

TORTURED SCIENCE

Health Studies, Ethics, and Nuclear Weapons in the United States

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CHAPTER 4

Democracy and Public Health at Rocky Flats: The Examples of Edward A. Martell and Carl J. Johnson *LeRoy Moore*

A fundamental contradiction exists between democracy and the practice of building nuclear weapons. This truth is strikingly evident in the history of public health science as played out at the Rocky Flats nuclear bomb factory near Denver, Colorado, where over a period of nearly 40 years the fissionable plutonium “pit” for every nuclear weapon in the US arsenal was manufactured.

This chapter, written to counter the art of denial, explores two versions of public health science, one oriented to the “nuclear establishment,” the other to public service. The former includes personnel affiliated with the industry and with government agencies that at least implicitly give priority to the industry. The latter comes to focus here on two individuals, the late Edward A. Martell, a radiochemist with the National Center for Atmospheric Research (NCAR), a private nonprofit research body located in Boulder, and the late Carl J. Johnson, MD, who for several years was the chief public health officer for Jefferson County, where Rocky Flats is located. Martell was the first to alert the public to dangers at Rocky Flats about which insider scientists remained silent. Johnson became a lightning rod for efforts to curb abuses resulting from operations at Rocky Flats.

I. EDWARD MARTELL: PUBLIC SERVICE FOR PUBLIC HEALTH

Martell's Revelation

On the afternoon of May 11, 1969, people throughout the Denver area saw smoke billowing from a building at the Rocky Flats nuclear bomb factory located at the base of the mountains 16 miles northwest of central Denver. The fire, soon labeled the most expensive industrial fire to date in US history, caught the attention of NCAR radiochemist Ed Martell. He feared that the strong winds common at Rocky Flats had carried potentially lethal particles of plutonium toward unsuspecting people in the Denver area. So he asked Rocky Flats officials to sample offsite soil for plutonium. When they declined, he and colleague Stuart E. Poet took their own samples. At various locations east of the facility they found plutonium deposits in the top centimeter (0.39 inch) of soil up to 400 times average background concentrations from global fallout [1].

In February 1970, Martell and Poet met with officials from Rocky Flats and the Colorado Department of Health (CDH) [2] to discuss their findings. Plant officials insisted that what they found didn't come from the May 1969 fire. A more likely source was either a fire that occurred on September 11, 1957 [3], or leaks from thousands of drums of plutonium-laced waste stored outside in the plant's 903 area from 1954 till 1968. These two events were the sources of the largest plutonium releases from Rocky Flats since operations began at the plant in 1953. Thus did the state government and the public learn about the worst accidents ever at Rocky Flats [4].

In this meeting a high-ranking Atomic Energy Commission (AEC) official, having learned that two of Martell's colleagues worked for the Commerce Department and that NCAR was a private research center supported by the National Science Foundation, let it be known that he would "bring this matter up with the appropriate officials of the Department of Commerce and the National Science Foundation." He said he had "a personal hangup about one federal agency engaging in activities critical of another federal agency"[5]. This moment cast a dark shadow over Martell's future career.

Shortly after the meeting, Martell distributed a paper that included the following observations:

- Anyone who inhales particles of plutonium like those released from Rocky Flats would be "subject to

radiation millions of times more intense than from an average naturally occurring radioactive dust particle of the same size. . . . Only minute amounts in the lung are sufficient to cause cancer.”

•Neither Rocky Flats officials nor Colorado public health officers had provided any data on plutonium in the environment.

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•Whether production should continue at Rocky Flats needs to be resolved based on a “thorough assessment” of health effects “by qualified medical researchers who are independent of the AEC [6].

AEC Response to Martell: Krey

The AEC brought in P. W. Krey, a specialist of their own, to sample for plutonium in soil off the Rocky Flats site. He not only confirmed Martell’s results but also showed that plutonium from Rocky Flats was very widely distributed throughout the metro area. When Krey reported his results in *Health Physics*, he mapped plutonium distribution in a series of amoeba-like isopleths graded to show concentrations ranging from higher levels near the facility to lower ones further out until deposits from Rocky Flats could not be distinguished from background [7] (see Figure 1[m1]).

Most of Krey’s samples consisted of a composite of material from the top 20 centimeters (7.8 inches) of soil. This sampling method may have enabled Krey to estimate the total inventory in soil of plutonium released from Rocky Flats, but it could not show surface concentrations, since his method diluted surface deposits by mixing them with less contaminated soil from below the surface. Also, his isopleths only approximate reality, since they were based on samples taken at only twenty-five offsite locations over a very large area, with Rocky Flats plutonium found at only fifteen.

Colorado Sets a Standard for Plutonium in Soil

In response to revelations of major releases of radiation from Rocky Flats, Colorado established the first standard anywhere for plutonium in soil. In January 1973, it mandated that land where plutonium contamination exceeds 0.2 disintegrations per minute per gram of soil (dpm/g) is “unfit for residential use, subdivision development, or commercial and industrial uses” [8]. Less than two months later the state increased by tenfold the amount of plutonium to which exposure was allowed, from 0.2 to 2.0 dpm/g. At the same time, the state lifted its prohibition against residential, commercial, or industrial uses in areas too contaminated to meet the standard; hereafter it would merely require “special techniques” for construction in such areas, such as plowing plutonium under [9]. Thus, the standard was completely gutted of its original provisions for public health. In 1975, Martell criticized the state standard for being at least twenty

times too high and not protective of public health [10]. Nonetheless, the revised standard remains in effect today.

The State's Misleading Soil Sampling Practice

In February 1974, the Rocky Flats site more than tripled in size by the addition of 4,550 acres eleven months after establishment of the state's 2.0

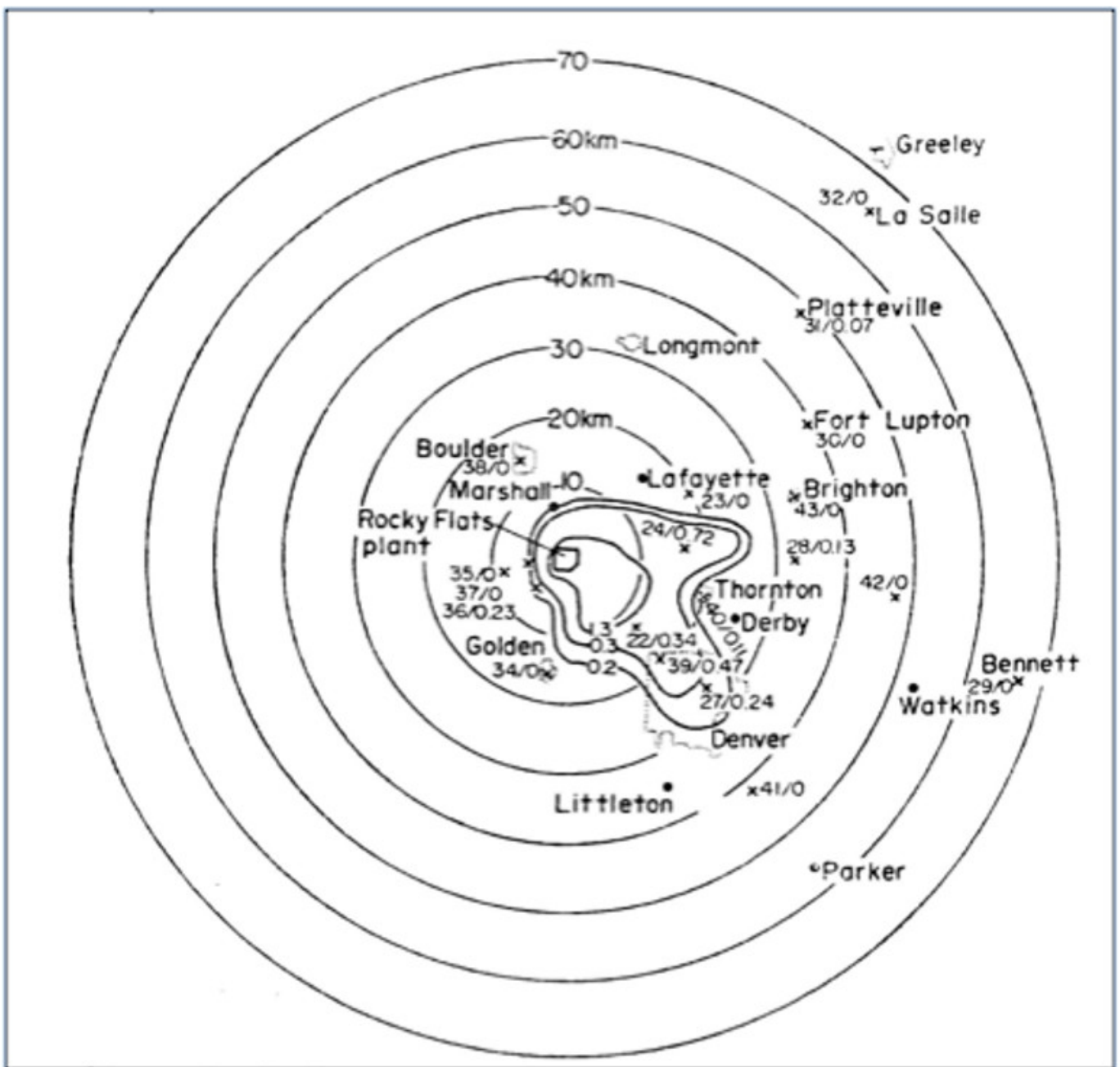


Figure 1. Soil sampling sites in north central Colorado are designated by X. The first of the adjacent pair of numbers to the site represents the site number. The second (following the slash) represents Rocky Flats plutonium in millicuries per square kilometer (mCi/km²) measured at that site (one millicurie is 1/1000th of a curie). The heavy irregular lines of the isopleths reflect the isoconcentration contours of Rocky Flats plutonium in the soil expressed as mCi/km². The concentric circles reflect the radial distances from the center of the Rocky Flats plant. From Krey, "Remote Plutonium Contamination and Total Inventories from Rocky Flats," *Health Physics*, 30 February 1976, p. 210, reprinted with permission.

dpm/g standard for plutonium in offsite soil, the Rocky Flats site was more than tripled in size by the addition of 4,550 acres. The site's boundary on the predominantly downwind, down gradient east side was moved out to Indiana Street. In enforcing its new standard for areas east of the enlarged site, CDH employed from the outset a sampling method that thwarted its ability to locate places where the plutonium

concentration exceeded the standard. Rather than analyzing specific samples for their radiation content, CDH divided the area to be sampled into large sectors, then calculated the average plutonium

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concentration in each sector by compositing all the soil collected from twenty-five samples taken from within that sector [11]. This approach may show average distribution in large areas, but it dilutes particular points with high readings by averaging them with lower ones, making identification of hot spots impossible.

The CDH's soil sampling also misrepresented reality in that over time it collected samples to increasingly greater depth, thereby diluting the material measured and giving the impression that the quantity of plutonium in soil was steadily decreasing. An internal study criticized this practice and concluded that plutonium concentrations in soil around Rocky Flats had changed little from 1970 until 1991 [12]. For public health assessments, CDH eventually adopted the practice of compositing samples taken from the top quarter-inch of soil within a given area. The words of German analyst Ulrich Beck are apt: "Whoever limits pollution has also concurred in it." Standards for "permissible" exposure "may indeed prevent the very worst from happening, but they are at the same time 'blank checks' to poison nature and humankind a bit" [13]."

Martell and the Public

Martell's revelations after the 1969 fire sparked public awareness and action. "Nobody knew anything about Rocky Flats until his study," said Judy Danielson, a physical therapist recently returned from doing humanitarian work in Vietnam. She used Martell's work to organize people to go door-to-door in areas east of Rocky Flats asking residents if they could collect a scoop of dirt from their yards to test for radiation content. They labeled these samples with names and addresses and took them to public meetings of candidates for Congress in 1972, asking those running for office to get the samples analyzed and to explain what they'd do about Rocky Flat [14]. This attracted media attention and helped make Rocky Flats an issue that candidates for public office could not ignore.

In 1974, Danielson, a Quaker, and Pam Solo, a nun from the socially active Sisters of Loretto, were hired to share a staff position at the Denver office of the American Friends Service Committee (AFSC). Their focus: nuclear weapons production at Rocky Flats. Thus began what by the end of the decade had blossomed into a national and global movement of resistance to nuclear weapons. The Rocky Flats Action Group, an umbrella body that grew out of the AFSC activities, labeled Rocky Flats a “local hazard and a global threat.” The “local hazard” was the public health and environmental danger Martell had exposed, the “global threat” the nuclear holocaust whose possibility haunted him. Observing bomb tests in the South Pacific as an Army radiation health specialist made him, he said, “quite a pacifist. If you appreciate the effects of thermonuclear explosions, you aren’t going to be disposed toward the military and wars as the means of settling national affairs” [14, p. 162]. The Rocky Flats movement thus articulated and elaborated Martell’s twin concerns.

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Back in 1970 Martell had called for a “thorough assessment” of plutonium health effects at Rocky Flats. This never happened. But pressure from those he had energized led to the creation, in late 1974, of the Lamm-Wirth Task Force on Rocky Flats by newly elected Governor Dick Lamm and Congressman Tim Wirth, whose district included Rocky Flats. In 1975 the Task Force recommended that Rocky Flats be closed and its work be relocated [15].

The government’s response was to form the Rocky Flats Monitoring Committee, probably the first citizen oversight group created for a nuclear weapons facility anywhere. Pam Solo, who says she was the only “adversary” appointed to this body, reported that they met on a regular basis, toured the Rocky Flats buildings, saw everything, were dazzled with technology, and were treated like VIPs. “The language and euphemisms that they used—a nuclear excursion, as though it was a trip up the Colorado River. You kind of kill off the language.” She pressed them: “The Task Force says shut it down and convert it. How are we going to move on this? They would all look at me like I had pulled their pants down.” Those meetings, she said, left her “totally numb and sick” [16].

Meanwhile, through the early and mid-1970s Martell was in considerable demand as a speaker on radiation issues. Toward the end of the decade he cut back on this activity out of frustration “with the media and others whose claims exceeded the scientific evidence” [14, p. 182]. Science could be used, but it could also be abused. In 1986-87, when DOE wanted to incinerate plutonium-laced waste at Rocky Flats, Martell supported a small group of scientists who worked directly with local people to defeat this plan.

Needless to say, the DOE was in no rush to shut down Rocky Flats. After the Lamm-Wirth recommendation fourteen contentious years would pass—years of repeated workshops, vigils, large demonstrations, and acts of civil disobedience —before production was halted in late 1989 because it could not be done without violating federal environmental laws. The change of the Rocky Flats mission from production to cleanup was finally made in 1992 [17].

ALPHA RADIATION: NATURAL BACKGROUND AND GLOBAL FALLOUT

According to Martell, alpha particles released by plutonium taken into the body don't distribute uniformly in an organ as assumed by those "who persist in using the average whole organ dose as the measure of cancer risk" for setting exposure standards. Instead, within the body, alpha particles clump in "hotspots" where their energy is concentrated at levels 100 to 1000 times their average organ concentrations. Also, by means of alpha recoil, they subdivide into a cloud of smaller particles, thereby enhancing their microdistribution and intensifying the potential for harm to surrounding cells, possibly inducing cancer or creating conditions for other ailments [18]. Martell pointed out that "plutonium in fallout from nuclear tests is now present at measurable levels in

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all human organs." While the amount is very small, it "will certainly contribute to the initiation and progression of malignancy in the general population," particularly when radiation from other sources is added [18, ch. 7, pp. 7-8]. He estimated that 80 percent of all cancers are radiation induced, most of them "attributable to lifetime exposures to natural background radiation" [19]. Those who ignore the adverse role of naturally occurring radiation, he noted, find it easy to allow additional exposure from human-made sources. Internal alpha emitters, from natural as well as unnatural sources, "may be the principal agent of radiation-induced cancer" as well as the major contributing factor in arteriosclerosis and resultant cardiovascular disease [20]. The record from Rocky Flats and other plutonium-processing sites suggests increased incidence of coronaries among plutonium workers [21].

Effects of Radiation on Plutonium Workers

In 1975, Karl Z. Morgan, for 29 years head of health physics at DOE's Oak Ridge Lab and a major figure in establishing radiation exposure standards, proposed reducing the maximum allowable lifetime plutonium body burden for nuclear workers 200-fold [22]. Martell noted that this "well justified recommendation" was ignored by standard-setting agencies, but said that he thought Morgan had nevertheless overlooked data that indicate that the worker standard should be reduced by a factor not of 200 but of 1000 or more [18, , ch. 6, p. 38].

In early 1994, encouraged by the openness initiative of then-Energy Secretary Hazel O'Leary, Martell wrote to her specifically about plutonium workers:

[A] complete, objective, independent follow-up of the medical histories and body burdens of plutonium . . . workers is long overdue and would shed considerable light on the full magnitude of plutonium cancer risks. . . . [It is] exceedingly important to have the best possible assessment of plutonium cancer risks *before* cleanup of plutonium contaminated sites at Rocky Flats and elsewhere. . . . For more than 40 years, assessment of the health risks of radionuclides has been controlled by a vested interest establishment that has contrived to minimize or ignore adverse effects of all sources of human exposure to ionizing radiation [23].

All such research, Martell's letter concluded, should be removed from the nuclear establishment. O'Leary made no reply. Now, two decades later, the plight of former workers at facilities like Rocky Flats whose health was destroyed by on-the-job exposures has become a national disgrace, mainly because many of them cannot get promised compensation [24].

When Martell died in 1995, chemist Niels Schonbeck of Denver's Metro State College called him a "whistleblower" who, despite three decades of original radiochemical research at NCAR, was never named a Senior Scientist [25]. In the early 1980s, perhaps because of the aforementioned intervention of an AEC official, his research group was broken up and he lost his lab; he kept his job only due to the support of colleagues [26]. Not long before his death he said he didn't realize when he joined NCAR in 1962 that "the point was, if there's something disturbing going on, look the other way. . . . I worry about all future generations, because we're not studying radiation-induced health effects, not objectively, not thoroughly" [27].

II. CARL JOHNSON: AGAINST THE TIDE

Innovative Dust Sampling Stops Residential Development

In September 1973 Carl Johnson became Director of the Health Department of Jefferson County, which, with a population of about 250,000, was then the second-most populous county in Colorado. His involvement with Rocky Flats began in December 1974 when Jefferson County Commissioner Joanne Paterson sought his opinion on whether the commissioners should permit a new housing development on land just east of Rocky Flats. The CDH had already approved the project, despite their having found plutonium in surface soil there up to seven times the state standard (they would require plowing prior to construction). "If she had not called me," Johnson later said, "the land would have been developed and there'd be about 10,000 people living there" [28]. He was not deterred by CDH's prior approval, having already seen "gross errors" in other CDH work [29]. The county commissioners gave Johnson the go-ahead to do a "validation survey of plutonium around the plant" with two soil-science specialists from the US Geological Survey. Johnson and his USGS colleagues developed a protocol for the study and got concurrence from scientists with CDH and the Colorado School of Mines. The samples would be split and analyzed by two labs, one at CDH, the other at Rocky Flats [30].

This project began in the spring of 1975, using Johnson's innovative method of sampling respirable dust. Dust samples taken at 25 locations showed plutonium concentrations, on average, 44 times greater than what had been measured at the same locations in previous surveys using whole-soil samples collected to a variety of depths. Several of the readings exceeded previous ones by 100 times or more, one by 285 times [31]. Readings were 10 to 40 times greater than what Martell and Poet had found in the top centimeter of soil [32]. When the County Commissioners saw Johnson's results in September 1975,

they vetoed residential development on the land in question. Later that year, Marcus Church, owner of the land, sued the Energy Research and Development Administration (ERDA, predecessor to the DOE) and its Rocky Flats contractors, Dow Chemical and Rockwell International, for damages.

Meanwhile Johnson, having stopped a housing development on contaminated land, suddenly met resistance. Though the principal parties had been consulted beforehand and had accepted the dust-sampling protocol Johnson and his USGS colleagues had developed, as soon as their results became known, officials at ERDA, EPA, CDH, and Rockwell began to criticize their sampling method, and the CDH and Rocky Flats labs announced they would no longer analyze samples taken by Johnson's group. The negativity would affect all Johnson's future work related to Rocky Flats. Martell, to the contrary, saw Johnson's sampling method as a stroke of genius "that shouldn't be overlooked in any discussion of offsite risk and health studies" [33].

When Johnson and his colleagues reported their work in *SCIENCE*, they faulted the Colorado plutonium-in-soil standard for making no provision for what to do if additional plutonium gets deposited atop what is already present, and for allowing those who build where plutonium contamination exceeds the standard to plow it under; in their view, future activity like gardening or construction could bring it back to the surface. A "more realistic" standard for plutonium in surface soil, they said, would be based "on the respirable-dust fraction because the very small particles in this fraction have the greatest potential for suspension and inhalation" [34].

Johnson Proposes a New Standard for Plutonium in Soil

In October 1975 Johnson formally proposed that for, purposes of assessing health risk, the state set a new standard based on plutonium in respirable dust on the surface of the soil [35]. "The coarser materials which are not inhaled and retained," he pointed out, "have no bearing on the actual hazard to health and serve only to dilute the amount of radioactivity found by analysis, and may yield a spurious low concentration of plutonium that is misleading" [36].

The CDH did not welcome Johnson's proposal. To resolve the issue, the Colorado Land Use Commission brought in Karl Z. Morgan, former chair of the internal dose committee of both the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection and recently retired from DOE's Oak Ridge Lab. Morgan was asked whether for assessing the public health risk

from plutonium in surface soil it was better to follow Johnson in using dust samples or the CDH in collecting whole-soil samples. Morgan sided with Johnson, in favor of using samples limited to “the respirable portion, less than 5 microns dust particles.” Employing Johnson’s method, he realized, would make the State’s 2.0 dpm/g plutonium

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standard far more protective, since, for samples taken at the same location, Johnson’s method shows concentrations 40 or more times greater than the CDH whole-soil approach. He added a cautionary note that it would be best to apply the 2.0 dpm/g standard as a limit not for plutonium alone but for the sum of all radionuclides in the environment [37]. Colorado officials, having gotten from Morgan the advice they sought, chose to ignore it.

Shortly after his visit, Morgan wrote Johnson: “The situation is much worse than I had suspected. . . . I am amazed that the State of Colorado . . . has not been out front from the beginning, collecting this type of data, pointing out the environmental hazard and doing all it could to ameliorate the problem” [38].

Enlarged Survey of Plutonium in Surface Respirable Dust

Johnson’s group soon followed up their plutonium sampling done on land near Rocky Flats with a much larger survey in which they collected dust samples from 72 locations along the compass coordinates and in areas of known or suspected contamination out as far as 32 kilometers, or about 18 miles, from Rocky Flats. Krey had said that at about this distance out Rocky Flats plutonium could not readily be distinguished from background; Johnson’s group, however, found plutonium at this extremity in varying amounts up to as high as 17 times background. Their highest reading was 3,390 times background, at a point just east of the site boundary. Values generally decreased with samples taken further to the east and southeast, displaying a non-uniform pattern of distribution [39].

Cesium, Strontium, and the Criticality Question

In doing this larger survey Johnson's group found cesium-137 at four offsite locations with concentrations considerably higher than plutonium sampled at the same places. The presence of cesium suggested the likelihood of "a significant fission reaction," or "criticality," of plutonium at the plant. If so, other fission products, e.g., strontium-90 and iodine-131, should also be found. Johnson wanted offsite soil sampled for these radionuclides and "a review of incidents" on site "to determine the source of the cesium" [39].

When Johnson learned that an explosion had accompanied the 1957 fire, he suspected it was a fission reaction. He thus countered the Rocky Flats orthodoxy that there had never been a criticality at the site. He soon had results from eight more samples that also showed cesium, with two from widely separated locations east of the site giving readings of 30 and 31 times background respectively [40]. The CDH, ignoring Johnson's findings, declared that there was no proof that cesium found locally had come from Rocky Flats [41]. Johnson later saw reports uncovered in the discovery proceedings of the

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Church case that referred to elevated levels of both cesium and strontium in soil at the site [42]. The issue of strontium remains contentious at Rocky Flats [43].

Another Innovation: Isopleths and Census Tracts

To assess adverse health effects among residents of offsite areas shown by Krey to be contaminated with plutonium from Rocky Flats, Johnson introduced into the field of epidemiology an important innovation. Rather than determine his area of study by drawing concentric circles around the point-source of the contaminant (i.e., Rocky Flats), he defined his study area by the pattern of wind-blown distribution of plutonium from the source as indicated by Krey's isopleths [44]. Comparing 1975 leukemia and lung cancer death certificates for residents of contaminated census tracts near Rocky Flats and in Golden with death certificates from non-contaminated tracts elsewhere, he found a significantly higher incidence of death

from these two causes in the former areas by comparison to the latter [45]. Again employing the isopleth approach but focusing on different census tracts, he found an excess of birth defects in the City of Arvada [46]. The method of combining isopleths with census tracts he would soon use for a cancer incidence study for the Denver metro area, his best known but also most controversial project.

Interlude: The 1957 Fire

Based on previously secret documents uncovered by discovery proceedings in the Church landowner lawsuit filed in 1975, Johnson concluded that adverse health effects he had documented probably resulted from exposure to plutonium released during the 1957 fire. He learned the following:

- The fire and explosion totally destroyed the bank of 620 large (2' x 2') filters that existed to protect the public, allowing plutonium particles to escape unimpeded.
- These filters had not been changed since operations began four-and-a-half years earlier, so they were caked with plutonium.
- The smokestack radiation monitors were not operational from the time the fire began until seven days later.
- Production resumed before either filters or monitors were restored.
- When stack monitors were turned back on eight days after the fire, the guidelines for stack emissions were exceeded by 16,000 times for that day.
- Soil samples were collected after the fire at only three offsite locations. High levels of “possible enriched uranium” were found at two widely

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separated schools. The only sample analyzed for plutonium taken on Church property registered 225 times background.

- The amount of plutonium released, while unknown, was large.
- No effort was made to survey the extent of contamination in offsite downwind areas [47].

Is It Safe to Live Near Rocky Flats?

In 1978 Johnson began a study that raised quite forcefully the question whether residing near Rocky Flats was more dangerous than living further away from the site. Funded by a grant from the National Cancer Institute, Johnson adapted Krey's isopleths for an epidemiological investigation of cancer incidence (not death rates) in Denver-area census tracts known to be contaminated with Rocky Flats plutonium compared to those contaminated only from global fallout. He made no attempt to estimate dose. It was the first attempt anywhere at a comprehensive analysis of the effect on an offsite population of carcinogens released from a nuclear weapons production facility [48].

Johnson framed his study with a review of plutonium's toxicity and the history of its releases from Rocky Flats, especially from the 1957 fire. He modified Krey's isopleths to reflect his own more extensive sampling (he had collected three times as many samples within a much smaller area), producing "three study areas with populations in the same order of size" [49]. His resultant "approximate but useful" figures divided the Denver Standard Metropolitan Statistical Area (1970 population: 1,019,131) into four areas [50].

For each of these areas he determined the cancer incidence among Anglos for 1969 through 1971, corrected for age, race, sex, and ethnicity [51]. Comparing the cancer data with the contamination data, he found a correspondence between zones of increased cancer and zones of increased contamination. Cancer incidence in Area IV, his non-contaminated control area, was essentially identical to the rest of the state. Area I, nearest Rocky Flats, showed 16 percent more cancer incidence than Area IV and 8.5 percent more than Area II, the urban center [52]. The incidence for Area II was 10 percent above Area IV; Area III was 6 percent greater than Area IV. Incidence of cancers of "radiosensitive organs" (those found in excess among Hiroshima and Nagasaki survivors) was higher near Rocky Flats. Overall, he "found a higher incidence of all cancer in areas contaminated with plutonium, compared to the unexposed area" [53](see Figure 2).

Johnson first presented his findings in a paper dated February 9, 1979. What he had to say was big news in the Denver area. CDH, DOE, NRC, and EPA produced critiques, all answered point by point by Johnson. The essence of the CDH critique showed up in a May 11, 1979, *Denver Post* editorial. A decade later a *Post* reporter revealed that DOE had given its contractor, Rockwell, a

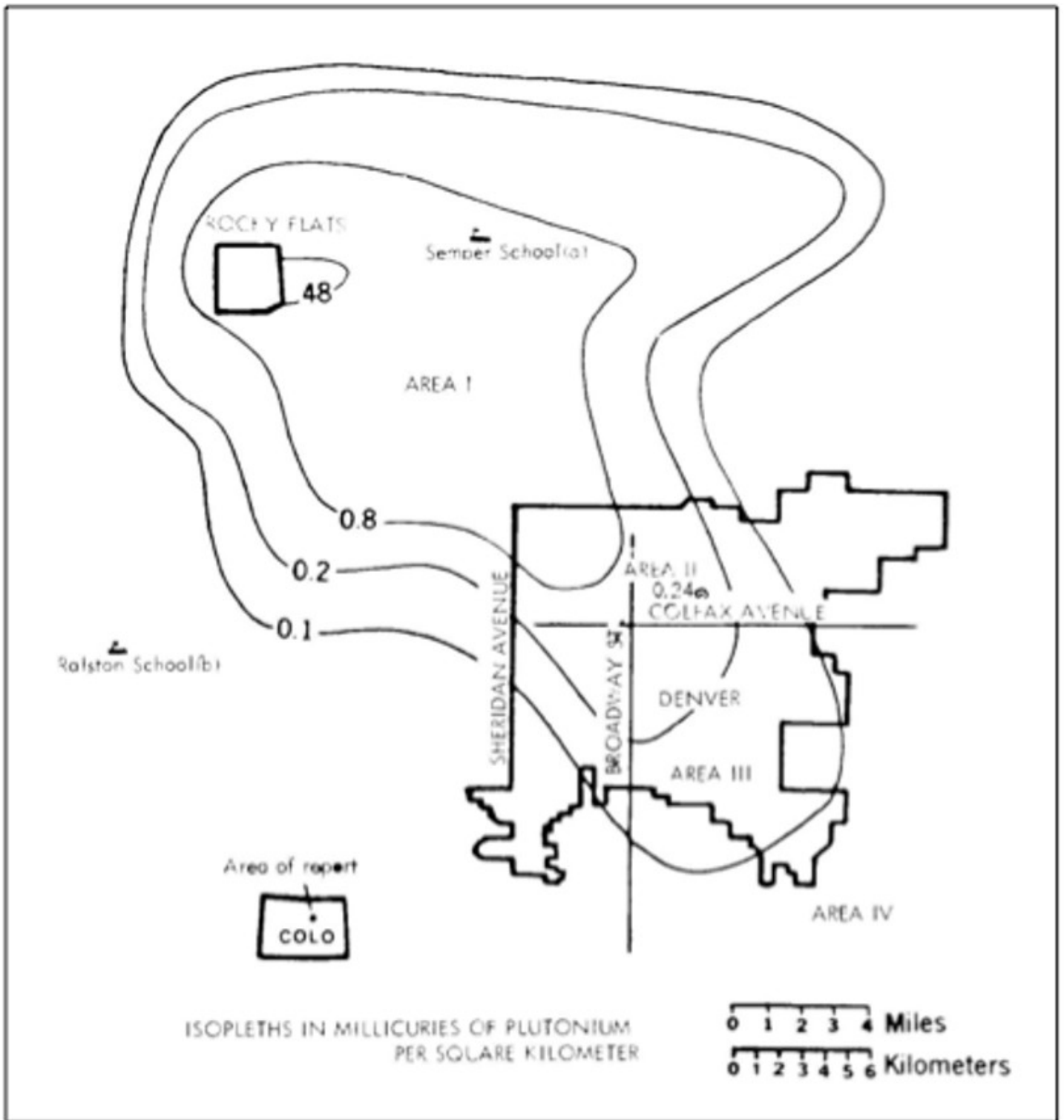


Figure 2. Carl Johnson studied cancer incidence for 1969-1971 among Anglos in three areas downwind of Rocky Flats defined by levels of plutonium contamination in millicuries per square kilometer (mCi/km²) as compared to the uncontaminated control area. See the text above for cancer incidence rate for each area. From Johnson, "Cancer Incidence in an Area Contaminated with Radionuclides Near a Nuclear Installation," *Ambio*, 10, 4, October 1981, page 177 and Table 3 (copyright Royal Swedish

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bonus for persuading the *Post* to publish the editorial questioning Johnson [54]. Through 1979 and 1980 Johnson used criticisms of his study to continue revising his paper, even as he presented it at several national and international scientific gatherings. In October 1981, after extensive peer review, the finished study was published in *Ambio*, journal of the Royal Swedish Academy of Sciences [55]. Subsequently, reports of the study and replies to critics appeared in other publications [56].

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In 1982 Rockwell gave a citizen review group its report listing eight negative reviews of Johnson's study. It fell to Johnson to inform the group that all the critics cited by Rockwell were linked to nuclear agencies, that he had already responded in detail to their criticisms, and that Rockwell had failed to cite any of the numerous positive reviews his study had received from other specialists [57].

The Rocky Flats Advisory Notice

Johnson's study clearly disturbed people associated with the nuclear establishment. But it also troubled those who wanted unimpeded development in the burgeoning suburbs moving closer and closer to the Rocky Flats site. Perhaps the biggest threat to real estate interests came in March 1979 when the federal Department of Housing and Urban Development required anyone seeking federal mortgage insurance on property being bought within 10 miles of Rocky Flats to sign the "Rocky Flats Advisory Notice." The notice referred to "varying amounts of plutonium contamination of the soil" and said an "Emergency Response Plan" would be implemented in the event of "an accidental release of radioactive materials" from Rocky Flats. Shortly after Ronald Reagan took office in January 1981 the Advisory Notice requirement was abandoned.

Johnson Loses His Job

In May 1981, five months prior to publication of his cancer incidence study in a prestigious journal, Johnson lost his position as Director of the Jefferson County Health Department. He had worked for two bodies, the County Commissioners and the County Board of Health, the latter appointed by the former. Though his Rocky Flats work had often been opposed by the President of the Board of Health (a wealthy individual who owned 20 acres of land within a mile of the Rocky Flats site), he always had the support of a majority of both the Board of Health and the Commissioners. The makeup of the Board of Health began to change, however, after the election in 1980 of a realtor as a County Commissioner. In April 1981 a reconstituted Board of Health held a secret meeting at which they voted to ask Johnson to resign. He requested a hearing, which occurred on May 15, 1981. The Board's attorney advised them that they did not need to state a reason for discharging a health officer who served "at the pleasure of the Board." When the Board, by a vote of three to two, gave Johnson the choice of being fired (and losing all accrued benefits) or of resigning immediately, he resigned [58]. Martell, on hearing this news, called Johnson the "only man in the Denver public health community who is concerned about public health" [59].

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Johnson Goes to Court to Save His Job

Within days of his termination, an ad hoc Citizens Health Committee persuaded Johnson to file suit in the Jefferson County Court to seek reinstatement to the position from which he had been terminated. This group thought the Health Board had violated Johnson's rights and flouted due process by failing to reveal their own conflicts of interest. When the case went to trial, one of the three Health Board members who had voted against Johnson said that, in his view, a health officer "could be fired for the color of his tie" if the Board didn't like it" [60]. The judge ruled that since Johnson served at the pleasure of the Board, he could not be reinstated.

The case was appealed to the State Supreme Court, which on April 18, 1983, in a unanimous decision, annulled the County Court verdict and remanded the case for retrial. The Supreme Court also disqualified the original judge for saying that "it would be a disaster if Johnson gets his position back."

Meanwhile, in December 1984, before Johnson's case could be retried, the Church lawsuit was settled. The owners of the land near Rocky Flats on which Johnson had prevented residential development were paid \$9 million, and it was mandated that the contested land could be used only for open space or an industrial park. One week after announcement of this settlement, the Jefferson County Commissioners offered to

settle with Johnson for \$150,000. He accepted [61]. By this time he had become the chief public health officer for the State of South Dakota.

Crump and Johnson

Johnson was gone from Colorado, but not forgotten. DOE paid Kenneth S. Crump and colleagues \$70,000 (a hefty sum at the time) to refute Johnson's cancer-incidence study. Using the same data that Johnson had used, Crump et al replicated his findings. When they examined data from a decade later (1979 through 1981), they found a reduced cancer incidence in Area I nearest Rocky Flats (the opposite, they said, of what one would expect), with the highest incidence now in Area II, the urban core. They advanced the thesis that the cancer incidence levels in both 1969-71 and 1979-81 had nothing to do with Rocky Flats but were due to the "urban effect" measured by distance from the State Capitol building in Denver. They found no evidence of "a relation between environmental exposure to plutonium from Rocky Flats and cancer incidence" [62].

Johnson, in a published response, pointed out that Crump and colleagues were able to claim less cancer for areas near Rocky Flats only by setting aside his isopleth approach in favor of dividing the Denver region into six sectors radiating out from the State Capitol building in downtown Denver. The sector on their map containing the Rocky Flats area also includes the sizeable unexposed upwind city of Boulder (1970 population 66,870). This results in

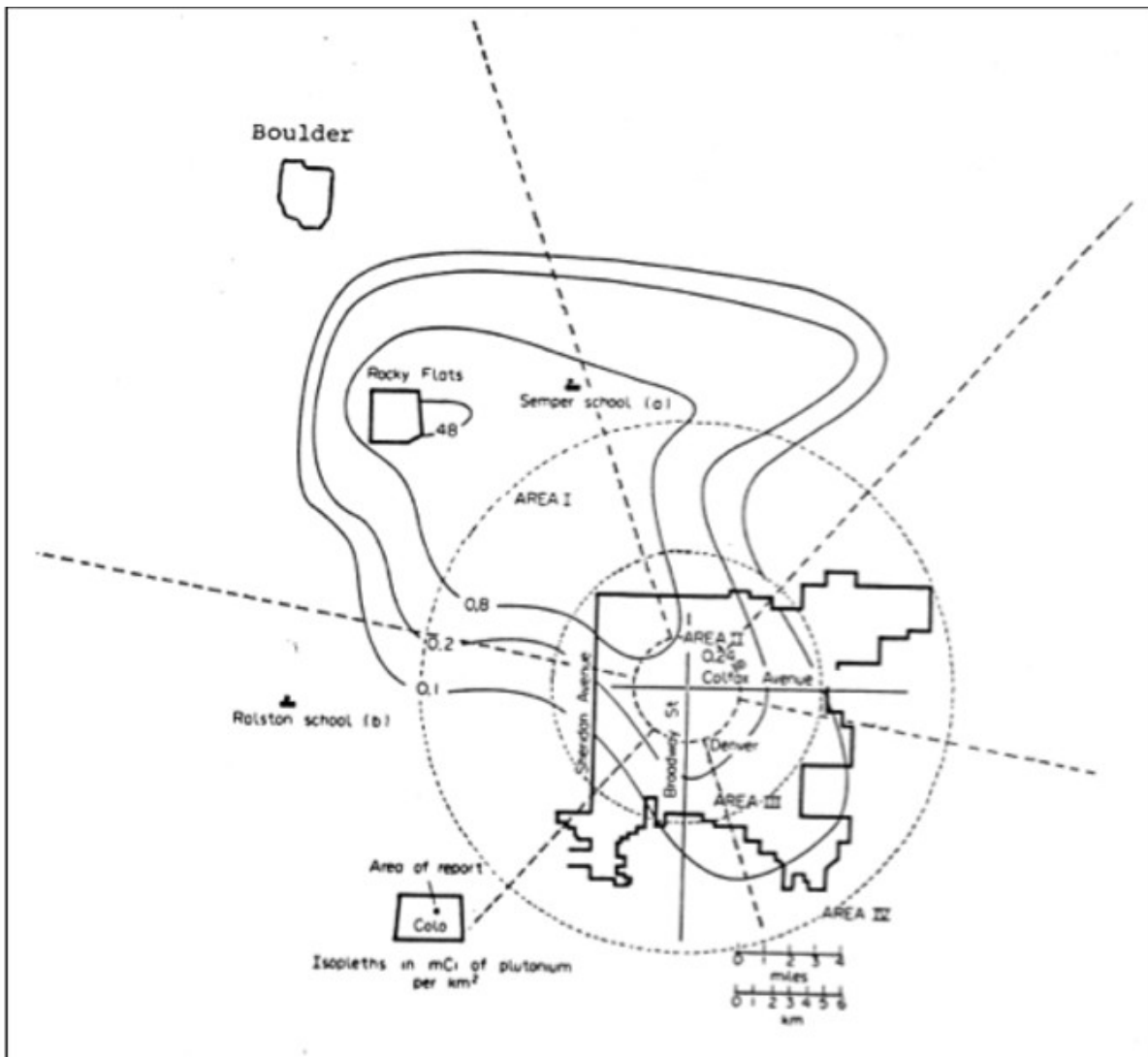


Figure 3. Crump divided the Denver area into six sectors radiating outward from the state capitol, then analyzed data from these sectors to demonstrate the “urban effect” on cancer incidence patterns. The figure above superimposes Crump’s sectors on Johnson’s map, showing that the city of Boulder is included in the sector that contains Rocky Flats; this results in gross undercounting of cancer incidence attributed to Rocky Flats. For Crump’s sectors, see Crump et al., “Statistical analyses of cancer incidence patterns in the Denver metropolitan area in relation to the Rocky Flats plant,” Report of research done under DOE contract #DE AC04-76EVO1013, Subcontract 8115006 from the Lovelace Inhalation Toxicology Research Institute, Albuquerque, NM, August 20, 1984, page 80. The image above is from an unpublished paper by Johnson, “Rocky Flats Revisited: Follow-up Studies,” April 1988, p. 15.

greatly undercounting cancer incidence related to Rocky Flats per se (see Figure 3).

When, on the other hand, Crump et al. used Johnson's isopleth approach they got the same results he had for 1969-71, while for 1979-81 they found, as noted, a decline of cancer incidence in the area nearest Rocky Flats. Johnson attributed this reduction to the very large in-migration into Area I through the 1970s, significantly diluting the contaminated population he had counted in his earlier study [63] Despite Johnson's careful rebuttal, government agencies ignored what he wrote and continued to tout the Crump study as a definitive refutation of Johnson.

The Staging of the Church Case: The CDH Shows Its Hand

Though the 1984 settlement of the Church lawsuit had confirmed Johnson's original position that housing should not be allowed on the contaminated land, in other respects the case played out in ways not favorable to Johnson. First, in his words, according to the settlement, the plaintiffs (landowners) were paid \$9 million "in exchange for a court hearing staged for the judge and the press by the attorneys and witnesses for the defendants. Nothing was to be heard from the experts for the plaintiffs [including Johnson], and there was to be no cross examination of defendants' witnesses" [64].

With Johnson effectively gagged, Stanley W. Ferguson of the CDH, citing Crump, pointedly dismissed Johnson's cancer incidence study, then stated the position of CDH: "There is no scientifically valid evidence of the creation or intensification of any health effects as the result of the existence and operations of the Rocky Flats Plant, or by the existence of any materials from the Rocky Flats Plant on soils outside of the plant" [65]. Also, reversing their earlier statement that plutonium on Church land exceeded the state's 2 dpm/g standard by up to seven times, CDH now gave the landowners a certificate stating that plutonium contamination on their land did not exceed the standard.

From Johnson's unheard testimony:

Based on my education, training, and experience as a medical doctor, and my understanding of how the body works, and of the effects of ionizing radiation on the human body, and based on my studies of the

radioactive emissions of the Rocky Flats Plant and the area-wide contamination of the Denver area from those releases, and my studies of cancer mortality and cancer incidence in contaminated areas, and having considered other possible causes, it is my opinion, within a reasonable degree of medical probability, that the radioactive emissions from the Rocky Flats Plant have caused an excess of cancer in the exposed areas [66].

Johnson called for a standard for plutonium in surface respirable dust of 0.4 dpm/g, evacuation of all residential areas within four miles of the plant site and

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no new housing within ten miles—due to contamination already present or likely to be added later [66].

The Public Betrayed: Secrecy Prevails

In settling the Church case, the DOE and the contractors gained control of all internal documents reviewed in the case and had them sealed, thereby depriving the public of access to crucial information regarding contaminants released from Rocky Flats [14, pp. 200-201]. This was repeated with a vengeance after the June 1989 FBI raid of Rocky Flats; federal authorities used the subsequent grand jury investigation to gather evidence of wrongdoing and then sealed the record [67]. In both instances, the court allowed the Rocky Flats operators to withhold from the public data about the nature and extent of contamination on and off the site. In October 2006, DOE announced completion of the Rocky Flats “cleanup” without this information being available. There seems a conspiracy of silence, whether unconscious or otherwise, between those who contaminated the land and those who prefer not to know that it’s contaminated. Neither is interested in the truth. Johnson, at least, stood against this collective denial, as well as and as long as he could.

Context: Risk Assessment and Cost-Benefit Analysis

In the 1970s and 80s, at just the time Martell and Johnson were most active in efforts to protect public health, others were developing the tools of risk assessment and cost-benefit analysis. These tools enable US decision-makers to deal with threats to public health and environmental integrity without unduly impeding enterprises like the nuclear industry. Incorporation of these tools into the decision-making process is based on the assumption that scientists can understand the impact of human activities on ecological and human systems well enough to predict harm and to estimate risk. The resultant risk-based regulatory regime that now prevails in the US puts a price on human health and ecological well being without really knowing what that price is. It presupposes that some level of harm is acceptable without asking those affected whether it is acceptable to them. Abstract and abstruse formulations of risk are employed to consign some to disease, deformity, and premature death, whether soon or in the wholly unknown long term.

Persistence of Johnson's Question: Varied Answers

Dose-reconstruction project

In response to the June 1989 FBI raid on Rocky Flats to collect evidence of alleged lawbreaking, DOE funded CDH to manage a dose reconstruction study for Rocky Flats. The goal was to determine the history of contaminant releases

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and to estimate doses that people offsite may have received in order to decide whether further study was warranted. Colorado Governor Roy Romer appointed a 12-member oversight Health Advisory Panel that included, besides prominent scientists and local people, two officials from CDH (one would chair the panel) and one each from DOE and CDC. Such a panel would not stray far from the risk assessment orthodoxy that typically informs studies of this sort.

The nine-year study (1990-1999) estimated that total offsite plutonium releases for the production years, 1952-1989, ranged from 4.8 to 51.3 curies [68]. One curie is the quantity of any radioactive material that

undergoes 37 billion disintegrations or releases of radiation per second. Thus, according to the foregoing estimate, plutonium released from Rocky Flats to the offsite environment emits between 176.6 billion and 1.9 trillion bursts of alpha radiation each second. After 24,110 years (the half-life of plutonium-239), the number of alpha bursts per second will be reduced by half. The material remains in the environment in the form of particles too small to see, but not too small to be inhaled or ingested.

Periodic meetings to involve the public in the study were fairly well attended, though often held when most working people could not attend. The meetings could be informative, tedious, and contentious. Technical specialists and the engaged public interacted intensely in efforts to reconstruct major accidents and contaminant releases. But when it came to estimating risk, the abstractions of the “experts” left me and I suspect others with the sense of being reduced to a spectator. The study’s final report session had something of the feel of a triumphal celebration, as if those affected were expected to rejoice at learning that, though as much as 51.3 curies of plutonium may have been released offsite, risks were inconsequential and further studies were not warranted. It was a bit unnerving.

The CDH calls the dose reconstruction study a “health study,” but it was no such thing. Indeed, it concluded that an actual health study was not warranted. The only situation in which a dose reconstruction study would point to the need for direct health study would be where there is an indisputable correspondence between known large releases of a particular contaminant and its known physical effects. An example is large releases of radioactive iodine from DOE’s Hanford facility matched by the high incidence in the area of childhood thyroid cancer, a cancer attributed solely to the presence of iodine in a single organ [69]. Plutonium released from Rocky Flats can certainly cause cancer in exposed people, but any cancer caused by plutonium can also have other causes.

The CDH has generally interpreted the study as providing scientific confirmation of the absence of adverse health effects. Unknown to outsiders, some members of the Health Advisory Panel wanted additional research on plutonium in water as it affects downstream communities, a proposal vetoed by the panel’s CDH chair. Others thought the final report should emphasize in the strongest manner possible that the Denver-area population had been subject to the risk of a major cataclysm due to careless operation of the plant. Specifically, had the 1969 fire breached the roof of the building where it raged, Denver almost certainly

would have faced evacuation [14, chap. 8]. Because the final report downplayed this matter, David Albright, a prestigious independent scientist who had been a very active member of the panel, refused to sign on to it

[70].

The study concluded that the largest single plutonium release was from the 1957 fire and that the person likely to have received the highest exposure was a laborer working outdoors in the direct path of the plume of plutonium-laden smoke from that fire (see Figure 4). The researchers produced a dose calculator that could be used by persons present in the Denver area at the time of the fire to estimate their dose according to their location. By the time the calculator was finished, however, the CDH had in effect dissolved the oversight panel by the simple expedient of convening no more meetings. The calculator thus was never made available, and affected people were denied the chance to learn of the dose they may have received back in 1957. Might they have learned of dangers like those to which Johnson and Martell had pointed but that the CDH had denied?

Calls for further studies

Despite the conclusion that there is no need for further health studies, several have disagreed. In 1982, Martell said that the plutonium in the soil east of Rocky Flats “involves risks that are sufficiently serious that only epidemiological studies of the next several generations of people living in that area can really find out what is going on” [71]. In 1996, nurses at the University of Colorado conducted a community needs assessment and concluded that community-based epidemiological studies should occur in areas affected by Rocky Flats [72].

Also in 1996, Boston University epidemiologist, Richard W. Clapp, found excessive incidence of lung and bone cancers in areas near Rocky Flats and concluded that “the most recent data are indicative of an ongoing health effect and support the need for surveillance of the incidence of cancer and other diseases on a continuing basis in the exposed communities” [73].

The programs that Clapp and others propose have never taken place. Indeed, there has never been any direct health study or medical monitoring of people who live in areas contaminated with plutonium released from Rocky Flats [74]. Hence, no one really knows the actual health effects of living in such areas.

Alternate assessments of risk in offsite areas

In 1998, the Colorado Central Cancer Registry of the CDH issued a report that purports to show that people who live near Rocky Flats have no higher incidence of cancer than those who live elsewhere in the Denver area [75]. German radiation specialist Bernd Franke criticized this report as seriously flawed: “It appears that the study design was chosen to calm people down, for public relations purposes, rather than for any

real scientific reason” [76].

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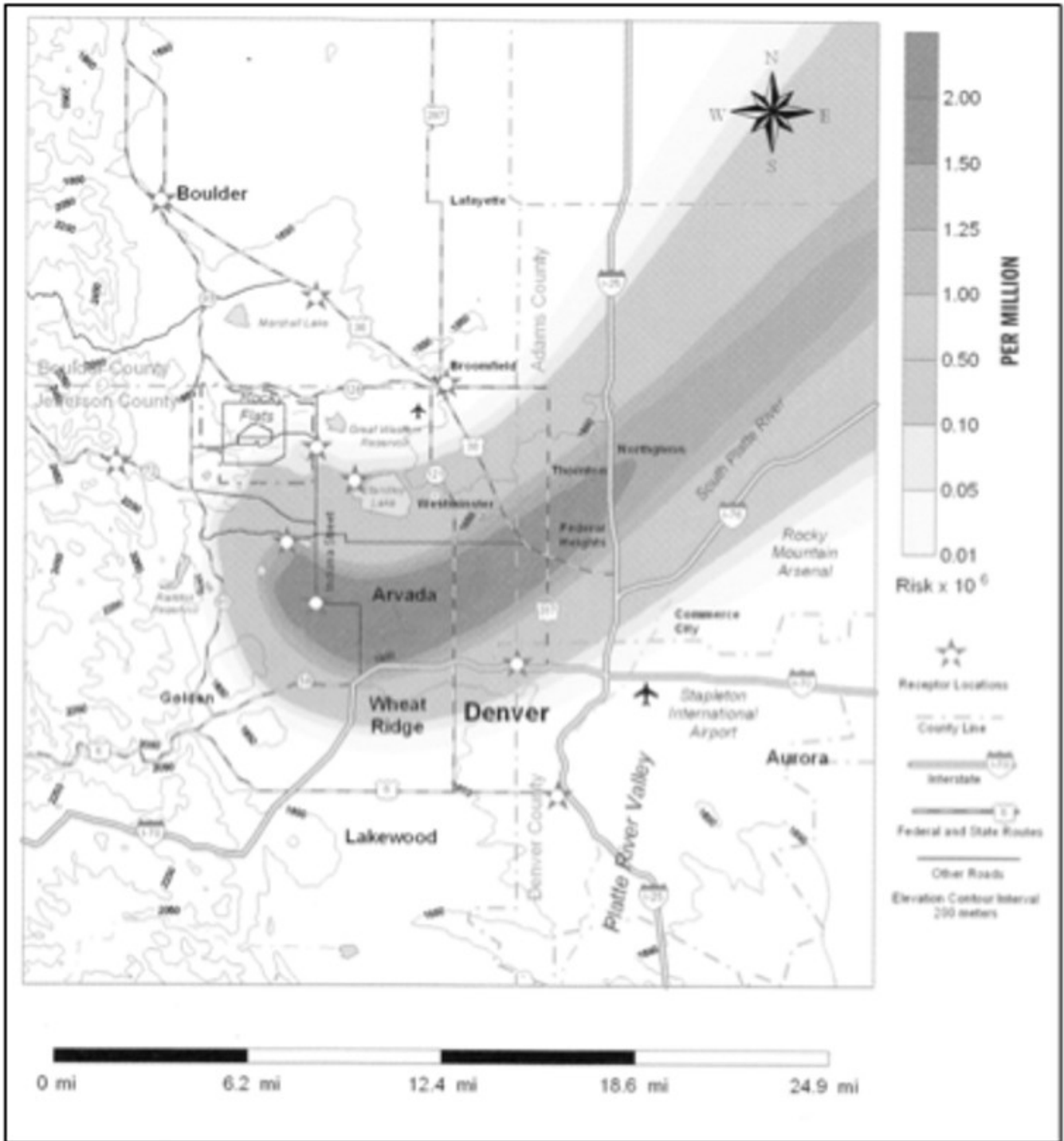


Figure 4. Trajectory of the plume of plutonium-laden smoke from the September 11, 1957, fire at Rocky Flats as calculated in the dose reconstruction study. Note that the map covers only the area defined for this study and thus presents no estimate for how far the plume traveled. From *Historical Public Exposure Studies on Rocky Flats*, Colorado Department of Public Health and Environment, August 1999, p. 19.

On February 14, 2006, the jury in a class action case heard in the federal court in Denver found Dow and Rockwell, the former operators of Rocky Flats, liable for harming the property of people who lived in areas shown by Krey to be contaminated with plutonium released from Rocky Flats and by implication endangering their health [77]. The jury assessed penalties of \$554 million. This

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suggests that when essentially uninformed people are presented evidence of a kind with which Johnson was very familiar, along with countervailing arguments, they are likely to reach conclusions approximating Johnson's views regarding the dangers posed by Rocky Flats. The huge sum of money, a record-breaking amount, awarded as compensation by the jury to the property holders in the specified off-site contaminated area may never reach those affected, since the case was overturned by the Appeals Court in March 2010.

Johnson's Legacy

The Rocky Flats work for which Johnson was celebrated and vilified and for which he was forced from office was done in the final six years and five months of his seven years and eight months term as Director of Public Health for Jefferson County. Since the termination of his very brief tenure, no one remotely like him has occupied an official position related to public health vis-à-vis Rocky Flats—no county official, no state official, no federal official. Johnson stands alone as an untiring advocate for people with public health concerns, whether inside or outside the facility. Though he made himself available to concerned individuals and groups (he met with a study group I organized in 1979), the primary arena of his work was with personnel from government agencies, especially DOE and CDH. His Rocky Flats work is densely documented in the many articles and reports he prepared as well as in his voluminous correspondence [78].

By the time Johnson died on December 29, 1988, he was a much-published, internationally respected practitioner and specialist on radiation health effects. At the urging of former Interior Secretary Stewart Udall he did the first-ever study of downwinders from the Nevada Test Site [79]. He was in considerable demand abroad as well as elsewhere in the US. But in Colorado he was in eclipse, dismissed by nuclear

technocrats as well as by promoters of urban sprawl. Indeed, the constant criticisms of his cancer incidence study by nuclear establishment figures gave boosters of urban development a rationale for ignoring his warnings.

On December 18, 1988, less than two weeks before he died, Johnson published in the *New York Times* an op-ed called “Rocky Flats: Death, Inc.” He recounted his years with Jefferson County, explaining various studies he had done and how, “as a result of the buildup of enormous political pressures by vested interests,” he was forced from office. He concluded that if people are “to be properly protected, all studies of nuclear contamination and associated health effects should be conducted primarily by independent scientists who are insulated from cynical retaliation.”

The Denver Post published a tribute to the deceased Johnson headlined “Doctor warned of Rocky Flats danger” six days after the FBI raided Rocky Flats on June 6, 1989, to collect evidence of environmental crimes allegedly committed at the facility. The article came close to saying that Carl Johnson was

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right all along. An anonymous Rocky Flats insider said Johnson “wasn’t as off-base as we used to say he was,” while a CDH official praised him as a “workhorse” but said he presented some of his results in ways that “overstated reality.” For many, the fact that the FBI was investigating Rocky Flats confirmed that Johnson knew what he was talking about.

III. CONCLUSION: PROPER HEALTH PROTECTION

Johnson and Martell blew the whistle on Rocky Flats. They delved into the details of radiation health effects to understand in the most thorough way possible what “proper” protection of public health would entail. They remind us that any purportedly “safe” dose of radiation may be the one that will tip the scales against us. They warn that our fate may be sealed 20 or 30 years before symptoms appear. They were exemplars of caution on behalf of the unassuming public. But the rules by which they worked were not the rules by which others played the game. There is a striking difference between public health as service to the public and public health as obeisance to the nuclear industry and the economy of denial.

The tale told here is one of systemic failure of the U.S. system of representative democracy, by means of which, purportedly, the well-being of the public is served by elected representatives and the bureaucrats and technocrats up and down the governmental chain of command who are charged with implementing

the will of the people. The system fails because of the fundamental conflict between the democracy professed on the one hand and denied on the other. Nuclear weapons that supposedly protect our democracy destroy it, because, to exist, they require secrecy and centralized decision-making, which in turn allow deceit, damage, and denial.

Martell, in discovering that plutonium had been released from Rocky Flats to the offsite environment, exposed damage that led to the unraveling of some of the deceit. He and the public learned for the first time about previously unknown major accidents. But an AEC official, practiced perhaps in the art of denial, made sure that Martell would pay for what he'd done. Martell kept his job because of the support of colleagues, but the loss of his lab and of funding for research hobbled his career in ways that are beyond measure.

Johnson, who did lose his job, seems clearly to fall victim not to the lords of the nuclear priesthood but merely to the greed and corruption of local government. But this is only half the story. The Colorado Department of Health had already tried to marginalize him by rejecting his innovative dust sampling method that, as Karl Morgan pointed out, was up to 40 times more protective than the method they employed. Undeterred, Johnson proceeded with a series of reports culminating in his major study that showed a correspondence between zones of cancer incidence and zones of contamination from Rocky Flats. The DOE, in a fit of denial, hired Crump to refute Johnson and then buried Johnson's own rebuttal in a repetitious tide of deceit that can only lead to more

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of the very kind of damage Johnson was exposing. The CDH, not to be outdone, after Johnson was gagged in a federal courtroom, cited Crump to dismiss Johnson, only later to have him in mind when they produced their PR piece asserting that living near Rocky Flats is no riskier than living anywhere else in the metro area. Some within the CDH undoubtedly viewed Johnson as an impediment to economic development, like the realtor who became a Jefferson County Commissioner so he could ax Johnson. This sort of distorted cost-benefit calculation is not simply an instance of corrupt local or regional politics; it's a characteristic blindness of the culture, essential to the economy of denial.

In the dead end of this failed system, one has two responsibilities: first, to create a public record for those who will come after, and, second, to articulate as clearly as possible a positive alternative to the failed system. The present narrative contributes to the essential public record. It can be supplemented by my account of the inadequate "cleanup" at Rocky Flats [80]. The second responsibility, pointing to an alternative, can here be alluded to only in outline. To deal with radiation health effects in and around

facilities like Rocky Flats we need to begin anew and to implement what can most appropriately be called “ecological democracy.” By this term I mean direct democracy informed by the awareness that we are inseparable from the ecology in which we live and move and have our being. For any human action likely to affect public health or environmental integrity, insofar as possible, affected parties must participate directly in decisions about the action. Otherwise, they are forced to endure the results of decisions made by others, which is what has happened at Rocky Flats, where the range of public participation has been limited at best to spectator activities, at worst to disdainful dismissal. In the practice of ecological democracy, the only role for representative democracy is to ensure that voice is given to parties who cannot be present—that is, to the very young, the very old, the infirm, the unborn, plus the whole spectrum of non-human creatures that inhabited the land long before we arrived and will be there long after we have passed.

Public health science deserves to align itself with ecological democracy because its primary intent is to sustain ecological well-being and to work with and for people rather than against them and without them. The problems for Johnson and Martell were not that they lacked independence but, as Johnson made clear, that they were vulnerable to “cynical retaliation” from those who deny harmful effects even as they foster harmful ends. All science serves some interest. Ecological democracy entails a shift in decision-making power that puts science irrevocably in the service of people and planet.

NOTES

1. Martell, E A. Interviewed by Niels Schonbeck for the Health Advisory Panel as part of the Rocky Flats Dose Reconstruction Study, 21 February 1995, p. 25. In

this same interview Martell pointed out that P. W. Krey (see note 7 below) measured plutonium at the east boundary of the Rocky Flats site at 1,500 times background.

2. On July 1, 1994, CDH changed its name to Colorado Department of Public Health and Environment.

Throughout this article this agency is referred to as CDH.

3. Within one month in 1957 a major disaster occurred at a production facility in each of the only three countries then known to be making nuclear bombs, the US, Britain and the USSR.

See <http://www.rockyflatsnuclearguardianship.org/leroy-moores-blog/papers-by-leroy-moore-phd-2/>

4. After the 1957 fire, AEC officials told the *Denver Post* that it “resulted in no spread of radioactive contamination of any consequence.” “Atomic Plant Fire Causes \$50,000 Loss,” *Denver Post*, 12 September, p. 1, 1957. Available on line at www.rockyflatsnuclearguardianship.org/site-map.html

5. Metzger, P. 1972. *The Atomic Establishment*. New York: Simon and Schuster. p. 259.

6. Martell, E. A. 24 February 1970. *Plutonium contamination in the Denver area*. Press Release of the Colorado Committee for Environmental Information, Boulder, Colorado; See also Poet, S. E., and Martell, E. A. 1972. Plutonium 239 and Americium 241 contamination in the Denver area. *Health Physics*. 23:537.

7. Krey, P. W. February 1976. Remote plutonium contamination and total inventories from Rocky Flats, *Health Physics* 30. See also Krey, P. W. and Hardy, E. P. Hardy. 1 August 1970. *Plutonium in Soil around the Rocky Flats plant*, HASL-235. New York: U.S. Atomic Energy Commission, Health and Safety Laboratory.

8. Cleere, R.L. 24 January 1973. Public notice of plutonium contamination in the area of the Dow Chemical Rocky Flats Plant, signed R. L. Cleere, Executive Director, CDH.

9. Amendment to the State of Colorado Rules and Regulations Pertaining to Radiation Control, Subpart RH 4.21.1, adopted Colorado State Board of Health, 21 March 1973.

10. Martell, E. A. January 1975. *Basic considerations in the assessment of the cancer risks and standards for internal alpha emitters*. Statement presented at the public hearings on plutonium standards, US EPA, Denver, pp. 17, 20.

11. Love, J. June 1994. *Rocky Flats Soil Plutonium 239=240 Survey from 1970 to 1991*. Denver: CDH.

12. Jones, R. H. and Zhang, Y. 19 September 1994. *Spatial and temporal analysis of the Rocky Flats soil plutonium data*. Denver: CDH.

13. Beck, U. 1992. *Risk Society: Towards a new modernity*, trans. Mark Ritter. London: Sage. p. 64.

14. Ackland, L. 1999. *Making a Real Killing: Rocky Flats and the Nuclear West*. Albuquerque: University of New Mexico Press, p. 169.

15. Lamm-Wirth Task Force on Rocky Flats. October 1975. *Final Report*.

16. Solo, Pam. Interviewed by Moore, L. Newton, MA. 23 September 1996.

17. For more on local activism, see Moore, L. et al. 1992. *Citizen's Guide to Rocky Flats*. Boulder: Rocky Mountain Peace Center. pp. 52-54; and Ackland, L. *Making a Real Killing*, chaps. 9, 10, and 13.

18. Martell, E. A. *Natural radionuclides and life* (unpublished manuscript), chap. 4.

19. Martell, E. A. Chap. 7, p. 11. Martell viewed naturally occurring radiation as the likely source of the energy necessary for the evolution of life. See Martell, E. A. 1992. Radionuclide-induced evolution of DNA and the origin of life. *Journal of Molecular Evolution*. 35:346-355.
20. Martell, E. A. July-August 1975. Tobacco radioactivity and cancer in smokers. *American Scientist* 63: 409-410.
21. Martell, E. A. Interviewed by Robert Del Tredici, 22 July 1982.
22. Morgan, K. Z. 1975. Suggested reduction of permissible exposure to plutonium and other transuranium elements. *American Industrial Hygiene Association Journal* 567-575.
23. Martell, E. A. to Energy Secretary H. O'Leary, 9 February 1994.
24. Denver journalist Laura Frank has covered this issue extensively for former Rocky Flats workers but also for workers at other DOE facilities.
See http://www.zoominfo.com/people/Frank_Laura_393007209.aspx
25. Schonbeck, N. Obituary for Martell. Delivered 19 July 1995.
26. Medrud, N. (Martell's NCAR colleague). Interviewed by Moore. 3 June 2005.
27. Martell, E. A. Interviewed by Niels Schonbeck for the Health Advisory Panel as part of the Rocky Flats Dose Reconstruction Study. 21 February 1995. On an explicit threat to Martell and colleagues by an AEC official, see note 5.
28. Johnson, C. Interviewed by Robert Del Tredici, 20 July 1982.
29. Some errors are cited in Johnson, C., and Holland, J. R. 1985. Politicization of Public Health. Presented at the U.S. Conference of Local Health Officers, and the American Public Health Association, Washington, DC, 18 November 1985, p. 8.
30. Johnson, Carl. (no date). The public health impact of the Rocky Flats nuclear weapons plant in the Denver Area: A case history with recommendations.
31. Johnson, C. 12 September 1975. Survey of land proposed for residential development east of Rocky Flats, for plutonium 239 contamination of respirable dust on the surface of the soil and proposal of a new standard to define the potential airborne-plutonium-particle hazard in terms of concentration of plutonium in respirable dust. Report to the Jefferson County Commissioners and the Colorado State Health Department.

32. Martell, E. A. Interviewed by Robert Del Tredici, 22 July 1982.
33. Martell, E. A. Interviewed by Niels Schonbeck, 21 February 1995.
34. Johnson, C., Tidball, R. R., and Severson, R. C. 6 August 1976. Plutonium hazard in respirable dust on the surface soil. *SCIENCE* 193:488-490. Johnson et al. answered criticisms regarding dust particle size made by John A. Hayden of Rockwell in *SCIENCE* 196 (June 3, 1977):1126.
35. Johnson, C., to Colorado Board of Health, "Proposal of a new interim standard to define the potential airborne-plutonium particle hazard in terms of concentration of plutonium in respirable dust on the surface of the land," 14 October 1975. For Johnson's detailed response to EPA on sampling methods and related matters, see his "Critique of the EPA's 'Proposed Federal Radiation Protection Guidance on Dose Limits For Persons Exposed to Transuranium Elements In The Environment,'" 14 October 1975.
36. Johnson, C. 21 January 1976. "Remarks to the State Board of Health concerning a proposed new interim standard for contamination of soil with plutonium." See Hazle, A. J. and Johnson, C. 20 January 1976. "Joint statement of some alternatives

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to the State Board of Health concerning the proposal for a new interim standard for plutonium based on the respirable dust on the surface of the ground."

37. Morgan, K. Z. 21 January 1976. Transcript of Presentation, Colorado Land Use Commission Meeting. pp. 12-13.
38. Morgan, K. Z. to C. Johnson. 30 January 1976.
39. Report to the Jefferson County Board of Health, 31 March 1977.
40. Johnson, C., to A. Robbins, Executive Director of CDH. 17 May 1977.
41. Johnson, C., to A. Robbins. 5 October 1977. Refers to a 27 September 1977 CDH report on this matter.

42. Johnson, C. (no date). The public health impact of the Rocky Flats nuclear weapons plant in the Denver Area, p. 10. Refers to Murray, R. L., "Gamma analysis of plutonium-contaminated soil at Rocky Flats." Unpublished report. E.S. 376-77-197. Rocky Flats Plant. 10 January 1977; and Anon., Rocky Flats Environmental Monitoring Results, Dow Chemical Corp., Rocky Flats Plant, Golden, May 1970.

43. Strontium as a contested issue reappeared in January 2005 when former FBI agent Jon Lipsky, who had led the June 1989 FBI raid of Rocky Flats, announced at a news conference in Denver that he had seen documentation of high levels of strontium contamination at the site. For more on the strontium issue, see McKinley, W., and Balkany, C. 2004. *The ambushed grand jury: How the Justice Department covered up government nuclear crimes and how we caught them red handed*. New York: Apex. pp. 122, 187, 194-196.

44. Johnson, C. Interviewed by Del Tredici, R. 20 July 1982.

45. Johnson, C. 1977. Leukemia death rates of residents of areas contaminated with plutonium. Proceedings of the 105th Annual Meeting of the American Public Health Association, Washington, DC, 1 November 1977; Johnson, C. 1977. Evaluation of the hazard to residents of areas contaminated with plutonium. *Proceedings of the IVth International Congress of the International Radiation Protection Association*. Paris, 24-30 April 1977. 1: 243-246; and Johnson, C., to Jefferson County Board of Health. 20 November 1977. "Report on death rates from lung cancer in the eight census tracts near Rocky Flats and in Golden, and in nineteen census tracts at the south end of Jefferson County."

46. Johnson, Ca. to Jefferson County Board of Health. 31 March 1978. "Report on rates of congenital malformations in an area contaminated with plutonium."

47. Johnson, C. 26 September 1980. Comments on the 1957 fire at the Rocky Flats Plant, Jefferson County, Colorado. Johnson, C. 17 September 1980. A case history of a disaster at the plant which could serve as a model for a future disaster emergency response plan exercise.

48. Johnson, C. 1982. Environmental and health effects of the nuclear industry and nuclear weapons: a current evaluation. *Ecology of Disease*. I(2/3):135-152.

49. Johnson, C., to S. Ferguson of CDH. 2 May 1979.

50. Johnson, C. October 1981. Cancer incidence in an area contaminated with radionuclides near a nuclear installation. *Ambio*. 10(4):178.

51. Johnson restricted his study to Anglos because the population of suburban areas nearest Rocky Flats was at the time predominantly Anglo.

52. In a 2 May 1979, letter to S. Ferguson of CDH, Johnson explained that the Area I census tracts closest to Rocky Flats had a very small population when operations

began at the plant but later grew rapidly from in-migration. Many residents of this area thus had not lived there long enough to develop Rocky Flats-induced cancers by 1969-71. Including these newcomers in his calculations meant that he understated actual cancer incidence for Area I compared to Area IV.

53. Johnson, Carl. 1981. Cancer incidence. *Ambio*. 10(4):181.

54. Obmascik, Mark. Rockwell won bonuses despite errors. *Denver Post*. 7 January 1990.

55. Johnson, C. 1981. Cancer incidence. *Ambio*. 10(4):176-182; see also Johnson, C. 1982. Rocky Flats revisited. *Ambio*. 11(6):377-378.

56. Places of presentation and/or publication are referenced in Johnson, C., and Holland, J. R. Politicization of Public Health, notes 13-22.

57. Johnson, C., to J. W. Spensley, Executive Director, Rocky Flats Blue Ribbon Citizens' Committee. 21 January 1983. Comment on the *Safety Analyses and Risk Assessment Report* for the Rocky Flats nuclear weapons plant, prepared by Rockwell International. November 1982.

58. Johnson, C., and Holland, J. R. *Politicization of Public Health*. This document provides details regarding Johnson's termination. I personally was present when the Board of Health forced him to resign.

59. Lange, T. They fired Dr. Johnson. *Westword*. 28 May 1981.

60. Citizens Health Committee. January-March 1982. *Citizens Healthwatch*.

61. Johnson, C., and Holland, J. R. *Politicization of Public Health*, p. 44.

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66. Johnson, C. (no date). The public health impact of the Rocky Flats nuclear weapons plant in the Denver Area: A case history with recommendations.

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68. Summary of Findings, Historical Public Exposures Studies on Rocky Flats. August 1999, Health Advisory Panel and CDPHE.
69. Connor, T. 1997. *Burdens of proof: Science and public accountability in the field of environmental epidemiology, with a focus on low dose radiation community health studies*. Columbia, SC: Energy Research Foundation.
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71. Martell, E. A. Interviewed by Robert Del Tredici. 1982.
72. Brown, N. J. et al. 1996. Rocky Flats communiQ needs assessment report. Denver: UCHSC School of Nursing, p, 46,
73. Clapp, Richard W. Report submitted 13 November 1996 for plaintiff's counsel in *Cook vs. Dow Chemical and Rockwell International*, United States District Court, District of Colorado.
74. An example of what is needed but has never been available for Rocky Flats is the Fernald Medical Monitoring Program established at DOE's Fernald uranium processing facility near Cincinnati, Ohio. Created as a result of a class action lawsuit, this program, which ended in 2007, provided comprehensive monitoring of the health of about 9,500 individuals over a period of 18 years. The monitoring relieved some individuals of worry while for others it provided an early warning of problems in need of attention. <http://www.genmed.uc.edu/fmmp/> A program of this sort should have been set up by the federal government for all DOE nuclear weapons facilities.
75. Colorado Central Cancer Registry. 1998. *Ratios of cancer incidence in ten areas around Rocky Flats, Colorado compared to the remainder of Metropolitan Denver, 1980-89 with update for selected areas,*

1990-95. CDPHE.

76. Franke, B. of Institut für Energie-und Umweltforschung, Heidelberg, to C. Balkany, Esq. 2 December 2002. A copy of this letter is in my possession.

77. Civil Action No. 90-cv-00181(JLK), *Cook vs. Dow Chemical & Rockwell International*, U.S. District Court, District of Colorado, 14 February 2006.

78. The papers of both C. Johnson and E. Martell are archived at the University of Colorado, Boulder.

79. Johnson, C. 1984. Cancer incidence in an area of radioactive fallout downwind from the Nevada Test Site. *Journal of the American Medical Association* 251:230-236.

80. Moore, L. January-February 2005. Rocky Flats: The bait and switch cleanup. *Bulletin of the Atomic Scientists*. <http://bos.sagepub.com/content/61/1/50.full>. See also Moore, L. 28 March 2010. People and plutonium don't mix. <http://www.rockyflatsnuclearguardianship.org/leroy-moores-blog/papers-by-leroy-moore-phd-2/>