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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
08/31/2006	00	First approved issue. New document to describe the parameters to consider when processing claims for CTWs. Incorporates formal internal review comments and comments from the Worker Outreach meetings with the Hanford PACE Local (Steelworkers and Guards) on 05/22/2005 and the Central Washington Building and Construction Trades Council on 01/15/2005. Revised to incorporate additional NIOSH comments. There is an increase in assigned dose and a PER is required. Training required: As determined by the Task Manager. Initiated by Melton H. Chew and John A. Devanney.

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EXECUTIVE SUMMARY

This document provides guidance for performing dose reconstructions for unmonitored construction trade workers (CTWs).

An investigation of the Department of Energy (DOE) complex was conducted to determine the ratio of the external and internal annual doses received by CTWs to those received by all other monitored workers (AMWs). In general, it was found that for the DOE complex the internal and external annual doses received by the CTWs were usually bounded by those received by the AMWs. Examination of the individual DOE sites indicated that in some instances, at some sites, the external annual doses received by the CTWs exceeded those of AMWs. In these instances, the observed ratios of CTWs to AMWs external doses were further examined. This resulted in the development of a favorable to claimant adjustment factor of 1.4, which will be applied by dose reconstructors to all unmonitored CTWs throughout the DOE complex. Guidance is provided for dose reconstructors on the use of this adjustment factor.

Examination of the individual DOE sites for internal dose indicated that only the Hanford site required adjustment. For the Hanford site, the intake rates in the Hanford coworker study should be multiplied by a factor of 2. Guidance is provided for dose reconstructors on the determination of internal dose.

1.0 INTRODUCTION

Technical Information Bulletins (TIBs) are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). TIBs may be used to assist the NIOSH staff in the completion of individual dose reconstructions.

In this document, the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy (DOE) facility" as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 [52 U.S.C. Sections 7385l(5) and (12)].

This document presents information that compares doses received by monitored CTWs to doses received by all other monitored workers. For the purposes of this document CTWs include, but are not limited to, laborers, mechanics, masons, carpenters, electricians, painters, pipe-fitters, insulators, boilermakers, sheet-metal workers, operating engineers, and iron workers.

For the initial comparison on CTW and AMW doses, five DOE sites were selected to represent the DOE complex as a whole. These sites (Rocky Flats, Savannah River, Y-12, K-25, and Oak Ridge National Laboratory [ORNL]) represent the full spectrum of work (plutonium and uranium processing, reactor operations, weapons production, and research laboratory operations) that is associated with DOE facilities. Using external dosimetry data from these sites, an investigation and comparison was made to determine the relationship between the annual external doses received by CTWs and those received by AMWs at the 95th percentile. The annual external doses for CTWs are represented by over 200,000 histories, while those for AMWs are represented by over 1,000,000 histories. The investigation showed that for the years 1943 to 2005 the annual external doses to the CTWs were typically bounded by the doses to AMWs. In a more detailed comparison, seven individual DOE sites were examined to determine if, at any time, the external dose to the CTWs exceeded that to AMWs. There were instances where external doses to CTWs exceeded that of AMWs. This document presents the data that supports the use of an adjustment factor to account for instances where CTWs received higher doses.

As part of the more detailed comparison mentioned above, six of the DOE sites were analyzed to determine if, at any time, the bioassay results for CTWs exceeded those of AMWs. It was concluded that no adjustment factors were needed for internal dose except Hanford (see Section 8.4).

For new facility construction, most CTWs were unmonitored because no radioactive material would be installed until after the facility was commissioned. However, modifications or major maintenance of existing facilities could have involved exposure to radioactive materials and would require monitoring of some CTWs.

Radiation safety regulations (e.g., AEC Manual-0523 and AEC Manual-0524) dating back to the 1950s required all personnel working in a radiation area to wear a gamma-measuring film-badge. At some sites, such as the Nevada Test Site (NTS), all personnel entering the site were required to wear a gamma-measuring film-badge in conjunction with their security badge (NTSO-0525). Consequently, all persons, including CTWs, working in a radiation area were routinely monitored for exposure to external radiation. In most instances, CTWs were not routinely included in the bioassay program of the site. However, CTWs were included in the bioassay program when they were suspected of having experienced a radioactive material intake.

While safety regulations and facility-specific radiation protection practices required monitoring of radiation workers, it is recognized that under some circumstances some of the CTWs at a facility may not have been fully covered or monitored by the radiation protection programs at a site, regardless of whether they were employed by the M&O contractor or a construction subcontractor. The reasons for partial or altered monitoring of CTWs varied from facility to facility within a site, but it was not uncommon to have minimal or alternative monitoring in place during the construction of new facilities that were separate from existing facilities. Furthermore, there are instances in which a CTWs dose records may be incomplete or unavailable. In cases such as these, the ability to perform a dose reconstruction for this CTW is limited by a lack of claimant-specific information and data, so the claimant is categorized as an unmonitored construction worker. During the development of this ORAU Team TIB (OTIB), there was a consistent effort to identify CTWs who were monitored regardless of whether they were employed by the M&O contractor or a subcontractor. This document provides the basis and guidance for performing dose reconstructions for unmonitored CTWs.

Although there are limitations and conditions on the data sets used within this OTIB, it is possible to separate and compare the external and internal doses received by CTWs and AMWs at a site. These comparisons are provided graphically in this OTIB. From these comparisons, which are presented for sites that had differing missions, operations, facilities, and radioactive source terms, the relationship between doses received by CTWs and AMWs becomes evident. Specifically, the comparisons demonstrate that, with some important exceptions and conditions, the dose received by the monitored CTWs was typically bounded by the dose received by AMWs on the same site. In order to account for instances where unmonitored CTWs may have received higher doses than other monitored workers, the need for an adjustment factor was identified. The adjustment factor provides a dose reconstruction method that is favorable to claimants that have been categorized as unmonitored CTWs.

2.0 PURPOSE

This document provides guidance for performing dose reconstructions for unmonitored CTWs. For the purpose of this document, unmonitored CTWs are defined as workers who worked onsite at any time in the site's history and may have been employed by the M&O contractor at any DOE site. These unmonitored CTWs include, but are not limited to, laborers, mechanics, masons, carpenters, electricians, painters, pipe-fitters, insulators, boilermakers, sheet-metal workers, operating engineers, and iron workers. It should be noted that, in some instances, the prime contractor is not necessarily the M&O contractor. For example, in the late 1980s at Hanford, the M&O contractor in the 100 Area was Westinghouse while the prime contractor was Kaiser.

3.0 SCOPE

The guidance developed in this OTIB is limited to dose reconstruction for unmonitored CTWs who:

1. Were employed by subcontractors or worked directly for the M&O contractor at any DOE site. These workers may have been brought onsite by subcontractors to do construction work, but may not have been covered under the site's radiological protection program.

2. Worked at any time in the site's history.

3. Do not have a complete exposure history such that for external exposure, they had no external monitoring at all or there were gaps of at least a year in their external monitoring or for internal exposure, they had no internal monitoring at all or the monitoring they had was inadequate to bound their potential exposure.

4.0 SOURCES OF DATA

Many sources of data were used to develop this document. These included databases, such as the Comprehensive Epidemiologic Data Resource (CEDR), the Center for Epidemiologic Research (CER), the Radiation Exposure Monitoring System (REMS), and the Savannah River Site Health Protection Annual Radiation Exposure History (HPAREH), as well as annual reports based on AEC Form 190. The quality, usability, and accessibility of the data varied, making a standardized comparison among sites difficult. For example, some data are available in a modern database as official records while others are available only as summaries in centralized compilations. Some data have rigorously characterized parametric descriptions, while others are described only by a mean value. Sometimes the AMW group includes the CTWs and in others it does not. During the review and query of the databases, there was a consistent effort to identify all CTWs regardless of whether they were employed by the M&O contractor or a subcontractor.

Since the source and degree of data specificity varied among the sites, a brief description of the source and treatment of data associated with each DOE site is provided.

4.1 GENERAL DESCRIPTION OF EXTERNAL DOSE DATA

External dose data represents the most widely available dosimetry data for radiation workers. Very large and well-defined external dosimetry databases exist for most DOE facilities. A number of the databases cover or contain data from the entire history of a site.

Data for penetrating dose are contained in various databases some of which have more detail than others. Data for AMWs and CTWs are reported for the following sites: Savannah River Site (SRS), Y-12, ORNL, K-25, Hanford, Idaho National Laboratory (INL), and Rocky Flats. However, only the arithmetic mean of the annual external dose is available for INL and Hanford.

4.2 GENERAL DESCRIPTION OF THE ADJUSTMENT FACTOR

The need for an adjustment factor is considered when the annual external penetrating dose for CTWs exceeds that for AMWs. If the observed ratio of the annual external penetrating dose for CTWs to that of AMWs is less than 1.2, the observed ratios were not included in the site-specific tables. The value of 1.2 is a value based on the characteristics of the dosimeter systems and their ability to measure dose (NRC 1989).

The adjustment factor addresses instances in which the annual external penetrating dose for CTWs exceeded that for AMWs. Because data from all sites within the DOE complex were not readily available for analysis and inclusion in this OTIB, a prescribed DOE complex-wide adjustment factor is developed and described in Section 7.1.

4.3 GENERAL DESCRIPTION OF BIOASSAY DATA USED FOR INTERNAL DOSE

Bioassay data are available to cover the majority of the large DOE sites. Bioassay programs are typically established based on the need to monitor individuals or groups who had a recognized potential for intake of radioactive material. Consequently, bioassay sampling programs or internal dose monitoring practices are more highly focused and applied more selectively to a smaller group of workers than external monitoring programs. In most instances, CTWs were not included in the routine bioassay program of the site. However, CTWs were regularly included in the bioassay program when they were suspected of having experienced a radioactive material intake.

4.4 GENERAL DESCRIPTION OF NON-PENETRATING DOSE DATA

Non-penetrating dose data for CTWs and AMWs were available only for the SRS and Rocky Flats Plant.

5.0 COMPARISON OF CTW AND AMW DOSES

Five major DOE sites (SRS, Rocky Flats, Y-12, K-25, and ORNL) were selected to represent the DOE complex in an investigation to determine the relationship between the external annual doses received by CTWs and AMWs at the 95th percentile. These sites were selected because they represent a spectrum of DOE sites where major construction activities took place. A total of over 215,000 histories for CTWs and over 1,000,000 histories for AMWs were examined. Figure 5-1 is a composite graph of the sites and shows the annual external penetrating dose for the time period of 1943 through 2005. Except for the year 1955, Figure 5-1 shows that the external annual dose received by CTWs is well bounded by that received by AMWs. In 1955, the external annual dose received by CTWs exceeded that received by AMWs by approximately 20%. Based on this observation, seven sites were examined individually to determine if, at any time, the external or internal dose to CTWs exceeded the dose to AMWs. The seven sites included SRS, Rocky Flats, Y-12, K-25, X-10, INL, and Hanford. Hanford and INL were not included with the initial five DOE sites because the dosimetry data available for them only addressed the mean of the external dose as opposed to the 95th percentile.

As indicated in Figure 5-1, doses to CTWs occasionally exceeded doses to AMWs in the 1980s and later. A review of the data used in the figure indicated that these exceedances are an artifact caused by a large number of AMWs with no measured dose. The large number of AMWs with no measured dose led to a smaller value for the 95th-percentile annual dose, making the 95th-percentile annual dose for CTWs comparatively larger.

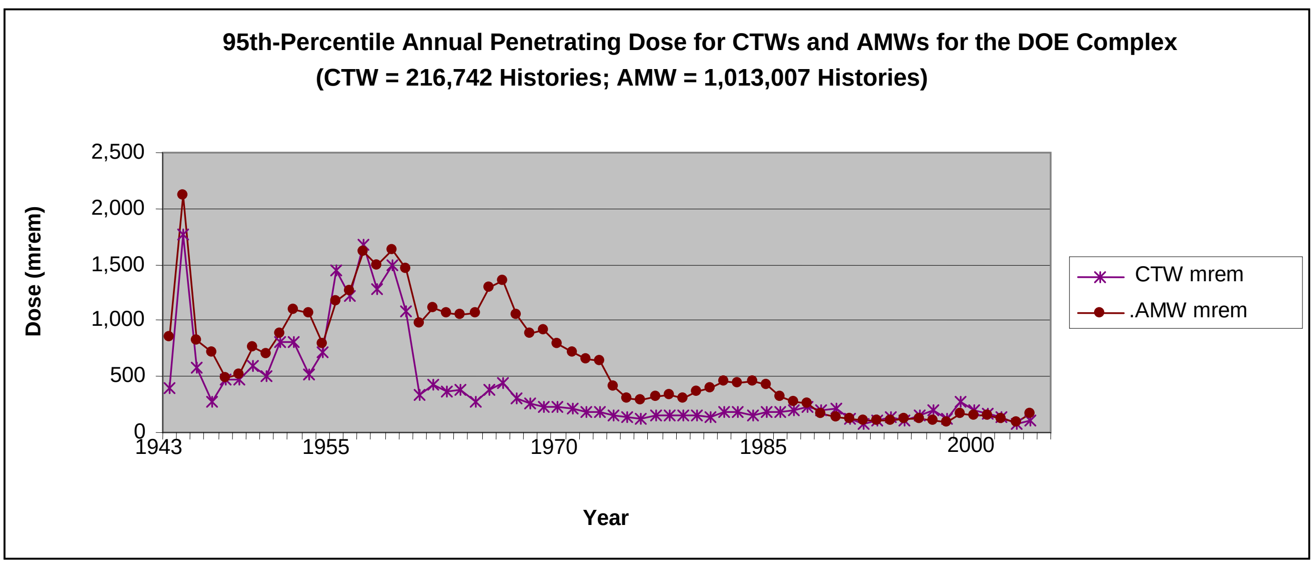

Figure 5-1. 95th-percentile annual penetrating dose for CTWs and AMWs for the DOE complex.

5.1 SRS PENETRATING DOSE COMPARISON

Information for the period from 1953 through 1999 concerning penetrating doses for SRS CTWs is contained in the onsite personnel dosimetry database, HPAREH. The dosimetry data for the SRS CTWs in the HPAREH database are identified as Payroll 4 (ROLL 4). This information is subdivided to identify specific construction trades. However, some trades were not represented or represented only a few individuals. As a consequence, conclusions for the period from 1953 through 1999 are based only from ROLL 4 data as a whole.

Dosimetry data include annual deep doses (i.e., external photon radiation) and annual shallow doses (i.e., penetrating photons plus non-penetrating radiation). Summary statistics presented in this document do not extend post 1999 because, at the time information supporting this document was collected, sufficient data beyond that year were not available.

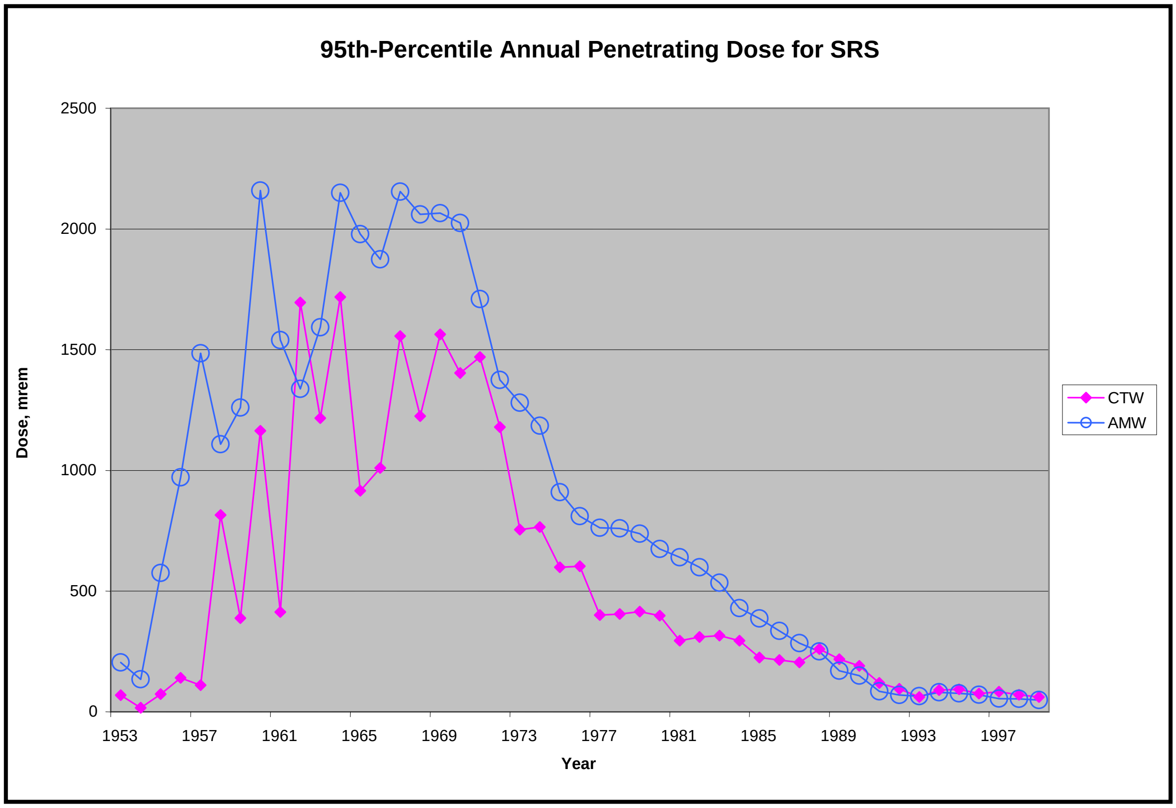

Figure 5-2. 95th-percentile penetrating dose for SRS.

Table 5-1 lists the observed ratios that are greater than 1.2 for CTWs and AMWs at SRS.

Table 5-1. Observed ratios for SRS.

Year	CTWs			AMWs			Observed ratios (CTWs/AMWs)
	Number monitored	Number with measurable dose	95th-percentile dose (mrem)	Number monitored	Number with measurable dose	95th-percentile dose (mrem)	
1962	259	236	1696	3371	3101	1337	1.3
1989	2408	1818	218	15517	8749	170	1.3
1990	2440	1567	190	18494	8503	150	1.3
1991	2202	1104	120	18630	6468	85	1.4
1992	1902	792	95	17780	5016	70	1.4
1997	949	317	83	11344	2410	55	1.5
1998	870	280	71	10750	2210	54	1.3
1999	785	240	62	10365	2159	49	1.3

5.2 SRS INTERNAL DOSE COMPARISON

For the SRS, no coworker study has been published and bioassay data are not available electronically before about 1990. Records prior to 1990 are stored both on and off the site in paper files and on microfiche. During the development of this OTIB, a random sample of records stored on the site was obtained for workers with a non-zero external dose recorded in the HPAREH database.

Equal number of records for CTWs and other workers were requested for individuals employed from 1955 through 2000. CTWs were identified by ROLL 4 in the HPAREH database.

This sampling produced a data set containing approximately 1,830 plutonium-in-urine measurements, one-third of which represented CTWs. According to ORAUT 2005d, prior to 1981 (1988 for special samples) the total activity from alpha-emitting isotopes was used to report the amount of plutonium in urine, whereas ^{238}Pu and $^{239+240}$Pu results were reported separately from 1981 to the present. Since this comparison is of the relative activities in the samples, no adjustments were made. All results were normalized to 1,400-mL sample size. Results for employees with multiple bioassay samples in the same year following a significant intake were removed prior to plotting. This was done so as not to bias the results for more typical workers. However, results less than 10 dpm/1,400 mL were retained even if there were other samples collected in the same year. Results for three non-CTWs and one CTW were removed using this method.

For non-CTWs, 93% of the results were below the reporting level, while for CTWs, 97% of the results were below the reporting level. Only results greater than the reporting level are plotted in Figure 5-3. Due to the limited amount of data greater than the reporting level in any given period, no attempt was made to calculate 50th-percentile values. Figure 5-3 also includes the typical reporting level estimated by a visual inspection of the various periods for comparison. This plot shows that non-CTWs were more likely to have results above the reporting level and more likely to have higher results than CTWs.

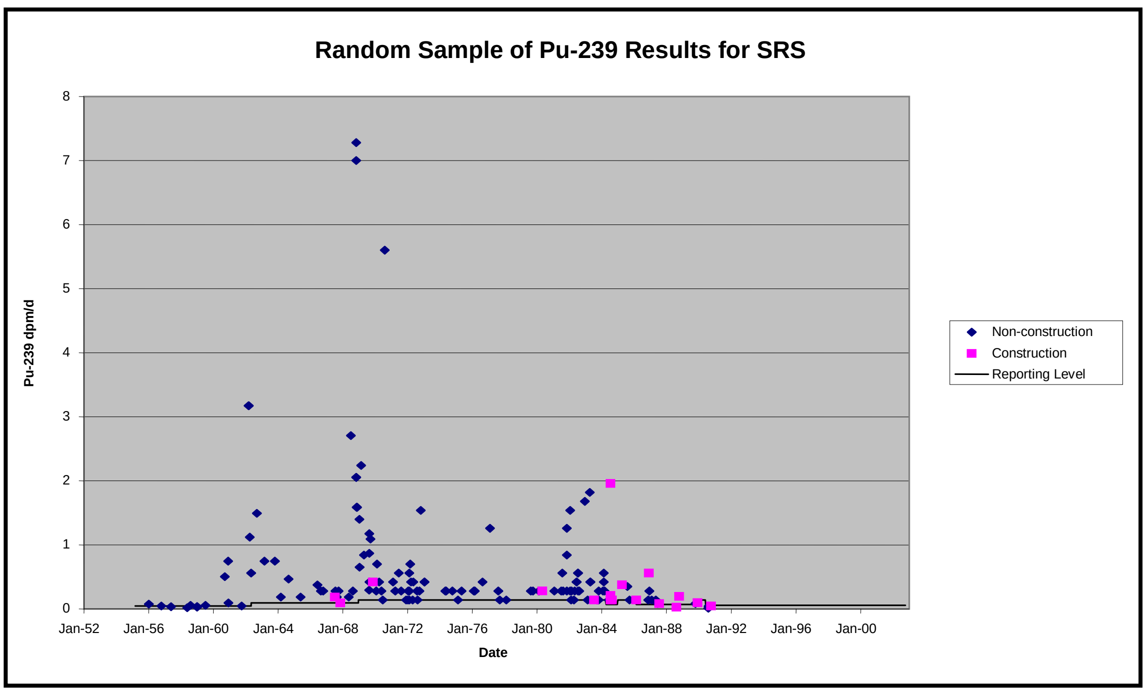

Figure 5-3. Results of bioassay samples above the reporting level for randomly selected CTWs and non-CTWs at SRS.

5.3 SRS NON-PENETRATING DOSE COMPARISON

As mentioned in Section 5.1, information for the period from 1953 through 1999 concerning non-penetrating doses for SRS AMWs and CTWs are contained in the onsite personnel dosimetry database, HPAREH. The dosimetry data for the SRS CTWs are identified as Payroll 4 (ROLL 4) in the HPAREH database.

The results for the 95th-percentile annual non-penetrating doses appear in Figure 5-4. As is evident in Figure 5-4, the annual non-penetrating dose received by the monitored CTWs is adequately bounded by the dose received by AMWs at the SRS.

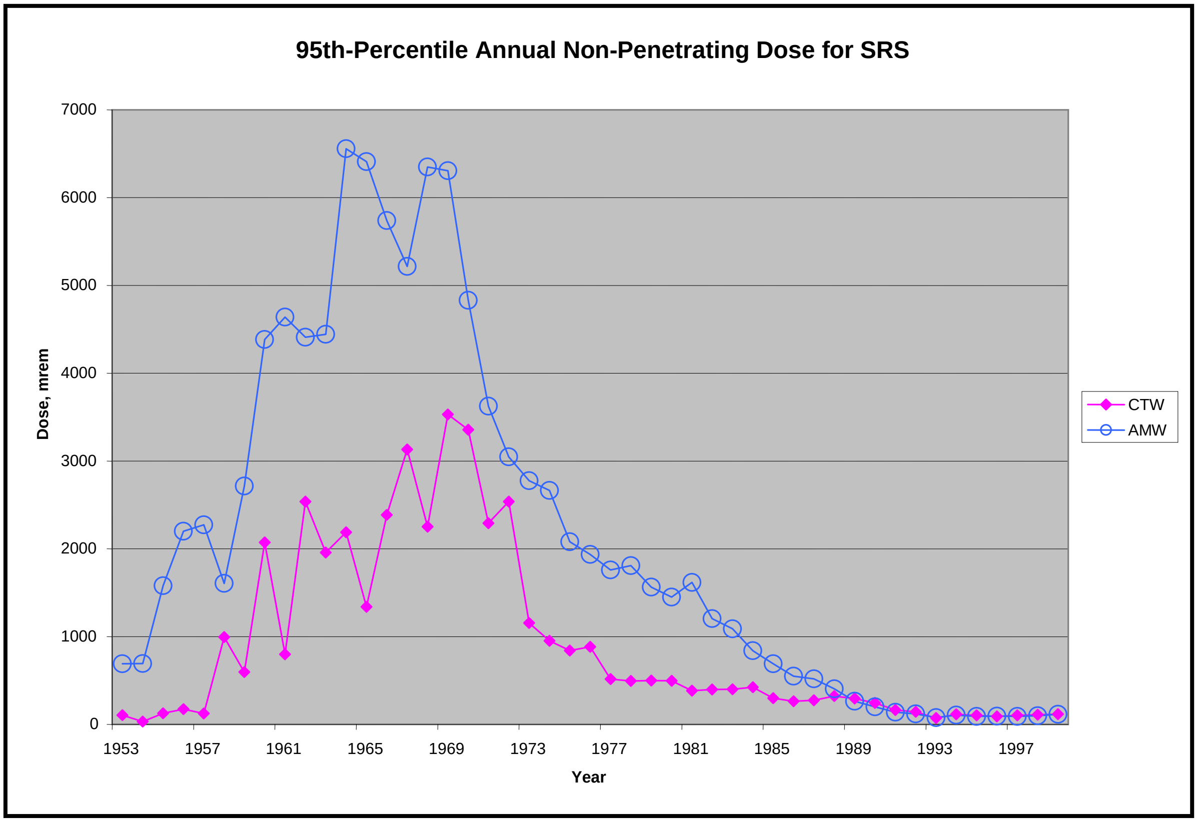

Figure 5-4. 95th-percentile non-penetrating dose for SRS.

5.4 ROCKY FLATS PENETRATING DOSE COMPARISON

Construction worker data for Rocky Flats was obtained from the HIS-20 (TM CANBERRA) database. This database was the plant's last dosimetry data tracking system and contains dosimeter results from the entire plant history. The CTW data set consisted of workers with the company names "Kaiser-Hill Company, L.L.C." (where the department field contained "construct"), "Kaiser-Hill RFETS\10389" (where the department field contained "construct"), "Swinerton & Walberg Company," and "J. A. Jones Construction\3893." The latter two companies were the construction contractors for most of the plant's history.

Figure 5-5 shows the annual penetrating doses for monitored CTWs and AMWs for the period 1955 through 2005.

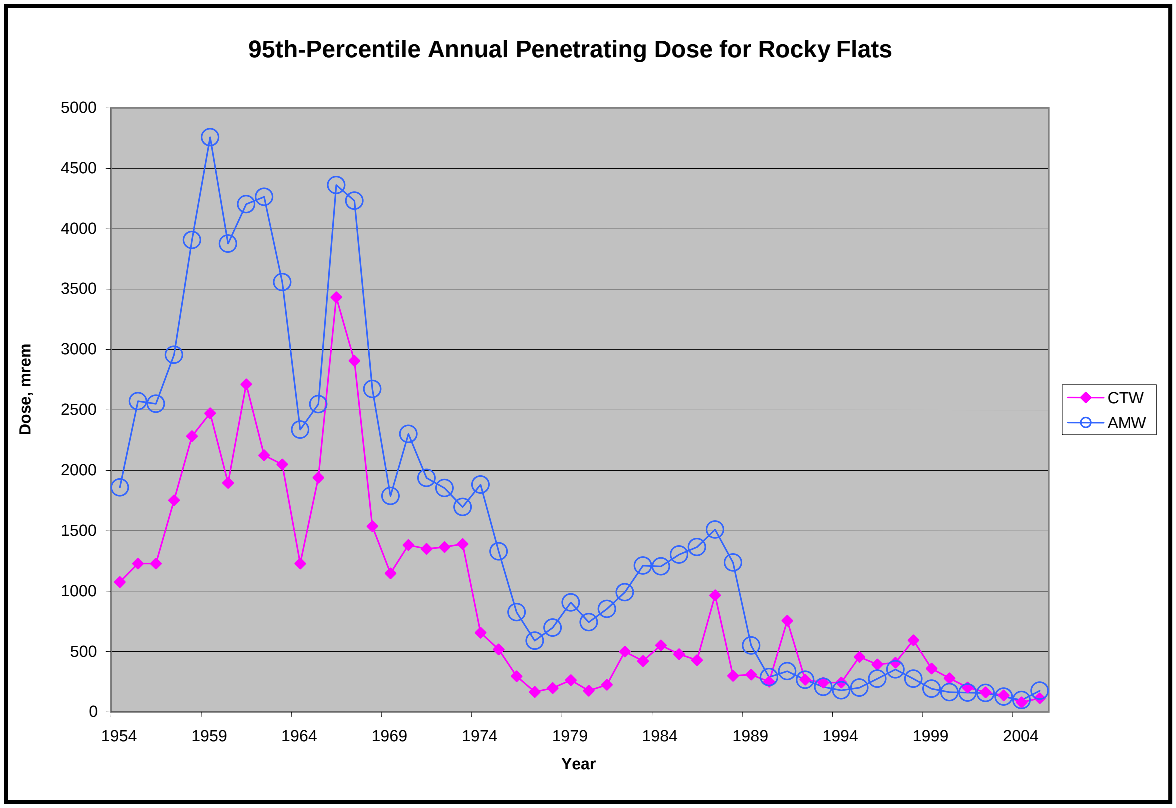

Figure 5-5. 95th-percentile penetrating dose for Rocky Flats.

Table 5-2 lists the observed ratios that are greater than 1.2 for CTWs and AMWs at Rocky Flats.

Table 5-2. Observed ratios for Rocky Flats.

Year	CTWs			AMWs			Observed ratios (CTWs/AMWs)
	Number monitored	Number with measurable dose	95th-percentile dose (mrem)	Number monitored	Number with measurable dose	95th-percentile dose (mrem)	
1991	386	340	755	5641	4951	337	2.2
1994	147	96	242	4839	3198	179	1.4
1995	138	88	455	4130	2502	200	2.3
1996	109	95	393	3454	2761	274	1.4
1998	265	218	592	3470	2036	275	2.2
1999	197	151	359	3655	2138	192	1.9
2000	175	110	278	3576	1256	164	1.7
2001	185	108	202	3443	1518	160	1.3

5.5 ROCKY FLATS INTERNAL DOSE COMPARISON

Construction worker data for Rocky Flats internal dose comparison was obtained from the HIS-20 (TM CANBERRA) database. Two sets of data containing urine results for the entire history of the site were drawn from the database. The first data set consisted of workers with the company names "EG&G Rocky Flats Plant," "Kaiser-Hill Company, L.L.C." (where the department field did not contain "construct"), "Kaiser-Hill RFETS\10389" (where the department field did not contain "construct"), "Safe Sites of Colorado, L.L.C.," and "Rocky Mt Remediation Srv\10528." This set was selected to represent AMWs.

The second data set consisted of workers with the company names ”Kaiser-Hill Company, L.L.C.” (where the department field contained “construct”), “Kaiser-Hill RFETS\10389” (where the department field contained “construct”), “Swinerton & Walberg Company,” and “J. A. Jones Construction\3893.” The latter two companies were the construction contractors for most of the site’s history. This second data set was used to represent CTWs. There were a number of smaller companies that could have been added, but the number of urine results would not have increased significantly.

The data set only included results that were identified in the database as “P,” “Pu239,” or “Pu-239.” The results included the activity of all plutonium alphas in the early years, and only Pu-239 and Pu-240 activity after analysis by alpha spectroscopy was initiated (see ORAUT 2005a for details). For the period from 1953 through 2005, 129,225 results were collected for AMWs and 5,571 results were collected for CTWs.

The Rocky Flats data were analyzed by applying the basic techniques discussed in ORAUT 2005c for coworker studies. The data were assumed to be lognormally distributed. Results for highly exposed workers who were followed-up with multiple samples in one year were removed from the population, so as not to bias the results for more typical workers. However, not all high results were removed. This resulted in multiple individuals having their results removed from the AMW data set, but only one individual’s results were removed from the CTW data set. The data were analyzed annually for AMWs, while the data for CTWs were grouped in intervals of every five years in order to include enough data for statistical analysis. Each group was examined, and duplicate and invalid results were eliminated. Negative and zero results were replaced by a uniform (linear) distribution ending at the MDA value published in the ORAUT 2005a. The results were assumed to represent 24-hr samples or were normalized to 24-hr samples by volume in years where volumes were recorded in the database. The results were sorted and ranked using the midpoint of the rank. A linear regression analysis of the rank versus the natural log of the result was performed and plotted. The R^2 value of the regression and the plot were inspected to ensure that an adequate fit to the data had been obtained. From the regression, the values for the 50th- and the 84th-percentile of the distributions were calculated and are shown in Figures 5-6 and 5-7, respectively. As shown in Figures 5-6 and 5-7, the results for plutonium in the urine of the CTWs are comparable to results for AMWs who were monitored routinely at Rocky Flats.

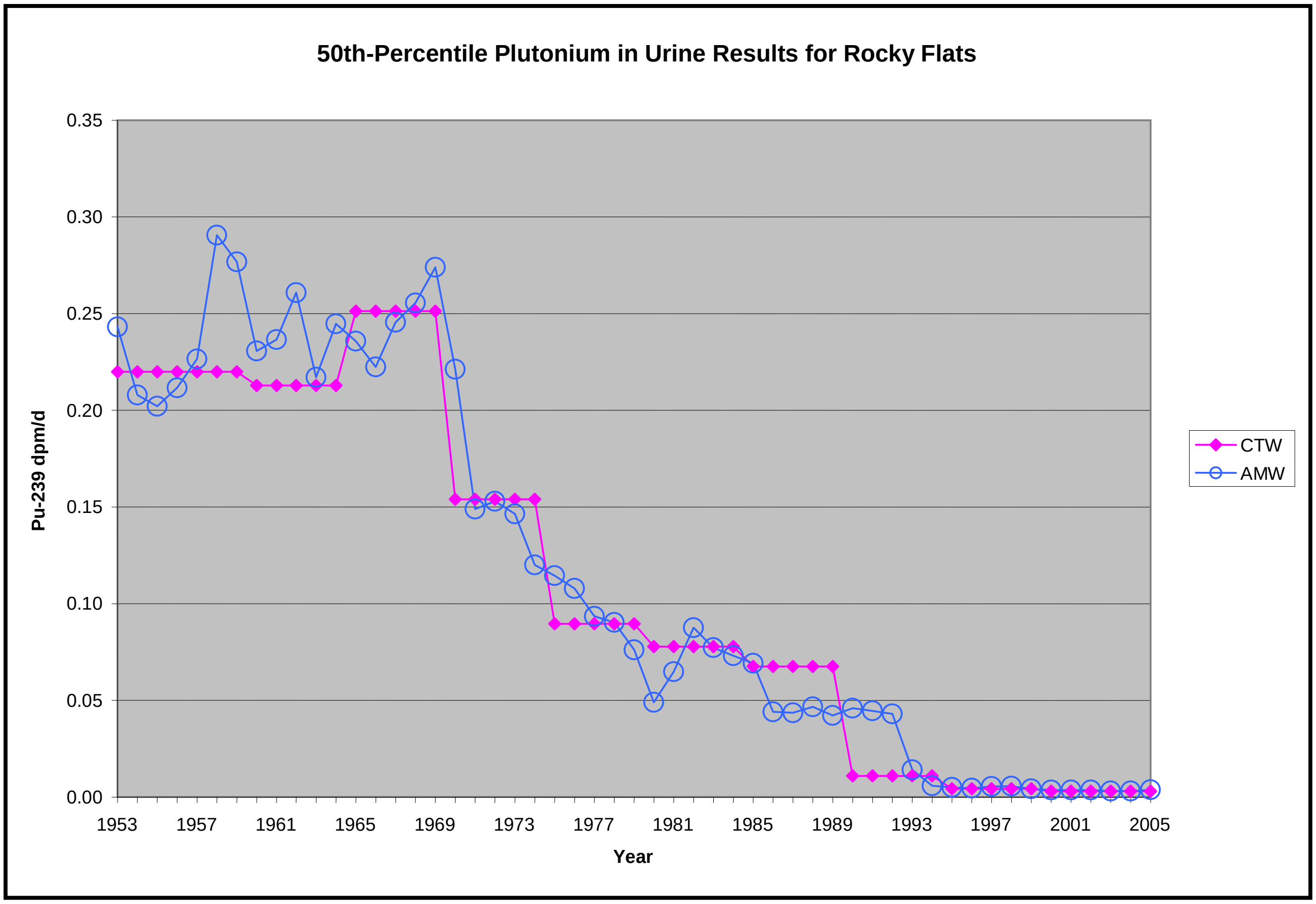

Figure 5-6. 50th-percentile plutonium in urine for Rocky Flats.

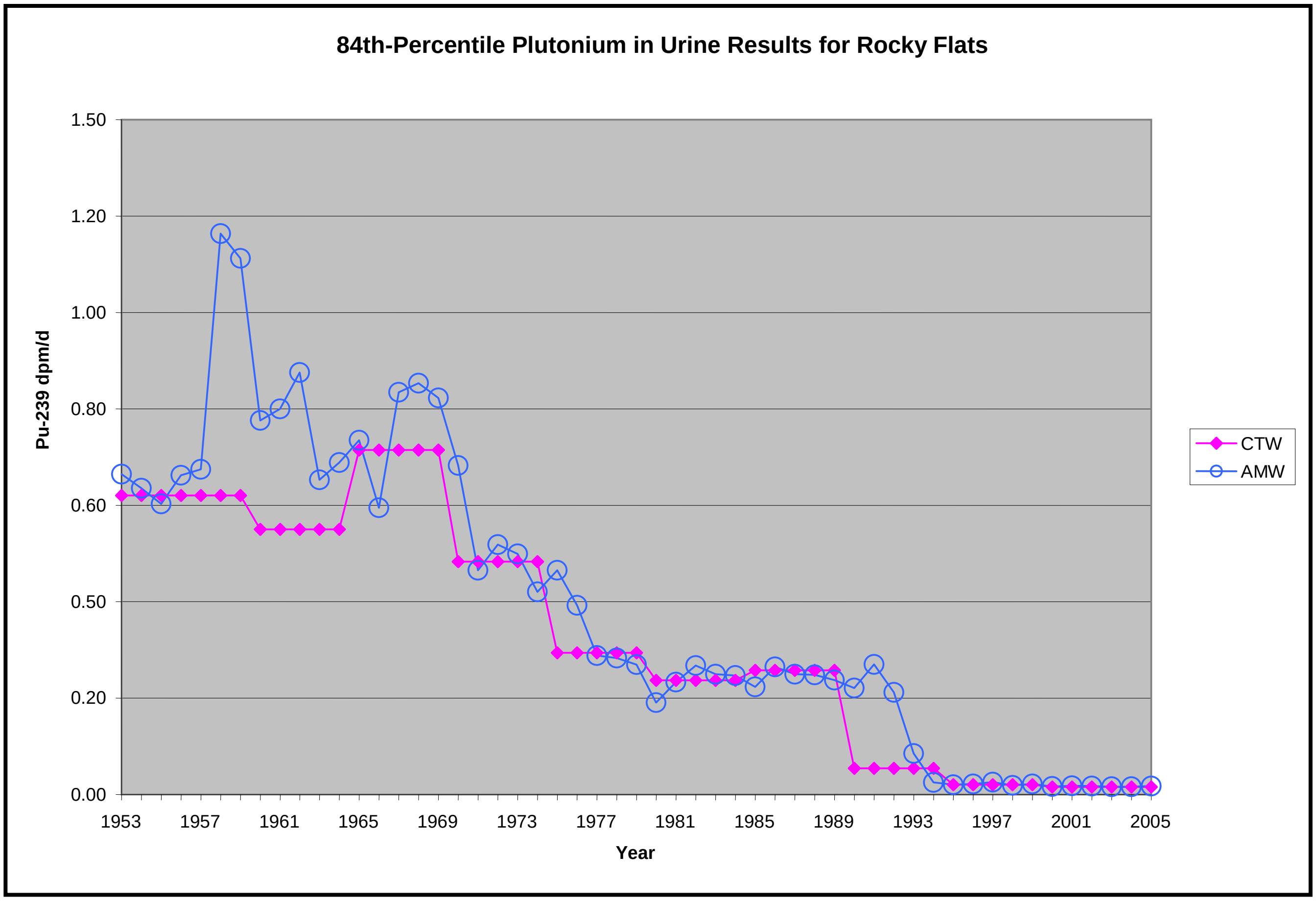

Figure 5-7. 84th-percentile plutonium in urine for Rocky Flats.

5.6 ROCKY FLATS NON-PENETRATING DOSE COMPARISON

CTW and AMW data for Rocky Flats was obtained from the HIS-20 database using the criteria discussed under the penetrating dose section.

The results for the 95th-percentile annual non-penetrating doses appear in Figure 5-8 and show that at the 95th percentile, the annual non-penetrating dose received by the monitored CTWs at the Rocky Flats Plant is adequately bounded by the dose received by AMWs at the Rocky Flats Plant.

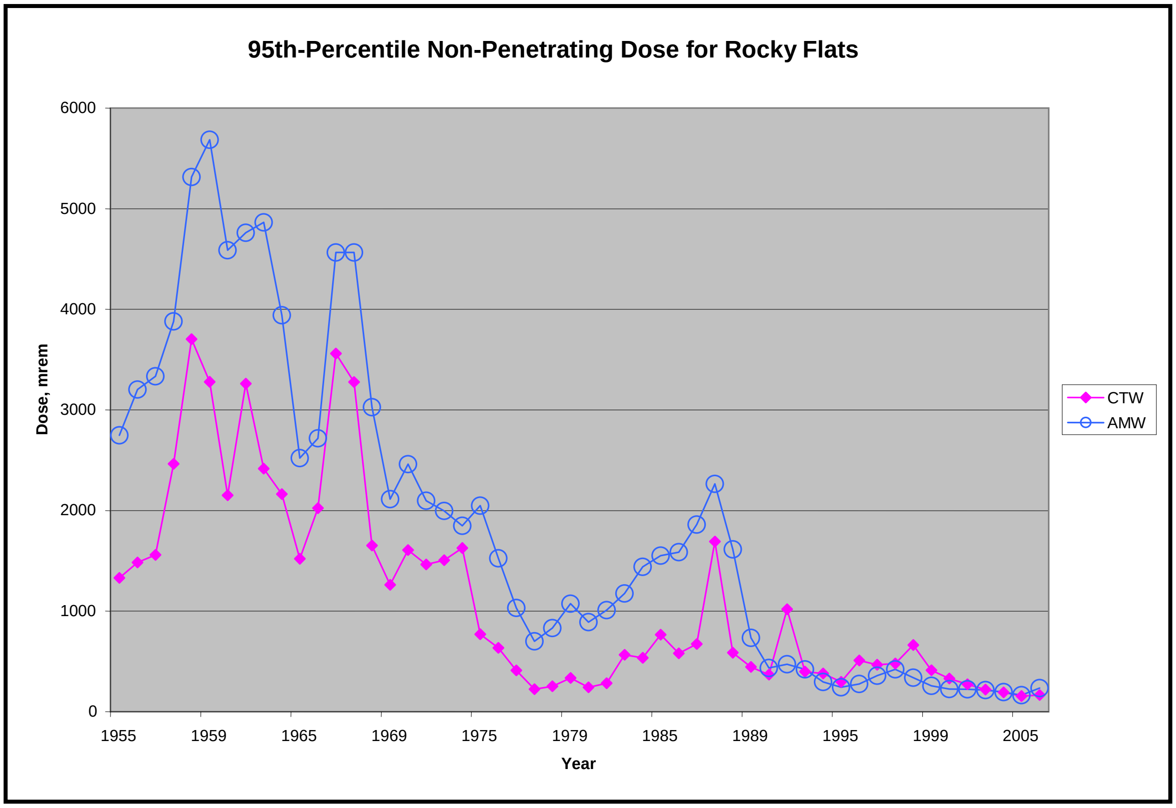

Figure 5-8. 95th-percentile non-penetrating dose for Rocky Flats.

5.7 Y-12 PENETRATING DOSE COMPARISON

External dose data for Oak Ridge Y-12 are taken from the Oak Ridge Institute for Science and Education (ORISE) CER database (ORAUT 2005c). The records in this database include external radiation exposure measurement results pertinent to the health and safety monitoring of employees and contract employees of the DOE and its predecessor organizations. Data on CTWs were obtained using a query designed to extract job titles associated with construction work. Data on any worker with a job title that included any of the following words or portions of words were included in the CTW data set: craft, carp, equip, heavy, plumb, pipef, millw, ship, skill, laborer, black, linem, boil, brick, tile, metal w, metal, crane, paint, mason, sheet, maint, truck, weld, rigger, or iron.

Figure 5-9 shows the data for 95th-percentile penetrating dose for both monitored CTWs and AMWs for the period from 1950 through 1988. As shown in Figure 5-9, the 95th-percentile annual penetrating dose received by the monitored CTWs at Y-12 is adequately bounded by the doses received by AMWs at Y-12.

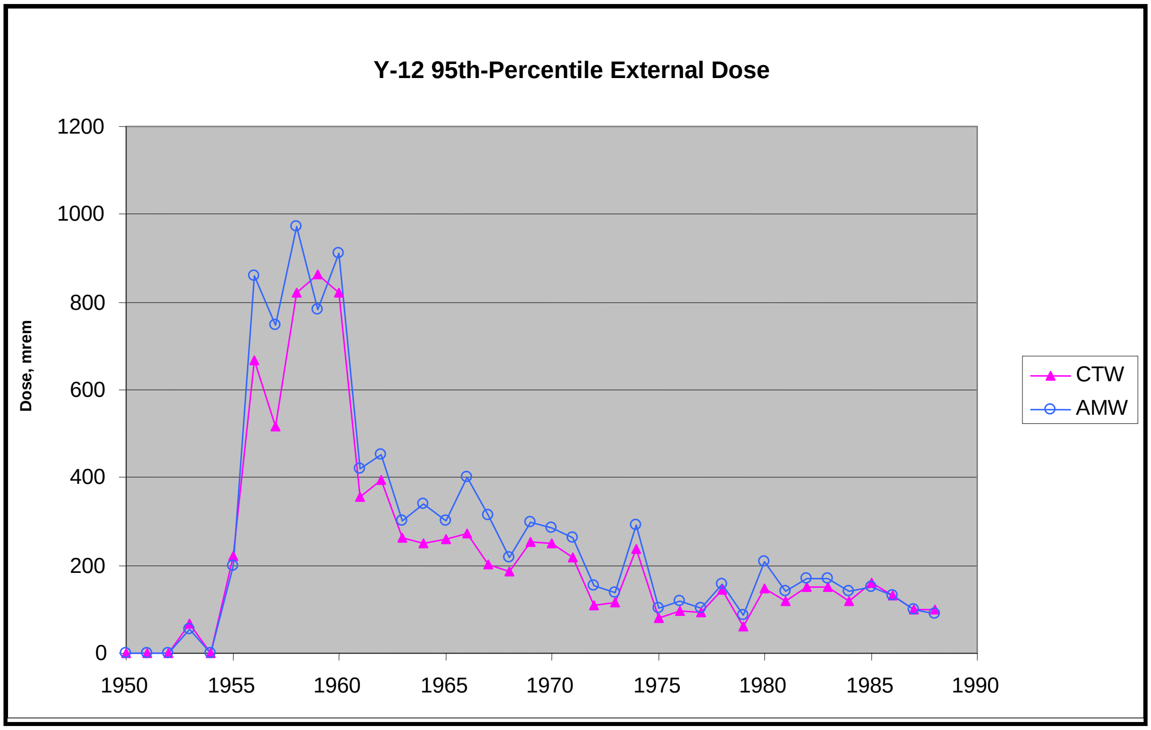

Figure 5-9. 95th-percentile penetrating dose for Y-12.

5.8 Y-12 INTERNAL DOSE COMPARISON

Bioassay results for uranium in urine samples for personnel who worked at Oak Ridge Y-12 are taken from the ORISE CER database (ORAUT 2005c). Data on CTWs was obtained using a query designed to extract job titles associated with construction work. (See Section 5.7 for details on the data query.)

Data generated by the query were reviewed to determine if a singular sample result or results associated with unusual incidents were unduly influencing the overall data comparison. Such data are characterized as outliers and these results were removed from the data set in order to improve the value of the data comparison.

The 50th and 84th percentile of these bioassay results are shown by year in Figures 5-10 and 5-11, respectively. In general, there is good agreement between the sample results for CTWs and AMWs.

The graph represents the 50th-percentile of uranium in urine for Y-12.

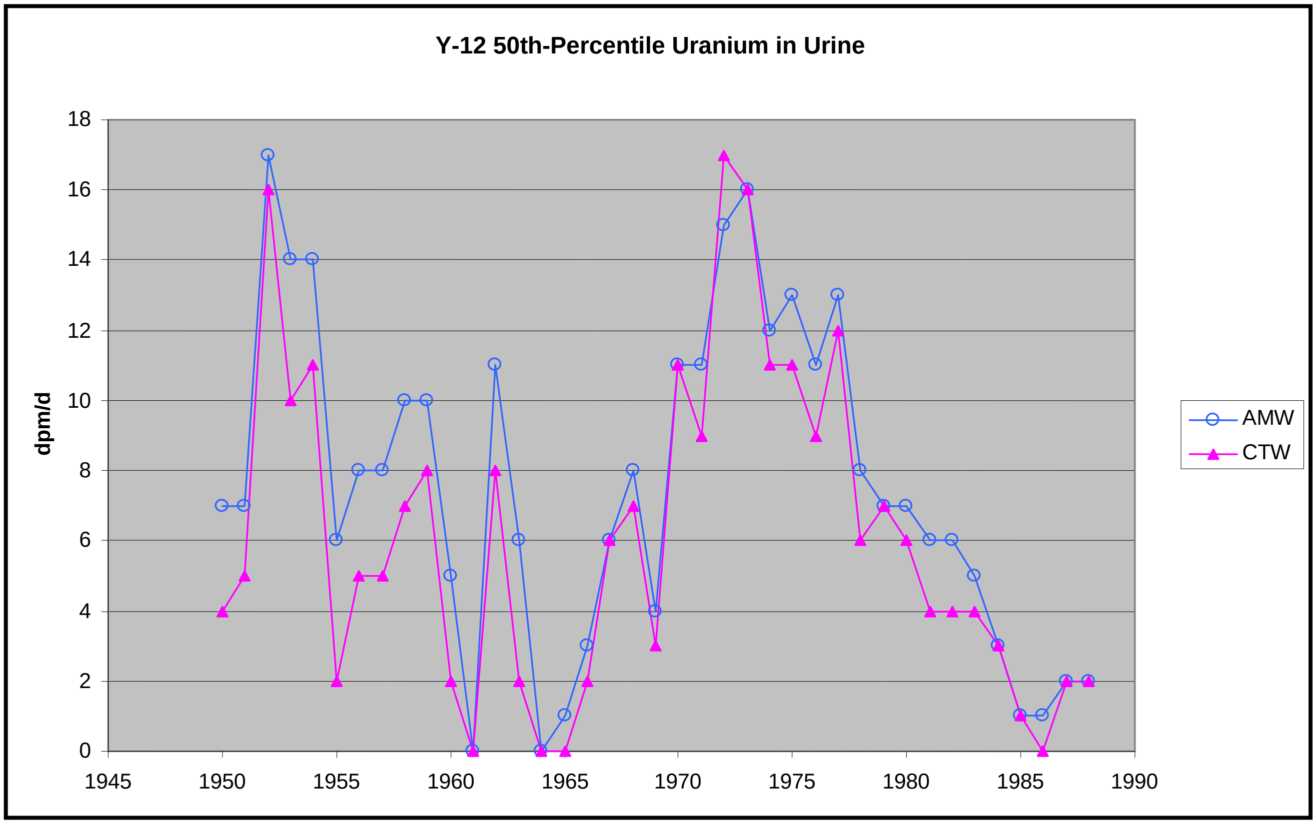

Figure 5-10. 50th-percentile uranium in urine for Y-12.

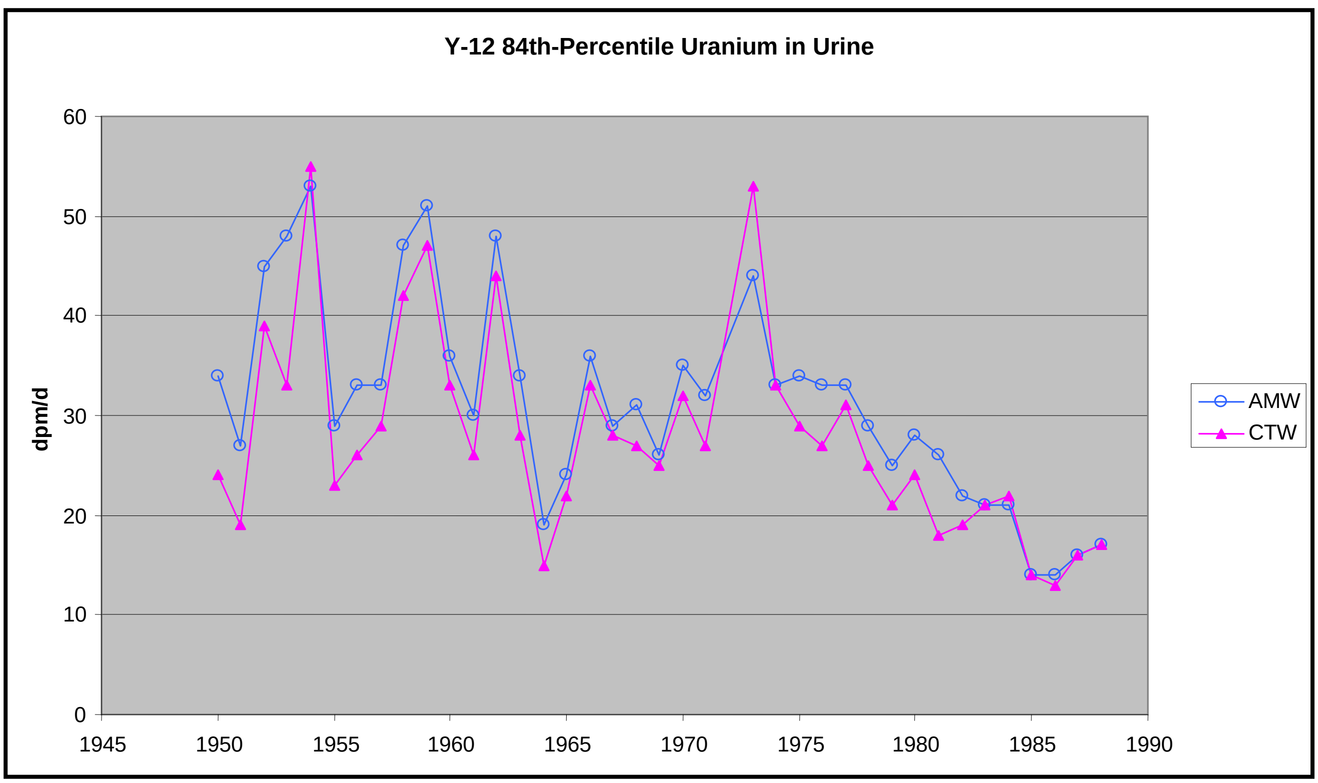

Figure 5-11. 84th-percentile uranium in urine for Y-12.

5.9 K-25 PENETRATING DOSE COMPARISON

External dose data for K-25 are taken from the ORISE CER database (ORAUT 2005c). The records in this database include external radiation exposure measurement results pertinent to the health and safety monitoring of employees and contract employees of the DOE and its predecessor organizations. Data on CTWs were obtained using a query designed to extract job titles associated with construction work. (See Section 5.7 for details on the data query.)

Figure 5-12 shows the data for the 95th-percentile penetrating dose for both monitored CTWs and AMWs for the period beginning in 1943 and ending in 1988. Figure 5-12 shows that the annual penetrating dose received by the monitored CTWs at K-25 is adequately bounded by the doses received by AMWs at K-25.

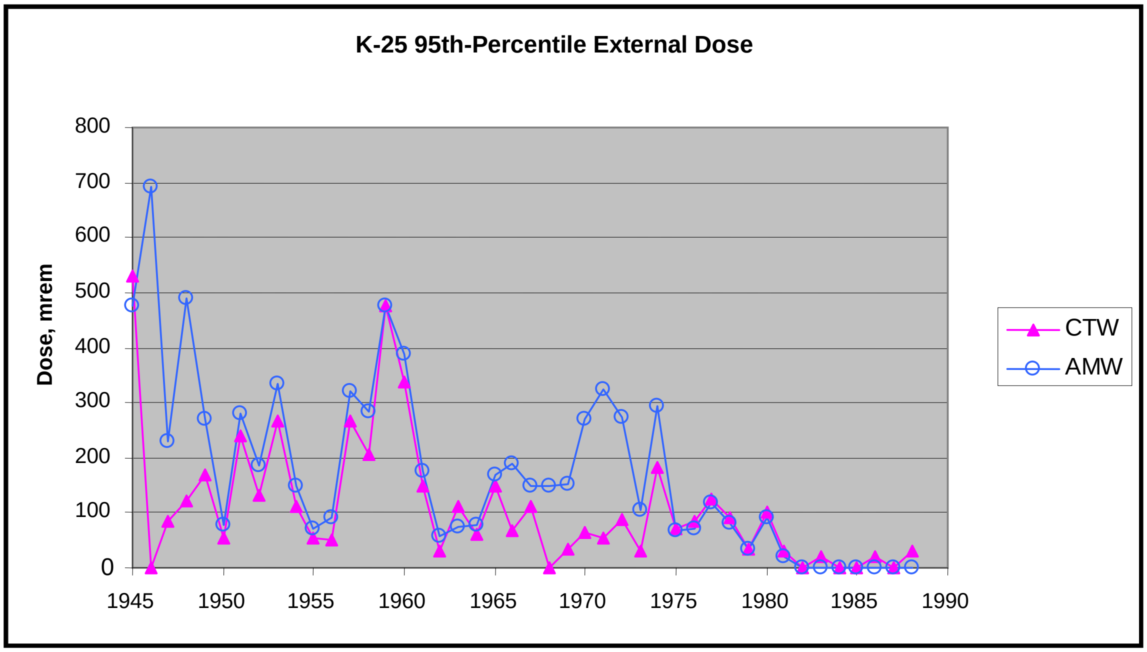

Figure 5-12. 95th-percentile penetrating dose for K-25.

5.10 K-25 INTERNAL DOSE COMPARISON

Bioassay results for uranium in urine samples for personnel who worked at K-25 are taken from the ORISE CER database (ORAUT 2005c). Data on CTWs were obtained using a query designed to extract job titles associated with construction work. (See Section 5.7 for details on the data query.)

The 50th and 84th percentile of these bioassay results are shown in Figures 5-13 and 5-14, respectively. In general, there is good agreement between the sample results for CTWs and AMWs.

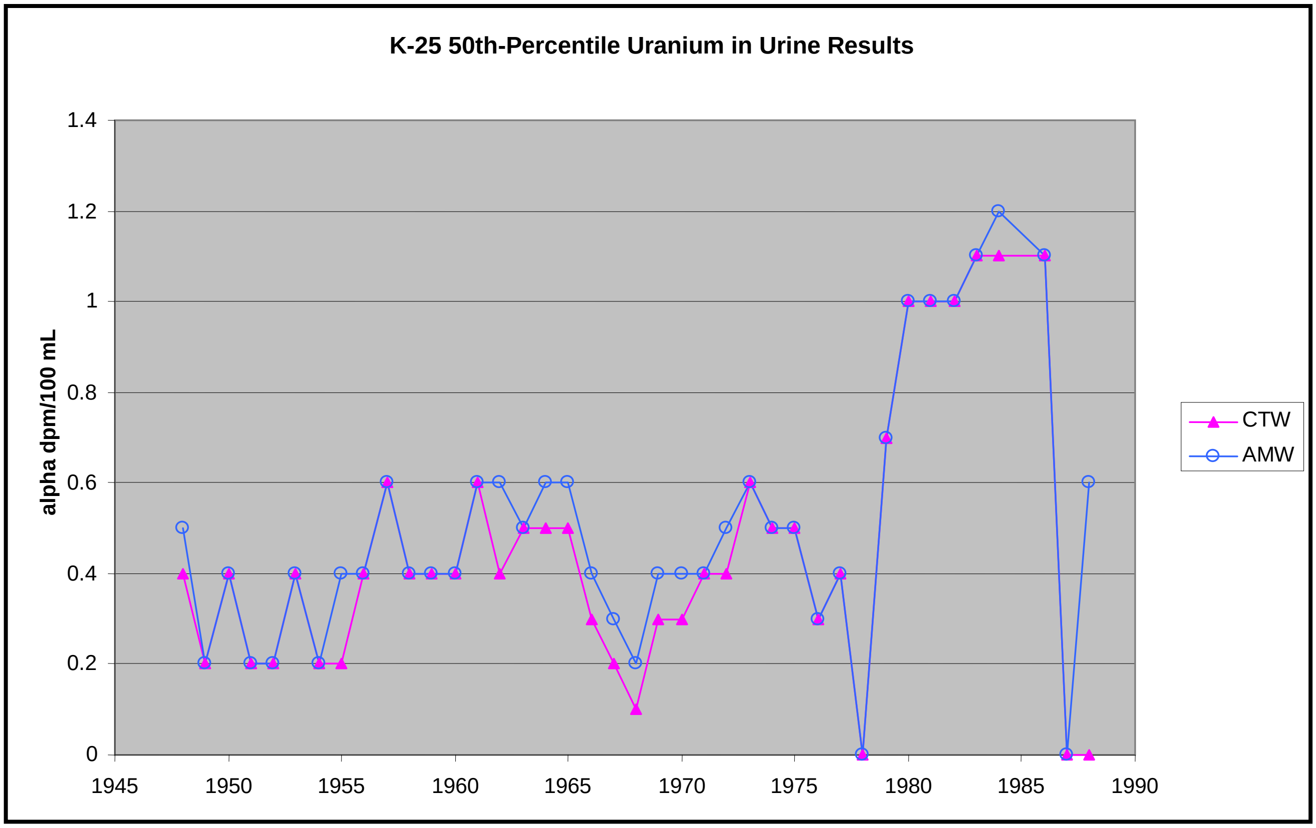

Figure 5-13. 50th-percentile uranium in urine for K-25.

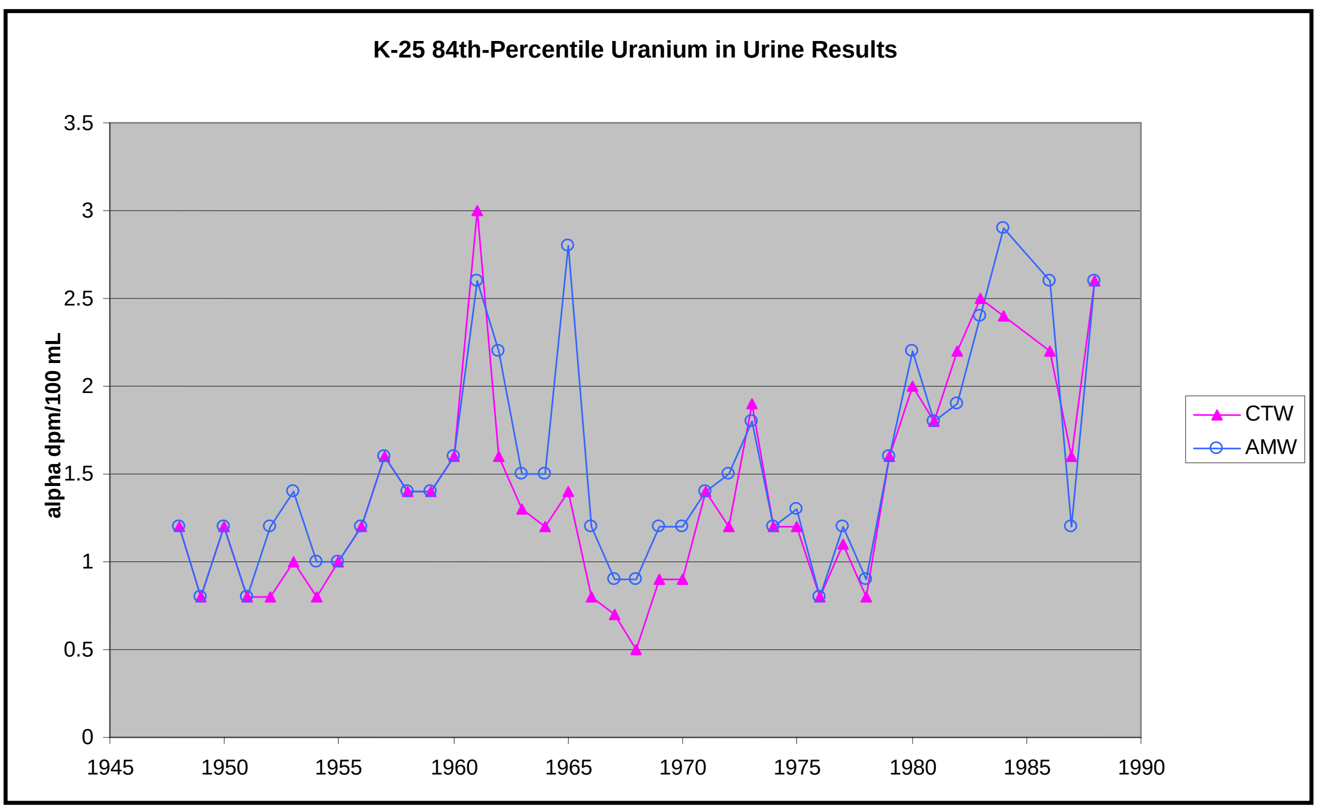

Figure 5-14. 84th-percentile uranium in urine for K-25.

5.11 ORNL PENETRATING DOSE COMPARISON

External dose data for ORNL are taken from the ORISE CER database (ORAUT 2005c). The records in this database include external radiation exposure measurement results pertinent to the health and safety monitoring of employees and contract employees of the DOE and its predecessor organizations. Data on CTWs were obtained using a query designed to extract job titles associated with construction work. (See Section 5.7 for details on the data query.)

Figure 5-15 shows the 95th-percentile annual penetrating dose for both monitored CTWs and AMWs at the ORNL for the period from 1943 through 1988.

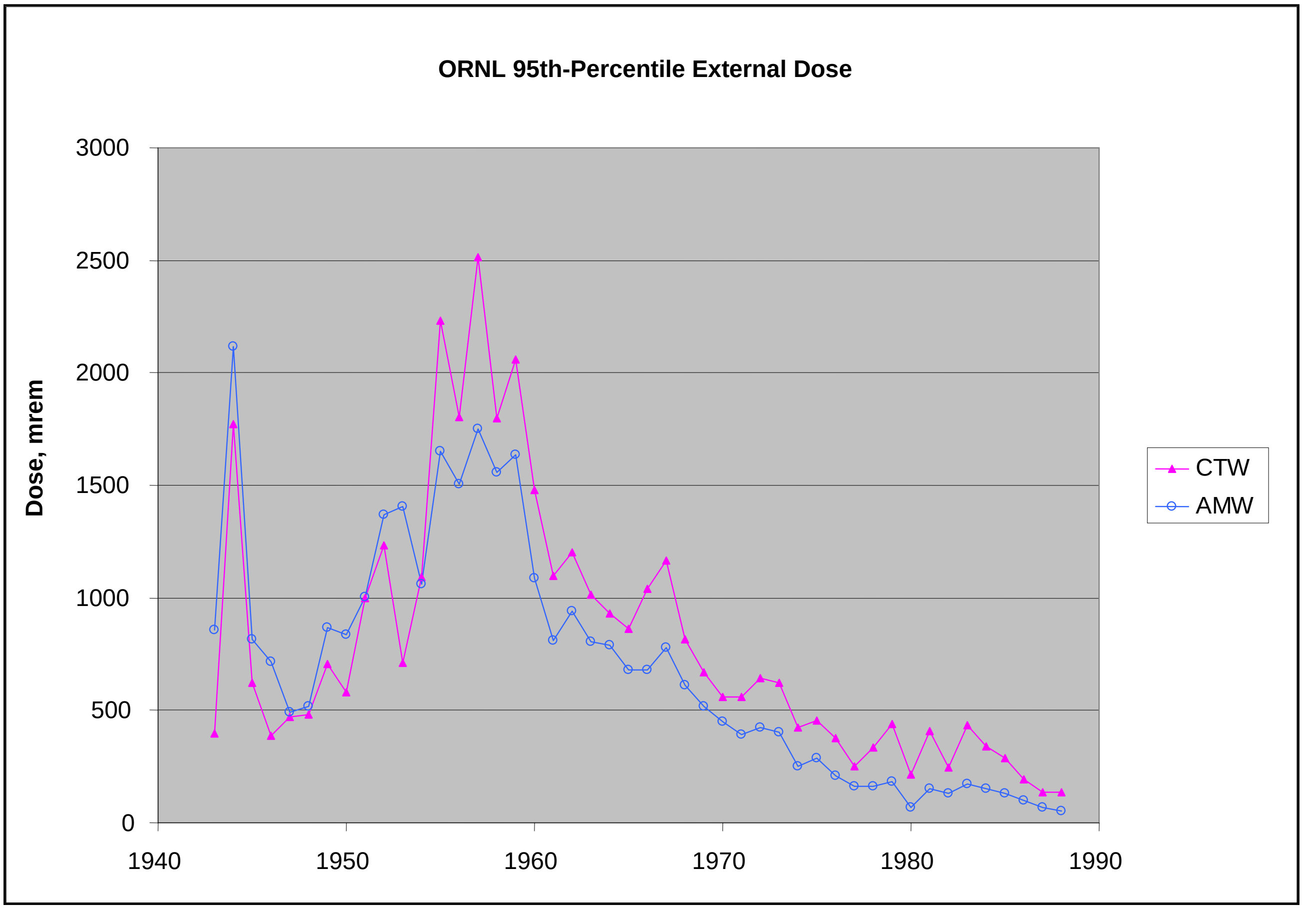

Figure 5-15. 95th-percentile penetrating dose for ORNL.

Table 5-3 lists the observed ratios that are greater than 1.2 for CTWs and AMWs at ORNL.

Table 5-3. Observed ratios for ORNL.

Year	CTWs			AMWs			Observed ratios (CTWs/AMWs)
	Number monitored	Number with measurable dose	95th-percentile dose (mrem)	Number monitored	Number with measurable dose	95th-percentile dose (mrem)	
1955	604	470	2231	3931	**2193**	1650	1.4
1957	623	608	2515	4277	**3734**	1750	1.4
1959	704	696	2058	4698	**4350**	1636	1.3
1960	682	618	1480	4793	**3427**	1087	1.4
1961	695	627	1096	4779	**3785**	810	1.4
1962	722	696	1200	4953	**4591**	940	1.3
1963	750	681	1015	5174	**4243**	803	1.3
1965	817	551	864	5646	**2930**	680	1.3
1966	822	582	1040	5972	**2765**	680	1.5
1967	878	585	1163	6252	**2657**	780	1.5
1968	852	542	814	5981	**2303**	610	1.3
1969	808	403	670	5809	**1754**	516	1.3
1971	725	318	558	5154	**1428**	390	1.4
1972	691	289	645	5097	**1203**	422	1.5
1973	661	315	620	4984	**1336**	400	1.6
1974	739	363	421	5407	**1611**	250	1.7
1975	767	283	457	5788	**1129**	290	1.6
1976	784	268	378	6123	**1169**	210	1.8
1977	804	228	250	6434	**1042**	160	1.6
1978	798	206	333	6660	**899**	160	2.1
1979	776	209	440	6357	**915**	182	2.4
1980	754	130	214	6480	**635**	70	3.1
1981	723	170	409	6313	**606**	150	2.7
1982	667	119	247	5782	**480**	130	1.9
1983	608	146	436	5562	**489**	170	2.6
1984	602	144	339	5610	**522**	150	2.3
1985	585	139	288	5641	**502**	130	2.2
1986	514	94	193	4998	**430**	100	1.9
1987	482	92	138	4894	**382**	70	2.0
1988	484	91	134	5102	**372**	50	2.7

5.12 ORNL INTERNAL DOSE COMPARISON

Bioassay results for urine samples for personnel who worked at Oak Ridge National Laboratory are taken from the Oak Ridge Institute for Science and Education (ORISE) Center for Epidemiology Research (CER) database (ORAUT 2005c). Data on CTWs were obtained using a query designed to extract job titles associated with construction work. (See Section 5.7 for details on the data query.)

From 1951 through 1964 plutonium in urine was measured as gross alpha. From 1965 to 1987 the analysis method became specific for plutonium. The 50th percentile and 84th percentile of these bioassay results are shown by year in Figures 5-16 and 5-17, respectively.

Uranium in urine was also measured at ORNL. Figures 5-18 and 5-19 show the results of the median and 84^{th} percentile for this analysis, respectively.

In general, there is good agreement between the CTW and AMW data for both plutonium and uranium at the 50th and 84th percentile.

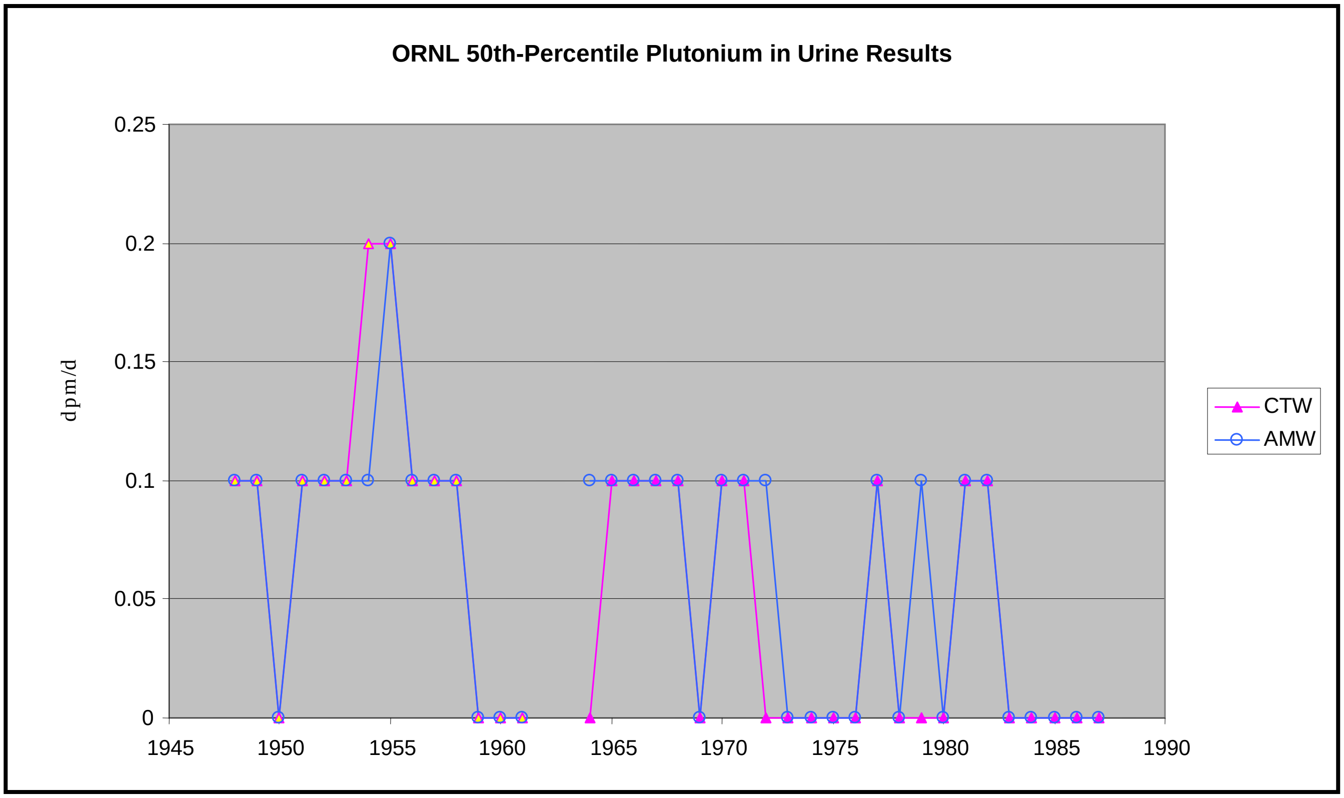

Figure 5-16. 50th-percentile plutonium in urine for ORNL.

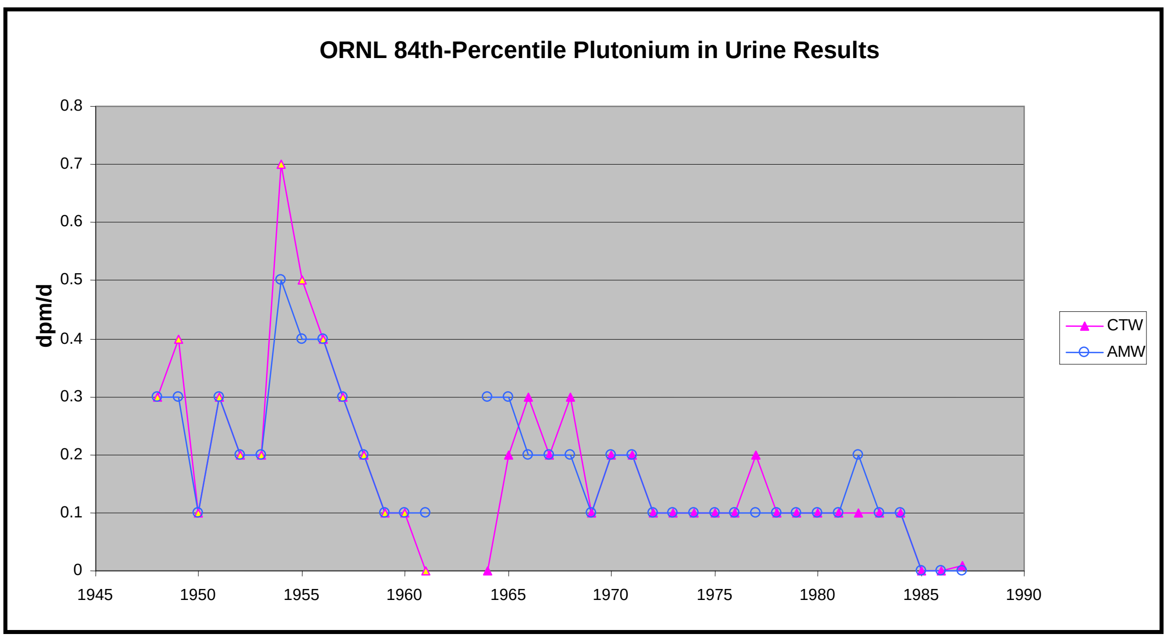

Figure 5-17. 84th-percentile plutonium in urine for ORNL.

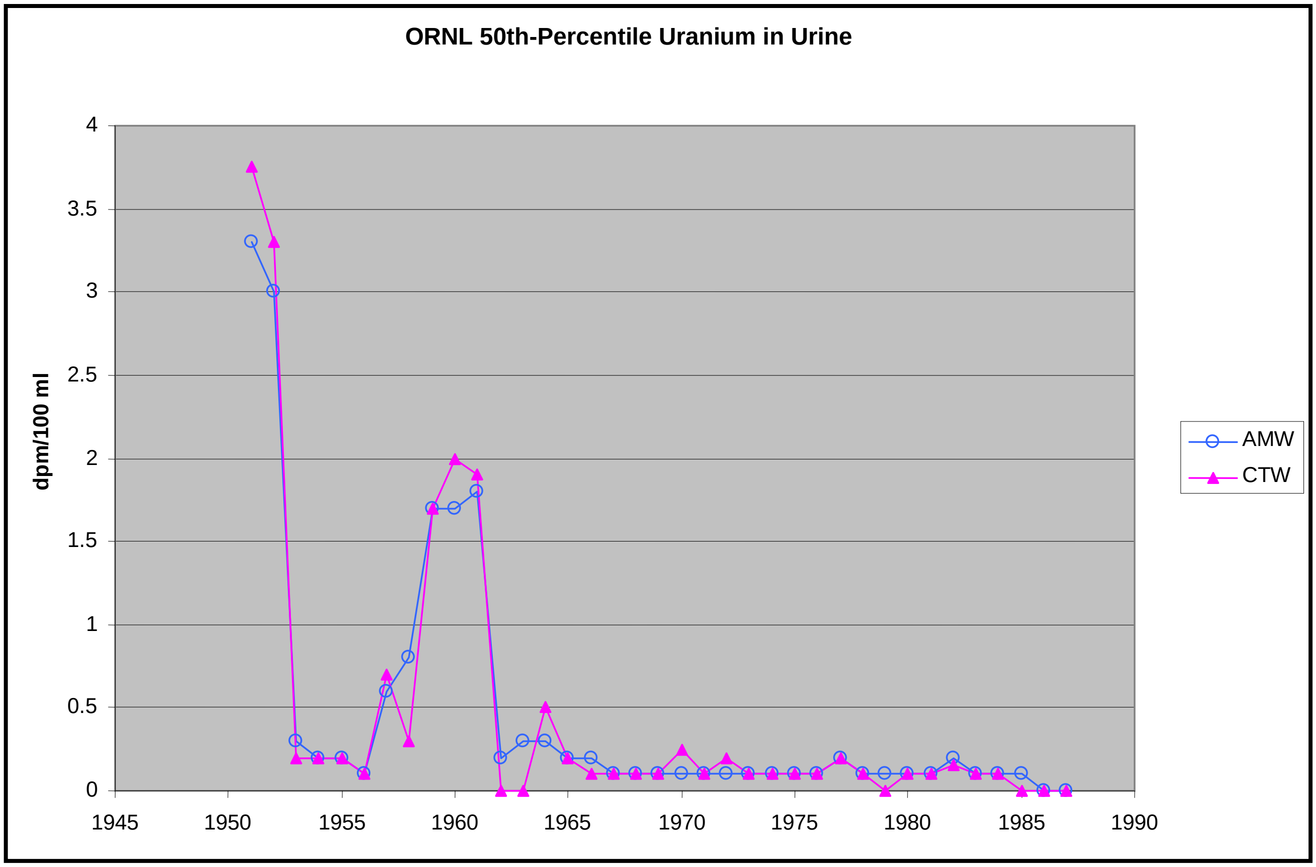

Figure 5-18. 50th-percentile uranium in urine for ORNL.

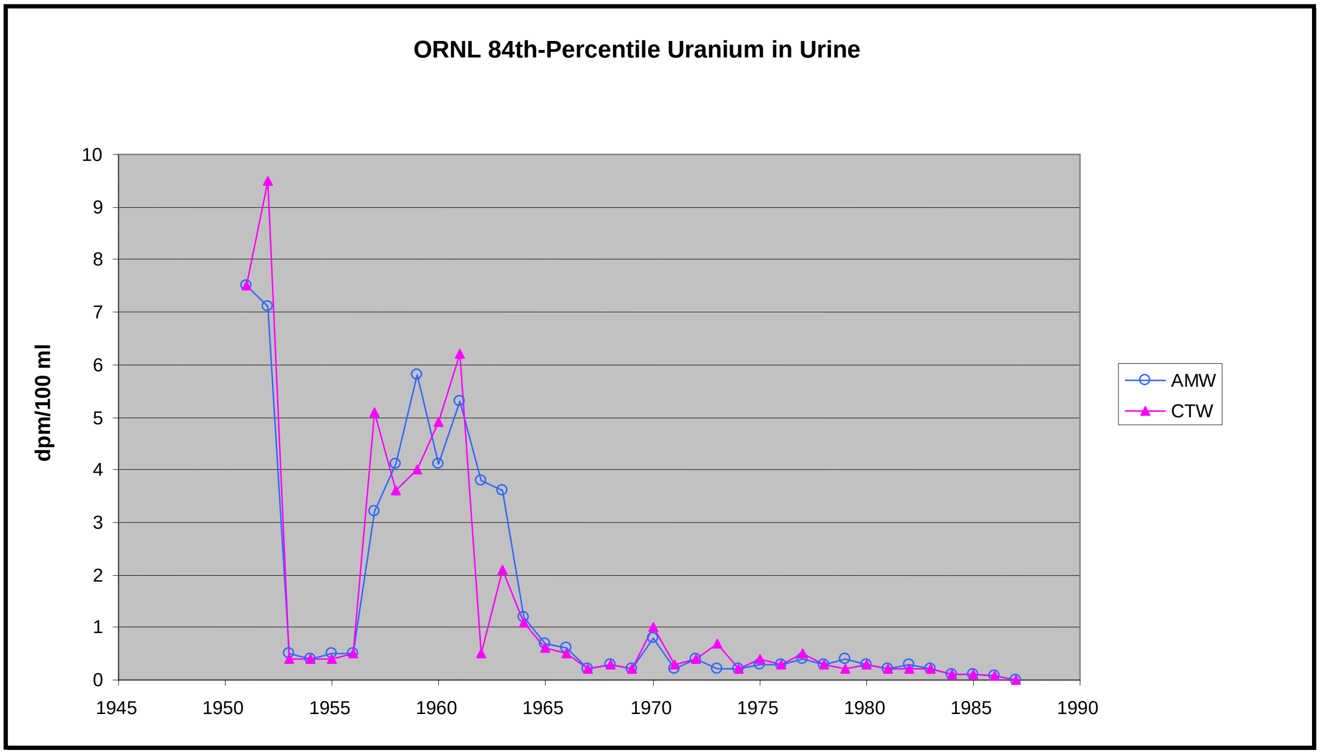

Figure 5-19. 84th-percentile uranium in urine for ORNL.

5.13 INL PENETRATING DOSE COMPARISON

Penetrating doses for INL are presented in Figure 5-20 for the period beginning in 1974 and ending in 2005. Radiation exposure data prior to 1974 was not available. However, in "Occupational Radiation Exposure History of Idaho Field Office Operations at the INEL," John R. Horan and Julie B. Braun discuss construction worker exposures during the early period: "[Construction personnel] exposures were negligible during the first decade and were almost all below 0.5 rem/yr thereafter."

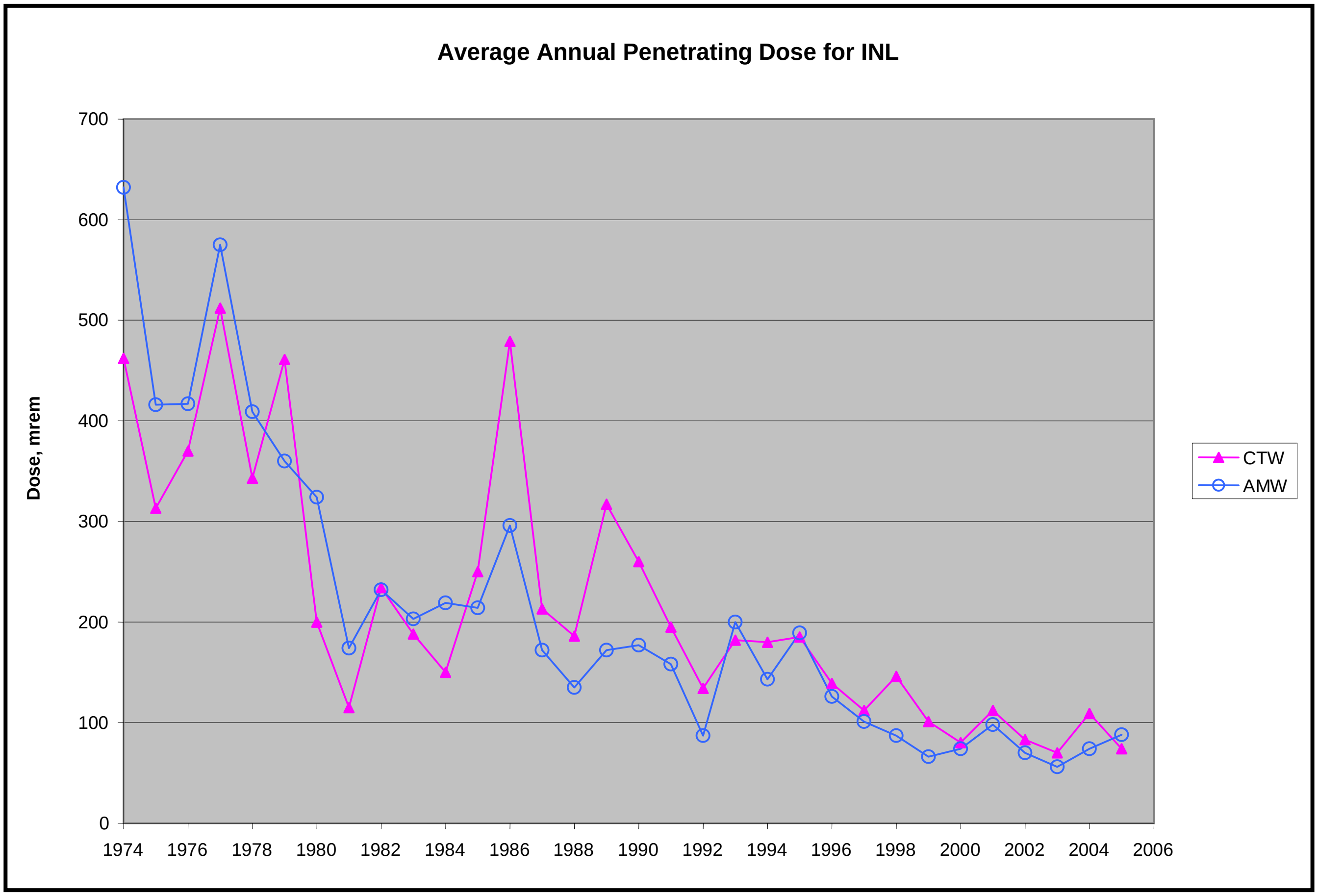

Figure 5-20. Mean value for penetrating dose for INL.

Table 5-4 lists the observed ratios that are greater than 1.2 for CTWs and AMWs at INL.

Table 5-4. Observed ratios for INL.

Year	CTWs			AMWs			Observed ratios (CTWs/AMWs)
	Number monitored	Number with measurable dose	Average dose (mrem)	Number monitored	Number with measurable dose	Average dose (mrem)	
1979	953	396	461	5097	2407	360	1.3
1986	1321	536	479	5956	1994	296	1.6
1988	463	311	186	4813	1751	135	1.4
1989	416	263	317	5385	1829	172	1.8
1990	430	223	260	6033	1960	177	1.5
1992	427	157	134	5889	1007	87	1.5
1994	418	211	180	6006	1659	143	1.3
1998	384	104	146	5075	743	87	1.7
1999	565	95	101	8885	729	66	1.5
2003	422	155	70	4682	1141	56	1.3
2004	428	186	109	3853	1471	74	1.5

5.14 INL INTERNAL AND NON-PENETRATING DOSE COMPARISON

Data for internal exposures for workers at the INL was not available. However, Horan and Braun's report briefly discusses non-penetrating and internal exposures, and indicates that they were traditionally negligible: "Non-penetrating radiation exposure to the skin from soft X-rays or Beta particles were also not included along with irradiation by internally deposited radionuclides since historically they have been extremely rare events and as a result a very minor contributor to the effective dose."

6.0 HANFORD SITE

Hanford was the first facility to generate and separate special nuclear material for weapons production. As such, Hanford can be viewed as a type of R&D facility where chemical separation and reactor process were one-of-a-kind experimental prototypes. As the research/information base grew and new chemical processes were developed, contaminated facilities were retrofitted or replaced to accommodate the new processes. It is postulated that this practice was responsible for elevated doses to the CTWs. Consequently, adjustment factors are developed to augment the dose to the CTWs during specific time periods.

6.1 HANFORD SITE PENETRATING DOSE COMPARISON

The data were extracted from various sources including a scientific paper (Keene 1960), a series of annual reports based on AEC Form 190 (Heffelbower 1963–1970), a series of letter reports (Annual Radiation Exposure Summary to USAEC from the Manager, Radiation Protection, Hanford Laboratory), the annual summary reports of radiation exposures (see Summary Annual Reports in the References Section), the REMS database (DOE 2006), and a Hanford coworker study of external dose (ORAUT 2005e).

The data from Keene (1960) for the period from 1944 through1959 consists of the fourteen job categories that have the highest accumulated dose for that time period. Five of the job categories are assumed to represent CTWs. The number of workers, the average service in years, and the average dose is provided for each job category. From these data, average doses per year are calculated for CTWs and AMWs. Starting in 1960, reports generally present the annual dose in ranges (e.g., 0 – 1 rem, 1 – 2 rem, etc.). In those instances, the value of the midpoint of each range was used to calculate the average dose.

For the period from 1991 through 2005 the doses for the CTWs and AMWs are determined using the REMS database. The annual collective penetrating dose is determined by subtracting the collective committed effective dose equivalent (if any) from the collective total effective dose equivalent (person-mrem). The average penetrating dose is determined by dividing the annual dose by the number of workers with measured dose.

For the CTWs, the annual dose is determined by summing the annual doses for the REMS “Construction” and “Laborer” labor categories. The workers in the REMS “Laborers” category are segregated by the reporting organizations. The annual doses reported by the organizations that are not the M&O contractor are summed and added to the annual dose for the REMS “Construction” category. Doses in the range less than 100 mrem are not included. This eliminates most visitors and administrative personnel from the REMS data. The average annual dose for CTWs is determined by dividing the annual dose for the “Laborers” and the “Construction” categories by the number of workers in those categories with measurable dose.

For AMWs, the average annual dose is determined by summing the annual doses in the REMS “All” category (i.e., management, scientists, service, etc.) and dividing that sum by the sum of workers who had measured dose in the “All” category.

Penetrating doses for monitored CTWs and AMWs are shown in Figure 6-1. Table 6-1 lists the observed ratios that are greater than 1.2 for CTWs and AMWs at Hanford. As indicated in the graph and table, the doses for the CTWs and AMWs are comparable with two exceptions: the period from 1968 through 1981 and the period from 1985 through 1988. These time periods generally coincide with the increased work activity associated with the shut-down of the production reactors from 1968 through 1981 and the restart of the Purex Plant from 1985 through 1988. Due to the nature and time period for this work, it is unlikely that any unmonitored CTWs were involved. Therefore, these data points were not considered as representative and meaningful for the purposes of this OTIB.

6.2 HANFORD SITE INTERNAL DOSE COMPARISON

An internal dosimetry coworker study that includes both CTWs and AMWs has been published for the Hanford site (ORAUT 2006). The database used to develop the coworker study had limited descriptive information for workers such that data for CTWs cannot be identified before 1965. For the period from 1965 through 1978, plutonium data for CTWs is identified by a company-field in the database. These data were processed in accordance with ORAUT 2006 to develop datasets for CTWs. For the period from 1965 through 1975, the datasets were analyzed annually as opposed to quarterly due to their small size. For the period from 1975 through 1978, the datasets were grouped and analyzed together. (See ORAUT 2006 for additional details.)

For the period from 1978 through 1989, the plutonium data for CTWs is very limited and appears to consist mainly of special samples following incidents. Where it was appropriate, duplicates and data for highly exposed individuals were removed since these data are not truly representative of CTWs as a group. However, no attempt was made to remove all special (follow-up) results. This approach in reviewing and qualifying the data recognized that small intakes were essentially a part of routine operations. As in ORAUT (2006), results with volumes less than 400 mL were not used in the statistics.

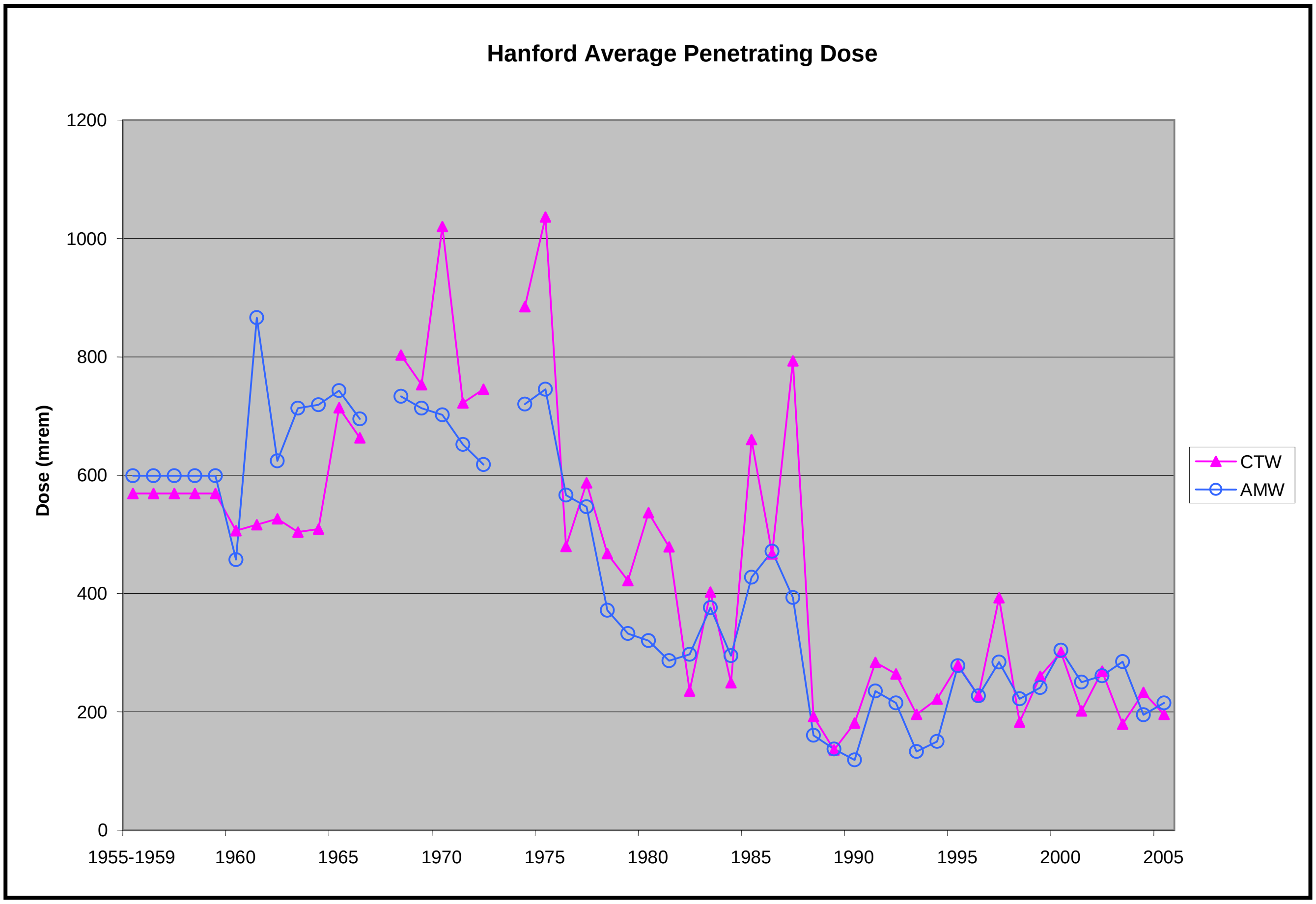

Figure 6-1. Average annual penetrating dose for Hanford.

The results were assumed to be lognormally distributed and were analyzed using the basic techniques for coworker studies described in ORAUT-OTIB-0019, *Analysis of Coworker Data for Internal Dose Assignment* (ORAUT 2005d). The resultant 50th- and 84th-percentile values were multiplied by 0.835 to convert total plutonium alpha to ^{239}Pu activity, assuming 10-yr-aged fuel-grade plutonium. This conversion was necessary to make the results directly comparable to the values in ORAUT (2006).

The Hanford data-forms included a field to enter the reason for the bioassay ("reason code"). Unfortunately, this field was not used consistently over the years in question. Nor was it reported in the Hanford coworker study. It appears that a high percentage of special bioassay samples may have biased the data for the years where the data for CTWs is higher than the data for AMWs. The maximum difference between the CTW data and the AMW data was about a factor of two, but, as is evident in Figures 6-2 and 6-3, the difference varied from year to year. It appears that applying a factor of two to the intake rates in the Hanford coworker study is favorable to construction worker claimants.

The results of the analysis and the data from ORAUT (2006) appear in Figures 6-2 and 6-3.

Table 6-1. Observed ratios and average penetrating dose for CTWs and AMWs at Hanford.

Year	CTWs			AMWs		Observed ratios (CTWs/AMWs)
	Number monitored	Number with measurable dose	Average dose (mrem)	Number with measurable dose	Average dose (mrem)	
1970	1,365	1,158	1,020	10,053	702	1.5
1975	408	402	1,036	3,578	745	1.4
1978	1,917	1,864	467	6,882	372	1.3
1979	1,915	1,770	422	7,517	332	1.3
1980	1,585	1,437	537	6,917	320	1.7
1981	1,542	1,386	479	7,182	286	1.7
1985	1,642	808	660	5,954	427	1.5
1987	1,804	1,225	793	6,697	393	2.0
1990	934	428	181	3,753	119	1.5
1993	1,351	556	196	3,147	133	1.5
1994	1,696	567	222	3,166	150	1.5
1997	1,022	366	393	2,058	284	1.4

1960-1973 from various Hanford letter reports
1975-1990 from DOE annual dose reports
1991-2005 from the DOE REMS database

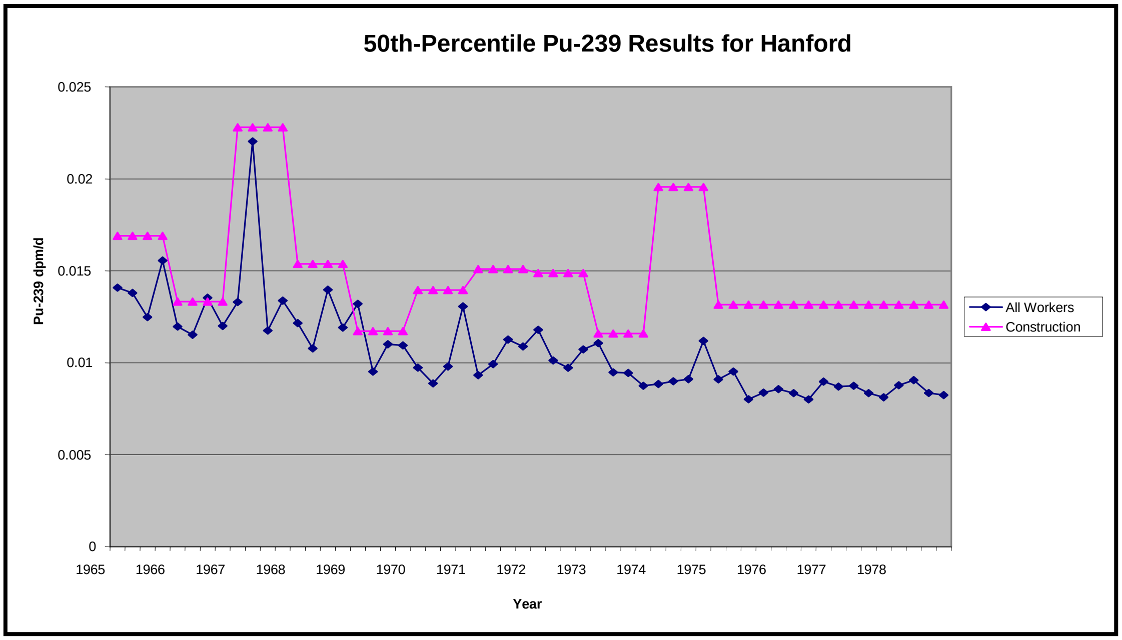

Figure 6-2. 50th-percentile for Pu-239 in urine for Hanford.

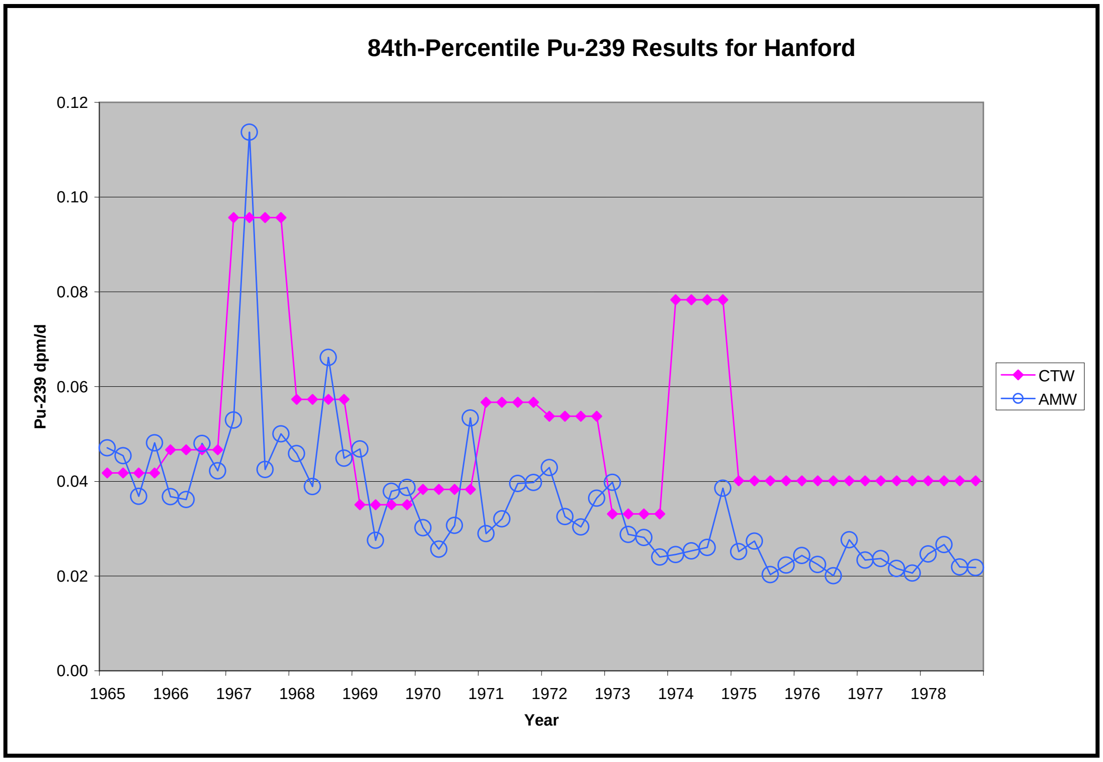

Figure 6-3. 84th-percentile for Pu-239 in urine for Hanford.

7.0 CONCLUSIONS

Comparisons between the doses received by CTWs and AMWs have shown that, with some exceptions and conditions, the dose received by the monitored CTWs was usually bounded by the dose received by AMWs on the same site.

This relationship between the doses received by CTWs and AMWs can be combined with the premise that the nature of the construction work (e.g., carpentry, masonry, pipe-fitting, etc.) performed by unmonitored CTWs was not significantly different (from a radiation protection perspective) than the construction work activity performed by monitored CTWs. Doses to monitored CTWs can therefore serve as an acceptable surrogate for doses to unmonitored CTWs.

An analysis of the specific DOE sites identified specific years that CTWs doses exceeded AMWs doses. To address these instances, an adjustment factor is needed.

7.1 PRESCRIBED EXTERNAL ADJUSTMENT FACTOR FOR ALL DOE FACILITIES

Due to limitations on the availability and specificity of CTW and AMW data from other DOE sites, this OTIB presents a limited analysis and comparison of CTW and AMW data. In order to reconcile this limited data analysis with the site-specific comparisons that indicate that external doses to CTWs occasionally exceeded doses to AMWs, a prescribed adjustment factor is needed for dose reconstructions for unmonitored CTWs.

The prescribed external dose adjustment factor was based on consideration of the relative magnitude and trend in CTW and AMW doses shown in Figure 5-1, specifically:

- CTW doses occasionally exceeded AMW doses during the late 1980s and 1990s. However, this reflects work within the DOE complex when radiation protection programs were well established and nearly all potentially exposed workers were monitored. Furthermore, these occasional exceedances have been identified as artifacts caused by a large number of AMWs with no measurable dose.

- CTW doses were significantly lower than AMW doses for an extended period that started in 1961. This indicates that the adjustment factor should be based on instances where CTW doses exceeded AMW doses prior to 1961.

- The values for pre-1961 adjustment factors range from 1.3 to 1.4.

- The maximum value of 1.4 was selected as the prescribed favorable to claimant external dose adjustment factor (i.e., dose multiplier) for all DOE facilities for all years.

8.0 LIMITATIONS AND APPLICATIONS

8.1 LIMITATIONS

The application of the conclusions and adjustment factors derived in this document are limited to dose reconstructions for unmonitored construction workers at sites with applicable coworker data or an acceptable method for dose reconstruction for unmonitored workers.

8.2 GUIDANCE ON THE DETERMINATION OF PENETRATING DOSE FOR UNMONITORED CTWS

Use the guidance in ORAUT-OTIB-0020 to assign a penetrating dose that is favorable to unmonitored CTWs. The value of the measured dose 95th percentile should be used unless there is compelling evidence to use another coworker percentile value. Apply an adjustment factor of 1.4 to the appropriate percentile of the measured coworker data for the site, plus the assigned coworker missed dose, to determine the total assigned penetrating dose that is favorable to unmonitored CTWs.

For non-prime CTWs, the dose reconstruction method should use applicable coworker doses and the adjustment factor. For any prime CTWs that have unmonitored periods where they should have been monitored, the dose reconstruction method should use coworker doses with the adjustment factor of 1.4.

8.3 GUIDANCE ON THE DETERMINATION OF NON-PENETRATING DOSE FOR UNMONITORED CTWS

Based on the comparison from SRS and Rocky Flats, the 95th percentiles for the annual non-penetrating doses in the other coworker studies may be used to assign annual non-penetrating dose to those CTWs whose dose history is either unavailable or incomplete unless there is compelling evidence to use another coworker percentile value.

Due to a lack of data, it was not possible to provide a comparison of non-penetrating doses from Hanford. Dose reconstructors should not apply any adjustment factors for non-penetrating dose.

8.4 GUIDANCE ON THE DETERMINATION OF INTERNAL DOSE

For Hanford dose reconstructions covered by this OTIB, the intake rates in the Hanford coworker document should be multiplied by a factor of two.

For all other sites, the internal dose should be determined using the same method that is applied to all other workers. If coworker data studies are available for a site, the 50th percentile should be used with the appropriate GSD unless there is compelling evidence to use another coworker percentile value.

8.5 GUIDANCE ON THE DETERMINATION OF OCCUPATIONAL MEDICAL DOSE

Dose reconstructors should review the claim file for X-ray records.

1. If there are X-ray records in the file, the dose reconstructor should use the Technical Basis Document (TBD) for the site where the worker performed the work to assign X-ray dose. For example, a worker who worked for Atkinson/Jones at Hanford could have X-ray records in his/her file. The X-ray dose should be assigned from the Hanford TBD organ dose tables.

2. For sites where “X-ray records do not exist” is indicated and there are in fact no-X-ray records in the file or for sites that are not currently including X-ray records, such as Y-12 and INL, the dose reconstructor should use the TBD for the site where the worker performed the work to assign the frequency or X-ray procedures that are clearly not a result of work-related injury. However, since these procedures may have been performed off-site, the assigned organ doses should come from *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (ORAUT 2005f). All X-ray procedures in this category should be assumed to be standard X-rays (not PFG) since PFG was an X-ray technique suitable to screening large groups of people at one time. Assuming the X-rays were performed off-site at a local clinic or hospital, it is unlikely that this screening occurred en masse with PFG.

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