airborne radioactive waste (effluent) release tables.

Table B1-b. Radionuclides contributing to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory for 2010 to 2014.

Radionuclide (Half Life)	Curies released in 2010	Curies released in 2011	Curies released in 2012	Curies released in 2013	Curies released in 2014
Tritium (H-3) (12.3 year)	708	835	896	601	559
Carbon-14 (5,700 year)	1.61E-7	0.137	0.113	0.344	1.03
Chlorine-36 (301,000 year)					
Argon-41 (1.83 hour)	1680	1130	718	1140	848
Chromium-51 (27.7 day)	2.98E-4	8.06E-3	9.58E-3	6.03E-3	6.67E-3
Cobalt-60 (5.27 year)	2.37E-2	1.22E-1	1.54E-2	2.45E-2	2.97E-2
Zinc-65 (244 day)	3.42E-5	8.83E-5	7.85E-5	1.30E-4	1.48E-4
Krypton-85 (10.7 year)	1710	1450	1200	1000	863
Strontium-90 (28.6 year)	2.84E-2	4.70E-2	4.88E-2	5.20E-2	7.88E-2
Antimony-125 (2.73 year)	1.6E-5	1.61E-4	1.80E-6	1.07E-6	2.38E-5
Iodine-129 (16,000,000 year)	3.40E-2	3.00E-2	2.7E-2	2.50E-2	2.21E-2
Iodine-131 (8.04 day)	1.06	8.10E-3	2.45E-3	8.49E-3	6.86E-3
Cesium-137 (30.2 year)	8.52E-2	6.78E-2	3.43E-2	3.72E-2	3.06E-2
Plutonium-238 (87.7 year)	9.06E-4	1.25E-3	6.89E-5	6.36E-5	9.47E-5
Plutonium-239 (24,000 year)	9.60E-4	3.13E-3	5.01E-4	4.68E-4	1.26E-3
Plutonium-240 (6580 year)	3.12E-4	6.99E-4	1.77E-4	1.67E-4	3.00E-4
Plutonium-241 (14.35 year)	8.37E-3	1.19E-2	5.40E-3	4.79E-3	5.31E-3
Americium-241 (458 year)	7.90E-3	4.24E-3	5.13E-4	1.83E-4	3.53E-3
Uranium-234 (246,000 year)	3.39E-7	3.32E-6	4.36E-7	3.04E-7	7.43E-7
Uranium-238 (4.47E9 year)	2.00E-7	1.09E-6	1.04E-7	1.17E-7	1.69E-6

Radionuclide (Half Life)	Curies released in 2010	Curies released in 2011	Curies released in 2012	Curies released in 2013	Curies released in 2014
Total curies	4320	3520	2930	2890	2350
MEI effective whole-body dose, mrem	0.058	0.046	0.036	0.03	0.036 CAP88, 0.058 "Reference resident"

Table notes: MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead. Only the radionuclides that tended to be contributors to effective whole-body dose were listed; additional radionuclides may be listed in INL airborne radioactive waste (effluent) release tables.

Table B1-c. Radionuclides contributing to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory for 2005 to 2009.

Radionuclide (Half Life)	Curies released in 2005	Curies released in 2006	Curies released in 2007	Curies released in 2008	Curies released in 2009
Tritium (H-3) (12.3 year)	802	1000	1170	1600	1030
Carbon-14 (5,700 year)	0.94	0.941	0.0481	0.195	?? Other 7.62
Chlorine-36 (301,000 year)					?
Argon-41 (1.83 hour)	553	542	736	1220	1690, Noble gases
Chromium-51 (27.7 day)	9.38E-2	7.23E-2	2.73E-3	2.16E-2	? See FP and activation products
Cobalt-60 (5.27 year)	6.35E-2	2.15E-2	6.40E-2	7.36E-3	? See FP and activation products
Zinc-65 (244 day)	5.17E-5	4.84E-5	9.49E-5	1.43E-3	? See FP and activation products
Krypton-85 (10.7 year)	5190	4420	2720	2340	4594
Strontium-90 (28.6 year)	0.166	0.0546	0.207	0.404	9.66E-3, Total radiostrontium
Antimony-125 (2.73 year)	6.04E-3	1.74E-5	1.67E-4	9.99E-4	See Total Fission Products
Iodine-129 (16,000,000 year)	5.97E-2	5.04E-2	4.67E-2	1.34E-1	0.11, Total radioiodine
Iodine-131 (8.04 day)	0.383	0.178	0.156	0.603	See Total radioiodine
Cesium-137 (30.2 year)	0.195	0.253	0.537	1.47	0.18, Total fission products and activation products
Plutonium-238 (87.7 year)	5.55E-4	7.66E-6	3.32E-4	1.21E-4	2.21E-2, Total plutonium
Plutonium-239 (24,000 year)	2.68E-3	1.49E-4	8.16E-3	7.43E-3	See Total plutonium
Plutonium-240 (6580 year)	5.68E-4	1.49E-4	1.52E-3	1.55E-3	See Total plutonium
Plutonium-241	1.51E-2	6.20E-9	1.18E-2	1.94E-2	See Total

Radionuclide (Half Life)	Curies released in 2005	Curies released in 2006	Curies released in 2007	Curies released in 2008	Curies released in 2009
(14.35 year)					plutonium
Americium-241 (458 year)	2.12E-3	2.1E-4	2.62E-3	3.18E-3	1.83E-3, Other actinides
Uranium-234 (246,000 year)	2.34E-4	2.49E-4	1.11E-3	4.99E-7	1.83E-3, Total uranium
Uranium-238 (4.47E9 year)	1.85E-5	2.65E-4	5.05E-5	1.18E-4	See Total Uranium
Total curies	6614	6340	4720	5330	7320
MEI effective whole-body dose, mrem	0.077	0.039	0.093	0.131	0.069

Table notes: Airborne radioactive waste in 2009 was reported differently than other years, by grouping curie totals and not reporting specific curie amounts for many radionuclides. In 2009, the category "other" was said to not be "noble gases, activation or fission products or actinides [which are uranium, plutonium, americium, etc.]." MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead. Only the radionuclides that tended to be contributors to effective whole-body dose were listed; additional radionuclides may be listed in INL airborne radioactive waste (effluent) release tables.

Table B1-d. Radionuclides contributing to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory for 2000 to 2004.

Radionuclide (Half Life)	Curies released in 2000	Curies released in 2001	Curies released in 2002	Curies released in 2003	Curies released in 2004
Tritium (H-3) (12.3 year)	684 (plus 103.5 liquid)	1963	1180	1100	1210
Carbon-14 (5,700 year)	1.50	1.14	1.24	1.23	1.23
Chlorine-36 (301,000 year)	-	-	-	-	1.32E-5
Argon-41 (1.83 hour)	1420	985.2	1050	821	660
Chromium-51 (27.7 day)	5.29E-3 (plus 0.91 liquid)	-	-	1.97E-2	0.119
Cobalt-60 (5.27 year)	2.1E-3 (plus 1.10 liquid)	0.026	0.026	6.89E-2	6.89E-2
Zinc-65 (244 day)	-	-	-	3.42E-4	2.27E-3
Krypton-85 (10.7 year)	2540	13,761	8181	5840	6770
Strontium-90 (28.6 year)	0.10 (plus 0.21 liquid)	3.42E-3	0.11	4.10E-2	1.16E-2
Antimony-125 (2.73 year)	9.22E-6	2.29E-3	5.11E-5	3.57E-5	1.06E-3
Iodine-129 (16,000,000 year)	0.022	0.035	0.12	0.0721	0.107
Iodine-131 (8.04 day)	0.0556	0.029	0.0046	0.207	0.00128
Cesium-137 (30.2 year)	0.11 (plus 8.73E-2 liquid)	2.81E-3	0.11	0.276	0.130
Plutonium-238 (87.7 year)	1.04E-3	6.94E-6	4.42E-4	1.81E-4	1.46E-3
Plutonium-239 (24,000 year)	1.04E-5	3.75E-5	8.05E-5	? missing	4.38E-4
Plutonium-240 (6580 year)	-	1.11E-5	-	? missing	1.65E-4
Plutonium-241 (14.35 year)	-	7.77E-4	0.023	-	1.47E-3
Americium-241 (458 year)	-	3.83E-5	2.1E-5	2.76E-4	1.02E-3
Uranium-234	-	-	-	5.9E-6	1.51E-4

Radionuclide (Half Life)	Curies released in 2000	Curies released in 2001	Curies released in 2002	Curies released in 2003	Curies released in 2004
(246,000 year)					
Uranium-238 (4.47E9 year)	-	-	-	5.42E-6	1.14E-3
Total curies	4740	16,833	10,442	7796 *but wrong value in ESER Table 4-2	8820
MEI effective whole-body dose, mrem (Assumes no contribution from liquid pond effluents noted)	0.057	0.035	0.055	0.024	0.044

Table notes: In 2000, although it was not included in the radiation dose, the liquid release to ponds is included in this table because some portion of this release to the pond may have evaporated rather than leached into groundwater. ESER has apparently assumed the entire liquid pond release did not contribute to airborne emissions in 2000. MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead. Only the radionuclides that tended to be contributors to effective whole-body dose were listed; additional radionuclides may be listed in INL airborne radioactive waste (effluent) release tables.

Table B1-e. Radionuclides contributing to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory for 1995 to 1999.

Radionuclide (Half Life)	Curies released in 1995	Curies released in 1996	Curies released in 1997	Curies released in 1998	Curies released in 1999
Tritium (H-3) (12.3 year)	4.6 (plus 80 liquid)	153 (plus 70.5 liquid)	426 (plus 96.3 liquid)	104 (plus 75.3 liquid)	75.35 (plus 87.2 liquid)
Carbon-14 (5,700 year)	0.80	1.1	0.91	0.80	0.63
Chlorine-36 (301,000 year)					
Argon-41 (1.83 hour)	1310	1804	1554	1175	1219
Chromium-51 (27.7 day)	1.0E-3	1.4 (plus 1.5 liquid)	5.6E-3 (plus 2.4 liquid)	3.7E-3 (plus 2.3 liquid)	2.47E-3 (plus 0.76 liquid)
Cobalt-60 (5.27 year)	(plus 0.26 liquid)	(plus 0.2 liquid)	(plus 0.4 liquid)	(plus 0.24 liquid)	(plus 1.76 liquid)
Zinc-65 (244 day)	(plus 3.9E-2 liquid)	-	-	-	(plus 1.72E-2 liquid)
Krypton-85 (10.7 year)	6.5	1038	3579	4587	1863
Strontium-90 (28.6 year)	6.7E-5 (plus 2.9E-2 liquid)	3.1E-5 (plus 1.7E-2 liquid)	7.0E-4 (plus 3.1E-2 liquid	3.1E-4 (plus 1.4E-3 liquid)	1.27E-4 (plus 1.19E-2 liquid)
Antimony-125 (2.73 year)	5.0E-5	3.6E-5	2.7E-5	1.3E-4	7.71E-5
Iodine-129 (16,000,000 year)	9.6E-3	8.6E-2	5.8E-2	1.8E-2	2.61E-3
Iodine-131 (8.04 day)	6.0E-4 (plus 1.7E-2 liquid)	8.0E-4	1.7E-3	6.7E-4	8.91E-4
Cesium-137 (30.2 year)	3.0E-4 (plus 5.1E-2 liquid)	2.4E-4 (plus 1.0E-2 liquid)	7.1E-3 (plus 1.7E-2 liquid)	1.3E-3	5.96E-4
Plutonium-238 (87.7 year)	9.5E-7	6.3E-6 (plus 3.0E-6 liquid)	5.1E-6	5.0E-6	2.17E-6
Plutonium-239 (24,000 year)	1.6E-7	1.3E-7	1.6E-6 (plus 3.5E-3 liquid)	5.3E-7	2.05E-7

Radionuclide (Half Life)	Curies released in 1995	Curies released in 1996	Curies released in 1997	Curies released in 1998	Curies released in 1999
Plutonium-240 (6580 year)	-	-	-	-	-
Plutonium-241 (14.35 year)	-	-	-	-	-
Americium-241 (458 year)	-	-	-	-	-
Uranium-234 (246,000 year)	-	-	-	5.0E-3	4.82E-2
Uranium-238 (4.47E9 year)	-	-	-	-	-
Total curies	1380	3048	5595	5995	3183
MEI effective whole-body dose, mrem (Assumes no contribution from liquid pond effluents noted)	0.018	0.03	0.03	0.007	0.008

Table notes: From 1995 to 1999, although it was not included in the radiation dose, the liquid release to ponds is included in this table because some portion of this release to the pond may have evaporated rather than leached into groundwater. ESER has apparently assumed the entire liquid pond releases did not contribute to airborne emissions. MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead. Only the radionuclides that tended to be contributors to effective whole-body dose were listed; additional radionuclides may be listed in INL airborne radioactive waste (effluent) release tables.

Table B1-f. Radionuclides contributing to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory for 1990 to 1994.

Radionuclide (Half Life)	Curies released in 1990	Curies released in 1991	Curies released in 1992	Curies released in 1993	Curies released in 1994
Tritium (H-3) (12.3 year)	4.0 (plus 180 liquid)	44 (plus 167 liquid)	1.5 (plus 183 liquid)	101 (plus 120 liquid)	33 (plus 47 liquid)
Carbon-14 (5,700 year)	0.28	0.11	0.14	0.92	0.50
Chlorine-36 (301,000 year)					
Argon-41 (1.83 hour)	3300	2900	2500	1300	1030
Chromium-51 (27.7 day)	(plus 3.4 liquid)	7.6E-3 (plus 2.5 liquid)	5.5E-3 (plus 3.2 liquid)	3.8E-3 (plus 1.8 liquid)	(plus 1.9 liquid)
Cobalt-60 (5.27 year)	(plus 0.10 liquid)	(plus 4.9E-2 liquid)	(plus 0.28 liquid)	(plus 2.1 liquid)	(plus 0.56 liquid)
Zinc-65 (244 day)	-	-	(plus 1.3E-2 liquid)	(plus 7.7E-2 liquid)	-
Krypton-85 (10.7 year)	<20,000	<10,000	<20,000	70	5.2
Strontium-90 (28.6 year)	5.7E-5 (plus 3.3E-2 liquid)	2.82E-3 (plus 1.2E-2 liquid)	2.4E-4 (plus 5.1E-2 liquid	1.1E-3 (plus 0.22 liquid)	9.9E-4 (plus 0.18 liquid)
Antimony-125 (2.73 year)	2.1E-4	4.5E-4	1.1E-4	7.3E-5	3.2E-5
Iodine-129 (16,000,000 year)	3.5E-3	6.4E-2	6.1E-5	9.8E-2	3.0E-3
Iodine-131 (8.04 day)	1.1E-3	4.5E-4 (plus 1.3E-2 liquid)	1.3E-3 (plus 1.2E-2 liquid)	1.1E-4	3.8E-4
Cesium-137 (30.2 year)	3.0E-4 (plus 5.1E-2 liquid)	2.4E-4 (plus 1.0E-2 liquid)	7.1E-3 (plus 1.7E-2 liquid)	1.3E-3	5.96E-4
Plutonium-238 (87.7 year)	See Pu Total	See Pu Total	See Pu Total	See Pu Total	See Pu Total
Plutonium-239 (24,000 year)	Pu Total 2.7E-8 (plus 4.8E-4 liquid)	Pu Total 2.9E-9 (plus 3.5E-4 liquid)	Pu Total 4.9E-6 (plus 8.5E-5 liquid)	Pu Total 2.5E-9 (plus 4.8E-5 liquid)	5.7E-7 (plus <1.0E-2 liquid, inconsistent and higher

Radionuclide (Half Life)	Curies released in 1990	Curies released in 1991	Curies released in 1992	Curies released in 1993	Curies released in 1994
					threshold for reporting of liquid effluent compared to earlier years)
Plutonium-240 (6580 year)	See Pu Total	See Pu Total	See Pu Total	See Pu Total	See Pu Total
Plutonium-241 (14.35 year)	See Pu Total	See Pu Total	See Pu Total	See Pu Total	See Pu Total
Americium-241 (458 year)	Not reported?	Not reported?	Not reported?	Not reported?	Not reported?
Uranium-234 (246,000 year)	Not reported?	Not reported?	Not reported?	Not reported?	Not reported?
Uranium-238 (4.47E9 year)	Not reported?	Not reported?	Not reported?	Not reported?	Not reported?
Total curies	<24,000	<14,000	<24,000	2800	2300
MEI effective whole-body dose, mrem (assumes no contribution from liquid pond effluents noted)	0.001	0.02 (0.0089 mrem from Ar-41; 0.008 mrem from I-129)	0.004	0.011	0.004

Table notes: From 1995 to 1999, although it was not included in the radiation dose, the liquid release to ponds is included in this table because some portion of this release to the pond may have evaporated rather than leached into groundwater. ESER has apparently assumed the entire liquid pond releases did not contribute to airborne emissions. MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead. Only the radionuclides that tended to be contributors to effective whole-body dose were listed; additional radionuclides may be listed in INL airborne radioactive waste (effluent) release tables.

Table B1-g. Radionuclides contributing to estimated radiation dose from airborne radionuclide effluents at the Idaho National Laboratory for 1985 to 1989.

Radionuclide (Half Life)	Curies released in 1985	Curies released in 1986	Curies released in 1987	Curies released in 1988	Curies released in 1989
Tritium (H-3) (12.3 year)	160 (liquid not reported)	29 (plus 330 liquid)	920 (plus 350 liquid)	770 (plus 260 liquid)	2.7 (plus 130 liquid)
Carbon-14 (5,700 year)	0.57	0.40	4.0	2.7	0.19
Chlorine-36 (301,000 year)	-	-	-	-	-
Argon-41 (1.83 hour)	2100	1850	2500	2100	1400
Chromium-51 (27.7 day)	Not reported	1.2E-2 (plus 13 liquid)	(plus 8.0 liquid)	1.0E-2 (plus 5.1 liquid)	2.3E-3 (plus 5.7 liquid)
Cobalt-60 (5.27 year)	Not reported	4.4E-4 (plus 1.3 liquid)	(plus 0.28 liquid)	(plus 2.1 liquid)	(plus 0.56 liquid)
Zinc-65 (244 day)	Not reported	Not reported	-	-	-
Krypton-85 (10.7 year)	64,000 plus 10 from LOFT	10,800	<20,000	70	5.2
Strontium-90 (28.6 year)	1.9E-3 (liquid not reported)	2.2E-4 (no Sr-90 reported in liquid)	2.6E-4 (plus 0.17 liquid	3.3E-4 (plus 5.8E-2 liquid)	9.1E-5 (plus 3.3E-2 liquid)
Antimony-125 (2.73 year)	6.2E-3	0.93	16	7.4	3.9E-4
Iodine-129 (16,000,000 year)	7.1E-3	6.1E-3	0.2 (plus 7.7E-3 liquid)	0.24 (plus 5.2E-3 liquid)	1.4E-3
Iodine-131 (8.04 day)	1.6E-4 plus 2.4E-2 from LOFT	8.8E-4	5.3E-4 (plus 2.4E-2 liquid)	1.7E-4	3.8E-4
Cesium-137 (30.2 year)	6.0E-3 (liquid not reported)	2.3E-3 plus 0.2 liquid	5.5E-4 (plus 0.79 liquid)	6.8E-4 (plus 0.18 liquid)	2.1E-4 (plus 9.3E-2 liquid)
Plutonium-238 (87.7 year)	6.6E-5	1.2E-5	See Pu Total	See Pu Total	See Pu Total

Radionuclide (Half Life)	Curies released in 1985	Curies released in 1986	Curies released in 1987	Curies released in 1988	Curies released in 1989
Plutonium-239 (24,000 year)	1.3E-5 as Pu-239/240	1.2E-6 as Pu-239/240	Pu Total of 2.0E-5 (plus 9.6E-3 liquid)	Pu Total of 1.6E-5 (plus 5.0E-3 liquid)	Pu Total of 8.1E-8 (not legible) (plus 2.3E-3 liquid)
Plutonium-240 (6580 year)	See Pu-239	See Pu-239	See Pu Total	See Pu Total	See Pu Total
Plutonium-241 (14.35 year)	Not reported	Not reported	See Pu Total	See Pu Total	See Pu Total
Americium-241 (458 year)	Not reported	Not reported	Not reported?	Not reported?	Not reported?
Uranium-234 (246,000 year)	Not reported	Not reported	Not reported?	Not reported?	Not reported?
Uranium-238 (4.47E9 year)	Not reported	Not reported	Not reported?	Not reported?	Not reported?
Total curies	68,400 (w/o LOFT) 68,410 with LOFT	14,500	<165,000	<124,000	<22,000
MEI effective whole-body dose, mrem (Assumes no contribution from liquid pond effluents noted)	0.0511 plus 0.003 LOFT mainly from I-131	0.107, mainly Sb-125	0.5406, mainly Sb-125	0.02, Mainly Sb-125, I-239 with honorable mention from Ru-106, 0.19 curies	0.0066, mainly Ar-41

Table notes: From 1985 to 1989, although it was not included in the radiation dose, the liquid release to ponds is included in this table because some portion of this release to the pond may have evaporated rather than leached into groundwater. ESER has apparently assumed the entire liquid pond releases did not contribute to airborne emissions. MEI is the hypothetical maximally exposed individual located near the Idaho National Laboratory residing south of the INL near the Big Southern Butte. A mrem is the annual radiation dose in units of millirem, or 1.0E-3 rem. The source data for the radionuclide curie releases and the estimated radiation dose is from the Department of Energy's Idahoeser.com website for those years. Note that uranium, plutonium and americium decay half-lives are only the beginning of long decay series of radionuclides before ultimately decaying to a stable isotope of lead. Only the radionuclides that tended to be contributors to effective whole-body dose were listed; additional radionuclides may be listed in INL airborne radioactive waste (effluent) release tables.

APPENDIX C – Department of Energy Reporting of Radiological Monitoring

Before 2003, the Department of Energy radiological monitoring reports typically presented the result as the mean value and the analytical uncertainties were expressed as plus or minus ± 2s with s being an estimate of the population standard deviation "σ." For example, 3 ± 2 pCi/L (2s).

In 2003, the same result would be expressed as the mean and the analytical uncertainties were expressed as ± 1 standard deviation, for example, 3 ± 2 pCi/L (1s). This choice would be arbitrary and does not affect the results.

But what did change in 2003 was that results were deemed "not detected" or not reliably detected and not included in the annual results unless the mean result was at least three times the standard deviation.

So results that would have been provided before, such as 2.9 ± 2 pCi/L (2s) were omitted. In this case, 1s is equal to 1 pCi/L and 3s is equal to 3 pCi/L and the result 2.9 is less than 3s and was therefore not considered a valid detection in 2003 or thereafter.

This effectively raised the bar on what would be considered a valid detection. While results with a mean less than 3s are not as strong as those with 3s or greater mean values, results between 2s and 3s are statistically significant and there is no valid reason to eliminate all results below 3s.

Table C1-a. Specific radionuclide activity for cerium-141 and cerium-144 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Ce-141, E-15uCi/mL (32.5-day half-life)				Ce-144, E-15uCi/mL (284.3-day half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	<MDC	<MDC	1.0 ± 0.8	2	-	-	-	-
1986	<MDC	4 ± 3	"NSS"	2	<MDC	<MDC	NSS	7
1987	<MDC	1.1 ± 1.0	NSS	2	-	-	-	-
1988	<MDC	5 ± 4	NSS	2	-	-	-	-
1989	<MDC	5 ± 4	NSS	2	-	-	-	-
1990	-	-	-	-	-	-	-	-
1991	<MDC	5 ± 4	0.2 ± 1.2	2	<MDC	<MDC	-1.5 ± 1.4	1
1992	<MDC	<MDC	1.2 ± 0.7	2	<MDC	<MDC	-1.3 ± 0.9	1
1993	-	-	-	-	-	-	-	-
1994	-	(7 ± 6 onsite at EFS)	(0.7 ± 4.9 onsite at EFS)	Not stated	-	(15 ± 10 onsite at ARA)	(2.2 ± 12 onsite at ARA)	Not stated
1995	-	-	-	-	-	11 ± 10 Craters of the Moon	-	? LITCO
1995 to 2019	-	-	-	-	-	-	-	-

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2s. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. Cerium-141 is Ce-141 with radioactive half-life of 32.5 days. Cerium-144 is Ce-144 with radioactive half-life 411 days (or 1.12 year). The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant, or zero is included within the 95% confidence internal for the mean." A dash (-) means no results were reported. Note that the 1995 specific radionuclide data were from ESER report of LITCO contractor Table 4.5.

Table C1-b. Specific radionuclide activity for cobalt-60 and manganese-54 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Co-60, E-15uCi/mL (5.3-year half-life)				Mn-54, E-15uCi/mL (312.5-day half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	-	-	-	-	<MDC	0.7 ± 0.4	NSS	1
1986	<MDC	<MDC	NSS	2	<MDC	1.0 ± 0.8	NSS	1
1987	<MDC	0.18 ± 0.16	0.8 ± 0.16	2	<MDC	<MDC	NSS	1
1988	<MDC	<MDC	NSS	2	<MDC	<MDC	NSS	1
1989	-	-	-	-	<MDC	0.7 ± 0.4	NSS	1
1990	-	-	-	-	-	-	-	-
1991	<MDC	<MDC	0.04 ± 0.12	0.1	<MDC	<MDC	-0.12 ± 0.18	1
1992	<MDC	<MDC	0.02 ± 0.11	0.1	<MDC	<MDC	0.12 ± 0.09	1
1993	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	(2.3 ± 2.2	(0.3 ± 2	Not

	Co-60, E-15uCi/mL (5.3-year half-life)				Mn-54, E-15uCi/mL (312.5-day half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
						onsite)	onsite ARA)	stated
1995	-	(5 ± 4 onsite PBF)	-	? LITCO	-	-	-	-
1996 to 2019	-	-	-	-	-	-	-	-

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2 s. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant, or zero is included within the 95% confidence internal for the mean." A dash (-) means no results were reported. Note that the 1995 specific radionuclide data were from ESER report of LITCO contractor Table 4.5.

Table C1-c Specific radionuclide activity of cesium-134 and cesium-137 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Cs-134, E-15uCi/mL (2.06-year half-life)				Cs-137, E-15uCi/mL (30.0-year half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	<MDC	<MDC	0.3 ± 0.2	2	<MDC	1.2 ± 1.0	0.20 ± 0.17	1
1986	<MDC	13 ± 2	3 ± 2	2	<MDC	26 ± 3	6 ± 4	1
1987	<MDC	<MDC	0.16 ± 0.08	2	<MDC	<MDC	NSS	1
1988	<MDC	<MDC	0.12 ± 0.10	2	<MDC	0.8 ± 0.6	NSS	1
1989	-	-	-	-	<MDC	1.1 ± 1.0	NSS	1
1990	-	-	-	-	<MDC	<MDC	NSS	1
1991	<MDC	<MDC	-0.11 ± 0.19	6	<MDC	<MDC	0.05 ± 0.14	2
1992	<MDC	<MDC	0.03 ± 0.17	8	<MDC	<MDC	0.17 ± 0.12	2
1993	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	0.46 ± 0.43	?
1996	-	-	-	-	-	-	0.3 ± 0.3	?
1997	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	0.04 ± 0.02	?
2001	-	-	-	-	-	-	1.4089 ± 1.2501	?
2002	-__	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	ND	?
2005	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	2.390 ± 0.563 (1s)	?
2007	-	-	-	-	-	-	0.630 ± 0.177 (1s)	?

	Cs-134, E-15uCi/mL (2.06-year half-life)				Cs-137, E-15uCi/mL (30.0-year half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
2008	-	-	-	-	-	-	0.529 ± 0.136 (1s)	
2009	-	-	-	-	-	-	ND	-
2010	-	-	-	-	-	-	-	-
2011 (Fuku-shima)	-	-	1.31 (in Idaho Falls, by M&O)	?	-	-	0.562	? (M&O)
2012	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2 s. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant, or zero is included within the 95% confidence internal for the mean." A dash (-) means no results were reported.

Table C1-d. Specific radionuclide activity or ruthenium-103 and ruthenium-106 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Ru-103, E-15uCi/mL (39.26-day half-life)				Ru-106, E-15uCi/mL (373.59-day half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	-	-	-	-	<MDC	<MDC	NSS	10
1986	<MDC	42 ± 6	8 ± 6	1	<MDC	24 ± 12	4 ± 3	10
1987	<MDC	1.8 ± 1.6	NSS	1	-	-	-	-
1988	<MDC	<MDC	NSS	1	<MDC	<MDC	NSS	10
1989	-	-	-	-	<MDC	<MDC	NSS	10
1990	-	-	-	-	<MDC	9 ± 8	NSS	10
1991	<MDC	<MDC	1 ± 0.8	0.1	<MDC	<MDC	0.0 ± 2	6
1992	<MDC	<MDC	0.09 ± 0.5	0.1	<MDC	<MDC	-1.8 ± 1.3	8
1993	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-
1995 to 2019	-	-	-	-	-	-	-	-

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2 s. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant."

Table C1-e. Specific radionuclide activity for strontium-90 and antimony-125 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Sr-90, E-15uCi/mL (29.12-year half-life)				Sb-125, E-15uCi/mL (2.77-year half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	<MDC	0.4 ± 0.3	0.12 ± 0.10	0.6	<MDC	3 ± 2	NSS	6
1986	<MDC	0.88 ± 0.14	NSS	0.1	<MDC	12 ± 3	NSS	6
1987	<MDC	0.36 ± 0.18	0.14 ± 0.12	0.1	<MDC	7.2 ± 2.2	2.2 ± 0.08	6
1988	<MDC	0.31 ± 0.16	0.12 ± 0.10	0.1	<MDC	4 ± 2	NSS	6
1989	<MDC	0.32 ± 0.16	0.09 ± 0.08	0.1	<MDC	<MDC	NSS	6
1990	-	-	-	-	-	-	-	-
1991	<MDC	0.21 ± 0.18	0.05 ± 0.08	0.1	<MDC	<MDC	0.4 ± 0.4	0.1
1992	<MDC	0.37 ± 0.16	0.13 ± 0.11	0.1	<MDC	<MDC	0.2 ± 0.4	0.1
1993	-	-	-	-	-	-	-	-
1994	-	-	0.5 ± 0.2	0.035	-	-	-	-
1995	-	-	0.064 ± 0.054	0.035	-	-	-	-
1996	-	-	0.20 ± 0.06	0.035	-	-	-	-
1997	-	-	0.30 ± 0.06	0.035	-	-	-	-
1998 *	-	-	0.13 ± 0.068	0.16	-	-	-	-
1999	-	-	0.104 ± 0.004	0.035	-	-	-	-
2000	-	-	0.04 ± 0.026	0.1	-	-	-	-
2001	-	-	0.159 ± 0.060	0.1	-	-	-	-
2002	-	-	0.0306 ± 0.030	0.06	-	-	-	-
2003	-	-	0.0602 ± 0.0175 (1s)	0.06			(1.2 ± 0.399 (1s) onsite EFS)	?
2004	-	-	0.0396 ± 0.012 (1s)	0.06	-	-	-	-
2005	-	-	0.390 ± 0.123 (1s)		-	-	-	-
2006	-	-	ND	-	-	-	-	-
2007	-	-	0.286 ± 0.031 (1s)		-	-	-	-
2007	-	-	3.510 ± 0.439 (1s) by M&O for Idaho Falls					
2008	-	-	0.160 ± 0.50 (1s) by M&O		-	-	-	-
2009	-	-	ND or not analyzed	?	-	-	-	-
2010	-	-	-	-	-	-	-	-

	Sr-90, E-15uCi/mL (29.12-year half-life)				Sb-125, E-15uCi/mL (2.77-year half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
2011	-	-	0.33 ± 0.0142 (1s) (onsite by ESER, no upper range values offsite provided)	0.06	-	-	-	-
2012	-	-	0.0989 ± 0.0154 (1s)					
2012	-	-	0.148 ± 0.096 (1s) Jackson	-	-	-	-	-
2013	-	-	0.0745 8 ± 0.0013 (1s)		-	-	-	-
2014	-	-	0.0301 ± 0.0095 (1s)		-	-	-	-
2015	-	-	0.024 ± 0.0057 (1s)		-	-	-	-
2016	-	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2s, except where noted. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant." The offsite result for 1998 is from the site's M&O Contractor rather than by ESER. The MDC is stated in 2000 and 2001 for Sr-90 as 1.0E-6uCi/mL, but apparently, they meant 1.0E-16uCi/mL as they are the units used for Sr-90. In 2006, the result "ND" was stated to mean "not detected (result < 3s analytical uncertainty or result not valid." Previously, more easily detected results had been reported and results with less than 3s had been reported.

Table C1-f. Specific radionuclide activity of zirconium-95 and zinc-65 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Zr-95, E-15uCi/mL (63.98-day half-life)				Zn-65, E-15uCi/mL (243.9-day half-life)			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	<MDC	<MDC	NSS	1	-	-	-	-
1986	-	-	-	-	-	-	-	-
1987	<MDC	<MDC	NSS	1	-	-	-	-
1988	-	-	-	-	-	-	-	-
1989	<MDC	2.5 ± 2.2	NSS	1	-	-	-	-
1990	-	-	-	-	-	-	-	-
1991	<MDC	<MDC	-0.4 ± 0.6	6	-	-	-	-
1992	<MDC	<MDC	-0.6 ± 0.7	6	-	-	-	-
1993	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	(8 ± 6 onsite)	(4.2 ± 3.8 onsite)	?
1995	-	-	-	-	-	11 ± 10, Blackfoot, 2Q 5 ± 4, Rexburg, 2Q and 4Q	-	? Data from M&O LMITCO
1996 to 2019	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	(0.3 ± 0.093 onsite, NRF	-	0.27

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2 s. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant." Note that the 1995 specific radionuclide data were from ESER report of LITCO contractor Table 4.5. Also note that in 1995, scandium-46 (radioactive half-life 83.83 days) was detected in Rexburg in the third and fourth quarters (3Q and 4Q). The results were 3.7 ± 3.6 (2s) and 3.6 ± 3.2 (2s) for Sc-46 in Rexburg.

Table C1-g. Specific radionuclide activity for americium-241 and plutonium-239 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Am-241, E-18uCi/mL				Pu-239, E-18uCi/mL			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	<MDC	<MDC	NSS	6	<MDC	<MDC	NSS	6
1986	<MDC	25 ± 8	NSS	6	<MDC	<MDC	NSS	6
1987	<MDC	74 ± 14	NSS	6	<MDC	<MDC	NSS	6
1988	<MDC	7 ± 6	NSS	8	<MDC	<MDC	NSS	6
1989	<MDC	<MDC	NSS	8	<MDC	<MDC	NSS	6
1990	<MDC	<MDC	NSS	8	<MDC	<MDC	NSS	6
1991	<MDC	<MDC	-2 ± 2	6	<MDC	11 ± 8	2 ± 3	6
1992	<MDC	<MDC	4 ± 8	6	<MDC	3 ± 2	1.6 ± 1.1	6

	Am-241, E-18uCi/mL				Pu-239, E-18uCi/mL			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1993	-	-	-	8	-	-	-	6
1994	-	(5 ± 4 onsite by M&O)	(1.2 ± 3.9 onsite by M&O)	8 (2 M&O)	-	-	-	6 (2 M&O)
1995	-	-	9.8 ± 3.6	2	-	-	23 ± 5 Arco	2
1996	-	-	9 ± 3	8	-	-	3.3 ± 3.2, Blackfoot, M&O	7 (2 M&O)
1997	-	-	9 ± 3	2	-	-	2 ± 1	3
1998	-	-	2.1 ± 1.5	2	-	-	-	3
1999	-	-	5.8 ± 4.4	2	-	-	4.4 ± 3.4	3
2000	-	-	22 ± 18	2	-	-	16 ± 14	2
2001	-	-	4.7 ± 2.7	2	-	-	3.5 ± 2.7	2
2002	-	-	8.4 ± 4.1	2	-	-	4.0 ± 3.5, Black-foot 4.4 ± 2.3, Jackson	2
2003 (1s)	-	-	9.21 ± 2.5 (1s)	2	-	-	8.3 ± 1.9 (1s)	2
2004	-	-	5.4 ± 1.4 (1s)	2	-	21.2 ± 3.8 (1s)	-	2
2005	-	-	-	2	-	-	-	2
2006	-	-	16.1	2	-	14.7	-	2
2007	-	-	2.0 ± 0.12 (1s)	2	-	5.5 ± 1.2 (1s)	-	2
2008	-	-	3.3 ± 0.62 (1s)	2	-	13 ± 1.6 (1s)	-	2
2009	-	-	7.6 ± 1.2 (1s)	2	-	ND	-	2
2010	-	8.04 ± 2.40 (1s) by M&O offsite; (20.8 ± 4.6 onsite by M&O)	-	?	-	(12.6 ± 3.0 (1s) onsite by M&O)	-	?
2011	-	-	-	2	-	-	-	2
2012	-	-	-	2	-	-	-	2
2012	-	-	-	2	-	-	-	2
2013	-	-	-	4.6	-	4.20 ± 1.31 (1s)	-	3.5
2014	-	-	-	4.6	-	-	-	3.5
2015	-	-	-	4.6	-	-	-	3.5
2016	-	6.6 ± 1.3	-	4.6	-	2.0 ± 0.53	-	3.5

	Am-241, E-18uCi/mL				Pu-239, E-18uCi/mL			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
2017	-	1.9 ± 0.5	-	4.6	-	1.8 ± 0.5	-	3.5
2018	-	(43.1 onsite by M&O)	-	4.6	-	(7.55 onsite by M&O)	-	3.5
2019	-	(19.4 onsite by M&O)	-	4.6	-	(8.23 onsite by M&O)	-	3.5

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2s, except where noted. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant." The offsite result for 1998 is from the site's M&O Contractor rather than by ESER. In 2006, the result "ND" was stated to mean "not detected (result < 3s analytical uncertainty or result not valid." Previously, more easily detected results had been reported and results with less than 3s had been reported.

Table C1-h. Specific radionuclide activity for americium-241 and plutonium-239 in air offsite locations (the maximum of distant and/or boundary locations) monitored by the Department of Energy.

	Pu-238, E-18uCi/mL				Pu-239, E-18uCi/mL			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
1985	<MDC	<MDC	NSS	6	<MDC	<MDC	NSS	6
1986	<MDC	5 ± 4	NSS	6	<MDC	<MDC	NSS	6
1987	<MDC	11 ± 10	NSS	6	<MDC	<MDC	NSS	6
1988	<MDC	<MDC	NSS	6	<MDC	<MDC	NSS	6
1989	<MDC	6 ± 4	NSS	6	<MDC	<MDC	NSS	6
1990	<MDC	<MDC	NSS	6	<MDC	<MDC	NSS	6
1991	<MDC	<MDC	1 ± 3	6	<MDC	11 ± 8	2 ± 3	6
1992	<MDC	3 ± 2	0.5 ± 1.4	6	<MDC	3 ± 2	1.6 ± 1.1	6
1993	-	-	-	6	-	-	-	6
1994	-	-	(19 ± 8 onsite by M&O)	6 (2 M&O)	-	-	-	6 (2 M&O)
1995	-	-	1.6 ± 1.4	2	-	-	23 ± 5 Arco	2
1996	-	-	-	7	-	-	3.3 ± 3.2, Blackfoot, M&O	7 (2 M&O)
1997	-	-	-	2	-	-	2 ± 1	3
1998	-	-	-	2	-	-	-	3
1999	-	-	-	2	-	-	4.4 ± 3.4	3
2000	-	-	-	2	-	-	16 ± 14	2
2001	-	-	5.3 ± 4.1 Rexburg	2	-	-	3.5 ± 2.7	2
2002	-	-	1.2 ± 1.1 Arco	2	-	-	4.0 ± 3.5, Black-foot 4.4 ± 2.3, Jackso	2

	Pu-238, E-18uCi/mL				Pu-239, E-18uCi/mL			
Year	**Min**	**Max**	**Ave**	**MDC**	**Min**	**Max**	**Ave**	**MDC**
							n	
2003 (1s)	-	-	9.1 ± 2.8 (1s) Howe	2	-	-	8.3 ± 1.9 (1s)	2
2004	-	-	-	2	-	21.2 ± 3.8 (1s)	-	2
2005	-	-	16.8 ± 3.47 (1s) Rexburg	2	-	-	-	2
2006	-	-	21.2 Rexburg, 37.5 Jackson, 70.50 Craters of Moon	2	-	14.7	-	2
2007	-	-	(57.3 ± 7.8 (1s) onsite CFA)	2	-	5.5 ± 1.2 (1s)	-	2
2008	-	-	-	2	-	13 ± 1.6 (1s)	-	2
2009	-	-	-	2	-	ND	-	2
2010	-	(8.66 ± 2.78 (1s) onsite by M&O	-	?	-	(12.6 ± 3.0 (1s) onsite by M&O)	-	2
2011	-	-	-	2	-	-	-	2
2012	-	-	-	2	-	-	-	2
2012	-	3.51 ± 1.05, Mud Lake	-	2	-	-	-	2
2013	-	3.34 ± 1.03, Atomic City	-	4.6	-	4.20 ± 1.31 (1s)	-	3.5
2014	-	-	-	4.6	-	-	-	3.5
2015	-	-	-	4.6	-	-	-	3.5
2016	-	-	-	4.6	-	2.0 ± 0.53	-	3.5
2017	-	2.1 ± 0.59 Blackfoot, 2.5 ± 0.65	-	4.6	-	1.8 ± 0.5, Blackfoot	-	3.5
2018	-	-	-	4.6	-	(7.55 onsite by M&O)	-	3.5
2019	-	-	-	4.6	-	(8.23 onsite by M&O)	-	3.5

Table notes. Units are E-15 microcuries per milliliter (E-15 uCi/mL). Minimum detectable concentration is MDC. Uncertainty is reported as ± 2s, except where noted. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. The onsite results have not been included. "NSS" was the ESER entry stated as "mean is not statistically significant." The offsite result for 1998 is from the site's M&O Contractor rather than by ESER. In

2006, the result "ND" was stated to mean "not detected (result < 3s analytical uncertainty or result not valid." Previously, more easily detected results had been reported and results with less than 3s had been reported.

Table C2. Strontium-90 in air filter quarterly sample analysis, E-18uCi/mL or aCi/m^3 from Department of Energy quarterly reports.

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
1998	First quarter Onsite	0		30 E-8uCi/mL	
	First quarter Offsite	0		30 E-18uCi/mL	
	Second quarter Onsite	3	66 ± 50 to 97 ± 64	M&O contractor	NRF, TRA, and INTEC
	Second quarter Offsite	0		30 E-18uCi/mL	
	Third quarter Onsite	6	71 ± 65 to **160 ± 77**	M&O contractor	TRA, EFS, INTEC, NRF, CFA
	Third quarter Offsite	3	74 ± 64 to 130 ± 85	M&O contractor	Blackfoot, Idaho Falls, Rexburg
	Fourth quarter Onsite	0		30 E-18uCi/mL	
	Fourth quarter Offsite	0		30 E-18uCi/mL	
1999	First quarter Onsite	1	**228 ± 70**	30 E-18uCi/mL	EFS
	First quarter Offsite	2	64 ± 34 to 104 ± 40	30 E-18uCi/mL	Atomic City, Mud Lake
	Second quarter Onsite	2	15 ± 14 to 60 ± 28	30 E-18uCi/mL	Main Gate, FAA Tower
	Second quarter Offsite	1	89 ± 38	30 E-18uCi/mL	Monteview
	Third quarter Onsite	1	127 ± 62	30 E-18uCi/mL	EFS
	Third quarter Offsite	4	47 ± 36 to 76 ± 42	30 E-18uCi/mL	Rexburg, Mud Lake, Idaho Falls, Atomic City
	Fourth quarter Onsite	3	**119 ± 62 to 179 ± 78**	M&O Contractor	PBF, TRA, EFS

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Fourth quarter Offsite	1	26 ± 34 (as stated)	30 E-18uCi/mL	Monteview
2000	First quarter Onsite	0		100 E-18uCi/mL	
	First quarter Offsite	2	27 ± 26 to **40 ± 26**	100 E-18uCi/mL	Atomic City, Rexburg
	Second quarter Onsite	0		100 E-18uCi/mL	
	Second quarter Offsite	0		100 E-18uCi/mL	
	Third quarter Onsite	0		100 E-18uCi/mL	
	Third quarter Offsite	0		100 E-18uCi/mL	
	Fourth quarter Onsite	0		100 E-18uCi/mL	
	Fourth quarter Offsite	0		100 E-18uCi/mL	
2001	First quarter Onsite	0		100 E-18uCi/mL	
	First quarter Offsite	0		100 E-18uCi/mL	
	Second quarter Onsite	1	61.4 ± 55	100 E-18uCi/mL	
	Second quarter Offsite	1	47 ± 41	100 E-18uCi/mL	
	Third quarter Onsite	1	72.2 ± 53	100 E-18uCi/mL	Main Gate
	Third quarter Offsite	7	60 ± 57 to **159 ± 60**	100 E-18uCi/mL	Mud Lake, Dubois, Arco, Jackson, Blue Dome
	Fourth quarter Onsite	2	53.9 ± 43 to 60.6 ± 48	100 E-18uCi/mL	EFS, Van Buren
	Fourth quarter Offsite	0		100 E-18uCi/mL	
2002	First quarter Onsite	0		60 E-18uCi/mL	
	First quarter	0		60	

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Offsite			E-18uCi/mL	
	Second quarter Onsite	0		60 E-18uCi/mL	
	Second quarter Offsite	0		60 E-18uCi/mL	
	Third quarter Onsite	0		60 E-18uCi/mL	
	Third quarter Offsite	0		60 E-18uCi/mL	
	Fourth quarter Onsite	0		60 E-18uCi/mL	
	Fourth quarter Offsite	1	30.6 ± 30	60 E-18uCi/mL	Mud Lake
2003	First quarter Onsite	0		60 E-18uCi/mL	
	First quarter Offsite	0		60 E-18uCi/mL	
	Second quarter Onsite	Not analyzed		60 E-18uCi/mL	
	Second quarter Offsite	Not analyzed		60 E-18uCi/mL	
	Third quarter Onsite	1	**224 ± 122.2**	M&O Contractor	Van Buren
	Third quarter Offsite	2	60.2 ± 35 to 62.3 ± 41	60 E-18uCi/mL	Dubois, Mud Lake
	Fourth quarter Onsite	1	111 ± 65.4	M&O Contractor	INTEC (CPP)
	Fourth quarter Offsite	0		60 E-18uCi/mL	
2004	First quarter Onsite	1	114 ± 74	M&O Contractor	Van Buren
	First quarter Offsite	0		60 E-18uCi/mL	
	Second quarter Onsite	3	103 ± 64 to **186 ± 112**	M&O Contractor	EBR-1, Rest Area, TRA
	Second quarter Offsite	0		60 E-18uCi/mL	
	Third quarter	2	220 ± 120 to	M&O	TRA, ARA

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Onsite		**250 ± 140**	Contractor	
	Third quarter Offsite	1	33.5 ± 22	60 E-18uCi/mL	Monteview, Rexburg nearly 3s with 27.6 ± 22
	Fourth quarter Onsite	0		60 E-18uCi/mL	
	Fourth quarter Offsite	1	39.6 ± 24	60 E-18uCi/mL	Blackfoot
2005	First quarter Onsite	0			
	First quarter Offsite	0			
	Second quarter Onsite	0			
	Second quarter Offsite	0			
	Third quarter Onsite	0			
	Third quarter Offsite	2	**333 ± 199 to 390 ± 246**		Arco, Atomic City
	Fourth quarter Onsite	1	20.1 ± 10.84	By Contractor	INTEC
	Fourth quarter Offsite	1	118 ± 29		Craters of the Moon
2006	First quarter Onsite				
	First quarter Offsite	2	41.5 to 41.6		Howe, Monteview
	Second quarter Onsite				
	Second quarter Offsite	3	49.3 to 89.6		Atomic City, Jackson, Blue Dome
	Third quarter Onsite	1			

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Third quarter Offsite	0			
	Fourth quarter Onsite	0			
	Fourth quarter Offsite	0			
2007	First quarter Onsite	0		49 E-18uCi/mL	
	First quarter Offsite	0			
	Second quarter Onsite	3	1010 ± 626 to 1880 ± 786 This data appears to be in error.	By Contractor	EBR-1, EFS, Gate 4 [95th page of annual ESER report, did they report Cs-137 as Sr-90?]
	Second quarter Offsite	2	62 ± 38 to **286 ± 62**		Atomic City, Rexburg
	Second quarter Offsite	1	3510 ± 878 This data appears to be in error.	By Contractor	Idaho Falls [95th page of annual ESER report, did they report Cs-137 as Sr-90?]
	Third quarter Onsite	1	44 ± 28		Main Gate
	Third quarter Offsite	0			
	Fourth quarter Onsite	0			
	Fourth quarter Offsite	0			
2008	First quarter	2	**216 ± 120 to**	By Contractor	Location A

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Onsite		**580 ± 200**		near RWMC and TAN.
	First quarter Offsite				
	Second quarter Onsite	1	**300 ± 140**	By Contractor	CFA
	Second quarter Offsite	2	160 ± 100 to **280 ± 140**	By Contractor	Craters of the Moon, Blackfoot
	Third quarter Onsite	0			
	Third quarter Offsite	0			
	Fourth quarter Onsite	0			
	Fourth quarter Offsite	0			
2009	First quarter Onsite	1	82 ± 32	60 E-18uCi/mL	FAA Tower
	First quarter Offsite	0			
	Second quarter Onsite	0			
	Second quarter Offsite	0			
	Third quarter Onsite	0			
	Third quarter Offsite	0			
	Fourth quarter Onsite	0			
	Fourth quarter Offsite	0			
2010	First quarter Onsite	0			
	First quarter Offsite	0			
	Second quarter	0			

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Onsite				
	Second quarter Offsite	0			
	Third quarter Onsite	0			
	Third quarter Offsite	0			
	Fourth quarter Onsite	0			
	Fourth quarter Offsite	0			
2011	First quarter Onsite				ESER states that Fukushima fallout occurred between the second half of March and also in April
	First quarter Offsite				No ESER Sr-90 monitoring results
	Second quarter Onsite				No ESER Sr-90 monitoring results
	Second quarter Offsite				No ESER Sr-90 monitoring results
	Third quarter Onsite		**330 ± ?**	ESER quarterly report does not report Sr-90 results although the annual ESER report states there were numerous detections.	Van Buren, ESER annual report does not give the uncertainty, says the origin in unclear and says there were many detections but

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
					doesn't list them.
	Third quarter Offsite			See note for 3Q Onsite	ESER says the origin is unclear
	Fourth quarter Onsite				
	Fourth quarter Offsite		32 ± ? no table in annual report and no data in the quarterly report		Idaho Falls, as stated in the annual report but no Sr-90 results are provided in the quarterly report
2012	First quarter Onsite	0		60 E-18uCi/mL	
	First quarter Offsite	0			
	Second quarter Onsite	1	64.2 ± 2.14		FAA Tower
	Second quarter Offsite	3	61.3 ± 11.0 to 98.9 ± 30.8		Dubois, Craters, Atomic City
	Third quarter Onsite	2	34.8 ± 19.6 to 79.2 ± 25.4		EFS, Main Gate
	Third quarter Offsite	4	32.7 ± 18.2 to 148 ± 19.2		Jackson, Blackfoot, Monteview (2)
	Fourth quarter Onsite	2	23.5 ± 11.6 to 43.7 ± 16.8		EFS, Van Buren
	Fourth quarter Offsite	3	54.9 ± 19.8 to 24.5 ± 15.2		Howe, Arco, Mud Lake
2013	First quarter Onsite	0			Numerous detections declared invalid, see notes.

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	First quarter Offsite	1	14.7 ± 9.2		Dubois
	Second quarter Onsite	0			
	Second quarter Offsite	1	74.5 ± 2.6		Blue Dome
	Third quarter Onsite	0			
	Third quarter Offsite	1	23.3 ± 13.2		Dubois
	Fourth quarter Onsite	0			
	Fourth quarter Offsite	1	20.0 ± 10.4		Blackfoot
2014	First quarter Onsite				(Some valid 2s detections)
	First quarter Offsite				
	Second quarter Onsite				
	Second quarter Offsite				
	Third quarter Onsite	Below 3s	13.6 ± 10.2	19.2 E-18uCi/mL	Van Buren
	Third quarter Onsite	1	55.9 ± 31.8	By Contractor	SDA
	Third quarter Offsite	Below 3s	11.90 ± 12.08 13.90 ± 11.3	19.2 E-18uCi/mL	Sugar City, Howe
	Fourth quarter Onsite	Below 3s	14.4 ± 9.62	16.5 E-18uCi/mL	Main Gate
	Fourth quarter Offsite	Below 3s	8.32 ± 9.92	16.5 E-18uCi/mL	Idaho Falls
2015	First quarter Onsite	1	26 ± 16.2	34 E-18uCi/mL	CFA
	First quarter Offsite	1	22 ± 13		Howe
	Second quarter Onsite				
	Second quarter				

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Offsite				
	Third quarter Onsite	1	21 ± 10.4		EFS
	Third quarter Offsite	1	24 ± 11.4 15 ± 9.8		Dubois, Mud Lake
	Fourth quarter Onsite	1	31.7 ± 19.6	By Contractor	SDA
	Fourth quarter Offsite				
2016	First quarter Onsite	0		34 E-18uCi/mL	
	First quarter Offsite	0			
	Second quarter Onsite	0			
	Second quarter Offsite	0			
	Third quarter Onsite	0			
	Third quarter Offsite	0			
	Fourth quarter Onsite	1	40.2 ± 22.6	By Contractor	INTEC
	Fourth quarter Offsite				
2017	First quarter Onsite			34 E-18uCi/mL	
	First quarter Offsite				
	Second quarter Onsite				
	Second quarter Offsite				
	Third quarter Onsite				
	Third quarter Offsite				
	Fourth quarter Onsite				

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Fourth quarter Offsite				
2018	First quarter Onsite			34 E-18uCi/mL	
	First quarter Offsite				
	Second quarter Onsite				
	Second quarter Offsite	1	56 ± 10.4	34 E-18uCi/mL	Arco
	Third quarter Onsite				
	Third quarter Offsite				
	Fourth quarter Onsite				
	Fourth quarter Offsite				
2019	First quarter Onsite			34 E-18uCi/mL	Large negative values noted such as minus 23.
	First quarter Offsite				
	Second quarter Onsite	0		By Contractor	SDA 119th page has a chart of Sr-90, but no results in any table.
	Second quarter Offsite	Below 3s	35 ± 23.8		Blue Dome
	Third quarter Onsite			27 E-18uCi/mL	
	Third quarter Offsite	Below 3s, Very odd result	-112 ± 18.6	27 E-18uCi/mL	Main Gate

Year	Quarter	Detections	Range	Minimum Detectable Concentration	Location of Maximum result
	Fourth quarter Onsite				
	Fourth quarter Offsite				

Table notes: Department of Energy environmental surveillance reports from Idahoeser.com or INLdigitallibrary.inl.gov. Values in units of 1.0E-18uCi/mL air (±2s) or 2 standard deviations and the maximum onsite or offsite value for the year is shown in **bold**. M&O contractor minimum detectable concentration usually not stated in source reports. Location of maximum detection listed in order of highest to lowest value detected in that quarter. Not all quarters onsite are sampled by DOE's environmental surveillance. Earlier monitoring results were reported using 2 standard deviations, from 1998 to 2002. For reports from 2003 on, the results were reported using 1s, so in this table I have multiplied 1s by 2, so that all the entries are reported with 2 standard deviations. For 2013, numerous detections of Sr-90 were declared invalid. The reason given was that the samples were full of uranium-238 decay product bismuth-210.

Table C3. Iodine-131, strontium-90 and cesium-137 radioactivity in milk samples monitored by the Department of Energy.

	Iodine-131, pCi/L		Strontium-90, pCi/L		Cesium-137, pCi/L	
Year	**MDC**	**Max**	**MDC**	**Max**	**MDC**	**Max**
1990	3	ND	2	ND	-	-
1991	1	ND	2	1.9 ± 1.6 (in Idaho Falls, 1 of 10 samples detected Sr-90)	-	-
1992	1	ND	2	1.1 ± 0.8 2.3 ± 1.4 (6 of 10 samples detected Sr-90, locations not stated)	-	-
1993	1	ND	2	1.6 ± 0.5 (Roberts)	-	-
1994	1	ND	2	1.5 ± 1.4 (Arco) 2.7 ± 2.4 (Dietrich)	-	-
1995	2	9.1 ± 8.7	0.5	0.7 ± 0.3 (Terreton) 1.3 ± 0.7 (Dietrich)	-	-
1996	2	4.4 ± 4.1	0.5	0.09 ± 0.06 to 2.2 ± 1.1 (Dietrich) (8 of 9 samples detected Sr-90)	-	-
1997	2	1.9 ± 1.6 (Idaho Falls) 2.4 ± 2.3 (Arco)	0.3	0.6 ± 0.3 (Idaho Falls) 1.4 ± 0.3 (Blackfoot)	-	-
1998	2	ND	0.3	0.31 ± 0.26 (Howe) 0.68 ± 0.33 (Dietrich)	-	-
1999	2	ND	0.3	0.44 ± 0.18 (Arco) 1.1 ± 0.3 (Carey)	-	-
2000	3	ND	5	0.46 ± 0.41 (Minidoka) 1.7 ± 1.6	(1E-7 microcuries	2.59 ± 2.22 (Howe) 15.4 ± 5.94

Year	Iodine-131, pCi/L		Strontium-90, pCi/L		Cesium-137, pCi/L	
	MDC	Max	MDC	Max	MDC	Max
				(Roberts)	per gram)	pCi/L (Minidoka) (20 Cs-137 detections in milk samples)
2001	3	1.9 ± 1.7 to 8.1 ± 4.4 (no locations given for the 6 detections out of 316 samples)	5	0.4 ± 0.3 (Moreland) 1.2 ± 0.7 (Roberts) (9 of 10 samples had Sr-90 detection)	Not available	1.7 ± 1.6 6.2 ± 6.0 pCi/L (Idaho Falls) (9 Cs-137 detections in milk samples)
2002	3	5.26 ± 3.02 (Roberts)	5	0.49 ± 0.38 (Rupert) 5.89 ± 4.60 (Blackfoot) (11 of 13 samples had Sr-90 detection)	1	1.57 ± 1.49 (Idaho Falls) (1 Cs-137 detection in milk samples)
2003	3	ND	5	0.7 ± 0.2 (Howe) 1.4 ± 0.3 (1s) (Terreton)	1	ND
2004	3	ND	5	0.6 ± 0.2 (1s) (Idaho Falls) 1.2 ± 0.2 (1s) (Roberts) (3 of 9 samples had Sr-90 detection)	1	ND
2005.	3	ND	5	0.3 ± ? (Moreland) 1.2 ± ? (Carey) (8 of 9 samples had Sr-90 detection)	1	3.1 ± ? (Idaho Falls) (1 Cs-137 detection in milk samples)
2006	3	ND	5	0.26 ± ? (Howe) 1.05 ± ?	1	4.1 ± ? (Ucon, Deitrich or

Year	Iodine-131, pCi/L		Strontium-90, pCi/L		Cesium-137, pCi/L	
	MDC	Max	MDC	Max	MDC	Max
				(Carey) (9 of 10 samples had Sr-90 detection)		Moreland) (6 Cs-137 detections in milk samples)
2007	3	ND	5	0.3 ± ? (Terreton) 0.57 ± ? (Moreland) (8 of 8 samples had Sr-90 detection)	1	ND
2008	3	ND	5	0.24 ± ? (Fort Hall) 0.73 ± ? (Terreton) (5 of 7 samples had Sr-90 detection)	1	ND
2009	3	ND	5	0.28 ± ? (Dietrich) 1.2 ± ? (Idaho Falls) (6 of 6 samples had Sr-90 detection)	1	ND
2010	3	ND	5	0.06 ± ? (Howe) 1.84 ± ? (Rupert) (12 of 15 samples had Sr-90 detection)	1	One detection "just above detection limit" but on further scrutiny, no radioactivity found.
2011	3	5.1 ± ? (Idaho Falls) 14.3 ± ? (Fort Hall)	5	0.09 ± ? (Howe) 0.65 ± ? (Fort Hall) (7 of 15 samples had Sr-90 detection)	1	ND
2012	3	ND	5	0.07 ± ?	1	States that

Year	Iodine-131, pCi/L		Strontium-90, pCi/L		Cesium-137, pCi/L	
	MDC	Max	MDC	Max	MDC	Max
				(Terreton) 2.13 ± ? (Howe) (9 of 13 samples had Sr-90 detection)		one sample was at "lower detection limit" and on recount was not detected.
2013	1	ND	0.2	0.68 ± ? (Fort Hall) 2.37 ± ? (Fort Hall) (16 of 16 samples had Sr-90 detection)	1	ND
2014	1	ND	0.2	0.14 ± ? (Howe) 0.66 ± ? (Rupert) (13 of 16 samples had Sr-90 detection)	1	ND
2015	0.61 (Q2)	ND	0.2	0.11 ± ? (Blackfoot) 0.64 ± ? (Idaho Falls) (13 of 15 samples had Sr-90 detection)	No longer reported in annual report, see 2nd and 4th quarterly reports.	ND Annual reports stated "not detected" without stating detection capability
2016	0.55 (Q2)	ND	0.24	0.03 ± 10 (1s) (Howe) **-0.58 ± 10 (1s) (Howe)*** 0.51 ± 0.1 (1s) (Blackfoot) 0.51 ± 0.1 (1s) (Blackfoot) (10 of 14 samples had Sr-90	0.85	ND

Year	Iodine-131, pCi/L		Strontium-90, pCi/L		Cesium-137, pCi/L	
	MDC	Max	MDC	Max	MDC	Max
				detection)		
2017	0.27	ND	0.22	0.22 ± 0.05 (1s) (Howe) 0.42 ± 0.06 (1s) (Blackfoot) (9 of 13 samples had Sr-90 detection)	0.83	ND
2018	0.5	ND	0.075 (Q2)	0.14 ± 0.05 (1s) (Howe) 0.21 ± 0.05 (1s) (Blackfoot) (3 of 13 samples had Sr-90 detection)	1	ND
2019	0.5	ND	0.2 (Q4)	0.27 ± 0.09 (1s) (Terreton) (1 of 13 samples had Sr-90 detection)	1 (2Q)	ND

Table notes. Units are picocuries per liter (pCi/L) where pico is E-12. Minimum detectable concentration is MDC. Uncertainty is reported here in given in the annual report. The annual reports gave uncertainty as 2 standard deviations (± 2s) until 2003 when the results were expressed as 1 standard deviation (± 1 s). Uncertainties may be available in quarterly reports but were not reported here if not available in the annual report. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. "ND" means reported as not detected. In 2016, the large negative value for strontium-90 in milk is unusual and has the effect of lowering the average value the annual report stated in its Table 7-2.

In 2016, a quite large negative result was reported for strontium-90 in milk in Howe. A large net radioactivity indicates that the background level was higher than the level in the milk, but this raises questions as to why the background or blank was so much more radioactive than the milk sample. Such questions never appear to be raised by the Department of Energy as increasingly more commonly, large negative values are reported.

Table C4. Tritium in milk, tritium in atmospheric vapor and tritium in precipitation as monitored by the Department of Energy.

	Tritium in milk, pCi/L		Tritium in atmospheric vapor, E-15uCi/mL		Tritium in precipitation, pCi/L	
Year	**MDC**	**Max**	**MDC**	**Max**	**MDC**	**Max**
1990	400 pCi/L (is equal to 4E-7 uCi/mL)	ND	10,000 E-15uCi/mL (is equal to 1.0E-11 uCi/mL)	1590 ± 80 (2s) (Idaho Falls)	-	-
1991	400	ND	10,000	700 ± 200 (2s) (onsite CFA or Van Buren)	-	-
1992	400	ND	10,000	800 (onsite EFS)	400	ND
1993	400	ND	10,000	ND	400	900 ± 200 (2s) (onsite EFS)
1994	400	ND	10,000	ND	400	ND
1995	300	170 (Blackfoot)	300	700 ± 200 (2s) (Idaho Falls)	300	190 ± 170 (2s) (Idaho Falls)
1996	300	150 (Arco)	300	100 ± 80 (2s) (Idaho Falls)	300	360 ± 100 (2s) (Idaho Falls)
1997	100	ND	300	"detection questionable"	100	190 ± 100 (2s) (onsite EFS)
1998	100	ND	4000	490 ± 200 (2s) (Blackfoot) 460 ± 200 (2s) (Idaho Falls)	100	490 ± 110 (2s) (onsite EFS)
1999	100	ND	4000	970 ± 720 (2s) (Rexburg)	100	270 ± 100 (2s) (onsite EFS)
2000	300	No analysis performed [92]	4000	265 ± 92 (2s) (Idaho Falls) 297 ± 147 (2s) (Blackfoot)	300	553 ± 78 (2s) (onsite EFS)
2001	300	102.7 ± 71.9 (2s) (Roberts)	4000	**2000 ± 510 (2s) (Atomic City)**	300	269 ± 65.8 (2s) (onsite EFS)
2002	300	ND	200	**9340 ± 490 (2s) (Idaho Falls)** * note that there is no data in the	100	290 ± 59.4 (2s) (onsite CFA)

Year	Tritium in milk, pCi/L		Tritium in atmospheric vapor, E-15uCi/mL		Tritium in precipitation, pCi/L	
	MDC	Max	MDC	Max	MDC	Max
				2Q report for 2002		
2003	300	ND	200	**4900 ± 510 (1s) (Atomic City)**	100	292 ± 29.4 (1s) (onsite CFA)
2004	300	107 ± 27 (2s) (Blackfoot)	200	775 ± 180 (1s) Rexburg	100	200 ± 28 (1s) (onsite EFS)
2005	300	ND	200	980 ± 140 (1s) Blackfoot	100	185 ± 31.3 (1s) (Idaho Falls) EPA RadNet 1720 pCi/L on October 15, and in 2005, NRF ceases reporting in ESER
2006	300	115 ± ? (1s) (Idaho Falls) (detected in 3 of 9 samples)	200	1420 ± 130 (1s) (Rexburg)	100	274 (no uncertainties given) (onsite CFA)
2007	300	ND	200	1700 ± 280 (1s) (Idaho Falls)	100	164 ± 31 (1s) (Idaho Falls) 331 ± 35 (1s) (onsite EFS)
2008	300	117 ± ? (1s) (detected in 3 of 7 samples, no locations given)	200	1900 ± 280 (1s) (Blackfoot)	100	221 ± 36 (1s) (onsite EFS) *note that ESER text and table state incorrect units
2009	150	154 ± ? (1s) (Rupert)	200	**3400 ± 380 (1s) (Atomic City)** **1900 ± 380 (1s)**	100	333 ± 38 (1s) (Idaho Falls)

Year	Tritium in milk, pCi/L		Tritium in atmospheric vapor, E-15uCi/mL		Tritium in precipitation, pCi/L	
	MDC	Max	MDC	Max	MDC	Max
		(detected in two of six samples)		**(Rexburg)**		375 ± 39 (1s) (onsite EFS)
2010	150	219 ± ? (1s) (Rupert) (detected in 3 of 16 samples)	200	**5000 ± 1500 (1s) (Idaho Falls)**	100	137 ± 34 (1s) (Idaho Falls 251 ± 36 (1s) (onsite EFS)
2011	150	285 ± ? (1s) (Terreton) (detected in 3 of 15 samples)	200	930 in Idaho Falls to 1010 in Blackfoot to 1180 in Rexburg to 1410 in Atomic City. No uncertainties provided in annual report.	100	177 in Idaho Falls, 206 onsite EFS. No uncertainties given in annual report.
2012	150	139 ± ? (1s) (Dietrich) (detected in 8 of 12 samples)	200	1180 (Rexburg) 1170 (Idaho Falls) No uncertainties provided.	100	357 in Idaho Falls, no uncertainties given
2013	150	204 ± ? (1s) (Fort Hall) (detected in 9 of 16 samples)	200	1540 (Rexburg/Sugar City) No uncertainties provided.	150	163 in Idaho Falls
2014	100	141 ± ? (no uncertainty given) (Dietrich) (detected in 6 of 16 samples)	200	**2833 (Idaho Falls) No uncertainties given.**	100	311 onsite at EFS. -62 to 188 in Idaho Falls. Uncertainties not reported.
2015	74.8	144 ± ? (1s) (Dietrich) (detected in	200	1550 (Sugar City)	100	393 ± 27.1 (1s) (Idaho Falls)

Year	Tritium in milk, pCi/L		Tritium in atmospheric vapor, E-15uCi/mL		Tritium in precipitation, pCi/L	
	MDC	Max	MDC	Max	MDC	Max
		9 of 15 samples)				
2016	86.6	177 ± ? (1s) (Howe) (detected in 10 of 14 samples)	75.8	**2160 ± 280 (Sugar City)**	100	-173 ± 20.4 (onsite CFA) 192 ± 26.7 (onsite CFA) -223 ± 26 (Idaho Falls) (1s)
2017	92.1	87 ± ? (1s) (Terreton) (detected in 4 of 14 samples)	200	1580 ± 210 (Atomic City)	83.8	-116 ± 23.9 (1s) (Howe) 207 ± 25.5 (1s) (Atomic City)
2018	85.8	171 ± 30 (1s) (Minidoka) (detected in 6 of 14 samples)	200	1740 ± 220 (Idaho Falls)	88	299 in Idaho Falls
2019	92.2 (4Q)	ND	200 (440 in 4Q)	1280 ± 229 (Idaho Falls)	88 (93.4 in 4Q)	144 ± 25.1 (1s) (Atomic City

Table notes. Units for tritium in milk or precipitation are given here in picocuries per liter (pCi/L) where pico is E-12. Tritium concentrations in air in atmospheric moisture, is given here in E-15 microcuries per milliliter (E-15 uCi/mL) where micro is E-6. Values of tritium in atmospheric vapor exceeding 2000 E-15uCi/mL are **bolded**. Minimum detectable concentration is MDC. Uncertainty is reported here in given in the annual report. The annual reports gave uncertainty as 2 standard deviations (± 2s) until 2003 when the results were expressed as 1 standard deviation (± 1 s). Uncertainties may be available in quarterly reports but were not reported here if not available in the annual report. "<MDC" represents "below MDC" and this is the entry in the ESER monitoring results. "ND" means reported as not detected. In 2016, the large negative value for strontium-90 in milk is unusual and has the effect of lowering the average value the annual report stated in its Table 7-2.

APPENDIX D – Idaho Department of Environmental Quality Radiological Monitoring

The State of Idaho DEQ has removed from its website all of the data and annual surveillance reports from its INL Oversight Program prior to 2013. The increased releases from the INL between 2000 and 2013 and the increased monitoring program detections have been removed from public online access by the Idaho Department of Environmental Quality.

The State of Idaho DEQ went from displaying all of their environmental monitoring reports to displaying ten years of the reports, to know displaying only six years of annual reports and only 4 years of quarterly data reports from 2013 to 2018.

A warning about radionuclide air concentration units — the units can make your head spin. The units often used by the Idaho Department of Environmental Quality's INL Oversight Program [79] that included radiological surveillance are femtocuries/m^3 and by the Department of Energy, 1.0E-15 microcuries/mL and these units are actually equivalent. It can be helpful to know that femto is 1.0E-15, that micro is 1.0E-6 and often symbolized with the Greek letter µ or simply the letter "u" and that there are 1000 milliliters in a liter, and there are 1000 liters in 1 cubic meter ($m^{3)}$.

1.0 fCi/m^3 = 1.0E-15Ci/m^3 = 1.0E-15 microcuries/mL

Similarly, concentrations in air of a particular radionuclide are often expressed in attocuries, or 1.0E-18 curies/m^3 which equals 1.0E-18 microcuries/milliliter.

1.0 aCi/m^3 = 1.0E-18 Ci/m^3 = 1.0E-18 microcuries/mL

Table D1. Gross alpha and gross beta air monitoring by the Idaho DEQ, 2013 to 2018, the only years data available on the Idaho Department of Environmental Quality website despite monitoring since the 1989.

Analyte	Date	Min (fCi/m^3)	Max (fCi/m^3)	Average (fCi/m^3)	MDC (fCi/m^3)	100 mrem DOE DCG (fCi/m^3)
Gross Alpha	2013	0.01	2.97	0.95 ± 0.12	?	40
Gross Alpha	2014	0.12	4.98	0.95 ± 0.12		40
Gross Alpha	2015	0.10	5.79	0.99 ± 0.12		40
Gross Alpha	2016	-0.32	4.35	0.89 ± 0.12		40
Gross Alpha	2017	-0.03	4.8	0.9 ± 0.2		40
Gross Alpha	2018	0.1	4.0	1.0 ± 0.1		40
Gross Alpha	2019	0.1	3.3	0.9 ± 0.1		40
Gross Beta	2013	8.35	116.6	31.1 ± 0.6	?	240
Gross Beta	2014	6.58	95.97	25.95 ± 0.59		240

[79] See Idaho Department of Environmental Qualities INL Oversight Program monitoring annual and quarterly reports online at https://www.deq.idaho.gov/idaho-national-laboratory-oversight/inl-oversight-program/monitoring-activities/

Analyte	Date	Min (fCi/m^3)	Max (fCi/m^3)	Average (fCi/m^3)	MDC (fCi/m^3)	100 mrem DOE DCG (fCi/m^3)
Gross Beta	2015	5.58	155.21	26.90 ± 0.58		240
Gross Beta	2016	6.46	86.71	25.62 ± 0.59		240
Gross Beta	2017	3.0	109.8	26.9 ± 1.2		240
Gross Beta	2018	9.2	77.2	27.9 ± 0.6		240
Gross Beta	2019	6.9	167.8	30.3 ± 1.3		240

Table notes: MDC is minimum detectable concentration. Units: fCi/m^3 is femtocuries per cubic meter or 1.0E-15 Ci/m^3

Table D2. Tritium air monitoring by the Idaho DEQ, 2013 to 2018.

Analyte	Date	Min	Max	Average (pCi/m^3)	MDC (pCi/m^3)	[DOE DCG] (pCi/m^3)
Tritium, EFS	2013, July 22 through August 22	-	-	1.09 ± 0.45		[DOE DCG of 210,000]
Tritium, EFS	2014, August 7 through August 22	-	-	1.97 ± 1.14	?	
Tritium, EFS	2015, July 20 through August 11	-	-	0.86 ± 0.86	?	
Tritium, Van Buren	2015, June 23 through July 2	-	-	1.18 ± 0.55	?	
Tritium, EFS	2017, August 4 through September 7	-	-	0.88 ± 0.42	0.63	
Tritium, EFS	2018, August 27 to September 25	-	-	1.25 ± 0.77	0.77	

Table notes: MDC is minimum detectable concentration. Units: pCi/m^3 is picocuries per cubic meter or 1.0E-12 Ci/m^3. According to quarterly reports, tritium air monitoring by the Idaho DEQ has an action level of 150 pCi/m^3 which corresponds to 150,000 fCi/m^3 or 150,000 E-15 Ci/m^3.

Table D3. Strontium-90, americium-241, plutonium-238 and plutonium-239 air monitoring by the Idaho DEQ, 2013 to 2018.

Analyte/ Location	Date	Min	Max	Average (aCi/m^3)	MDC (aCi/m^3)	40 CFR 61 (aCi/m^3)	DOE DCG (fCi/m^3)
Sr-90, Rest Area	2013	-	-	23.2 ± 9.1	14.3	1900	25,000 fCi/m^3 or 25,000,000 aCi/m3
Sr-90, EFS	2014	-	-	16.4 ± 7.6	13.2		25,000 fCi/m^3
Sr-90, Atomic City	2018	-	-	18.8 ± 8.2	13.5		25,000 fCi/m^3

Analyte/ Location	Date	Min	Max	Average (aCi/m^3)	MDC (aCi/m^3)	40 CFR 61 (aCi/m^3)	DOE DCG (fCi/m^3)
Sr-90, Mud Lake	2018	-	-	19.8 ± 8.1	13.0		25,000 fCi/m^3
Sr-90, Craters of the Moon	2018	-	-	14.2 ± 6.6	10.7		25,000 fCi/m^3
Sr-90, Fort Hall	2018	-	-	19.1 ± 7.3	11.4		25,000 fCi/m^3
Sr-90, Rest Area	2019	-	-	23.9 ± 8.0	9.0		25,000 fCi/m^3
Sr-90, EFS	2019	-	-	**148.4 ± 36.6**	15.7		25,000 fCi/m^3
Sr-90, Sand Dunes	2019	-	-	9.0 ± 3.8	4.9		25,000 fCi/m^3
Sr-90, Van Buren	2019	-	-	**115.7 ± 28.9**	11.4		25,000 fCi/m^3
Sr-90, Atomic City	2019	-	-	47.0 ± 12.9	9.2		25,000 fCi/m^3
Sr-90, Howe	2019	-	-	28.8 ± 8.5	7.8		25,000 fCi/m^3
Sr-90, Monteview	2019	-	-	31.3 ± 9.5	8.5		25,000 fCi/m^3
Sr-90, Mud Lake	2019	-	-	50 ± 13.9	10.2		25,000 fCi/m^3
Sr-90, Craters of the Moon	2019	-	-	25.9 ± 7.8	7.4		25,000 fCi/m^3
Sr-90, Fort Hall	2019	-	-	16.4 ± 9	13.1		25,000 fCi/m^3
Sr-90, Idaho Falls	2019	-	-	13.1 ± 8.2	12.3		25,000 fCi/m^3
Am-241, Van Buren	2013	-	-	2.3 ± 1.6	2.1	190	41 fCi/m^3
Am-241, Idaho Falls	2017	-	-	3.3 ± 2.6 (~2s)	3.6	190	41 fCi/m^3
Am-241, Idaho Falls	2017	-	-	3.5 ± 3.2 (~2s)	4.7	190	41 fCi/m^3
Am-241, Idaho Falls	2018	-	-	5.5 ± 4.1 (~2s)	6.0	190	41 fCi/m^3
Am-241, EFS	2019	-	-	0.3 ± 0.3 (~2s)	0.4	190	41 fCi/m^3
Am-241, Fort Hall	2019	-	-	0.4 ± 0.2 (~2s)	0.3	190	41 fCi/m^3
Pu-238	(2013)			ND	?	210	37 fCi/m^3
Pu-238, Idaho Falls	2014	-	-	3.2 ± 2.0	2.7	210	37 fCi/m^3

Analyte/ Location	Date	Min	Max	Average (aCi/m^3)	MDC (aCi/m^3)	40 CFR 61 (aCi/m^3)	DOE DCG (fCi/m^3)
Pu-238, Howe	2015	-	-	7.5 ± 4.9	6.6	210	37 fCi/m^3
Pu-238, Sand Dunes Tower	2015	-	-	5.7 ± 4.0	5.5	210	37 fCi/m^3
Pu-238, Howe	2018	-	-	7.2 ± 3.8	4.8	210	37 fCi/m^3
Pu-238, Monteview	2018	-	-	5.8 ± 3.9	5.7	210	37 fCi/m^3
Pu-238, Craters of the Moon	2018	-	-	7.9 ± 4.6	6.3	210	37 fCi/m^3
Pu-238, Atomic City	2018	-	-	7.3 ± 3.8	4.9	210	37 fCi/m^3
Pu-238, Rest Area	2018	-	-	9.9 ± 4.2	4.7	210	37 fCi/m^3
Pu-238, Idaho Falls	2018	-	-	9.6 ± 4.7	6.1	210	37 fCi/m^3
Pu-238, EFS	2019	-	-	0.5 ± 0.4	0.6	210	37 fCi/m^3
Pu-238, Van Buren	2019	-	-	0.3 ± 0.2	0.1	210	37 fCi/m^3
Pu-238, Monteview	2019	-	-	0.3 ± 0.2	0.1	210	37 fCi/m^3
Pu-238, Mud Lake	2019	-	-	0.3 ± 0.2	0.1	210	37 fCi/m^3
Pu-238, Craters	2019	-	-	0.2 ± 0.2	0.1	210	37 fCi/m^3
Pu-239/240, EFS	2014	-	-	1.7 ± 1.2	1.5	200	34 fCi/m^3
Pu-239/240, Idaho Falls	2014	-	-	2.5 ± 1.3	1.1	200	34 fCi/m^3
Pu-239/240, Atomic City	2015	-	-	1.4 ± 1.6	1.0	200	34 fCi/m^3
Pu-239/240, Howe	2015	-	-	2.4 ± 2.0	1.1	200	34 fCi/m^3
Pu-239/240, Rest Area	2015	-	-	3.2 ± 2.0	0.9	200	34 fCi/m^3
Pu-239/240, Sand Dunes Tower	2015	-	-	1.4 ± 1.6	1.0	200	34 fCi/m^3
Pu-239/240, Atomic City	2017	-	-	0.9 ± 1.3	0.8	200	34 fCi/m^3
Pu-239/240, Monteview	2017	-	-	2.0 ± 1.6	1.9	200	34 fCi/m^3
Pu-239/240, Howe	2018	-	-	4.9 ± 2.6	2.5	200	34 fCi/m^3
Pu-239/240, Mud Lake	2018	-	-	2.1 ± 1.6	0.8	200	34 fCi/m^3

Analyte/ Location	Date	Min	Max	Average (aCi/m^3)	MDC (aCi/m^3)	40 CFR 61 (aCi/m^3)	DOE DCG (fCi/m^3)
Pu-239/240, Craters of the Moon	2018	-	-	2.9 ± 2.1	2.7	200	34 fCi/m^3
Pu-239/240, Rest Area	2019	-	-	0.3 ± 0.2	0.1	200	34 fCi/m^3
Pu-239/240, EFS	2019	-	-	0.7 ± 0.5	0.6	200	34 fCi/m^3
Pu-239/240, Van Buren	2019	-	-	0.5 ± 0.2	0.2	200	34 fCi/m^3
Pu-239/240, Atomic City	2019	-	-	0.4 ± 0.2	0.2	200	34 fCi/m^3
Pu-239/240, Mud Lake	2019	-	-	0.6 ± 0.4	0.3	200	34 fCi/m^3
Pu-239/240, Craters of the Moon	2019	-	-	0.4 ± 0.2	0.1	200	34 fCi/m^3
Pu-239/240, Fort Hall	2019	-	-	0.7 ± 0.4	0.2	200	34 fCi/m^3
Pu-239/240, Idaho Falls	2019	-	-	0.4 ± 0.3	0.3	200	34 fCi/m^3

Table notes: MDC is minimum detectable concentration. Units: fCi/m^3 is femtocuries per cubic meter or 1.0E-15 Ci/m^3; aCi/m^3 is attocuries per cubic meter or 1.0E-18 Ci/m^3. The action levels from the Idaho DEQ monitoring reports are said to be 10 percent of Appendix E, Table 2 of 40 CFR 61. The Department of Energy "Derived Concentration Guidelines" (DCG) were taken from a 2013 Idahoeser.com Idaho National Laboratory Environmental Monitoring report, which was based on DOE-STD-1196-2011 and supposedly for 100 mrem/yr.

Appendix D - Correspondence of cancelling the TRA Pond Air Permit, May 29, 2020 on the Idaho Department of Environmental Quality website

STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY
1410 North Hilton • Boise, ID 83706 • (208) 373-0502
www.deq.idaho.gov
Brad Little, Governor
John H. Tippets, Director

May 29, 2020

VIA EMAIL

William E. Miller
Deputy Manager for Nuclear Energy Facilities and Operations
U.S. Department of Energy – Idaho Operations Office
1955 Fremont Avenue, MS 1235
Idaho Falls, ID 83415

RE: Facility ID No. 023-00001, U.S. Department of Energy – Idaho Operations Office
Permit to Construct Termination, PTC No. 023-00001

Dear Mr. Miller:

On March 2, 2020, DEQ received a request from the Idaho National Laboratory (INL) to terminate PTC No. 023-00001, issued on September 9, 2002, to the U.S. Department of Energy for the TRA Evaporation Pond.

On March 16, 2020, DEQ received documentation from the INL that dose modeling was conducted to verify that the dose to the maximally exposed person from operation of the TRA Evaporation Pond met the 0.1 mrem/yr exemption threshold so that approval to construct from the Environmental Protection Agency in accordance with 40 CFR Part 61, Subpart H, §61.96 would not be required. Actual dose impacts were reported to range from 2.85E-3 mrem/yr to 6.90E-3 mrem/yr between 2011 and 2018. Since approval to construct would not be required by 40 CFR Part 61, Subpart H, the source would also qualify for an exemption from the need to obtain a permit to construct (PTC) from the DEQ in accordance with IDAPA58.01.01.221.02.

Since the operation of the TRA pond would qualify for an exemption in accordance with IDAPA58.01.01.221.02 today, DEQ hereby terminates Permit to Construct No. PTC No. 023-00001, issued on September 9, 2002, including any permit conditions that originated from 40 CFR 52.21, effective immediately. At the time of initial permit issuance on October 26, 1990 the TRA Evaporation pond was subject the permit requirements of 40 CFR 52.21 due solely to radionuclide emissions. Since that time 40 CFR 52.21 has been amended and radionuclides are no longer subject to those permitting

requirements and the requirements originating from that regulation may be rescinded in accordance with 40 CFR 52.21(w)(3).
This termination does not relieve INL from the obligation to comply with all other applicable requirements of 40 CFR Part 61, Subpart H.

If you have any questions about this termination, please contact me at (208) 373-0500 or daniel.pitman@deq.idaho.gov.

Sincerely,
Dan Pitman, PE
Senior Permitting Engineer
Air Quality Division

Permit No. 023-00001 PROJ 62397