The Public Health Risk
of Disturbing the Soil Along Indiana Street
for Jefferson Parkway Construction

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Introduction

This paper states my position on the public health risk of disturbing the soil along Indiana Street for construction of the Jefferson Parkway. It is written for contemplation by my fellow members of the Jefferson Parkway Advisory Committee (JPAC), in preparation for our May 17th, 2018 meeting, at which consideration of this topic by the committee will commence.

My position on this issue is informed by intensive research over the last year into studies of offsite soil contamination from the Rocky Flats Nuclear Weapons Plant (RFNWP), and into studies of potential health impact of the contamination on the downwind population. That research involved obtaining copies of pertinent studies and documents, some rare and hard to find, through visits to the CU Norlin Library's Special Collections and Archive unit, Freedom of Information Act requests to the Department of Energy (DoE), and visits to the Federal Records Center and US District Court clerk's office to review the case files and exhibits from *Church v. United States* and *Cook v. Rockwell* (two important lawsuits in Rocky Flats history, both of which were settled or decided for the plaintiffs).

I undertook this research after becoming interested in Rocky Flats contamination and consequences from reading Kristen Iversen's book *Full Body Burden*, and Caron Balkany and Wes McKinley's book *The Ambushed Grand Jury*. In fact the starting points for my research were the endnotes in those books, though the research pulled in additional sources as it fanned out and ran its course.

It is my position, based on all the relevant information I've reviewed, that disturbing the soil along Indiana Street for construction of the Jefferson Parkway could pose a significant risk to public health downwind of the site. That is because:

(i) The soil along Indiana Street is contaminated with plutonium to levels representing hundreds of times background radiation;
(ii) Available evidence demonstrates increased rates of cancers in the downwind population from 1969 (first year studied) through today;
(iii) Inhalation of plutonium-laden dust is the exposure pathway of greatest concern, and construction activities could raise large volumes of respirable plutonium-laden dust into the air and wind; and
(iv) There could exist undetected and unremediated nuclear waste burial sites that could be encountered during parkway construction.

Because of this potential significant public health risk, it is also my position that the Jefferson Parkway Public Highway Authority (JPPHA) should take certain definite steps to further characterize and mitigate the risk prior to commencing construction of the parkway, as a matter of moral obligation.

The remaining sections of this paper provide the substantiation of the contentions listed above, and an enumeration of the definite steps I believe the JPPHA has a moral obligation to take before progressing with the parkway.

Plutonium Contamination in the Indiana Corridor

Eleven studies from a variety of sources spanning 43 years have all consistently found plutonium contamination in the soil along the Indiana Street corridor at levels representing hundreds of times background radiation from fallout from atmospheric nuclear weapons testing. This soil was not remediated in the Rocky Flats cleanup, which was limited to just the former industrial area of the nuclear weapons plant. Since plutonium-239 has a half-life of 24,100 years, that contamination remains in place except to the extent the plutonium is moved by weather elements or the activities of animals and humans. Figure 1 shows the locations of soil samples from these studies, and the multiples of background radiation found in the samples. Subsequent paragraphs summarize each study and contain links to copies of each study.

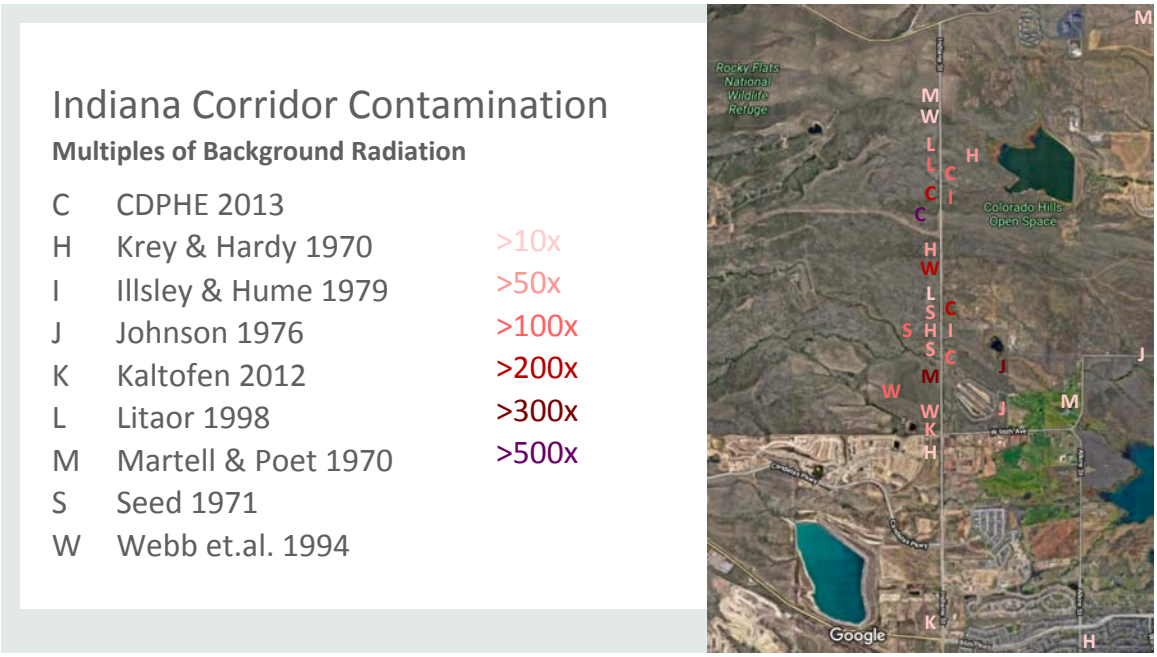

Figure 1: Locations of samples containing high multiples of background radiation from studies of offsite soil contamination. The letter identifies the study containing the sample, and the color indicates the multiple of background radiation found in the sample, using 0.0434 dpm/g as background.

The first study of offsite soil contamination was conducted by Ph.D. radiochemist Dr. Edward Martell, after the Mother's Day 1969 fire at the Rocky Flats plant. A West Point graduate who'd studied radiation effects on humans from nuclear weapons tests in the Pacific, Dr. Martell was working at the National Center for Atmospheric Research in Boulder at the time of the 1969 fire, and became concerned about possible contamination releases. Dr. Martell collected offsite soil samples in August 1969, and first published his findings in a January 1970 letter to the chairman of the United States Atomic Energy Commission (USAEC). Photographs of that letter, and Dr. Martell's report on his findings, are stored in a folder on my Google Drive at https://drive.google.com/open?id=1ovD5Rb-1_bbiLhM2rWDTys-zlzlYib__. He found 311x background at Indiana Street and Woman Creek. Dr. Martell also measured background radiation at 0.0434 disintegrations per minute per gram (dpm/g) of soil at Boyd Lake, CO.

In response to Dr. Martell's findings, the USAEC sent two scientists from its Health and Safety Laboratory, P.W. Krey and E.P. Hardy, to conduct their own study. Krey and Hardy produced a report dated August 1, 1970, which confirmed Martell's findings, and which contained the original "Krey Hardy map" showing offsite plutonium isopleths. An enhanced version of the Krey Hardy map in wide circulation is appended as Figure 2, and a scan of Krey and Hardy's original report is located at https://drive.google.com/open?id=1Uetf4i28YV9lkjghykYukj2ctPWjjeIp.

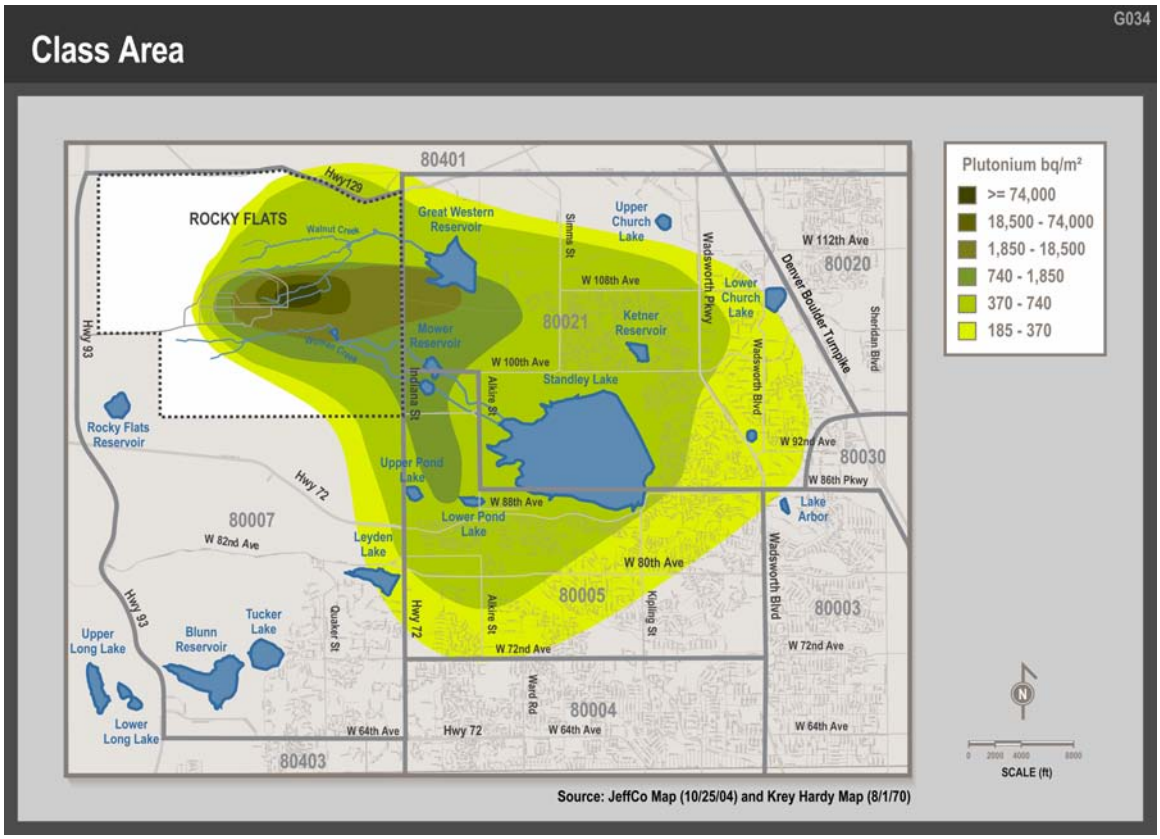

Figure 2: The enhanced version of the Krey Hardy map with colored plutonium isopleths in Bq/m². Note that 1,850 Bq/m² represents 171x background radiation, using 0.0434 dpm/g as background.

RFNWP operator Dow Chemical then conducted its own study to assess the accuracy of Martell's, and Krey and Hardy's, findings and reports. Dow appointed a committee of its employees, chaired by Robert Seed, to do the work. Thus the committee's report became known as "The Seed Report". Not only did The Seed Report corroborate Martell's and Krey and Hardy's findings, but it also produced a new isopleth map, which the authors claimed was more accurate than the Krey Hardy map. That map is reproduced as Figure 3, and a scan of the Seed report is at https://drive.google.com/open?id=1PK5vdsvPy7AsAkm_N2U5SA4OGynpF9hV.

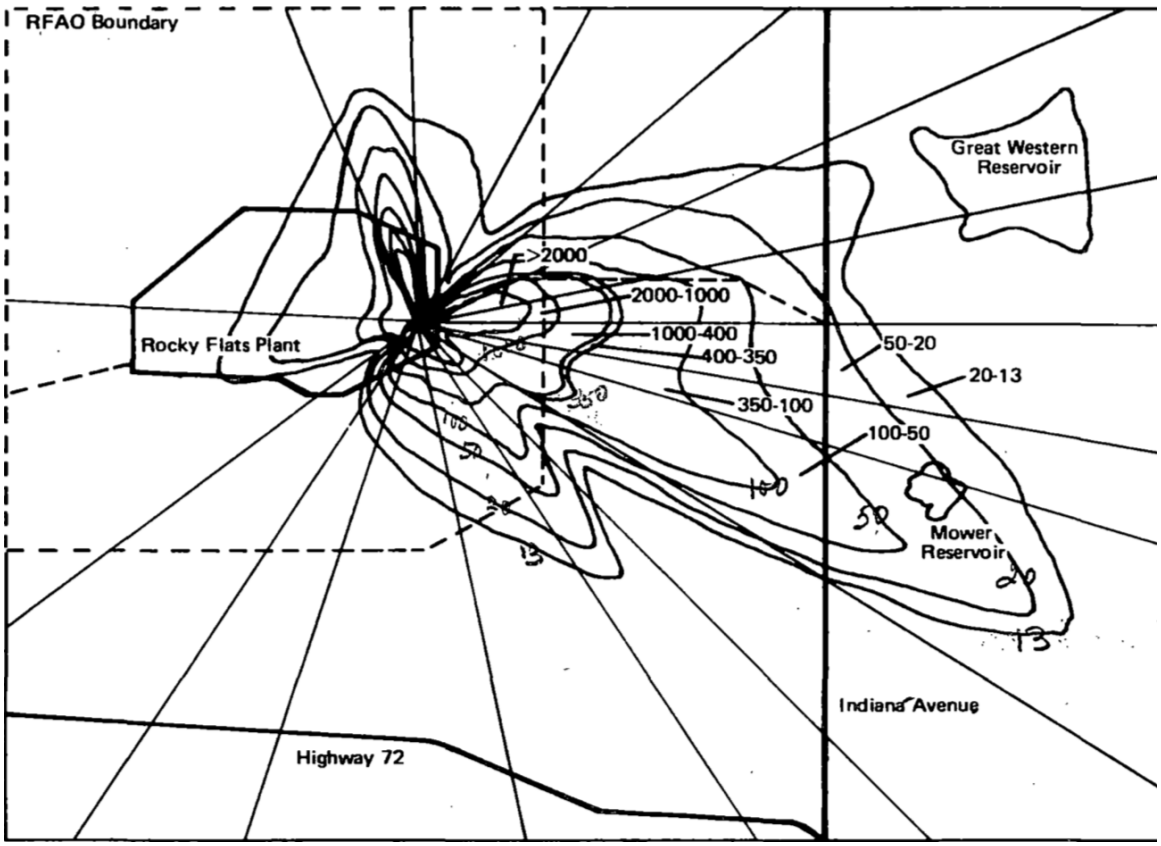

Figure 3: The plutonium isopleth map from The Seed Report, in picocuries per gram (pCi/g) of soil. The 100-50 pCi/g band crossing Indiana Street represents 341-171x background radiation. Note the plant boundary at the time did not include the "buffer zone". Because of the contamination found, The Seed Report recommended purchasing additional land around the plant as a buffer zone, which happened.

After the initial spate of studies triggered by the 1969 fire, the next significant offsite soil contamination study was conducted by Jefferson County Health Director Dr. Carl Johnson and published in Science magazine in 1976. Dr. Johnson held an MD degree from the Ohio State University and an MPH from the University of California at Berkeley, and specialized in radiation and epidemiology. His study was conducted at the request of the Jefferson County Board of Commissioners in relation to planning and zoning requests for new residential development east of Rocky Flats, so Dr. Johnson analyzed soil in sections of land between Indiana and Alkire Streets, and 88th to 112th Avenues. Some of his findings

are tabulated in Table 1, and photographs of his Science magazine article are at https://drive.google.com/open?id=1S11NkXwgGyCI3XIoV_d_Py6ZbyHceZua.

Table 1: Dr. Johnson's findings of plutonium concentrations in offsite soils east of Rocky Flats.

Location	Concentration	x Background
Section 7 (Indiana to Alkire, 104th to 112th)	14.1 dpm/g	325x
Section 18 (Indiana to Alkire, 96th to 104th)	2.96 dpm/g	68x
Section 19 (Indiana to Alkire, 88th to 96th)	0.23 dpm/g	5x
Section 8 (Alkire to Simms, 104th to 112th)	0.72 dpm/g	17x

In 1975 Marcus Church, heir of the homesteaded Church Ranch, part of which was appropriated by the United States government in 1951 to create the RFNWP, sued the United States government for contaminating his surrounding ranchland and thereby lowering its value for residential development. As part of the defense in that lawsuit, two employees of Rockwell International Corporation (which succeeded Dow Chemical as RFNWP operator) named C.T. Illsley and M.W. Hume conducted a study in 1979 sampling soil at 71 locations outside the plant boundary. Illsley and Hume found hotspots as high as 174x background just east of Indiana Street, as circled in Figure 4 below. Photographs of their study are at https://drive.google.com/open?id=1UuGwRB7onXLdH6EO1bTx04pPZPgdIAyF.

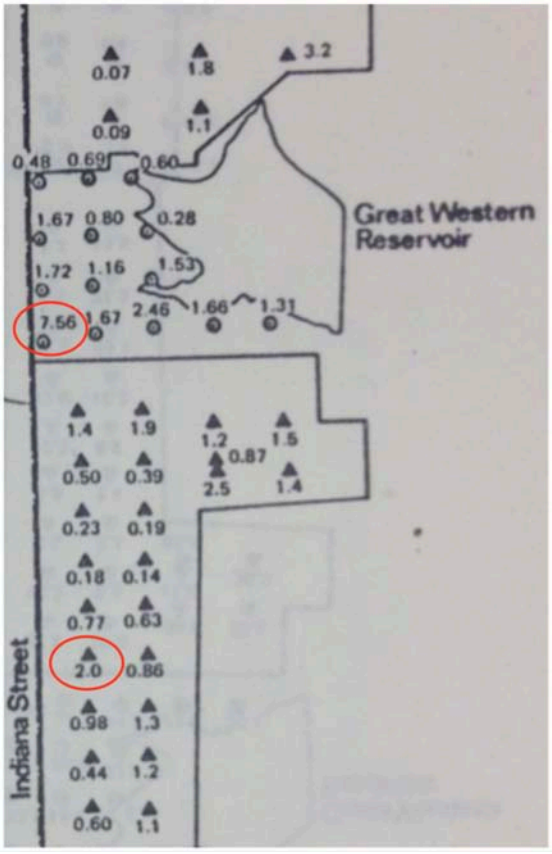

Figure 4: Hotspots found by Illsley and Hume in dpm/g. Note 7.56 dpm/g is 174x background.

Former plant engineer and whistleblower Jim Stone teamed with CSU professor Dr. Ward Whicker and two other authors in 1994 to conduct a study titled "The Spatial Distribution of Plutonium in Soil Near the Rocky Flats Plant." The soil sampling locations in this study are mapped in Figure 5, below. At location AX6 on the southwest corner of Indiana Street and East Gate Road, the study found a hotspot of 211x background radiation. Further south at location CX6 the study found a 100x background hotspot, and at location CX7 a 40x background hotspot 12-15" deep in the soil. A scan of this study is located at https://drive.google.com/open?id=11U7lSZ0CWhYjx7fkAYKB4UeuVCBWLO-O.

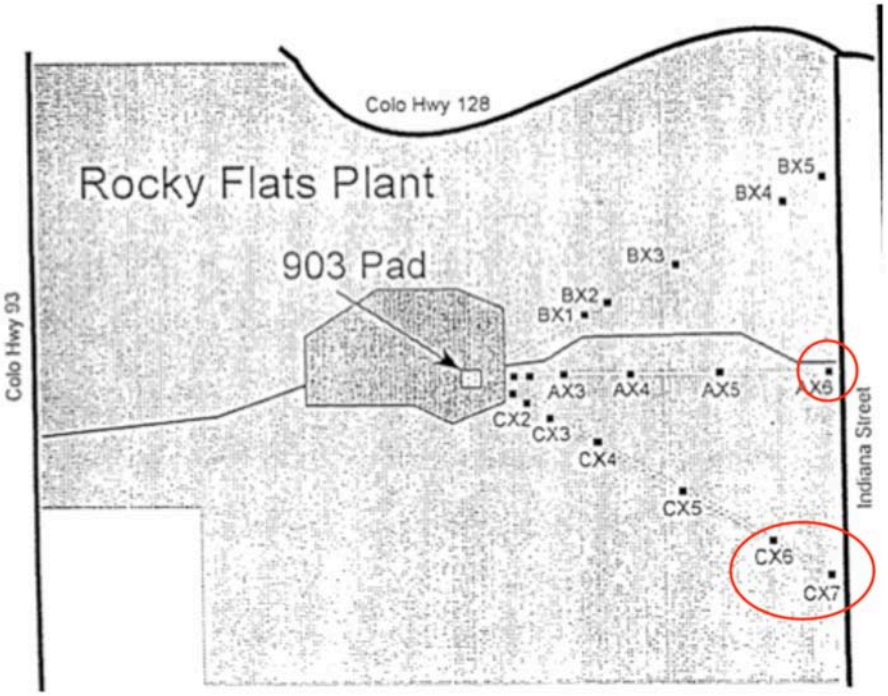

Figure 5: Sampling locations in the Webb / Stone / Ibrahim / Whicker study. A 211x background hotspot was found at AX6, and a 40x background hotspot at CX7 12-15" deep.

Dr. Iggy Litaor published a study titled "Plutonium Contamination in Soils in Open Space and Residential Areas Near Rocky Flats, Colorado" in *Heath Physics* 17: 171-179, 1998. Dr. Litaor held a Ph.D. with post-doctoral research in soil geochemistry, and had worked at Rocky Flats since 1990 for successive operators EG&G and Kaiser Hill. His study not only found plutonium hotspots of 111x and 71x background just east of Indiana Street, but also analyzed the ^{240}Pu:^{239}Pu isotope ratio in the soil samples to confirm Rocky Flats as the origin of the found plutonium (since Rocky Flats plutonium has a different isotope ratio than background fallout plutonium). Figure 6 below shows the isotope ratios, and offsite isopleths found by Dr. Litaor's study. Photos of this study can be viewed at https://drive.google.com/open?id=19FcOUlQyR1rL1LKf7q-r7-MUg0nIAj_T.

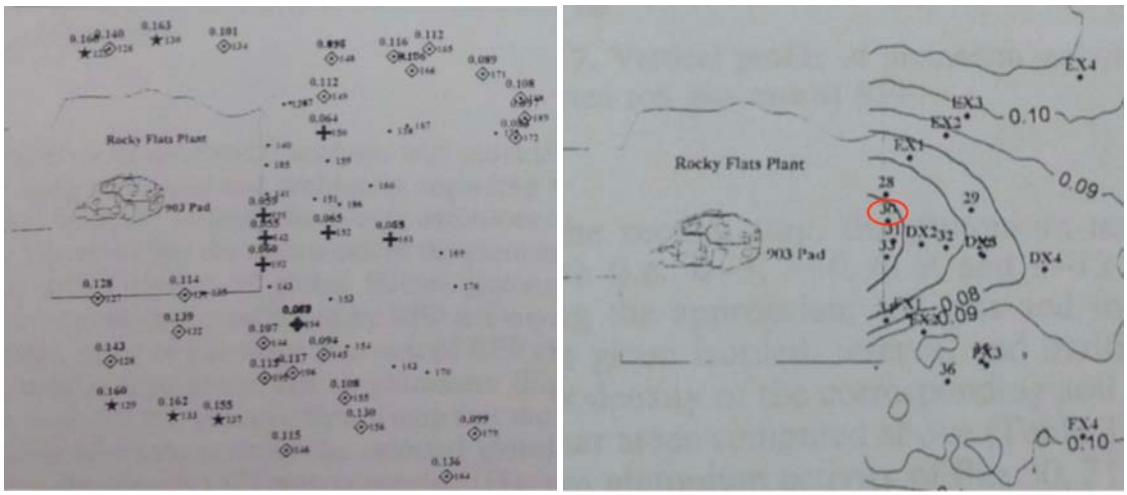

Figure 6: Plutonium isotope ratios (at left) found in Dr. Litaor's study. Ratios of 0.06 are Rocky Flats plutonium. Ratios of 0.16 are fallout plutonium. Ratios in between are a weighted blend. At right, sampling location 30 yielded 111x background radiation, and location 28 yielded 73x.

Colorado Governor Roy Romer appointed a Health Advisory Panel in 1990 to oversee a Rocky Flats Historical Public Exposure Studies project – a dose reconstruction study - administered by the Colorado Department of Public Health and Environment (CDPHE). That Health Advisory Panel in turn created a Citizens Environmental Sampling Committee which collected and analyzed offsite soil samples in 1994. An article describing this work was subsequently published in 2004 in the Journal of Environmental Radioactivity by Todd Margulies, Neils Schonbeck, and three other authors. Their article, a scan of which is available at https://drive.google.com/open?id=15aqk0m4T2ENjU8Fvi34A1f4t95QQhK1V, contains the following conclusion:

> Results in this paper correlate well with concentrations and distribution of ^{239,240}Pu reported by previous investigators and summarized and analyzed by Litaor et al. (1995). Overall, data collected in this study were consistent with prior results in areas known to have been affected by past releases. Activity of ^{239,240}Pu in soil close to the eastern edge of the Rocky Flats Plant boundary was 10–100 times higher than average background from fallout.

Another product from this work, available at https://www.lm.doe.gov/cercla/documents/rockyflats_docs/OU03/OU03-A-000585.pdf, states the following conclusion:

> The sampling results confirm conclusions from past soil studies: plutonium was released by the Rocky Flats Plant to the nearby off-site environment, generating soil concentrations above the upper limit of background

> expected from nuclear weapons testing fallout. The elevated plutonium values correspond in magnitude and location to those reported by other researchers, but the scope of this study cannot exclude the possibility of having missed hot spots.

The Agency for Toxic Substances and Disease Registry (ATSDR), associated with the Centers for Disease Control (CDC), was created by the 1980 "Superfund" legislation (formally, the Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA). The ATSDR maintains toxicological profile documents for a vast number of environmental contaminants, including plutonium. The ATSDR toxicological profile document for plutonium, available at https://www.atsdr.cdc.gov/toxprofiles/tp143.pdf, states the following with respect to Rocky Flats offsite soil contamination, on page 177:

> The highest off-site concentration of ^{239,240}Pu observed during a remedial investigation was 6,500 pCi/kg (240 Bq/kg). A separate sampling study conducted in the 1990s at 42 locations adjacent to RFETS measured ^{239,240}Pu concentrations in soil ranging from 0.22 to 14.80 Bq/kg (5.9–400 pCi/kg) (Litaor 1999).

Note that 6,500 pCi/kg represents 332 times background radiation, and 400 pCi/kg represents 20x background. Thus the ATSDR / CDC reports offsite contamination of 20-332x background.

The second most recent study and report of offsite soil contamination was conducted by Marco Kaltofen of Boston Chemical Data Corporation, under contract to Dr. LeRoy Moore of the Rocky Flats Nuclear Guardianship organization. Kaltofen's study collected 50 soil samples in 2010 and 2011 at locations in the Indiana Street corridor and elsewhere. In January 2012 Kaltofen reported his findings, including a detection of 81x background radiation just west of Indiana Street at 96th Avenue. Kaltofen's summation contains the following passages:

> Plutonium exceeded reported background levels by two orders of magnitude at locations that match those noted in the Krey Hardy report. (P. W. Krey and E. P. Hardy, 1970, "Plutonium in Soil Around the Rocky Flats Plant")
> …
> There was no statistically significant difference between this data set and the 1970 data set. Plutonium losses appear to be approximately equal in magnitude to plutonium inputs in the Indiana St. area.

The plutonium inputs to which Kaltofen alludes are most likely from contaminated soil areas upwind. Figure 7 shows the locations of plutonium detections in

Kaltofen's study, and his report may be viewed at https://drive.google.com/open?id=1Nh-W49VbTU0S0P4BvzW2fNkBwD7Di2eL.

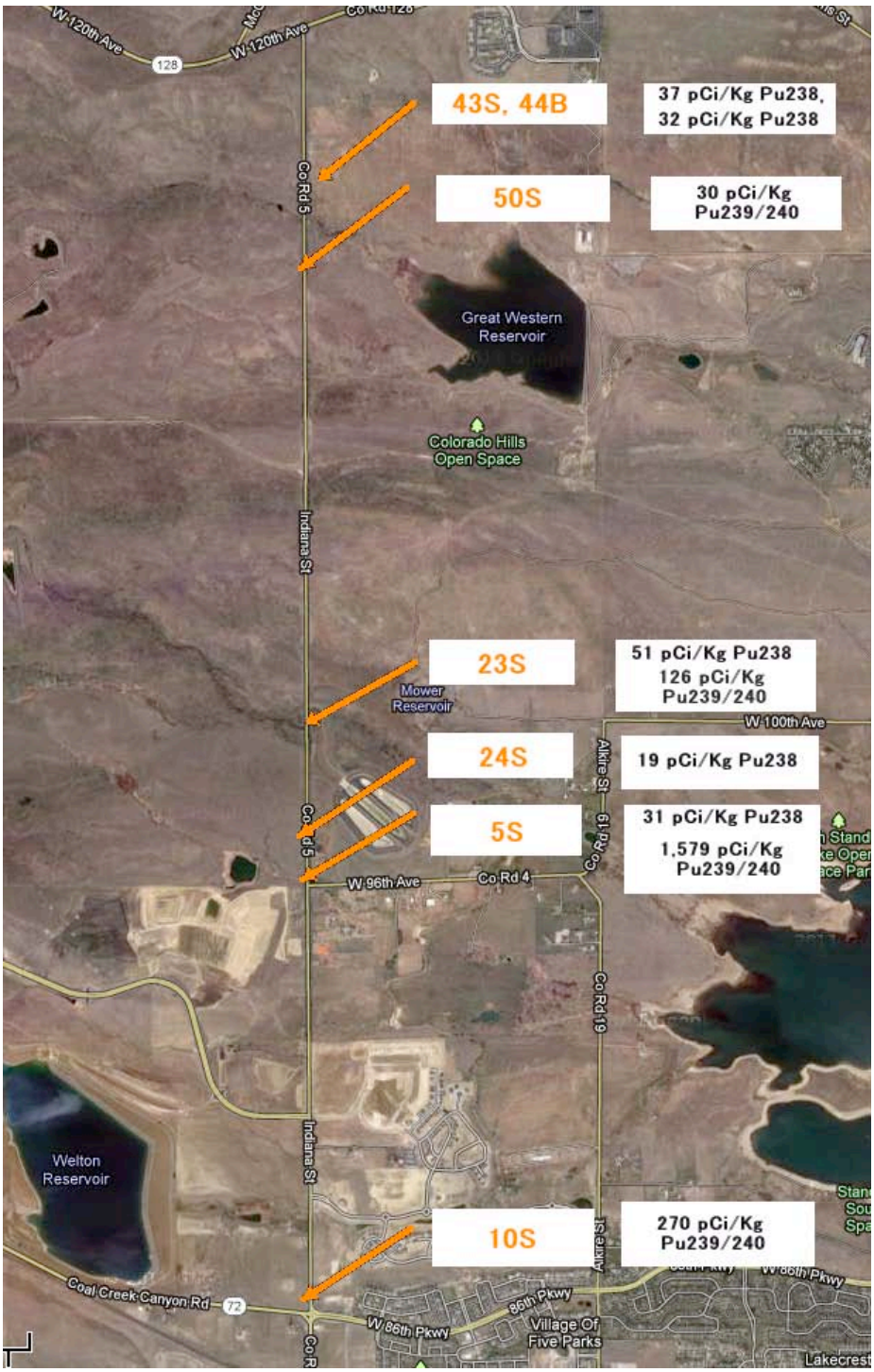

Figure 7: Locations and concentrations of plutonium detections in Kaltofen's 2011 study. Note that 1,579 pCi/kg at Indiana Street and 96th Avenue represents 81x background radiation.

Finally there is the CDPHE's own data, presented to the Rocky Flats Stewardship Council (RFSC) in 2013. At the RFSC's February 4th meeting that year, Carl Spreng of the CDPHE gave a presentation titled "Operable Unit 3 Offsite Areas", explaining the selected remedy / corrective action decision of "no action" in those offsite areas. That presentation is available at http://www.rockyflatssc.org/OU3-RFSC-4Feb13.pdf. Page 7 of that presentation is a CDPHE / DoE plutonium isopleth map in picocuries per gram of soil, reproduced below as Figure 8. Just west of Indiana Street at East Gate Road, there is a 10 pCi/g isopleth line. That concentration of plutonium, 10 pCi/g, represents 512x background radiation. Furthermore there is a 5 pCi/g isopleth, representing 256x background radiation, crossing Indiana Street to the east side.

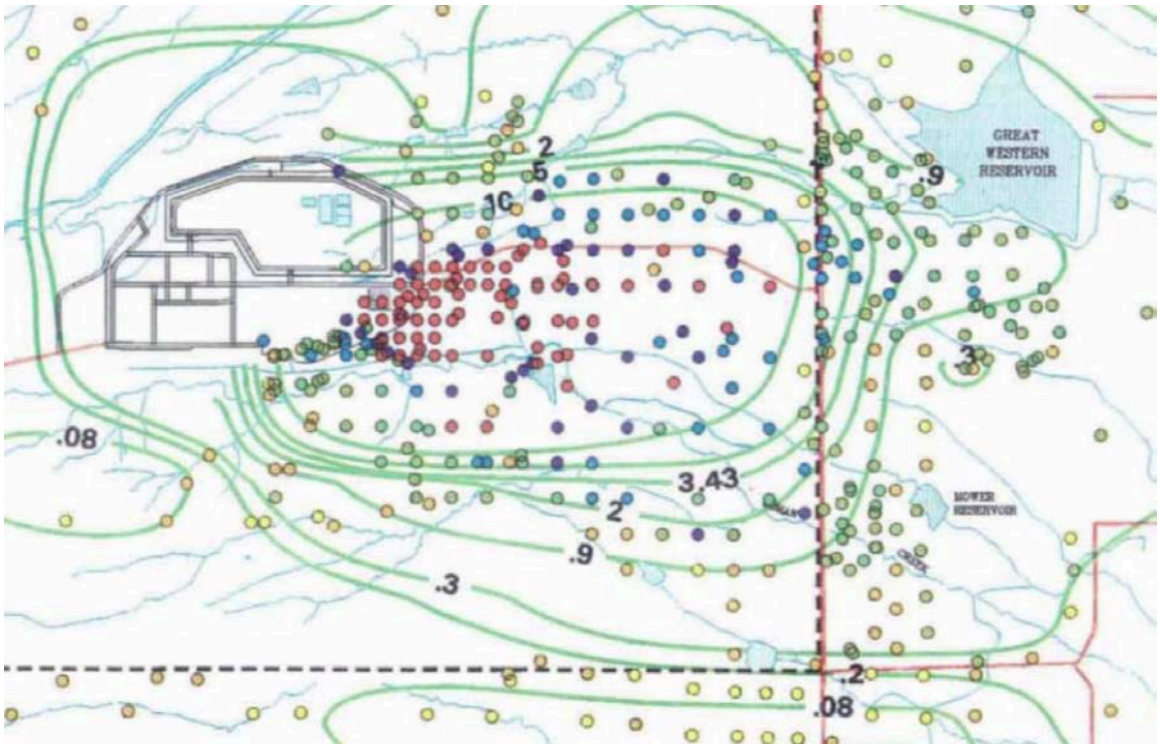

Figure 8: Plutonium isopleths in pCi/g from CDPHE's own 2013 presentation. Note 10 pCi/g just west of Indiana Street at East Gate Road represents 512x background radiation.

Summarizing plutonium contamination in the Indiana Corridor, the eleven studies cited above, spanning the years 1970-2013, have all consistently found plutonium contamination from the Rocky Flats Nuclear Weapons Plant in the Indiana Street corridor at levels representing hundreds of times background radiation.

Evidence of Increased Rates of Disease in the Downwind Population

Compared to the number of offsite soil contamination studies, there have been precious few studies of potential health effects of Rocky Flats contamination in the downwind population. Six studies have been performed, over the course of Rocky Flats history, of cancer incidence in areas surrounding the site. And another study analyzed plutonium content in tissues collected at autopsy from downwind residents compared to a control population. There never has been a comprehensive health-monitoring program for nearby residents, and no studies have been performed on potential health effects besides cancer. However there have been anecdotes about health impacts for nearly as long as the plant site has existed. The following paragraphs summarize and evaluate the available evidence, and the different viewpoints on risk and safety with respect to plutonium exposure.

Former Jefferson County Health Director Dr. Carl Johnson was the first person to study cancer incidence in the population downwind of Rocky Flats in comparison to cancer rates in areas further from the site. He was also the only investigator to ever publish such an epidemiological study in a peer-reviewed medical journal: "Cancer Incidence in an Area Contaminated with Radionuclides near a Nuclear Installation," *Ambio* 10: 176-182, 1981. Dr. Johnson reported the following findings based on comparing cancer incidence between geographical areas in the Denver metropolitan area separated by distance from Rocky Flats. The data were obtained at census tract granularity from the National Cancer Institute's Third National Cancer Survey 1969-1971 (i.e. new diagnoses made in those years).

1. Cancer incidence in males was 24% higher, and in females, 10% higher in the most contaminated suburban area nearest the plant, compared to the unexposed area.
2. The excess cases of cancer were mostly leukemia, lymphoma and myeloma and cancer of the lung, thyroid, breast, esophagus, stomach and colon, a pattern similar to that observed in the survivors of Hiroshima and Nagasaki.
3. Cancer of the gonads (especially of the testes), liver, and, in females, pancreas and brain contributed to the higher incidence of all cancer in areas near the plant.
4. The increase in incidence of all cancer and for certain classes of cancer in the exposed population supports the hypothesis that exposure of general populations to small concentrations of plutonium and other radionuclides may have an effect on cancer incidence.
5. Preliminary study of congenital malformations coded at birth found a rate of 14.5 per 1000 births for a large suburban city near the plant compared with a rate of 10.4 for the remainder of the county, and 10.1 for the state of Colorado, a difference of interest.
6. A most unexpected discovery was the unusually high incidence of cancer of the testis (40 cases observed/18 expected) throughout

> the exposed area. The incidence of cancer of the ovary was also higher (24%) throughout the exposed areas. The remarkably higher incidence of cancer of the testis in the three exposed areas merits special attention. One possible explanation is the demonstrated propensity of plutonium to concentrate in gonads. The higher incidence of cancer of the ovary is also consistent with this hypothesis.

A reprint of Dr. Johnson's *Ambio* article may be viewed at https://drive.google.com/open?id=1oPbKbMfiwmBp0gGTidYsisU83dX-0nYy.

Complementing Dr. Johnson's study, plaintiffs' counsel in *Church v. United States* Howard Holme, of the law firm Fairfield & Woods, hired CU physicist Stephen Chinn to perform additional analysis on the same Third National Cancer Survey 1969-1971 data set Johnson had studied. With advice from renowned radiation epidemiologist Dr. Alice Stewart and others, Chinn performed multiple regression analysis on the data set studied by Dr. Johnson, to identify which of some 50 factors were most strongly correlated with the increased cancer incidence near the plant discovered by Johnson. Chinn's findings were as follows:

1. Residence downwind of the Rocky Flats facility or in the area with plutonium contamination were the most significant risk correlates [in the higher cancer incidence nearer the plant].
2. Control for the other factors [socioeconomic status, air pollution, urban/rural factors, population mobility, and possible sources of carcinogens], singly or in combination, failed to account for the excess risk.
3. The excess was primarily of organs considered to be radiosensitive by the IRCP [International Commission on Radiological Protection] and was more pronounced in men than in women.

Chinn's report dated September 29, 1981 and titled "The Relation of the Rocky Flats Plant and Other Factors to 1969-1971 Cancer Incidence in the Denver Area", which was essentially part of the plaintiffs' pre-trial statement in *Church v. United States*, is at https://drive.google.com/open?id=1SMizzhf2Bxu4r5JrJOjJN9ryAtKrcCBz, in photographs. Since Chinn found downwind direction from the plant to be one of the most important factors in greater cancer incidence, Figure 9 below, excerpted from Chinn's report, shows an average wind rose from Rocky Flats for the years 1953-1970. As Figure 9 shows, the prevailing winds at Rocky Flats are from the west, sometimes with a northerly or southerly component, with an average velocity of 12mph.

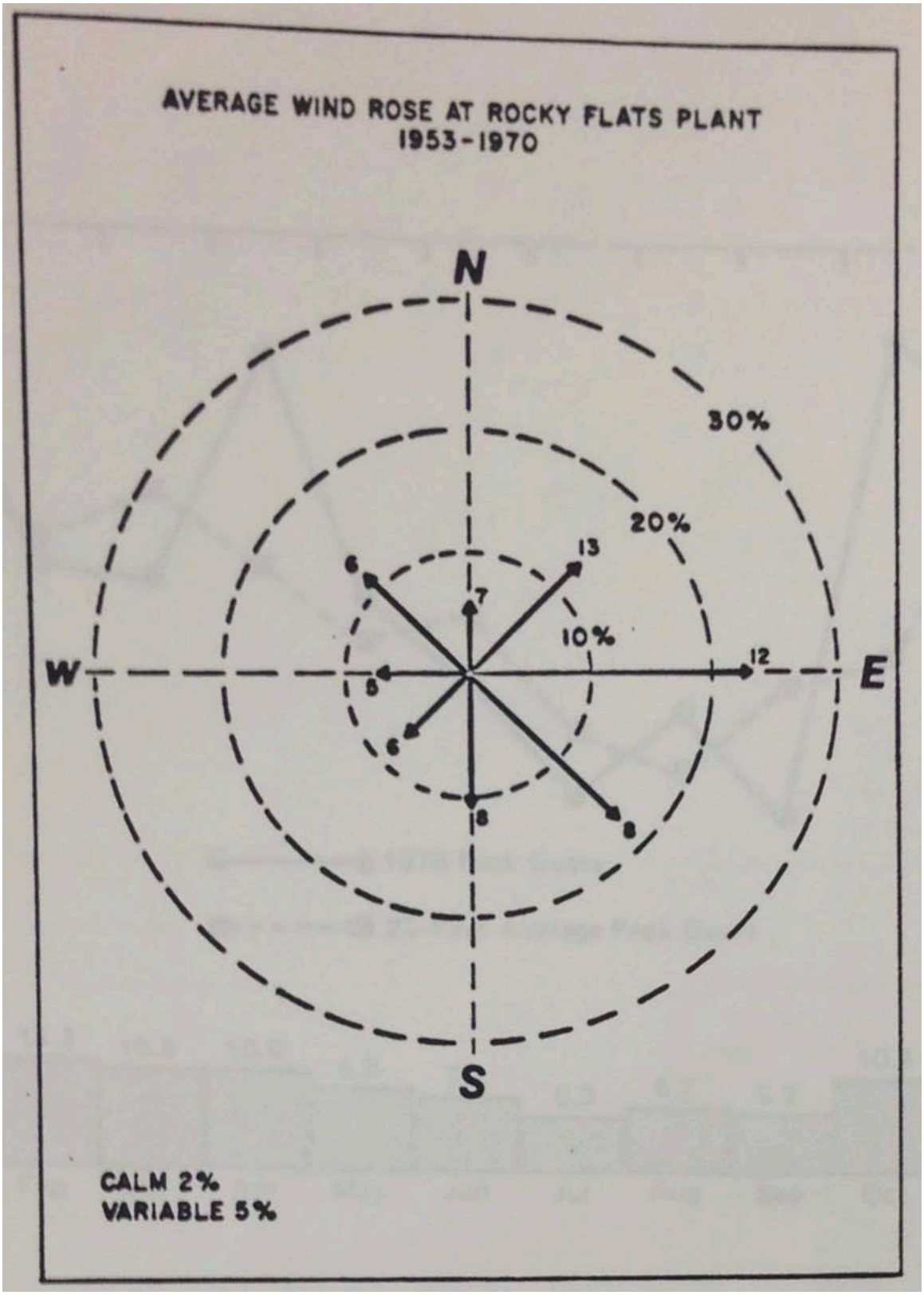

Figure 9: Average wind rose at Rocky Flats Plant 1953-1970. Arrows point in direction wind blows. Numbers at ends of arrows are wind velocity in MPH. Length of arrows and concentric circles reflect frequency of wind direction.

In response to the studies by Dr. Johnson and Stephen Chinn, a DoE-funded cancer incidence study was subsequently conducted, with its report completed in October 1984. This study and report were led by Kenny S. Crump for the Inhalation Toxicology Research Institute, a longtime Atomic Energy Commission contractor. Crump's report, titled "Statistical Analyses of Cancer Incidence Patterns in the Denver Metropolitan Area in Relation to the Rocky Flats Plant", contains the following statements in its executive summary:

> In Section II of this report, cancer incidence data for 1969 to 1971 are analyzed in a manner similar to that reported by Johnson. Ratios of observed/expected cancers were calculated for people living in four exposure areas determined by isopleths of plutonium concentrations in soil (contours of constant plutonium soil concentrations) that were used by Johnson. Area I is the area nearest the Rocky Flats plant and has the highest plutonium soil concentrations; Area IV consists of that part of the Denver SMSA outside of the lowest soil concentration contour. Cancer incidence patterns were analyzed for total cancer and 13 specific cancer types also studied by Johnson. Expected cancer incidences were based upon the cancer incidences in Area IV. *Johnson's results were closely reproduced using data collected for this study* [emphasis mine]. Statistically significant differences occurred between Area I and Area IV in total cancer and in the cancer categories of lung and bronchi, lymphoma and myeloma, colon and rectum, and testes for males, and in total cancer and colon and rectum cancer for females.

In later sections of the report, Crump applied an urbanization adjustment to his (and Johnson's and Chinn's) findings, which negated Johnson's and Chinn's conclusions of greater cancer incidence with closer proximity to Rocky Flats. This adjustment by Crump was later criticized as "highly unorthodox" by Dr. Richard Clapp, expert witness for the plaintiffs in *Cook v. Rockwell*, who holds a Doctor of Science in epidemiology from Boston University and a Master of Public Health from Harvard, and who was a former Director of the Massachusetts Cancer Registry. The study is at https://drive.google.com/open?id=1CfdH3NgLaeXz71NpPapVcn7e3G8LLyMA.

In the landmark case *Cook v. Rockwell*, the courts found in favor of the plaintiff class, homeowners east of Rocky Flats whose property was contaminated by the plant (trespass of contaminants onto their property, and nuisance of those contaminants, were the charges brought), and awarded the plaintiff class $375,000,000 in settlement on May 19, 2016. Plaintiffs' counsel presented Dr. Richard Clapp, described above, as an expert witness in the case, and admitted into

evidence a study conducted by Dr. Clapp on cancer incidence downwind of the site. For his role in the case, Dr. Clapp first reviewed all previous studies of cancer incidence in the downwind population, sharply criticized the Crump study as mentioned above, and stated that Johnson's and Chinn's findings "provide justification for purposeful and ongoing medical surveillance of exposed populations" (which never happened). He then analyzed lung and bone cancer incidence for the years 1979-1992 as a function of proximity to Rocky Flats, and wrote the following in his report admitted into evidence.

> The most relevant finding is that for the time period 1989-1992, the risk of lung cancer was elevated in all the exposure scenarios comparing the two contours closest to the Rocky Flats plant to other contours further away. The odds ratios range from 1.09 to 1.29 depending on the exposure scenario and the sex of the cases. … These years correspond to an approximate latency of 20-35 years from the time of maximum plutonium emissions from the plant and may therefore be more representative of a health effect in the exposed population.
>
> In addition, bone cancer incidence was examined in the same time periods and with respect to plutonium levels in soil (Krey and Hardy, 1970). … In this analysis, there is evidence that the incidence of bone cancer in the Zip Codes in the inner two contours (the areas associated with the highest plutonium levels) was greater than in areas associated with lower plutonium levels further away. This is especially true in the period 1984-1988 when the adjusted odds ratio was 1.9.

The "odds ratio" of 1.29 for lung cancer means that according to the cancer incidence data, people closer to Rocky Flats had 29% more lung cancer cases than people farther away. The odds ratio of 1.9 for bone cancer means that people closer to Rocky Flats had 90% more bone cancer cases than people farther away. And the relevance of the 20-35-year latency period is that for cancers caused by internal bodily exposure to low-level ionizing radiation, there can be a latency period of decades (for adults) between exposure and disease onset, as documented in the ATSDR's toxicological profile for plutonium cited earlier. Dr. Clapp's report is at https://drive.google.com/open?id=1WkZVLjjye9TC37DmjOb8QwZZ06fb5rEz.

The CDPHE conducted cancer studies in 1998 and 2016, available at https://www.colorado.gov/pacific/cdphe/cdphe-rocky-flats-cancer-study. Though the CDPHE's website states the 1998 study was "independent" (meaning unknown), that study's acknowledgements page states "This project was supported in part by the U.S. Department of Energy State Health Agreement Program through grant #DE-

FG01-94EH89530." The studies analyzed incidence of ten selected types of cancer in ten Regional Statistical Areas (RSA) "selected primarily for their proximity to Rocky Flats." Those ten types of cancer were: esophagus, stomach, colon and rectum, liver, lung, prostate, bone, leukemias, lymphomas, and brain and central nervous system. The 1998 study's findings, echoed by later CDPHE studies, were:

> For the entire 10-RSA region and the 10 individual RSAs, the incidence of all [10 studied] cancers combined for persons of all ages and for children during 1980-1989 was not higher than expected compared to the remainder of the Denver Metro area. Also for the entire 10-RSA region, none of the ten selected cancers for persons of all ages was found to be higher than expected.

However the CDPHE studies have a number of design flaws limiting their ability to detect increased cancer incidence in the downwind population. Those flaws are:

1. The ten RSAs selected "for their proximity to Rocky Flats" include mostly areas that were not downwind and were not contaminated, for example north of US 36 and Highway 128, east of I-25, west of I-70, etc. See Figure 10 for a map of the RSAs studied. Since these areas were not as contaminated, it is expected that cancer incidence in those areas would be lower. That lower incidence dilutes the incidence found across the entire 10-RSA region. In the map in Figure 10, really only RSAs 202 and 203 should have been compared to "the remainder of the Denver Metro area".
2. Even the RSA granularity is too large to isolate cancer incidence increases as a function of distance and direction from the site. For example RSA 202, containing Standley Lake, stretches all the way from Highway 93 to east of US 36. Whereas Dr. Johnson worked at census tract granularity, and Dr. Clapp worked at zip code granularity, allowing their studies to focus on finer geographical units in relation to distance and direction from the site.
3. The list of cancer types studied had important omissions from the perspective of radiosensitive cancers, for example cancers of the gonads and thyroid. Therefore the studies weren't designed to find all of the data necessary to answer the question of whether there is increased incidence of radiosensitive cancers downwind of Rocky Flats.
4. The studies used estimates of population, therefore the accuracy of their findings is sensitive to the quality of their population estimation approach.
5. The 2017 supplement covering thyroid and "rare" cancers only analyzed 1990-2014 data, not also 1980-1989 data as in the 1998 study. Thus the 2017 supplement is incomplete.

As quoted in *The Ambushed Grand Jury* (p.200), radioecologist Bernd Franke, upon reviewing the 1998 CDPHE study, stated "It appears the study design was chosen for public relations purposes, to calm people down, rather than for any real scientific reason." Dr. LeRoy Moore has also sharply criticized the CDPHE study in a paper at https://drive.google.com/open?id=1bl3BCdPU8Os8e4Vf2CooXG1Q2UEk4ANQ.

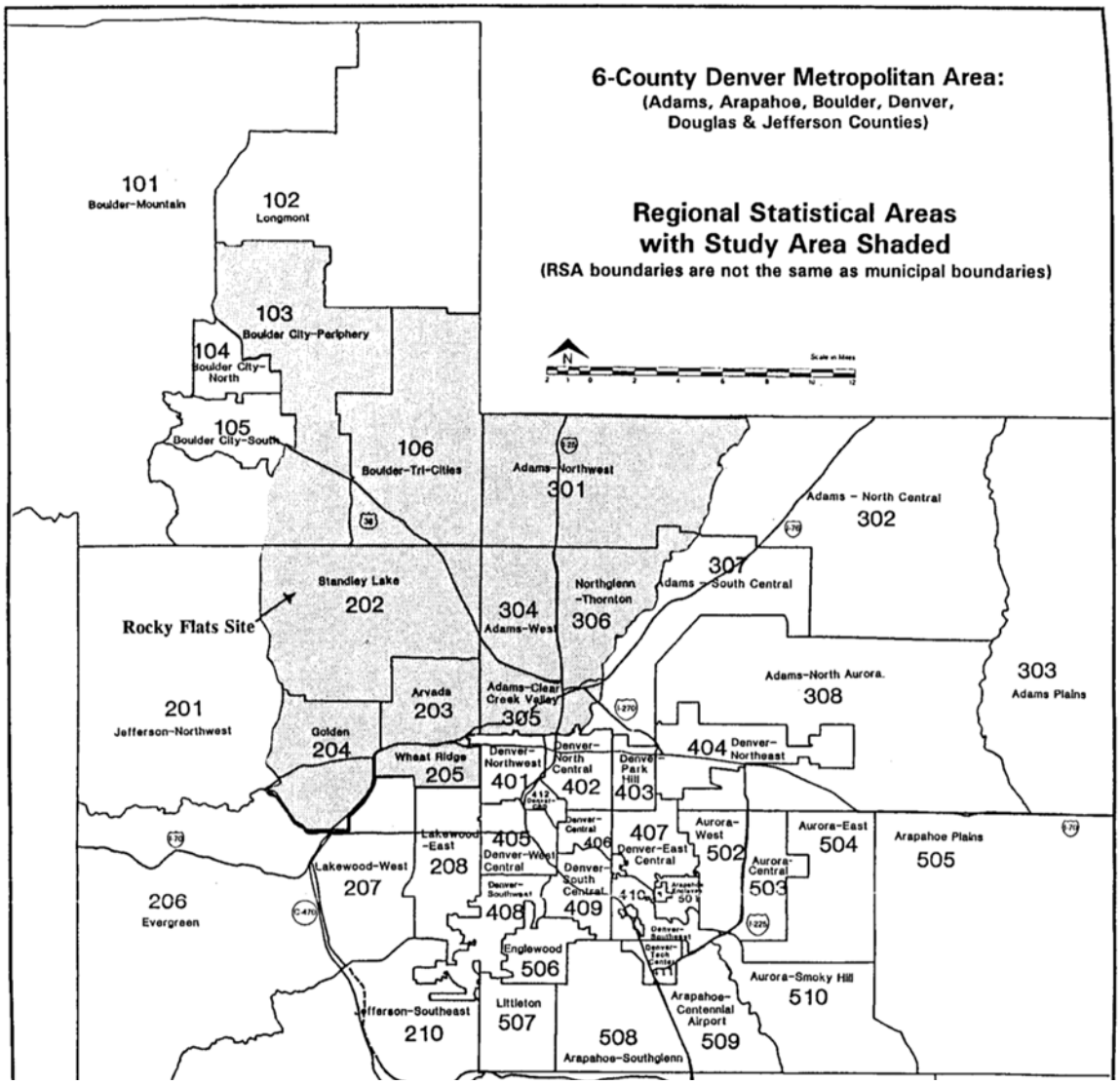

Figure 10: Regional Statistical Areas "selected primarily for their proximity to Rocky Flats" in the CDPHE cancer incidence studies.

In making assessments and representations about the safety of the Rocky Flats area currently, CDPHE relies upon mathematical models based on assumed safe standards of radioactivity in soil and assumed permissible doses of radioactivity in humans. The models relate contaminant concentrations in soil to committed doses of radiation in people, through different exposure scenarios for different groups of people, and relate those committed doses to excess cancer risk.

But a model is not reality. Paraphrasing from Dr. Eberhardt Rechtin's seminal work *Systems Architecting* from the aerospace industry, a model is an abstraction of how its creators think and hope a system works. What is actually observed from the system is almost always different. A quote from test flights of aircraft goes: "before the flight it's opinion; after the flight it's obvious." In this case the "flight" was the release of contaminants from the Rocky Flats plant.

Reality is the findings of Dr. Johnson's, Chinn's, and Dr. Clapp's epidemiological studies. Reality is the findings of Metropolitan State University's (MSU) Rocky Flats Downwinders Health Survey. Though not an epidemiological study, the survey's results suggest the need for new comprehensive epidemiological studies. The survey's preliminary findings revealed that 414 (49%) of 848 reported cancer cases were designated as rare cancers. The survey produced geo-plots, shown in Figure 11, of the addresses of respondents reporting cancer, overlaid with the path of the 1957 fire smoke plume, and with the Krey Hardy map. Those geo-plots are striking visual evidence of the potential correlation between Rocky Flats contamination releases and downwind disease incidence. A report on the survey's preliminary findings is at http://rockyflatsdownwinders.com/wp-content/uploads/2016/05/RFD-Health-Survey-Executive-Summary-Final.pdf.

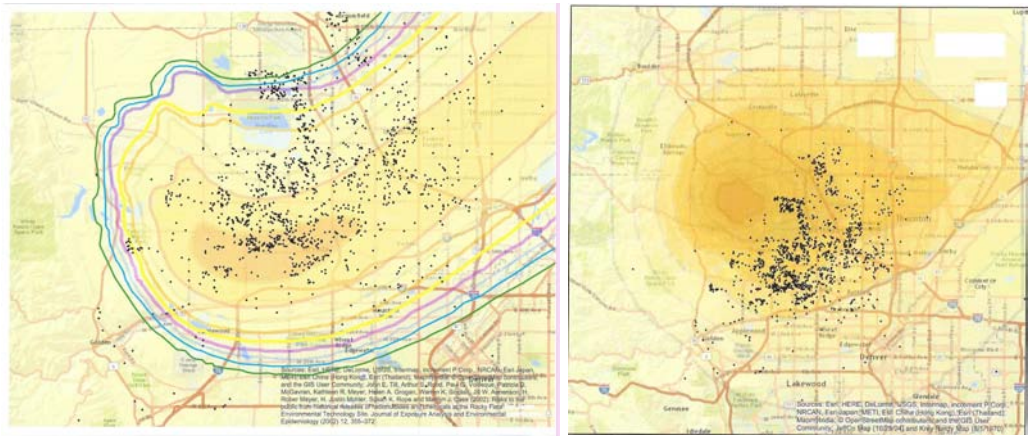

Figure 11: Geo-plots of cancer sufferers' addresses (black dots) from the MSU health survey overlaid at left with the path of the 1957 fire smoke plume and at right with the Krey Hardy map isopleths.

Reality is the disease incidence in Five Parks, a nearby downwind neighborhood at 86th and Indiana, which is only fifteen years old. In the last few years in that neighborhood there have been two cases of an extremely rare heart cancer, cardiac angiosarcoma, multiple cases of other radiosensitive cancers, and multiple cases of neurological disease. That cannot be all coincidence. Former Five Parks resident Elaine McNeely, widow of cardiac angiosarcoma victim Brian McNeely, describes the disease incidence in Five Parks at 59:10 of https://www.youtube.com/watch?v=9XTtu2DRb3k, in a public comment at the most recent Rocky Flats Stewardship Council meeting. KDVR news also ran this story: http://kdvr.com/2018/04/02/safety-concerns-continue-at-rocky-flats-months-ahead-of-new-trails-opening-up/. And there are many, many other

anecdotes amongst Arvada residents of multiple family members, neighbors, friends, and classmates all dying of cancer, or having neurological disease, or thyroid conditions. The Facebook groups "Arvada Neighbors" and "Let's Talk, Arvada" are veritable gold mines of anecdotal evidence.

Reality is the study performed by former CU School of Medicine Professor and Department Chair of Preventative Medicine Dr. John Cobb. Dr. Cobb conducted a long-running EPA-funded study of plutonium content in deceased downwinders' lung and liver tissue, compared to plutonium content in the lungs and livers of a control population of deceased persons from Pueblo, Colorado. These tissues were collected at autopsy, with permission, from a total of 519 people. While the amount of plutonium in the downwinders' tissues was only very slightly higher than the amount in the Puebloans' tissues, the really important finding from Dr. Cobb's study was that the downwinders' tissue plutonium was definitely from Rocky Flats, based on analysis of ^{240}Pu:^{239}Pu isotope ratio (Rocky Flats plutonium has a different ratio of those isotopes than does atmospheric fallout plutonium). How did that Rocky Flats plutonium get into those downwinders' lungs and livers? That is an important question. Photographs of an affidavit by Dr. Cobb attesting to these findings are at https://drive.google.com/open?id=1mKMnlJiDSwBKWqulYhoRm0AdauhdnlXq.

Finally, reality is establishing a causal connection between Rocky Flats contamination and cancer, by analyzing tumor tissue or decedents' remains for Rocky Flats –specific plutonium. Precedent for establishing such a causal connection exists in the cases of Lloyd Mixon and Kristen Haag, for example. Lloyd Mixon was a rancher who lived downwind of Rocky Flats and who developed cancer (and who also observed a number of deformities in his ranch animals). In the movie *Dark Circle*, Mr. Mixon describes having his excised malignant tumors analyzed for plutonium, with positive findings. Kristen Haag was a downwind teenager who died of cancer after having a leg amputated because of the same cancer. She was cremated, and her ashes were analyzed for Rocky Flats plutonium, with positive findings. In *Dark Circle* her father Rex Haag tells Kristen's story, and her case is also described in *Full Body Burden*.

In light of those realities, the assumptions upon which CDPHE relies, about safe standards of plutonium in soil, and permissible doses of plutonium in humans, could very well be invalid. In January 1973, then-Director of the Colorado Department of Health (CDPHE's former name) established for the first time a plutonium soil standard of 0.2 dpm/g for Colorado, writing that level of contamination "presents a sufficient radiation hazard to the public health to render the land unfit for residential use, subdivision development, or commercial and industrial uses." But because the existing contamination already exceeded that threshold by an order of magnitude as far away as east of US 36 and south of 64th Avenue, the standard was arbitrarily changed to 2.0 dpm/g just a few months later. A photo of the public notice of the initial (0.2 dpm/g) soil standard is at https://drive.google.com/open?id=1n1imFzFR53h5qaF88lwERczWJXTKAqxD.

Regarding permissible doses of plutonium, pioneers in the fields of health physics, nuclear chemistry, and radiation epidemiology have all stated under oath in court proceedings that there is no safe level of exposure to plutonium for human beings. The documentary film *Decision at Rocky Flats* (https://vimeo.com/groups/161968/videos/45547905), about the 1978 trespassing trial of the Rocky Flats Truth Force, contains the testimony of these pioneers starting at 07:45. Dr. Karl Morgan (https://en.wikipedia.org/wiki/Karl_Z._Morgan) testified that "there is no dose, no exposure, to ionizing radiation so low that the risk is zero" and that "the cancer risk is much, much greater than it was thought to be when these earlier standards [of permissible dose] were established," and that those standards create a false sense of security. Dr. John Gofman (https://en.wikipedia.org/wiki/John_Gofman) testified that "I don't find any permissible dose to be permissible, because to me a standard or a permissible dose is simply a legalized permit to commit murder. So I don't think of things as a permissible, I think of things only in how many deaths there will be per unit dose, which is the only scientifically meaningful thing." A 2004 report by a United Kingdom government committee also found that cancer risk from plutonium may be an order of magnitude greater than previously thought (https://www.newscientist.com/article/dn6152-plutonium-cancer-risk-may-be-higher-than-thought/).

Despite CDPHE's mission stated in its 2016-2019 strategic plan (https://www.colorado.gov/pacific/sites/default/files/OPP-StrategicPlan2016-19-July2017.pdf), "to protect and improve the health of Colorado's people and the quality of its environment," CDPHE has never conducted a health monitoring program for the population downwind of Rocky Flats, instead choosing to rely on modeling and assumptions, and to publish studies with major methodological flaws, and to attack or ignore the large body of dissenting information from highly credible sources, all while being funded by the DoE. Measurement of actual public health would far outweigh modeling of hypothetical health risk, and would better align with CDPHE's stated mission.

Summarizing the evidence of increased rates of disease in the downwind population, three valid epidemiological studies by highly credible investigators have all found significantly increased rates of cancer in close proximity downwind of Rocky Flats than farther away. Two of these studies were expert reports in lawsuits against Rocky Flats that were settled or decided for the plaintiffs. Meanwhile the two DoE-funded studies have used highly unorthodox techniques, or major methodological flaws, to find no significant difference in cancer near Rocky Flats than elsewhere in the Denver Metropolitan area. To claim the area is safe, CDPHE relies on modeling that would be outweighed by measurement of the reality downwind, and on probably invalid assumptions about soil standards and permissible doses for plutonium.

Respirable Plutonium-Laden Dust Likely from Construction Activities

With respect to the plutonium contamination in the soil along the Indiana Street corridor (consistently found by eleven different studies spanning the years 1970-2013), the exposure pathway of greatest concern for the surrounding population is inhalation of plutonium-laden dust. Quoting ATSDR's toxicological profile for plutonium again:

> **Plutonium can enter your body when it is inhaled or swallowed:** When you breathe air that contains plutonium, some of it will get trapped in your lungs. Some of the trapped plutonium will move to other parts of your body, mainly your bones and liver. The amount of plutonium that stays in your lungs depends on the solubility of the plutonium that is in the air you breathe.
>
> A small amount of the plutonium you swallow (much less than 1%) will enter other parts of your body (mainly your bones and liver).
>
> If plutonium gets onto your healthy skin, very little, if any, plutonium will enter your body. More plutonium will enter your body if gets onto injured skin, such as a cut or burn.
>
> **Plutonium in your body will remain there for many years:** Plutonium leaves your body very slowly in the urine and feces. If plutonium were to enter your lungs today, much of the plutonium would still be in your body 30–50 years later. [p.4]
> …
> Cancer is the major latent harmful effect produced by ionizing radiation and the one that most people exposed to radiation are concerned about. The ability of alpha, beta, and gamma radiation to produce cancer in virtually every tissue and organ in laboratory animals has been well-demonstrated. The development of cancer is not an immediate effect. Radiation-induced leukemia has the shortest latent period at 2 years, while other radiation induced cancers have latent periods >20 years. The mechanism by which cancer is induced in living cells is complex and is a topic of intense study. Exposure to ionizing radiation can produce cancer at any site within the body; however, some sites appear to be more common than others, such as the breast, lung, stomach, and thyroid. [p.D-9]

Further, former Jefferson County Health Director Dr. Carl Johnson's article in the peer-reviewed medical journal *Ambio*, titled "Cancer Incidence in an Area Contaminated with Radionuclides near a Nuclear Installation", states as follows:

> The major route of exposure is the inhalation of airborne particles of Pu and other radionuclides by people living in the path of exhaust plumes from the plant, and (for those living near the plant), the inhalation of Pu in resuspended surface dust.
> …
> Resuspension of Pu-contaminated soil increases with wind speed to the 2.1 power, and the ratio of Pu 238 to Pu 239 increases from about 2 percent (surface soil) to 20-40 percent in airborne soil (31). As much as 50 pCi/g of Pu in airborne soil has been reported in the area. A study of Pu particle size in the soil suggested that single Pu atoms and Pu particles with diameters less than the minimum detectable equivalent diameter (0.09 pm) accounted for the majority of Pu 239 and Pu 240 activity in the soil (32).

The reference (31) cited in Dr. Johnson's article was "G A Sehmel, in Transactions of Meeting on Rocky Flats Buffer Zone, Ecological and Environmental Research Meeting, (Rockwell International, Rocky Flats Plant, Golden, Colorado, 1977)." G.A. Sehmel was an expert on airborne particle resuspension and distribution. The reference (32) was "L M McDowell, S W Whicker, Health Physics 35, 239, (1978)" referring to an article titled "Size Characteristics of Plutonium Particles in Rocky Flats Soil".

Thus it is established that inhalation is the plutonium exposure pathway of greatest concern, and that resuspension of plutonium-containing Rocky Flats soil into the air increases as the square of wind speed at the site. All it takes to get highly carcinogenic Rocky Flats plutonium into a person's lungs is one unlucky breath on a breezy day.

Construction of the Jefferson Parkway will certainly raise dust into the air - dust from plutonium-contaminated soil in the Indiana Street corridor. Figure 12 below depicts construction activity on C-470 between Broadway and Santa Fe Drive at 12:53 p.m. on April 12th, 2018, when the wind at nearby Chatfield Reservoir was blowing 27mph and gusting to 44mph. The dust from a dump truck's tires, and from a bulldozer ahead of it, is plainly evident in the photograph, to the extent that it was creating a driving visibility hazard on westbound C-470. There is no reason to believe the same degree of dust resuspension will not occur during Jefferson Parkway construction, with the amount of cut-and-fill by heavy equipment contemplated by the project, and with the scope of a project the parkway's size.

Figure 12: Dust resuspended by construction on C-470 on a breezy day April 12th. Note the dust kicked up by the dump truck's tires, and a bulldozer ahead raising enough dust to create a visibility hazard.

Wind-borne dust can travel surprising distances. On April 17th the Colorado Front Range had a high wind event. Hurricane-strength gusts were recorded at A Rising Star Equestrian Center at 96th Avenue and Indiana Street. Farther south at Chatfield Reservoir, west winds gusted to 48mph at 3:00 p.m., and over 30mph from noon to 9:00 p.m. Chatfield State Park's facilities are currently undergoing massive reconstruction for the Chatfield Storage Reallocation Project (https://chatfieldreallocation.org). Consequently the swim beach is closed this summer, and the entire western shore of the lake has been excavated and rebuilt by trains of large earth movers. The next afternoon, April 18th, upon visiting my 30-foot sailboat in the marina, I found her white decks to be covered with reddish-brown dirt from the lake's western shore. The distance from the western shore excavation to the marina is over a mile. Dust from that windstorm traveled that distance in a single afternoon.

Undetected Buried Nuclear Waste Possible in Parkway Right-of-Way

There is a possibility, however remote, that undetected nuclear waste burial sites exist in ground that would be excavated for the Jefferson Parkway. Record-keeping as to the location and content of waste burial sites by the plant's operators was incomplete.

In *Church v. United States*, plaintiffs' counsel Howard Holme filed a 500-page pre-trial statement considered the most complete public account of accidents and contamination releases by the plant (see https://www.nytimes.com/1990/02/15/us/weapons-plant-pressed-for-accounting-of-toll-on-environment-and-health.html). During discovery for the court case, Mr. Holme reviewed 60,000 DoE and contractor documents onsite at the Rocky Flats plant. A scan of "the Holme report" is available for viewing at https://drive.google.com/open?id=1NjPLtcUaf7j_7-o_bMtWM1j5ERTu0sry.

On p.12 of Holme's pre-trial statement, he writes: "Besides the Mound, many other burials were made at Rocky Flats between 1954 and 1970. Recordkeeping was poor, and new burials were discovered as recently as the soil sampling hearings in 1977." On p.189 of Holme's pre-trial statement, he writes "due to incomplete record-keeping the number and location of burial sites at Rocky Flats is probably not known." This is in the context of very revealing transcripts of a "plant problems meeting" and a congressional Joint Committee on Atomic Energy meeting, spanning pp. 176-186 of the Holme report.

Jerry Harden worked at Rocky Flats for 37 years, retiring as a Senior Radiation Technician. He was a three-term president of Steelworkers Local 8031, which represented production workers at Rocky Flats. Mr. Harden is described further at https://leroymoore.wordpress.com/2011/02/21/rocky-flats-legacy-nuclear-workers-stories/. He was on the work crew that cleaned up the 903 area in 1968, pumping what remained of plutonium-laced oil from corroded barrels left out in a field into new drums, prior to removing the ~5,200 barrels from the 903 area for paving it over. Mr. Harden has stated publicly that he thinks there will be revelations coming from this site for many decades to come. In 2010 he testified in the Colorado legislature in favor of HB1127 proposing signage at Rocky Flats to inform visitors of the site's history and risks. Mr. Harden has also stated to me that if he could survey the site in its current state with a Micro-R gross survey instrument, he is confident that he "could find things".

Given the incomplete record-keeping as to waste burial locations and contents discovered by Howard Holme, and given the predictions about the site made by a very prominent worker there, it's entirely possible that waste burial locations exist in the former buffer zone that were not identified in the cleanup planning. If a piece of heavy equipment involved in excavation for Jefferson Parkway construction were to plow into an unknown cache of deteriorated barrels of nuclear waste, that would constitute a fairly major environmental crisis.

Steps JPPHA Has a Moral Obligation to Take Before Building

Thus it is my position that, given the well-studied existence of hundreds of times background radiation in the Indiana corridor, and given the evidence of increased cancer and disease in the downwind population, and given the certainty that Jefferson Parkway construction will resuspend highly carcinogenic respirable plutonium-laden dust into the air, and given the unignorable possibility of encountering an unknown nuclear waste burial site during construction, the Jefferson Parkway Public Highway Authority has a moral obligation to the local citizenry, as an inter-governmental entity directed by elected representatives of local governments, for the sake of public health, to take certain steps before proceeding with construction of the project. These steps are enumerated and elaborated in the following paragraphs.

1. The JPPHA should sponsor an independent review, by a qualified national institution independent of the Department of Energy, of all past studies of buffer zone and offsite soil contamination, and of public health impacts of Rocky Flats contamination. The National Academy of Sciences is a leading example of a candidate institution. Such a review would have the potential to quell, for all time, any conflict between any findings of different studies of these matters in the past.
2. The JPPHA should sponsor new studies of current contamination levels of soil that would be disturbed by parkway construction, to understand what contamination and therefore risk is present, prior to commencing construction. We are fortunate to have in Denver a highly-qualified potential investigator of plutonium contamination in Indiana corridor soils, in Dr. Michael Ketterer of Metropolitan State University, who specializes in precisely this field of study.
3. The JPPHA should seek to review ALL available sources of information about buffer zone and offsite contamination, in order to know everything possible about contaminant releases and potential environmental conditions, as part of making a morally responsible decision about whether and how to proceed. In particular, the JPPHA should seek to understand exactly how any cleanup was done in the parkway right-of-way strip, and exactly how it knows the area is “safe”.
4. The JPPHA should consider changing the alignment of the parkway to go up Highway 93 and cut across to the Northwest Parkway from north of Rocky Flats, to avoid the whole controversy. Such an alignment may ultimately have less cost to the JPPHA than dealing with the controversy over, and mitigation of, contamination in the Indiana corridor.

5. Failing step 4 above, the JPPHA should develop very effective techniques for mitigating public health risk if constructing the parkway up Indiana Street. For example, suspending construction activity any time wind speeds increase above Force 2 on the Beaufort scale, and using highly effective dust suppression techniques at all times, which don't cause runoff of soils into local waters near the site.