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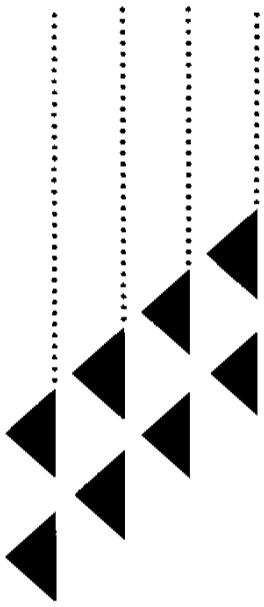
1997 Report on Occupational Radiation Exposures in Canada



Canada

1997 Report on Occupational Radiation Exposures in Canada

Environmental Health Directorate
Health Protection Branch

Published by authority of the
Minister of Health
1997

Our mission is to help the people of Canada
maintain and improve their health.
Health Canada

Également disponible en français sous le titre
Rapport de 1997 sur les radioexpositions professionnelles au Canada

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Cat. H46-2/97-213E
ISBN 0-662-26228-X

97-EHD-213

Abstract

This document was prepared by Dr. W.N. Sont and Dr. J.P. Ashmore of the Occupational Radiation Hazards Division, Radiation Protection Bureau. Acknowledgements are extended to Miss C. Boucher and Mr. B. Davies for their assistance.

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Introduction

This series of reports provides statistics on occupational radiation exposures of monitored workers in Canada. Previous issues of the report can be obtained from the authors [1-5].

The information is based on the data in the National Dose Registry (NDR) maintained by the Radiation Protection Bureau of Health Canada[6]. The Registry is a centralized record-keeping system containing dose information on all monitored workers in Canada. It includes records from the National Dosimetry Services (NDS), as well as data submitted by nuclear power generating stations, Atomic Energy of Canada Ltd., uranium mines, and private dosimeter processing companies. About 80 percent of the records are from the NDS.

Information for input into the NDR is received in a number of different physical forms. Data from the NDS are fed directly from the dosimeter reading stations into a computer, where they are processed, reported and entered into the NDR files. Most other dose records are submitted to the Registry in computer readable form.

The report provides data on the two consecutive years prior to the year in which the data are extracted from the database. The data for the second (i.e. more recent) year will be close to stable at the time of data extraction. Some changes may still occur, for which the most frequent causes are: (1) a high dose to a dosimeter is judged to be non-personal after investigation; (2) a job category of a worker is updated; or (3) dosimeters or data are returned late. The report therefore contains preliminary data on the second year, and more complete data on the first year.

For a description and a guide to interpretation of the data, the reader is referred to the next section “General Comments”. The section “Comments specific to this report” has been included to address situations that do not reoccur from year to year.

General Comments

The statistics include doses as they exist in the database at the time they are extracted for analysis, which in the case of this report is 8 July 1997. All NDS doses are assigned to the year in which the dosimeter was issued, even though some of the dosimeters may actually have been worn during part of the subsequent year. As the statistics are determined in the same manner each year, the annual dose figures are based on a 12-month period, though not necessarily the strict calendar year.

Dose records submitted by outside organizations such as nuclear power generating stations, uranium mines, and commercial processors are included to the extent that they have been received. The doses are representative of the calendar year only if the fourth quarter records have been received by the time of analysis. When statistics are based on partial data, the fact is indicated in the section “Comments specific to this report”.

All doses are in International System (SI) units and presented to the nearest hundredth of a millisievert (1 mSv = 100 mrem). For the external whole body doses recorded by the NDS there is a minimum reporting level of 0.2 mSv. Organizations submitting their own doses may have lower reporting levels.

The words “dose” and “exposure” are used interchangeably in this report. Doses of different types of radiation are expressed in mSv and added to give the dose stated in the report. The following dose types may be included:

- External whole body gamma
- External whole body high energy beta
- External whole body X-ray
- External whole body neutron
- Internal whole body tritium, as determined by urinalysis
- Radon progeny exposures, converted from WLM values (see below).

All types of exposure are given in one total. In Tables 3 and 4, the percentage contribution of radon progeny and tritium components are indicated for occupations related to mining and nuclear power generation, respectively. Skin doses and extremity doses are not included in the report but are recorded in the database.

In the NDR database, radon progeny exposures are expressed in Working Level Months (WLM), which are in most cases calculated by the mines on the basis of area monitoring.[7] In the report the radon progeny exposures are converted to dose equivalents (in mSv). The value used in this report is given in the specific comments section.

Job category designations are based on a standard list provided by the Registry and are updated when the Registry is notified. The job category is selected by the organization from a standard list maintained by the NDR. The NDR keeps the most recent job category that an organization submits for a worker in a given year. However, a worker can have records under more than one job category for the same year, if he has been monitored by more than one organization. Some organizations have their own job classification schemes, and translate them into the Registry's standardized list prior to submission of the records.

In this report, the data are tabulated as follows:

1996: Preliminary analysis

Table 1:

Table 1 gives the annual dose distributions by job category.

1995: Final analysis

Table 2:

In Table 2, statistics are broken down by job category and province or territory.

Table 3:

Table 3 contains dose distributions broken down by age and sex. In these tables job categories have been grouped into "job sectors".

Table 4:

Table 4 contains various dose statistics broken down by job category. The table also shows the parameters of the log-normal or hybrid lognormal distribution for positive doses, as produced by maximum likelihood estimation. From that information, it is possible to calculate estimates and confidence intervals of statistics of the distribution. For a more detailed discussion the reader is referred to the Appendix.

Table 4 also includes an accumulated dose distribution over the 5 year period 1991-1995 for the workers under the given job category.

Finally, Table 4 contains a histogram that shows the trend in average annual doses over the period 1986-1995.

It should be noted that in the tables, a worker is counted more than once if he(she) works in more than one job category, in more than one province, or in more than one job sector in the same year. For this reason the totals in Tables 2-4 may slightly differ.

Comments specific to this report

The conversion factor currently used to convert Radon progeny exposures is 10 mSv per WLM. This is based on the annual dose limits recommended by the ICRP[8] which are 50 mSv for external whole body doses and 4.8 WLM for Radon progeny exposures.

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Table 1
Breakdown of annual doses by job category for all of Canada

Job Category	Distribution of workers over dose intervals							Number of Workers	Avg. Dose (mSv)	Avg. of Positive Doses
	0 mSv	>0-1 mSv	>1-2 mSv	>2-5 mSv	>5-20 mSv	>20-50 mSv	>50 mSv			
Administration:										
Administrator	258	93	2	0	0	0	1	354	0.39	1.43
Office staff	3061	487	14	14	0	0	0	3576	0.07	0.50
Safety officer	66	27	1	0	0	0	0	94	0.12	0.40
Industry and Research:										
Fuel processor	23	47	32	43	35	0	0	180	2.82	3.24
Industrial radiographer	925	356	148	243	355	73	5	2105	3.34	5.95
Instructor (non-medical)	131	17	2	0	0	0	0	150	0.05	0.40
Instrument technician	1270	357	42	26	10	0	0	1705	0.22	0.85
Laboratory technician (industrial)	2453	578	45	29	11	0	0	3116	0.15	0.70
Scientist engineer (field)	618	705	33	21	9	1	0	1387	0.38	0.69
Scientist/engineer (laboratory)	3582	403	10	3	0	0	0	3998	0.04	0.37
Well logger	437	181	44	47	13	0	0	722	0.55	1.39
Medicine:										
Chiropractor	922	55	4	4	1	0	0	986	0.05	0.72
Dental assistant	6906	55	2	1	3	0	0	6967	0.01	0.99
Dental hygienist	6276	49	4	1	0	0	0	6330	0.00	0.46
Dental therapist/nurse	38	0	0	0	0	0	0	38	0.00	0.00
Dentist	6318	69	2	0	1	0	0	6390	0.00	0.44
Gynaecologist	31	1	0	0	0	0	0	32	0.01	0.30
Laboratory technician (medical)	2724	247	15	4	2	0	0	2992	0.04	0.46
Medical physicist	179	28	2	0	1	0	0	210	0.12	0.84
Medical radiation technologist	9433	1441	48	20	10	1	0	10953	0.07	0.48
Nuclear medicine technologist	395	351	193	246	33	0	0	1218	1.20	1.78

Table 1 (cont'd)
Breakdown of annual doses by job category for all of Canada

Job Category	Distribution of workers over dose intervals							Number of Workers	Avg. Dose (mSv)	Avg. of Positive Doses
	0 mSv	>0-1 mSv	>1-2 mSv	>2-5 mSv	>5-20 mSv	>20-50 mSv	>50 mSv			
Medicine (cont'd)										
Nurse	3521	363	18	6	0	0	0	3908	0.04	0.42
Physician	1497	246	24	8	2	0	0	1777	0.09	0.60
Radiation therapist	540	147	6	13	5	0	0	711	0.21	0.88
Radiologist (diagnostic)	1321	228	12	8	2	0	0	1571	0.09	0.56
Radiologist (therapeutic)	121	13	1	1	0	0	0	136	0.06	0.51
Veterinarian	3429	345	18	12	1	0	0	3805	0.05	0.48
Veterinary technician	5	1	0	0	0	0	0	6	0.05	0.30
Ward aide/orderly	1498	151	10	9	1	1	0	1670	0.08	0.73
Nuclear Power:										
Reactor – administration	3362	484	98	88	42	0	0	4074	0.21	1.19
Reactor – chemical and radiation control	125	118	55	42	47	0	0	387	1.91	2.83
Reactor – construction	690	351	85	132	85	0	0	1343	1.00	2.06
Reactor – control technician	48	24	14	18	8	0	0	112	1.38	2.42
Reactor – electrical maintenance	313	329	157	160	55	0	0	1014	1.19	1.72
Reactor – fuel handling	7	9	4	11	13	0	0	44	3.84	4.56
Reactor – general maintenance	695	320	85	126	72	0	0	1298	0.88	1.89
Reactor – health physics	57	15	3	5	3	0	0	83	0.54	1.73
Reactor – industrial radiographer	10	5	1	5	4	0	0	25	2.20	3.67
Reactor – mechanical maintenance	320	314	184	395	214	1	0	1428	2.32	2.99
Reactor – operations	533	598	306	280	151	0	0	1868	1.59	2.22
Reactor – scientific/professional	969	248	44	58	58	0	1	1378	1.27	4.27
Reactor – training	40	12	1	0	2	0	0	55	0.38	1.38
Reactor – visitor	25	4	0	5	1	0	0	35	0.64	2.24

Table 1 (cont'd)
Breakdown of annual doses by job category for all of Canada

Job Category	Distribution of workers over dose intervals							Number of Workers	Avg. Dose (mSv)	Avg. of Positive Doses
	0 mSv	>0-1 mSv	>1-2 mSv	>2-5 mSv	>5-20 mSv	>20-50 mSv	>50 mSv			
Mining:										
Uranium mine mill maintenance	12	23	39	62	27	0	0	163	2.79	3.02
Uranium mine mill worker	10	55	43	95	42	0	0	245	2.99	3.11
Uranium mine nurse	3	2	0	0	0	0	0	5	0.18	0.45
Uranium mine office staff	14	53	27	2	0	0	0	96	0.69	0.80
Uranium mine support worker	11	25	16	28	53	0	0	133	4.62	5.04
Uranium mine surface maintenance	54	86	63	25	17	0	0	245	1.34	1.72
Uranium mine surface miner	65	44	54	47	4	0	0	214	1.30	1.87
Uranium mine surface personnel	18	29	7	7	0	0	0	61	0.75	1.06
Uranium mine surface support worker	97	95	70	27	7	0	0	296	0.98	1.46
Uranium mine underground maintenance	3	16	21	33	28	0	0	101	3.85	3.97
Uranium mine underground miner	12	44	33	70	254	55	0	468	9.64	9.90
Uranium mine underground personnel	170	91	27	30	15	0	0	333	0.95	1.95
Uranium mine visitor	135	87	7	2	0	0	0	231	0.21	0.51
Miscellaneous/Unknown:										
Miscellaneous/unknown	30974	8985	966	743	280	15	0	41963	0.24	0.90

Table 2
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Administration													
Administrator	4	0	6	4	34	342	15	1	19	16	0	0	441
	0.00	0.00	0.00	0.00	0.01	0.26	0.00	0.00	0.35	0.06	0.00	0.00	0.22
Office staff	36	5	82	58	679	2454	228	62	188	262	11	2	4067
	0.02	0.00	0.03	0.01	0.03	0.15	0.01	0.01	0.01	0.02	0.03	0.00	0.10
Safety officer	3	1	13	2	14	28	23	4	5	9	0	0	102
	0.00	0.00	0.22	0.45	0.02	0.22	0.05	0.05	0.00	0.04	0.00	0.00	0.12
Overall	**43**	**6**	**101**	**64**	**727**	**2824**	**266**	**67**	**212**	**287**	**11**	**2**	**4610**
	0.01	**0.00**	**0.05**	**0.03**	**0.02**	**0.16**	**0.01**	**0.01**	**0.04**	**0.02**	**0.03**	**0.00**	**0.11**
Industry and Research													
Fuel processor	0	0	0	0	1	173	1	0	3	3	0	0	181
	0.00	0.00	0.00	0.00	0.00	2.70	0.00	0.00	0.00	0.00	0.00	0.00	2.59
Industrial radiographer	57	0	80	105	356	622	39	146	710	226	0	2	2343
	1.39	0.00	1.21	1.83	1.94	1.67	0.56	1.93	4.57	2.31	0.00	0.00	2.63
Instructor	8	0	16	3	10	71	7	2	19	25	1	0	162
	0.00	0.00	0.00	0.07	0.00	0.06	0.04	0.00	0.05	0.02	0.40	0.00	0.04
Instrument technician	82	1	78	54	402	750	59	25	221	134	0	0	1806
	0.08	0.00	0.09	0.16	0.04	0.36	0.11	0.06	1.31	0.21	0.00	0.00	0.35
Lab. technician (industrial)	53	16	110	32	731	1801	205	206	664	346	0	0	4164
	0.18	0.23	0.09	0.07	0.08	0.19	0.11	0.06	0.04	0.32	0.00	0.00	0.14
Scientist/engineer (field)	5	0	53	30	100	660	16	79	165	105	2	0	1215
	0.00	0.00	0.13	0.16	0.07	0.58	0.37	0.18	0.29	0.14	0.25	0.00	0.40
Scientist/engineer (laboratory)	138	0	136	19	1400	1806	133	156	232	849	0	0	4869
	0.05	0.00	0.07	0.14	0.03	0.13	0.01	0.02	0.02	0.05	0.00	0.00	0.07
Well logger	1	0	8	0	2	8	1	45	868	15	2	0	950
	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.14	0.49	0.54	0.00	0.00	0.46
Overall	**344**	**17**	**481**	**243**	**3002**	**5891**	**461**	**659**	**2882**	**1703**	**5**	**2**	**15690**
	0.30	**0.21**	**0.27**	**0.87**	**0.27**	**0.46**	**0.13**	**0.48**	**1.40**	**0.43**	**0.18**	**0.00**	**0.58**

Table 2 (cont'd)
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Medicine													
Chiropractor	0	0	2	1	334	359	62	16	176	39	0	0	989
	0.00	0.00	0.25	0.00	0.03	0.04	0.03	0.00	0.03	0.34	0.00	0.00	0.05
Dental assistant	57	12	163	108	1185	3138	452	245	300	460	12	13	6145
	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.01
Dental hygienist	51	34	177	88	2019	2834	435	185	253	397	13	11	6497
	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.04	0.00	0.01
Dental therapist/nurse	1	0	0	0	0	5	2	9	0	1	2	0	20
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dentist	84	12	146	83	2066	2851	507	126	182	303	12	9	6381
	0.00	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.03	0.00	0.01
Gynaecologist	1	0	4	0	4	11	6	0	0	2	0	0	28
	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Laboratory technician (medical)	36	3	136	9	1096	1404	230	124	307	325	0	0	3670
	0.00	0.00	0.06	0.29	0.05	0.04	0.02	0.03	0.02	0.06	0.00	0.00	0.04
Medical physicist	3	0	13	9	72	77	14	11	4	45	1	0	249
	0.00	0.00	0.14	0.09	0.10	0.08	0.01	0.00	0.00	0.02	0.00	0.00	0.07
Medical radiation technologist	304	75	343	344	2715	4355	694	663	1224	1348	25	9	12099
	0.06	0.04	0.12	0.05	0.08	0.04	0.03	0.05	0.04	0.04	0.01	0.07	0.05
Nuclear medicine technologist	20	3	49	30	480	546	65	23	91	144	0	0	1451
	1.78	2.07	1.11	1.15	1.38	0.79	0.65	1.29	0.49	0.38	0.00	0.00	0.96
Nurse	225	28	223	133	1126	2539	189	82	129	305	117	61	5157
	0.04	0.00	0.13	0.05	0.04	0.04	0.02	0.14	0.01	0.05	0.00	0.03	0.04
Physician	40	5	88	34	677	820	49	50	151	212	8	3	2137
	0.20	0.00	0.20	0.09	0.15	0.06	0.11	0.27	0.03	0.05	0.00	0.23	0.10
Radiation therapist	12	0	33	33	220	433	50	48	6	136	1	0	972
	0.75	0.00	0.11	0.07	0.34	0.07	0.03	0.14	0.03	0.16	0.00	0.00	0.15
Radiologist (diagnostic)	46	6	66	45	529	682	71	45	118	215	3	0	1826
	0.17	0.00	0.30	0.11	0.09	0.05	0.17	0.03	0.02	0.07	0.00	0.00	0.08
Radiologist (therapeutic)	4	0	5	9	45	59	20	4	2	15	0	0	163
	0.10	0.00	0.04	0.00	0.11	0.03	0.00	0.20	0.15	0.06	0.00	0.00	0.06

Table 2
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Medicine (cont'd)													
Veterinarian	29	41	141	59	551	1197	175	160	626	567	0	5	3551
	0.05	0.04	0.03	0.07	0.03	0.07	0.02	0.04	0.03	0.03	0.00	0.00	0.04
Veterinary technician	0	0	1	0	3	5	0	1	2	2	0	0	14
	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Ward aide/orderly	41	14	21	61	1110	370	74	38	41	103	7	0	1880
	0.07	0.00	0.09	0.03	0.05	0.06	0.02	0.08	0.04	0.02	0.00	0.00	0.05
Overall	**954**	**233**	**1611**	**1046**	**14232**	**21685**	**3095**	**1830**	**3612**	**4619**	**201**	**111**	**53229**
	0.10	**0.05**	**0.12**	**0.08**	**0.09**	**0.05**	**0.03**	**0.06**	**0.04**	**0.05**	**0.01**	**0.03**	**0.06**
Nuclear Power													
Reactor – administration	0	0	0	141	343	3417	0	0	0	0	0	0	3901
	0.00	0.00	0.00	0.41	0.28	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.26
Reactor – chemical and radiation control	0	0	0	22	46	322	0	0	0	0	0	0	390
	0.00	0.00	0.00	2.04	3.46	2.02	0.00	0.00	0.00	0.00	0.00	0.00	2.19
Reactor – construction	0	0	0	7	88	1273	0	0	0	0	0	0	1368
	0.00	0.00	0.00	0.00	0.29	4.13	0.00	0.00	0.00	0.00	0.00	0.00	3.86
Reactor – control technician	0	0	0	0	102	1	0	0	0	0	0	0	103
	0.00	0.00	0.00	0.00	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.99
Reactor – electrical maintenance	0	0	0	78	35	915	0	0	0	0	0	0	1028
	0.00	0.00	0.00	2.20	2.17	1.87	0.00	0.00	0.00	0.00	0.00	0.00	1.90
Reactor – fuel handling	0	0	0	56	11	93	0	0	0	0	0	0	160
	0.00	0.00	0.00	5.49	4.68	8.06	0.00	0.00	0.00	0.00	0.00	0.00	6.93
Reactor – general maintenance	0	0	0	208	73	906	0	0	0	0	0	0	1187
	0.00	0.00	0.00	1.88	4.29	1.20	0.00	0.00	0.00	0.00	0.00	0.00	1.51
Reactor – health physics	0	0	0	28	10	58	0	0	0	0	0	0	96
	0.00	0.00	0.00	3.37	0.95	0.32	0.00	0.00	0.00	0.00	0.00	0.00	1.28
Reactor – industrial radiographer	0	0	0	0	0	24	0	0	0	0	0	0	24
	0.00	0.00	0.00	0.00	0.00	3.71	0.00	0.00	0.00	0.00	0.00	0.00	3.71
Reactor – mechanical maintenance	0	0	0	150	139	1175	0	0	0	0	0	0	1464
	0.00	0.00	0.00	4.99	5.25	3.68	0.00	0.00	0.00	0.00	0.00	0.00	3.96
Reactor – operations	0	0	0	82	103	1509	0	0	0	0	0	0	1694
	0.00	0.00	0.00	2.05	1.74	1.69	0.00	0.00	0.00	0.00	0.00	0.00	1.71

Table 2 (cont'd)
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Nuclear Power (cont'd)													
Reactor – scientific/professional	0	0	0	420	141	951	0	0	0	0	0	0	1512
	0.00	0.00	0.00	2.92	0.91	0.75	0.00	0.00	0.00	0.00	0.00	0.00	1.37
Reactor – training	0	0	0	26	20	7	0	0	0	0	0	0	53
	0.00	0.00	0.00	0.43	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65
Reactor – visitor	0	0	0	0	2	37	0	0	0	0	0	0	39
	0.00	0.00	0.00	0.00	0.00	1.94	0.00	0.00	0.00	0.00	0.00	0.00	1.84
Overall	**0**	**0**	**0**	**1218**	**1113**	**10688**	**0**	**0**	**0**	**0**	**0**	**0**	**13019**
	0.00	**0.00**	**0.00**	**2.64**	**1.79**	**1.69**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.79**
Uranium Mining													
Uranium mine mill maintenance	0	0	0	0	0	12	0	172	0	0	0	0	184
	0.00	0.00	0.00	0.00	0.00	0.12	0.00	1.97	0.00	0.00	0.00	0.00	1.85
Uranium mine mill worker	0	0	0	0	0	42	0	184	0	0	0	0	226
	0.00	0.00	0.00	0.00	0.00	0.83	0.00	2.56	0.00	0.00	0.00	0.00	2.24
Uranium mine nurse	0	0	0	0	0	0	0	5	0	0	0	0	5
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.16
Uranium mine office staff	0	0	0	0	0	26	0	77	0	0	0	0	103
	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.73	0.00	0.00	0.00	0.00	1.00
Uranium mine support worker	0	0	0	0	0	80	0	57	0	0	0	0	137
	0.00	0.00	0.00	0.00	0.00	9.09	0.00	5.85	0.00	0.00	0.00	0.00	7.74
Uranium mine surface maintenance	0	0	0	0	0	74	0	137	0	0	0	0	211
	0.00	0.00	0.00	0.00	0.00	2.04	0.00	0.92	0.00	0.00	0.00	0.00	1.31
Uranium mine surface miner	0	0	0	0	0	0	0	154	0	0	0	0	154
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.00	0.00	1.24
Uranium mine surface personnel	0	0	0	0	0	0	0	50	0	0	0	0	50
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.59
Uranium mine surface support worker	0	0	0	0	0	74	0	181	0	0	0	0	255
	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.98	0.00	0.00	0.00	000	0.77
Uranium mine underground maintenance	0	0	0	0	0	61	0	48	0	0	0	0	109
	0.00	0.00	0.00	0.00	0.00	6.83	0.00	3.51	0.00	0.00	0.00	0.00	5.37

Table 2 (cont'd)
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Uranium Mining (cont'd)													
Uranium mine underground miner	0	0	0	0	0	149	0	237	0	0	0	0	386
	0.00	0.00	0.00	0.00	0.00	15.66	0.00	7.90	0.00	0.00	0.00	0.00	10.90
Uranium mine underground personnel	0	0	0	0	0	147	0	229	0	0	0	0	376
	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.98	0.00	0.00	0.00	0.00	0.96
Uranium mine visitor	0	0	0	0	0	0	0	296	0	0	0	0	296
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.40
Overall	**0**	**0**	**0**	**0**	**0**	**665**	**0**	**1827**	**0**	**0**	**0**	**0**	**2492**
	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**5.82**	**0.00**	**2.15**	**0.00**	**0.00**	**0.00**	**0.00**	**3.20**

1995 Final Analysis

Table 3
Dose distribution broken down by job sector, age and sex

			Sex			
Job Sector	Age	Statistic	Male	Female	Unknown	Overall
Administration	Below 25	Number of Workers	13	289	0	302
		Average dose (mSv)	0.60	0.02	0.00	0.04
	25-34	Number of Workers	96	1125	3	1224
		Average dose (mSv)	0.25	0.05	0.00	0.07
	35-44	Number of Workers	222	1332	8	1562
		Average dose (mSv)	0.35	0.07	0.03	0.11
	45-54	Number of Workers	288	824	4	1116
		Average dose (mSv)	0.38	0.09	0.00	0.17
	55-up	Number of Workers	85	259	7	351
		Average dose (mSv)	0.30	0.04	0.03	0.10
	Unknown	Number of Workers	17	34	0	51
		Average dose (mSv)	0.40	0.10	0.00	0.20
	Overall	**Number of Workers**	**721**	**3863**	**22**	**4606**
		Average dose (mSv)	**0.35**	**0.06**	**0.02**	**0.11**
Industry and Research	Below 25	Number of Workers	767	410	4	1181
		Average dose (mSv)	1.55	0.06	0.68	1.03
	25-34	Number of Workers	3564	1479	12	5055
		Average dose (mSv)	0.93	0.06	0.05	0.67
	35-44	Number of Workers	4239	1034	23	5296
		Average dose (mSv)	0.68	0.08	0.18	0.56
	45-54	Number of Workers	2411	443	7	2861
		Average dose (mSv)	0.48	0.12	0.00	0.42
	55-up	Number of Workers	844	94	15	953
		Average dose (mSv)	0.35	0.13	0.99	0.34
	Unknown	Number of Workers	157	16	1	174
		Average dose (mSv)	0.47	0.14	0.00	0.43
	Overall	**Number of Workers**	**11982**	**3476**	**62**	**15520**
		Average dose (mSv)	**0.74**	**0.08**	**0.36**	**0.59**
Medicine	Below 25	Number of Workers	376	3760	7	4143
		Average dose (mSv)	0.12	0.05	0.06	0.06
	25-34	Number of Workers	3645	13989	41	17675
		Average dose (mSv)	0.11	0.06	0.06	0.07
	35-44	Number of Workers	5214	11768	38	17020
		Average dose (mSv)	0.09	0.05	0.05	0.07
	45-54	Number of Workers	4128	5827	38	9993
		Average dose (mSv)	0.06	0.05	0.03	0.06
	55-up	Number of Workers	2218	1244	58	3520
		Average dose (mSv)	0.07	0.05	0.03	0.06
	Unknown	Number of Workers	283	270	0	553
		Average dose (mSv)	0.08	0.03	0.00	0.05
	Overall	**Number of Workers**	**15864**	**36858**	**182**	**52904**
		Average dose (mSv)	**0.09**	**0.05**	**0.04**	**0.06**

Table 3 (cont'd)
Dose distribution broken down by job sector, age and sex

			Sex			
Job Sector	Age	Statistic	Male	Female	Unknown	Overall
Nuclear Power	Below 25	Number of Workers	186	76	0	262
		Average dose (mSv)	1.64	0.10	0.00	1.20
		% tritium	17.6	33.8	0.0	18.0
	25-34	Number of Workers	2491	513	0	3004
		Average dose (mSv)	2.66	0.58	0.00	2.30
		% tritium	23.7	29.2	0.0	23.9
	35-44	Number of Workers	4663	636	2	5301
		Average dose (mSv)	2.03	0.35	0.05	1.83
		% tritium	21.3	27.0	0.0	21.4
	45-54	Number of Workers	3216	267	1	3484
		Average dose (mSv)	1.46	0.31	0.00	1.38
		% tritium	19.0	24.5	0.0	19.1
	55-up	Number of Workers	657	14	0	671
		Average dose (mSv)	1.89	0.05	0.00	1.86
		% tritium	13.9	32.8	0.0	13.9
	Unknown	Number of Workers	149	4	0	153
		Average dose (mSv)	2.06	0.00	0.00	2.01
		% tritium	16.6	0.0	0.0	16.6
	Overall	**Number of Workers**	**11362**	**1510**	**3**	**12875**
		Average dose (mSv)	**2.00**	**0.41**	**0.03**	**1.81**
		% tritium	**21.0**	**27.8**	**0.0**	**21.2**
Mining	Below 25	Number of Workers	141	36	0	177
		Average dose (mSv)	1.78	0.40	0.00	1.50
		% radon progeny	58.6	75.9	0.0	59.6
	25-34	Number of Workers	458	78	0	536
		Average dose (mSv)	2.97	0.83	0.00	2.66
		% radon progeny	57.4	61.0	0.0	57.6
	35-44	Number of Workers	814	51	0	865
		Average dose (mSv)	4.39	0.66	0.00	4.17
		% radon progeny	67.5	67.7	0.0	67.5
	45-54	Number of Workers	544	30	0	574
		Average dose (mSv)	3.38	0.55	0.00	3.23
		% radon progeny	66.1	60.6	0.0	66.1
	55-up	Number of Workers	226	8	0	234
		Average dose (mSv)	2.26	0.25	0.00	2.19
		% radon progeny	67.2	70.0	0.0	67.2
	Unknown	Number of Workers	52	3	0	55
		Average dose (mSv)	5.96	0.10	0.00	5.64
		% radon progeny	69.8	0.0	0.0	69.7
	Overall	**Number of Workers**	**2235**	**206**	**0**	**2441**
		Average dose (mSv)	**3.51**	**0.64**	**0.00**	**3.27**
		% radon progeny	**65.2**	**64.3**	**0.0**	**65.2**

1995 Final Analysis

Table 4
Dose statistics by job category
Administrator

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	257	0.00	0.00
>0 - 1	173	76.89	0.44
>1 - 2	8	9.73	1.22
>2 - 5	1	2.70	2.70
>5 - 20	1	6.20	6.20
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	440	95.52	0.22
			Five year period 1991-1995
0	276	0.00	0.00
>0 - 5	333	531.32	1.60
>5 - 25	23	150.22	6.53
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	632	681.54	1.08

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.5217

μ: -1.4086

σ^2: 1.4317

Sample Size: 183

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

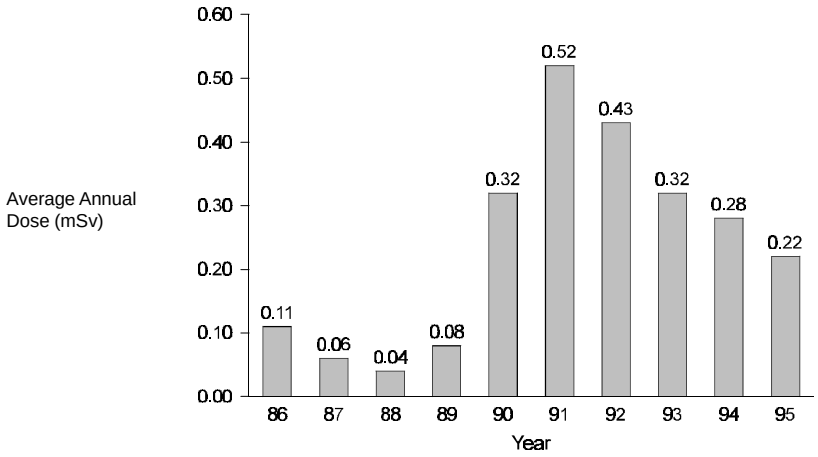


Table 4 (Cont'd)
Office Staff

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	3267	0.00	0.00
>0 - 1	759	331.24	0.44
>1 - 2	32	39.65	1.24
>2 - 5	6	17.16	2.86
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	4064	388.05	0.10
			Five year period 1991-1995
0	5116	0.00	0.00
>0 - 5	1624	2300.93	1.42
>5 - 25	63	463.42	7.36
>25 - 100	4	157.77	39.44
>100	0	0.00	0.00
Total	6807	2922.12	0.43

Hybrid lognormal parameters for positive doses in 1995:

ρ: 2.2779

μ: +0.8610

σ^2: 3.0760

Sample Size: 797

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

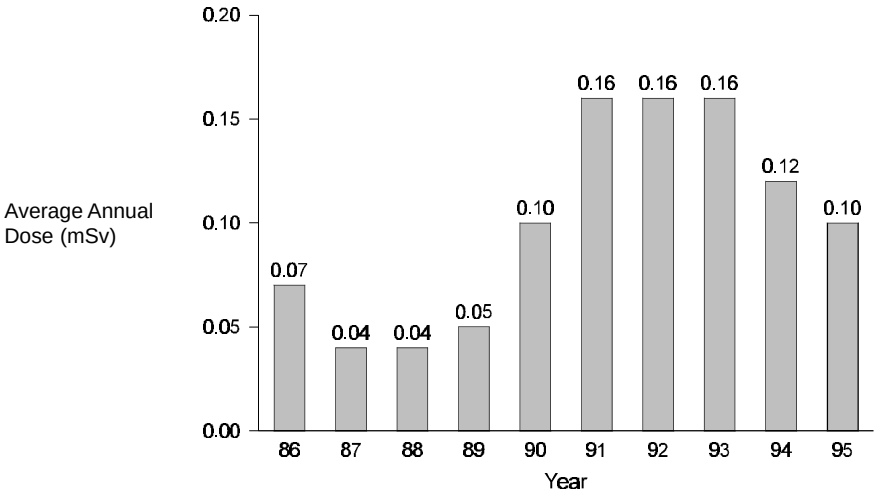


Table 4 (Cont'd)
Safety Officer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	73	0.00	0.00
>0 - 1	29	11.97	0.41
>1 - 2	0	0.00	0.00
>2 - 5	0	0.00	0.00
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	102	11.97	0.12
			Five year period 1991-1995
0	80	0.00	0.00
>0 - 5	51	56.23	1.10
>5 - 25	2	12.59	6.30
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	133	68.82	0.52

Lognormal parameters for positive doses in 1995:

μ: -1.0429

σ^2: 0.3227

Sample size: 29

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

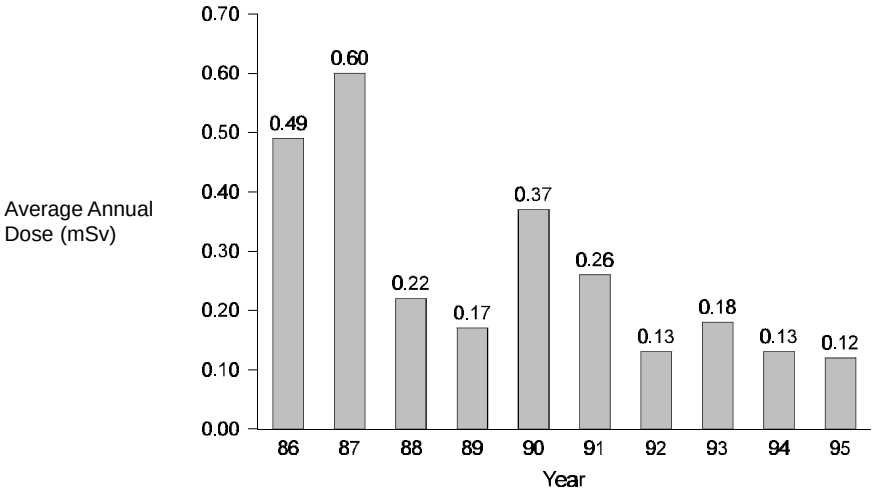


Table 4 (Cont'd)
Industrial Radiographer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	1046	0.00	0.00
>0 - 1	374	165.20	0.44
>1 - 2	153	230.88	1.51
>2 - 5	278	920.12	3.31
>5 - 20	349	3490.01	10.00
>20 - 50	52	1381.32	26.56
>50	0	0.00	0.00
Total	2252	6187.53	2.75
			Five year period 1991-1995
0	1088	0.00	0.00
>0 - 5	1151	1554.73	1.35
>5 - 25	685	8860.98	12.94
>25 - 100	483	21572.88	44.66
>100	37	5183.37	140.09
Total	3444	37171.96	10.79

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.0518

μ: -1.8943

σ^2: 2.9312

Sample Size: 1206

See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

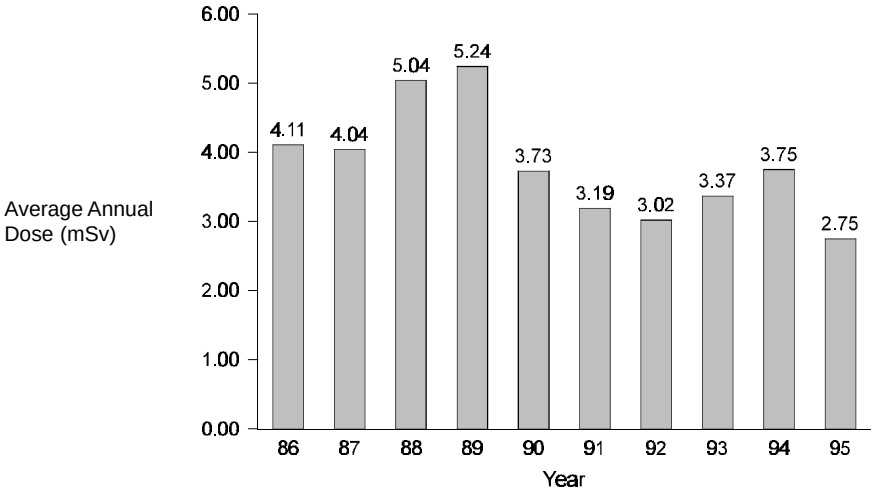


Table 4 (Cont'd)
Instructor (Non-Medical)

Dose Interval	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	146	0.00	0.00
>0 - 1	16	7.01	0.44
>1 - 2	0	0.00	0.00
>2 - 5	0	0.00	0.00
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	162	7.01	0.04
			Five year period 1991-1995
0	173	0.00	0.00
>0 - 5	82	57.55	0.70
>5 - 25	2	11.70	5.85
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	257	69.25	0.27

Lognormal parameters for positive doses in 1995:

μ: -0.9565

σ^2: 0.2577

Sample Size: 16

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

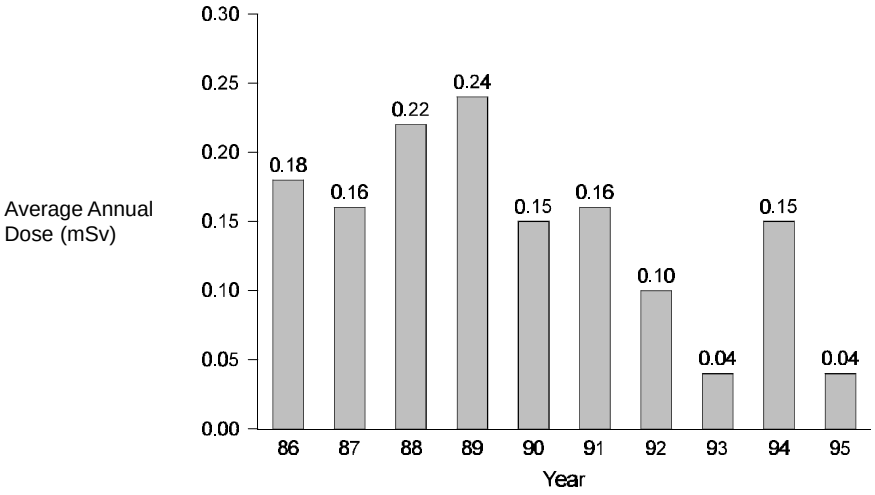


Table 4 (Cont'd)
Instrument Technician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	1316	0.00	0.00
>0 - 1	377	152.99	0.41
>1 - 2	49	67.44	1.38
>2 - 5	30	96.84	3.23
>5 - 20	22	187.95	8.54
>20 - 50	5	139.20	27.84
>50	0	0.00	0.00
Total	1799	644.42	0.36
			Five year period 1991-1995
0	1397	0.00	0.00
>0 - 5	1078	1109.60	1.03
>5 - 25	101	989.54	9.80
>25 - 100	18	668.10	37.12
>100	1	103.90	103.90
	2595	2871.14	1.11

Lognormal parameters for positive doses in 1995:

μ: -0.6473

σ^2: 1.3973

Sample Size: 483

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

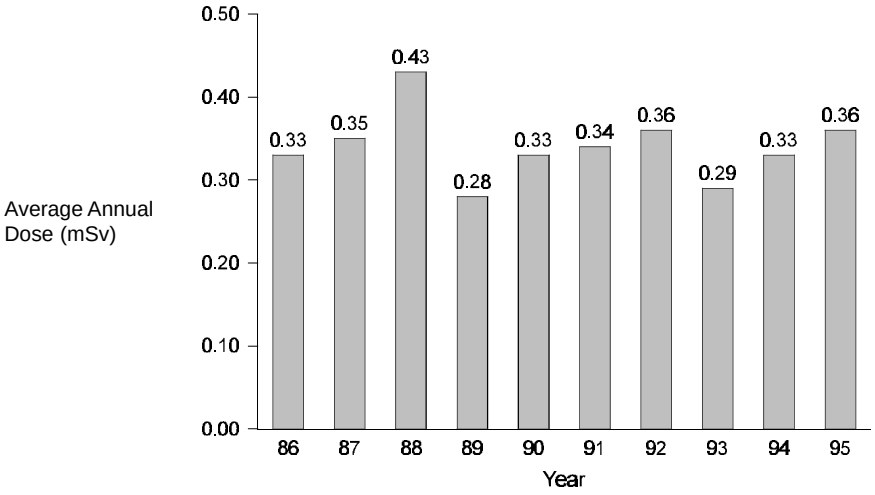


Table 4 (Cont'd)
Laboratory Technician (Industrial)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	3372	0.00	0.00
>0 - 1	640	248.09	0.39
>1 - 2	77	107.84	1.40
>2 - 5	50	157.04	3.14
>5 - 20	11	85.71	7.79
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	4150	598.68	0.14
			Five year period 1991-1995
0	5273	0.00	0.00
>0 - 5	2401	1928.16	0.80
>5 - 25	133	1388.02	10.44
>25 - 100	24	853.89	35.58
>100	1	550.00	550.00
Total	7832	4720.07	0.60

Lognormal parameters for positive doses in 1995:

μ: -0.8310

σ^2: 1.0214

Sample Size: 778

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

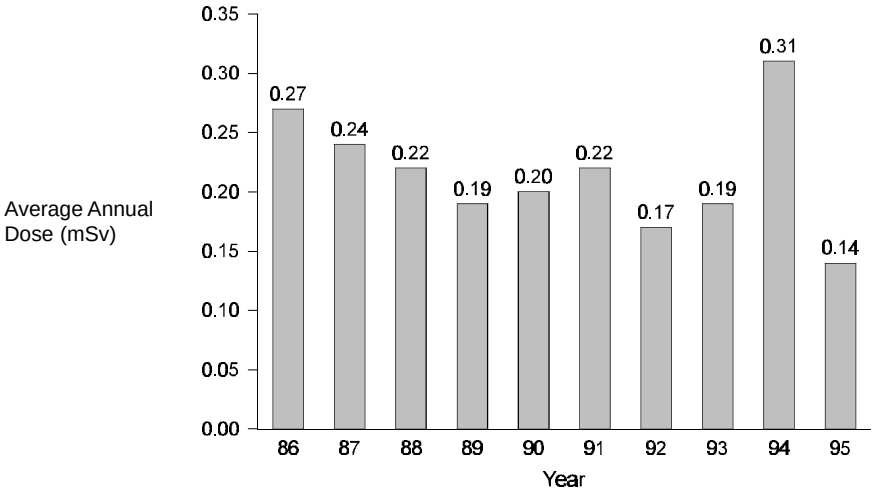


Table 4 (Cont'd)
Nuclear Fuel Processor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	37	0.00	0.00
>0 - 1	47	25.50	0.54
>1 - 2	25	37.20	1.49
>2 - 5	32	107.10	3.35
>5 - 20	40	298.10	7.45
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	181	467.90	2.59
			Five year period 1991-1995
0	33	0.00	0.00
>0 - 5	78	165.51	2.12
>5 - 25	94	1178.60	12.54
>25 - 100	14	512.40	36.60
>100	0	0.00	0.00
Total	219	1856.51	8.48

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.1423

μ: -0.8582

σ^2: 2.4214

Sample Size: 144

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

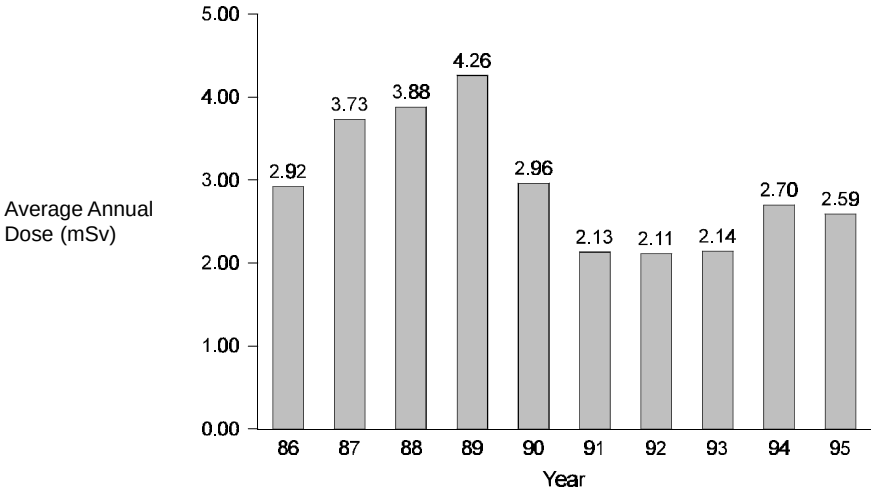


Table 4 (Cont'd)
Scientist/Engineer (Field)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	621	0.00	0.00
>0 - 1	497	224.04	0.45
>1 - 2	45	59.34	1.32
>2 - 5	31	102.67	3.31
>5 - 20	14	123.50	8.82
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
	1208	509.55	0.42
			Five year period 1991-1995
0	745	0.00	0.00
>0 - 5	1009	1343.46	1.33
>5 - 25	103	1031.98	10.02
>25 - 100	23	875.56	38.07
>100	0	0.00	0.00
Total	1880	3251.00	1.73

Lognormal parameters for positive doses in 1995:

μ: -0.7328

σ^2: 1.0302

Sample Size: 587

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

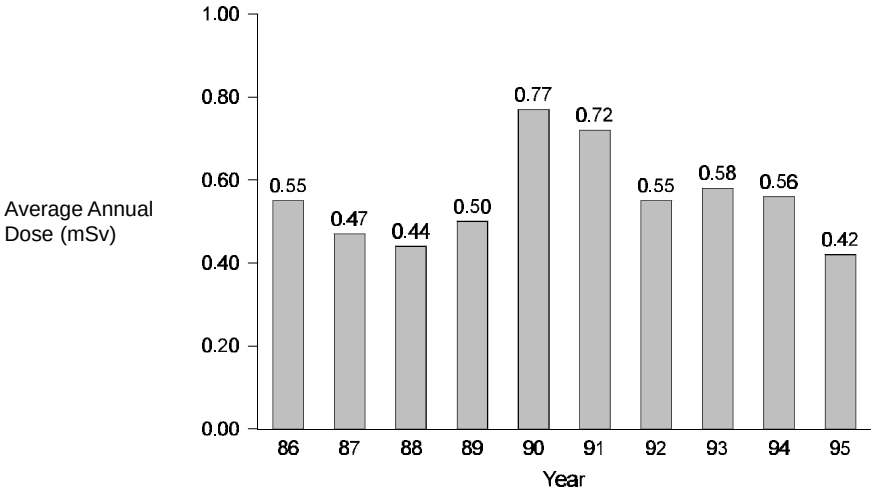


Table 4 (Cont'd)
Scientist/Engineer (Laboratory)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	4109	0.00	0.00
>0 - 1	689	248.65	0.36
>1 - 2	32	41.75	1.30
>2 - 5	13	37.30	2.87
>5 - 20	2	12.00	6.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	4845	339.70	0.07
			Five year period 1991-1995
0	5269	0.00	0.00
>0 - 5	2296	1703.52	0.74
>5 - 25	66	582.63	8.83
>25 - 100	3	97.60	32.53
>100	0	0.00	0.00
Total	7634	2383.75	0.31

Lognormal parameters for positive doses in 1995:

μ: -1.1110

σ^2: 0.6310

Sample Size: 736

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

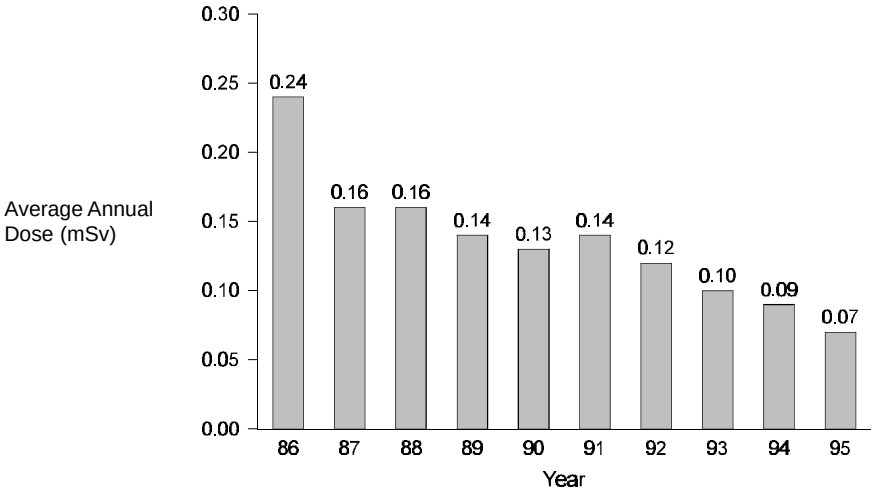


Table 4 (Cont'd)
Well Logger

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	581	0.00	0.00
>0 - 1	247	115.20	0.47
>1 - 2	55	83.60	1.52
>2 - 5	42	134.60	3.20
>5 - 20	16	107.70	6.73
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	941	441.10	0.47
			Five year period 1991-1995
0	439	0.00	0.00
>0 - 5	1020	1738.87	1.70
>5 - 25	212	1988.15	9.38
>25 - 100	8	312.40	39.05
>100	1	161.40	161.40
Total	1680	4200.82	2.50

Lognormal parameters for positive doses in 1995:

μ: -0.3505

σ^2: 1.0094

Sample Size: 360

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

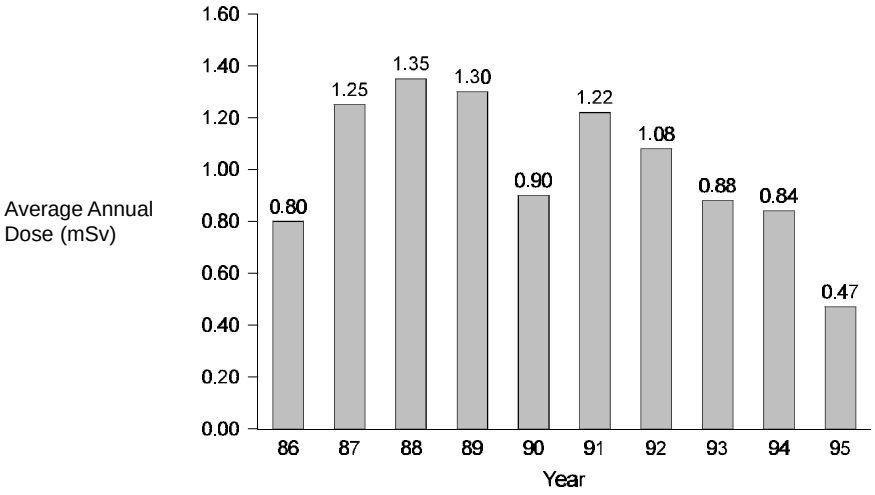


Table 4 (Cont'd)
Chiropractor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	914	0.00	0.00
>0 - 1	66	21.40	0.32
	5	6.70	1.34
>2 - 5	3	8.90	2.97
>5 - 20	1	10.20	10.20
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	989	47.20	0.05
			Five year period 1991-1995
0	994	0.00	0.00
>0 - 5	278	147.10	0.53
>5 - 25	7	57.60	8.23
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	1279	204.70	0.16

Lognormal parameters for positive doses in 1995:

μ: -1.0085

σ^2: 0.6754

Sample Size: 75

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

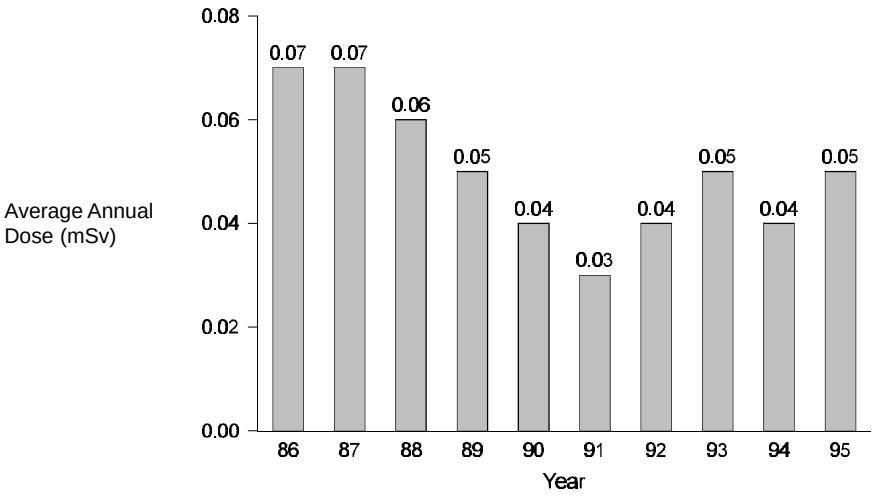


Table 4 (Cont'd)
Dental Assistant

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	6060	0.00	0.00
>0 - 1	59	18.20	0.31
>1 - 2	1	2.00	2.00
>2 - 5	2	6.20	3.10
>5 - 20	1	8.40	8.40
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	6123	34.80	0.01
			Five year period 1991-1995
0	6102	0.00	0.00
>0 - 5	155	67.40	0.43
>5 - 25	6	71.40	11.90
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	6263	138.80	0.02

Lognormal parameters for positive doses in 1995:

μ: -1.1119

σ^2: 0.5533

Sample Size: 63

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

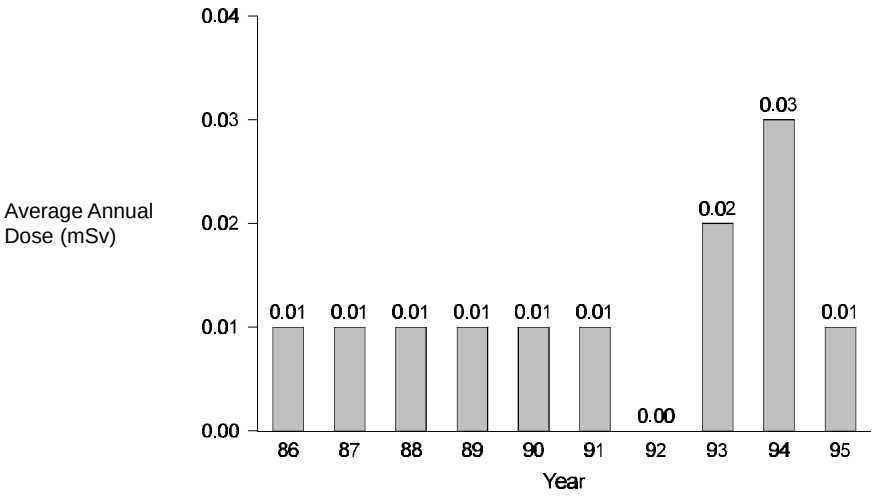


Table 4 (Cont'd)
Dental Hygienist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	6416	0.00	0.00
>0 - 1	59	21.60	0.37
>1 - 2	0	0.00	0.00
>2 - 5	2	6.00	3.00
>5 - 20	2	25.40	12.70
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	6479	53.00	0.01
			Five year period 1991-1995
0	9773	0.00	0.00
>0 - 5	360	155.90	0.43
>5 - 25	5	57.40	11.48
>25 - 100	3	0.00	0.00
>100	0	0.00	0.00
Total	10138	213.30	0.02

Lognormal parameters for positive doses in 1995:

μ: -0.9632

σ^2: 0.8001

Sample Size: 63

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

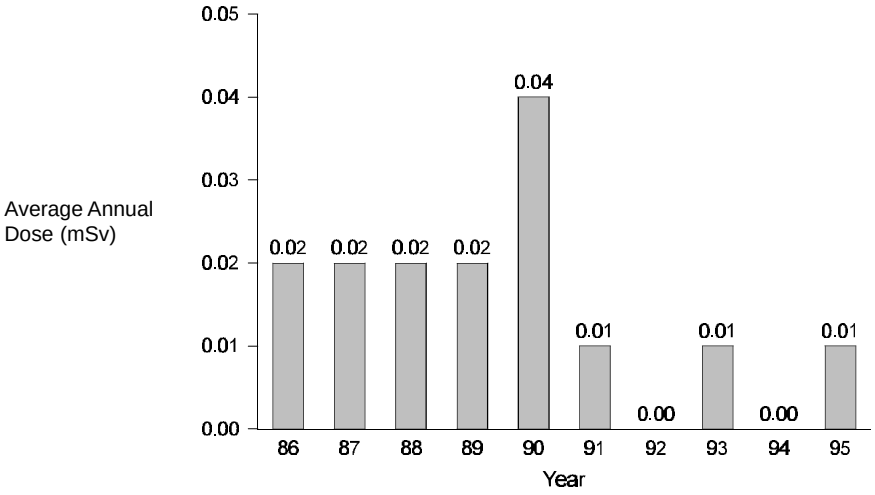


Table 4 (Cont'd)
Dental Therapist/Nurse

Dose Interval mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	20	0.00	0.00
>0 - 1	0	0.00	0.00
>1 - 2	0	0.00	0.00
>2 - 5	0	0.00	0.00
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	20	0.00	0.00
			Five year period 1991-1995
0	20	0.00	0.00
>0 - 5	0	0.00	0.00
>5 - 25	0	0.00	0.00
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	20	0.00	0.00

Lognormal or hybrid lognormal parameters for positive doses in 1995:

Not applicable

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

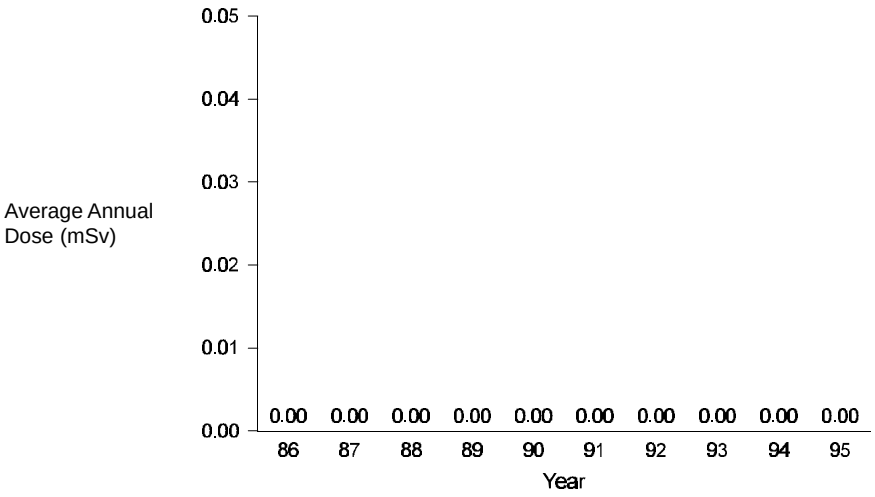


Table 4 (Cont'd)
Dentist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	6245	0.00	0.00
>0 - 1	98	27.60	0.28
>1 - 2	6	9.50	1.58
>2 - 5	3	9.20	3.07
>5 - 20	1	6.00	6.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	6353	52.30	0.01
			Five year period 1991-1995
0	7545	0.00	0.00
>0 - 5	451	204.30	0.45
>5 - 25	6	65.00	10.83
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	8002	269.30	0.03

Lognormal parameters for positive doses in 1995:

μ: -1.1444

σ^2: 0.5162

Sample Size: 108

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

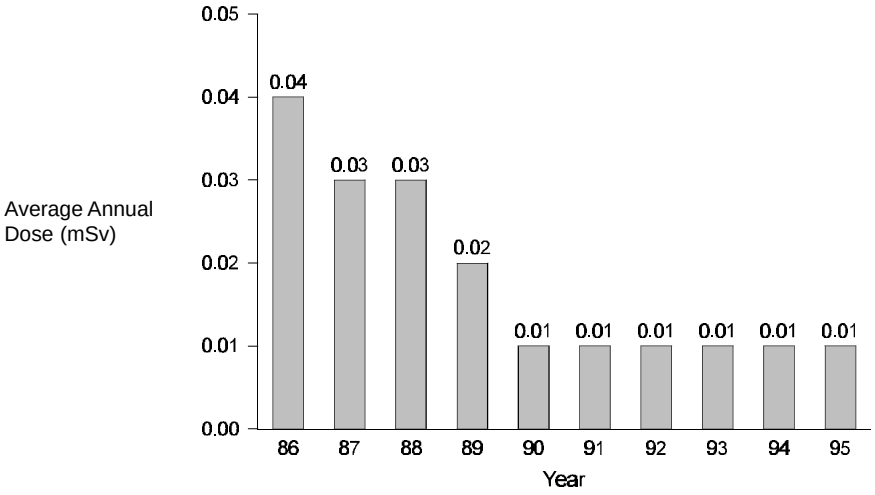


Table 4 (Cont'd)
Gynaecologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	27	0.00	0.00
>0 - 1	1	0.20	0.20
>1 - 2	0	0.00	0.00
>2 - 5	0	0.00	0.00
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	28	0.20	0.01
			Five year period 1991-1995
0	61	0.00	0.00
>0 - 5	12	6.10	0.51
>5 - 25	0	0.00	0.00
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	73	6.10	0.08

Lognormal or hybrid lognormal parameters for positive doses in 1995:

Not applicable

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

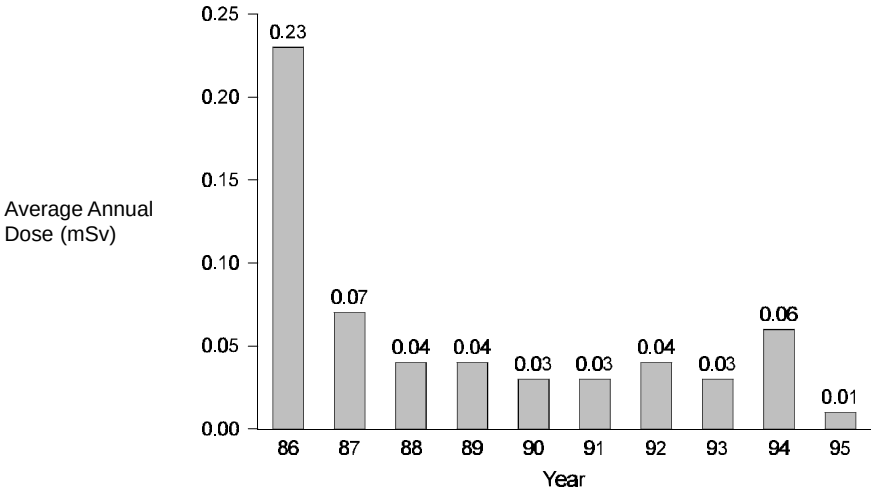


Table 4 (Cont'd)
Laboratory Technician (Medical)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	3345	0.00	0.00
>0 - 1	305	87.27	0.29
>1 - 2	9	15.20	1.69
>2 - 5	3	9.90	3.30
>5 - 20	5	37.90	7.58
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	3667	150.27	0.04
			Five year period 1991-1995
0	4726	0.00	0.00
>0 - 5	1761	929.92	0.53
>5 - 25	35	324.90	9.28
>25 - 100	3	109.10	36.37
>100	0	0.00	0.00
Total	6525	1363.92	0.21

Lognormal parameters for positive doses in 1995:

μ: -1.2341

σ^2: 0.4836

Sample Size: 322

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

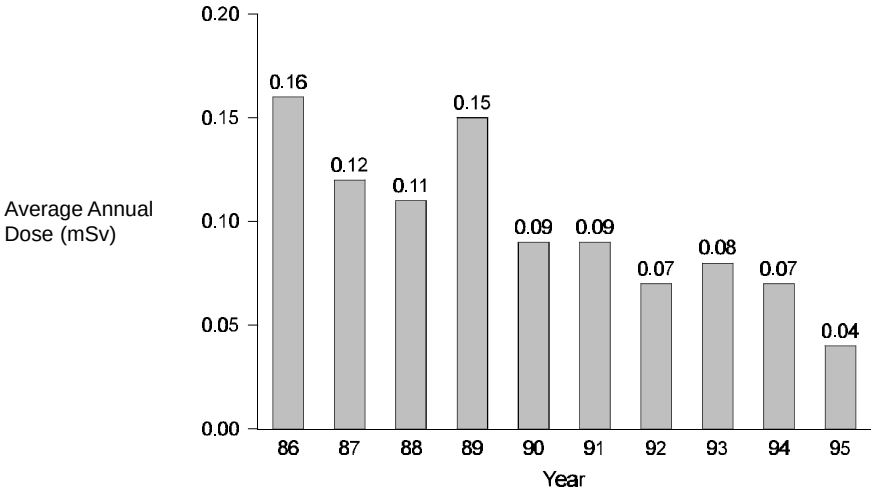


Table 4 (Cont'd)
Medical Physicist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	215	0.00	0.00
>0 - 1	25	7.70	0.31
>1 - 2	2	3.50	1.75
>2 - 5	2	5.70	2.85
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	244	16.90	0.07
			Five year period 1991-1995
0	246	0.00	0.00
>0 - 5	161	140.40	0.87
>5 - 25	2	14.60	7.30
>25 - 100	1	29.80	29.80
>100	0	0.00	0.00
Total	410	184.80	0.45

Lognormal parameters for positive doses in 1995:

μ: -1.0347

σ^2: 0.7501

Sample Size: 29

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

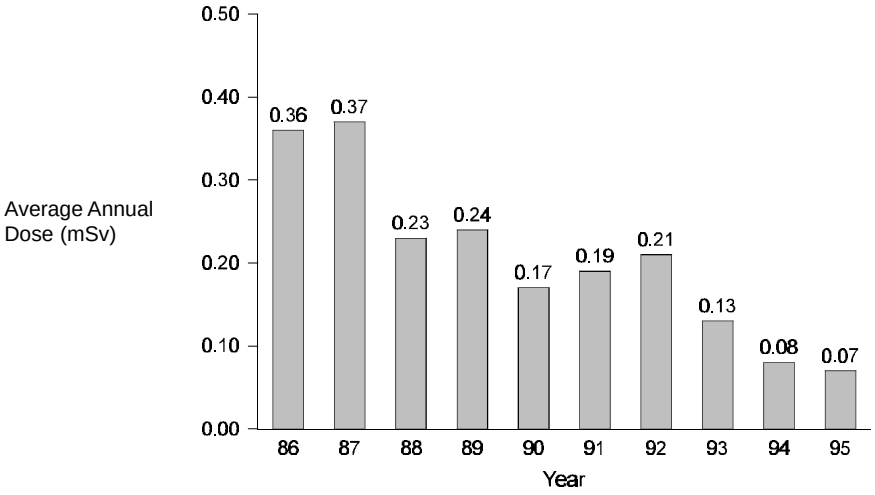


Table 4 (Cont'd)
Medical Radiation Technologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	10717	0.00	0.00
>0 - 1	1232	397.05	0.32
>1 - 2	64	95.20	1.49
>2 - 5	26	82.90	3.19
>5 - 20	2	17.60	8.80
>20 - 50	1	45.90	45.90
>50	0	0.00	0.00
Total	12042	638.65	0.05
			Five year period 1991-1995
0	8394	0.00	0.00
>0 - 5	6314	3779.55	0.60
>5 - 25	139	1187.70	8.54
>25 - 100	6	261.30	43.55
>100	0	0.00	0.00
Total	14853	5228.55	0.35

Lognormal parameters for positive doses in 1995:

μ: -1.1167

σ^2: 0.4529

Sample Size: 1325

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

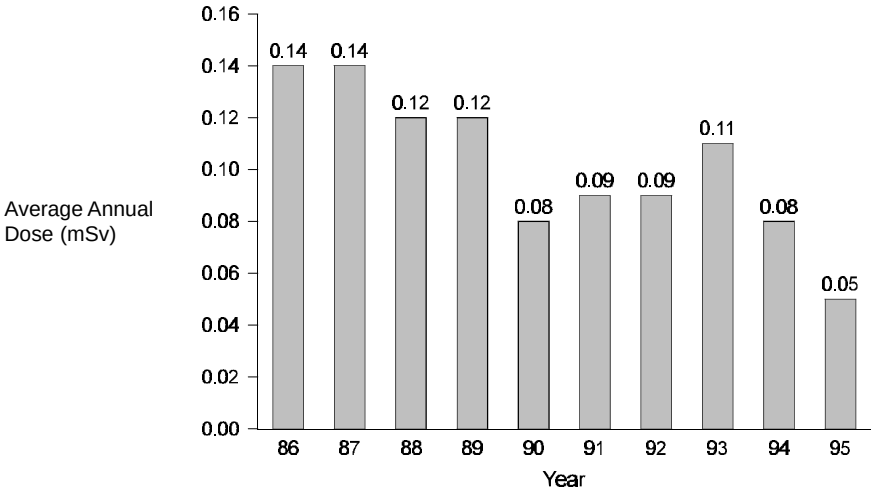


Table 4 (Cont'd)
Nuclear Medicine Technologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	526	0.00	0.00
>0 - 1	429	222.70	0.52
>1 - 2	251	383.10	1.53
>2 - 5	215	649.80	3.02
>5 - 20	19	141.20	7.43
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	1440	1396.80	0.97
			Five year period 1991-1995
0	528	0.00	0.00
>0 - 5	903	1689.64	1.87
>5 - 25	655	6994.80	10.68
>25 - 100	17	546.40	32.14
>100	0	0.00	0.00
Total	2103	9230.84	4.39

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.1039

μ: -2.0728

σ^2: 1.1146

Sample Size: 914

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

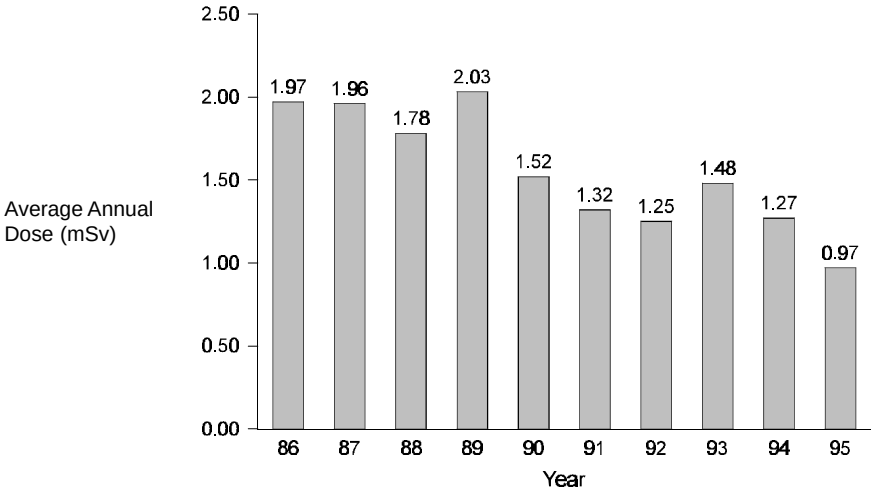


Table 4 (Cont'd)
Nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	4626	0.00	0.00
>0 - 1	495	160.74	0.32
>1 - 2	17	25.90	1.52
>2 - 5	10	32.90	3.29
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	5148	219.54	0.04
			Five year period 1991-1995
0	6003	0.00	0.00
>0 - 5	2350	1326.38	0.56
>5 - 25	22	221.20	10.05
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	8375	1547.58	0.18

Lognormal parameters for positive doses in 1995:

μ: -1.1562

σ^2: 0.4054

Sample Size: 522

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

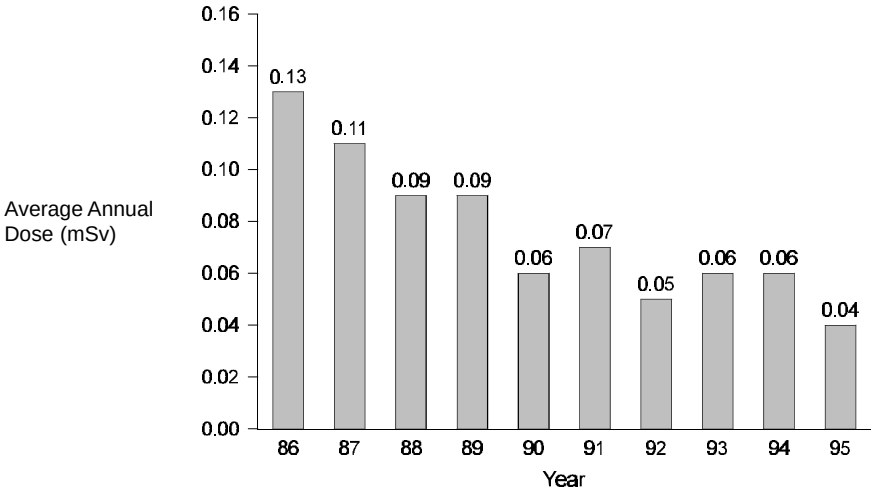


Table 4 (Cont'd)
Physician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	1815	0.00	0.00
>0 - 1	265	92.10	0.35
>1 - 2	26	38.70	1.49
>2 - 5	15	50.20	3.35
>5 - 20	4	34.70	8.68
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	2125	215.70	0.10
			Five year period 1991-1995
0	1862	0.00	0.00
>0 - 5	1272	987.60	0.78
>5 - 25	58	525.20	9.06
>25 - 100	8	297.90	37.24
>100	0	0.00	0.00
Total	3200	1810.70	0.57

Lognormal parameters for positive doses in 1995:

μ: -0.9040

σ^2: 0.7477

Sample Size: 310

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

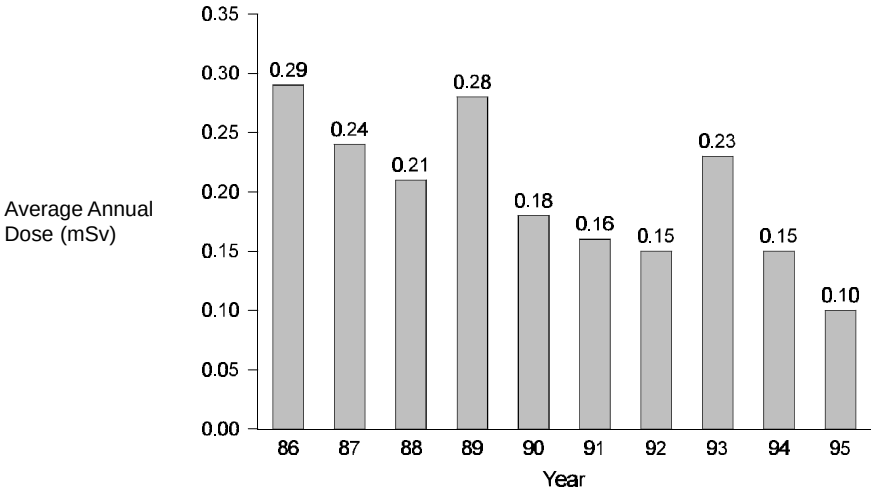


Table 4 (Cont'd)
Radiation Therapist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	725	0.00	0.00
>0 - 1	203	68.00	0.33
>1 - 2	19	29.00	1.53
>2 - 5	9	28.10	3.12
>5 - 20	3	23.40	7.80
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	959	148.50	0.15
			Five year period 1991-1995
0	440	0.00	0.00
>0 - 5	847	975.30	1.15
>5 - 25	65	593.45	9.13
>25 - 100	4	145.30	36.33
>100	0	0.00	0.00
Total	1356	1714.05	1.26

Lognormal parameters for positive doses in 1995:

μ: -0.9541

σ^2: 0.6807

Sample Size: 234

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

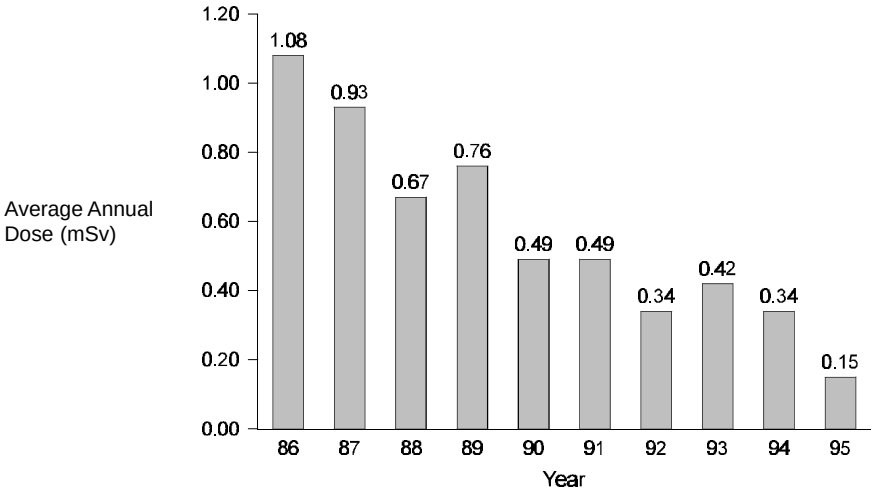


Table 4 (Cont'd)
Radiologist (Diagnostic)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	1557	0.00	0.00
>0 - 1	227	79.80	0.35
>1 - 2	10	15.30	1.53
>2 - 5	6	19.20	3.20
>5 - 20	5	32.80	6.56
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	1805	147.10	0.08
			Five year period 1991-1995
0	1277	0.00	0.00
>0 - 5	1107	851.40	0.77
>5 - 25	46	431.30	9.38
>25 - 100	1	60.70	60.70
>100	0	0.00	0.00
Total	2431	1343.40	0.55

Lognormal parameters for positive doses in 1995:

μ: -0.9931

σ^2: 0.5963

Sample Size: 248

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

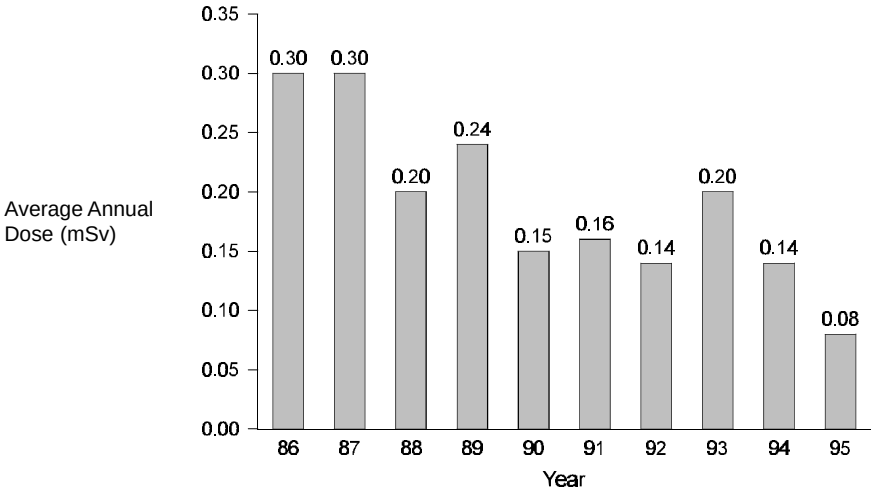


Table 4 (Cont'd)
Radiologist (Therapeutic)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	145	0.00	0.00
>0 - 1	16	5.50	0.34
>1 - 2	1	1.70	1.70
>2 - 5	1	2.10	2.10
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	163	9.30	0.06
			Five year period 1991-1995
0	128	0.00	0.00
>0 - 5	123	110.80	0.90
>5 - 25	6	51.60	8.60
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	257	162.40	0.63

Lognormal parameters for positive doses in 1995:

μ: -0.9653

σ^2: 0.4838

Sample Size: 18

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

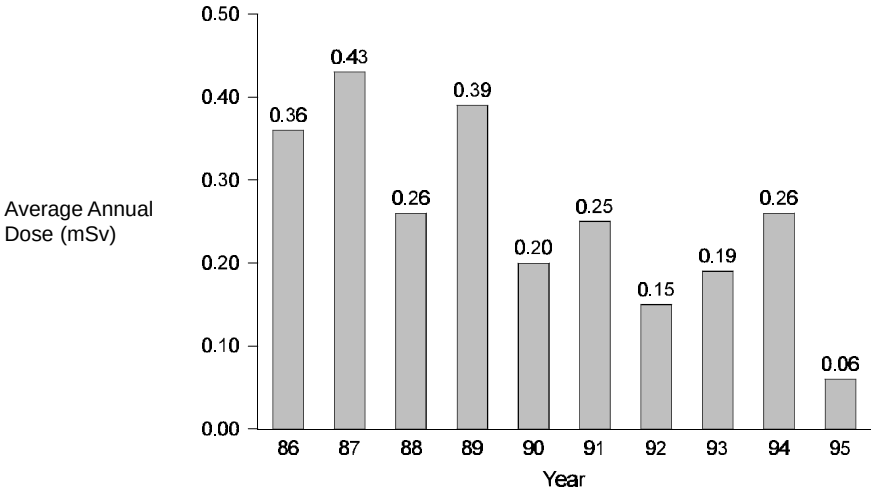


Table 4 (Cont'd)
Veterinarian

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	3142	0.00	0.00
>0 - 1	369	114.30	0.31
>1 - 2	13	18.10	1.39
>2 - 5	5	13.80	2.76
>5 - 20	1	7.40	7.40
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	3530	153.60	0.04
			Five year period 1991-1995
0	3142	0.00	0.00
>0 - 5	1282	743.29	0.58
>5 - 25	19	148.00	7.79
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	4443	891.29	0.20

Lognormal parameters for positive doses in 1995:

μ: -1.1949

σ^2: 0.3617

Sample Size: 388

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

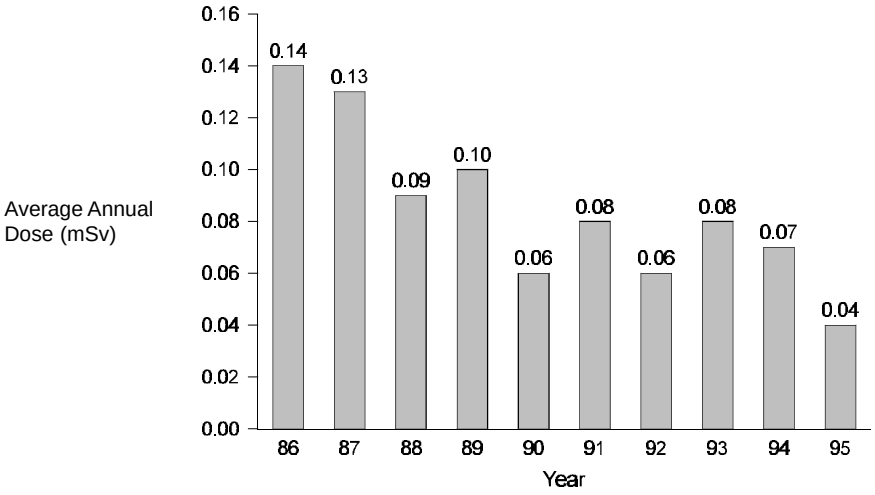


Table 4 (Cont'd)
Veterinary Technician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	13	0.00	0.00
>0 - 1	1	0.20	0.20
>1 - 2	0	0.00	0.00
>2 - 5	0	0.00	0.00
>5 - 20	0	0.00	0.00
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	14	0.20	0.01
			Five year period 1991-1995
0	17	0.00	0.00
>0 - 5	4	2.10	0.53
>5 - 25	0	0.00	0.00
>25 - 100	0	0.00	0.00
>100	0	0.00	0.00
Total	21	2.10	0.10

Lognormal or hybrid lognormal parameters for positive doses in 1995:

Not applicable

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

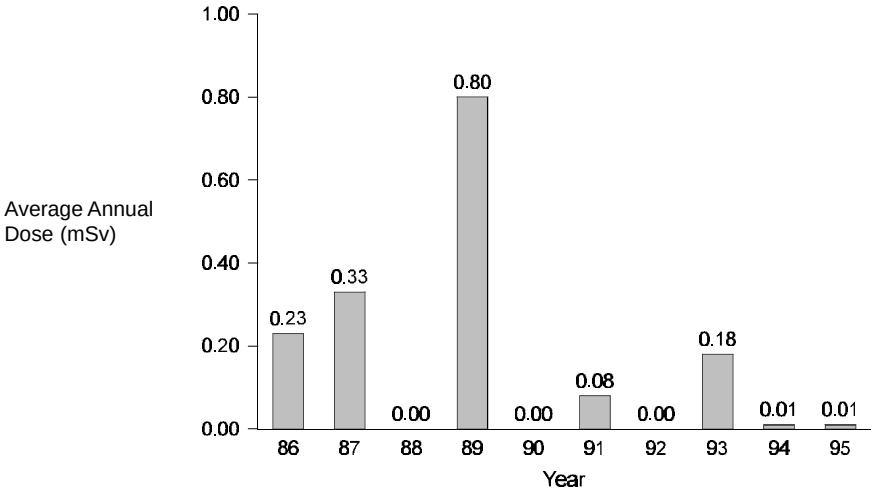


Table 4 (Cont'd)
Ward Aide/Orderly

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1995
0	1705	0.00	0.00
>0 - 1	150	47.90	0.32
>1 - 2	12	17.00	1.42
>2 - 5	8	22.70	2.84
>5 - 20	1	7.70	7.70
>20 - 50	0	0.00	0.00
>50	0	0.00	0.00
Total	1876	95.30	0.05
			Five year period 1991-1995
0	2531	0.00	0.00
>0 - 5	712	422.90	0.59
>5 - 25	24	228.20	9.51
>25 - 100	1	40.00	40.00
>100	0	0.00	0.00
Total	3268	691.10	0.21

Lognormal parameters for positive doses in 1995:

μ: -1.0286

σ^2: 0.6240

Sample Size: 171

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

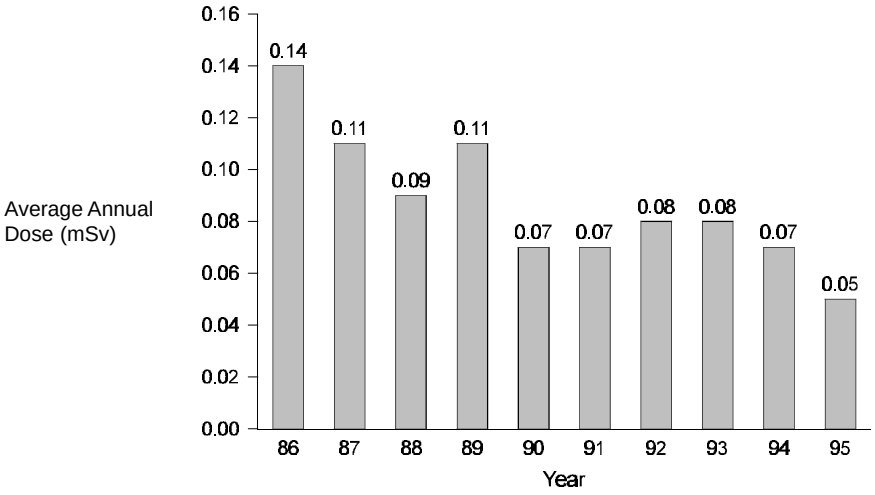


Table 4 (Cont'd)
Reactor – Administration

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	3194	0.00	0.00	0
>0 - 1	482	137.79	0.29	36
>1 - 2	72	102.60	1.43	31
>2 - 5	90	285.01	3.17	30
>5 - 20	63	480.41	7.63	25
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	3901	1005.81	0.26	29
				Five year period 1991-1995
0	4205	0.00	0.00	0
>0 - 5	1700	1273.83	0.75	30
>5 - 25	168	1561.34	9.29	25
>25 - 100	4	121.87	30.47	14
>100	0	0.00	0.00	0
Total	6077	2957.04	0.49	27

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.0887

μ: -3.1323

σ^2: 3.3260

Sample Size: 707

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

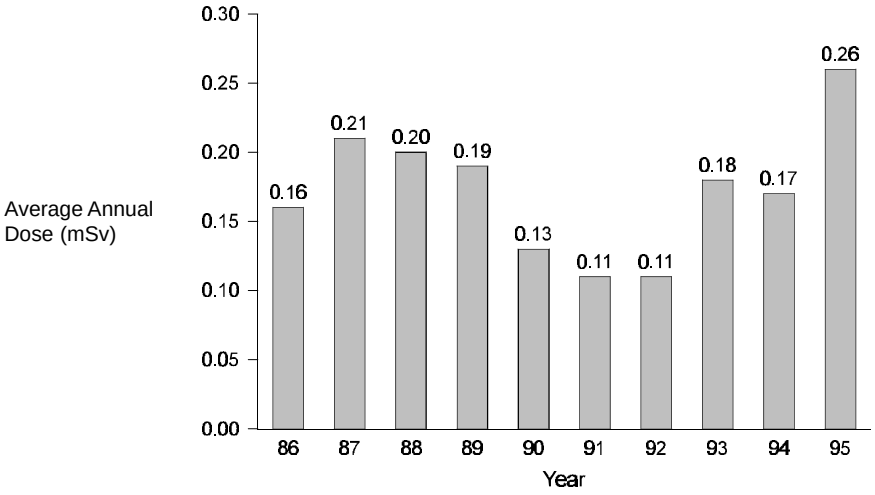


Table 4 (Cont'd)
Reactor – Chemical and Radiation Control

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	114	0.00	0.00	0
>0 - 1	120	45.69	0.38	48
>1 - 2	59	85.49	1.45	40
>2 - 5	39	124.03	3.18	33
>5 - 20	58	597.93	10.31	10
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	390	853.14	2.19	18
				Five year period 1991-1995
0	164	0.00	0.00	0
>0 - 5	285	382.27	1.34	46
>5 - 25	121	1381.45	11.42	35
>25 - 100	61	2922.97	47.92	7
>100	0	0.00	0.00	0
Total	631	4686.69	7.43	18

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.1079

μ: -1.8054

σ^2: 4.1755

Sample Size: 276

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

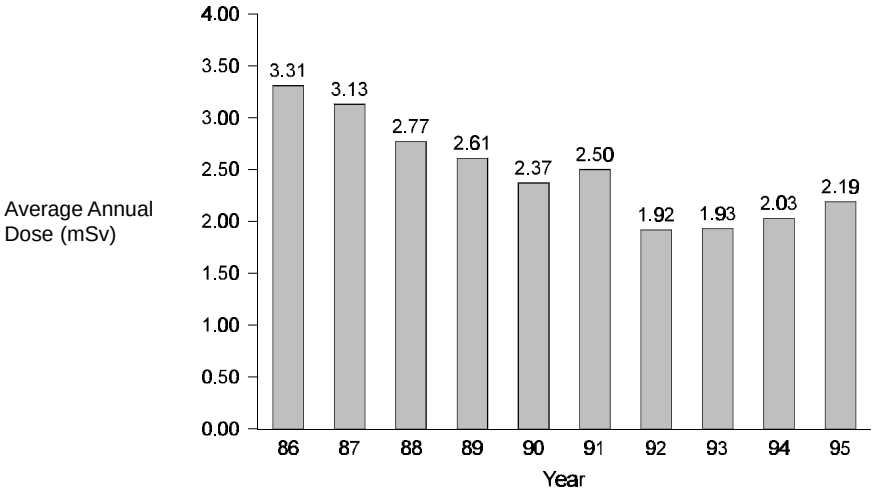


Table 4 (Cont'd)
Reactor – Construction

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	512	0.00	0.00	0
>0 - 1	232	86.64	0.37	27
>1 - 2	94	137.93	1.47	20
>2 - 5	158	533.08	3.37	17
>5 - 20	355	4121.54	11.61	8
>20 - 50	17	407.02	23.94	5
>50	0	0.00	0.00	0
Total	1368	5286.21	3.86	10
				Five year period 1991-1995
0	2905	0.00	0.00	0
>0 - 5	1614	1842.21	1.14	12
>5 - 25	741	9328.10	12.59	7
>25 - 100	233	9347.63	40.12	9
>100	0	0.00	0.00	0
Total	5493	20517.94	3.74	8

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.2087

μ: +0.6226

σ^2: 8.5326

Sample Size: 856

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

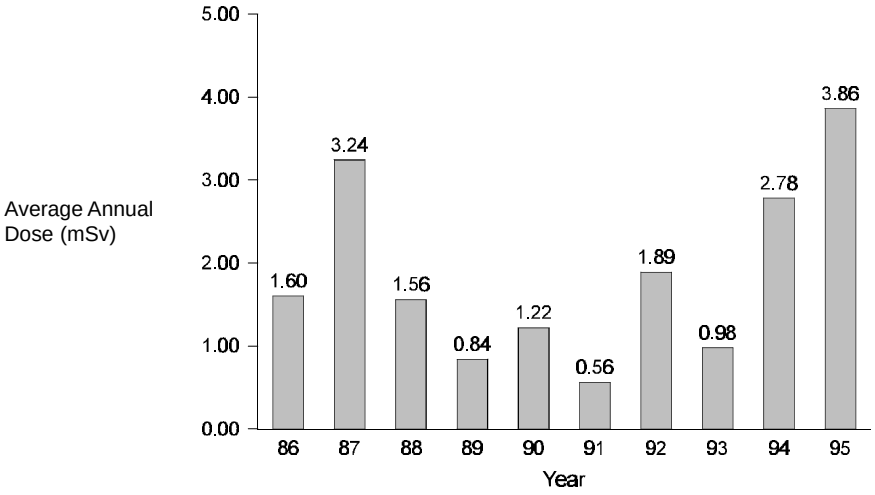


Table 4 (Cont'd)
Reactor – Control Technician

Dose Interval (mSv)	Numer of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	42	0.00	0.00	0
>0 - 1	15	5.59	0.37	30
>1 - 2	12	17.06	1.42	45
>2 - 5	23	81.83	3.56	39
>5 - 20	11	100.09	9.10	23
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	103	204.57	1.99	31
				Five year period 1991-1995
0	88	0.00	0.00	0
>0 - 5	88	116.12	1.32	30
>5 - 25	33	374.40	11.35	32
>25 - 100	2	53.76	26.88	16
>100	0	0.00	0.00	0
Total	211	544.28	2.58	30

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.2151

μ: -0.1914

σ^2: 3.5233

Sample Size: 61

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

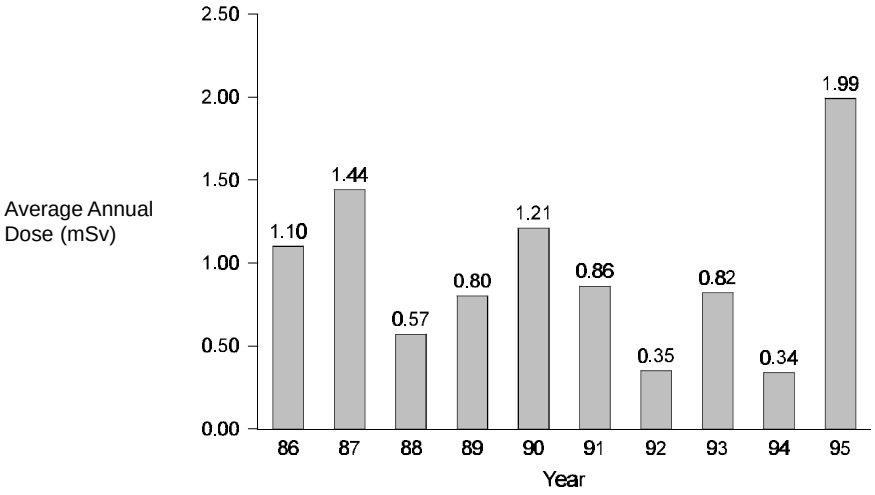


Table 4 (Cont'd)
Reactor – Electrical Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	280	0.00	0.00	0
>0 - 1	261	106.97	0.41	31
>1 - 2	146	216.51	1.48	29
>2 - 5	192	636.25	3.31	27
>5 - 20	149	995.49	6.68	23
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1028	1955.22	1.90	26
				Five year period 1991-1995
0	255	0.00	0.00	0
>0 - 5	649	1038.74	1.60	25
>5 - 25	455	5341.07	11.74	29
>25 - 100	42	1292.42	30.77	30
>100	0	0.00	0.00	0
Total	1401	7672.23	5.48	29

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.5209

μ: +0.9664

σ^2: 6.9799

Sample Size: 748

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

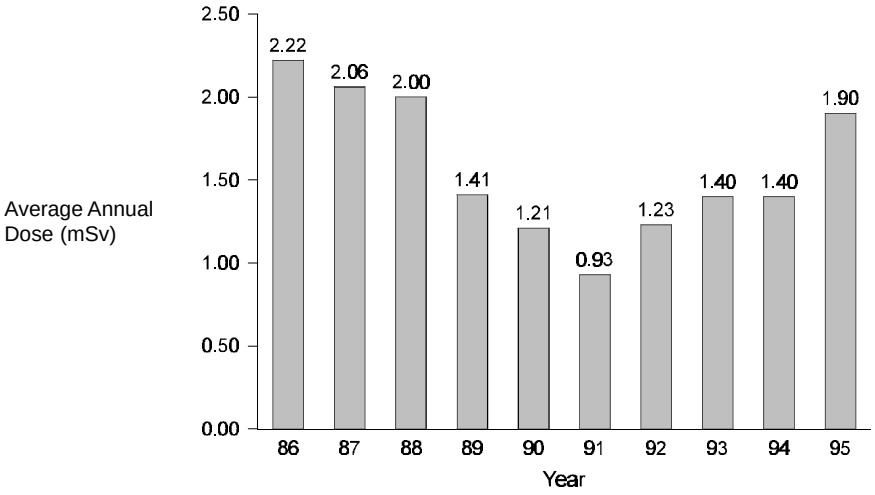


Table 4 (Cont'd)
Reactor – Fuel Handling

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	11	0.00	0.00	0
>0 - 1	23	14.60	0.63	11
>1 - 2	12	15.05	1.25	23
>2 - 5	18	58.45	3.25	34
>5 - 20	96	1020.32	10.63	18
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	160	1108.42	6.93	19
				Five year period 1991-1995
0	21	0.00	0.00	0
>0 - 5	51	96.44	1.89	22
>5 - 25	93	1423.65	15.31	16
>25 - 100	37	1249.92	33.78	24
>100	0	0.00	0.00	0
Total	202	2770.01	13.71	19

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.3980

μ: +3.5732

σ^2: 10.3233

Sample Size: 149

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

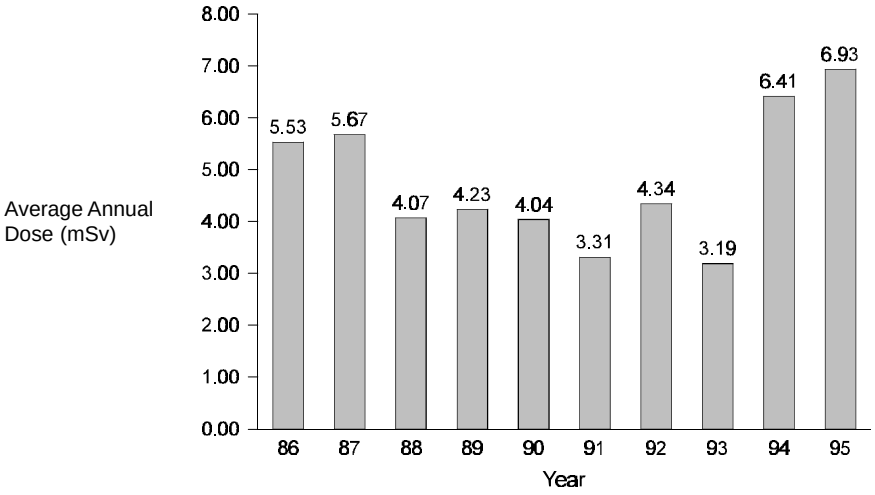


Table 4 (Cont'd)
Reactor – General Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	521	0.00	0.00	0
>0 - 1	303	100.03	0.33	40
>1 - 2	80	118.60	1.48	33
>2 - 5	160	558.84	3.49	32
>5 - 20	119	928.84	7.81	25
>20 - 50	4	87.77	21.94	14
>50	0	0.00	0.00	0
Total	1187	1794.08	1.51	28
				Five year period 1991-1995
0	853	0.00	0.00	0
>0 - 5	826	998.56	1.21	34
>5 - 25	331	3834.01	11.58	29
>25 - 100	33	969.34	29.37	36
>100	0	0.00	0.00	0
Total	2043	5801.91	2.84	31

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.2188

μ: -0.9548

σ^2: 5.5032

Sample Size: 666

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

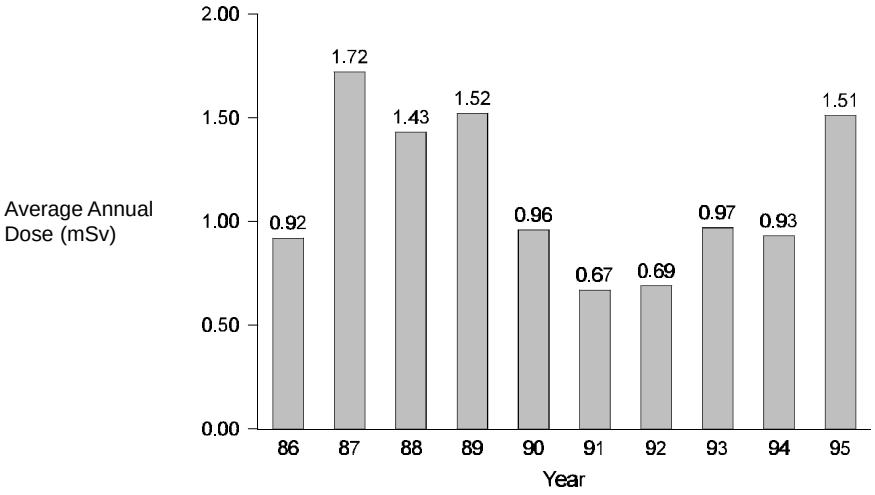


Table 4 (Cont'd)
Reactor – Health Physics

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	58	0.00	0.00	0
>0 - 1	17	6.15	0.36	26
>1 - 2	5	6.98	1.40	32
>2 - 5	7	26.49	3.78	33
>5 - 20	9	82.80	9.20	29
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	96	122.42	1.28	30
				Five year period 1991-1995
0	84	0.00	0.00	0
>0 - 5	84	66.66	0.79	21
>5 - 25	13	150.89	11.61	27
>25 - 100	3	90.73	30.24	26
>100	0	0.00	0.00	0
Total	184	308.28	1.68	26

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.2347

μ: -0.6084

σ^2: 6.8096

Sample Size: 38

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

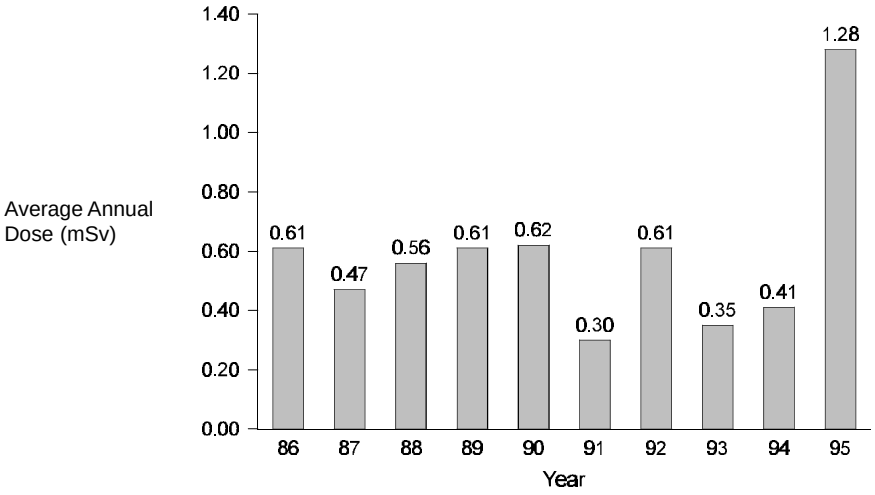


Table 4 (Cont'd)
Reactor – Industrial Radiographer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	9	0.00	0.00	0
>0 - 1	2	1.13	0.57	2
>1 - 2	3	5.18	1.73	0
>2 - 5	1	2.32	2.32	7
>5 - 20	9	80.40	8.93	5
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	24	89.03	3.71	5
				Five year period 1991-1995
0	32	0.00	0.00	0
>0 - 5	26	36.04	1.39	6
>5 - 25	19	229.84	12.10	5
>25 - 100	1	27.93	27.93	5
>100	0	0.00	0.00	0
Total	78	293.81	3.77	5

Lognormal parameters for positive doses in 1995:

μ: +1.3731

σ^2: 1.0855

Sample Size: 15

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

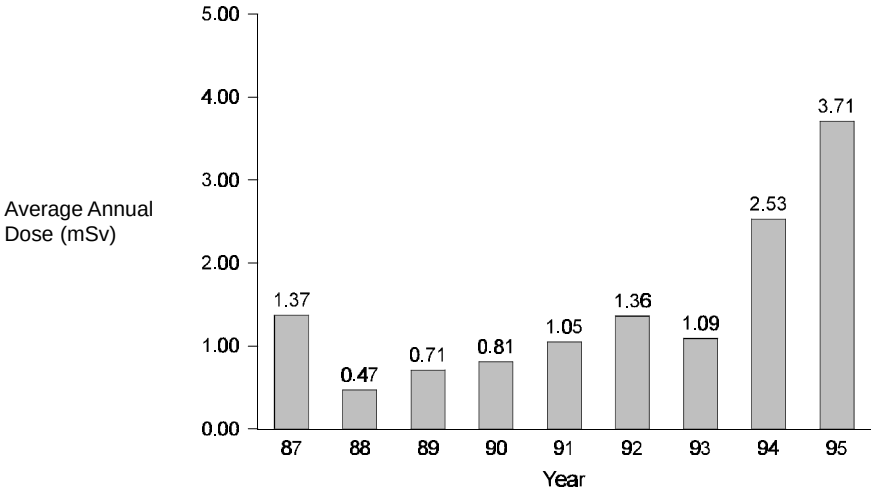


Table 4 (Cont'd)
Reactor – Mechanical Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	277	0.00	0.00	0
>0 - 1	232	90.89	0.39	32
>1 - 2	110	167.92	1.53	28
>2 - 5	299	997.79	3.34	23
>5 - 20	543	4478.99	8.25	20
>20 - 50	3	63.30	21.10	15
>50	0	0.00	0.00	0
Total	1464	5798.89	3.96	21
				Five year period 1991-1995
0	399	0.00	0.00	0
>0 - 5	628	1109.46	1.77	23
>5 - 25	786	10320.22	13.13	22
>25 - 100	327	10701.56	32.73	26
>100	0	0.00	0.00	0
Total	2140	22131.24	10.34	24

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.5577

μ: +3.1547

σ^2: 11.4040

Sample Size: 1187

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

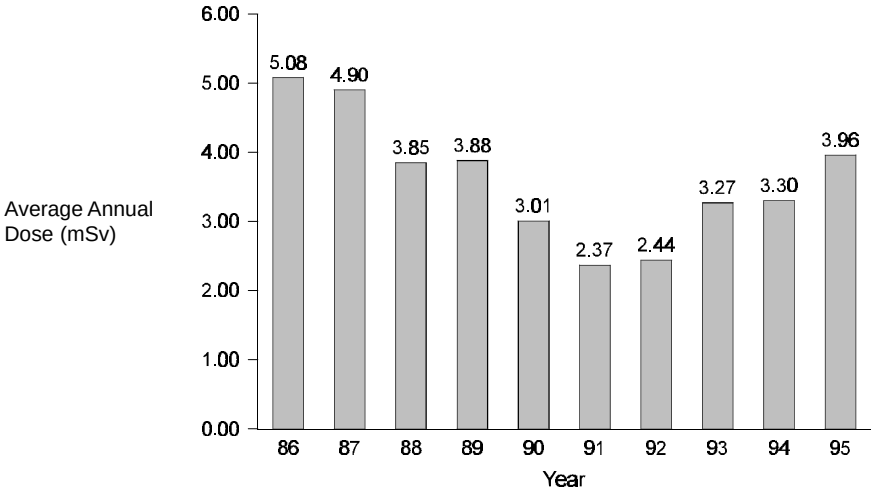


Table 4 (Cont'd)
Reactor – Operations

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	446	0.00	0.00	0
>0 - 1	485	177.32	0.37	46
>1 - 2	212	307.68	1.45	42
>2 - 5	378	1227.65	3.25	41
>5 - 20	173	1180.34	6.82	35
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1694	2892.99	1.71	39
				Five year period 1991-1995
0	237	0.00	0.00	0
>0 - 5	1001	1554.14	1.55	42
>5 - 25	734	9182.10	12.51	42
>25 - 100	105	3407.24	32.45	39
>100	0	0.00	0.00	0
Total	2077	14143.48	6.81	42

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.4958

μ: +0.5224

σ^2: 6.5535

Sample Size: 1248

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

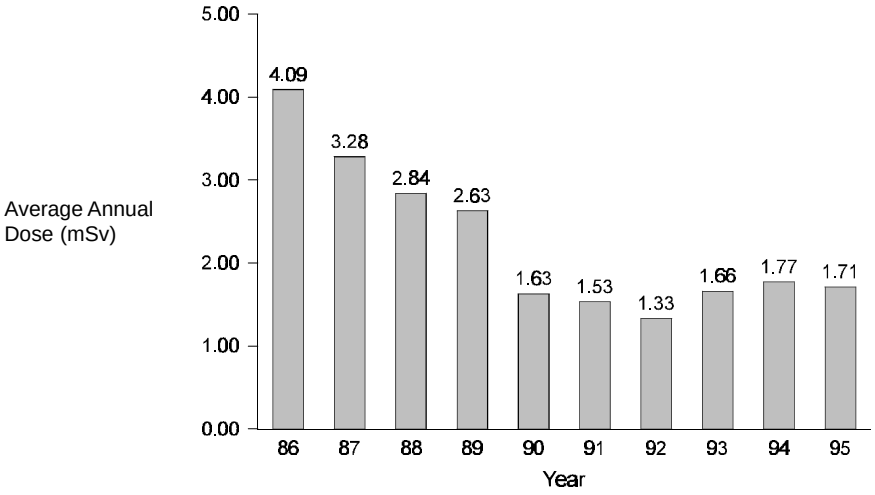


Table 4 (Cont'd)
Reactor – Scientific/Professional

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	955	0.00	0.00	0
>0 - 1	223	71.91	0.32	25
>1 - 2	60	89.31	1.49	25
>2 - 5	97	337.06	3.47	19
>5 - 20	166	1544.09	9.30	13
>20 - 50	1	26.24	26.24	10
>50	0	0.00	0.00	0
Total	1502	2068.61	1.38	15
				Five year period 1991-1995
0	1875	0.00	0.00	0
>0 - 5	775	800.12	1.03	20
>5 - 25	244	2716.90	11.13	14
>25 - 100	47	1645.27	35.01	13
>100	0	0.00	0.00	0
Total	2941	5162.29	1.76	14

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.2456

μ: -0.2543

σ^2: 7.9613

Sample Size: 547

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

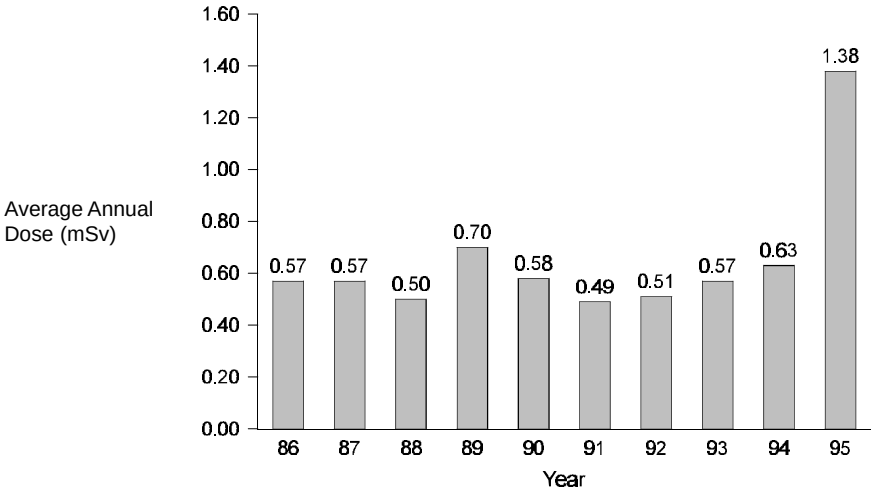


Table 4 (Cont'd)
Reactor – Training

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	40	0.00	0.00	0
>0 - 1	7	2.09	0.30	38
>1 - 2	2	3.25	1.63	18
>2 - 5	2	6.13	3.07	29
>5 - 20	2	22.93	11.47	18
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	53	34.40	0.65	21
				Five year period 1991-1995
0	105	0.00	0.00	0
>0 - 5	35	46.85	1.34	25
>5 - 25	7	77.92	11.13	23
>25 - 100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	147	124.77	0.85	23

Lognormal parameters for positive doses in 1995:

μ: -0.0706

σ^2: 2.0927

Sample Size: 13

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

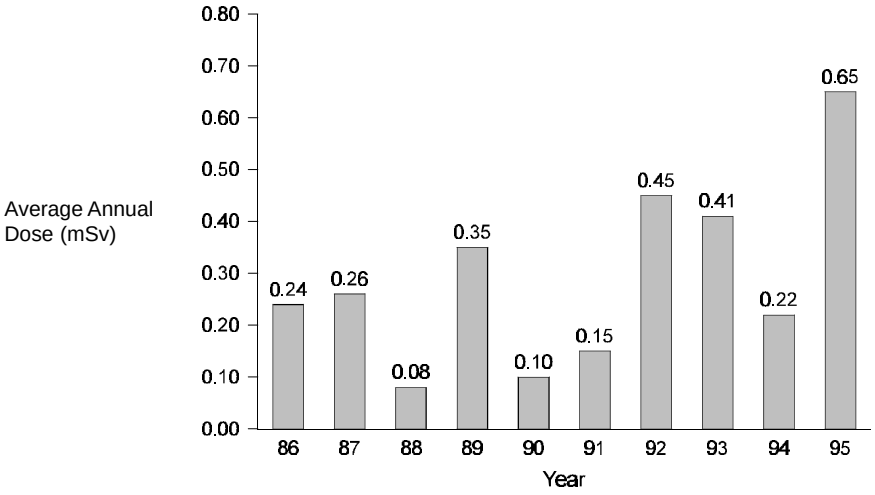


Table 4 (Cont'd)
Reactor – Visitor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1995
0	34	0.00	0.00	0
>0 - 1	1	0.14	0.14	0
>1 - 2	0	0.00	0.00	0
>2 - 5	0	0.00	0.00	0
>5 - 20	2	25.46	12.73	7
>20 - 50	2	46.01	23.01	8
>50	0	0.00	0.00	0
Total	39	71.61	1.84	7
				Five year period 1991-1995
0	89	0.00	0.00	0
>0 - 5	25	18.91	0.76	6
>5 - 25	5	66.86	13.37	6
>25 - 100	1	25.91	25.91	9
>100	0	0.00	0.00	0
Total	120	111.68	0.93	7

Lognormal parameters for positive doses in 1995:

μ: +1.8120

σ^2: 3.8237

Sample Size: 5

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

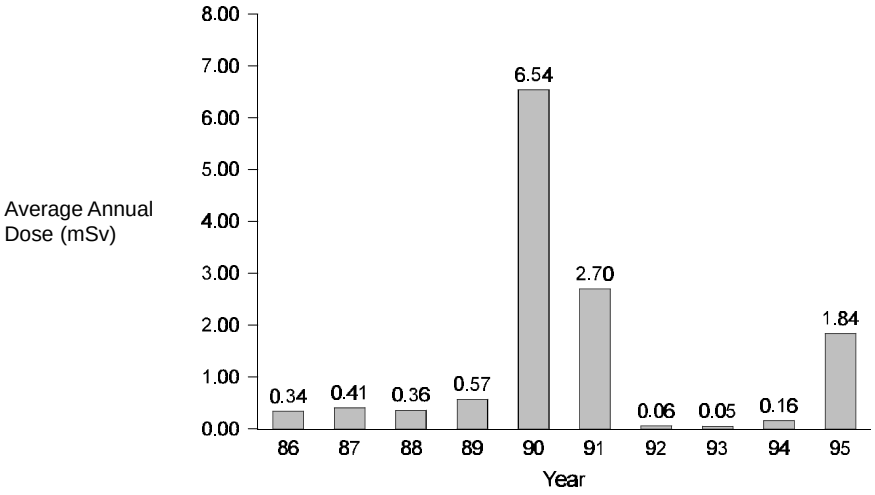


Table 4 (Cont'd)
Uranium Mine – Mill Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	24	0.00	0.00	0
>0 - 1	46	22.20	0.48	77
>1 - 2	42	65.10	1.55	82
>2 - 5	63	196.50	3.12	63
>5 - 20	9	56.60	6.29	37
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	184	340.40	1.85	63
				Five year period 1991-1995
0	25	0.00	0.00	0
>0 - 5	121	192.17	1.59	60
>5 - 25	102	1284.30	12.59	64
>25 - 100	4	110.10	27.53	38
>100	0	0.00	0.00	0
Total	252	1586.57	6.30	62

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.6306

μ: +1.2294

σ^2: 4.0879

Sample Size: 160

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

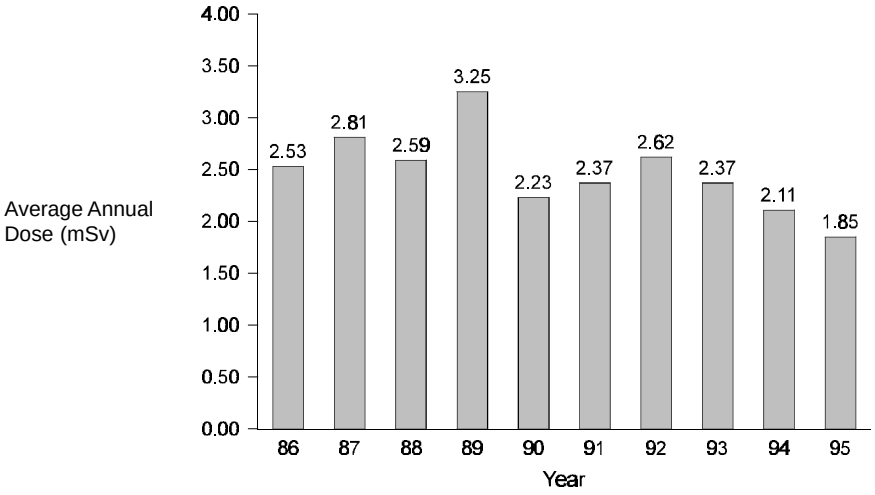


Table 4 (Cont'd)
Uranium Mine – Mill Worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	25	0.00	0.00	0
>0 - 1	39	22.10	0.57	50
>1 - 2	52	77.80	1.50	77
>2 - 5	94	300.80	3.20	63
>5 - 20	16	105.20	6.58	53
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	226	505.90	2.24	63
				Five year period 1991-1995
0	15	0.00	0.00	0
>0 - 5	204	415.20	2.04	54
>5 - 25	145	1898.80	13.10	63
>25 - 100	12	341.90	28.49	33
>100	0	0.00	0.00	0
Total	376	2655.90	7.06	58

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.3076

μ: +0.2411

σ^2: 1.7436

Sample Size: 201

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

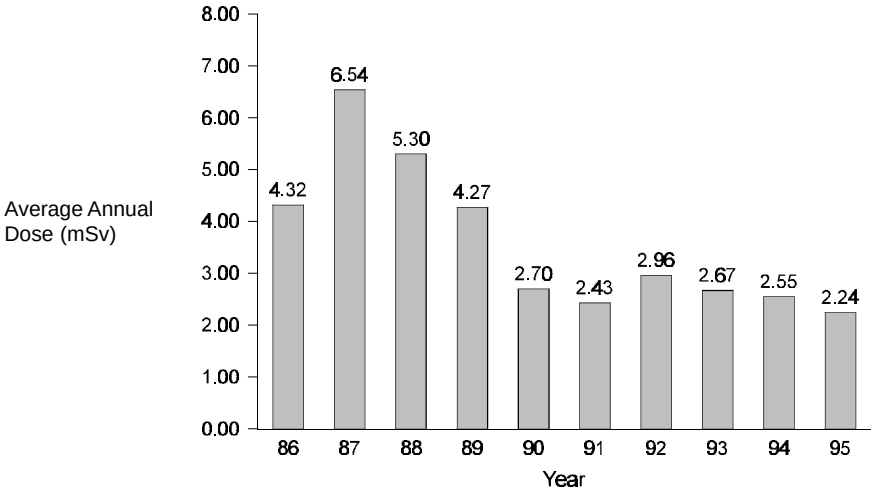


Table 4 (Cont'd)
Uranium Mine – Nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	2	0.00	0.00	0
>0 - 1	3	0.80	0.27	75
>1 - 2	0	0.00	0.00	0
>2 - 5	0	0.00	0.00	0
>5 - 20	0	0.00	0.00	0
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	5	0.80	0.16	75
				Five year period 1991-1995
0	2	0.00	0.00	0
>0 - 5	5	3.60	0.72	56
>5 - 25	0	0.00	0.00	0
>25 - 100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	7	3.60	0.51	56

Lognormal or hybrid lognormal parameters for positive doses in 1995:

Not applicable

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1987-1995

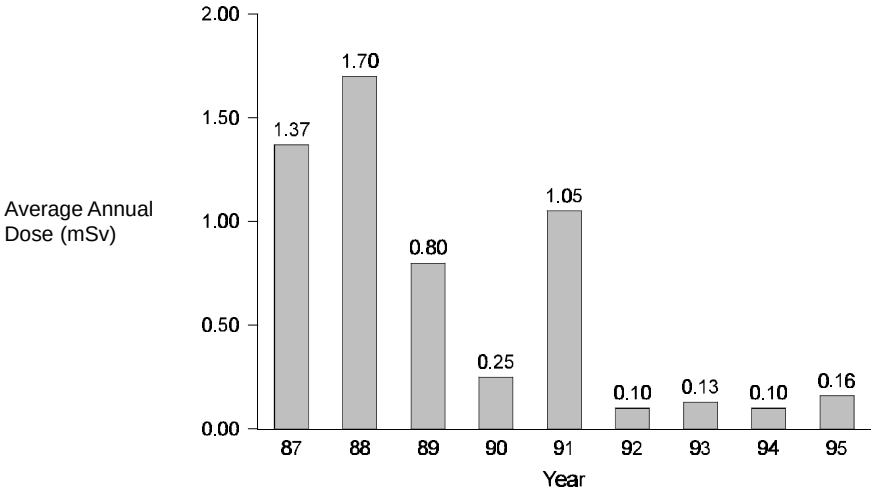


Table 4 (Cont'd)
Uranium Mine – Office Staff

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	10	0.00	0.00	0
>0 - 1	56	23.90	0.43	86
>1 - 2	29	36.60	1.26	89
>2 - 5	6	19.50	3.25	51
>5 - 20	2	22.50	11.25	75
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	103	102.50	1.00	78
				Five year period 1991-1995
0	17	0.00	0.00	0
>0 - 5	183	289.20	1.58	84
>5 - 25	41	327.10	7.98	84
>25 - 100	1	27.40	27.40	74
>100	0	0.00	0.00	0
Total	242	643.70	2.66	84

Lognormal parameters for positive doses in 1995:

μ: -0.4620

σ^2: 1.0688

Sample Size: 93

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

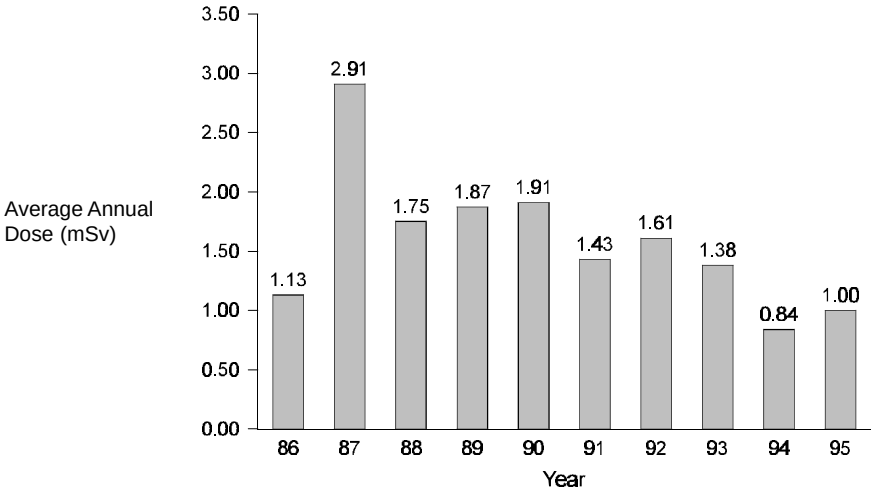


Table 4 (Cont'd)
Uranium Mine – Support Worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	6	0.00	0.00	0
>0 - 1	8	4.80	0.60	85
>1 - 2	24	36.10	1.50	75
>2 - 5	27	94.42	3.50	62
>5 - 20	67	813.50	12.14	70
>20 - 50	5	112.10	22.42	76
>50	0	0.00	0.00	0
Total	137	1060.92	7.74	70
				Five year period 1991-1995
0	16	0.00	0.00	0
>0 - 5	142	283.28	1.99	77
>5 - 25	201	2678.52	13.33	83
>25 - 100	79	4183.72	52.96	81
>100	9	1037.40	115.27	83
Total	447	8182.92	18.31	82

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.1180

μ: +0.4657

σ^2: 3.1913

Sample Size: 131

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

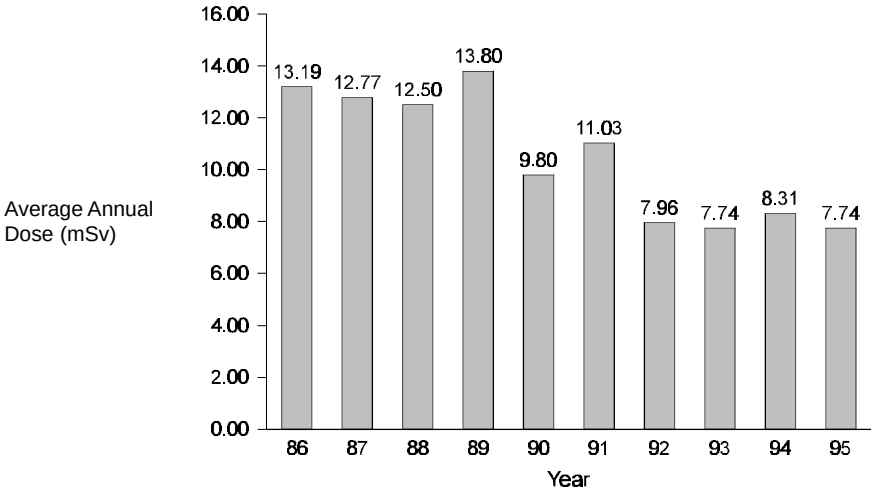


Table 4 (Cont'd)
Uranium Mine – Surface Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	47	0.00	0.00	0
>0 - 1	82	49.20	0.60	82
>1 - 2	50	67.90	1.36	86
>2 - 5	22	63.80	2.90	53
>5 - 20	10	95.90	9.59	84
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	211	276.80	1.31	77
				Five year period 1991-1995
0	52	0.00	0.00	0
>0 - 5	387	665.61	1.72	67
>5 - 25	276	3108.49	11.26	89
>25 - 100	6	219.91	36.65	89
>100	0	0.00	0.00	0
Total	721	3994.01	5.54	85

Lognormal parameters for positive doses in 1995:

μ: +0.0023

σ^2: 0.9957

Sample Size: 164

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

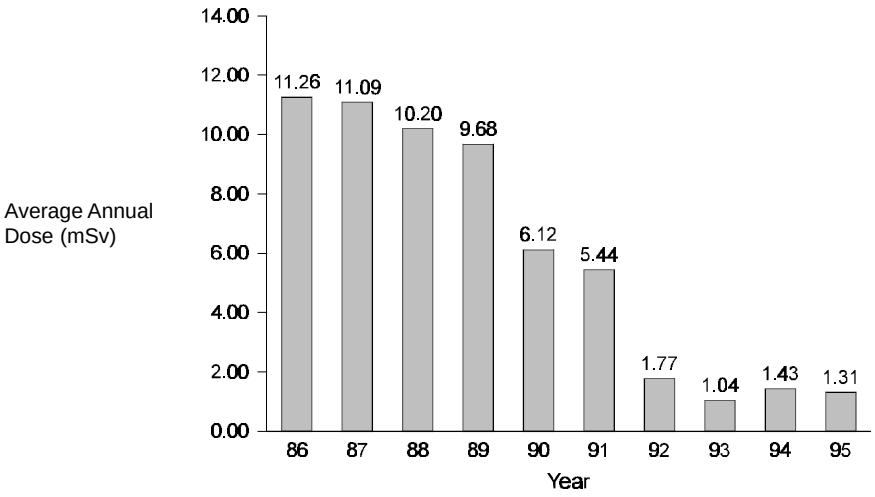


Table 4 (Cont'd)
Uranium Mine – Surface Miner

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	12	0.00	0.00	0
>0 - 1	49	21.10	0.43	68
>1 - 2	65	91.10	1.40	73
>2 - 5	27	73.60	2.73	43
>5 - 20	1	5.20	5.20	0
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	154	191.00	1.24	59
				Five year period 1991-1995
0	11	0.00	0.00	0
>0 - 5	101	138.70	1.37	57
>5 - 25	94	1326.97	14.12	77
>25 - 100	24	698.00	29.08	81
>100	0	0.00	0.00	0
Total	230	2163.67	9.41	77

Hybrid lognormal parameters for positive doses in 1995:

ρ: 1.0300

μ: +1.3772

σ^2: 3.4454

Sample Size: 142

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

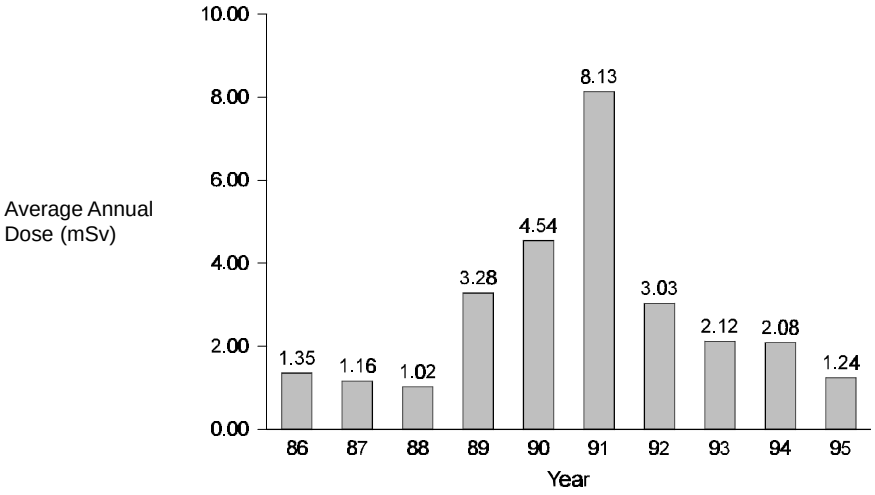


Table 4 (Cont'd)
Uranium Mine – Surface Personnel

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	10	0.00	0.00	0
>0 - 1	31	13.30	0.43	86
>1 - 2	7	10.50	1.50	76
>2 - 5	2	5.50	2.75	69
>5 - 20	0	0.00	0.00	0
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	50	29.30	0.59	80
				Five year period 1991-1995
0	22	0.00	0.00	0
>0 - 5	102	161.39	1.58	61
>5 - 25	15	126.70	8.45	74
>25 - 100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	139	288.09	2.07	67

Lognormal parameters for positive doses in 1995:

μ: -0.6601

σ^2: 0.7103

Sample Size: 40

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

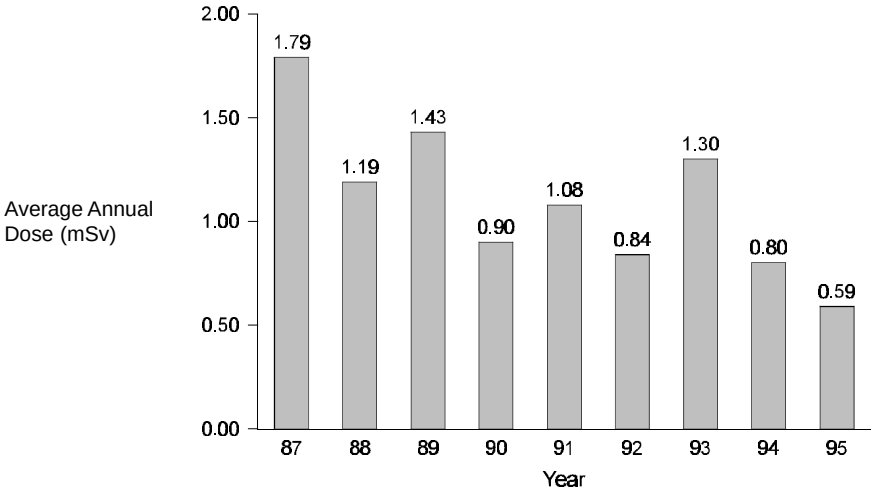


Table 4 (Cont'd)
Uranium Mine – Surface Support Worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	89	0.00	0.00	0
>0 - 1	88	46.30	0.53	67
>1 - 2	54	73.50	1.36	73
>2 - 5	22	61.80	2.81	59
>5 - 20	2	15.20	7.60	74
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	255	196.80	0.77	67
				Five year period 1991-1995
0	124	0.00	0.00	0
>0 - 5	459	807.66	1.76	70
>5 - 25	124	1225.30	9.88	61
>25 - 100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	707	2032.96	2.88	64

Lognormal parameters for positive doses in 1995:

μ: -0.1540

σ^2: 0.6664

Sample Size: 166

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

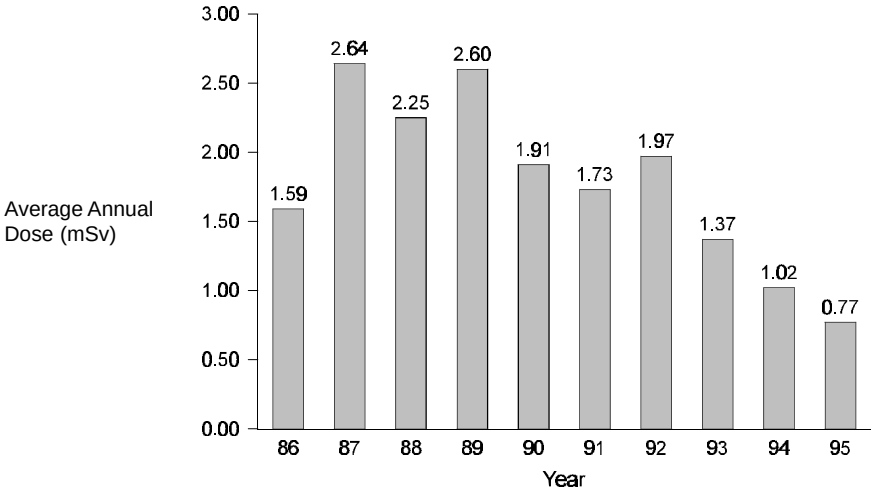


Table 4 (Cont'd)
Uranium Mine – Underground Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	3	0.00	0.00	0
>0 - 1	19	10.20	0.54	80
>1 - 2	11	19.60	1.78	61
>2 - 5	30	110.50	3.68	59
>5 - 20	46	444.90	9.67	68
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	109	585.20	5.37	66
				Five year period 1991-1995
0	4	0.00	0.00	0
>0 - 5	62	120.00	1.94	68
>5 - 25	76	1058.20	13.92	68
>25 - 100	33	1482.30	44.92	72
>100	0	0.00	0.00	0
Total	175	2660.50	15.20	71

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.2314

μ: +1.0349

σ: 4.6402

Sample Size: 106

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

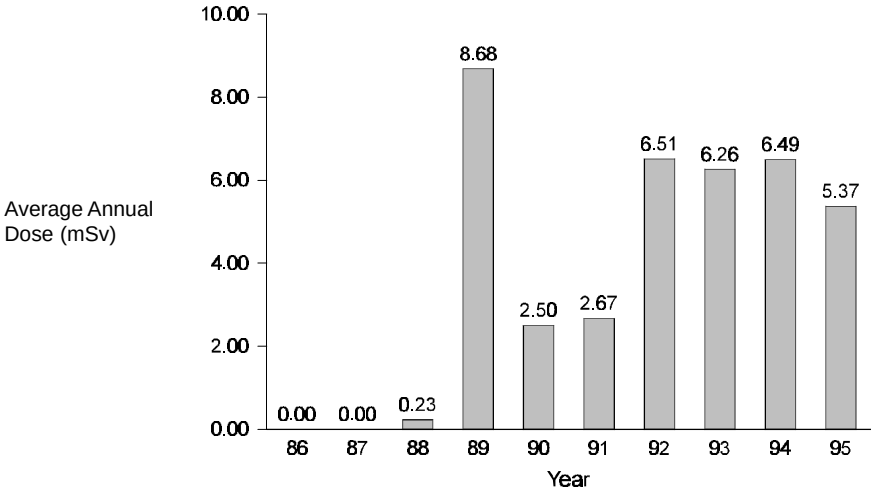


Table 4 (Cont'd)
Uranium Mine – Underground Miner

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	11	0.00	0.00	0
>0 - 1	33	15.40	0.47	73
>1 - 2	22	33.10	1.50	63
>2 - 5	56	194.70	3.48	53
>5 - 20	211	2748.30	13.03	61
>20 - 50	53	1214.00	22.91	71
>50	0	0.00	0.00	0
Total	386	4205.50	10.90	63
				Five year period 1991-1995
0	23	0.00	0.00	0
>0 - 5	282	607.12	2.15	70
>5 - 25	451	5901.07	13.08	73
>25 - 100	219	12121.72	55.35	67
>100	63	7735.40	122.78	82
Total	1038	26365.31	25.40	73

Hybrid lognormal parameters for positive doses in 1995:

ρ: 0.3100

μ: +4.2717

σ^2: 12.0271

Sample Size: 375

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

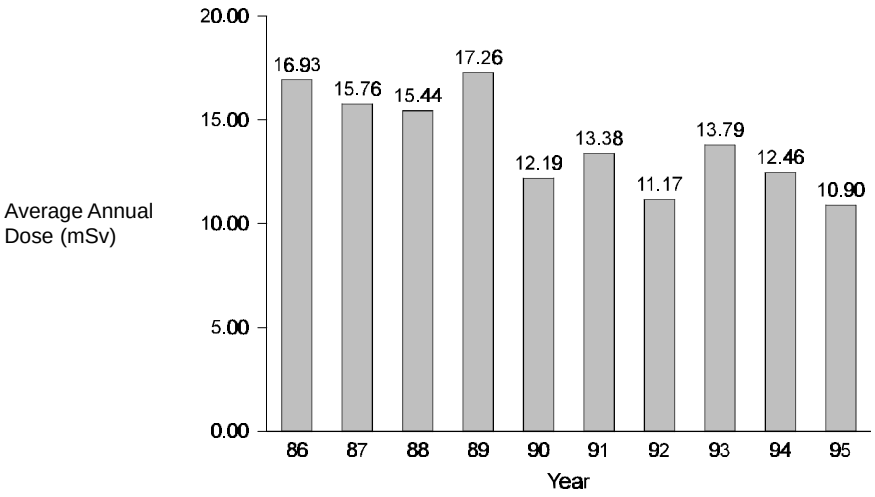


Table 4 (Cont'd)
Uranium Mine – Underground Personnel

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	220	0.00	0.00	0
>0 - 1	75	30.90	0.41	33
>1 - 2	18	27.80	1.54	45
>2 - 5	29	95.30	3.29	68
>5 - 20	26	207.40	7.98	70
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	368	361.40	0.98	64
				Five year period 1991-1995
0	462	0.00	0.00	0
>0 - 5	451	531.87	1.18	27
>5 - 25	110	1323.86	12.04	79
>25 - 100	28	1035.29	36.97	81
>100	0	0.00	0.00	0
Total	1051	2891.02	2.75	70

Lognormal parameters for positive doses in 1995:

μ: +0.1127

σ^2: 1.7177

Sample size: 148

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995

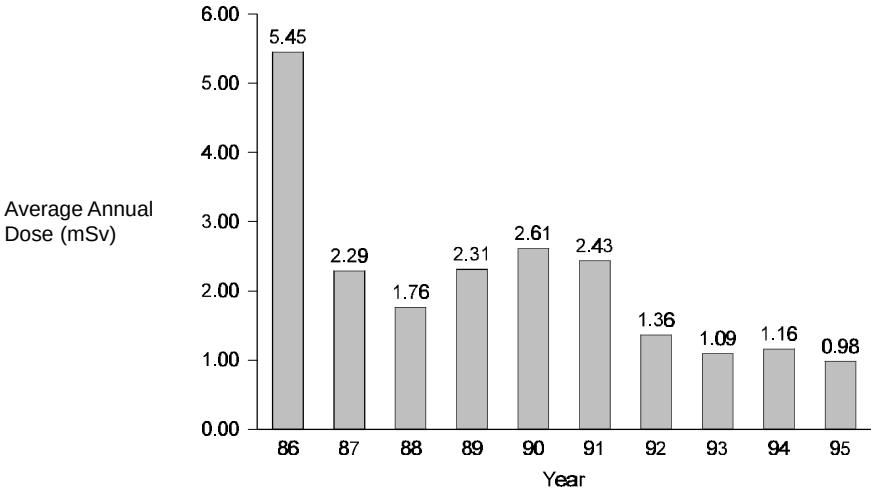


Table 4 (Cont'd)
Uranium Mine – Visitor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1995
0	114	0.00	0.00	0
>0 - 1	150	66.00	0.44	74
>1 - 2	26	36.90	1.42	57
>2 - 5	6	14.70	2.45	29
>5 - 20	0	0.00	0.00	0
>20 - 50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	296	117.60	0.40	63
				Five year period 1991-1995
0	121	0.00	0.00	0
>0 - 5	260	208.30	0.80	59
>5 - 25	10	63.50	6.35	62
>25 - 100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	391	271.80	0.70	60

Lognormal parameters for positive doses in 1995:

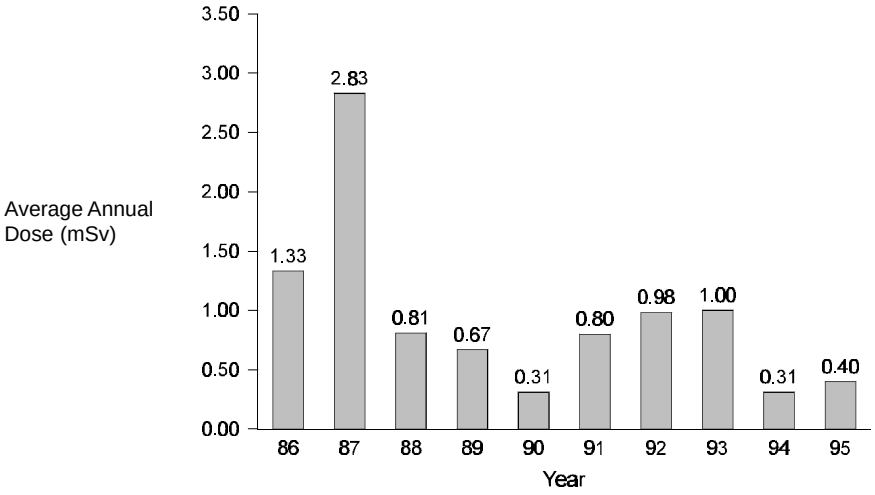
μ: -0.7869

σ^2: 0.7650

Sample Size: 182

(See Appendix for explanation)

Histogram of average annual doses over ten year period 1986-1995



Appendix
The lognormal and hybrid lognormal distributions

The appendix explains how the data can be fitted to a statistical distribution, so that: (1) the sample of doses can be described by 3 or 4 quantities (the parameters of the distribution and the sample size); and, (2) from these quantities, any dose statistic can be estimated, including any statistic not listed in this report, such as the 9-th decile.

Statistical distributions, such as the lognormal or hybrid lognormal distribution, are defined by a probability density function, containing a variable x, which in our case represents the occupational dose. This function is interpreted as follows:

The probability that a dose value lies between a and b equals

$$\int_a^b f(x)\,dx \ ,$$

where f represents the probability density function.

Besides the variable (occupational dose) the probability density function contains a number of parameters, which determine the shape of the function. Only when the parameters have been specified is the statistical model for the occupational dose defined. Parameters are adjusted to fit the data.

The lognormal probability density function f is given by:

$$f(x:\mu,\sigma^2)= (1/x)\ (2\pi\sigma^2)^{-½}\ \exp(-(\ln(x)-\mu)^2/2\sigma^2) \quad .$$

The hybrid lognormal probability density function f is given by:

$$f(x:\rho,\mu,\sigma^2)= (\rho+1/x)\ (2\pi\sigma^2)^{-½}\ \exp(-(\ln(\rho x)+\rho x-\mu)^2/2\sigma^2).$$

In these functions, the quantities μ and σ^2 are parameters of the distribution. The hybrid lognormal distribution contains an extra parameter ρ. This distribution was introduced by Kumazawa[9] *et al*, for the purpose of describing a workforce that makes a sustained effort to stay below a regulatory limit. This distribution often gives a better fit than the lognormal distribution for certain high dose occupations, such as nuclear medicine workers. It is similar to a lognormal distribution for low doses and to a normal distribution for high doses.

If the parameters for the probability density function f are known, one can estimate any dose statistic. For example, the mean dose is estimated as

$$\int_0^\infty x\ f(x)\,dx$$

(since the dose values x are between 0 and infinity).

The variance of the dose is estimated as:

$$\int_0^\infty (x - \text{mean})^2\ f(x)\,dx$$

and the standard deviation as the square root thereof.

The probability that a dose exceeds, for example, 50 mSv, is estimated as:

$$\int_{50}^\infty f(x)\,dx \ .$$

The 95-th percentile is estimated as that dose value v for which:

$$\int_0^v f(x)\,dx \ = 95/100 \ .$$

The fraction of the collective dose due to doses exceeding 15 mSv is estimated as:

$$\frac{\int_{15}^\infty x\ f(x)\,dx}{\int_0^\infty x\ f(x)\,dx}$$

The parameters are determined from the actual dose data. They are chosen to give the best 'fit' with the sample of observed data, for which purpose there exists a variety of methods. The parameters in Table 4 have been estimated with the Maximum Likelihood method. With this method, dose statistics can be estimated with the formulas given above, with the tabulated parameter values substituted for (ρ,) μ, and σ^2.

Software is available from the authors for the purpose of estimating occupational dose statistics and their confidence intervals. Since the lognormal and hybrid lognormal distribution do not apply to zero doses, as evident from the formulas of their probability density functions, the software will determine parameters based on positive doses, and the estimated statistics will refer to positive doses only. Estimates for the total of all doses can be derived if the numbers of zero and positive doses in the sample are taken into account. For example, consider a sample in which half the doses are zero. If the parametric estimate is 2 mSv for the mean of the positive doses, then the estimate of the mean of all doses is 1 mSv. Or, if a parametric estimate for the 95-th percentile of all doses is needed, it is calculated as the estimate of the 90-th percentile for the positive doses.