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Subject Expert(s): Matthew G. Arno, Joseph C. Lochamy and James M. Mahathy

Site Expert(s): Thomas R. LaBone

Approval:	Richard E. Merrill Signature on File for Donald N. Stewart, Document Owner	Approval Date:	02/10/2011
Concurrence:	Signature on File John M. Byrne, Objective 1 Manager	Concurrence Date:	02/07/2011
Concurrence:	Keith A. McCartney Signature on File for Edward F. Maher, Objective 3 Manager	Concurrence Date:	02/07/2011
Concurrence:	Signature on File Kate Kimpan, Project Director	Concurrence Date:	02/09/2011
Approval:	Signature on File James W. Neton, Associate Director for Science	Approval Date:	02/17/2011

☐ New ☒ Total Rewrite ☐ Revision ☐ Page Change

FOR DOCUMENTS MARKED AS A TOTAL REWRITE, REVISION, OR PAGE CHANGE, REPLACE THE PRIOR REVISION AND DISCARD / DESTROY ALL COPIES OF THE PRIOR REVISION.

PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
06/22/2007	00	Approved new technical information bulletin for assigning Mound internal doses based on coworker bioassay data. Incorporates formal internal and NIOSH review comments. There is no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by Clark B. Barton.
02/17/2011	01	Revision to change modeling of intakes of Type S plutonium to provide best-estimate intakes. Deleted previous underestimating intakes and instructions for dose reconstructors to perform case-specific intake modeling. Added 95th-percentile intake rates for all radionuclides. Constitutes a total rewrite or the document. Incorporates formal internal and NIOSH review comments. Training required: As determined by the Objective Manager. Initiated by Matthew G. Arno.

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ACRONYMS AND ABBREVIATIONS

AMAD	activity median aerodynamic diameter
Bq	becquerel
d	day
DOE	U.S. Department of Energy
DTPA	diethylene triamine pentaacetic acid
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
GSD	geometric standard deviation
hr	hour
HSPU	heat-source plutonium
IMBA	Integrated Modules for Bioassay Analysis
IREP	Interactive RadioEpidemiological Program
m	meter
mL	milliliter
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
pCi	picocurie
PER	Program Evaluation Report
POC	probability of causation
TIB	technical information bulletin
U.S.C.	United States Code
WGPU	weapons-grade plutonium
μm	micrometer
§	section or sections

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 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 [42 U.S.C. § 7384l(5) and (12)].

ORAUT-OTIB-0019, *Analysis of Coworker Bioassay Data for Internal Dose Assignment* (ORAUT 2005), describes the general process that is used to analyze bioassay data for assigning doses to individuals based on coworker results. ORAUT-PLAN-0014, *Coworker Data Exposure Profile Development* (ORAUT 2004), describes the approach and processes to be used to develop reasonable exposure profiles based on available dosimetric information for workers at DOE sites.

Bioassay results were obtained through the PORECON (Polonium Reconstruction) and PURECON (Plutonium Reconstruction) databases that were created at the Mound Laboratory from logbooks and other original hard-copy records. Based on a spot check, this data set coincides well with original Mound paper records. It is appropriate for use only at Mound. The databases are representative of worker bioassay results at Mound during a substantial part of the operating history at this site.

The database results were labeled with units that varied among the radionuclides, analysis techniques, and measurement periods. These units were assembled into a common format to expedite the statistical analysis. The specific units for each radionuclide are provided in the appropriate sections of this document.

A statistical analysis of the data was performed as specified in ORAUT-OTIB-0019 (ORAUT 2005) and its implementing procedure, ORAUT-PROC-0095, *Generating Summary Statistics for Coworker Bioassay Data* (ORAUT 2006). The results were entered in the Integrated Modules for Bioassay Analysis (IMBA) computer software version 4.0.9 to obtain intake rates for assigning dose distributions.

2.0 PURPOSE

Some employees at DOE sites might not have been monitored for potential intakes of radioactive material. For other employees the records of such monitoring might be incomplete or unavailable. In such cases, data from monitored coworkers can be used to estimate an individual’s potential intake of radioactive material and the resulting internal dose. The purpose of this TIB is to provide monitored coworker information for calculating and assigning occupational internal doses to employees at Mound whose job titles, facility assignments, and other case-specific information indicate that they have the potential for unmonitored intakes of ^{210}Po or plutonium.

Attributions and annotations, indicated by bracketed callouts, are used to identify the source, justification, or clarification of the associated information, are presented in Section 6.0.

3.0 DATA OVERVIEW

This section provides information on the general selection characteristics of the data and the methods of analysis. Plutonium and ^{210}Po are the radionuclides of interest, and significant numbers of monitoring records exist for them. More detailed radionuclide-specific information for these two nuclides is provided in Section 4.0.

3.1 BIOASSAY DATA SELECTION

3.1.1 Polonium Urinalysis Data

The urine bioassay data were extracted from the *verified* PORECON_FINAL_COPY database (Mound undated a), “dbo_SAMPLES” table, “BQ_DAY” field. By verified, it is meant that the original PORECON database was created by Mound from information that was recorded on cards as well as from a review of the original chemistry logbooks from which the cards were created. Data entry clerks entered the data using double-entry methods. Following this task, data entry was reviewed by health physicists. Samples with PROBLEM_FLG = “R” or BQ_DAY = blank were not included in the statistical analysis [1]. Samples were excluded for the following reasons:

- 147 non-urine (blood, feces) samples
- 116 lost in processing
- 182 no sample submitted (vacation, illness, etc.)
- 1595 insufficient volume
- 1685 duplicates or recounts
- 162 rejected because they were submitted too late
- 36 contaminated samples
- 79 marked as “beta counts”
- 56 with no result and blank or cryptic comment

3.1.2 Plutonium Urinalysis Data

Urine bioassay data (SAMPLE_TYPE = U) and the analysis date (Date = SAMPLE_DATE) were extracted from the PURECON table of the *verified* PURECON_MERGED database (Mound undated b). By verified, it is meant that the original PURECON database used for this analysis was created by Mound from logbooks and other original hard-copy records. Results with any of the following identifiers were excluded: PROBLEM_FLG = nonblank, DTPA = nonblank, LNAME = QC, or Result field (PICOC_PU238 or PICOC_PU239) = blank. There was a comment field for each result and, in most cases with a PROBLEM_FLG = nonblank, the comment indicated the reason for the flag. These included samples with low recovery, no tracer added, samples lost in process, insufficient volume for analysis, samples with no result, samples following diethylene triamine pentaacetic acid (DTPA) administration (chelation therapy), and samples that were analyzed for nuclides other than plutonium. There were 1,413 of 58,893 results marked with a problem flag. For the first quarter of 1983, 26 sample results were excluded because the comment field indicated that ^{239}Pu was added to the sample [2]. Samples were excluded for the following reasons:

- 57 were not analyzed for Pu (Ra, Cm, Th)
- 70 QC samples
- 2307 DTPA (265 of which had a problem flag)
- 140 contaminated
- 453 lost in processing (sample spilled, tracer not added, low recovery)
- 10 insufficient volume
- 46 no result, no clear reason

- 137 with blank or cryptic comment

3.2 ANALYSIS

3.2.1 Polonium Bioassay Analysis

Data were analyzed by calendar quarter from July 1944 through the end of 1970 and by year from 1971 through part of 1973. The results of samples that were reported in 1940 and 1941 were not used because the site was not yet operational. Spot samples were collected for analysis; 50- or 100-mL aliquots were analyzed, and the results were typically reported in units of counts per minute or disintegrations per minute. Values in the “BQ_DAY” field originally had been calculated and entered into the database assuming a counting efficiency of 50% and a chemical recovery of 85%. They were normalized to a 24-hour sample assuming an excretion rate of 1,400 mL/d. Before the statistical analysis was run, the results from 1944 through 1963 were multiplied by a factor of 8.5 in accordance with the guidance in ORAUT-TKBS-0016-6, *Technical Basis Document for the Mound Site – Occupational Internal Dosimetry* (ORAUT 2010), which specifies a recovery efficiency of 10% (instead of 85%) for this timeframe. A factor of 1.35 was applied to results from 1964 through 1973, again according to ORAUT-TKBS-0016-6, which specifies a recovery efficiency of 63% (instead of 85%) for this timeframe.

A lognormal distribution was assumed for the urinary excretion data, and the 50th- and 84th-percentile excretion rates were calculated using the method ORAUT-PROC-0095 prescribes (ORAUT 2006). These excretion rates are given in Tables A-1 and A-2. Bioassay data that was collected over a specified period were analyzed to determine the 50th- and 84th-percentile excretion rates for that period. The effective bioassay dates are the midpoints of the periods, and they were used with IMBA to calculate the intake rates.

3.2.2 Plutonium Bioassay Analysis

Data were analyzed by year from 1956 through the end of 1961 and by calendar quarter from 1962 through 1990. The results from 1954 through 1960 were multiplied by a factor of 8.5, as specified in ORAUT-TKBS-0016-5 (ORAUT 2010). Analyses before June 1, 1981, which measured total plutonium alpha, were reported in the “PICOC_PU238” field, whereas later results, which were isotopic plutonium, were reported in the fields “PICOC_PU238” and “PICOC_PU239.” The ^{238}Pu and $^{239/240}$Pu results for each sample that was analyzed after June 1, 1981, were summed to create a total plutonium result for these samples. Most plutonium samples were 24-hour samples. Samples with no volume listed or more than 1000 mL were assumed to be 24-hour samples. Samples with volumes less than 1000 mL were normalized to a 24-hour sample assuming an excretion rate of 1,400 mL/d.

A lognormal distribution was assumed for the urinary excretion data, and the 50th- and 84th-percentile excretion rates were calculated using the method in ORAUT-PROC-0095 (ORAUT 2006). These excretion rates are given in Tables A-5 and A-6. Bioassay data that was collected over a specified period were analyzed to determine the 50th- and 84th-percentile excretion rates for that period. The effective bioassay dates are the midpoints of the periods and they are to be used in IMBA to calculate the intake rates.

4.0 INTAKE MODELING

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

4.1 ASSUMPTIONS

4.1.1 Polonium Assumptions

Each urinary excretion rate used in the intake calculations was assumed to be normally distributed. A uniform absolute error of 1 was applied to all results, which thus assigned the same weight to each result [4]. IMBA requires results in units of activity per day; therefore, all urinalysis results were normalized, as needed, to 24-hour samples using 1,400 mL, which is the volume of urine that is excreted by Reference Man in a 24-hour period [3].

The excretion data were modeled with IMBA for multiple chronic intakes of type F or type M ^{210}Po. Examination of excretion results for polonium indicated that relatively chronic exposures appear to have been likely at the start of the polonium program. Therefore, a chronic exposure pattern was assumed throughout the program because it also approximates a series of acute intakes with unknown intake dates. Intakes were assumed to be via inhalation with a default breathing rate of 1.2 m^3/hr and a 5-µm activity median aerodynamic diameter (AMAD) particle size distribution [4].

4.1.2 Plutonium Assumptions

All urinary excretion rates were modeled as normally distributed 24-hr urine samples having a uniform absolute error of 1, which thus assigned the same weight to each urinary excretion rate. The excretion data were modeled with IMBA for multiple chronic intakes of type M and type S plutonium. Although it is unlikely that workers at Mound were chronically exposed to plutonium, this approach approximates a series of acute intakes with unknown intake dates. Intakes were assumed to be via inhalation with a default breathing rate of 1.2 m^3/hr and a 5-µm AMAD particle size distribution [5].

4.2 BIOASSAY FITTING

4.2.1 Polonium Fitting

The excretion data were modeled with IMBA for multiple chronic intakes of type F or type M ^{210}Po. Polonium data from 1944 through 1973 were fit as a series of chronic intakes.

The intake assumptions were based on patterns that were observed in the bioassay data. Periods with constant chronic intake rates were chosen by selecting periods during which 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, the period from 1944 through 1973 was divided into several chronic intake periods [6].

4.2.2 Plutonium Fitting

The excretion data were modeled with IMBA for multiple chronic intakes of type M and type S plutonium. Plutonium data from 1956 through 1990 were fit as a series of chronic intakes.

The intake assumptions were based on patterns that were observed in the bioassay data. Periods with constant chronic intake rates were chosen by selecting periods during which 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, the period from 1956 through 1990 was divided into several chronic intake periods [7].

4.3 MATERIAL TYPES

ORAUT-TKBS-0016-6 discusses Mound internal dosimetry data and includes guidance for the appropriate use of that information (ORAUT 2010). According to that document, workers at Mound had the potential to receive intakes of polonium and plutonium.

4.3.1 Polonium

Excretion data for the 50th- and 84th-percentile values of ^{210}Po for 1944 through 1973 are shown in Table A-1. Note that the third quarter of 1970 was omitted because of poor statistics [8]. The solid lines in Figures B-1 and B-2 show the individual fits to the 50th- and 84th-percentile excretion rates, respectively, for type M ^{210}Po material. The solid lines in Figures B-3 and B-4 show the individual fits to the 50th- and 84th-percentile excretion rates, respectively, for type F ^{210}Po material [9].

4.3.2 Plutonium

Because plutonium of either type S or type M has a very long half-life and the material is retained in the body for long periods, excretion results are not independent. For example, an intake in the early 1950s could contribute to urinary excretion in the 1980s and later. To avoid potential underestimation of intakes for people who worked for relatively short periods, each intake period was fit independently using only the bioassay results from that intake period. For a particular dose reconstruction, this fitting method will result in a best estimate of dose if the person worked in only one period and a potential overestimate if an individual worked in multiple periods [10].

Plutonium urinalysis results were analyzed with IMBA using types M and S materials to derive intake rates for 1956 to 1990 [11].

Plutonium type M: The solid lines in Figures B-5 to B-10 show the individual fits to the 50th-percentile excretion rates for type M materials. The solid lines in Figures B-11 to B-17 show the individual fits to the 84th-percentile excretion rates for type M materials. The same intake periods were not applied for both percentiles because the values followed different patterns [12].

Plutonium type S: The solid lines in Figures B-18 to B-23 show the individual fits to the 50th-percentile excretion rates for type S materials. The solid lines in Figures B-24 to B-29 show the individual fits to the 84th-percentile excretion rates for type S materials [13].

Table A-4 provides the bioassay data that were used for the intake modeling [14].

5.0 ASSIGNING INTAKES AND DOSES

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

5.1 INTAKE RATE SUMMARY

5.1.1 Polonium

Five intake periods were fit to the derived 50th- and 84th-percentile polonium excretion data. Because many of the geometric standard deviations (GSDs) were relatively similar, they were combined and the largest value in a given timeframe was assigned for simplicity [15].

The intake rates, GSDs, and periods in which they are applicable are given in Table A-2 for type M ^{210}Po and Table A-3 for type F ^{210}Po. In most cases, doses for individuals who were potentially exposed routinely should be calculated from the 50th-percentile intake rates by assuming the solubility type that results in the largest probability of causation (POC)[1]. Table 5-1 summarizes the derived polonium intake rates that produced the data-fitting results in Attachment B. Note that the results in Table 5-1 are in becquerels per day, because the original data were recorded as such [16]. If picocuries per day are preferred, divide the Table 5-1 values by 0.037.

Table 5-1. Derived polonium intakes, 1944 to 1973.

	Type F material			**Type M material**		
Period	**50th percentile (Bq/d)**	**GSD**	**95th percentile (Bq/d)**	**50th percentile (Bq/d)**	**GSD**	**95th percentile (Bq/d)**
07/1944–03/1946	1,189.5	3.89	11,113	4,097.6	3.9	38,444
04/1946–03/1949	254.96	5.56	4,287	800.19	5.8	14,422
04/1949–03/1960	12.192	7.99	372	39.851	8.0	1,219
04/1960–03/1965	2.0696	6.70	47.3	5.7883	6.2	116
04/1965–12/1973	0.10303	8.88	3.74	0.34853	8.8	12.5

5.1.2 Plutonium

Seven intake periods were fit to the derived 50th- and 84th-percentile plutonium excretion data for type M material. Five intake periods were fit to the derived 50th- and 84th-percentile plutonium excretion data for type S material. If the GSD was less than 3, the value was set to 3 to account for biological variation when determining dose [17].

The intake rates, GSDs, and applicable periods are given in Table A-5 for type M plutonium and Table A-6 for type S plutonium. In most cases, doses for individuals who were potentially exposed routinely should be calculated from the 50th-percentile intake rates by assuming the solubility type that results in the largest POC. Table 5-2 summarizes the derived plutonium intake rates that produced the data-fitting results in Attachment B. Note that the results in Table 5-2 are in picocuries per day, because the original data were recorded as such [18]. If becquerels per day are preferred, multiply the Table 5-2 values by 0.037.

Table 5-2. Derived plutonium intake rates, 1956 to 1990.

Period	**50th percentile (pCi/d)**	**GSD**	**95th percentile (pCi/d)**
Type M material			
1956–1957	750.98	3.00[a]	4,576
1958–1960	436.49	3.00[a]	2,659
1961–1967	12.141	5.42	196
1968–1969	12.141	11.69	693
1970–1977	2.2361	9.14	85.2
1978–1984	2.2361	5.82	40.5
1985–1990	0.59706	8.16	18.9
Type S material			
1956–1957	27,150	3.00[a]	165,437
1958–1960	12,880	4.11	131,730
1961–1969	209.9	5.12	3,081
1970–1984	31.31	5.12	460
1985–1990	11.66	8.26	376

a. Actual GSD <3. Adjusted to 3 for dose calculations.

5.2 DOSE ASSIGNMENT

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

1 The U.S. Department of Labor is responsible under EEOICPA for determining the POC.

The lognormal distribution is selected in the Interactive RadioEpidemiology 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 that are determined from the intake period.

There are situations when the 95th percentile of the coworker distribution and a constant distribution are more appropriate than the 50th percentile and lognormal GSDs. For cases where the 50th-percentile intake rates are not appropriate, dose reconstructors should use the 95th-percentile intake rates. The 95th-percentile intakes should be assigned as a constant rather than lognormal distribution.

To calculate doses from plutonium, the intakes of "total Pu" should be classified as either weapons-grade plutonium (WGPU) or heat-source plutonium (HSPU) using the established protocol for Mound. HSPU is assumed to be 100% ^{238}Pu by activity, but determining the isotopic mix of WGPU is more complex. Table 5-3 lists three WGPU mixes aged 1, 3.2, and 10 years. These values are taken from the technical basis document (ORAUT 2010). If the age of the isotopic mix is not known, the 10-year-aged material should be selected to be favorable to claimants in relation to the ingrowth of ^{241}Am from ^{241}Pu [19].

Table 5-3. Dose calculations for WGPU intakes.

Material age (yr)	Percentage of alpha activity			Beta activity (times $A_{Pu-239/240}$)
	Pu-239/240	Pu-238	Am-241	Pu-241
1	92.9	6.6	0.55	4.8
3.2	91.6	6.4	2.0	4.3
10	88.4	6.0	5.6	3.1

6.0 ATTRIBUTIONS AND ANNOTATIONS

Where appropriate in this document, bracketed callouts have been inserted to indicate information, conclusions, and recommendations provided to assist in the process of worker dose reconstruction. These callouts are listed here in the Attributions and Annotations section, with information to identify the source and justification for each associated item. Conventional References, which are provided in the next section of this document, link data, quotations, and other information to documents available for review on the Project's Site Research Database.

Thomas LaBone serves as a Site Expert for this document. As such, he is responsible for advising on site-specific issues and incidents as necessary and ensures the completeness and accuracy of the document. Because of his prior work experience for the site, he possesses, or is aware of information that is relevant for reconstructing radiation doses experienced by claimants who worked at the site. In all cases where such information or prior studies or writings are included or relied upon by the document owner, those materials are fully attributed. Mr. LaBone's Disclosure Statement is available at www.oraucoc.org.

[1] Lochamy, Joseph C. ORAU Team. Senior Health Physicist. February 2007.
PORECON records with "R" (Rejected) entries in the PROBLEM_FLG field were not used because they had been flagged as unreliable for some reason. Null entries in the results (BQ_DAY) field obviously cannot be used, because there are no data to use.

[2] Lochamy, Joseph C. ORAU Team. Senior Health Physicist. February 2007.
PURECON records with nonblank fields for PROBLEM_FLG or DTPA, LNAME=QC, or a blank result field were not used because they were unreliable (e.g., nonblank PROBLEM_FLG), not

representative of normal exposures (e.g., nonblank DPTA entry), a quality control sample (e.g., LNAME=QC), or contained no results.

[3] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. The uniform absolute error of 1 weights all results equally; other fitting schemes weight high values or low values disproportionally. Because the median and 84th-percentile values were determined from statistical analysis of many samples in each interval, there was no *a priori* reason to weight results from one interval over another. In addition, the polonium results were recorded as activity per milliliter and the statistical analyses were performed in those units. However, the IMBA software requires that all excreta data be entered as total excretion per day; therefore, the statistical parameters were converted to excretion per day before intake calculations were made using IMBA.

[4] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist. The breathing rate and particle size distribution are Project default values to be used unless site-specific information indicates otherwise. No information has been found about intakes at Mound that shows that the default values should not be used. See, for instance, OCAS-IG-002, *Internal Dose Reconstruction Implementation Guide* (NIOSH 2002), and ICRP Publication 66, *Human Respiratory Tract Model for Radiological Protection* (ICRP 1994).

[5] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist. The breathing rate and particle size distribution are Project default values to be used unless site-specific information indicates otherwise. No information has been found about intakes at Mound that shows that the default values should not be used. See, for instance, OCAS-IG-002, *Internal Dose Reconstruction Implementation Guide* (NIOSH 2002), and ICRP Publication 66, *Human Respiratory Tract Model for Radiological Protection* (ICRP 1994).

[6] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist.

[7] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist.

[8] Mahathy, Michael, and Lochamy, Joseph C. ORAU Team. Coworker Statistics Analyst and Senior Health Physicist. February 2007.
The table was compiled by Lochamy from data that was generated by Mahathy.

[9] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. Figures were generated by LaBone from IMBA results.

[10] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist.

[11] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007. Determinations were made in accordance with ORAUT (2005). The choice of types and applications were peer reviewed by the Principal Internal Dosimetrist.

[12] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007.
Figures were generated by LaBone from IMBA results.

[13] Arno, Matthew G. ORAU Team. Senior Health Physicist. February 2007.
Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist. Figures were generated by Arno from IMBA results.

[14] LaBone, Thomas R., and Lochamy, Joseph C. ORAU Team. Deputy Principal Internal Dosimetrist and Senior Health Physicist. February 2007.
Determinations were made by LaBone in accordance with ORAUT (2005). The tables were compiled by Lochamy from data generated by Lochamy.

[15] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007.
Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist.

[16] LaBone, Thomas R., Mahathy, Michael, and Lochamy, Joseph C. ORAU Team. Deputy Principal Internal Dosimetrist, Coworker Statistics Analyst, and Senior Health Physicist. February 2007.
Determinations were made by LaBone in accordance with ORAUT (2005). The table was compiled by Lochamy from data generated by Mahathy.

[17] LaBone, Thomas R. ORAU Team. Deputy Principal Internal Dosimetrist. February 2007.
Determinations were made in accordance with ORAUT (2005). The choice of intervals and resulting fits were peer reviewed by the Principal Internal Dosimetrist. The minimum GSD of 3 is established in ORAUT-OTIB-0060, *Internal Dose Reconstruction* (ORAUT 2007). It reflects the overall uncertainty that is associated with biokinetic modeling as well as usual radiochemical analysis, and it indicates that even though the spread in coworker excreta results for a given population (e.g., a year of excreta samples) can have a GSD of <3, the uncertainty of intakes that were determined using the biokinetic models is no less than 3.

[18] LaBone, Thomas R., and Lochamy, Joseph C. ORAU Team. Deputy Principal Internal Dosimetrist and Senior Health Physicist. February 2007.
Determinations were made by LaBone in accordance with ORAUT (2005). The tables were compiled by Lochamy from data that were generated by Lochamy.

[19] LaBone, Thomas R., and Lochamy, Joseph C. ORAU Team. Deputy Principal Internal Dosimetrist and Senior Health Physicist. February 2007.
Determinations were made by LaBone in accordance with ORAUT (2005) and ORAUT (2004b). The table was compiled by Lochamy from ORAUT (2004b).

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ORAUT (Oak Ridge Associated Universities Team), 2007, *Internal Dose Reconstruction*, ORAUT-OTIB-0060, Rev. 00, Oak Ridge, Tennessee, February 6.

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ATTACHMENT A
COWORKER DATA TABLES
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Table A-1. 50th- and 84th-percentile urinary excretion rates of ^{210}Po, 1944 to 1973 (Bq/d).

Effective	50th percentile	84th percentile	# of samples	# of employees
08/15/1944	8.33E+01	5.07E+02	531	48
11/15/1944	8.89E+01	3.56E+02	618	59
02/15/1945	1.01E+02	2.97E+02	716	72
05/15/1945	1.39E+02	5.13E+02	887	162
08/15/1945	5.17E+01	2.03E+02	1,582	241
11/15/1945	5.45E+01	2.27E+02	1,917	272
02/15/1946	4.56E+01	1.99E+02	2,052	289
05/15/1946	8.63E+01	2.92E+02	937	205
08/15/1946	2.10E+01	1.04E+02	2,277	333
11/15/1946	1.88E+01	9.53E+01	2,162	324
02/15/1947	9.26E+00	6.78E+01	2,541	362
05/15/1947	1.01E+01	6.84E+01	2,520	396
08/15/1947	1.32E+01	8.68E+01	3,027	486
11/15/1947	2.16E+01	1.10E+02	3,578	500
02/15/1948	3.18E+01	1.71E+02	4,247	553
05/15/1948	2.62E+01	1.36E+02	3,540	560
08/15/1948	1.52E+01	8.99E+01	3,395	556
11/15/1948	1.90E+01	1.23E+02	3,482	476
02/15/1949	7.12E+00	7.36E+01	3,220	517
05/15/1949	2.88E+00	2.27E+01	4,342	803
08/15/1949	2.77E+00	2.02E+01	3,919	773
11/15/1949	2.29E+00	2.00E+01	4,818	796
02/15/1950	1.43E+00	1.39E+01	4,907	786
05/15/1950	7.55E-01	8.97E+00	4,490	750
08/15/1950	7.96E-01	7.03E+00	4,138	739
11/15/1950	6.05E-01	8.06E+00	4,281	728
02/15/1951	1.02E+00	7.32E+00	4,269	708
05/15/1951	1.30E+00	9.08E+00	4,258	729
08/15/1951	1.41E+00	8.73E+00	4,085	735
11/15/1951	1.10E+00	7.89E+00	4,578	745
02/15/1952	1.25E+00	6.68E+00	4,822	733
05/15/1952	9.10E-01	5.33E+00	4,450	761
08/15/1952	7.03E-01	4.84E+00	4,380	784
11/15/1952	1.18E+00	7.19E+00	4,616	759
02/15/1953	1.05E+00	7.53E+00	4,814	767
05/15/1953	9.60E-01	5.68E+00	2,541	582
08/15/1953	1.03E+00	4.51E+00	1,975	479
11/15/1953	4.56E-01	4.09E+00	1,555	420
02/15/1954	7.22E-01	6.44E+00	844	210
05/15/1954	1.47E+00	6.37E+00	690	184
08/15/1954	3.24E+00	9.88E+00	482	154
11/15/1954	1.41E+00	8.96E+00	576	131
02/15/1955	1.62E+00	5.72E+00	470	126
05/15/1955	5.26E-01	2.62E+00	418	96
08/15/1955	5.54E-01	3.90E+00	421	91
11/15/1955	9.41E-01	1.26E+01	432	88
02/15/1956	4.31E-01	7.80E+00	498	95

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Effective	50th percentile	84th percentile	# of samples	# of employees
05/15/1956	8.55E-01	5.51E+00	424	75
08/15/1956	1.78E-01	2.44E+00	452	90
11/15/1956	6.41E-02	3.01E+00	551	106
02/15/1957	2.98E-01	6.07E+00	562	111
05/15/1957	4.53E-02	2.09E+00	541	113
08/15/1957	4.34E-01	3.23E+00	569	97
11/15/1957	6.68E-01	6.92E+00	616	125
02/15/1958	9.75E-01	6.67E+00	716	145
05/15/1958	1.00E+00	1.20E+01	704	129
08/15/1958	6.22E-01	9.34E+00	577	123
11/15/1958	6.82E-01	8.50E+00	739	137
02/15/1959	1.37E+00	1.28E+01	751	138
05/15/1959	1.32E+00	7.19E+00	778	173
08/15/1959	9.35E-01	7.44E+00	703	169
11/15/1959	1.32E+00	1.08E+01	969	186
02/15/1960	6.88E-01	6.49E+00	1,142	215
05/15/1960	4.01E-01	4.16E+00	1,256	224
08/15/1960	5.34E-01	4.58E+00	1,266	231
11/15/1960	5.92E-01	4.91E+00	1,450	247
02/15/1961	6.98E-01	6.04E+00	1,498	244
05/15/1961	5.02E-01	3.75E+00	1,529	263
08/15/1961	4.12E-01	2.57E+00	1,553	259
11/15/1961	2.89E-01	2.33E+00	1,882	287
02/15/1962	2.51E-01	1.42E+00	2,016	293
05/15/1962	3.46E-01	1.98E+00	1,938	282
08/15/1962	4.88E-01	2.63E+00	1,760	293
11/15/1962	1.85E-01	1.80E+00	2,023	301
02/15/1963	2.09E-01	1.57E+00	1,721	287
05/15/1963	9.66E-02	7.90E-01	1,813	297
08/15/1963	9.01E-02	5.51E-01	2,158	336
11/15/1963	3.38E-01	1.66E+00	2,183	343
02/15/1964	4.71E-02	2.68E-01	2,114	317
05/15/1964	1.86E-02	1.56E-01	2,156	318
08/15/1964	4.43E-02	2.03E-01	2,030	319
11/15/1964	4.35E-02	2.00E-01	2,059	307
02/15/1965	3.60E-02	1.33E-01	2,185	319
05/15/1965	1.90E-02	6.91E-02	1,762	284
08/15/1965	3.27E-02	1.07E-01	1,506	288
11/15/1965	1.34E-02	7.85E-02	1,634	295
02/15/1966	8.63E-03	4.57E-02	1,798	287
05/15/1966	1.12E-02	5.53E-02	1,599	287
08/15/1966	1.53E-02	9.59E-02	1,605	305
11/15/1966	1.77E-02	8.22E-02	1,657	296
02/15/1967	2.11E-02	7.49E-02	1,901	315
05/15/1967	9.13E-03	4.15E-02	1,942	307
08/15/1967	2.00E-03	2.33E-02	1,757	317
11/15/1967	7.77E-04	2.24E-02	1,927	311
02/15/1968	4.09E-03	5.91E-02	1,702	288
05/15/1968	1.30E-02	9.17E-02	1,866	312

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Effective	50th percentile	84th percentile	# of samples	# of employees
08/15/1968	2.19E-03	1.24E-01	1,555	267
11/15/1968	7.16E-03	9.72E-02	1,313	264
02/15/1969	1.87E-03	2.55E-02	1,286	248
05/15/1969	5.10E-03	2.35E-02	747	153
08/15/1969	1.14E-03	1.15E-02	582	135
11/15/1969	3.99E-05	1.58E-03	572	116
02/15/1970	1.45E-03	9.66E-03	500	116
05/15/1970	1.37E-02	4.73E-02	272	88
11/15/1970	2.20E-02	6.67E-02	98	25
07/01/1971	5.96E-04	1.52E-02	353	56
07/01/1972	1.06E-02	2.40E-01	73	13
07/01/1973	4.38E-03	4.61E-01	30	3

Table A-2. Type M ^{210}Po intake rates (Bq/d) and dates.

Start	End	50th percentile	84th percentile	GSD
07/01/1944	03/31/1946	4097.6	15796	3.9
04/01/1946	03/31/1949	800.19	4602.3	5.8
04/01/1949	03/31/1960	39.851	320.28	8.0
04/01/1960	03/31/1965	5.7883	36.121	6.2
04/01/1965	12/31/1973	0.34853	3.0638	8.8

Table A-3. Type F ^{210}Po intake rates (Bq/d) and dates.

Start	End	50th percentile	84th percentile	GSD
07/01/1944	03/31/1946	1189.5	4628	3.89
04/01/1946	03/31/1949	254.96	1416.8	5.56
04/01/1949	03/31/1960	12.192	97.456	7.99
04/01/1960	03/31/1965	2.0696	13.856	6.70
04/01/1965	12/31/1973	0.10303	0.91451	8.88

Table A-4. 50th- and 84th-percentile urinary excretion rates of total plutonium, 1956 to 1990 (pCi/d).

Effective	50th percentile	84th percentile	# of samples	# of employees
07/01/1956	1.88E+00	4.49E+00	38	7
07/01/1957	2.26E+00	4.03E+00	86	19
07/01/1958	1.14E+00	2.00E+00	77	32
07/01/1959	1.53E+00	2.73E+00	99	32
07/01/1960	1.72E+00	9.81E+00	336	89
07/01/1961	8.01E-02	6.50E-01	792	178
02/15/1962	3.49E-02	2.25E-01	351	174
05/15/1962	7.15E-02	4.42E-01	338	169
08/15/1962	1.01E-01	3.63E-01	296	186
11/15/1962	1.06E-01	4.27E-01	390	205
02/15/1963	5.31E-02	2.88E-01	356	183
05/15/1963	7.53E-02	5.73E-01	553	317
08/15/1963	5.19E-02	3.41E-01	558	319
11/15/1963	7.01E-02	3.65E-01	535	327
02/15/1964	8.98E-02	3.53E-01	606	316
05/15/1964	1.19E-01	3.64E-01	674	408
08/15/1964	1.18E-01	3.62E-01	585	381

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COWORKER DATA TABLES

Effective	50th percentile	84th percentile	# of samples	# of employees
11/15/1964	1.59E-01	6.00E-01	755	443
02/15/1965	1.03E-01	5.95E-01	857	460
05/15/1965	1.07E-01	5.11E-01	835	492
08/15/1965	1.07E-01	5.58E-01	783	477
11/15/1965	5.56E-02	2.62E-01	723	474
02/15/1966	9.62E-02	3.70E-01	726	435
05/15/1966	7.11E-02	2.94E-01	897	578
08/15/1966	7.09E-02	2.29E-01	957	603
11/15/1966	8.56E-02	2.87E-01	954	567
02/15/1967	7.68E-02	2.87E-01	1,086	640
05/15/1967	8.63E-02	3.37E-01	791	515
08/15/1967	7.38E-02	2.91E-01	826	544
11/15/1967	4.86E-02	2.27E-01	911	550
02/15/1968	5.01E-02	2.17E-01	834	498
05/15/1968	7.91E-02	2.70E-01	769	476
08/15/1968	6.23E-02	2.26E-01	541	297
11/15/1968	4.47E-02	2.67E-01	670	363
02/15/1969	5.42E-02	4.69E-01	680	310
05/15/1969	5.14E-02	3.87E-01	674	351
08/15/1969	8.76E-02	8.74E-01	579	278
11/15/1969	4.45E-02	2.63E-01	489	246
02/15/1970	2.42E-02	1.47E-01	659	398
05/15/1970	3.27E-02	1.75E-01	632	370
08/15/1970	2.93E-02	1.31E-01	626	373
11/15/1970	1.98E-02	9.93E-02	796	484
02/15/1971	2.90E-02	1.64E-01	608	399
05/15/1971	2.03E-02	1.16E-01	629	416
08/15/1971	2.21E-02	1.15E-01	484	339
11/15/1971	2.77E-02	1.46E-01	540	375
02/15/1972	2.83E-02	1.62E-01	708	392
05/15/1972	2.01E-02	1.15E-01	653	387
08/15/1972	2.05E-02	1.21E-01	685	389
11/15/1972	2.21E-02	1.27E-01	533	360
02/15/1973	3.80E-02	1.80E-01	517	376
05/15/1973	3.32E-02	1.40E-01	502	354
08/15/1973	2.29E-02	1.08E-01	535	387
11/15/1973	1.21E-02	8.04E-02	525	369
02/15/1974	3.65E-02	1.41E-01	545	364
05/15/1974	4.34E-02	1.91E-01	453	328
08/15/1974	3.70E-02	1.83E-01	532	366
11/15/1974	4.74E-02	2.06E-01	407	296
02/15/1975	1.10E-02	7.75E-02	510	339
05/15/1975	1.13E-02	9.84E-02	499	326
08/15/1975	3.49E-02	1.69E-01	199	153
11/15/1975	1.71E-02	8.51E-02	320	273
02/15/1976	3.49E-02	1.66E-01	283	195
05/15/1976	1.19E-02	7.15E-02	327	246
08/15/1976	1.46E-02	6.91E-02	261	204

ATTACHMENT A
COMPARISON OF CTWs TO NCTWs

Effective	50th percentile	84th percentile	# of samples	# of employees
11/15/1976	1.80E-02	8.28E-02	278	213
02/15/1977	2.13E-02	9.59E-02	347	250
05/15/1977	2.13E-02	9.50E-02	294	233
08/15/1977	1.15E-02	7.02E-02	350	268
11/15/1977	1.56E-02	8.01E-02	278	227
02/15/1978	7.79E-03	4.92E-02	370	294
05/15/1978	4.68E-03	4.20E-02	298	236
08/15/1978	4.44E-03	2.99E-02	371	297
11/15/1978	8.12E-03	6.62E-02	272	231
02/15/1979	2.78E-03	2.96E-02	385	326
05/15/1979	6.74E-03	5.00E-02	304	246
08/15/1979	1.80E-02	7.82E-02	293	260
11/15/1979	7.70E-03	6.01E-02	210	196
02/15/1980	6.84E-03	4.16E-02	334	287
05/15/1980	1.77E-02	9.15E-02	268	237
08/15/1980	1.80E-02	7.22E-02	294	255
11/15/1980	2.41E-02	1.33E-01	284	235
02/15/1981	2.22E-02	1.06E-01	346	284
05/15/1981	2.63E-02	8.57E-02	323	282
08/15/1981	2.02E-02	9.85E-02	274	243
11/15/1981	2.17E-02	1.17E-01	283	247
02/15/1982	1.89E-02	9.22E-02	301	249
05/15/1982	9.69E-03	5.85E-02	340	301
08/15/1982	1.23E-02	7.39E-02	279	244
11/15/1982	2.97E-02	9.91E-02	269	243
02/15/1983	1.24E-02	6.12E-02	243	205
05/15/1983	1.24E-02	7.51E-02	365	308
08/15/1983	1.08E-02	6.97E-02	290	252
11/15/1983	7.71E-03	5.37E-02	310	287
02/15/1984	9.94E-03	5.88E-02	289	250
05/15/1984	1.22E-02	6.80E-02	339	304
08/15/1984	7.50E-03	4.01E-02	316	263
11/15/1984	8.39E-03	4.20E-02	315	283
02/15/1985	2.49E-03	2.29E-02	325	284
05/15/1985	3.05E-03	2.84E-02	363	319
08/15/1985	1.12E-03	1.44E-02	368	300
11/15/1985	1.28E-03	1.51E-02	266	249
02/15/1986	2.25E-03	2.05E-02	359	292
05/15/1986	3.86E-03	3.76E-02	316	275
08/15/1986	3.09E-03	2.71E-02	318	280
11/15/1986	4.11E-03	3.44E-02	147	136
02/15/1987	6.20E-03	3.27E-02	239	232
05/15/1987	6.85E-03	4.20E-02	173	168
08/15/1987	4.05E-03	2.85E-02	205	201
11/15/1987	4.61E-03	3.01E-02	200	197
02/15/1988	5.23E-03	3.55E-02	189	185
05/15/1988	5.50E-03	3.60E-02	211	202
08/15/1988	3.47E-03	2.52E-02	183	179

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Effective	50th percentile	84th percentile	# of samples	# of employees
11/15/1988	2.65E-03	3.32E-02	199	185
02/15/1989	3.17E-03	3.06E-02	178	164
05/15/1989	3.90E-03	3.11E-02	204	201
08/15/1989	1.88E-03	1.83E-02	235	183
11/15/1989	1.23E-03	1.66E-02	300	247
02/15/1990	1.16E-03	1.52E-02	340	283
05/15/1990	1.27E-03	1.40E-02	288	242
08/15/1990	6.78E-04	1.07E-02	411	360
11/15/1990	1.83E-03	1.18E-02	350	286

Table A-5. Type M plutonium intake rates (pCi/d) and dates.

Start	End	50th percentile	84th percentile	GSD
01/01/1956	12/31/1957	750.98	1,073.4	1.43[a]
01/01/1958	12/31/1960	436.49	1,073.4	2.46[a]
01/01/1961	12/31/1967	12.141	65.823	5.42
01/01/1968	12/31/1969	12.141	141.98	11.69
01/01/1970	12/31/1977	2.2361	20.445	9.14
01/01/1978	12/31/1984	2.2361	13.013	5.82
01/01/1985	12/31/1990	0.59706	4.872	8.16

a. Actual. Adjust all GSD <3 to 3 for dose calculations.

Table A-6. Type S plutonium intake rates (pCi/d) and dates.

Start	End	50th percentile	84th percentile	GSD
01/01/1956	12/31/1957	27,150	52,240	1.92[a]
1/1/1958	12/31/1960	12,880	53,000	4.11
1/1/1961	12/31/1969	209.9	1,301	4.91
1/1/1970	12/31/1984	31.31	160.2	5.12
1/1/1985	12/31/1990	11.66	96.33	8.26

a. Actual. Adjust all GSD <3 to 3 for dose calculations.

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COWORKER DATA FIGURES
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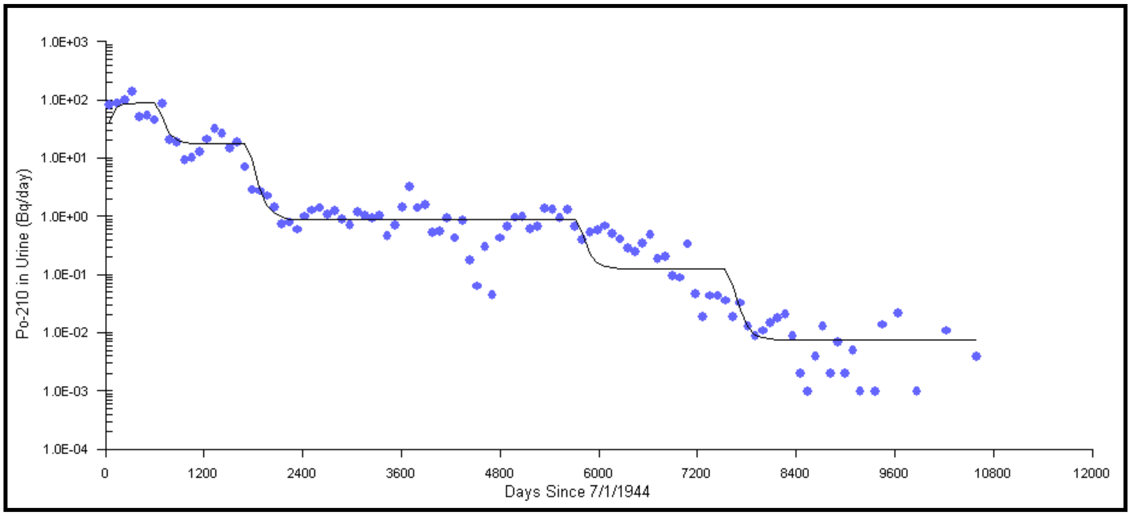

Figure B-1. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type M ^{210}Po.

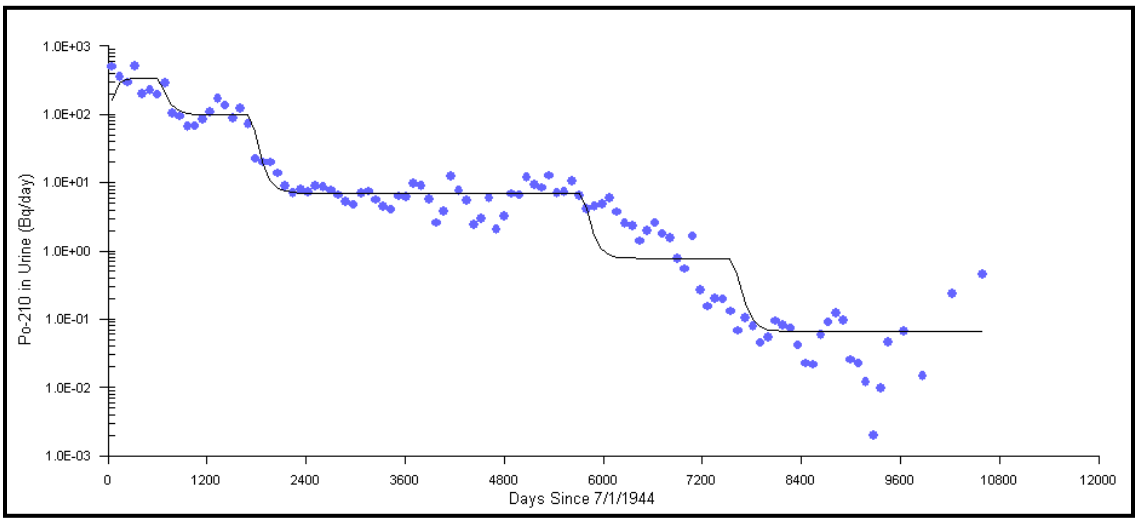

Figure B-2. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M ^{210}Po.

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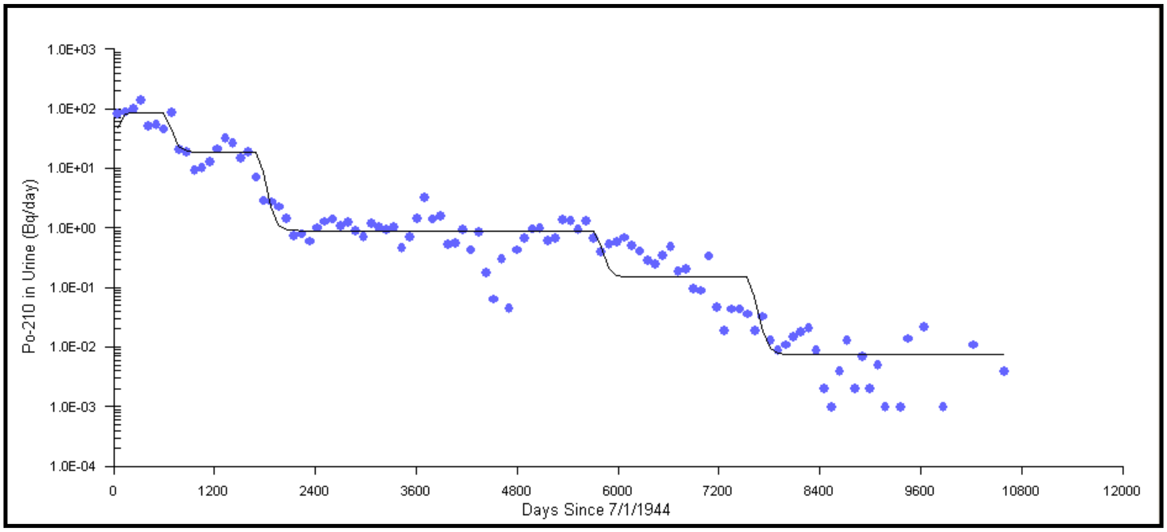

Figure B-3. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type F ^{210}Po.

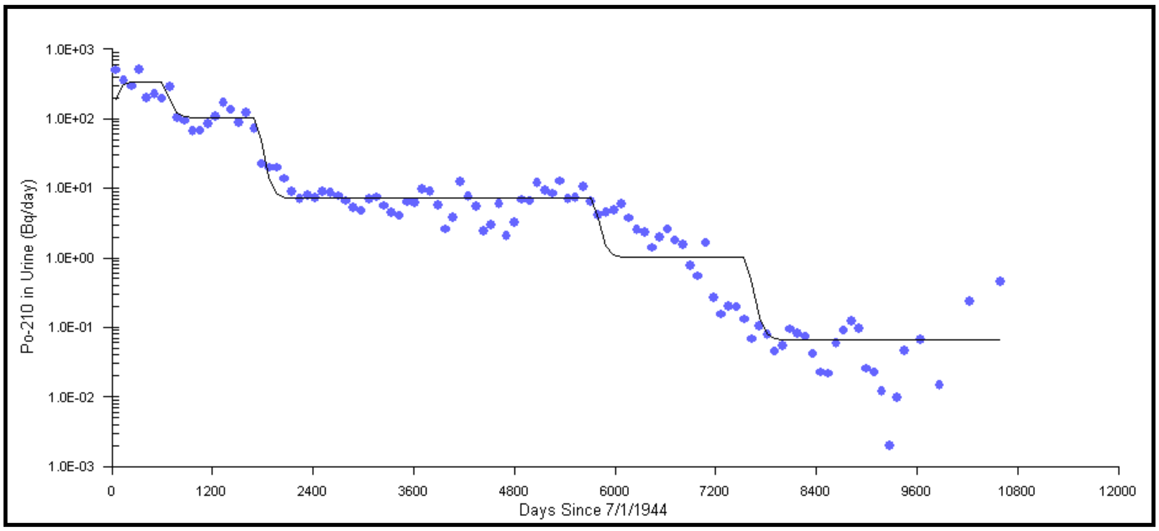

Figure B-4. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type F ^{210}Po.

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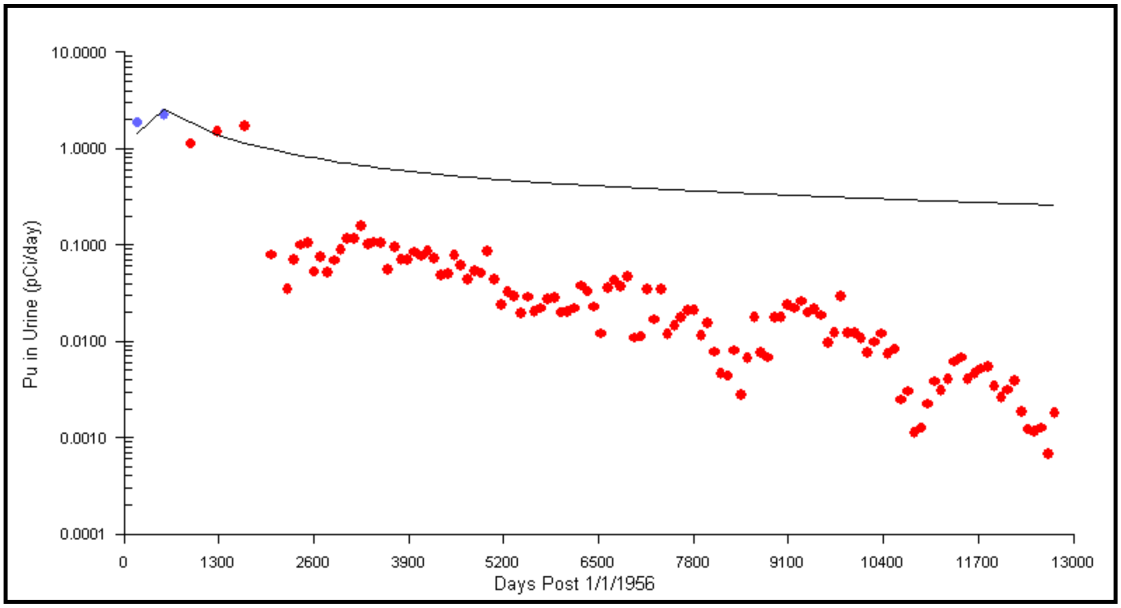

Figure B-5. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1956 to 1957.

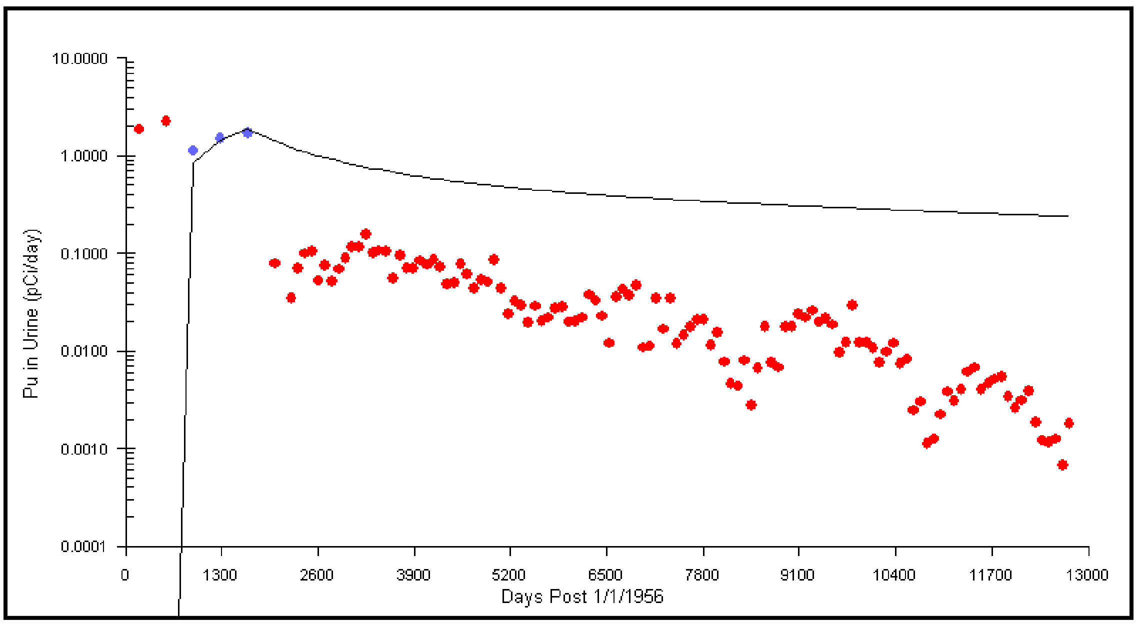

Figure B-6. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1958 to 1960.

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COWORKER DATA FIGURES
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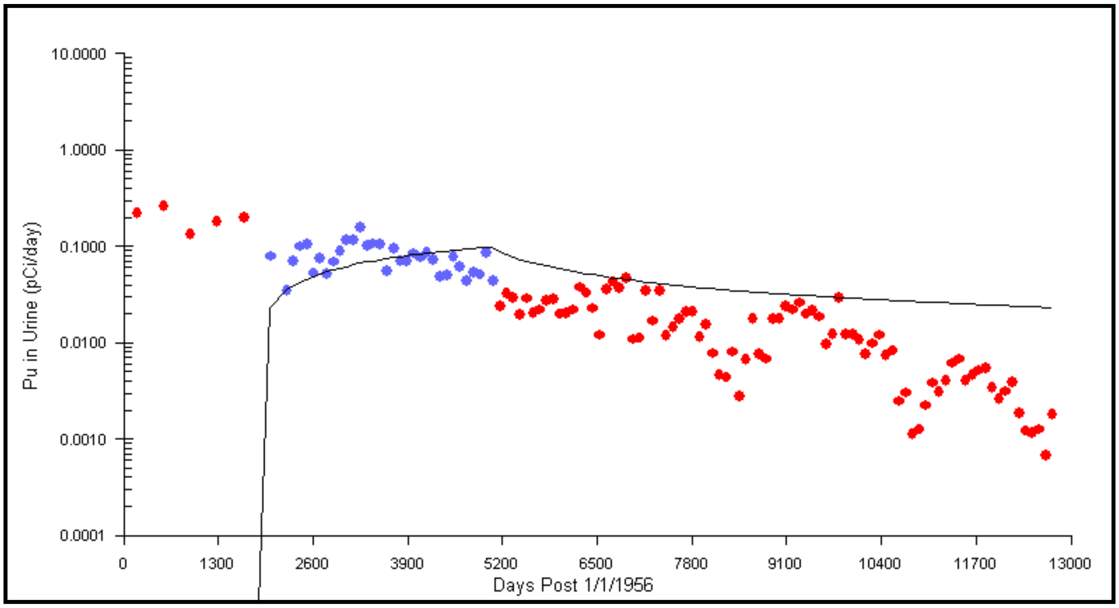

Figure B-7. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1961 to 1969.

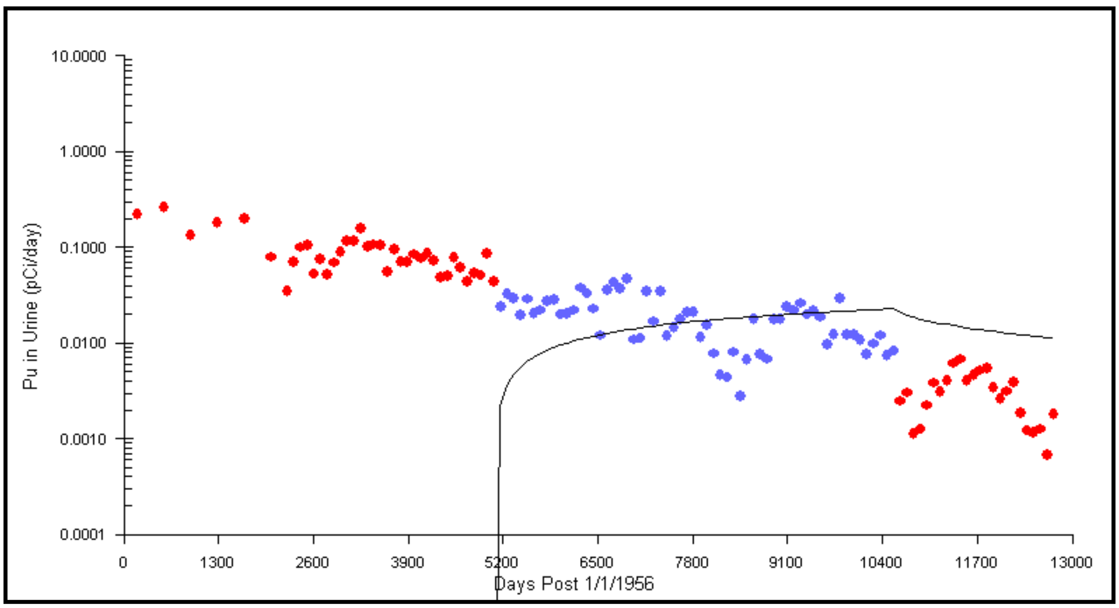

Figure B-8. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1970 to 1984.

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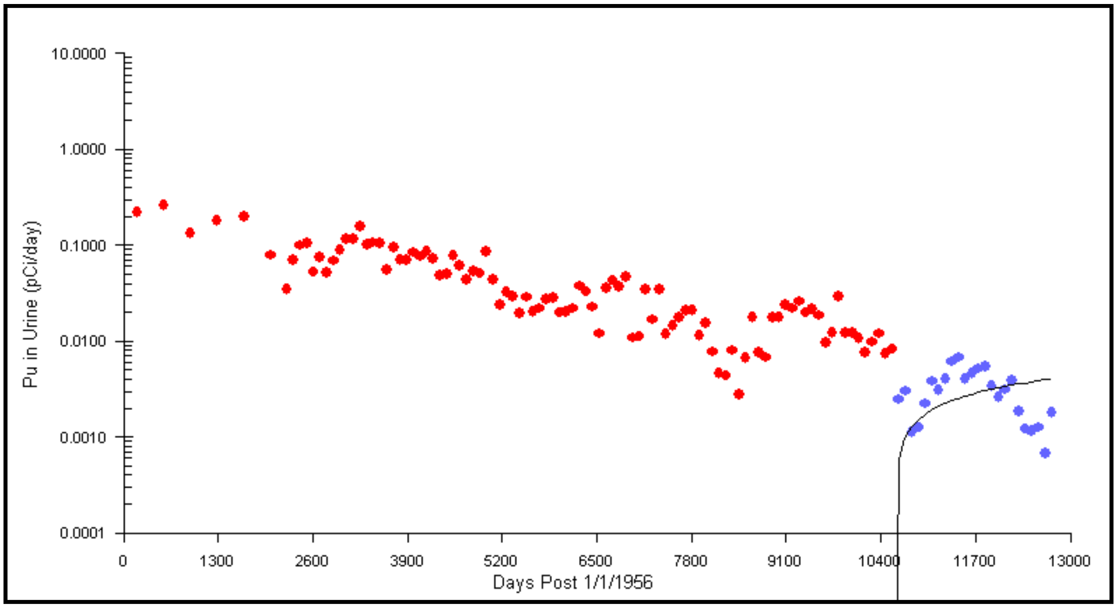

Figure B-9. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1985 to 1990.

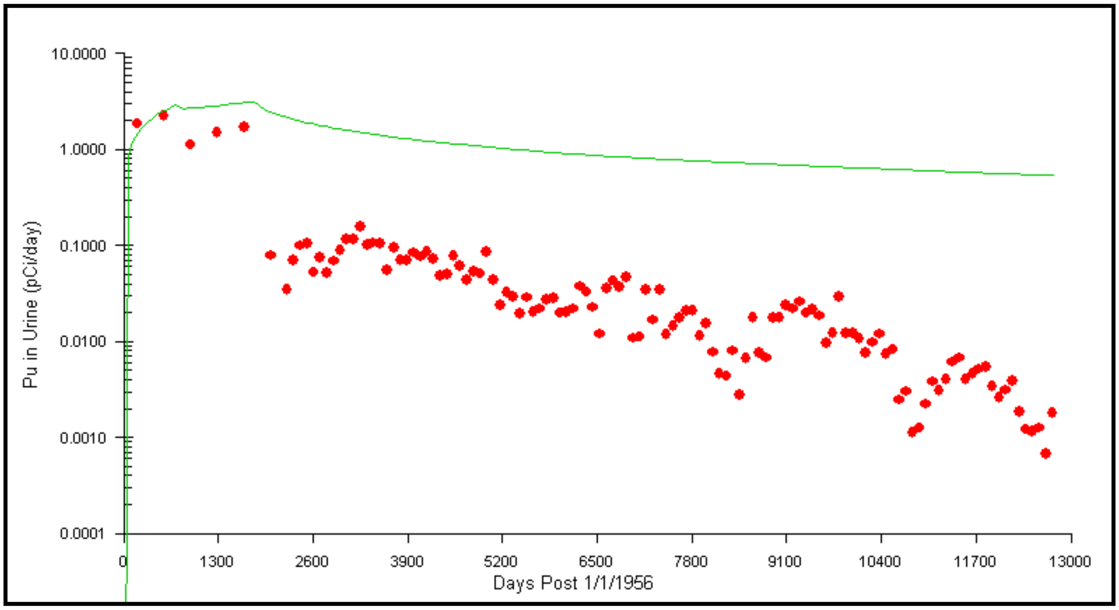

Figure B-10. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1956 to 1990.

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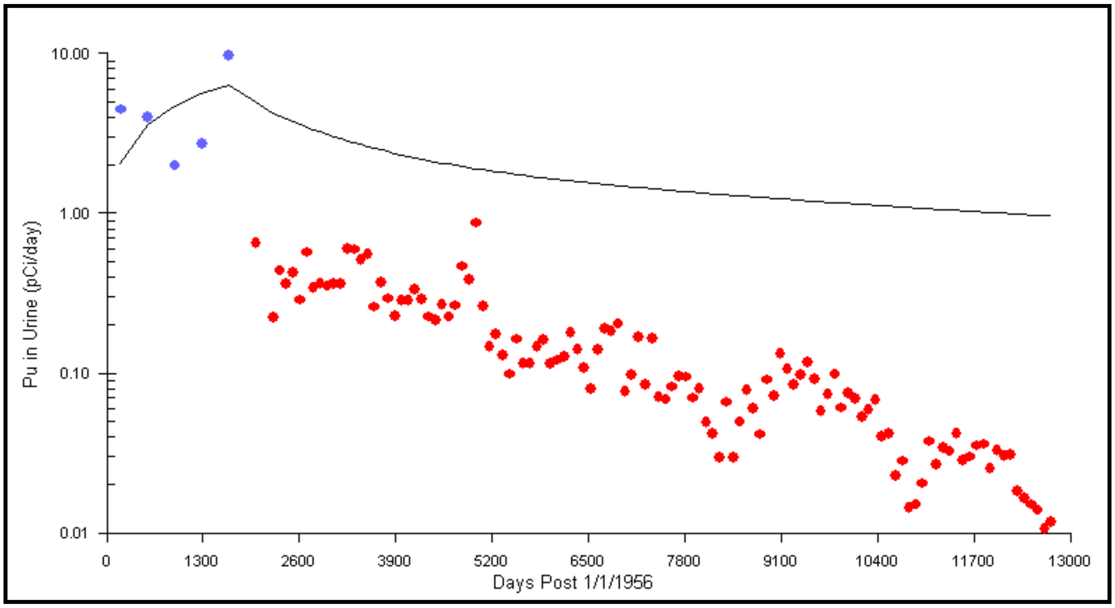

Figure B-11. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1956 to 1960.

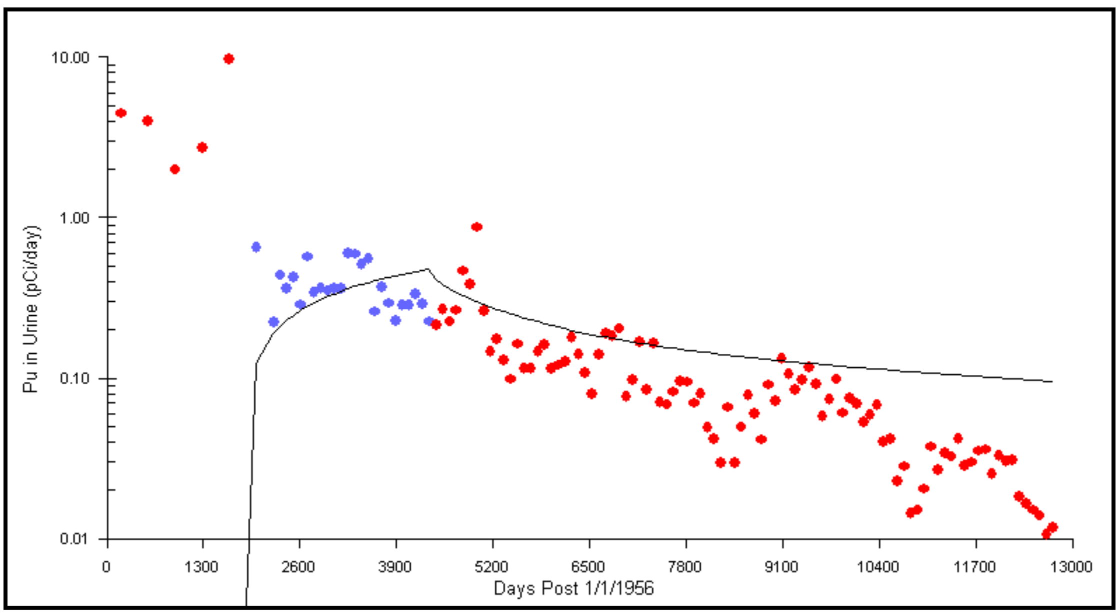

Figure B-12. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1961 to 1967.

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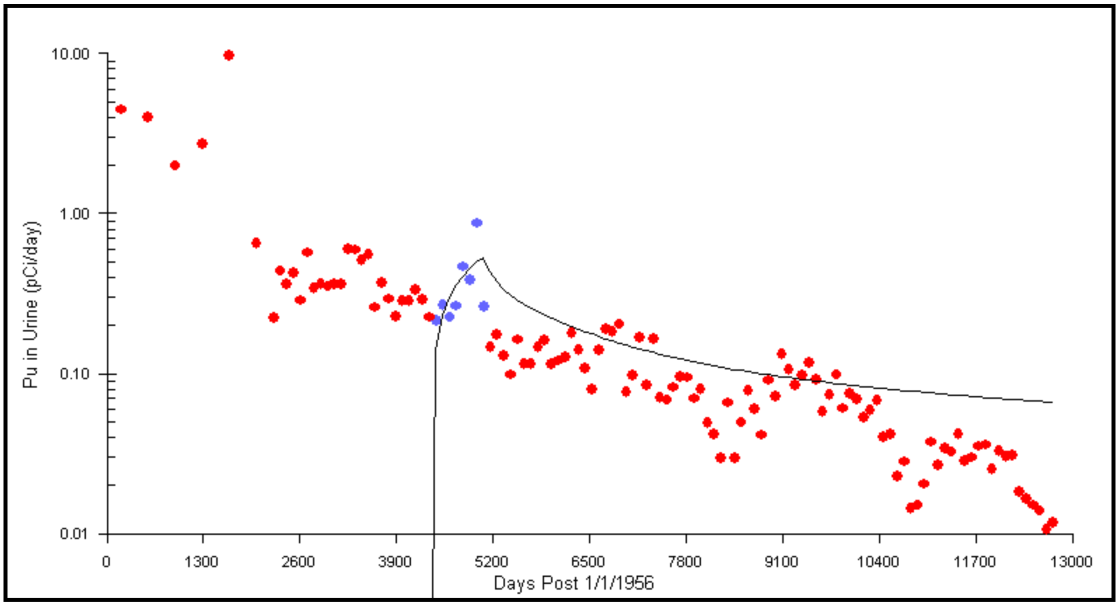

Figure B-13. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1968 to 1969.

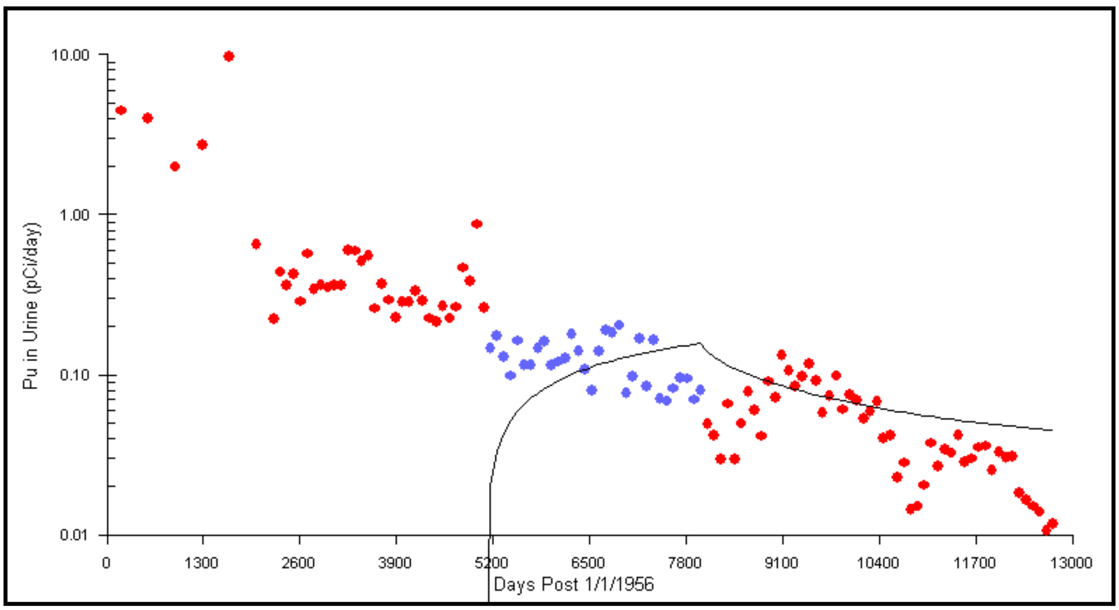

Figure B-14. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1970 to 1977.

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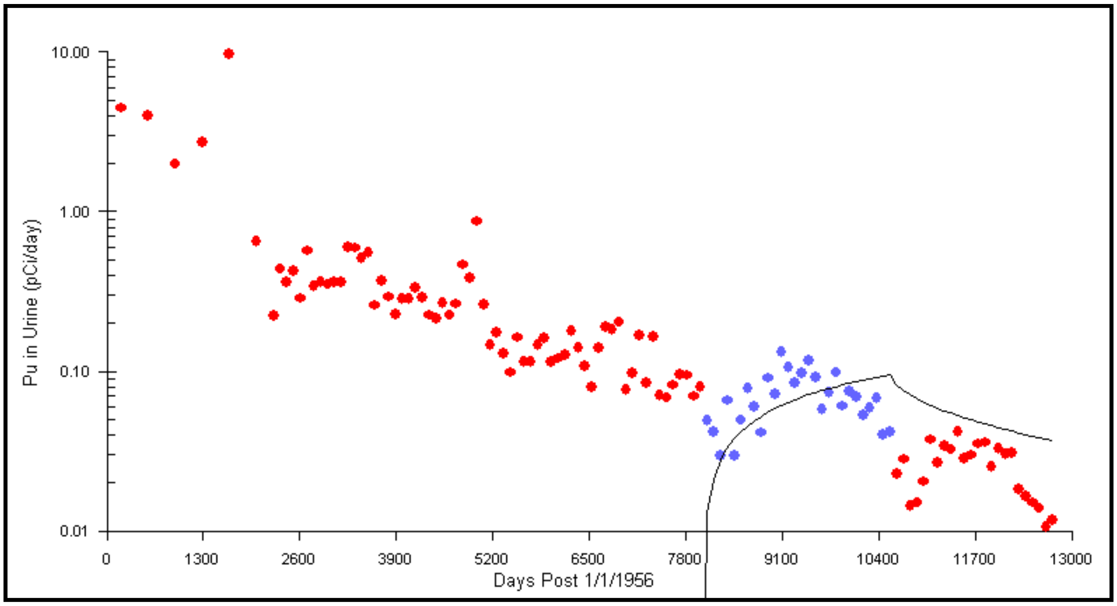

Figure B-15. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1978 to 1984.

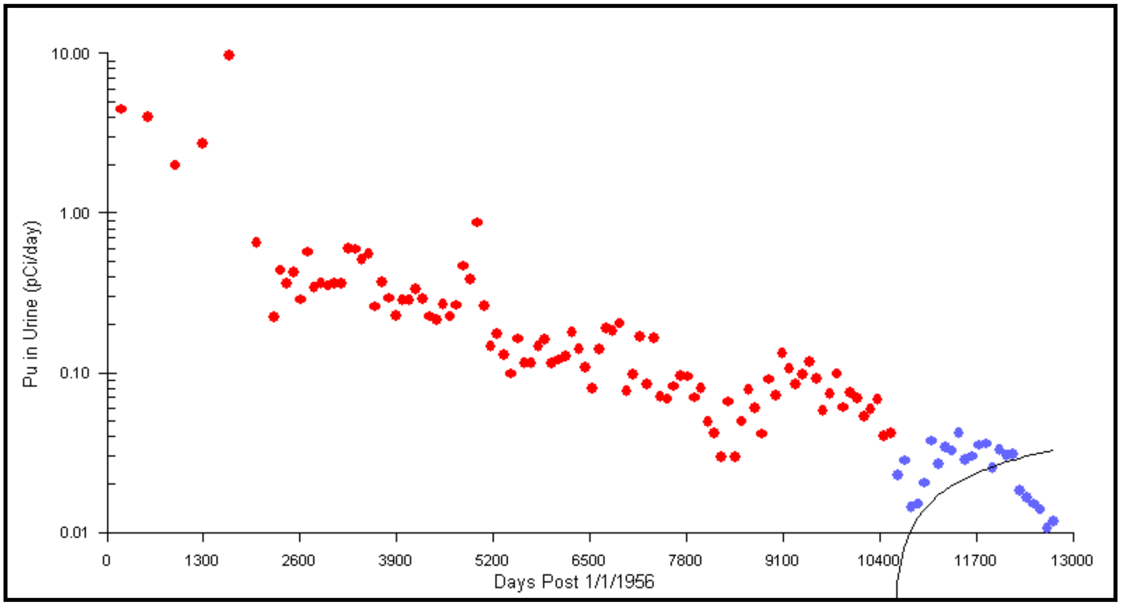

Figure B-16. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1985 to 1990.

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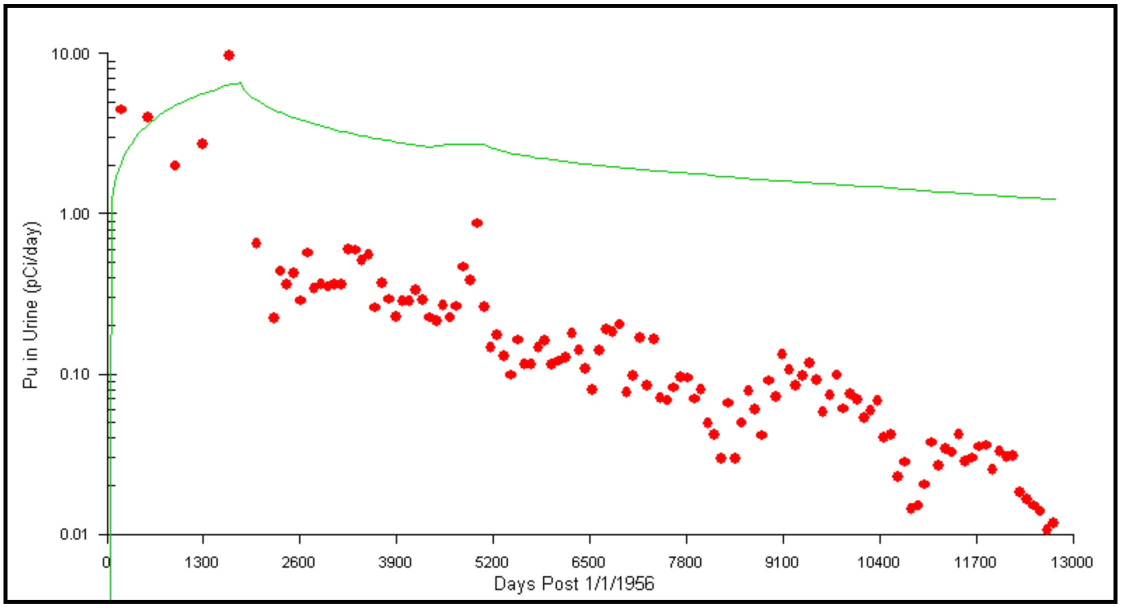

Figure B-17. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming inhalation intakes of type M plutonium, 1956 to 1990.

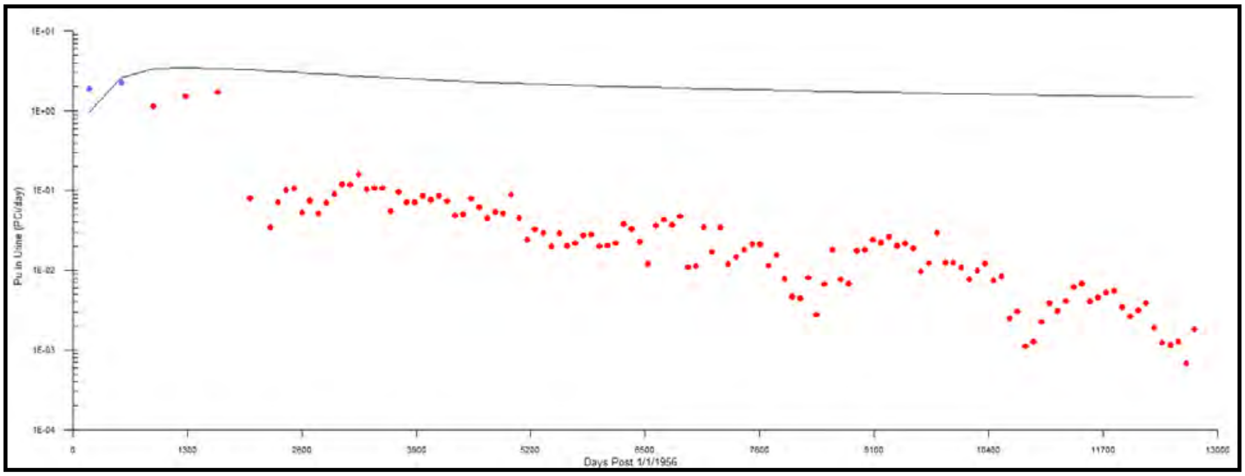

Figure B-18. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1956 to 1957.

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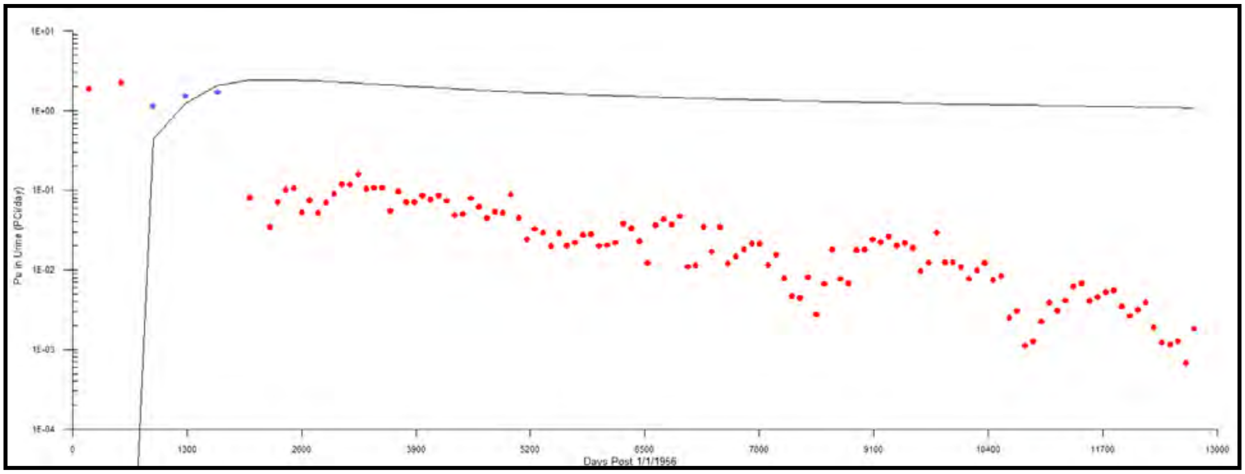

Figure B-19. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1958 to 1960.

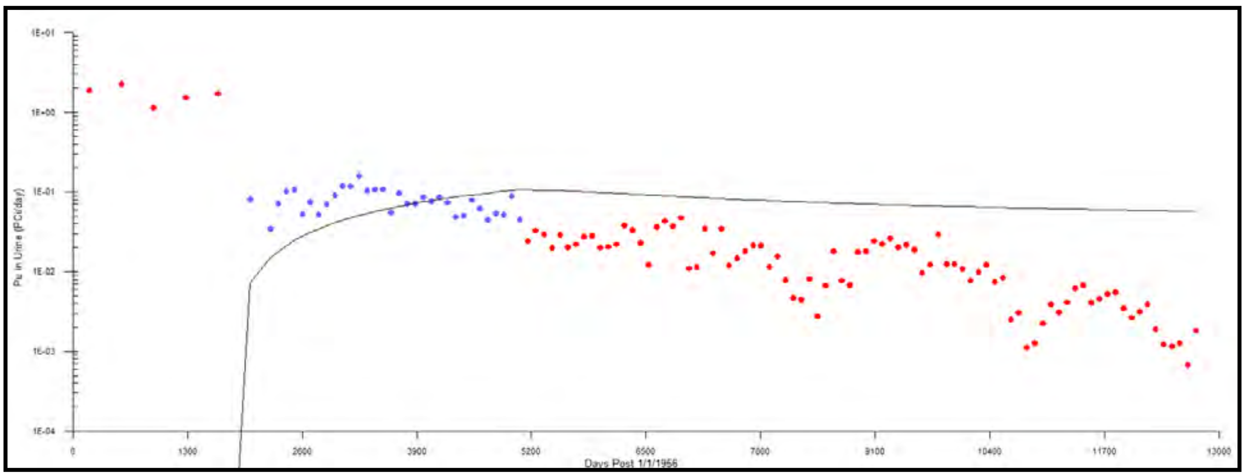

Figure B-20. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1961 to 1969.

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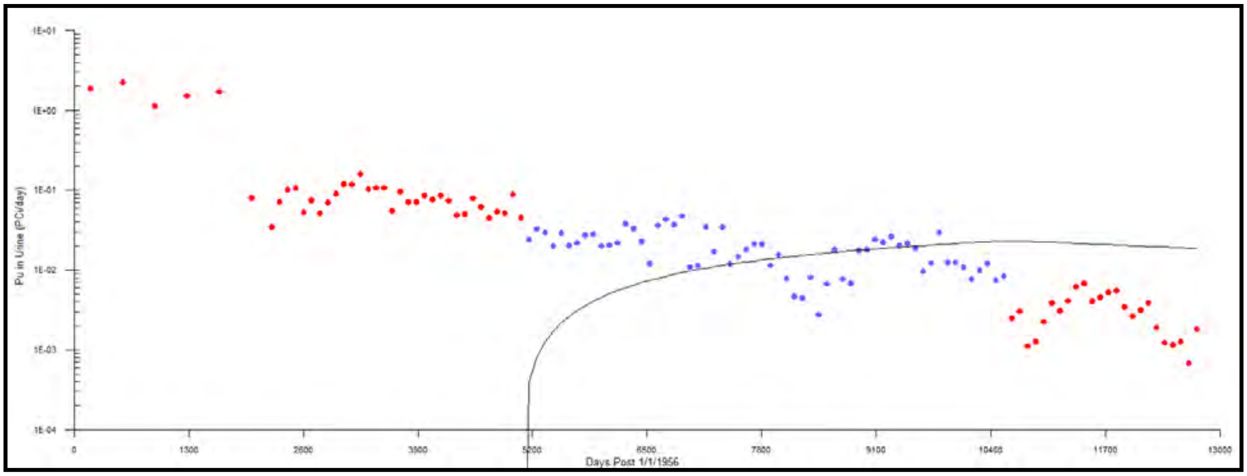

Figure B-21. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1970 to 1984.

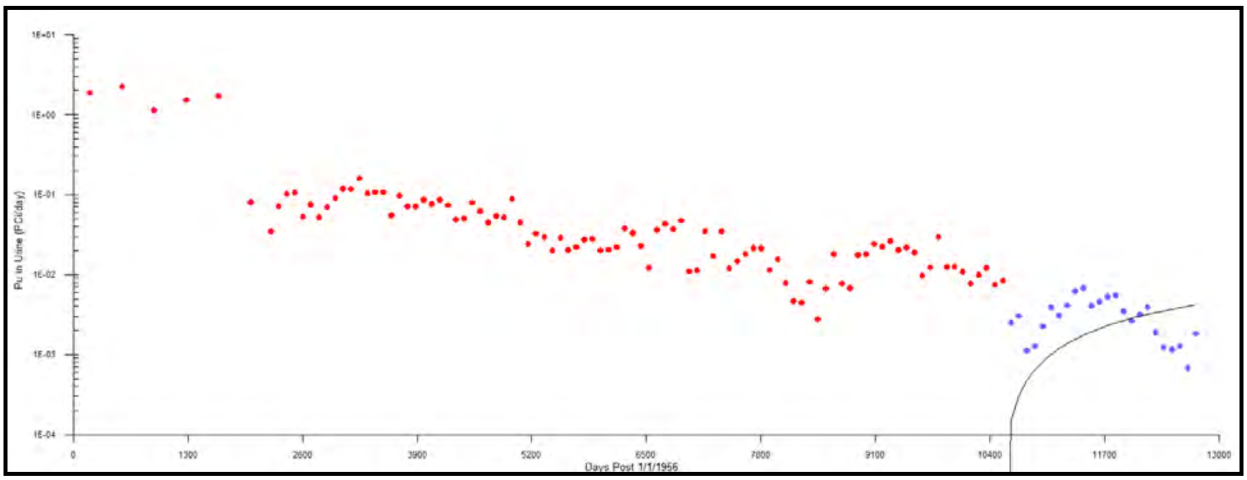

Figure B-22. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1985 to 1990.

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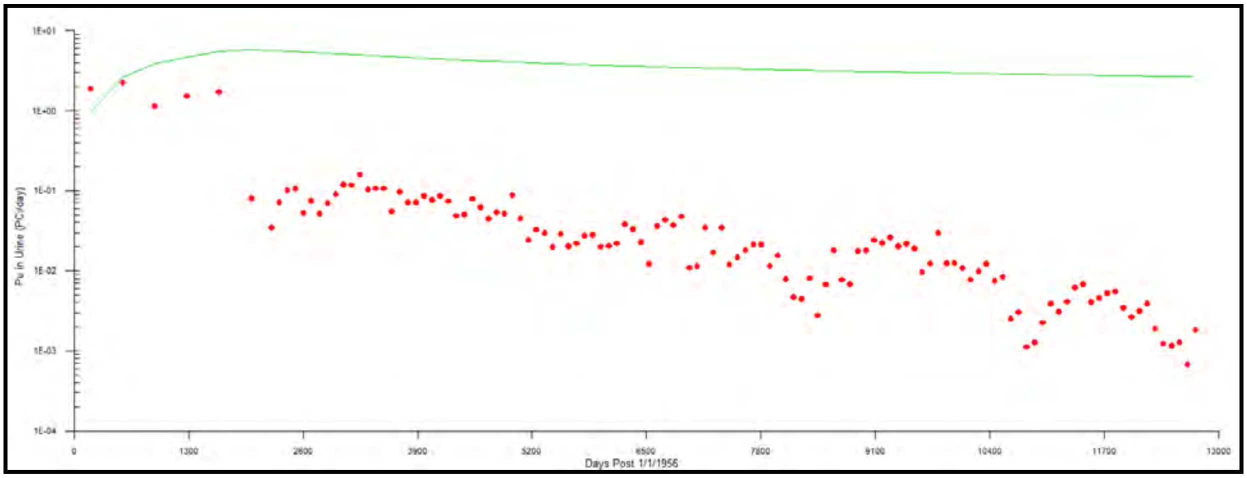

Figure B-23. Predicted (line) and observed (dots) 50th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1956 to 1990.

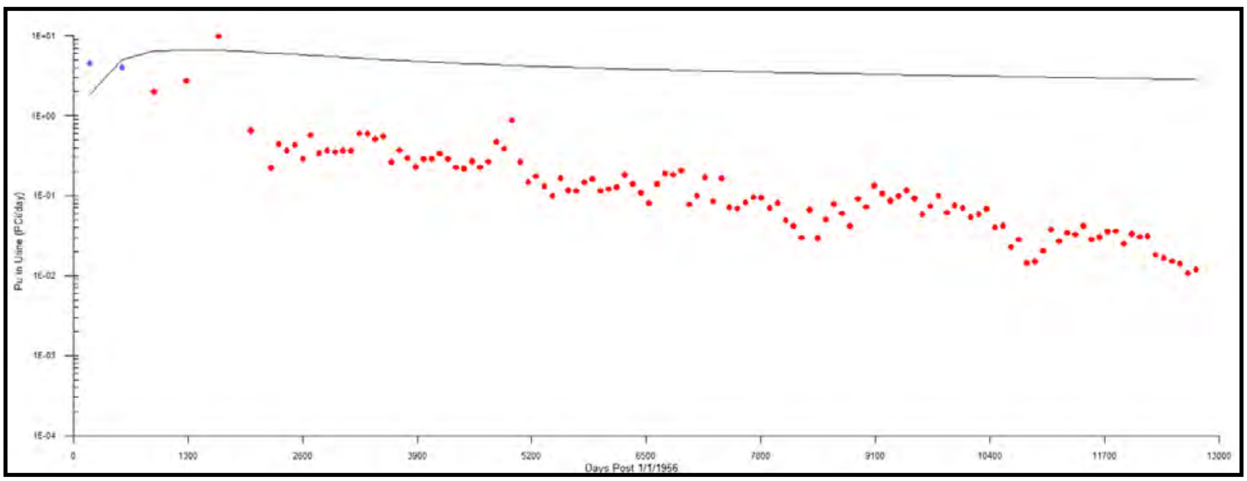

Figure B-24. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1956 to 1957.

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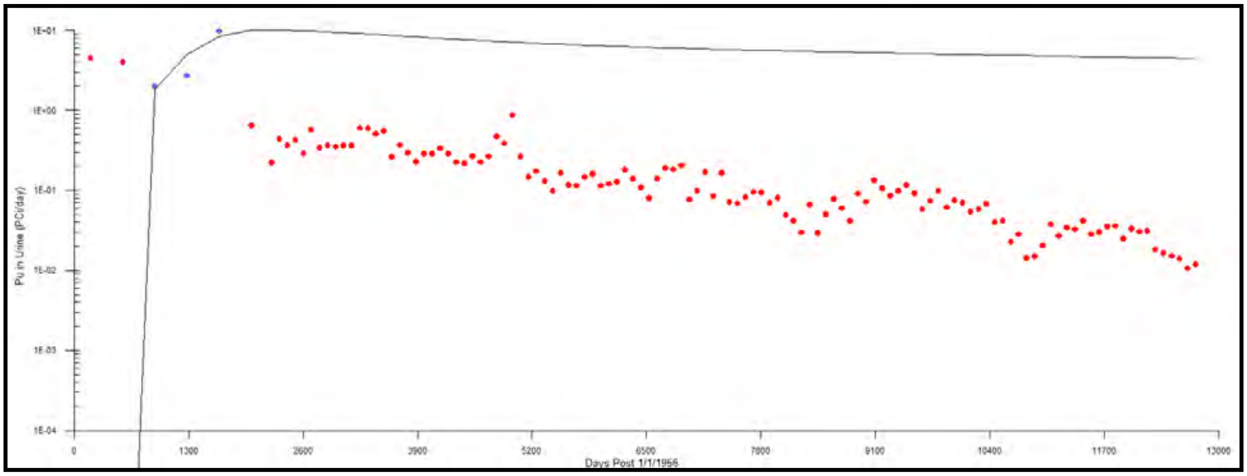

Figure B-25. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1958 to 1960.

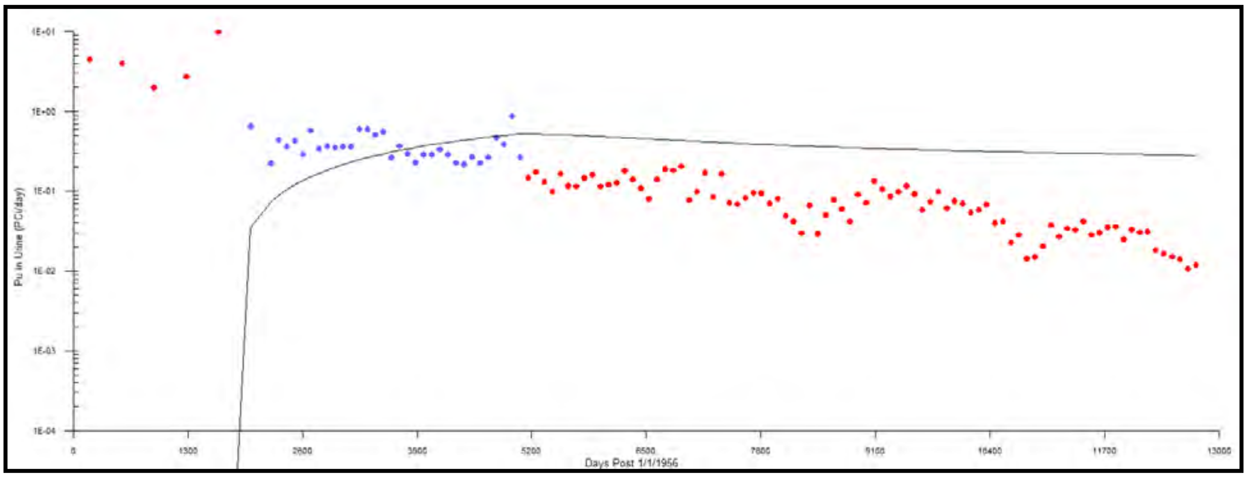

Figure B-26. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1961 to 1969.

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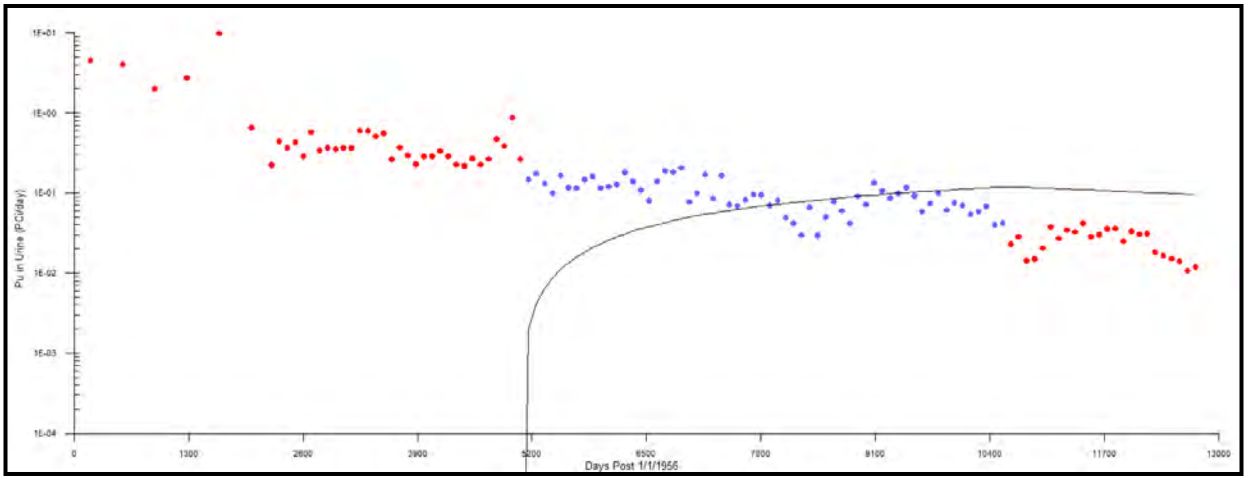

Figure B-27. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1970 to 1984.

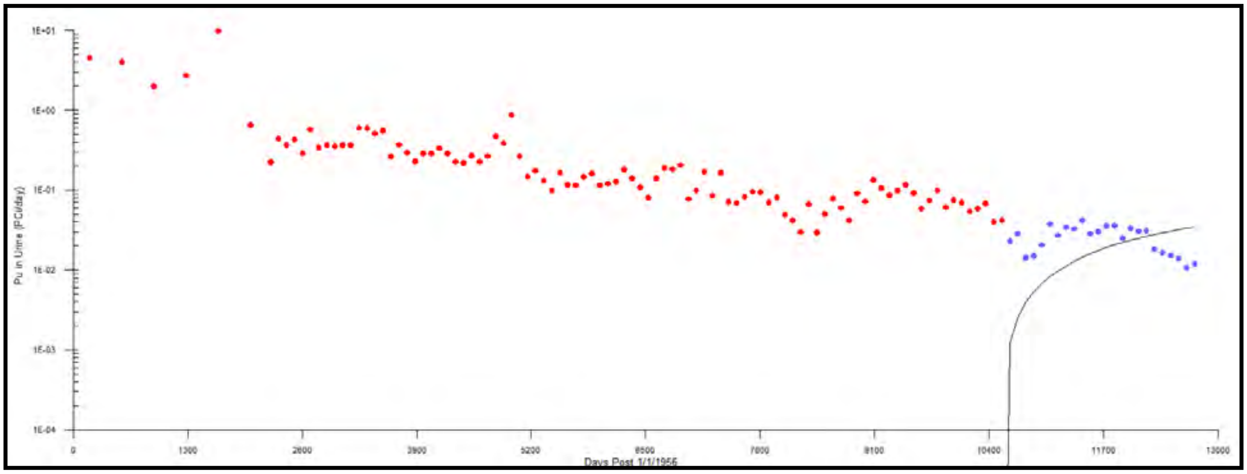

Figure B-28. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1985 to 1990.

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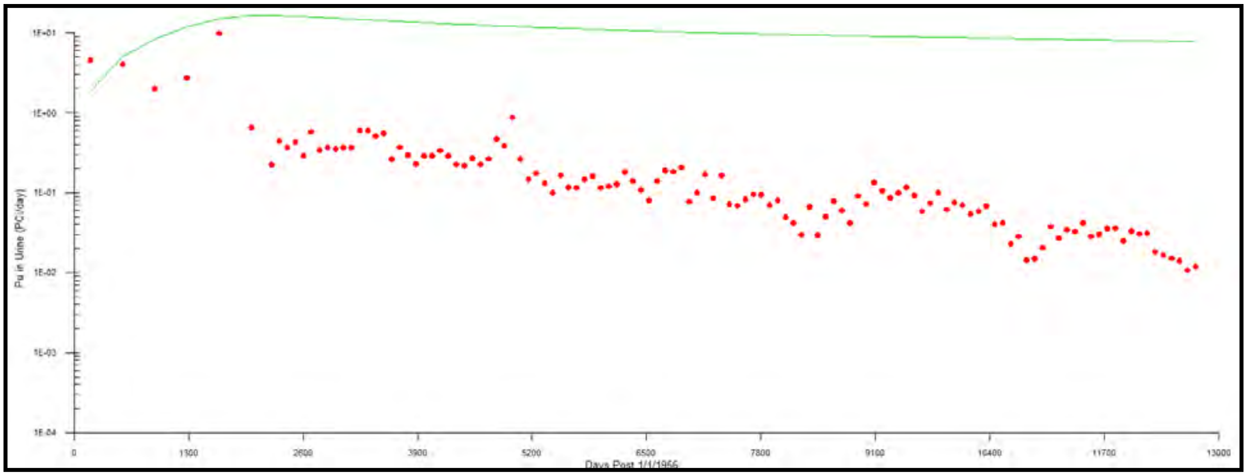

Figure B-29. Predicted (line) and observed (dots) 84th-percentile urinary excretion assuming a single chronic inhalation intake of type S plutonium, 1956 to 1990.