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**ADVISORY BOARD ON
RADIATION AND WORKER HEALTH**

National Institute for Occupational Safety and Health

**SC&A CLARIFYING QUESTIONS FOR FERNALD ISSUES
MATRIX – DRAFT WORKING DOCUMENT**

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SC&A, Inc.
2200 Wilson Boulevard, Suite 300
Arlington, VA 22201-3324

Saliant, Inc.
5579 Catholic Church Road
Jefferson, Maryland 21755

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SC&A, INC.:

Technical Support for the Advisory Board on Radiation and Worker Health Review of NIOSH Dose Reconstruction Program

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0 (Draft)	2/22/2018	Initial issue

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TBD FINDINGS 7, 8: URANIUM- AND RADIUM-POOR RAFFINATE MATERIAL

BACKGROUND

Current dose reconstruction methods have been developed for potential internal exposures to raffinate material by utilizing the indicator radionuclides of radium and uranium along with appropriate contaminant ratios. In the former case, radon breath analysis was used to estimate a radium body burden which can then be used with source term data to reconstruct the dose from other contaminants present in the raffinate material. In the latter case, uranium urinalysis results are used with appropriate ratios to other unmonitored contaminants. However, using these two methods becomes problematic when addressing any potential exposures to uranium- and radium-poor raffinate material.

This issue has most recently been discussed at the December 2014 and July 2017 Fernald Work Group meetings. In December 2014, NIOSH had tacitly proposed a framework by which daily weighted exposure studies conducted in Plant 2/3 could be applied to reconstruct doses to uranium- and radium-poor raffinate source terms (see ABRWH 2014, pages 128–150). During the July 2017 Work Group meeting, NIOSH’s position was essentially twofold (see ABRWH 2017, pages 13–25):

- Due to the nature of the raffinate process, existing engineering controls, and source term characteristics (raffinate material was a wet slurry), no internal exposure potential existed for uranium- and radium-poor raffinate material.
- In the event that any internal exposures did occur to uranium- and radium-poor raffinate material, such exposures would be considered not reconstructable with sufficient accuracy and thus would be included in the currently existing Special Exposure Cohort (SEC) for thorium.

During that meeting, NIOSH indicated they had a formal rationale for their conclusions but that the document had not been transmitted to the Work Group or SC&A at that time (ABRWH 2017, page 24). To date, SC&A does not believe it has received any new documentation specific to radium- and uranium-poor raffinate material. The most current response from NIOSH takes the form of a traditional matrix and states the following concerning TBD Findings 7 and 8 (NIOSH 2017b):

10/24/2017: NIOSH’s position is that there was little potential for exposure to uranium- and radium-poor raffinates, since they were liquids that were pumped to disposal pits. If there were exposures to uranium- and radium-poor raffinates, doses from those exposures cannot be reconstructed with sufficient accuracy, given the information available to NIOSH. Any such exposures occurred within the period of the existing “thorium” SEC class. Therefore no further SEC action is required, and doses resulting from exposure to uranium- and radium-poor raffinates will not be included in partial dose reconstructions.

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DISCUSSION

The NIOSH response states that there was little potential for exposure to uranium- and radium-poor raffinates. However, specific documentation or references (whether it be descriptions of the specific process streams and equipment utilized, interviews with former workers in the area, or other such justification) has not been provided with respect to this issue. Furthermore, NIOSH states that any such exposures (if the potential existed) cannot be reconstructed with sufficient accuracy.

SC&A notes that audits that occurred in the 1950s noted on several occasions that an operator was shoveling solvent cake with measurements in the range of 40 to 69 dpm/m³ (SRDBs 29301, 29330, and 29340) in the Plant 3 hot raffinate building. About 90 minutes per shift were spent doing this by raffinate operators. In 1955 (SRDB 29340), it was noted an operator was pushing material down a pipe (or maybe chute?) into the drumming station in the hot raffinate building that came from the Oliver filter, but this was low-radioactive material and no respirator was worn. No respiratory equipment was noted on a couple of occasions throughout the surveys. Auditors noted use of an air hose to unplug a chute (SRDB 43291, 43299). The control panel area of the Plant 3 hot raffinate building measured 122 dpm/m³ (SRDB 29340). Other general area measurements were as high as 237 dpm/m³. Most measurements, however, were much less, say 1 to 20 dpm/m³ (background about 0.23 c/m). While SC&A acknowledges that many of these exposures were to hot raffinates on the upstream end of the process, there remains a concern that there could have also been exposures to radium- and uranium-poor (cold) raffinates on the back end of the operation, notwithstanding that the material was contained in piping during normal operations.

A number of studies are available in which daily weighted exposures (DWE) were calculated for Plants 2 and 3 (SRDBs 41050, 41063, 41084, 41111, and 41126). While most DWE values were less than 70 dpm/m³ alpha (MAC, or maximum allowable concentration), some Plant 3 areas exceeded the MAC (the mobile hoppers, 3rd level of denitration, and 4th level denitration) (SRDB 41050). Some of these studies determined DWE values for hot raffinate workers. While the results were typically low, about 0.1 to 0.2 times the MAC (SRDB 41063, 41084, and 41126), the studies demonstrate that exposures can be calculated. Exposures therefore were recorded for workers from raffinate operations, although the exposures were not necessarily related to exposure to the raffinate itself.

While it is not immediately clear whether such DWE studies are appropriately representative and could be applied to potential exposures to uranium- and radium-poor raffinate material (namely Th-230), a substantive discussion on what data is available and why it cannot be used to reconstruct doses would help clarify the decision to close the issue. Such discussions also provide programmatic transparency to the claimants and other interested parties.

SC&A Clarifying Question 1: What specific documentation or references (whether it be descriptions of the specific process streams and equipment utilized, interviews with former workers in the area, or other such justification) was used by NIOSH in concluding that exposures to uranium- and radium-poor raffinate material are negligible? Or alternately, what evaluation and analysis was performed to determine that air sampling data available for Plant 2/3 is not appropriate for partial dose reconstruction and should be included in the SEC for Th-232?

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TBD FINDINGS 9 AND 11 AND SEC FINDING 3: RECYCLED URANIUM CONTAMINANT RATIOS (PU, NP, TC)

BACKGROUND

SC&A's review of Revision 03 of the Fernald Internal Technical Basis Document (NIOSH 2017a) noted that the agreed-upon parameters for recycled uranium contaminants had changed for the period of 1961–1972. The originally agreed-upon parameters were described in a 2011 NIOSH white paper, *Issues Related to the Ability to Bound Internal Dose from Recycled Uranium Trace Level Contaminants at Fernald* (NIOSH 2011):

The period of interest for RU contaminants at Fernald is 1961 (see references above). The initial phases post 1961 to 1973 were in the 5 ppbPu from Hanford, 3 ppbPu for SRS range. Process sub group 6A is a fair representation of the receipt data from Hanford – with blending, and processing the concentrations will decrease, with an equivalent increase in the subgroup #8, MgF stream from both concentration of some activity in the MgF and a significant reduction in the uranium in this process stream. Due to the fact that DR for claimants to date have used defaults (Pu at 100 ppbU) an administrative decision to continue default at 100 ppbU for the 1961 to 1970, while defaulting at 400 ppbU during the 1973 through 1985 period.

Specifically, the assumed contaminant concentration of plutonium had decreased by an order of magnitude from 100 ppb Pu to 10 ppb Pu on a uranium mass basis (the other contaminant ratios for neptunium and technetium decreased accordingly).

During the Fernald Work Group teleconference held on July 28, 2017, NIOSH indicated that the change was due to a re-examination of this earlier period and the determination that the majority of recycled uranium lots received prior to 1973 were all likely less than 10 ppb (ABRWH pp. 34–37). It is worth noting that during the Work Group discussion in July 2017, NIOSH acknowledged that certain processes resulted in contaminants being concentrated above the ratios observed upon receipt (in particular the magnesium-fluoride reduction process). However, NIOSH's position was that such operations were short in duration and thus would not represent a consistent source of exposure (ABRWH pp. 35–36).

NIOSH's position is echoed in the most recent version of the issues matrix (NIOSH 2017b), which states:

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

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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.

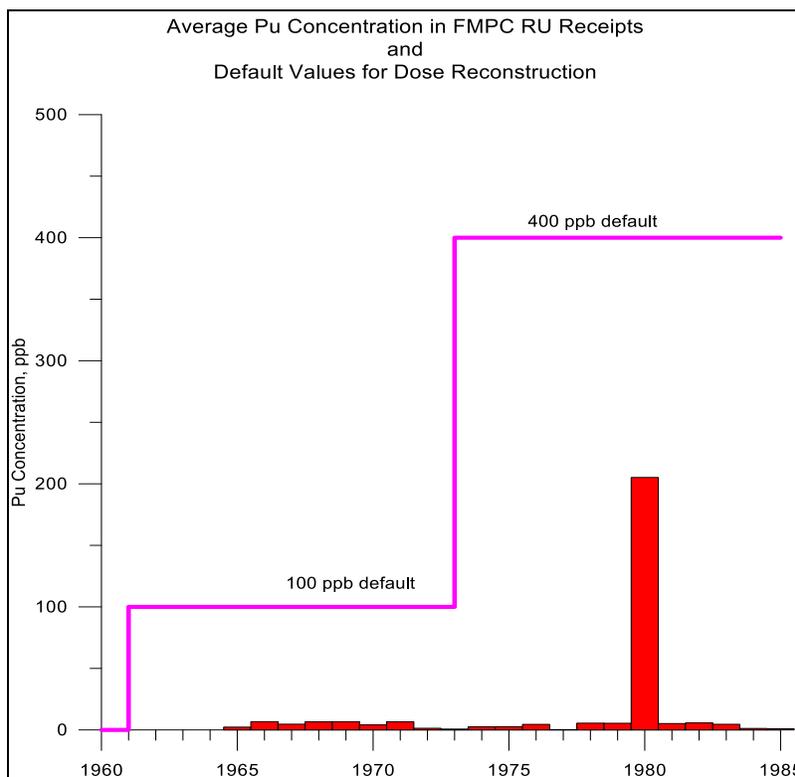
SC&A's concerns about the magnesium fluoride concentration process were reflected in SC&A 2012 and 2017. SC&A 2012 stated the following:

The topic of whether the original defaults (e.g., 100 ppb Pu) would adequately bound Plant 5 metal production workers and associated Plant 1 millwrights who were exposed to high constituent concentrations in MgF₂ in the pre-1973 period was discussed in the April and August 2011 Work Group meetings... At that time, SC&A contended that if chemical concentration of downblended material was the sole mechanism that resulted in the high concentrations in MgF₂ documented in DOE 2000 [Recycled Uranium Project Report], then the higher defaults (e.g., 400 ppb Pu) would apply during the entire period of metal production employing RU, and not just after POOS receipts began in 1973. The discovery of NLO [1985, titled: "Processing 168 MTU of UO₃ Containing Recycle Contaminants"] among the 49 new references identified...was a key factor in SC&A's acceptance of the original defaults for the 1961–1972 timeframe.

DISCUSSION

SC&A examined the original Recycled Uranium Project Report (DOE 2000) to identify which recycled uranium lots are applicable to the pre-1973 timeframe. Unfortunately, the original report does not identify a specific date with each lot sample; however, the report does indicate on page 577 that additional information on each lot sample can be provided upon request. It appears that NIOSH made such a request and received additional working documents and database files as indicated on page 3 of NIOSH 2011. In addition, NIOSH 2011 contains a chart which shows average plutonium contaminant ratios as far back as 1965 (this chart is shown as Figure 1, below).

Figure 1. Chart from 2011 NIOSH Document: Issues Related to RU Dose Reconstruction Draft 01 8-5-11 (NIOSH 2011)



SC&A located a database that appears to contain the expanded information on the recycled uranium analysis contained in DOE 2000. This database can be located at the following network location: [REDACTED]

[REDACTED]. This database contains a date column (column “AC” on the “U_Recycle_Final” tab); however, a date was only specified on 995 of 3,737 total entries (~27% of the total entries). Examination of entries that specified a date indicate that the earliest receipt was from August 1962, which indicated 942.5 Pu ppb. The next dated sample found is dated May 1974.

NIOSH 2011 seems to indicate that for the period prior to 1973, Subgroup 6A (UO₃ from Hanford) was utilized in arriving at 10 Pu ppb. However, it is not clear if the Subgroup 6A data was extrapolated backwards from post 1973 to the earlier period. If data is being back extrapolated, further discussion of the use of this data as a substitute may be warranted. NIOSH 2011 further states:

*This RU was blended with existing materials, including natural uranium to meet enrichment specifications and others. **The MgF buildup would be reflective of a concentration from single digit contaminants from the blending and processing to the default of 10 ppbPu.***

The analytical basis for assuming the MgF contaminant buildup would be bounded at 10 ppbPu is not clear. However, based on the recent discussions in ABRWH 2017, it appears that the

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position is not that contaminants would be bounded at 10 ppbPu but rather that the short duration of these concentrating activities would be “averaged out” over a full year of uranium processing activities.

SC&A Clarifying Question 2: How was NIOSH able to determine which lots were processed prior to 1973 as was indicated in Figure 1 (above) as well as the most recent responses contained in NIOSH 2017b?

SC&A Clarifying Question 3: NIOSH 2011 indicates that for the period prior to 1973, Subgroup 6A (UO₃ from Hanford) was utilized in arriving at 10 Pu ppb, though it is not clear if this assumption is still being utilized. It is also not clear if the Subgroup 6A data was extrapolated backwards from post-1973 to the earlier period. If data is being back extrapolated, further discussion of the use of this later data as a substitute may be warranted.

SC&A Clarifying Question 4: What analytical basis was used to determine the potential contaminant ratios experienced by workers involved in the MgF process in the 1961–1972 period? Furthermore, what is the analytical basis used to conclude that workers exposed to the MgF source term would be sufficiently “averaged out” with exposures to other less contaminated recycled uranium?

THORIUM COWORKER MODEL FINDING 6: THORON PARAMETER SELECTION

BACKGROUND

NIOSH developed a model for assigning exposures to thoron from thorium storage operations in its white paper, *Fernald Dose Reconstruction Methodology for the Post Special Exposure Cohort (SEC) Period, 1979–2006* (NIOSH 2014), which was also migrated into Appendix B of NIOSH 2017a. SC&A reviewed NIOSH 2014 and had the following finding related to thoron (SC&A 2014):

***Finding 6:** The underlying assumptions employed in NIOSH 2014a to reconstruct doses to thoron are not well established or referenced. The assumptions concerning thorium source term inventory, release fraction, equilibrium factor, occupancy time, and specific activity of thoron must be thoroughly defined based on credible documentation and site specific records.*

This issue was initially discussed in during the December 2014 Fernald Work Group meeting (ABRWH 2014) and again during the July 2017 Work Group meeting. After discussions at the latter meeting, the following actionable items were indicated by NIOSH as under their purview:

1. Specific analysis of Building 65 to estimate potential thoron doses (ABRWH 2017, page 170).
2. Further discussion of the release fraction assumed: 1×10^{-4} (ABRWH 2017, page 170).
3. Justification for the chosen occupancy times (ABRWH 2017, pages 172–173).

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DISCUSSION

NIOSH 2017b provides additional discussion of parameter selection for the thoron dose reconstruction model. Actionable Item 1 (above) was discussed in NIOSH 2017b under item 2 found after the matrix; this discussion included a quantitative assessment of Building 65 working levels based on an air sampling measurement of 267 pCi/l made in Building 65 in 1996. The analysis shows that thoron estimates using the Building 65 empirical data comport well with the site-wide thoron estimates developed in NIOSH's thoron model.

A qualitative discussion of the assumed release fraction (Actionable Item 2, above) is contained under item 5 in NIOSH 2017b. In that discussion, NIOSH indicated that stored materials tended to have lower release fractions due to the short half-life of the material, which would not allow for significant diffusion within the source material. Furthermore, NIOSH states that the chosen release fraction of 10^{-4} when used in combination with other assumed parameters matches reasonably well with thoron working level estimates calculated using an empirical measurement from Building 65. It must be noted that release fractions generally range from 10^{-3} to 10^{-4} and thus NIOSH's chosen value is at the low end of the potential range. No additional documentation in the form of referenced studies or measurements was provided to justify the lower release fraction.

Based on NIOSH 2017b, an occupancy time of 25% or 3 months per year was assumed. However, no further information or discussion is provided to justify that assumption.

Finally, NIOSH calculates working level months per year (WLM/yr) as ~0.5 WLM/yr in NIOSH 2017b. However, NIOSH 2017a calculates a thoron dose assignment of 1.5 WLM/yr for "1954-1989, various storage sites Available for release." It is not clear if the calculated thoron doses in NIOSH 2017b are meant to replace the estimates provided in NIOSH 2017a.

SC&A Clarifying Question 5: What additional resources, references, or documentation (if any) were consulted in determining that the originally assumed release fraction of 10^{-4} is the most appropriate?

SC&A Clarifying Question 6: NIOSH 2017b indicates that the occupancy factor should remain at 25% (3 months per year) for the period from 1954 to 1989 but does not provide any additional justification or discussion. It is also not clear if the assumption of 1 month of exposure per year from 1990 to 2006 still applies. SC&A requests clarification as to how the currently assumed occupancy times were substantiated.

SC&A Clarifying Question 7: It is not clear what the final thoron dose assignment is intended to be, as NIOSH 2017a and NIOSH 2017b contain different estimates. In addition, SC&A asks for clarification on the calculation steps presented in NIOSH 2017b, as it appears the conversion from working levels to working level-months in NIOSH 2017b may be in error.

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