



**ORAU TEAM
Dose Reconstruction
Project for NIOSH**

Oak Ridge Associated Universities | NV5|Dade Moeller | MJW Technical Services

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**Evaluation of Monday Morning Uranium
Urine Samples**

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☒ New

☐ Total Rewrite

☐ Revision

PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
07/30/2026	00	Technical information bulletin for the evaluation of Monday morning uranium urine samples. Current models do not accurately assess a chronic inhalation intake of uranium when morning urine spot samples are collected. Intakes are underestimated when the samples follow a 1- or 2-day break from work and overestimated for other days. Incorporates formal internal and NIOSH review comments. Training is required: As determined by the Objective Manager. Initiated by Wade C. Morris and authored by Elizabeth M. Brackett.

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ACRONYMS AND ABBREVIATIONS

AWE	Atomic Weapons Employer
CF	correction factor
d	day
DOE	U.S. Department of Energy
dpm	disintegrations per minute
F	fast (absorption type)
GSD	geometric standard deviation
ICRP	International Commission on Radiological Protection
IMBA	Integrated Modules for Bioassay Analysis
IRF	intake retention fraction
M	moderate (absorption type)
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
ORAUT	ORAU Team
S	slow (absorption type)
SRDB Ref ID	Site Research Database Reference Identification (number)
TIB	technical information bulletin
TWOPOS	time-weighted one person–one statistic
U.S.C.	<i>United States Code</i>
wk	week
§	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 historical 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), such as changing scientific understanding of operations, processes, or procedures involving radioactive materials. TIBs may be used to assist NIOSH staff in the completion of individual dose reconstructions.

In this document the word “facility” is used to refer to an area, building, or group of buildings that served a specific purpose at a U.S. Department of Energy (DOE) or Atomic Weapons Employer (AWE) facility. It does not mean, nor should it be equated to, an “AWE facility” or a “DOE facility.” The terms AWE and DOE facility are defined in 42 *United States Code* (U.S.C.) § 7384l(5) and (12) of the Energy Employees Occupational Illness Compensation Program Act of 2000, respectively.

Bioassay programs are used at facilities to verify that workplace controls are functioning properly and to ensure that workers have not exceeded a specified internal dose limit. For potential uranium exposures, urinalysis samples are frequently used, particularly when the uranium is in a soluble form.

Spot samples were used historically, particularly for natural and depleted uranium where a mass measurement was performed because kidney damage is a concern.

As the name implies, a Monday morning urine sample is a urine sample collected first thing Monday morning before the worker has the potential for exposure to uranium at work. The concept of a Monday morning sample is linked to an exposure pattern in which the worker is chronically exposed to uranium in the workplace from the beginning of the day Monday to the end of the day on Friday, with no exposure on Saturday or Sunday. This “5-day week” chronic exposure is in contrast to the “7-day week” chronic exposure that is frequently used to model bioassay data, in which the worker is assumed to be exposed chronically around the clock every day of the week.

The practice of collecting a spot sample, a single void of urine, before starting work on a Monday after having the 2-day weekend off was common at many uranium facilities in the past. Internal dose models and limits at the time were based on activity deposition and dose rate rather than total dose [International Commission on Radiological Protection (ICRP) 1959], and the collection of a sample before exposure began for the week allowed the fast-clearing urinary excretion compartments that deliver little dose to empty over the weekend. This yielded a more accurate estimate of the amount of uranium in the slow-clearing compartments that was contributing to the dose rate. Current models relate to intake and total dose, so adjustments are sometimes needed when evaluating a bioassay result.

The term “Monday morning urine sample” in general refers to a spot urine sample collected after a break from exposure to uranium in the workplace. For example, if a person has Tuesday and Wednesday off work, the spot sample collected first thing Thursday morning is a “Monday morning sample.”

2.0 PURPOSE

The purpose of this TIB is to discuss the effect that a 5-day week exposure pattern, combined with the collection of a spot urine sample before returning to work after a 2-day break from work, has on chronic intake rates of uranium that are calculated using standard assessment software such as the Integrated Modules for Bioassay Analysis (IMBA) program.

Adjustment factors that can be implemented using existing software tools (e.g., IMBA and Web CAD) are derived here. The adjustment factors should be applied as necessary for co-exposure studies during any period when a site consistently collected spot urine samples for uranium analysis after a 2-day break from work. This does not apply to simulated or full 24-hour samples.

The supporting data for this TIB are in Oak Ridge Associated Universities (ORAU) Team (ORAUT) [2026].

3.0 GENERAL ASSESSMENT METHOD

As noted in ORAUT-OTIB-0060, *Internal Dose Reconstruction*, the general assumption for internal dose reconstruction is that a worker was constantly exposed to at least some level of airborne radioactivity throughout employment [ORAUT 2025]. This might not be an accurate representation of the exposure pattern, but it best approximates the intakes given the available information and provides for consistency across all individuals.

An intake retention fraction (IRF), designated here by $m(t)$, is used to assess an intake rate from bioassay measurements as a function of time. For a chronic intake, the intake rate at a specified time is equal to the bioassay result divided by the IRF. Given an excretion rate of $M(t)$, the intake rate can be calculated as:

$$i = \frac{M(t)}{m(t)} \quad (3-1)$$

4.0 EVALUATION OF MONDAY MORNING URANIUM URINE SAMPLES

A Monday morning urine sample is collected first thing Monday morning before the worker has the potential for exposure to uranium at work. The concept of a Monday morning sample is linked to an exposure pattern in which the worker is chronically exposed to uranium in the workplace from the beginning of the day Monday to the end of the day on Friday with no exposure on Saturday or Sunday. As noted in Section 1.0, this can be shifted to any 5-day period followed by two days off. This 5-day week chronic exposure is in contrast to the 7-day week chronic exposure that is frequently used to model bioassay data in which the worker is assumed to be exposed chronically around the clock every day of the week. Intake evaluation software like IMBA typically assumes a constant chronic intake pattern where exposure to uranium occurs 24 hours a day, 7 days a week. Doses can be over- or underestimated when spot urine samples from workers with workweek exposures are used to generate co-exposure models. That is not the case if the spot samples are collected more uniformly throughout the week or 24-hour incremental urine samples are collected.

Urinalysis data from Y-12 (Figure 4-1), demonstrates the spot sample collection patterns. Monday morning sampling was implemented by procedure at Y-12 during the early days of the plant [ORAUT 2023], and the figure reflects that sample collection primarily occurred on Mondays in many of these years.

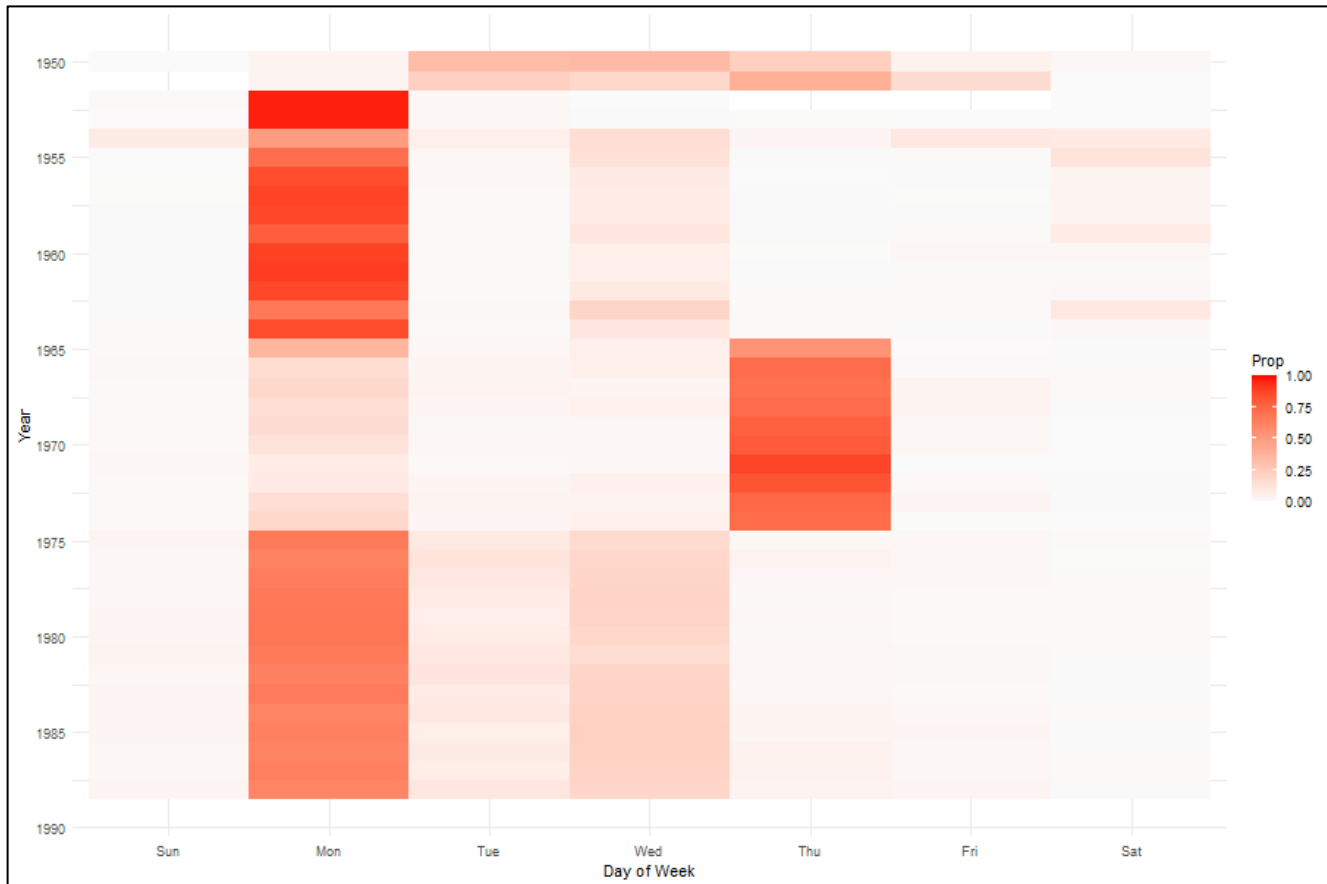


Figure 4-1. Heatmap of the day of week uranium urine samples submitted at Y-12, 1950 to 1988. Attachment A contains an extended description.

4.1 DEMONSTRATION OF THE ISSUE

In Figure 4-2, the uranium in spot samples (*instantaneous* urinary excretion rates) is plotted versus the time since the start of a chronic inhalation intake of Type F uranium. The dashed line is the excretion from a constant chronic intake of 1 dpm/d and is designated by the function $M_7(t)$. The solid line is the excretion from a constant chronic intake of 7/5 dpm/d for 5 days and no intake for the following 2 days; $M_5(t)$ is used to define this line. Thus, the constant chronic intake pattern and the workweek chronic intake have the same total intake for an integral number of weeks. The uranium in the urine on Monday day 7 for both intake patterns is given on the plot:

- $M_7(7) = 0.2114$ dpm is the uranium in the urine on day 7 after a constant chronic intake of 1 dpm/d for 7 days.
- $M_5(7) = 0.02985$ dpm is the uranium in the urine on day 7 after a workweek chronic intake of 7/5 dpm/d for 5 days.

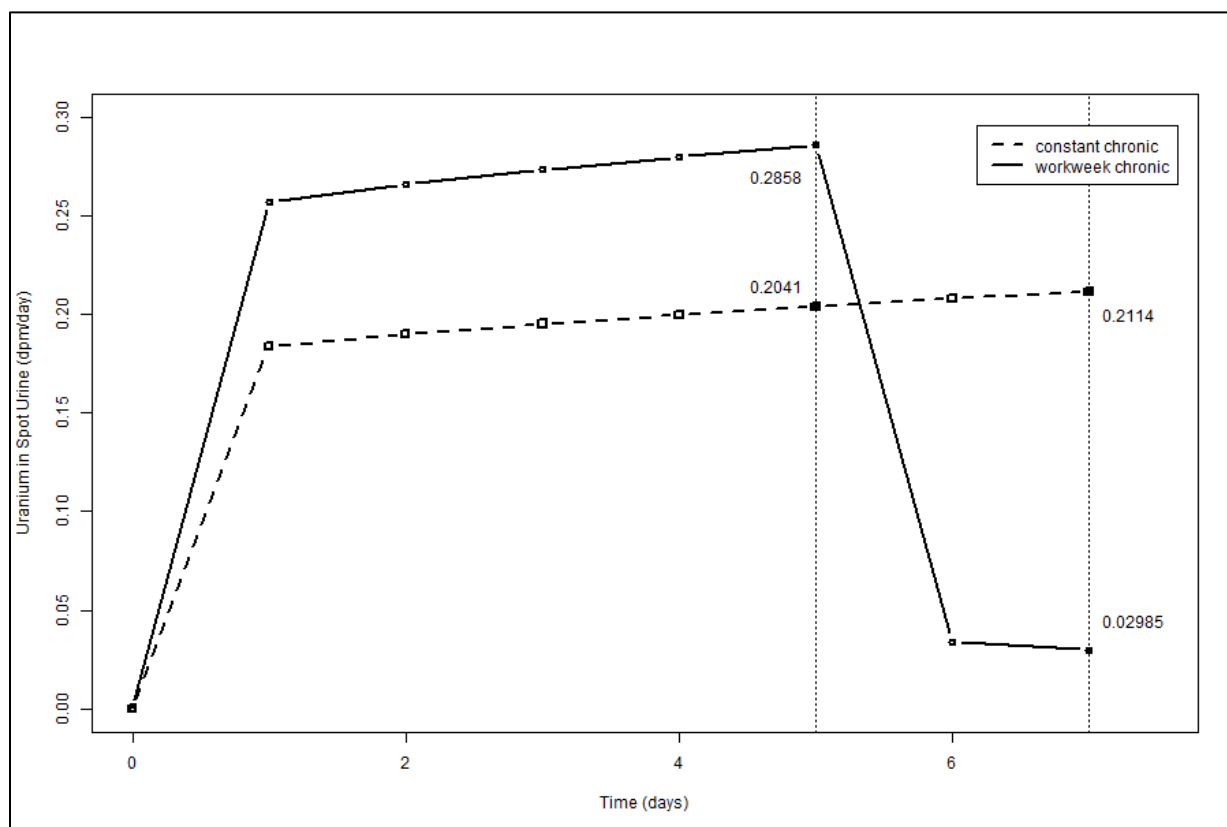


Figure 4-2. Urinary excretion from constant chronic and workweek chronic intakes of Type F uranium. Attachment A contains an extended description.

Given a constant chronic intake, a result greater than 0.2114 dpm in a sample on day 7 would indicate an intake rate that was more than 1 dpm/d, while a result less than that would yield an intake rate less than 1 dpm/d. Applying Equation 3-1:

$$i_5(7) = \frac{M_5(7)}{m_5(7)} \quad (4-1)$$

and

$$i_7(7) = \frac{M_7(7)}{m_7(7)} \quad (4-2)$$

Solving for the constant chronic IRF:

$$m_7(7) = \frac{M_7(7)}{i_7(7)} \quad (4-3)$$

When $M_5(7) = 0.02985$ dpm of uranium in the Monday morning urine sample is evaluated assuming a constant chronic intake, $m_7(7) = m_5(7)$ and the intake rate is:

$$i_5(7) = \frac{M_5(7)}{\left(\frac{M_7(7)}{i_7(7)} \right)} = i_7(7) \times \left[\frac{M_5(7)}{M_7(7)} \right] \quad (4-4)$$

Substituting values yields an intake rate of:

$$i_5 = (1 \text{ dpm/d}) \frac{0.02985}{0.2114} = 0.1412 \text{ dpm/d} \quad (4-5)$$

and the total uranium intake I is:

$$I = 7 \times i = 0.9884 \text{ dpm} \quad (4-6)$$

which is considerably lower than the true intake of $7/5 \text{ dpm/d} \times 5 \text{ days} = 7 \text{ dpm}$.

The uranium in the urine on day 5 for both intake patterns is also given on the plot:

- $M_7(5) = 0.2041$ dpm is the uranium in the urine after a constant chronic intake of 1 dpm/d for 5 days.
- $M_5(5) = 0.2858$ dpm is the uranium in the urine after a workweek chronic intake of $7/5 \text{ dpm/d}$ for 5 days.

When day 5 is evaluated in a manner similar to day 7 above, that is, $M_5(5)$ is evaluated with $M_7(5)$, the resulting intake rate is:

$$i = (1 \text{ dpm/d}) \frac{M_5(5)}{M_7(5)} = 1.400 \text{ dpm/d} \quad (4-7)$$

for a total intake of:

$$I = 5 \times i = 7.001 \text{ dpm} \quad (4-8)$$

which is correct: $7/5 \text{ dpm/d} \times 5 \text{ days} = 7 \text{ dpm}$. The first 5 days of the workweek exposure are simply a 5-day constant chronic intake, so intakes calculated assuming a constant chronic intake in the first 5 days will be correct. As shown below, this is the only time when this is true.

Figure 4-3 shows the uranium in urine on days 33 and 35.

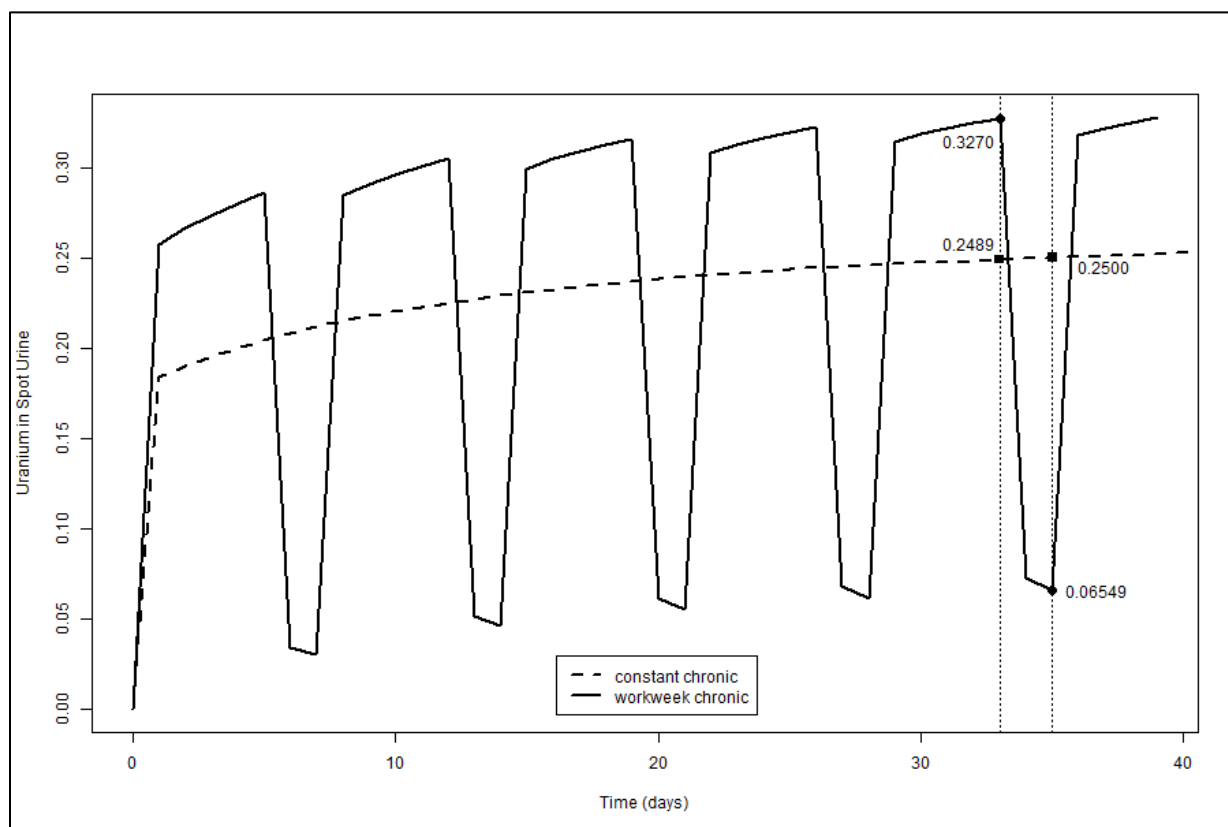


Figure 4-3. Urinary excretion from constant chronic and workweek chronic intakes of Type F uranium. Attachment A contains an extended description.

The uranium in the urine on day 35 for both intake patterns are given on the plot:

- $M_7(35) = 0.2500$ dpm is the uranium in the urine after a constant chronic intake of 1 dpm/d for 35 days.
- $M_5(35) = 0.06549$ dpm is the uranium in the urine after a workweek chronic intake of 7/5 dpm/d for 5 d/wk for 5 weeks.

Note that the total intake for the workweek chronic exposure is $5 \times 7 = 35$ dpm and the mean intake rate is 1 dpm/d. Seeing $M_5(35)$ in the Monday morning urine and evaluating it assuming a constant chronic intake gives an intake rate of:

$$i = (1 \text{ dpm/d}) \frac{M_5(35)}{M_7(35)} = 0.2619 \text{ dpm/d} \quad (4-9)$$

and a total intake of:

$$I = 35 \times i = 9.168 \text{ dpm} \quad (4-10)$$

which is less than the true intake of 35 dpm. The uranium in urine on day 33 for both intake patterns are also given on the plot:

- $M_7(33) = 0.2489$ dpm is the uranium in urine after a constant chronic intake of 1 dpm/d for 33 days.

- $M_5(33) = 0.3270$ dpm is the uranium in urine after a workweek chronic intake of 7/5 dpm/d for 5 d/wk for 5 weeks.

When $M_5(33)$ in the urine is evaluated with $M_7(33)$, the intake rate is:

$$\dot{I} = (1 \text{ dpm/d}) \frac{M_5(33)}{M_7(33)} = 1.314 \text{ dpm/d} \quad (4-11)$$

for a total intake of:

$$I = 33 \times \dot{I} = 43.35 \text{ dpm} \quad (4-12)$$

which is an overestimate of the true intake.

In summary, given a traditional 5-day workweek with constant exposure to uranium followed by 2 days with no exposure:

- Spot urine samples collected primarily in the hours shortly before returning to work after the weekend (e.g., Sunday or Monday morning before starting work) that are evaluated assuming a constant chronic intake will result in underestimates of the intake.
- Spot urine samples collected primarily on other days of the week (e.g., other than Sunday or first thing Monday morning) that are evaluated assuming a constant chronic intake will result in overestimates of the intake.

4.2 DETERMINATION OF A CORRECTION FACTOR

A general solution to the Monday morning problem would be to adjust the bioassay results with a Monday morning correction factor (CF) based on the expected sample measurement assuming a constant chronic intake, $M_7(t)$ and the expected sample measurement assuming a workweek exposure pattern, $M_5(t)$. For a single chronic intake, this is simply:

$$k_t = \frac{M_7(t)}{M_5(t)} \quad (4-13)$$

A Monday morning urine sample after 5 weeks of exposure, $M_5(35)$, adjusted with k_{35} is:

$$k_{35} = \frac{M_7(35)}{M_5(35)} = 3.818 \quad (4-14)$$

which yields a mean intake rate of:

$$\dot{I} = (1 \text{ dpm/d}) \frac{k_{35} M_5(35)}{M_7(35)} = 1 \text{ dpm/d} \quad (4-15)$$

which gives the correct intake of 35 dpm. A Friday evening sample in the fifth week of exposure, $M_5(33)$, adjusted with k_{33} :

$$k_{33} = \frac{M_7(33)}{M_5(33)} = 0.7613 \quad (4-16)$$

results in a mean intake rate of:

$$\dot{i} = (1 \text{ dpm/d}) \frac{k_{33} M_5(33)}{M_7(33)} = 1 \text{ dpm/d} \quad (4-17)$$

which gives a correct intake rate of 1 dpm/d. Because the assumption is a chronic intake for a full week (i.e., the total intake is spread over 7 days), the mean intake rate is multiplied by the total time of the assumed exposure period, which is 35 days. Therefore, 1 dpm/d times 35 days equals 35 dpm.

4.3 CORRECTION FACTORS OVER TIME

Figure 4-4 shows Monday morning CFs for a 10-year workweek chronic intake. Figure 4-5 shows a closeup view of the first 100 days. Table 4-1 lists the CFs on selected Mondays after the start of the chronic intake.

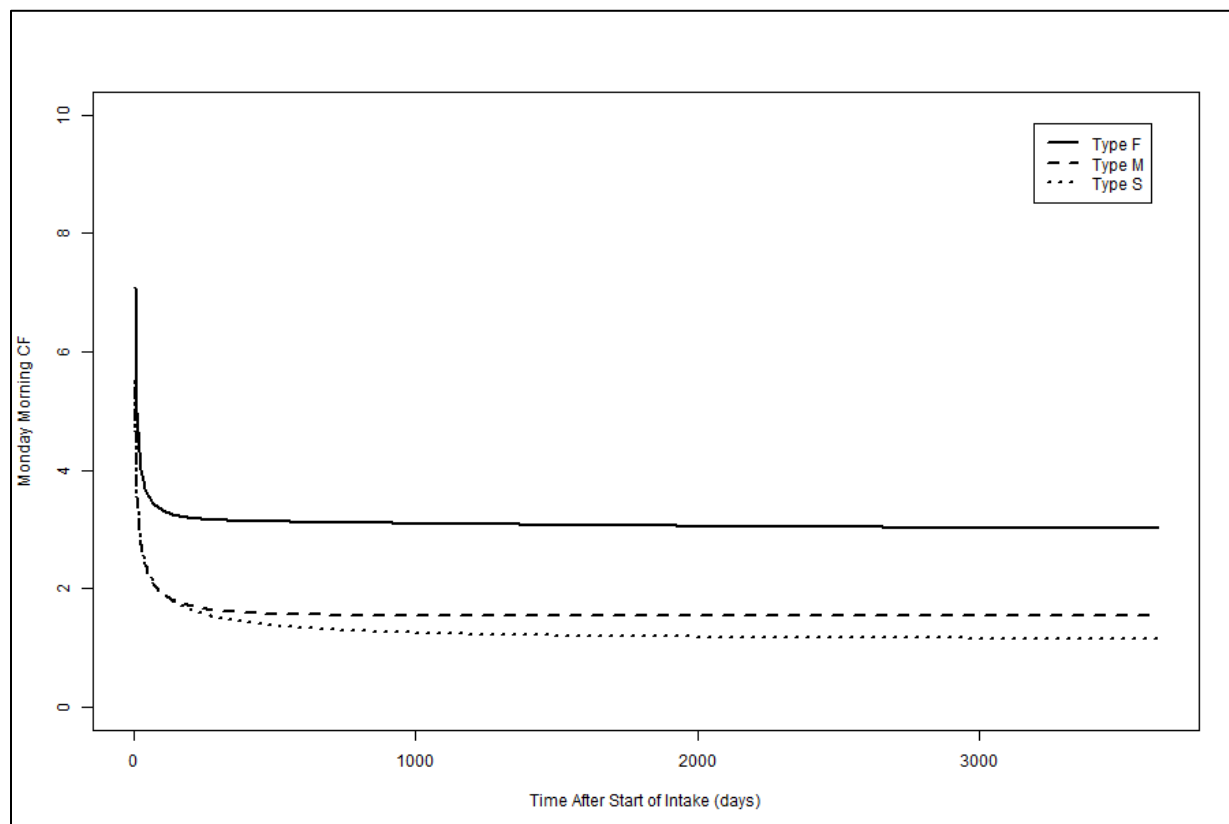


Figure 4-4. Monday morning CF for uranium urine samples as a function of time after the start of a 10-year constant chronic intake. Attachment A contains an extended description.

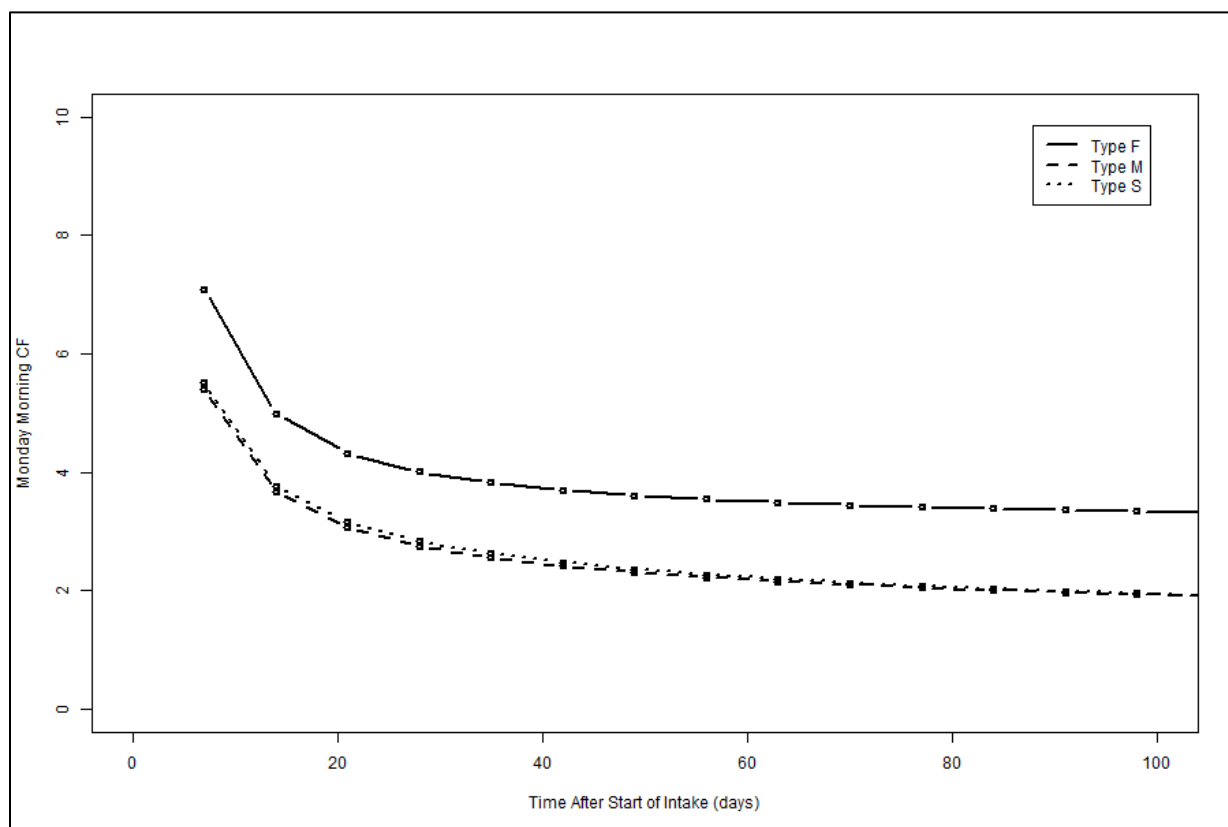


Figure 4-5. Expanded view of the first 100 days in Figure 4-4.

Table 4-1. Monday morning CFs for select Mondays after the beginning of a workweek chronic intake of uranium.

Day	Type F	Type M	Type S
7	7.08	5.40	5.52
28	4.00	2.75	2.83
56	3.54	2.22	2.27
91	3.36	1.97	1.98
119	3.28	1.86	1.85
182	3.20	1.73	1.68
364	3.14	1.60	1.45
728	3.11	1.55	1.30
1,827	3.06	1.54	1.19
3,633	3.01	1.53	1.15

5.0 DERIVATION OF GENERIC CORRECTION FACTORS

Adjusting a bioassay result with a CF is an appealing way to deal with Monday morning samples because the adjusted results can be evaluated with standard software like IMBA. Expanding on the examples in Section 4.1 through Section 4.3, Monday morning bioassay results are assumed at times t_1 and t_2 , $M(t_1)$ and $M(t_2)$, where t_2 is greater than t_1 . Further, two intakes are assumed, where chronic intake I_1 started at time τ_1 before t_1 and chronic intake I_2 started at time τ_2 between t_1 and t_2 . The relative times are shown graphically in Figure 5-1.

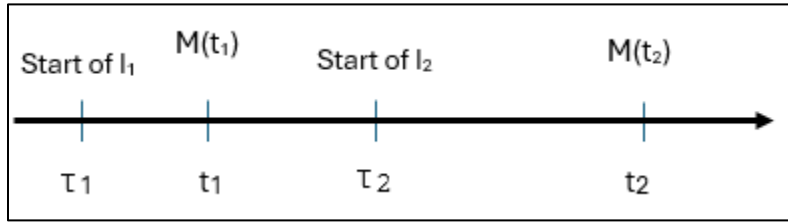


Figure 5-1. Graphic representation of the relative intake and bioassay times.

Bioassay results were from a single chronic intake in the discussion above. The following discussion expands the method to encompass multiple intake periods.

Given the IRF $m_1(t_1 - \tau_1)$ for the first intake at the time of the first bioassay result, the following relationship is established:

$$M(t_1) = I_1 \frac{m_1(t_1 - \tau_1)}{k_{1,1}} \quad (5-1)$$

where $k_{1,1}$ is the Monday morning CF for the first intake at time $t_1 - \tau_1$. The second bioassay result is a linear combination of both intakes:

$$M(t_2) = I_1 \frac{m_1(t_2 - \tau_1)}{k_{2,1}} + I_2 \frac{m_2(t_2 - \tau_2)}{k_{2,2}} \quad (5-2)$$

Where $m_1(t_2 - \tau_1)$ is the IRF for the first intake at the time of the second bioassay result, while $m_2(t_2 - \tau_2)$ is the IRF for the second intake at the time of the second bioassay result. The values $k_{2,1}$ and $k_{2,2}$ are the respective CFs for the IRFs.

This can be expanded to any bioassay result at time t_b with n intakes:

$$M(t_b) = \sum_{i=1}^n I_i \frac{m_i(t_b - \tau_i)}{k_{b,i}} \quad (5-3)$$

In an idealized scenario, the CF is a constant for all times and intakes after the start of the chronic intake, such that:

$$k = k_{2,1} = k_{2,2} = k_{b,i} \quad (5-4)$$

The CF could then be applied to the bioassay results rather than the IRFs:

$$kM(t_b) = \sum_{i=1}^n I_i m_i(t_b - \tau_i) \quad (5-5)$$

In this case existing evaluation software like IMBA could be used to estimate intakes by adjusting the bioassay data. However, the condition stated in Equation 5-4 is very restrictive in that it does not hold when:

- The individual intakes have different absorption types or particle size,

- There is a mixture of acute and chronic intakes (acute intakes are not susceptible to the Monday morning issue),
- The bioassay results are on different days of the week, or
- The CF is a function of the time after the start of the chronic intake.

If any of these conditions hold, then the CFs must be applied directly to the IRFs rather than the bioassay data, which means that IMBA cannot be used for intake calculations. Application of the CF to the IRF implies that the chronic intake periods are known and are not derived from patterns observed in the bioassay data. This is problematic because the CFs are dependent on the time between the start of intake and the time of sample collection so they must be calculated and applied before the intake patterns in the bioassay data are observed. This issue is addressed by using approximate day-of-the-week dependent CFs that are applied directly to the uranium urine samples before intakes are calculated.

6.0 APPLICATION TO CO-EXPOSURE INTAKES

6.1 APPROXIMATE CF VALUES

As derived in Section 5.0, the CF is dependent on the day of the week on which the sample was collected and the time between the start of the chronic intake and the sample date. Uranium co-exposure intakes typically are modeled over periods of several years, are modeled for each absorption type individually and for a single particle size, and do not include acute intakes. This eliminates many of the concerns itemized in the above bullets, allowing for a simplified approximation method using a single time, making it dependent only on the day of the week.

Figures 4-4 and 4-5 indicate a relatively rapid initial drop and subsequent leveling out of the Monday morning CF as a function of time. Table 4-1 shows that, after 6 months, the Monday morning CFs fall to within approximately 10% of their asymptotic values for Types F and M. Type S continues to drop a bit more rapidly, but 91 days after the start of intake is selected as providing a slightly claimant favorable value for the CF to be applied to Monday morning samples used in a co-exposure model. CFs for the subsequent days of the week are shown in Table 6-1.

Table 6-1. Approximate Monday morning CFs for each day of the week.

Day of week	Type F	Type M	Type S	Day
Monday	3.36	1.97	1.98	91
Tuesday	0.80	0.85	0.86	92
Wednesday	0.79	0.84	0.84	93
Thursday	0.78	0.84	0.84	94
Friday	0.78	0.83	0.83	95
Saturday	0.77	0.83	0.83	96
Sunday	3.06	1.84	1.82	97

6.2 USE IN CO-EXPOSURE MODELING

The following list outlines the current steps for constructing a co-exposure model with the addition of step 2. This is applied during timeframes identified in the site profile as meeting the required condition for adjustment, which is a protocol of collecting spot samples for uranium after a 2-day period away

from work. All other steps are performed as usual including the assumption of constant chronic intakes (7 d/wk).

1. Assemble urine bioassay data and express in units of activity excreted per day.
2. *Apply Monday morning CF based on the day of the week the sample was voided and the absorption type (see Table 6-1).*
3. If censored or nonpositive data (less than or equal to 0) are present, create an imputation model and replace those data with positive data (uncensored greater than 0).
4. Calculate time-weighted one person—one statistic (TWOPOS) for each individual.
5. Fit a lognormal model to the TWOPOS data in each year or multiple years if needed.
6. Calculate the 50th- and 84th-percentile excretion rate from the lognormal model for each year.
7. Model the annual 50th percentiles with IMBA assuming chronic intakes as if the data came from an individual. This could require multiple independent chronic intake periods. These intakes can be selected based on the patterns observed in the data.
8. Repeat step 7 for the 84th-percentile excretion rates.
9. From the 50th- and 84th-percentile chronic intake rates, calculate the geometric mean and geometric standard deviation (GSD) of the annual intake rates. Assign a GSD of 3 to any GSD that is less than 3.

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ATTACHMENT A EXTENDED DESCRIPTIONS OF FIGURES AND EQUATIONS

This attachment contains extended descriptions for figures and equations that exceed the character limit for in-line alt text. These descriptions are provided to enhance accessibility for screen reader users.

Figure 4-1

Table A-1 lists the values for Figure 4-1.

Table A-1. Day of the week uranium urine samples submitted at Y-12, 1950 to 1988.

Year	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1950	0.000887	0.031056	0.330967	0.346051	0.23425	0.041704	0.015084
1951	No data	0.032096	0.22491	0.181557	0.397126	0.162635	0.001677
1952	0.00917	0.96772	0.022737	0.000298	No data	No data	7.45E-05
1953	0.00559	0.967719	0.019075	0.003773	0.002166	0.001328	0.000349
1954	0.08361	0.503778	0.061751	0.145109	0.025587	0.095145	0.085021
1955	0.001882	0.710395	0.020923	0.135946	0.004428	0.007196	0.119229
1956	0.002089	0.849877	0.023204	0.081918	0.001862	0.003996	0.037054
1957	0.00238	0.882282	0.006444	0.073084	0.003186	0.0026	0.030025
1958	0.004089	0.871388	0.007634	0.076268	0.004737	0.00351	0.032375
1959	0.004988	0.788675	0.008273	0.107173	0.004841	0.008273	0.077776
1960	0.003864	0.888937	0.008794	0.059856	0.002595	0.017559	0.018395
1961	0.003624	0.903268	0.008686	0.066925	0.003999	0.007436	0.006061
1962	0.004095	0.867087	0.006499	0.088457	0.006954	0.010984	0.015924
1963	0.003994	0.665749	0.015494	0.201763	0.007299	0.010398	0.095304
1964	0.007994	0.851094	0.009576	0.103488	0.006677	0.004305	0.016867
1965	0.006859	0.364621	0.023285	0.052708	0.54278	0.005415	0.004332
1966	0.014582	0.157581	0.029329	0.055012	0.725435	0.010273	0.007788
1967	0.00895	0.181055	0.03953	0.027783	0.705202	0.030766	0.006713
1968	0.00846	0.151569	0.026613	0.046352	0.725767	0.038421	0.00282
1969	0.011043	0.161091	0.013641	0.020948	0.773141	0.018513	0.001624
1970	0.010976	0.130244	0.016341	0.022683	0.795122	0.022927	0.001707
1971	0.019243	0.075676	0.011459	0.016432	0.874378	0.001514	0.001297
1972	0.008914	0.080555	0.024761	0.050182	0.821723	0.010234	0.003632
1973	0.005973	0.152655	0.034735	0.03208	0.747124	0.024558	0.002876
1974	0.009699	0.181913	0.026474	0.055832	0.722412	0.002097	0.001573
1975	0.029014	0.66304	0.09034	0.16881	0.021101	0.018793	0.008902
1976	0.016145	0.626976	0.117726	0.187353	0.032291	0.017154	0.002355
1977	0.017379	0.65033	0.095586	0.193604	0.017379	0.018422	0.007299
1978	0.016937	0.669547	0.076046	0.20636	0.014518	0.010716	0.005876
1979	0.028335	0.674944	0.062401	0.198344	0.016237	0.012416	0.007323
1980	0.027383	0.680885	0.074776	0.181675	0.015271	0.012112	0.007899
1981	0.03767	0.664249	0.096631	0.157464	0.02059	0.013804	0.009593
1982	0.023188	0.628406	0.113816	0.19942	0.017005	0.01372	0.004444
1983	0.024864	0.656916	0.073966	0.204346	0.023611	0.011492	0.004806
1984	0.025167	0.610844	0.095855	0.21336	0.029608	0.017765	0.007402
1985	0.025952	0.629948	0.06124	0.221247	0.029686	0.027446	0.004481
1986	0.019746	0.615656	0.079866	0.216678	0.041079	0.018865	0.00811
1987	0.022991	0.634411	0.06948	0.202628	0.04194	0.022486	0.006064
1988	0.025387	0.6108	0.105207	0.194062	0.034639	0.025387	0.004518

Figure 4-2

Plot of uranium in spot urine on a scale of 0 to 0.3 dpm/d versus time from 0 to 7 days. The constant chronic line starts at 0 and increases in a straight line to about 0.18 dpm/d at 1 day. It then continues

ATTACHMENT A

EXTENDED DESCRIPTIONS OF FIGURES AND EQUATIONS

in a slightly increasing line to day 7. Day 5 is indicated to have a result of 0.2041 dpm/d while day 7 is 0.2114. The workweek chronic line starts at 0 and increases in a straight line to about 0.255 dpm/d at 1 day. It increases to 0.2858 dpm/d on day 5, then drops to about 0.03 on day 6 and continues to decrease slightly to day 7, which is indicated to have a result of 0.02985 dpm/d.

Figure 4-3

Plot of uranium in spot urine on a scale of 0 to 0.35 versus time from 0 to 40 days. The constant chronic curve starts at 0, rises to about 0.18 dpm/d at 1 day, and continues to rise slowly in a slightly curved line. A square on day 33 indicates a urine result of 0.2489 and another square marks the day 35 result of 0.25. The work week curve is a recurring pattern of the Figure 4-2 curve, sharply increases at the start, slowly rises for 5 days, then drops abruptly for 2 days. The overall pattern increases slightly over the 40 days. A circle on day 33 indicates a urine result of 0.3270, and another circle marks the day 35 result of 0.06549.

Figure 4-4

Plot of Monday morning CFs on a scale of 0 to 10 versus time after start of intake from 0 to about 3,500 days. The Type F curve starts on day 1 with a CF of about 7 and drops almost immediately to 4, curves slightly to about 3.5 within about 50 days, then progresses in a very slowly decreasing straight line to about 3 at the end of the plot (day 3500). Types M and S exhibit a similar pattern but drop more sharply in the first few months, both dropping to about 2 and then decreasing very slowly to day 3,500 with Type M ending with a CF of about 1.5 and Type S about 1.2.