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Straight Talk is Rare
Concerning Radioactive and Chemical Contamination from the Idaho National Laboratory in the Snake River Plain Aquifer

While the repeated refrain is that the US Geological Survey has been rigorously monitoring the Snake River Plain Aquifer since the Idaho National Laboratory's inception at the National Reactor Testing Station in 1949, there is a lot of devil in the details about what, when and where the contamination has spread.

How much and what was directly injected into the aquifer via disposal wells or seeped from percolation ponds, storage canal leakage or buried waste? Where did the contamination go and when? What levels of contamination reached people, farms and communities? How much dilution can be expected as the plume moves south of the INL? What is the role of global fallout in elevated tritium levels south of INL? How much more is poised to migrate into the aquifer and flow south, southwest or southeast? And what are the health implications of the contamination?

The understanding of each of these issues has continued to evolve and there is only one thing you can count on: you will not necessarily get straight answers from the Department of Energy or the US Geological Survey. [1]

I don't have all the answers. But let's explore some of the information.

How much and what was injected into disposal wells or seeped from percolation ponds, storage canal leakage or buried waste? Although USGS reports often provide helpful

[1] US Geological Survey website link: http://id.water.usgs.gov/projects/INL and INL bibliography at http://id.water.usgs.gov/INL/Pubs/INL_Bibliography.pdf . Select individual wells at the USGS mapper at http://maps.waterdata.usgs.gov/mapper/index.html **US Geological Survey Mapper Data**: See well data at http://maps.waterdata.usgs.gov/mapper/index.html. For USGS data, I find it easiest to type in the 15 digit well identifier to display the well, which will be highlighted in yellow. Click on the well, click "access data" and select water quality data. You can display all stored data by selecting the "table of data" option. Data for a radionuclide may have been stored in multiple codes over time, i.e., iodine-129 used code 29913 and also 18501. Tritium has used 07000 and 07005.

information about the amount of contaminants disposed of in the aquifer, a brief and ongoing review of INL CERCLA cleanup documents show that the USGS has failed on numerous occasions to identify the Department of Energy's sources of contamination like the disposal injection wells at the INL used for radionuclides. And often the total amount disposed of is unknown even after 20 years of CERCLA studies that begin in the 1990s. Even when Department of Energy disposal records are found, the records are often deliberately unreliable. [2]

Where did the contamination go and when? USGS reports on selected radionuclides at selected wells have often omitted important wells and radionuclides, including radionuclides in wells exceeding drinking water maximum contaminant levels (MCLs). The USGS has taken a decade or so between sampling some wells and rarely samples the same constituents. Trending is difficult by design. USGS has painted a picture in its reports that would lead the reader to assume that anything not reported would not be significant. Unfortunately, that is not the case on the INL site or off site. And don't trust the lines of flow on these figures like the one below, because they don't tell the whole story.

The USGS was monitoring wells and surface water as INL airborne emissions and the DOE's Nevada weapons test fallout blew into Idaho during the 1950s and 60s. But USGS was always under pressure to obscure DOE's weapon test fallout, especially after the 1963 above ground test ban, as well as INL fallout. Lapses in well monitoring, failure to publically report high monitored levels of tritium, for example, and now, the convenient excuse for any high tritium levels in offsite wells or surface water was that it was weapons testing, not the INL. High tritium levels in surface water, had it been reported, could have alarmed the public. High tritium levels in wells far from INL are still a health issue, and the USGS did not know and still doesn't know the source of the tritium. Clearly the USGS is no unbiased oversight institution. And the USGS at INL has focused on DOE's wish to make it appear that very little INL aquifer contamination flowed offsite.

The USGS water monitoring has often began over a decade late after the contamination began. Tritium measurement accuracy was dismal for years as anything under 2000 pCi/L was not distinguished. Tritium monitoring did not begin to be widely used until the 1960s, yet tritium (and more) was being injected into the aquifer via disposal wells and percolation ponds since 1952. The capability of detecting tritium has continued to evolve over the years and the presence of tritium from nuclear weapons testing in Nevada and around the globe by the US and other countries adds complexity which has been handled flippantly.

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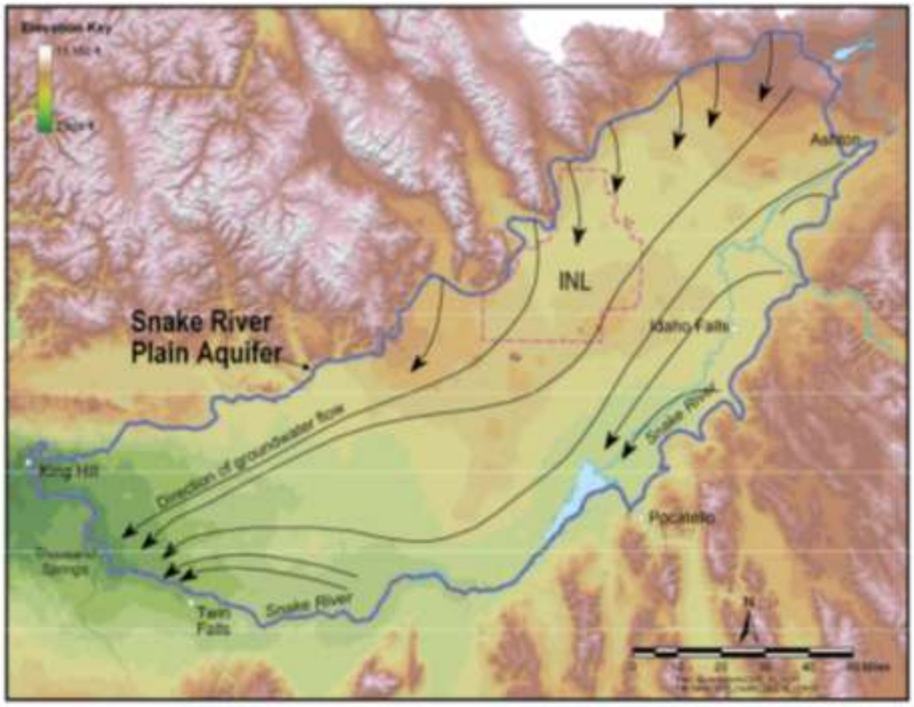
[2] US Geological Survey report 2006-5122 provides a brief history of waste-water disposal practices but identifies only one disposal well at the Test Reactor Area (now the ATR Complex). The "INEEL Subregional conceptual Model Report, Volume 3: Summary of Existing Knowledge of Natural and Anthropogenic Influences on the Release of Contaminants to the Subsurface Environment from Waste Source Terms at the INEEL," INEEL/EXT-03-01169 Rev. 2, September 2003 at https://inldigitallibrary.inl.gov/sti/3562854.pdf identifies two disposal wells at TRA. In addition to reactor and fuel storage pool operations, fuel separations were taking place in the TRA hot cell and hot alpha cave. These areas were washed down and likely flushed to the pond or these disposal wells. CERCLA investigations found 100 times the MCL for americium-241 in shallow perched water at TRA that USGS had never identified and still doesn't monitor or report.



Chemical contaminants in amounts that remain above federal MCLs at numerous INL locations and despite over twenty years of "cleanup" are still increasing. Levels of carbon tetrachloride at INL's Radioactive Waste Management Complex that are double what they were a decade ago are described as not increasing by the USGS, however. [3] Test Area North chemical contamination in the aquifer also continues to worsen despite vacuum vapor extraction at both TAN and RWMC as part of CERCLA cleanup there since 1995. [4]

Not only tritium was disposed of into the Snake River Plain Aquifer from the INL historical operations. Iodine-129, neptunium-237, technetium-99, chlorine-36, carbon-12 and other less mobile radionuclides such as uranium, strontium-90, and cesium-137 were injected into the aquifer at INL's INTEC, the chemical spent fuel separations facility to recover highly enriched uranium from government reactors. A uniquely important study by the USGS that sampled and analyzed aquifer contamination around INTEC was never reported in a USGS or DOE report. It was not made part of the USGS aquifer bibliography until my request that the study, hidden in a closed-access journal, be added to the USGS bibliography. [5]

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[3] See Idaho National Laboratory Citizen's Advisory Board meeting April 2016 at www.inlcab.energy.gov

[4] Department of Energy Idaho Operations Office, *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory Site,* Fiscal Years 2010-2014, DOE/ID-11513, December 2015.

[5] T. M. Beasley, P. R. Dixon, and L. J. Mann, "^{99}Tc, ^{236}U, and ^{237}Np in the Snake River Plain Aquifer at the Idaho National Engineering and Environmental Laboratory," Environmental Science & Technology, 2:3875-3881, 1998.

What levels of contamination reached people, farms and communities? How soon did the INTEC plume reach USGS 14 (also known as MV 61) south of the INL? DOE likes to say it was "by the 1990s." USGS likes to say it was "by the 1980s." But the study of unique contaminants in the well showed that the contamination reached USGS 14 much sooner.

The USGS study of radioactive Chlorine-36 discusses waste water reaching USGS 14 "at least by 1984." [6] But a more detailed report on this topic concludes that analysis of archived samples for Cl-36 showed the waste water had reached USGS 14 south of the INL and east of the Big Southern Butte by the 1970s. [7] This has big implications for the travel time of INTEC disposal injection well arrival times south of the INL.

It also means that the INTEC plume of aquifer contamination that was driven by the large injection volume of water reached Atomic City by the 1970s. And the aquifer there still has elevated tritium levels and other contaminants along with elevated chromium, sodium and nitrate, all markers of the INTEC plume. The contaminated drinking water at the INL's Central Facilities Area receives the INTEC plume and the contamination will slowly head south for years to come. The tritium levels at the Central Facilities area south of INTEC remain high despite the decades of decay for the 12.3 year half life isotope.

The travel time of contaminants in the aquifer is affected by the specific location they enter the aquifer and by whether the contaminants were injected directly into the aquifer with a large liquid waste volume or seeped to the aquifer from percolation ponds. Buried waste with only precipitation as the driver will be slower and the contaminants have to first migrate through soil to reach the aquifer.

The Department of Energy, since the 1980s, is no longer using injection wells. Percolation ponds were then used and pipe leakage from the tank farm and other leakages have continued. Waste was buried at the INL starting in the 1950s and has continued to be buried at INL although burial of transuranic waste from Rocky Flats did cease in the 1970s. The waste is still there above ground waiting to be shipped to the struggling to reopen WIPP underground salt facility in New Mexico. Keep in mind that the Department of Energy is planning to bury more waste at INL at the new replacement for the Radioactive Waste Management Complex. [8] And very little

[6] U.S. Geological Survey, "Evaluation of archived water samples using chlorine isotopic data, Idaho National Engineering and Environmental Laboratory, Idaho 1966-93," DOE/ID-22147, Report 98-4008, 1998. http://pubs.er.usgs.gov/usgspubs/wri/wri984008

[7] L. DeWayne Cecil, "Origin of Chlorine-36 in the Eastern Snake River Plain Aquifer, Idaho: Implications for Describing Ground Water Contamination Near a Nuclear Facility. A thesis presented to the University of Waterloo in fulfillment of the thesis requirement for the degree of Doctor of Philosophy In Earth Sciences Waterloo, Ontario, Canada, 2000. http://www.collectionscanada.gc.ca/obj/s4/f2/dsk3/ftp04/NQ60526.pdf

[8] US Department of Energy, "Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site," Final, DOE/EA-1793, December 2011. http://energy.gov/sites/prod/files/EA-1793-FEA-2011.pdf and see EDI's report "Unwarranted Confidence in DOE's Low-Level Waste Facility Performance Assessment – The INL Replacement Facility Will Contaminate Our Aquifer for Thousands of Years" at http://www.environmental-defense-institute.org/publications/rhllwFINALwithFigs4.pdf

of the buried waste at the Radioactive Waste Management Complex is actually being removed. [9] [10]

How much dilution can be expected as the plume moves south, southwest or southeast? The models being used by the Department of Energy represent mixing and dilution down aquifer from waste burial. But take a look at aquifer plumes and well monitoring values and a different perspective emerges. There are fast paths that don't have so much dilution. [11] Look at the relatively constant values of tritium or I-129 in wells south of INL. [12] Yes, there was dilution compared to the original source but there can be surprisingly persistent contaminant levels for miles.

The aquifer is said to flow in a southwest direction. But this is an oversimplification as the fast path report discusses: the flow path can be south and southeast as well. (There is also limited spreading upgradient from the contamination source.) Lines of flow depicted on various aquifer reports need to be taken with a grain of salt. This has important ramifications for the communities south of INTEC.

The USGS multilevel well monitoring at the southern INL boundary showed that significant stratification of contamination occurs. [13] The further away the waste was injected, the lower in the aquifer it tends to be found. The depth sampled can affect the contamination levels by a factor of 10 or 100. Aquifer depth varies and so does the pathway through the nonhomogeneous basalt.

The more heavily used INL drinking water or production wells or downstream agriculture wells draw more contamination toward them. The depth the sample was taken at and the mixing that occurred as well as the seasonal change in water depth in the well: many factors will affect the level of measured contamination at a particular location. This problem is made worse by the

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

[10] See that the publically available administrative record for RWMC cleanup does not contain the assessment of radionclide migration and radioactive doses after 10,000 years. The pre-10,000 year contaminant migration is artificially suppressed for the first 10,000 years and then rapidly escalates and stays elevated for hundreds of thousands of years. See the Administrative Record at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) documents for documents associated with this cleanup action, including "Record of Decision" documents and EPA mandated Five-year Reviews at http://ar.inel.gov or http://ar.icp.doe.gov

[11] Thomas M. Johnson et al., *Geology*, "Groundwater "fast paths" in the Snake River Plain aquifer; Radiogenic isotope ratios as natural groundwater tracers," October 2000; v. 28; no. 10; 871-874.

[12] L. Flint Hall, IDEQ, "Concentrations of Selected Trace Metals, Common Ions, Nutrients, and Radiological Analytes in Ground Water for Selected Sites, Snake River Plain Aquifer, South of the Idaho National Laboratory, Idaho," OP-06-03, 2005. https://www.deq.idaho.gov/inl-oversight/monitoring/reports/

[13] Bartholomay, R.C., Hopkins, C.B., and Maimer, N.V., 2015, Chemical constituents in groundwater from multiple zones in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2009–13: U.S. Geological Survey Scientific Investigations Report 2015–5002 (DOE/ID-22232), 110 p., *http://dx.doi.org/10.3133/sir20155002*.

USGS's irregular sampling practices. In fact, finding high radioactivity in wells did not necessarily lead to more sampling of offsite wells.

What is the role of global fallout in elevated tritium levels south of INL? Can the tritium levels above 100 pCi/L in the late 1990s be from global weapons testing and not the INL? Apparently yes. But with evolving and variable accuracies in tritium counting of the sample as well as variability of the concentration with depth in the aquifer and other factors, it gets complicated to sort out.

And what are the health implications of the contamination? What affect did the contaminated water have on residents of Atomic City or other people using the aquifer, even if the contaminants did not exceed federal maximum contaminant levels? Unfortunately, the DOE gets to decide whether the health of the residents should be studied. But the Idaho Cancer Registry does provide clues. [14]

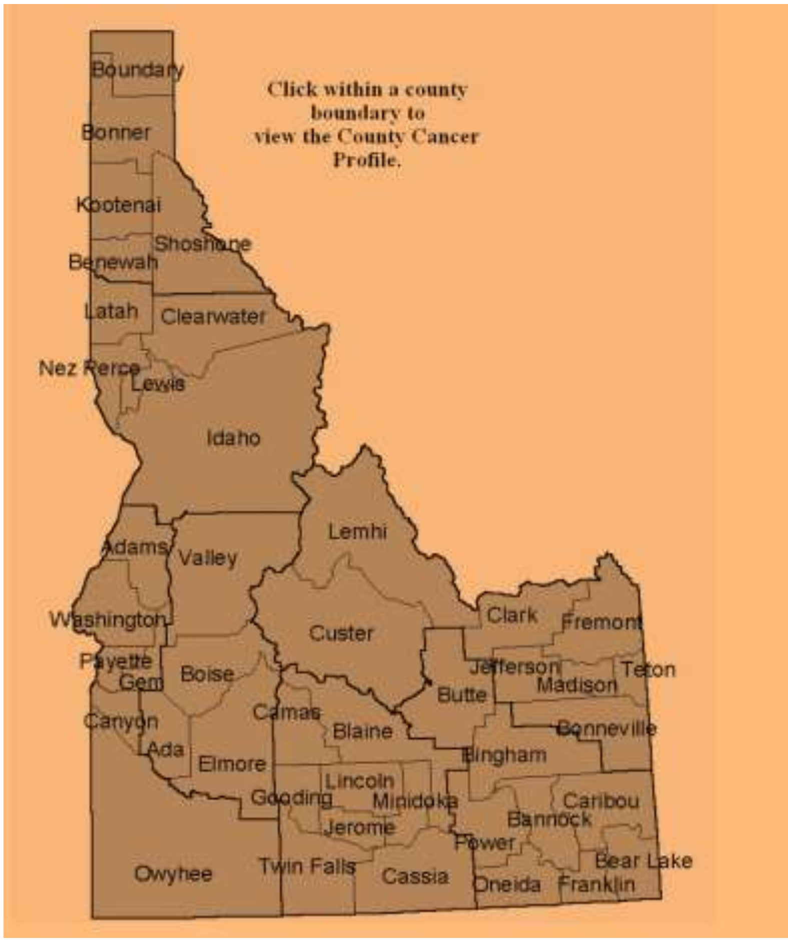
A Limited Review Idaho Cancer Rates from 2009 to 2013

The Idaho counties receiving the highest Nevada weapons test fallout in the 1950s and 1960s are Lemhi, Custer, Blaine and Gem. For perspective on the level of fallout, see the National Cancer Institute's Iodine-131 calculator that allows you to calculate the I-131 in fallout for any county in the US. [15] Lemhi has a much higher rate of cancer incidence (748.4 per 100,000 people) than the State average, 469.0 per 100,000 people. Custer comes in at a rate 674.5. These two adjacent counties with high weapons test fallout did not receive direct INL aquifer contamination and would have less airborne emissions from INL than counties closer to the INL. For both of these counties, Lemhi and Custer, the cancer sites having the higher, actually much higher, than state average rates for these cancer sites: breast, colorectal, esophagus, leukemia, lung and bronchus, skin melanoma, oral cavity and pharynx, and pancreas. Lemhi has much higher non-Hodgkin Lymphoma at 30.5 versus the state rate of 19. Custer has above the state average for thyroid cancer.

Blaine county's overall cancer rate is below the state average, but the county has higher rates of brain cancer, breast, and skin melanoma. Its rate of Non-Hodgkin Lymphoma is near the state average. Its rate of thyroid cancer is low; only 6.6 versus 16.0 for the state.

[14] Idaho Cancer Registry, see the map of counties that can be clicked on to get the 2009 to 2013 cancer incidence and mortality rates by county: http://www.idcancer.org/ContentFiles/special/CountyProfiles/CountyMap.htm

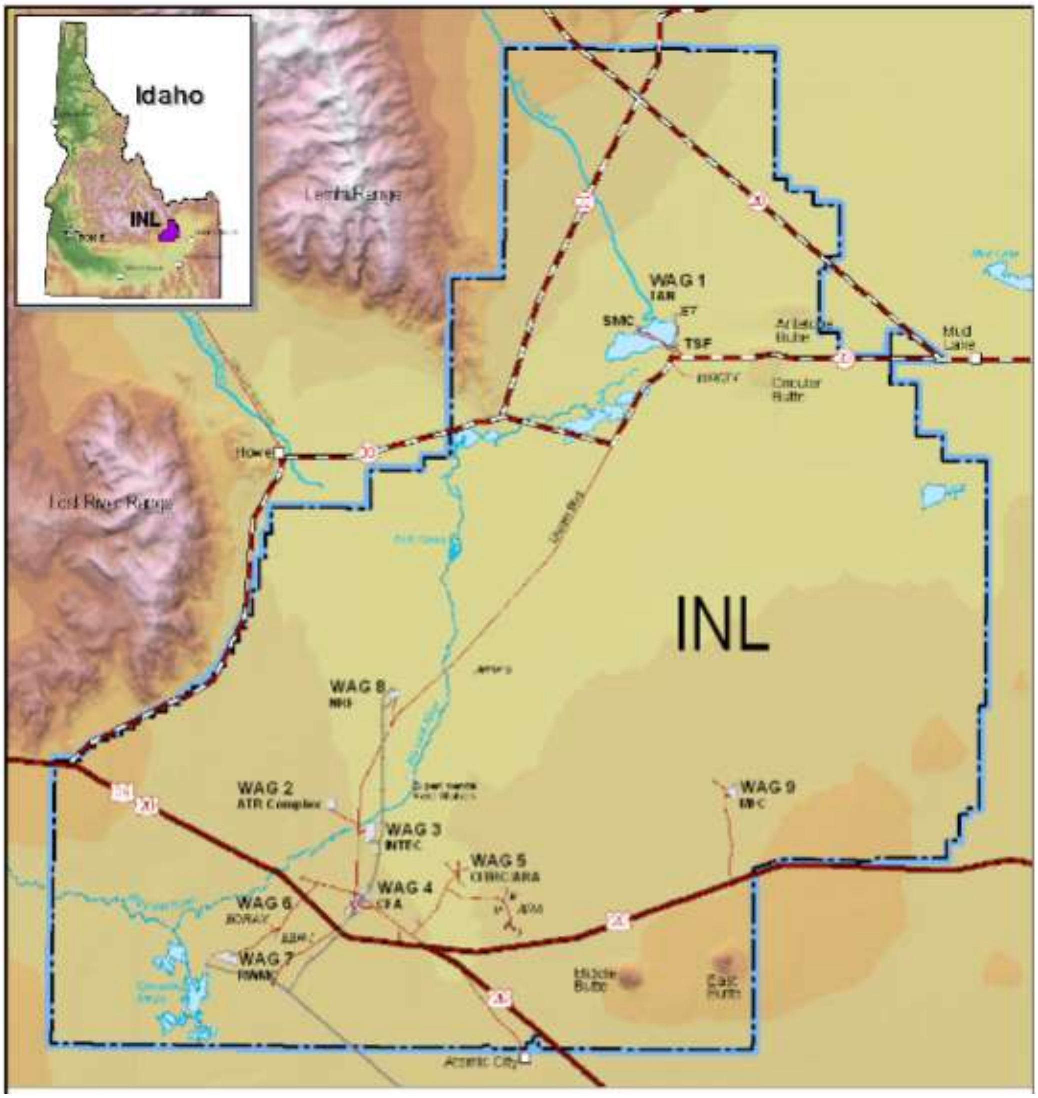
[15] National Cancer Institute, interactive webpage for Radioactive I-131 from Fallout. To see counties affected by weapons tests and dates, see http://www.cancer.gov/cancertopics/causes/i131 and https://ntsi131.nci.nih.gov/



Now a look at just two of the counties exposed to INL air emissions: Butte and Bonneville. There are other counties that get INL air emissions, but let's compare cancer site prevalence for these two. Aside from Butte County's Atomic City, the counties are not exposed to aquifer contamination from the INL. Unfortunately, the state's cancer registry does not allow one to separate Atomic City with its decades of aquifer contamination from INL from the rest of Butte county. Butte and Bonneville host a significant INL site worker population. Butte received more INL fallout from routine, episodic and accident emissions.

The age-adjusted overall cancer rates for the two counties are similar and below the state average. **Thyroid cancer is significantly higher than the state average, 28.8 and 27.7 for Butte and Bonneville county versus state rate of 15.9.** Bonneville and Butte county brain cancer and combined brain and central nervous system (CNS) cancer and leukemia rates nearing or slightly exceeding the state average using age-adjusted rates for Butte county's older population. Butte county has higher than state rates for colorectal, Hodgkin lymphoma, non-Hodgkin lymphoma, kidney and renal cancer, myeloma and testis cancer, making it share similarities with high weapons fallout areas and high INL emissions areas.

Jefferson county to the north of the INL has a cancer rate below the state average, but the age adjustment raises the rate from 342.1 to 420.4 per 100,000 people. That means that more young people are getting cancer in Jefferson county. Like Bonneville county, the brain and brain/CNS cancer rate is higher than the Idaho average. Hodgkin lymphoma, leukemia, and pancreas cancer rates are also very high. **The age adjusted thyroid cancer rate is 22.0 for Jefferson county while the state average is 15.8.** For every thyroid cancer there is likely to be many other cases of thyroid dysfunction that have especially serious implications for the unborn and for children.



While in most counties the age adjusted cancer incidence rate is lower than the basic statistics for the county, except for Butte county those counties surrounding the Idaho National Laboratory have higher age-adjusted cancer rates. This means that younger people are getting cancer at a higher rate than expected for the basic rate for the county in Bonneville, Bannock, Jefferson, Madison, Bingham, Jerome and Lincoln counties. Persistent soil and crop contamination from past and ongoing INL air emissions and genetic effects of radionuclide ingestion and radiation exposure passed on to children may play a role. Not neighboring the INL, Boise, Ada, Elmore, Franklin and Latah also had higher age-adjusted cancer incidence rates with some counties that may have past Hanford or weapons testing fallout to consider.

Now let's look at two adjacent counties south of the INL that may see INL aquifer contamination and may have some airborne emissions from INL: Jerome and Minidoka. They share a common set of cancer sites that exceed the state average: bladder, brain and brain/CNS, cervix, colorectal, corpus uteri, esophagus, Hodgkin lymphoma, larynx, myeloma, oral cavity and pharynx. But Minidoka exceeds the state cancer rate, sometimes almost doubling the rate for brain, breast, esophagus, Hodgkin lymphoma, lung and bronchus, myeloma, non-Hodgkin lymphoma and oral cavity and pharynx.

So what's the story in Minidoka? Could aquifer contaminants from the INL's disposal injection well that dumped vast amounts of radionuclide and chemical contaminants into the aquifer starting in 1953 be a factor? Forget everything USGS and the Department of Energy have ever said to dismiss or fail to see patterns to link contamination to the INL site. And forget every vague and mystifying discussion they have given about how long it takes for water to reach the Snake River at Thousand Springs.

The contaminant patterns at the Minidoka well match the trends in USGS 14, the well located south of the INL and east of the Big Southern Butte. The Minidoka well mimics USGS 14 in regard to some very important tell-tale contaminants from the INTEC chemical reprocessing of high enriched spent fuel disposed of into a disposal injection well: dissolved zinc, dissolved sodium, dissolved potassium, chloride, fluoride, sulfate, and Minidoka sees higher concentrations of these compared to Shoshone at Jerome. Both the Minidoka and Shoshone wells see similar gross alpha, gross beta, and chromium. See Idaho Department of Environmental Quality reports that monitored wells from 1994 to 2001. [16] [17]

At least a portion of the chromium has been found to be hexavalent chromium which the State of California adopted a more stringent limit for carcinogenic hexavalent chromium than the EPA's drinking water standard. California reduced the Maximum contaminant level of 100 mircograms/liter 10 fold after their experience with PG&E in California. [18]

The tritium levels are similar for the two locations but are also not well characterized currently or historically. With Idaho Falls tritium levels being about 50 pCi/L in the late 1990s, the tritium levels, often less than 3 pCi/L, that the USGS came up with in their 2001 report,

[16] L. Flint Hall, Idaho Department of Environmental Quality, "Water Quality Trends for Surveillance Monitoring Sites," 2002. https://www.deq.idaho.gov/inl-oversight/monitoring/reports/ Sample "blanks" were Idaho Falls tap water. ISU tritium counting spiked high apparently due to ISU accelerator cohabitation with the EML water analysis lab.

[17] L. Flint Hall, IDEQ, "Concentrations of Selected Trace Metals, Common Ions, Nutrients, and Radiological Analytes in Ground Water for Selected Sites, Snake River Plain Aquifer, South of the Idaho National Laboratory, Idaho," OP-06-03, 2005. https://www.deq.idaho.gov/inl-oversight/monitoring/reports/

[18] In July 2014, California passed a maximum contaminant level (MCL) for chromium-6 of 0.01 mg/L or 10 ppb.[18] The EPA standard for maximum concentration of chromium-6 remains 10 times higher at 0.1 milligrams per liter or 100 parts per billion (ppb). See http://www.valleywater.org/services/chromium-6.aspx

DOE/ID-22175 appear unbelievably low. The USGS values are also much lower than state sampling that found values from 60 to 100 pCi/L, as well as higher and lower results. So although nitrate plus nitrite is slightly higher at Shoshone in Jerome, the evidence for the INL contamination plume having reached Minidoka is clear. The timing of the plume's arrival is less clear, but US Geological Survey scientists know the plume reached USGS 14 by the early 1970s making it entirely plausible for the plume to have reached Minidoka by 1990.

That doesn't mean that the levels of contamination were not far more dilute than at location within a few miles of the disposal well at the INL site. But with variables such as the stratification of contamination with depth in the aquifer, more contamination reaching areas of highest use, highly variable flow paths through the basalt that yield some fast paths for contaminant travel, it takes multiple samples and routine sampling. The spotty sampling by USGS has been inconclusive by design to say the least. [19] And the still repeated exaggerations by the Department of Energy regarding how long it may take the contaminants to reach the Snake River distort the truth.

The actual soup of contaminants and health effects of the combination of contaminants that people were drinking has never been looked at from biological testing or routine meaningful monitoring. The immune system stress from the contaminants for life-long consumption could be more harmful than assumed by people trusting the federal maximum contaminant levels.

Beyond the aquifer, airborne emissions from the Idaho National Laboratory affect neighboring counties and not just those to the northeast in the direction of the prevailing wind. The climatology shows that the winds blow to the south and southeast as well, to Taber, west of Blackfoot, and on south the Minidoka and other counties. The INL is generous with its spread of radionuclides but frequently doesn't take credit for high airborne gross alpha and gross beta levels despite their own report's monitoring and statistical analysis that the contamination originated at the INL. [20]

Tritium and Your Baby

Tritium is released to the environment from nuclear plants, spent fuel pools, and nuclear weapons tests. The peak of weapons testing tritium emissions was in 1963 but underground tests also released tritium and other airborne radionuclides. The half life of tritium is 12.3 years so the tritium that rain deposited in your surface water would decay by half in that time and also would likely be diluted by additional precipitation or water inflow.

The US Geological Survey and Idaho Department of Environmental Quality show elevated levels for tritium in the Snake River Plain Aquifer south of the Idaho National Laboratory. Aside from recognized tritium plumes near Department of Energy facilities at the Idaho National

[19] US Geological Survey, "Radiochemical and Chemical Constituents in Water from Selected Wells South of the Idaho National Engineering and Environmental Laboratory, Idaho," DOE/ID-22175, Report 01-138. May 2001.

[20] See osti.gov for environmental monitoring reports including the DOE/ID-12082(yr) series reports.

Laboratory, it can be difficult to determine whether tritium is from the INL, Nevada Test Site above ground or post-1963 below ground weapons testing or weapons tests conducted by the US outside the continental US, or weapons testing by other countries. The focus of the US Geological Survey has often been more to obscure DOE weapons fallout as it was happening and later, to obscure contamination of groundwater off the INL site.

Leaving aside for a minute the question of whether it was weapons fallout or the INL, we need to understand what the elevated tritium levels mean.

The federal limit for tritium in drinking water is 20,000 pCi/L (picoCurie/liter). But is it safe to drink even 100 pCi/L? The answer to this question is no it is not safe and don't believe the NRC, the DOE or the Health Physics Society. The reason is that the total energy imparted by tritium is not as important at the fact that the hydrogen in tritium is incorporated into the bodies DNA. The damage caused by the radioactive decay is not randomly dispersed as is cosmic radiation to the body during an airplane ride. While powerful industry interests lobby to keep federal limits for tritium high, the State of California declared a drinking water goal for tritium of less than 100 pCi/L.

Because tritium emits only a very weak beta particle it is very difficult to detect even with normal radiation detection instrumentation. The most common portable radiation-detection instruments, such as Geiger counters and ionization chambers, are usually not capable of detecting tritium. The most reliable and widespread method for detecting tritium is known as liquid scintillation counting and involves mixing tritium samples with a phosphor containing fluid in vials and then placing the vials into a special piece of equipment for analysis. This method can be used to detect the presence of tritium in liquid samples, on surface wipes, or within the human body by collecting and analyzing the urine of a subject. [21] Independent laboratories such as those used by state environmental quality departments will test for tritium in a sample of water for example, for a $100 or more.

Basically all nuclear power plants in the US leak tritium into the environment via pipe leaks to groundwater and/or air emissions.

With rising hopes for small modular nuclear reactors, boosters are expressing the hope that these small plants will be sited even closer to residents as emergency planning zone distances could be reduced. This could worsen the plant emissions and water leakage issues that also affect public health of people living near the plants. Even with existing distances from plant stack to residents, the US Nuclear Regulatory Commission knows this: an honest and thorough study would likely show similar results to the German study of people living near German nuclear power plants: an increase in childhood leukemia and solid cancer.

What the German study did not determine is why. Ian Fairlie lays out the case for possible causes of the elevated levels of childhood leukemia and solid cancer and it ranges from

[21] Health Physics Society tritium factsheet at http://hps.org/documents/tritium_fact_sheet.pdf (The information sheet downplays the health effects of tritium and so the information should be marked "hazardous to your health.")

radioactive gamma shine, electromagnetic radiation from power lines, to water vapor releases from the plants. [22] Rather than the nuclear industry try to get real answers as to the reason for the elevated childhood leukemia and cancer rates near nuclear power plants, they refuse to acknowledge or study the causes.

Since the US Nuclear Regulatory Commission got to decide whether or not to fund the first real human epidemiology study near US nuclear plants and the study risks exposing adverse health effects and thus damaging the nuclear industry — surprise, surprise, the NRC decided not to fund the epidemiology study. Will somebody please tell me why the NRC gets to decide whether or not to perform a public health study? The NRC, as a proponent of nuclear power, has a conflict of interest, and therefore must not be involved in any health study.

We know that BEIR VII found that women were more radiosensitive than men and children more radiosentive than adults. [23] But Fairlie explains that a very important plausible case that the radiosensitivity of embryos and fetuses from internal radionuclides is much higher than has been acknowledged in existing radiation protection standards. He points specifically to the higher tritium and carbon-14 levels in fetal tissues following exposure and higher risk from internal radionuclides than that due to in utero x-rays that were found by Dr. Alice Stewart to cause an increase in leukemia and cancer for children x-rayed in utero.

The nuclear industry denies that the increased childhood leukemia and cancer are because of radioactive plant emissions because, they say, the emissions are too low to have caused the increased risk. The uncertainty in estimating the releases, spikes in releases, erroneous dispersion assumptions and incorrect body clearance assumptions can cause under-representation of dose. And incorrect understanding and modeling of fetal radiosensitivity and the health risk from the dose is highly plausible.

Solid cancer and leukemia are not the only effects of radionuclide exposure of the unborn and of children. Iodine-131 and long-lived Iodine-129 affect infant health. Radioactive air emissions are also known to increase infant deaths. This study of exposure from air emissions and milk ingestion, *The ATSDR Infant Mortality and Fetal Death Analysis*, finalized in November 2000, investigated the association between estimated I-131 exposure and infant

[22] Ian Fairlie, International Journal Occupational Environmental Health, "Hypothesis to Explain Childhood Cancer near Nuclear Power Plants," 2010;16:341-350. http://pgs.ca/wp-content/uploads/2009/06/TRITIUM.Fairlie.2010.IJOEH_July10_Fairlie1.pdf and see further articles at http://www.ncbi.nlm.nih.gov/pubmed/20662426

[23] "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.

mortality, fetal death, and preterm birth. [24] "The study focused on the years 1940–1952, and included the eight Washington counties in the HEDR project (Adams, Benton, Franklin, Grant, Kittitas, Klickitat, Walla Walla, and Yakima). The study used the HEDR project's 1945 exposure estimates for I-131, and found a 70% higher rate of preterm birth and a 30% higher rate of infant mortality in the areas with the highest estimates of I-131 exposures compared to areas with the lowest estimates of exposure." [25]

In the 1990 book, "Deadly Deceit – Low Level Radiation High Level Cover-Up" this epidemiological "whodunit" book discusses weapons tests, Chernobyl, Three Mile Island and more. Elevated infant mortality rates were investigated for two meltdowns at the Department of Energy Savannah River site in 1970. The radiological releases were kept secret until1988. The air-borne releases contaminated air and the food supply, persisting in peoples diets. "An infant eating a quarter pound of catfish during 1971 from the Savannah River would have ingested a radiation dose equivalent to about twenty chest X-rays." Strontium-90 levels in the bones of children in the south rose by 45 percent while falling in the rest of the country. Infant mortality increased in the affected areas near the Savannah River site while dropping in other parts of the country.

The Department of Energy has refused to collect birth statistics from radiation workers having significant exposures and/or routine ingestion of contaminated drinking water. [26]

Elevated radiation exposure can also cause children conceived after the exposure to be at elevated risk of illness or congenital defects because of DNA damage caused by the exposure.

No one, adult or child, should be allowed to drink water contaminated with tritium near the drinking water MCL of 20,000 pCi/L. But no one should be drinking tritium even at 100 pCi/L, especially not pregnant women.

Tritium at Indian Point

The Environmental Protection Agency's (EPA) standard limit for tritium in drinking water, established in 1976, is 20,000 picocuries per liter. A picocurie is 1E-12 curies but a single curie has 3.7E10 disintegrations per second. So 20,000 pCi/l has 740 radioactive decays per second but due to its low energy beta is less than 4 mrem/yr (depending on the calculation) if this were the only drinking water source used. But the health problem is greater than the radiation dose implies. Would you want to be drinking water at the federal standard also known as the maximum contaminant level (MCL) for tritium during your pregnancy?

[24] U.S. Department of Energy Office of Health Studies and U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, National Center for Environmental Health, National Institute for Occupational Safety and Health, Agenda for HHS Public Health Activities (For Fiscal Years 2003–2008) at U.S. Department of Energy Sites, March 2003. p. 27.

[25] HEDR is the CDC sponsored Hanford Environmental Dose Reconstruction Study.

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

The recent tritium leak at nuclear power plant Indian Point had a radioactivity level of more than 8 million picocuries per liter (or 400 times the drinking water MCL). [27] Previous levels had been acknowledged as 12,300 picocuries per liter, more than half of the MCL. The plant pipes in city water rather than use water from its own wells.

Tritium releases to groundwater are nothing new at Indian Point [28] or other nuclear reactors. There are more than three miles of inaccessible piping under the 239-acre site, and the inability of Entergy to properly assess possible corrosion within the pipes, according to one report. [29]

The utility and the US Nuclear Regulatory Commission downplay the entry of tritium into groundwater by avoiding specifying the monitoring data and avoiding comparison to drinking water standards. The utility provided this statement: "Entergy provided a news release of updated findings from follow-up groundwater tests at Indian Point that **confirm anticipated fluctuations** in tritium levels. The most recent samples from on-site groundwater monitoring wells show **elevated levels** of tritium. The levels of tritium identified including the new readings pose no threat to public health and safety. The tritium **levels remain less than one-tenth of one percent of Federal reporting guidelines**. [30]

Despite being 400 times the drinking water maximum contaminant level, all the utility has to do is say the water they contaminate will not be used for drinking so it doesn't need to meet drinking water standards. Then they can claim that if it is diluted enough as it moves into watersheds, it can be used for drinking water. Of course, the utility is not required to do any monitoring beyond its fence.

And since the health issues that arise will not be attributed to the plant's releases, especially not now that the NRC has cancelled any real epidemiology around the plants, there is no problem. . . . .unless you care about the health of living things.

INL's Advanced Test Reactor at the Idaho National Laboratory located at the ATR Complex was previously called the Test Reactor Area and two other large reactors were operated there: the Materials Test Reactor and the Engineering Test Reactor. As a result of reactor operations for materials testing, the tritium releases to groundwater have been large. Groundwater monitoring for CERCLA cleanup in 1991 found 2,510,000,000 pCi/L [Really! [31]] in shallow perched water

[27] CBS news report by Amy Kraft February 23, 2016 at http://www.cbsnews.com/news/indian-point-nuclear-power-plant-called-a-disaster-waiting-to-happen/

[28] Dot Earth reporter Andrew Revkin, "Indian Point's Tritium Problem and the NRC's Regulatory Problem," June 12, 2014 http://dotearth.blogs.nytimes.com/2014/06/12/indian-points-tritium-problem-and-the-n-r-c-s-regulatory-problem/?_r=0 Tritium level of 690,000 pCi/L monitored in 2014.

[29] Hoffpost Green reporter Roger Witherspoon February 15, 2016 at http://www.huffingtonpost.com/roger-witherspoon/indian-point-contaminates_b_9224302.html

[30] http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2016/20160211en.html

[31] Yes, it's not a mistake: the reported concentration was 2,510,000 pCi/milliliter, so this is multiplied by 1000 to convert to pCi/L.

that resulted from warm waste percolation ponds that the report mentions and spent fuel storage canal leakage and post-1993 retention basin leakage that they don't mention. [32]

DOE's Inspector General Reports of Cost Overruns at the Integrated Waste Treatment Unit

The Department of Energy is taking some heat from its own inspector general for the Idaho site's Integrated Waste Treatment Unit that DOE declared to have completed construction. [33] The series of tests and repairs since missing the 2012 Idaho Settlement Agreement milestone have resulted in costs termed operational costs exceeding $181 million, yet the facility has yet to process any waste.

The inspector general found that "the Department based its declaration of project completeness on Operational Readiness Reviews without the benefit of robust design reviews and thorough acceptance and startup testing using materials that simulate, to the greatest extent possible, the waste or other materials to be processed in the actual facility prior to the readiness reviews. According to Department officials, an Operational Readiness Review ensures that there is sufficient provision for off-normal events in the current design and that people are adequately trained to operate the plant as the hazards are introduced. While the Department's Office of Health, Safety, and Security initially concluded that these reviews were appropriately executed, it subsequently performed a lessons learned review following the system pressure event and concluded that the reviews were not sufficiently robust for this first -of-a-kind facility and operations personnel were not prepared for startup."

[32] Test Reactor Area Record of Decision, see an overview at Test Reactor Area Perched Water System Operable Unit 2-12 Idaho National Engineering Laboratory Idaho Falls, Idaho, December 1992. https://ar.icp.doe.gov/images/pdf/199302/1993020211083010W-T.pdf or the full document at http://ar.icp.doe.gov There's a lot wrong with the Record of Decision for groundwater at the Test Reactor Area and the subsequent monitoring. More about that to come.

[33] Department of Energy's Inspector General report: "Management of the Startup of the Sodium-Bearing Waste Treatment Facility" at http://energy.gov/ig/downloads/audit-report-doe-oig-16-09 Read about the faulty rationale to accept the results of two small scale tests: "The testing at Hazen Research Inc., which was used to help form the basis for the testing at the SBWTF [IWTU], was only a one-tenth scale prototype facility, and the testing consisted of only two test runs, one of which was unsuccessful. In addition, there were significant differences between the two facilities. For example, the primary system that transforms the waste at Hazen did not have the same internal components due to scale limitations. Also, the safety standards used during the pilot plant testing were much less stringent than those used at the SBWTF during operations, primarily because Hazen is a nonradiological, nonnuclear facility. While these differences were not considered significant during testing, Idaho officials told us they subsequently realized that the differences were significant enough that full scale or even half-scale pilot testing should have been conducted prior to startup."

The Idaho Falls Post Register reported that the DOE has informed state officials that the IWTU is unlikely to meet the September 30 deadline negotiated with the State concerning tanks the sodium bearing waste is stored in. [34]

Jack Zimmerman, DOE's deputy manager of the Idaho Cleanup Project stated he has "high confidence we will be able to make this process work." The facility is still plagued by a build up of "wall scale" that looks like tree bark and equipment problems. Conducting repairs on the plant after it treats radioactive material will be much more difficult, costly, and dangerous for workers.

If and when the facility begins radioactive operations, special monitoring of air emissions to determine that emissions do not exceed expected levels are planned. Air emissions during normal operations will probably be a combination of monitoring and estimation. Onsite and offsite air monitoring of INL radiological and chemical emissions by the state and environmental surveillance organization will remain important for verifying emissions are not excessive.

Articles by Tami Thatcher, for June 2016.

[34] Reporter Luke Ramseth, *Idaho Falls Post Register*, "DOE to miss another waste deadline – Officials say they're prioritizing safety over speed." May 21, 2016.