MEMORANDUM

TO: Fernald Work Group
FROM: SC&A, Inc.
DATE: June 13, 2018
SUBJECT: SC&A Analysis of Recycled Uranium Constituents at Fernald (1961–1972)

Background

The subject of appropriately bounding ratios of the main contaminants in recycled uranium (RU)—plutonium (Pu), neptunium (Np), and technetium (Tc)—at Fernald have been the subject of substantial and extensive discussions between the Work Group, the National Institute for Occupational Safety and Health (NIOSH), and SC&A for many years and numerous Work Group meetings. The most recent discussions occurred during the two prior Work Group teleconference meetings held on July 28, 2017, and March 15, 2018 (ABRWH 2017, 2018).

During the July 2017 meeting, SC&A expressed concern that the assumed contaminant ratios present in the updated Fernald site profile technical basis document for occupational internal dose (NIOSH 2017a) for the period from 1961 to 1972 did not comport with the contaminant ratios previously agreed upon by the Work Group, NIOSH, and SC&A.[1] In response, NIOSH indicated that the available data had been reexamined and the ratios prior to 1973 were actually much lower than what had been described in NIOSH 2011. In particular, the ratio of plutonium to uranium at the site were all likely less than 10 parts per billion (ppb) (a factor of 10 lower than the previously agreed-upon ratio of 100 ppb).

Subsequent to this meeting, NIOSH provided Revision 5 of the *Issues Resolution Matrix for Fernald Site Profile and SEC Petition* (NIOSH 2017b), which stated the position on RU constituents as based on the available RU data found in U.S. Department of Energy (DOE) 2000:

> *NIOSH's use of the 10 ppb Pu in RU through 1972 is based on the lot data found in Attachment C of the Ohio Field Office Report* [DOE 2000]. *From a quick review of the lots identified as being processed prior to 1973, it appears that more than 95% of the identified Pu concentrations are below 1 ppb. Of those that are above 1 ppb Pu, most of those are still below 10 ppb Pu. This means that any potential to exposures to RU with Pu concentrations great than 10 ppb would be considered rare and to be short in duration. The remaining and thus majority of any worker's exposure time would have been associated with materials well below the recommended default level of 10 ppb Pu. Therefore, NIOSH cannot*

[1] The ratios were discussed and agreed upon during the February 2012 Work Group meeting (see ABRWH 2012, pages 157–178).

identify any reason to believe that any worker could have an exposure for which the recommended default level of 10 ppb Pu would not be adequately conservative and bounding. [pages 3–4]

During the March 2018 Fernald Work Group meeting, SC&A presented a preliminary analysis of the DOE 2000 data that did not agree with the NIOSH conclusion that 95% of the data were below 1 ppb (ABRWH 2018). Because the SC&A analysis was preliminary and informal at that time, the Work Group tasked SC&A with formalizing their analysis for further consideration. This memorandum presents SC&A's formal presentation of the analysis of RU data found in DOE 2000 for the period of interest (1961–1972).

Analysis of Recycled Contaminant Database

As stated in the previous section, analytical data characterizing the relative constituent levels in RU are provided in DOE 2000. The DOE report provides a significant amount of data, which extend beyond the period of interest for this analysis (1961[2]–1972). However, NIOSH noted that the DOE report provides methods for interpreting the "Lot ID" of each data measurement to determine the date of the measurement. SC&A used this identification method to restrict its analysis to only recycled constituent measurements taken prior to 1973.

Table 1 shows the available constituent data for this period after they were fit to a lognormal distribution. As seen in the table, the lognormal geometric mean for plutonium is much less than NIOSH's assumed default value of 10 ppb and also less than 1 ppb. However, the associated geometric standard deviation associated with the lognormal fit is quite large (24.18) and results in a 95th-percentile contaminant ratio that is over a factor of 12 higher than the NIOSH default for plutonium contamination in RU. As was noted by NIOSH during the March 2018 Work Group meeting, the very high geometric standard deviation (and associated 95th-percentile value) is likely indicative of multiple distributions present in the dataset (see pages 22–23 of ABRWH 2018). Therefore, fitting all of the data to a single lognormal distribution may not be appropriate.

Table 1. Overview of Recycled Uranium Constituent Data Fit to a Lognormal Distribution (1962–1972)

Parameter	Plutonium (ppb)	Neptunium (ppb)	Technetium (ppb)
Lognormal geometric mean (ppb)	0.656	319.20	60.88
Lognormal geometric standard deviation	24.18	3.57	26.16
Lognormal 95th percentile (ppb)	124.14	2,592.60	13,074.98

As such, SC&A opted for a more simplistic analytical approach, as shown in Table 2. As seen in the table, the revised analysis includes traditional metrics, such as the arithmetic average,

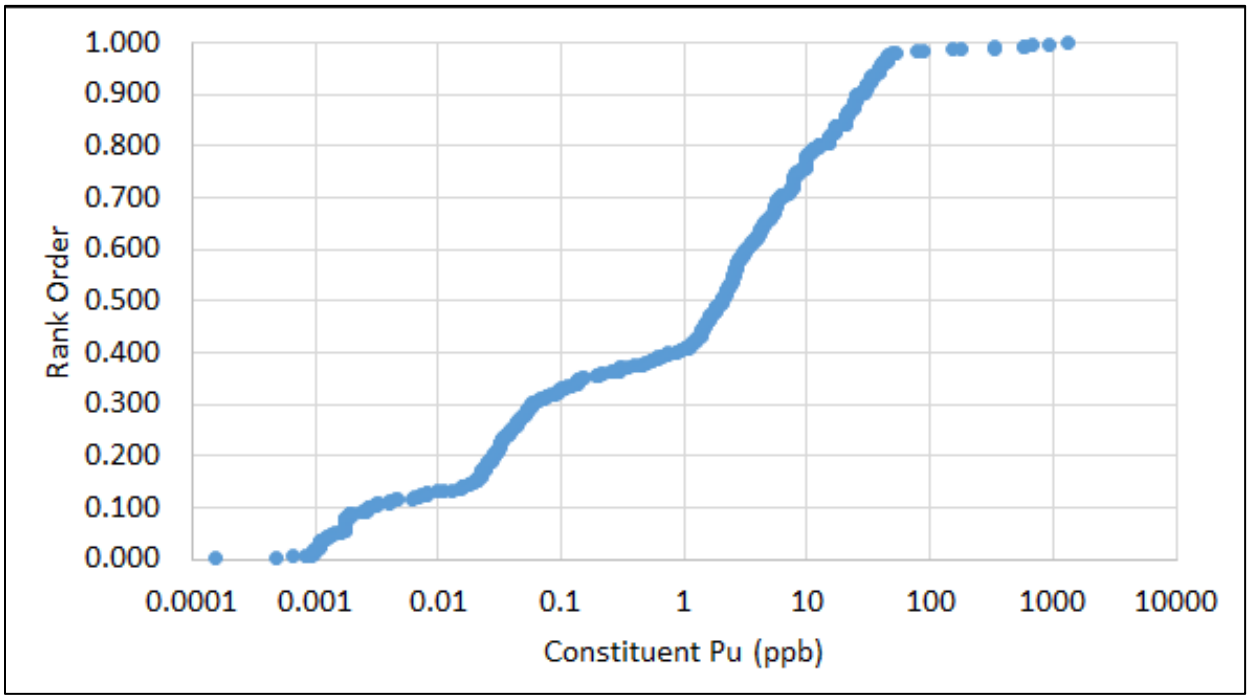
[2] Although the period of interest begins in 1961, the data in DOE 2000 do not begin until 1962.

arithmetic median, and rank-ordered 95th percentile. A simple rank ordering of the available plutonium data is also displayed in Figure 1. As seen in the table and figure, the 95th-percentile rank-ordered plutonium concentration is nearly 4 times the NIOSH-recommended default of 10 ppb. In addition, nearly 22% of the observed plutonium constituent data are above the 10 ppb recommended default value.

Table 2. Overview of Recycled Uranium Constituent Data by Traditional Metrics (1962–1972)

Parameter	Plutonium Data	Neptunium Data	Technetium Data
Arithmetic average (ppb)	15.21	1,383.85	3,283.99
Arithmetic median (ppb)	2.01	346.57	23.00
Rank-ordered 95th percentile (ppb)	38.71	1,862.97	11,950
Maximum observed sample (ppb)	1,305	75,837.84	207,619.2
Number of samples below NIOSH default values (%)	491 (78.2%)	223 (54.8%)	293 (83.5%)
Number of samples above NIOSH default values (%)	137 (21.8%)	184 (45.2%)	58 (16.5%)

Figure 1. Rank Order of Plutonium Contaminant Concentrations in Recycled Uranium (1962–1972)



SC&A also analyzed the data by the process subgroups developed in DOE 2000 (see Table 3). Analyzed constituent values are italicized in red in Table 3 if they are higher than the NIOSH-proposed default values. As seen in Table 3, the average plutonium constituent concentrations for DOE 2000 Subgroups 9, 10A, 10B, and 11 were all greater than the NIOSH default for plutonium and neptunium.

Table 3. Overview of Average RU Constituent Data by Subgroup, 1962–1972 (entries shown in red italics exceed the NIOSH-proposed defaults of 10 Pu ppb, 400 Np ppb, and 6,000 Tc ppb)

DOE 2000 Subgroup	# Pu Results	Arithmetic Average Pu (ppb)	# Np Results	Arithmetic Average Np (ppb)	# Tc Results	Arithmetic Average Tc (ppb)
1A	1	2.22	No Data	No Data	No Data	No Data
1B	39	0.92	39	107.58	2	0.55
2	1	0.13	1	15.95	No Data	No Data
3	No Data	No Data	No Data	No Data	No Data	No data
4	199	0.06	1	58.77	195	9.71
5	No Data	No Data	No Data	No Data	No Data	No data
6A	21	2.32	21	*401.04*	21	*9,118.10*
6B	34	1.78	34	*452.15*	34	*10,801.76*
6C	122	6.46	105	*1,092.26*	84	*6,823.87*
6D	No Data	No Data	No Data	No Data	No Data	No data
6E	No Data	No Data	No Data	No Data	No Data	No data
6F	No Data	No Data	No Data	No Data	No Data	No data
7A	No Data	No Data	No Data	No Data	No Data	No data
7B	1	1.38	1	344.52	1	2,279.00
8	No Data	No Data	No Data	No Data	No Data	No Data
9	25	*55.20*	24	*3825.81*	1	367.42
10A	20	*159.58*	20	*10,249.23*	No Data	No Data
10B	134	*21.86*	134	*519.18*	No Data	No Data
11	31	*35.59**	27	*1,990.99*	13	1,245.76
Total	628	*15.21*	407	*1,383.85*	351	3,283.99

*Note that this result is dominated by a single 1962 result of 942.5 ppb Pu described in the database as an "*Oliver Filter*" and also "*Discard Process Residues, Trailer Cakes, Waste Slurries, Raffinates, Etc.*" If this value is removed, the average drops to 5.36 ppb for Subgroup 11.

Finally, SC&A analyzed the data by year for the period of interest (see Table 4). Similar to the previous table, analyzed constituent values are italicized in red in Table 4 if they are higher than the NIOSH proposed default values. As seen in Table 4, the average plutonium constituent concentrations generally increased over time, with calculated average values above the NIOSH default values from 1969 to 1972. For neptunium, 9 of the 11 years analyzed showed average values above the recommended default.

Table 4. Overview of Average RU Constituent Data by Year, 1962–1972 (entries shown in red italics exceed the NIOSH-proposed defaults of 10 Pu ppb, 400 Np ppb, and 6,000 Tc ppb)

Subgroup	# Pu Results	Average Pu (ppb)	# Np Results	Average Np (ppb)	# Tc Results	Average Tc (ppb)
1962	174	6.99	66	*511.82*	143	1,356.97
1963	63	3.35	43	285.13	41	3,394.20
1964	59	5.31	44	*461.71*	47	2,725.59
1965	26	6.81	23	*509.51*	11	2,823.79
1966	36	7.97	21	*422.34*	12	249.59
1967	61	7.47	47	319.23	18	2,500.58
1968	53	9.47	22	*3,847.00*	28	3,603.84
1969	36	*20.01*	29	*1,446.76*	14	2,208.91
1970	34	*23.79*	34	*612.25*	8	*28,394.55*
1971	34	*79.84*	34	*4,863.72*	13	*16,678.72*
1972	52	*41.27*	44	*3,375.18*	16	2,280.59
Total	628	*15.21*	407	*1,383.85*	351	3,283.99

Summary Conclusion

Based on its review of the available constituent data provided in DOE 2000 and described above, SC&A does not feel that sufficient analytical evidence has been developed and discussed to justify the lower ratios of RU constituents as provided in NIOSH 2017a. SC&A does not agree with the rationale provided in NIOSH 2017b that 95% of the available constituent data for plutonium are less than 1 ppb and thus sufficiently bounded by an assumed default value of 10 ppb. It is recommended that NIOSH revisit its assumed default values to assure that assigned doses are sufficiently claimant favorable and bounding for all potentially exposed workers.

References

ABRWH 2012. Transcript: Meeting of the Advisory Board on Radiation and Worker Health, Fernald Work Group, Hebron, KY. February 9, 2012.

ABRWH 2017. Transcript: Teleconference Meeting of the Advisory Board on Radiation and Worker Health, Fernald Work Group. July 28, 2017.

ABRWH 2018. Transcript: Teleconference Meeting of the Advisory Board on Radiation and Worker Health, Fernald Work Group. March 15, 2018

DOE 2000. *Recycled Uranium Project Report*, DOE 00-0001, U.S. Department of Energy, Ohio Field Office. May 15, 2000. [SRDB Ref. ID 3644]

NIOSH 2011. *Issues Related to the Ability to Bound Internal Dose from Recycled Uranium Trace Level Contaminants at Fernald*, Draft 01, National Institute for Occupational Safety and Health, Cincinnati, OH. August 5, 2011.

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