From: David Wood, Candelas
To: Broomfield City Council
Date: August 15, 2019
Regarding: Factually wrong statements in [redacted]'s 25th July complaint about the 18 June Study Session.

Dear Council members,

Unlike my previous screed, this will be relatively brief. I promise there will be no further 'tit for tat' responses (unless requested by a member of the Council). As mentioned earlier, I *will* be dispatching a few short overviews of topics concerning radiation, risk, and Rocky Flats.

The significance of [redacted]'s anecdotes of unexpected (by him) cancers was addressed in my earlier letter dated August 10th; see the figure.

His points here:

- Ms. Opila stated . . . that the estimated lifetime cancer risk for a person living on Refuge land . . . would be 30.001% - one excess cancer in ten thousand people more than the risk for any Coloradoan. I am not sure where Ms. Opila got her numbers. The software package DevCan (version 6.7.5 run in April 2017) uses the National Cancer Institute's SEER database to determine current cancer outcomes. The margin figure (from this document) shows results as of April 2017. In any case, as stated in [2] in footnote 3 on page 12, the estimated excess cancer risk 2×10^{-6}, amounting to multiplying the chances of a cancer outcome by 1.000002. Thus, for example, for a woman (using the 'wildlife refuge worker' scenario) exposure to Rocky Flats-specific radioisotopes could be stated as changing the lifetime chances of *dying* of cancer from 18.8% to 18.80004%. These excess risks are far smaller than those stated by Ms. Opila.

- Dr. Urbina flatly stated "so, the one particle causing cancer is just simply not true", referencing one study by a longtime DOE contractor.

  Dr. Urbina is up to date on all statements he made, including this one. Dozens of journal articles and official reports in various European countries and the U.S. (not just 'a longtime DOE contractor') since 1974 have confirmed that a 'hot particle' has no more impact than an equivalent dose of radiation delivered uniformly to a whole organism (see, for example, the excellent 1978 review [3]).

  Since roughly 2003 the consensus is that 'hot particles' in fact have *less* impact, and are *less carcinogenic* as well [4].

- Dr. Tom Hei of Columbia University and colleagues concluded "[t]hese data provide direct evidence that a single alpha particle traversing a nucleus will have a high probability of resulting in a mutation and highlight the need for radiation protection at low doses."

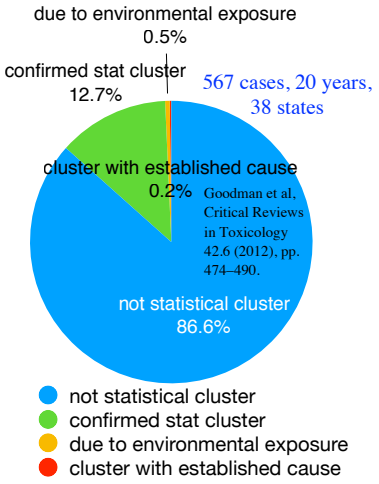


Figure 1: Statistics for outcomes of 567 cancer cluster investigations drawn from 38 states [1]; 'established cause' is [redacted]'s 'root cause analysis'.

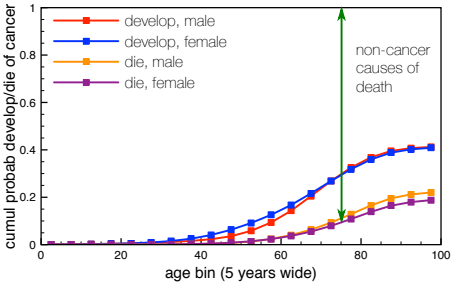


Figure 2: SEER database cancer rates by attained age

I cannot, of course, speak on behalf of Dr. Urbina or Ms. Opila, but instead speak on the basis of the dozens of articles I have read on this topic.

In current scientific literature 'low doses' of radiation generally include doses (up to 0.1 'gray') equivalent to decades of background radiation exposure, or 1000 chest x-rays.

For example: " "Low dose" is defined for the purposes of this discussion as less that 0.5 Gy because this appears to be a mechanistic threshold for saturation of many low-dose effects to be discussed here, although the linear relationship for human cancer does appear to hold down to 0.1 Gy." [5].

These experiments use 'particle microbeams' (see Wikipedia 'microbeam'), essentially firing a stream of particles microscopically restricted from going anywhere except right through the cell nucleus (98.4% hit rate). These effects are not unique to alpha particles (or even to nuclear radiation), but it is easier to control alpha particles in a microbeam to demonstrate them.

Ordinary ('wide beam' or isotope) radiation obeys random (Poisson) statistics and fairly intense doses are needed to guarantee an average nucleus receives an alpha 'hit'. As reported in the National Academy of Science's *Health Effects of Exposure to Radon* BEIR VI,

> Assuming . . . a low practical dose of about 0.1 Gy, on the average each cell nucleus will be traversed by a single alpha particle.

The nucleus of a mammalian cell occupies about 10% of the cell volume [Wikipedia]; the DNA itself occupies about 2% of the volume of the nucleus [6]: so DNA is about 0.002% of the cell volume. Targeting DNA with a microbeam is like using a precision machine gun with a long-range sight to shoot a long skinny snake far, far away.

With an annual average Colorado radiation dose (neglecting radon exposure) of 0.015 Gy, the assumed (non-microbeam) dose is about 67 years worth of non-radon exposure or about 1000 chest x-rays.

The point of the above estimate is that the doses needed to see even these 'single alpha' events are far about background radiaton doses. Alpha particle microbeam experiments *are* providing useful information about low-dose radiation, but [redacted] forgets that more than 95% of alpha radioactivity in Rocky Flats soil comes from *natural* radioisotopes present all over Colorado.

A reminder: the current prevailing view is that there is no epidemiological evidence for adults of radiation effects of any sort (cancer, etc) for total radiation doses below about 0.1 Gy (=gray, the international unit of absorbed radiation dose). See Wakeford's excellent elementary current review of radiation-induced cancer epidemiology.

If he will not read journals or definitive reports, may I refer [redacted] to the *Boulder Daily Camera*, where a high-school junior ably refuted LeRoy Moore's similar objection.

- Also typical of CDPHE orthodoxy is equating different types of radiation and doses received from them.

  But a chest x-ray is qualitatively different than an inhaled plutonium particle. The latter intensely irradiates immediately surrounding cells wherever in the body it settles. Whereas an x-ray is a different type of radiation absorbed by the entire body or portion thereof.

  These different types of radiation are not directly comparable on the localization or quantity of dose they entail. . .

  Does [redacted] really believe that radiation oncologists using 'gamma knives' and proton and alpha particle beams don't know the qualitative and quantitative differences? Where does he think they got their data?

  Everything in the bulleted statement above is misleading or wrong. (i) The different effects of alpha, beta, and gamma (or X-ray) radiation have been acknowledged in their 'relative biological effectiveness' for decades, and are part of the quantitative descriptions of radiation risk (which also include the specific sensitivities

A recent *Health Physics* journal overview notes that while "DNA damage induced by radiation has a slightly different "flavor" depending on radiation quality . . . " and that ". . . different DNA repair mechanisms are engaged after different types of radiation exposures, at least in cancer cells. . . ", . . . "in all the many decades of radiation research no study has documented that radiation-induced cancers (even at high doses) have any unique feature attributable to the radiation exposure, let alone a biomarker that separates them from "regular" non-radiation-induced cancers." [7]

of a variety of tissues) in both the international (International Commission on Radiological Protection, ICRP) and U.S. (National Commission on Radiation Protection and Measurement, NCRP) standards, updated every few years and used (for example) in the (Argonne National Laboratory) residual contamination/risk software RESRAD. This is used in turn by the DOE and the CDPHE.

(ii) [redacted] included a genuine fact, about the intense radiation around a 'hot particle'. This provoked an intense flurry of experimental animal research (not 'theoretical', not 'modeling') in the period 1974-1976 which made clear that hot particles were not a special danger.

In my document on hot particles I provide a careful estimate of the rate at which energy leaves a 3 micron diameter PuO_2 particle, three different estimates of the lifetime cancer risk and (in an appendix) the dose rate per cell around a hot particle. It *is* prodigious.

Personal remarks about the following:

- He admits in his own works that his Geiger counter is unable to detect alpha radiation from plutonium at the site.

  I have never stated that the Geiger-Müller counters I have are unable to detect alpha radiation–they *can* and *do* (if within range).

  [redacted] should know that no Geiger-Müller counter can tell you anything about the source (its chemical identity or radioisotope).

  and

  David Wood's academic specialization was in semiconductors . . . In other words David Wood is not a subject matter expert on these Rocky Flats –related topics. . . .

  Even less so are LeRoy Moore (Ph.D in divinity), or Drs. Harvey Nichols and Gale Biggs (Ph.Ds in meteorology). [redacted] is likely to be somewhat fuzzy on training for a physics doctorate.

  I will leave it to the Council to assess whether my expertise in nuclear physics is sufficient for their purposes. You should consult a health physicist, a radiation epidemiologist, or DOE experts if you doubt any of my statements.

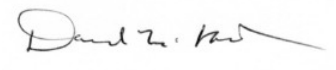
Measurements of *surface* radioactivity (as opposed to ambient radioactivity) are time consuming, and the protocol for measuring the 'ambient [radiation] dose equivalent rate' or ADER requires measurements one meter above the ground, far beyond the range of alpha particles. Plutonium isotopes represent less than 2% of soil radioactivity and emit almost no gamma radiation (and zero beta radiation), hard to distinguish from background for a Geiger-Müller counter.

It *is* true that most of my research into Rocky Flats occurred in an intense 7-month period beginning with my retirement in 2017.

With only a couple of exceptions, every calculation I did in estimating radiation doses, properties of hot particles, or in displaying Rocky Flats soil radiation contributions could have been done by an energetic college physics senior after one undergraduate nuclear physics course.

My principal suggestion to the City Council is: do not rely on activist groups for factual information about science, health, or epidemiology; they *are* reliable (if selective) about historical information.

Sincerely yours,



David M. Wood
Candelas

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