# Executive summary

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The contents of this website are the result of work I began in Fall 2013, after my wife and I had looked at houses in the new developments around the Rocky Flats National Wildlife Refuge. At that time information available via Google (for instance) was dominated by portentous statements about the dangers of plutonium and the history of Department of Energy (DOE) coverups of what went on when the plant was operating. The motives of the DOE, the Colorado Department of Health and the Environment and local municipalities were impugned. Both of us were concerned about what we read and heard.

I did all the 'due diligence' I had time for (reported in a free-standing document in our Knowledge Base) and concluded that there was no 'smoking gun' indicating problems (at least for those moving into new developments and thus not subject to fallout from the two fires at Rocky Flats and windblown radioactive dust from the '903 pad'). In the spring of 2016 I began a systematic study of the issues reported in the documents you will find in the Knowledge Base. They are made available so that no one else need go through the uncertainty, anxiety, and suspicion that we did.

I believe there are two distinct groups of people connected to the Rocky Flats National Wildlife Refuge. One consists of recent arrivals living in new housing developments, or potential recreational users (for example, mountain bikers) of the Refuge's trails eager to use the Refuge as a local amenity. The second is the group of people who lived around it during the time the plant was operating, were subject to fallout from fires and nasty waste disposal practices, and possibly worked at the plant. The second group remains suspicious of state and federal government (once burned, twice shy) and (in large part) adamantly opposed to the opening of the Wildlife Refuge to public use. While both groups are stakeholders, one is very definitely focused on the past while the other is focused on the medium future.

*Significance:* In retrospect, it is clear that in the calculations and estimates reported in the documents on the web site I chose to use essentially *no data* from the Department of Energy (or the Colorado Department of Health and the Environment) except what had been *measured* (and to a small degree, re-measured by citizen groups suspicious of the DOE in the 1990s). I did this **not** because I did not trust these sources but because I began with typical physicist audacity, "How hard can this be?" As a result, I had to teach myself some basic radiation biology about radiation dose and its biological effects, a little more nuclear physics, and read and follow enough of the scientific literature to find reliable epidemiological data (to translate radiation exposure into cancer risk). To me, the most important finding was that with this level of background knowledge I could (*independently* of the DOE) translate plutonium contamination levels around where I live directly into radiation doses and 50-year excess cancer risks that agreed to within better than 40% of what is produced[1] from the complex, comprehensive software tool RESRAD developed, distributed, and used by the DOE (and by other countries) in a test case designed to mimic contamination levels I used in my simple estimates. Most physicists would regard my calculations as reasonable. I am thus happy to rely (as does the DOE) on RESRAD to assess radiation dose and cancer risk and believe it is reliable.

This document is a summary of issues and conclusions I made that bear on the safety of living

[1] In the dose business this is remarkable because results depend on the nature and intensity of the radiation and the tissue involved.

around this particular former US Department of Energy nuclear plant as I have been able to discern them from what I have read, measured, analyzed, and estimated. (Most remarks hold equally well for the interior of the Wildlife Refuge. This statement will be revised when I have had a chance to examine in more detail the situation within the Refuge itself. ) The *explanations* for the validity of these statements are given in the detailed documents.

Reminder: I am not a professional in radiation exposure; I am a homeowner and physicist with experience explaining complex material. Life is short, so I will use the abbreviation RFNWR in place of 'Rocky Flats National Wildlife Refuge'. I urge you to prowl around the web site and read the much more careful (and interesting) mildly technical documents which give the data and explanations for the conclusions below.

# 1 The sociology

1. The US Department of Energy (DOE) has a relatively poor track record for managing nuclear processing facilities, largely because they subcontract management to for-profit entities whose commitment to public (as opposed to worker) safety varies. The historical secrecy surrounding nuclear weapons facilities has exacerbated public suspicion. A culture of distrust of the DOE by longtime Arvada residents persists. [See [1].]

2. Scrutiny by citizen groups such as the Rocky Mountain Peace and Justice Center of Boulder has been the hallmark of the history of the Rocky Flats area since the 1989 FBI raid.[2]

3. Misinformation surrounding radiation and plutonium has persisted despite decades of good information. This is often because people don't 'get' radiation and the statistical arguments about when it is not (or can be) dangerous. People in general are often *extremely* resistant to revising long-held opinions. Two key concerns: (i) the toxicity of Pu itself, and (ii) that 'hot particles' are especially dangerous, account for a great deal of public attention. That these are long-discredited myths (not supported by research, similar in flavor to those about vaccinating children) has not yet had any discernible impact among activist groups or public discourse.

# 2 The physics

1. Alpha particles (the most biologically damaging emission from the plutonium isotope around Rocky Flats) have a range in air of less than three inches. They can be stopped by a piece of paper and can penetrate tissue only through cracks in the skin.

2. Gamma rays (essentially very penetrating X rays, with ranges in air of tens of meters) are the dominant source of radiation exposure from the plutonium isotope $^{239}$Pu processed at Rocky Flats.

3. The americium isotope $^{241}$Am (a consequence of a contaminant of bomb-grade plutonium) is also present and emits beta particles (very high energy electrons, with ranges in air of also tens of meters). This isotope has a much shorter half-life than $^{239}$Pu (as does its parent radionuclide) and is present in much smaller quantities around the RFNWR.

# 3 Federal and state government entities

I apologize to the many competent professionals at federal and local levels for even having this section!

[2] This website is about current reality, not history. For more history, see the 'List of Players'.

1. Despite its difficulties managing active nuclear laboratories, and whatever the history of Rocky Flats 30 years ago, the DOE's role around Rocky Flats now (via the Office of Legacy Management) is protective.

2. Obviously the US is not alone in facing problems from accidents and radiation releases from nuclear facilities. Based on comparison with data from other countries (coordinated by the International Atomic Energy Agency, for example), international reports, and peer-reviewed literature, technical data and documentation from the DOE (which is definitive) and the Colorado Department of Health and the Environment are valid and reliable; those from the state are even readable.

# 4 The plutonium

1. There is nothing mystically toxic about plutonium. It emits alpha particles like other radioisotopes (artificial or natural), such as radon, and gamma rays.

2. The Wildlife Refuge itself and areas outside have never been mitigated for contamination, nor do they need to be (based on observed radiation levels).

3. The contamination within what is now the RFNWR is among the most thoroughly measured and documented in the world. Multiple studies since the 1980s (including some carried out by DOE-suspicious citizen groups in the 1990s) confirmed the levels of contamination before the cleanup. The 'central operating unit' (COU) as a man-made mess demanded (and, the evidence indicates, got) an adequate cleanup. Radiation levels are now and were (apart from the COU and a few patches of the Refuge) *low*. Just how low? Consider the worldwide soil average radioactivity (per unit mass of soil) of common, naturally occurring radioisotopes:

| *isotope* | *location* | *avg soil conc* (pCi/g) |
|---|---|---|
| $^{238}$U | worldwide | 0.2-1.6 |
| $^{226}$Ra | worldwide | 0.23-4.2 |
| $^{232}$Th | worldwide | 0.18-22 |
| $^{40}$K | worldwide | 2.5-37 |
| $^{239,240}$Pu | Front Range (avg) | 0.066 |
| $^{239}$Pu | Candelas area | 0.08 |
| $^{239}$Pu | worldwide | 0.01-0.1 |
| $^{239,240}$Pu | Refuge (avg) | 1.1 |
| $^{239,240}$Pu | Refuge (max) | 19 |
| $^{239,240}$Pu | avg in COU | 2.3 |
| $^{239,240}$Pu | max in COU | 49 |

Table 1: Black: levels of soil radioactivity due to common radioisotopes around the world; from [2], [3],[4]. Front Range background and Refuge values are from Colorado Department of Public Health and Environment table.

It is worth remembering that the human body does not ask *What isotope is this radiation coming from?* (Details of the isotope *do* determine what is emitted, however.) The worldwide range of thorium ($^{232}$Th) natural radiation levels already exceed the maximum Pu level within the Refuge.

The radiation impact for residents around the refuge is *not even close* to what occurs naturally. (This is why the scientific and nuclear engineering community pays so little attention to the Rocky Flats situation—it is a satisfactorily concluded issue from their perspective.) The post-cleanup

RFNWP residual levels are sufficiently minor that they could be simply neglected in terms of actual harm to human beings.

4. Radiation and soil contamination levels can be reliably measured at levels that are thousands of times lower than what would present a danger to human (or animal) health. Living with Pu is not qualitatively different than living with water contaminated with, say, benzene. We know it's not good, we can measure its concentration very accurately, and its levels are regulated and monitored.

## 5 Health impacts of radiation

1. Cancer is the principal risk of radiation exposure, whether it be from natural sources, medical diagnostics, or human-made radioactive materials.
2. Cancer rate *changes* associated with lifestyle choices (diet, smoking, obesity) are roughly 100,000 times more important than radiation-induced increases around Rocky Flats.
3. While the impact of radiation at the cellular level is only partially understood, the impact of moderate to high levels on large groups of human beings is quite well understood due to large-scale, careful studies since the 1940s.
4. Despite *high* natural background radiation levels, cancer rates in Colorado are among the *lowest* in the United States.
5. The impact of very low levels of radiation is not well understood because of the very large number of people that must be studied to tease out very delicate effects.
6. There is some evidence that low levels of radiation exposure prime the immune system and protect against larger doses.
7. Except within a few centimeters of the soil (the range of alpha particles), radiation doses (say, per year) due to Pu contamination around the RFNWP are 50,000 times lower than that *natural* radiation doses already present in Colorado (due to soil minerals and altitude).

## 6 Cancer clusters downwind of Rocky Flats

1. Cancer can only be diagnosed after an 'incubation' period that depends on the cancer type. The 'canary in the coal mine' for radiation-induced cancers is leukemia, which takes less than 4 years to develop. Almost 30 years have elapsed since the Rocky Flats plant closed; Standley Lake was developed in the 1990s. Had there been even a 'small' radiation problem, there would be hundreds of cases of leukemia (above what is statistically expected). Where are the cancers?
2. There is no evidence (only anecdote) of cancer clusters around the former Rocky Flats plant despite repeated state surveys. People living downwind during the fires of 1957 and 1969 and during the years of plant operation were exposed to radioactive contamination. This has no bearing on new housing developments, however. [3]
3. It is (statistically) extremely unlikely that cancer clusters around Arvada will be identified.

[3] Work by Carl J. Johnson concerned plant workers. I have been unable to find or read the original document.

## 7 The Wildlife Refuge itself

A document (with maps) about radiation dose from visiting the Refuge is accessible under the column entitled The Rocky Flats National Wildlife Refuge on the home page. Its principal conclusion is that despite distinctly higher Pu levels within the Refuge the additional radiation dose is *far below* what Colorado residents already experience due to altitude and radioactive minerals. It will be supersede by a more careful document later.

## 8 Red herrings

1. The idea that 'hot particles' (highly radioactive inhaled particles) pose a special radiation threat has been discredited by several careful studies in the US and abroad since the mid-1970s.
2. Burrowing animals *can* bring highly radioactive soil to the surface. The range of dirt redistribution is very likely comparable in size to the burrows themselves. (Resulting dust containing 'hot particles' is a non-issue, as you can read about in the Knowledge Base article.) Burrows have a fairly well-defined size and represent a tiny fraction of land area in the Wildlife Refuge and are unlikely to be near Refuge paths. The existence of animal burrows thus has essentially no significance for human health.

## 9 A few *opinions*

These have been formed by a great deal of reading and thought.

1. This site *should have been* unnecessary. I find that almost all issues have been examined and re-hashed over the last 25 years with relatively little change in the conclusions.
2. Yes, it is lamentable that all records around 'the ambushed grand jury' have not been released. However, this is history and not relevant to current 'ground truth' around Rocky Flats.
3. The enemy is not the DOE or the EPA or the Colorado Department of Health and Environment, it is inattention by the affected population to continued monitoring and oversight. This is the job of citizen groups, ideally thoe who live around the RFNWR.
4. A mechanism to mediate between the DOE's Office of Legacy Management and the public on local Rocky Flats issues appears needed. While the RF Stewardship Council performs yeoman service, it is ill-adapted to public outreach and its meetings vulnerable to disruption.
5. The claim that 'not enough is known' about the impacts on people around the former Rocky Flats plant (or about the interior of the Refuge) is simply inaccurate. Anyone who makes such claims has not done his or her homework or is selling you something. It is your job to find out what and why, and who's paying for it.
6. The idea that a 'concerned citizens' group should be able to pressure the Fish & Wildlife Service not to perform its job (in the context of controlled burns within the RFNWR) is *horrifying*. There are no circumstances I can envision in which a wildfire should be preferred over a controlled burn.
7. The fact that a 'concerned citizens' group has persuaded some school districts to block visits to the Wildlife Refuge based on 40-year suspicions rather than current science is distressing, especially in the current political climate.

## References


[1] *Remediation of the Rocky Flats Plant: An Ethical Analysis*, Goepfert, Paul (Honors Program CU Scholar program, Honors Program 2017), here.

[2] *Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials*, Committee on Evaluation of EPA Guidelines for Exposure to Naturally Occurring Radioactive Materials and Board on Radiation Effects and Research Commission on Life Sciences and National Research Council, (National Academy Press, Washington DC, 1999).

[3] *Radiocesium and plutonium: Still together in "background" soils after more than thirty years*, *Chemosphere*,**32**, 2067 (1996).

[4] *ToxGuide for Plutonium*, U.S. Department of Health and Human Services.