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RECORD OF ISSUE/REVISIONS			
ISSUE AUTHORIZATION DATE	**EFFECTIVE DATE**	**REV. NO.**	**DESCRIPTION**
12/07/2006	12/07/2006	0	New document initiated by David Allen to extend OTIB-38.

1.0 INTRODUCTION

Technical Information Bulletins (TIBs) are general working documents that provide guidance concerning the preparation of dose reconstructions at particular sites or categories of sites. They will be revised if additional relevant information is obtained. TIBs may be used to assist the National Institute for Occupational Safety and Health (NIOSH) 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[1] [DOE] facility" as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 [42 U.S.C. § 7384l(5) and (12)].

A Technical Information Bulletin (TIB) that analyzes Internal Dosimetry Co-worker data at the Rocky Flats Environmental Technology Site (RFETS) was previously completed (ORAUT 2006). That document analyzed the data from the beginning of operations at the site to 1988. For that effort, data was obtained from the Comprehensive Epidemiologic Data Resource (CEDR) repository of data.

In order to extend the analysis beyond 1988, data was obtained from the Rocky Flats site's HIS-20 database. The purpose of this TIB is to extend the previous TIB (ORAU 2006) utilizing the same methodology.

2.0 PURPOSE

Some employees at DOE sites were not monitored for internal ionizing radiation exposure or the records of such monitoring are incomplete or unavailable. In such

[1] References to DOE in this document include DOE and its predecessor agencies: the Manhattan Engineer District (1942 to 1946), the U.S. Atomic Energy Commission (1947 to 1975), the Energy Research and Development Administration (1975 to 1977), and DOE (1977 to the present).

cases, data from monitored coworkers can be used to estimate an individual's possible exposure. The purpose of this TIB is to provide monitored coworker information for calculating and assigning occupational internal doses to employees at RFETS for whom no or insufficient bioassay monitoring records exist.

3.0 DATA OVERVIEW

Urinalysis data for uranium and plutonium from 1989 to 2005 were extracted from the Rocky Flats Plant's HIS-20 database. Both the uranium and plutonium results were recorded as dpm/24 hr. Values were recorded as indicated by the analysis, that is, the actual results of the analyses were recorded even if it was a negative number. Since this analysis assumes the data can be represented by a lognormal distribution, the data had to be log transformed. This required the zero and negative results to be treated as censored values.

In vivo **^{241}Am lung data** was not addressed in this TIB. The number of samples dropped significantly in 1990.

Bioassay data were analyzed by quarter or year, depending on the amount of data available during the periods. A lognormal distribution was assumed. After log transforming the data, the 50th and 84th percentiles were determined for each period using the method described in ORAUT (2004a). Tables A-1 and A-2 in Attachment A show the statistical analysis results for uranium and plutonium respectively.

4.0 INTAKE MODELING

This section discusses intake modeling assumptions, intake fitting, and the intake materials (uranium and plutonium).

4.1 ASSUMPTIONS

Each result used in the intake calculations was assumed to be normally distributed. A uniform absolute error of 1 was applied to all results, thus assigning the same weight to each result. Because of the nature of work at RFETS, it is possible that intakes could have been either chronic or acute. However, a series of acute intakes can be approximated as a chronic intake. Therefore, intakes were assumed to be chronic and were assumed to occur through inhalation, using a default breathing rate of 1.2 m^3/hr and a 5-µm activity median aerodynamic diameter particle size distribution.

4.2 BIOASSAY FITTING

The IMBA Expert OCAS-Edition computer program was used to fit the bioassay results to a series of inhalation intakes. Data from 1989 through 2005 were fit as a series of chronic intakes.

The intake assumptions were based on patterns observed in the bioassay data. Periods with constant chronic intake rates were chosen by selecting periods where the bioassay results were similar. A new chronic intake period was started if the data indicated a

significant sustained change in the bioassay results. By this method, 1989 through 2005 was divided into multiple chronic intake periods.

4.3 MATERIAL TYPES

ORAUT (2004c) discusses Rocky Flats internal dosimetry data for the dose reconstructor, including guidance for the appropriate use of that information. Workers at Rocky Flats had the potential to receive intakes of plutonium, americium, enriched uranium, and depleted uranium. Site-specific internal dosimetry information for other radionuclides is rare or not available (ORAU 2004c).

4.3.1 Uranium

Because the uranium isotopes present at RFETS have very long radiological half-lives, and the material is retained in the body for long periods, excretion results are not independent. For example, an intake in the 1950s could contribute to urinary excretion in the 1980s and later. To avoid potential underestimation of intakes for people who worked at RFETS for relatively short periods, each chronic intake was fit independently, using only the bioassay results from the single intake period. This method will result in an overestimate of intakes for exposures extending through multiple assumed intake periods. Only the results within the intake period were selected for use in fitting each period. Excluded results are shown in light gray in the figures in Attachment B.

Uranium urinalysis results were analyzed with IMBA to derive intake rates for 1989 to 2005. Excretion data are shown in Table A-1. The solid lines in Figures B-1 and B-2 show the individual fits to the 50th-percentile excretion rates for type F material. Figure B-3 is the combined fit for all the intake periods. Figure B-4 shows the overall fit to the 84th-percentile excretion rates for type F material. The same intake periods were applied for both percentiles because the values followed a similar pattern. Similarly, Figures B-5 and B-6 show the individual fits to the 50th-percentile excretion rates for type M material. Figure B-7 is the combined fit for all the intake periods. Figure B-8 shows the overall fit to the 84th-percentile excretion rates for type M material. Figures B-9 and B-10 show the individual fits to the 50th-percentile excretion rates for type S material. Figure B-11 is the combined fit for all the intake periods. Figure B-12 shows the overall fit to the 84th-percentile excretion rates for type S material. Table B-1 tabulates the derived intake rates for Types F, M, and S materials at both the 50^{th} and 84^{th} percentiles levels along with the associated GSDs.

4.3.2 Plutonium

Plutonium urinalysis results were analyzed with IMBA using type M and S materials to derive intake rates for 1989 to 2005. Figures B-13 and B-14 show the individual fits to the 50th-percentile excretion rates for type M material. Figure B-15 is the combined fit for all the intake periods. Figure B-16 shows the overall fit to the 84th-percentile excretion rates for type M material. The same intake periods were applied for both percentiles because the values followed a similar pattern. Table B-2 lists the 50^{th} percentile and 84^{th} percentile intake rates along with the associated GSD determined from plutonium urinalysis for Type M material.

Plutonium Type S—Because type S plutonium clears slowly from the lungs, the plutonium exposure was fit as a single chronic intake based on the bioassay measurements from 1994 through 2005. This period was used because the measurements were relatively consistent; in addition, the values are relatively low so the intake rate represents a minimum. Figures B-17 and B-18 show the plutonium Type S 50th- and 84th-percentile excretion rates, respectively. Table B-3 lists the 50th percentile and 84th percentile intake rates along with the associated GSD determined from the plutonium urinalysis.

The type S intake rate can only be used as an *underestimate*. This underestimate should be used if the individual was employed after 1988. If the individual's full employment occurred prior to 1989, the underestimated type S intake from ORAUT 2006 should be used. If an *overestimate* or best estimate is needed for type S material, an individualized fit to the bioassay data for the specific work period of the energy employee being evaluated must be performed. Table A-2 provides the bioassay data to be used to perform the individualized fit.

5.0 ASSIGNING INTAKES AND DOSES

This section describes the derived intake rates and provides guidance for assigning doses.

5.1 INTAKE RATE SUMMARY

Two intake periods were fit to the derived 50th- and 84th-percentile uranium excretion data. Table 5-1 summarizes the derived uranium intake rates that produced the fits.

Two intake periods were fit to the data for type M material and one was fit for type S material to the derived 50th- and 84th-percentile plutonium excretion data. Table 5-2 summarizes the derived plutonium intake rates that produced the fits. Because of the interdependence between the bioassay results, it is not possible to fit type S plutonium to the data in a manner that would be representative of all individuals for all time periods. Therefore, only a minimizing intake has been calculated for type S plutonium. Type M plutonium should be applied for all systemic organs.

For ***non-systemic*** **(respiratory and GI tracts) organs**, the following shall be done:

1. Run the type M intakes. If this action does not result in a PoC[2] >50%,

2. Run the minimizing type S intake. The type S intake in this TIB should only be used if the individual's employment includes post 1988 employment. Otherwise, the type S intake from ORAUT 2006 should be used. If this action still does not yield a PoC >50%, then

3. Manually fit the coworker bioassay data for the time frame of interest for the employee, using the assumption of type S material.

[2] The U.S. Department of Labor is ultimately responsible under the EEOICPA for determining the POC.

Standard fitting techniques should be used to fit the plutonium urinalysis data from the employee's work period contained in Table A-2. Acute or chronic intakes can be assigned, depending on the patterns in the data. Both the 50th- and 84th-percentile data must be fit using the same intake dates or periods; the 50th-percentile intakes are used to assign the intake and the 84th-percentile is used to determine the GSD for each intake. For input into IREP, the dose from each intake must be determined separately.

4. The dose that is more favorable to the claimant from the type M and S fits should be assigned.

Table 5-1. Derived uranium intake rates, 1989 to 2005.

	Type F material		Type M material		Type S material	
Period	50th percentile (dpm/d)	Geometric standard deviation	50th percentile (dpm/d)	Geometric standard deviation	50th percentile (dpm/d)	Geometric standard deviation
1989-1993	0.171	7.98	0.753	7.73	15.11	7.61
1994-2005	0.038	9.86	0.154	9.93	2.06	10.65

Table 5-2. Derived plutonium intake rates, 1989 to 2005.

	Type M material	
Period	50th percentile (dpm/d)	Geometric standard deviation
1989-1993	0.780	12.18
1994-2005	0.053	9.67
	Type S material (underestimate)	
Period	50th percentile (dpm/d)	Geometric standard deviation
1952-2005	0.245	9.61

5.2 DOSE ASSIGNMENT

For most cases, doses to be assigned to individuals are calculated from the 50th-percentile intake rates. Dose reconstructors should select the material type that is the most favorable to the claimant.

The lognormal distribution is selected in the NIOSH Interactive RadioEpidemiological Program (IREP), with the calculated dose entered as Parameter 1 and the associated GSD as Parameter 2. The GSD is associated with the intake, so it is applied to all annual doses determined from the intake period.

REFERENCES

ICRP (International Commission on Radiological Protection), 1995, *Dose Coefficients for Intakes of Radionuclides by Workers*, Publication 68, Pergamon Press, Oxford, England.

ORAUT (Oak Ridge Associated Universities Team), 2004a, *Analysis of Coworker Bioassay Data for Internal Dose Assignment*, ORAUT-OTIB-0019, Rev. 00, Oak Ridge, Tennessee.

ORAUT (Oak Ridge Associated Universities Team), 2004c, *Technical Basis Document for the Rocky Flats Plant – Occupational Internal Dose*, ORAUT-TKBS-0011-5, Oak Ridge, Tennessee.

ORAUT (Oak Ridge Associated Universities Team), 2006, *Technical Information Bulletin – Internal Dosimetry Coworker Data for Rocky Flats Environmental Technology Site*, ORAUT-OTIB-0038, Oak Ridge, Tennessee.

ATTACHMENT A. COWORKER DATA TABLES

Table A-1. Summary of uranium urinary excretion rate analyses, 1989 to 2005

Effective sample date	50th percentile (dpm/24 hr)	84th percentile (dpm/24 hr)
2/15/1989	0.054	0.726
5/15/1989	0.042	0.337
8/15/1989	0.035	0.258
11/15/1989	0.053	0.290
7/1/1990	0.033	0.212
7/1/1991	0.037	0.187
7/1/1992	0.067	0.678
7/1/1993	0.048	0.278
2/15/1994	0.008	0.071
5/15/1994	0.027	0.182
8/15/1994	0.010	0.100
11/15/1994	0.021	0.126
7/1/1995	0.023	0.124
2/15/1996	0.006	0.075
5/15/1996	0.003	0.047
8/15/1996	0.004	0.042
11/15/1996	0.007	0.047
2/15/1997	0.010	0.067
5/15/1997	0.014	0.076
8/15/1997	0.014	0.060
11/15/1997	0.017	0.060
7/1/1998	0.004	0.024
7/1/1999	0.008	0.046
2/15/2000	0.007	0.046
5/15/2000	0.004	0.089
8/15/2000	0.004	0.036
11/15/2000	0.005	0.038
2/15/2001	0.010	0.041
5/15/2001	0.011	0.066
8/15/2001	0.007	0.049
11/15/2001	0.006	0.068
2/15/2002	0.009	0.072
5/15/2002	0.016	0.142
8/15/2002	0.012	0.655
11/15/2002	0.009	0.169
2/15/2003	0.006	0.110
5/15/2003	0.012	0.074
8/15/2003	0.003	0.032
11/15/2003	0.014	0.054
2/15/2004	0.018	0.089
5/15/2004	0.015	0.079
8/15/2004	0.008	0.055
11/15/2004	0.007	0.494
7/1/2005	0.012	0.048

All results shown in **bold** are annual averages rather than quarterly averages

Table A-2. Summary of plutonium urinary excretion rate analyses, 1989 to 2005

Effective sample date	50th percentile (dpm/24 hr)	84th percentile (dpm/24 hr)
2/15/1989	0.004	0.035
5/15/1989	0.011	0.072
8/15/1989	0.003	0.065
11/15/1989	0.007	0.085
2/15/1990	0.002	0.028
5/15/1990	0.004	0.031
8/15/1990	0.002	0.031
11/15/1990	0.004	0.038
2/15/1991	0.004	0.026
5/15/1991	0.001	0.063
8/15/1991	0.008	0.097
11/15/1991	0.001	0.039
2/15/1992	0.001	0.019
5/15/1992	0.003	0.020
8/15/1992	0.005	0.036
11/15/1992	0.009	0.107
7/1/1993	**0.004**	**0.065**
2/15/1994	0.000	0.005
5/15/1994	0.001	0.006
8/15/1994	0.001	0.007
11/15/1994	0.001	0.007
7/1/1995	**0.001**	**0.008**
2/15/1996	0.001	0.010
5/15/1996	0.001	0.007
8/15/1996	0.000	0.004
11/15/1996	0.000	0.005
2/15/1997	0.001	0.007
5/15/1997	0.001	0.006
8/15/1997	0.000	0.007
11/15/1997	0.000	0.001
7/1/1998	**0.000**	**0.003**
7/1/1999	**0.000**	**0.004**
2/15/2000	0.000	0.003
5/15/2000	0.001	0.003
8/15/2000	0.001	0.003
11/15/2000	0.000	0.003
2/15/2001	0.000	0.003
5/15/2001	0.000	0.004
8/15/2001	0.000	0.004
11/15/2001	0.000	0.003
2/15/2002	0.000	0.004
5/15/2002	0.000	0.004
8/15/2002	0.000	0.003
11/15/2002	0.000	0.003
2/15/2003	0.000	0.002
5/15/2003	0.000	0.003
8/15/2003	0.000	0.003
11/15/2003	0.000	0.003
2/15/2004	0.000	0.007
5/15/2004	0.000	0.003
8/15/2004	0.000	0.003
11/15/2004	0.000	0.002
7/1/2005	**0.000**	**0.003**

All results shown in **bold** are annual averages rather than quarterly averages.

ATTACHMENT B. COWORKER DATA FIGURES

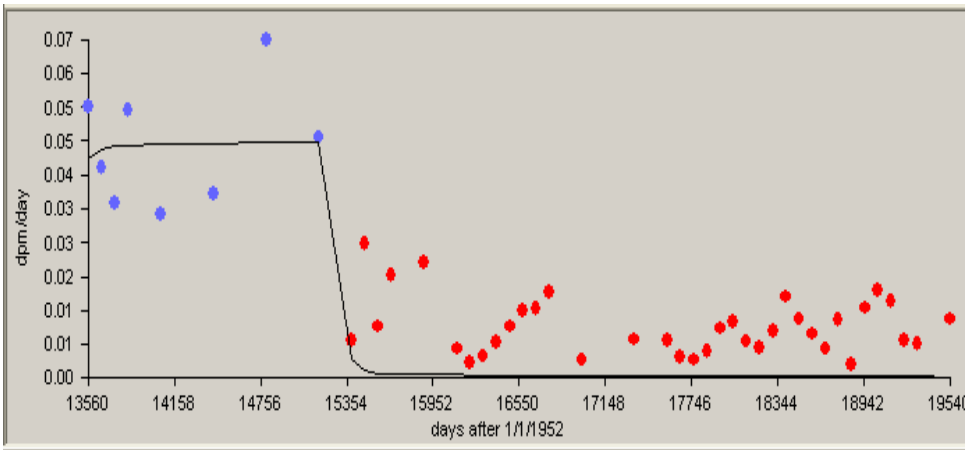

Figure B-1. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1989 to 12/31/1993, 50th-percentile, Type F.

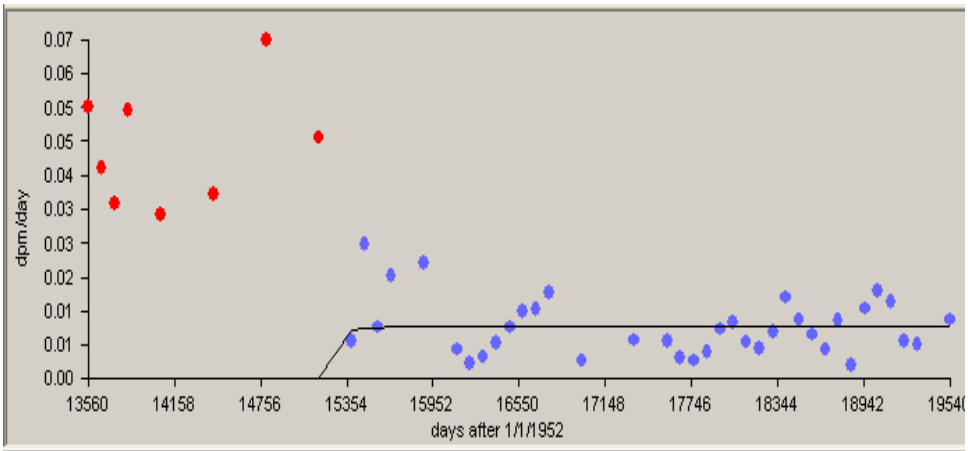

Figure B-2. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1994 to 12/31/2005, 50th-percentile, Type F.

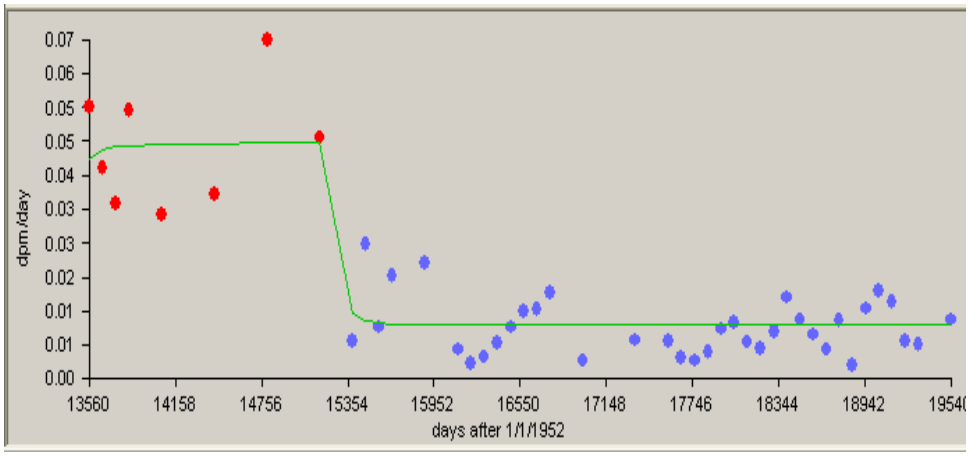

Figure B-3. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots) from all intakes 1/1/1989 to 12/31/2005, 50th-percentile, Type F.

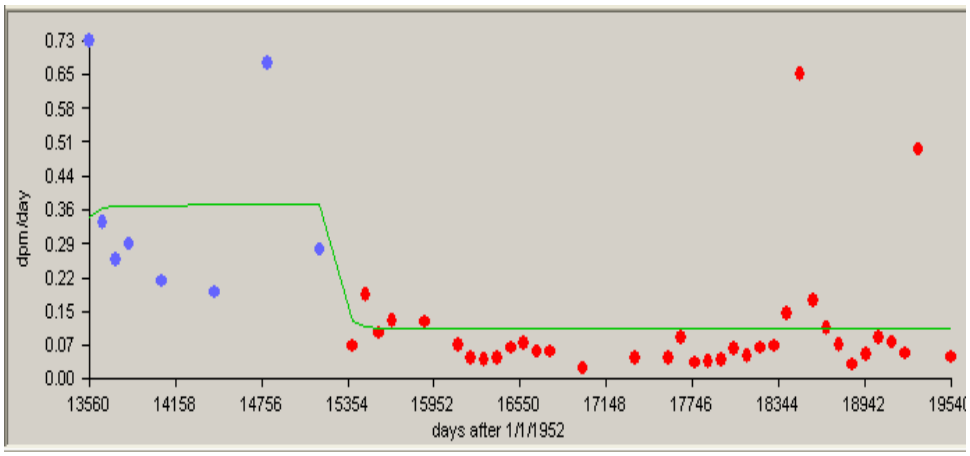

Figure B-4. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1989 to 12/31/2005, 84th-percentile, Type F.

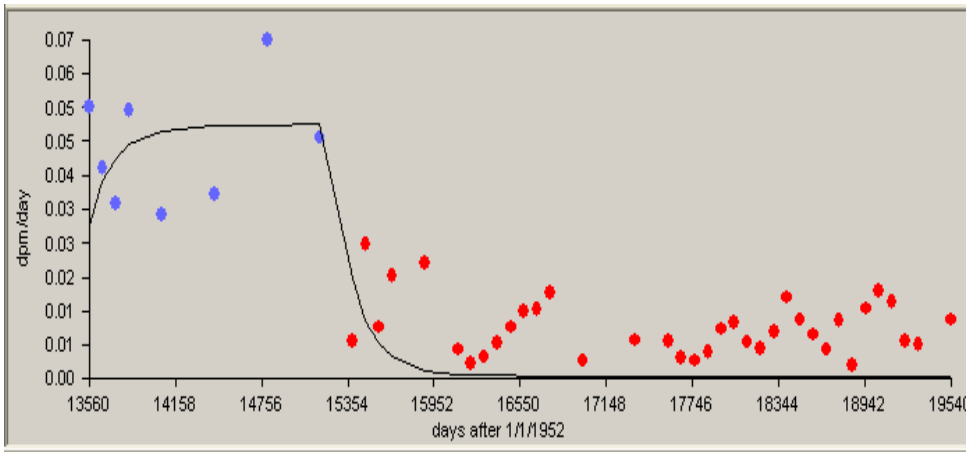

Figure B-5. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1989 to 12/31/1993, 50th-percentile, Type M.

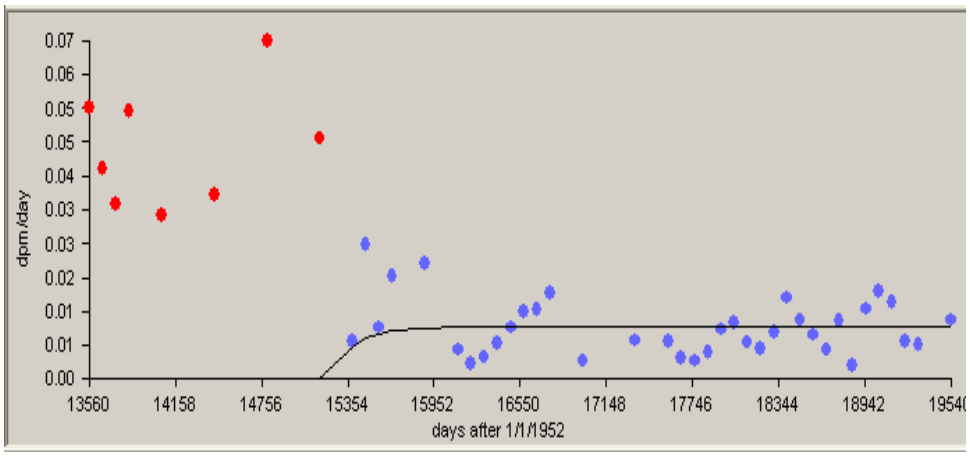

Figure B-6. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1994 to 12/31/2005, 50th-percentile, Type M.

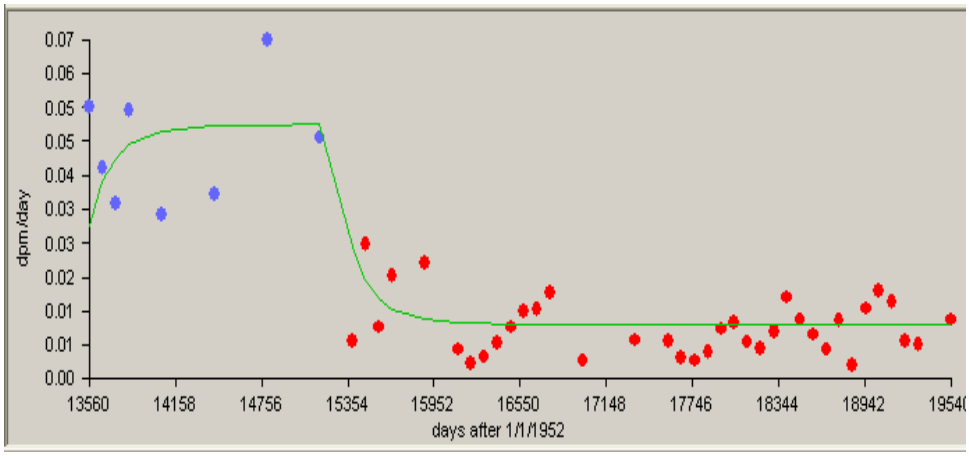

Figure B-7. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots) from all intakes 1/1/1989 to 12/31/2005, 50th-percentile, Type M.

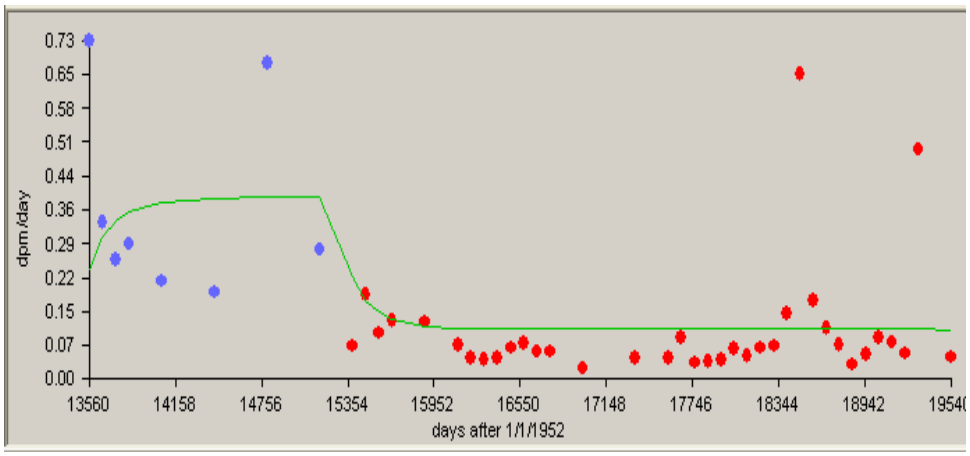

Figure B-8. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1989 to 12/31/2005, 84th-percentile, Type M.

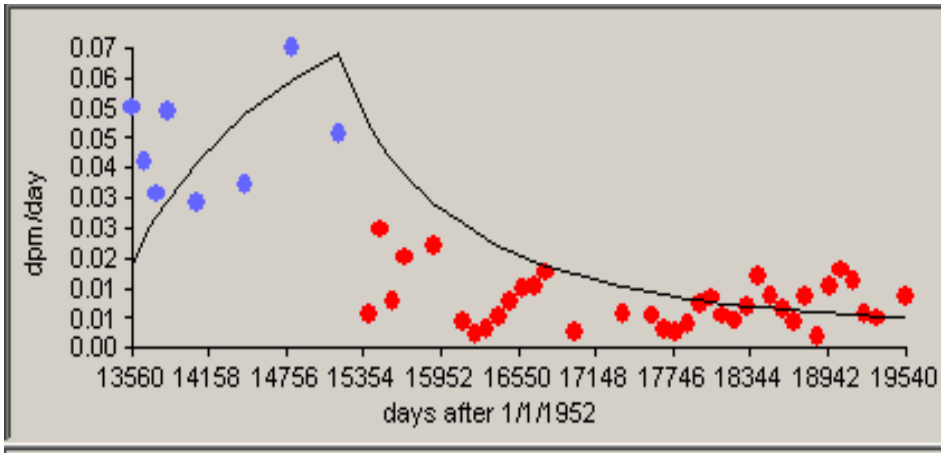

Figure B-9. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1989 to 12/31/1993, 50th-percentile, Type S.

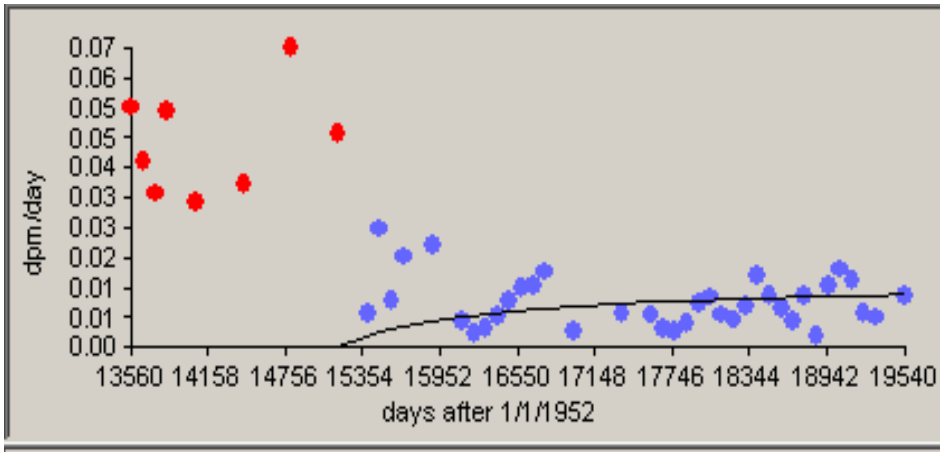

Figure B-10. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1994 to 12/31/2005, 50th-percentile, Type S.

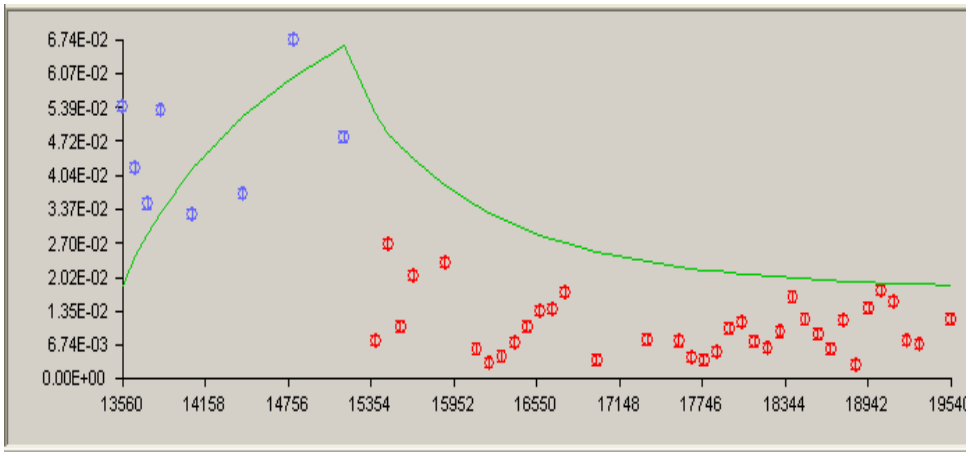

Figure B-11. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1989 to 12/31/2005, 50th-percentile, Type S.

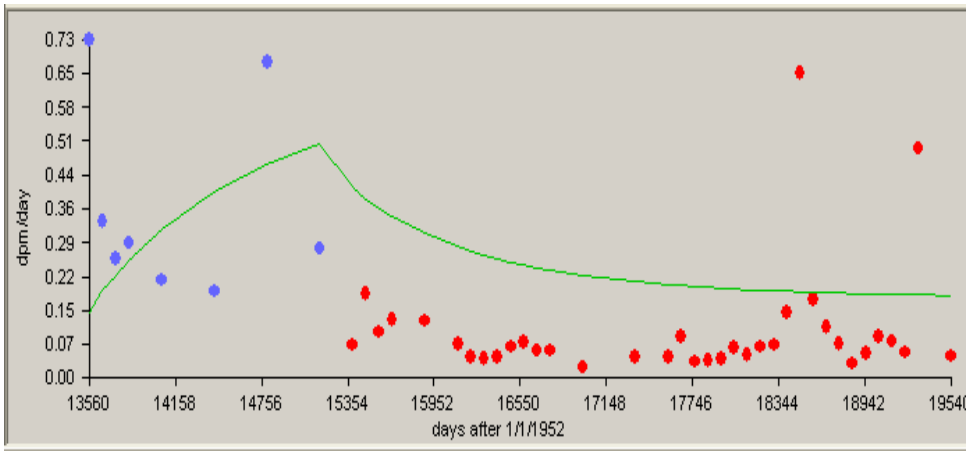

Figure B-12. Predicted uranium bioassay results (line) calculated using IMBA-derived U intake rates compared with measured uranium-in-urine results (dots), 1/1/1989 to 12/31/2005, 84th-percentile, Type S.

Table B-1. IMBA-derived uranium intake rates, dpm/day

	Type F			Type M			Type S		
Years	**50%**	**84%**	**GSD**	**50%**	**84%**	**GSD**	**50%**	**84%**	**GSD**
1989-1993	0.171	1.365	7.98	0.753	5.821	7.73	15.11	115.00	7.61
1994-2005	0.038	0.370	9.86	0.154	1.531	9.93	2.06	21.95	10.65

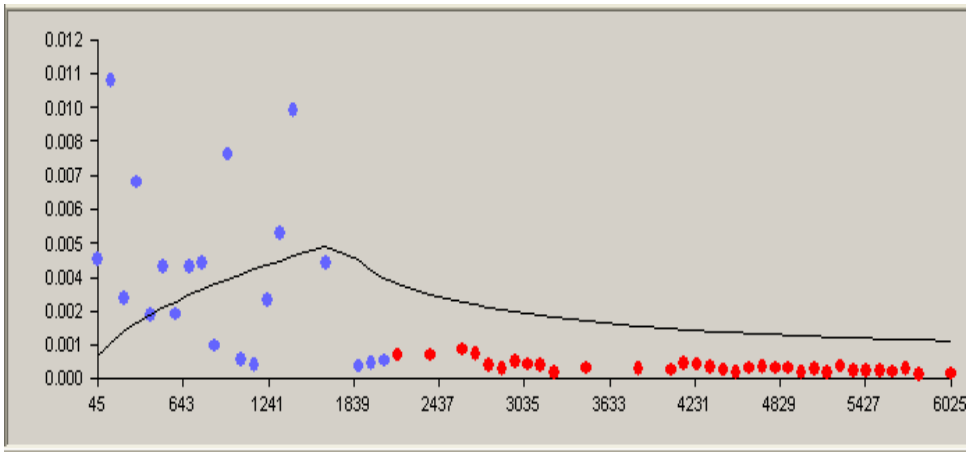

Figure B-13. Predicted plutonium bioassay results (line) calculated using IMBA-derived Pu intake rates compared with measured Pu-in-urine results (dots), 1/1/1989 to 12/31/1993, 50th-percentile, Type M.

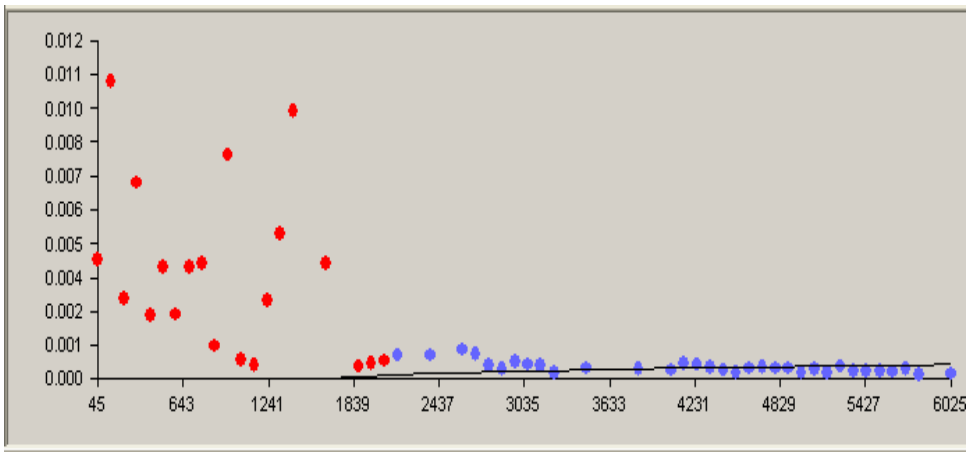

Figure B-14. Predicted plutonium bioassay results (line) calculated using IMBA-derived Pu intake rates compared with measured Pu-in-urine results (dots), 1/1/1994 to 12/31/2005, 50th-percentile, Type M.

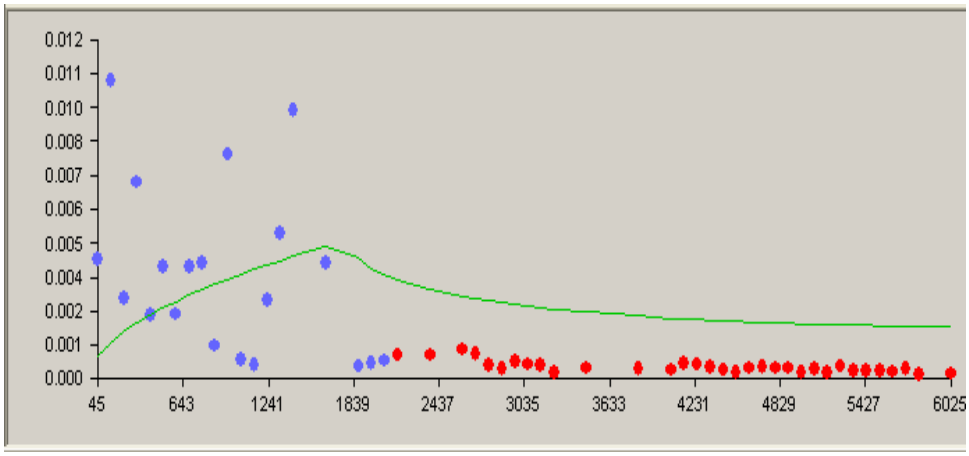

Figure B-15. Predicted plutonium bioassay results (line) calculated using IMBA-derived Pu intake rates compared with measured Pu-in-urine results (dots), 1/1/1989 to 12/31/2005, 50th-percentile, Type M.

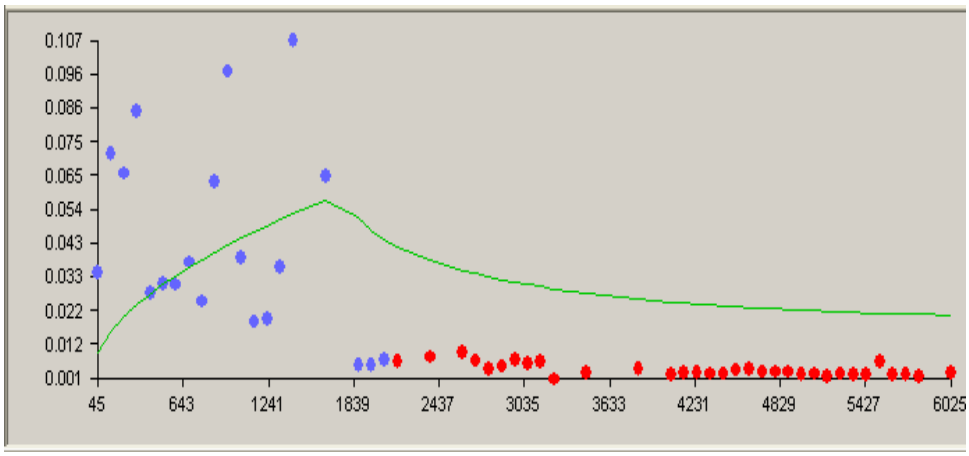

Figure B-16. Predicted plutonium bioassay results (line) calculated using IMBA-derived Pu intake rates compared with measured Pu-in-urine results (dots), 1/1/1989 to 12/31/2005, 84th-percentile, Type M.

Table B-2. IMBA-derived plutonium intake rates, Type M

Year	Plutonium urinalysis-based results, dpm/day		
	Pu 50%	Pu 84%	GSD
1989-1993	0.780	9.502	12.18
1994-2005	0.053	0.511	9.67

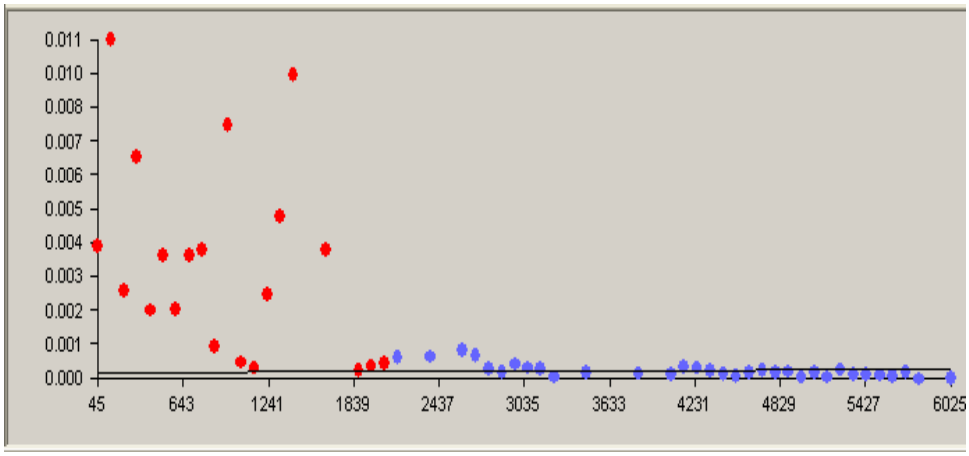

Figure B-17. Predicted plutonium bioassay results (line) calculated using IMBA-derived Pu intake rates compared with measured Pu-in-urine results (dots), 1/1/1952 to 12/31/2005, 50-percentile, Type S.

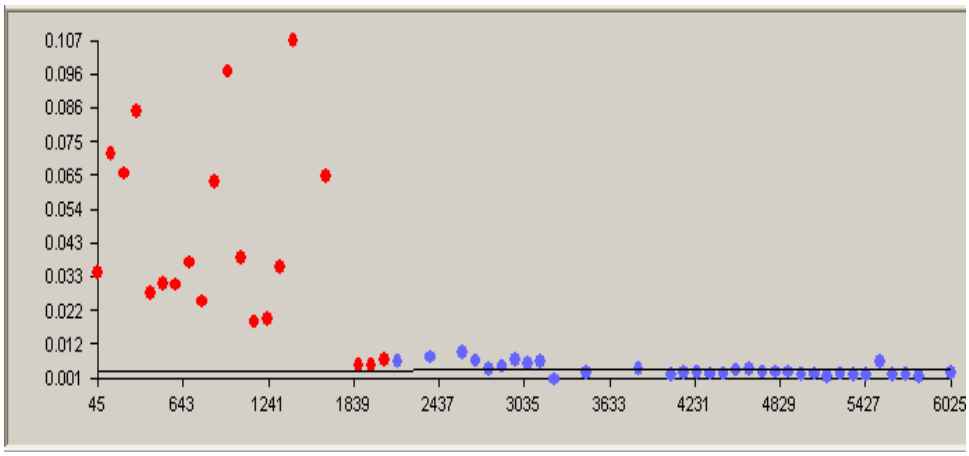

Figure B-18. Predicted plutonium bioassay results (line) calculated using IMBA-derived Pu intake rates compared with measured Pu-in-urine results (dots), 1/1/1952 to 12/31/2005, 84th-percentile, Type S.

Table B-3. IMBA-derived plutonium intake rates, Type S.

Year	Plutonium urinalysis-based results, dpm/day		
	Pu 50%	Pu 84%	GSD
1952-2005	0.245	2.349	9.61