

An Investigation of Brain Cancer, Melanoma and Other Neoplasms in Employees
of the Rocky Flats Nuclear Weapons Plant in Jefferson County, Colorado*

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The Rocky Flats (nuclear weapons) Plant is operated by the Rockwell International Corporation, a contractor to the U. S. Department of Energy (1). The plant began production in 1953, and until 1975 was managed by the Dow Chemical Company, a contractor to the U. S. Atomic Energy Commission. The A.E.C. has since reorganized as the Department of Energy and the Nuclear Regulatory Commission. The Office of Radiation Programs of the U. S. Environmental Protection Agency also absorbed some of the A.E.C. personnel and functions.

The plutonium and other fissionable components of nuclear weapons deteriorate with time. Old weapons components and other plutonium waste are sent to the Rocky Flats plant for reprocessing, casting and milling (1). In addition, weapons research and development are carried out at the plant. The amounts of plutonium and other fissionable materials which must be processed in this manner amount to some tons annually. Because of glove box leaks, accidents, and over 200 fires during the past 27 years, and aspiration of plant exhaust back into the plant ventilating system, workers at the plant have been exposed to external radiation, and, more importantly, to the deposition of a number of radionuclides in their bodies, principally through

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abnormalities will certainly result in even greater damage to single genes carried on chromosomes.

At this point it seems more is known about the effects of radiation injury in uranium miners than in nuclear plant workers. The chromosome changes found in nuclear plant workers with exposure to 400 to 4,000 picocuries of internal deposits of plutonium were similar in character and degree to those found in uranium miners with less than 100 working level months of exposure, who had a mean increase of 38% in the chromosome aberration rate (6).

The plant has hired 9,985 employees during its period of operation (1951-1979) (9). Of this number, 6,000 have been terminated, and are not retired or receiving benefits. Little is known about this group. In recent years an annual report has been issued with the morbidity, mortality and radiation exposure information for those Rocky Flats employees who are still active or are retired and receiving benefits (3,324 and 661, respectively, in 1979). This data has never been adequate to permit a comprehensive routine epidemiologic surveillance of workers for health effects due to their exposure to internal and external radiation. Since the spring of 1979, a group funded by the Department of Energy has been attempting an epidemiologic study of the U. S. trans-uranium workers at the Los Alamos Scientific Laboratory of the University of California in New Mexico. This study includes Rocky Flats workers.

Because such studies may take many years to complete and because this study in particular is an "in-house" study and so may be subject to bias, it is very important to release sufficient data that independent researchers can carry out their own epidemiologic investigations of health effects from radiation exposure to provide a proper balance. Sufficient time has now elapsed that the early workers (1952-1963) may be sustaining an increase in cancer incidence, although an increase in cancer death rates would not be noticed until later in a small population (figure 3).

with cancer as all white males in Colorado, cancer of the brain would account for 1.3% of all cancers. However, cancer of the brain actually accounted for 10.2% of all cancers, about eight times greater than expected. In this group of 3,937 employees we could expect to find 1.6 cases of brain tumor, but actually found 13 cases ($P < 0.005$) of which 13 have now died.

The expected pmr for malignant melanoma was 1.7% and can be compared to an observed pmr of 4.7%, nearly three times as great as expected. Six cases of melanoma were observed where 2.17 cases could be expected ($P < 0.01$). Four of the six cases have died. Malignant melanoma has been associated with exposure to sunlight. However, the control population, all Colorado white males, can be expected to have had similar exposures to sunlight as Rocky Flats plant workers, so this would not appear to be an important factor in accounting for the higher pmr for melanoma in workers.

A greater pmr for cancer of the lung was found than expected (22.7% observed, 18.1% expected). There were 29 cases of respiratory cancer, and 23 cases could have been expected. This apparent excess further supports the need for a comprehensive epidemiologic evaluation of all cancer in nuclear plant workers.

The pmr of cancer of the genitourinary and reproductive organs appears to be less than expected for the workers, but it is not possible with this classification to separate cancer of the prostate, one of the most common cancers in men and most age-dependent, from cancer of the testicle which is much less age-dependent, but which is of special interest because of the higher rate of cancer of the testicle in the population downwind from the plant (11). The pmr of cancer of hematologic and lymphatic systems, the respiratory tract, the gastrointestinal tract and "miscellaneous" cancers are similar in this simple comparison.

If man were as sensitive to melanoma induction by radium 228 as the beagle, inhalation of a single respirable particle 4 micrometers (4 microns) in diameter would have a 50% probability of inducing melanoma in a 70 kg man. However, no studies have been carried out in man.

There have been a number of reports of melanoma in man associated with prior exposure to radiation (22-25). Melanoma cases have also been reported in persons exposed to plutonium and other actinides (20, 26-29). Voeltz et al reported a case of malignant melanoma in a small group of 25 plutonium workers (1979) and Norwood and Newton reported a malignant melanoma death among 11 plutonium workers dying of cancer in a group of 30 who had gone to autopsy (1975) (26,20). It is extremely unlikely that all of these events could occur by chance alone. Caldwell at the U.S. Center for Disease Control noted seven melanoma cases in the Army group exposed to the detonation of the "Big Smokey" nuclear weapon, where only 3.5 cases could have been expected (27).. A five-fold excess of melanoma (19 cases where 4 were expected) was reported for the period 1972 - 1977 in workers at the Lawrence Livermore Laboratory of the University of California, in a population of 5,756 workers (1977) (28). Since 1953 the plant has been engaged in nuclear weapons research and production involving kilocurie amounts of plutonium and uranium. Additional cases have since been found, bringing the total to 30 cases over a period of 27 years. The Los Alamos Laboratory of the University of California in New Mexico also reports about 30 cases (29). The Hanford plant reports 12 deaths from malignant melanoma (29). Despite ample evidence to the contrary, an expert panel convened by the Department of Energy concluded that there was no link between the excess cases of melanoma and the exposure of the nuclear plant workers to ionizing radiation (30,31).

There has not been a study of the effect of radium and other alpha-emitting nuclides

active gases and particulates (including plutonium and americium) in plant exhaust fumes since 1953 (11). A study of cancer incidence for the period 1969-1971 did not demonstrate a significant excess of melanoma in the area near the plant compared to a local control population (11). However, the trend in melanoma deaths has been sharply higher in Jefferson County where the Rocky Flats plant is located. In the period 1950-1959 there were two deaths from melanoma in the county, an annual age-adjusted rate of 0.4/100,000 (table 5). In the period 1960-1969 there were 11 melanoma deaths (1.3/100,000) and for the period 1970-1977 (minus 1972) there were 27 melanoma deaths (3.9/100,000). This is an increase in rate of 191% in the period 1960-1969 over the period 1950-1959, and an increase of 737% for the period 1970-1977 (less 1972) over the period 1950-1959.

That this rate of increase is greater than the temporal trend noted for melanoma can be demonstrated by comparison with the age-adjusted death rates for melanoma in the state. There were 111 deaths from melanoma in Colorado in the period 1950-1959 (a rate of 1.2/100,000) and for the period 1960-1969, 150 deaths (1.8/100,000) and for the period 1970-1977 (less 1972), 174 deaths (2.5/100,000). The age-adjusted death rate for melanoma in Colorado in 1970-1977 (less 1972) was 100% higher than for the period 1950-1959 compared to an increase of 737% in the death rate from melanoma in Jefferson County over the same period of time, and the rate ratio was 56% higher in Jefferson County. The Rocky Flats plant has records documenting releases of plutonium (and other actinides) in exhaust plumes continuously since 1953 and exposure to these exhaust plumes may be an important factor in the sharp increase noted in the rate of melanoma in Jefferson County as compared with that for Colorado.

An excess of lung cancer cases could be expected because of the ability of plutonium

health, and which have no association or possible conflict of interest position with the 100 billion dollar nuclear industry. This work should be done with as much dispatch as possible, to provide adequate protection to workers and their families, and to develop rational radiation protection standards based on actual long-term risk to health. Such standards are also of great importance to the general public, who may reside near such installations and who may at times be living within exhaust plumes from these installations.

Diligent and comprehensive studies should also be carried out of the incidence of all cancer and individual classes of cancer in general populations near these plants. These investigations should be performed as soon as possible by independent scientists and epidemiologists in order to provide essential information for shaping national policy in this area.

References and Notes Continued

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Figure 1

-15-

HISTOGRAMS OF THE PREVALENCE OF STRUCTURAL CHROMOSOME ABERRATIONS IN ROCKY FLATS CONTROLS AND PLUTONIUM WORKERS, ARRANGED BY CHROMOSOME ABERRATION CATEGORIES*

N = 274 MEN (PLUS 57 REPEATS)
NUMBER OF CELLS = 31,836

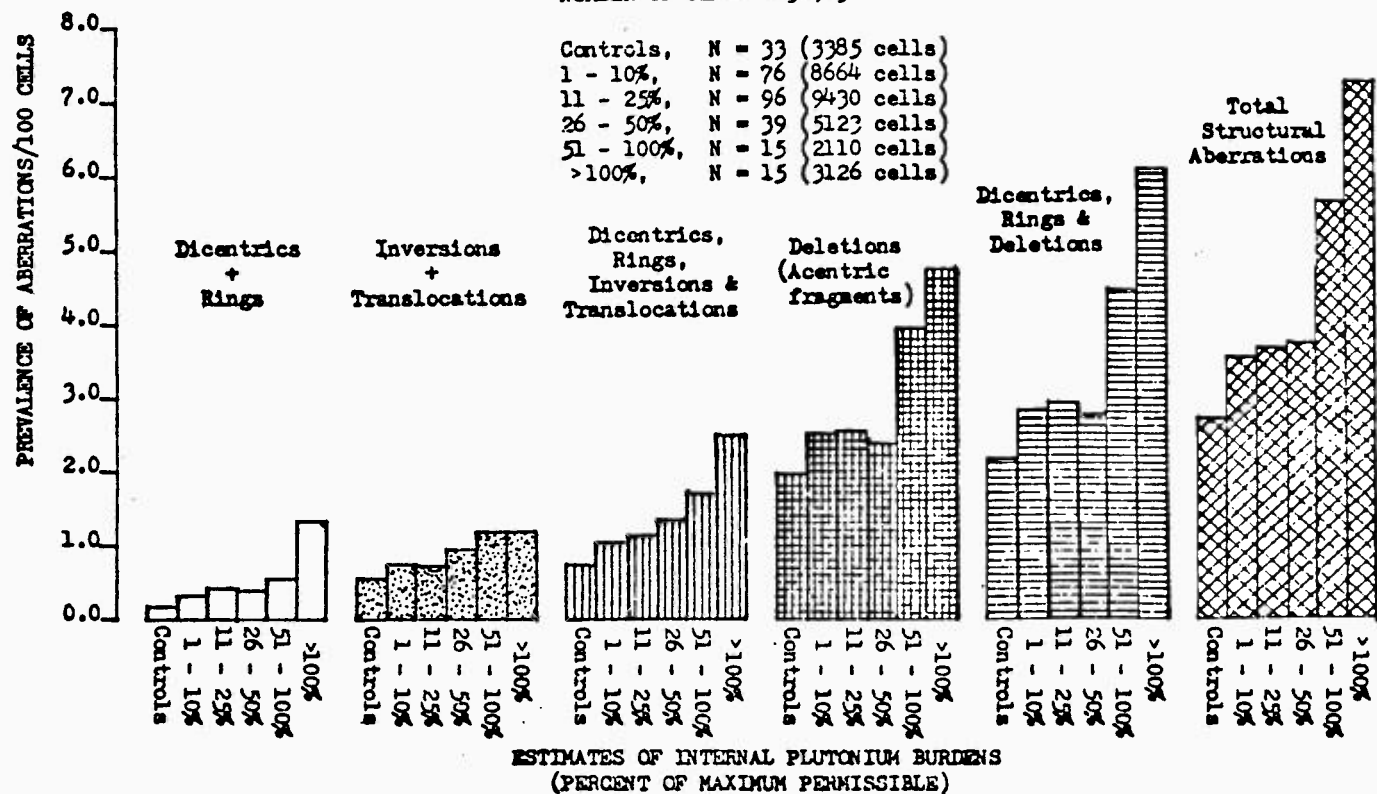


Figure 2

HISTOGRAMS OF CONTROL AND URANIUM MINER CHROMOSOMAL ABERRATIONS* TOTALS - N = 184 CELLS = 17,361

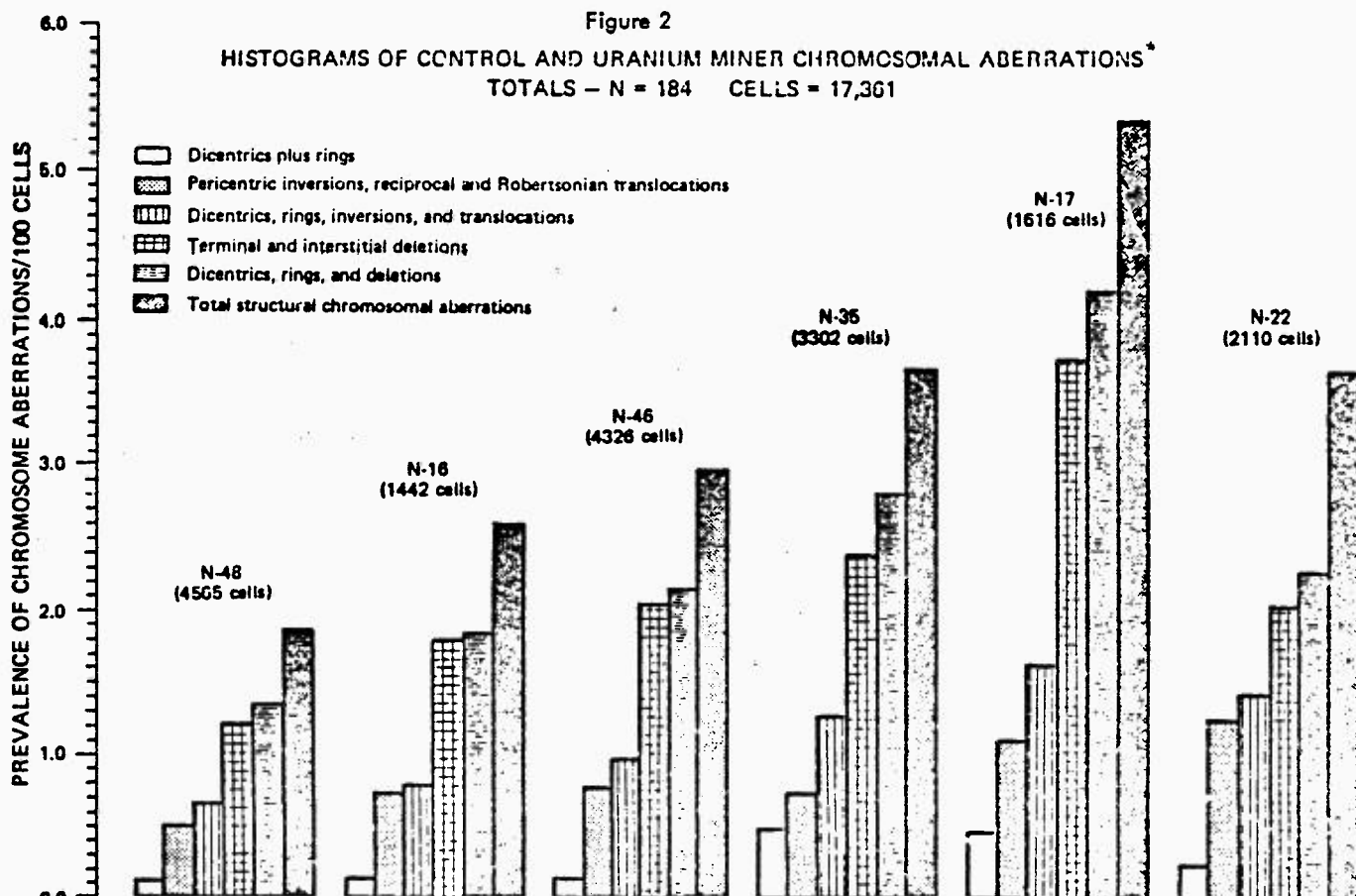


TABLE 1
ESTIMATED FUTURE YEARLY RELEASES OF NUCLIDES IN THE
EXHAUST PLUMES FROM THE ROCKY FLATS PLANT

ISOTOPE	YEARLY RELEASE (μCi)		RATIO TO PLUTONIUM 239
PLUTONIUM - 239	80	(a)	1.00
PLUTONIUM - 238	2	(a)	0.02
PLUTONIUM - 240	18	(a)	0.22
PLUTONIUM - 241	660	(b)	8.25
PLUTONIUM - 242	2×10^{-6}	(a)	0.00
AMERICIUM - 241	50	(a)	0.62
PROTACTINIUM - 234	77	(b)	0.96
THORIUM - 231	4	(b)	0.05
THORIUM - 234	77	(b)	0.96
URANIUM - 234	119	(a)	1.49
URANIUM - 235	4	(a)	0.05
URANIUM - 236	0.003	(a)	0.00
URANIUM - 238	77	(a)	0.96
TRITIUM (H-3)	100×10^6	(b)	
OTHER NUCLIDES LIKELY TO BE EMITTED IN THE EXHAUST PLUMES FROM ROCKY FLATS			
PHOSPHORUS 32	RHENIUM 103	NEPTUNIUM 237	
POTASSIUM 40	RUTHENIUM 103	PLUTONIUM 236	
COBALT 60	IODINE 129,131	CURIUM 244	
ZINC 65,66	CESIUM 134,137	VOLATILE AND GASEOUS	
STRONTIUM 90	RADIUM 226	NUCLIDES	
NIOBIUM 95	THORIUM 228	OTHER NUCLIDES DETECTABL	
ZIRCONIUM 95	URANIUM 233	BY GAMMA	
		SPECTROMETRY	

* Ref. #1 The total projected releases of actinides are about 15 times greater than the amount of plutonium 239 released.

Table 3

ulation age distribution of Rocky Flats workers and of white males in Colorado; age-specific cancer incidence rates per 100,000 for 1969 - 1971 for white males in Colorado, and the application of the Colorado age-specific cancer incidence rates to the age-specific groups of Rocky Flats workers in order to obtain a proximate expected proportionate morbidity ratio for cancer of the brain (C.N.S.), melanoma and cancer of the respiratory tract in Rocky Flats workers.*

Rocky Flats		Colorado						Cancer cases expected for Rocky Flats workers when Colorado age-specific cancer rates are applied to the age-specific groups of Rocky Flats workers.			
Number	%	Number	%	All cancer Per 100,000	Brain, CNS Per 100,000	Melanoma Per 100,000	Respiratory Per 100,000	All cancer (1 x 2)	Brain CNS (1 x 3)	Melanoma (1 x 4)	Respirator (1 x 5)
(1)				(2)	(3)	(4)	(5)				
10	0.3	417,526	40.1	13.8	2.35	0.01	0.1	.00138	.00024	.00001	.000
189	4.8	97,369	9.4	28.1	1.7	1.7	0.7	.05292	.00321	.00321	.001
390	9.9	73,694	7.1	33.5	1.8	5.0	0.9	.13065	.00702	.01950	.003
389	9.9	62,882	6.0	39.8	4.2	7.4	2.1	.15482	.01634	.02879	.008
429	10.9	60,165	5.8	63.7	2.8	5.0	7.2	.27327	.01201	.02145	.030
386	9.8	60,585	5.8	107.3	2.8	7.7	19.8	.41418	.01081	.02972	.076
400	10.2	58,751	5.6	211.6	9.1	10.2	43.1	.84640	.03640	.04080	.172
408	10.4	52,450	5.0	329.8	7.6	11.4	93.4	1.34558	.03101	.04651	.381
416	10.6	43,769	4.2	578.8	12.2	8.4	173.6	2.40864	.05075	.03494	.722
246	6.2	36,729	3.5	913	10.9	15.4	263.2	2.24598	.02681	.03768	.646
674	17.1	77,444	7.4	2100	12.1	16.0	288	14.15400	.08155	.10784	1.941
3937		1,041,364						22.028	0.276	0.371	3.984

$$\text{pmr for cancer of brain, CNS} = \frac{0.276}{22.028} = 1.3\%$$

$$\text{pmr for melanoma} = \frac{0.371}{22.028} = 1.7\%$$

$$\text{pmr for respiratory cancer} = \frac{3.984}{22.028} = 18.1\%$$

Table 4

The proportionate morbidity ratio (pmr) for cancer of employees (active and retired) of the Rocky Flats nuclear weapons plant in Jefferson County, Colorado for the period 1951-1979, compared to the pmr for white males in Colorado, age-adjusted, for the period 1969-1971 (a)

	Colorado 1969 - 1971		Rocky Flats 1951 - 1979			
	cases	pmr	observed		expected (b)	
			cases	pmr	pmr	cases
All Cancer	272.5 (c)	100. %	128 (c)	100 %	100. %	128
Genito-urinary and reproductive	90.6	33.2%	32*	25 %	37.1%	47.5
Hematologic and lymphatic	22.9	8.4%	9	7 %	7.0%	9.0
Gastrointestinal	64.4	23.6%	28	22.9%	24.8%	30.4
Miscellaneous	27.0	9.9%	11	8.6%	10.0%	12.8
Respiratory	57.1	21.0%	29	22.7%	18.1%	23.2
Melanoma	5.4	1.98%	6*	4.7%	1.7%	2.17
Brain, C.N.S.	5.1	1.88%	13**	10.2%	1.3%	1.66

(a) ref. 1, 2 Colorado case numbers are the average annual incidence for the period.

(b) expected case numbers calculated by the method illustrated in Table 3.

(c) excluding carcinoma-in-situ and non-melanoma skin cancers.