REPORT TO THE ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute of Occupational Safety and Health

Audit of Case PIID* from the Savannah River Site

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1.0 SUMMARY BACKGROUND INFORMATION

This report presents the results of an independent audit of a dose reconstruction performed by the National Institute of Occupational Safety and Health (NIOSH) for an energy employee that worked at the Savannah River Site (SRS) for a period of 5 months, from PIID*, to PIID*. The worker was diagnosed with esophageal cancer on PIID*.

SRS operations played an important role in the U.S. nuclear weapons program (DOE 1997). SRS processes included nuclear fuel fabrication, reactor operation, radiochemical processing, uranium recycling, plutonium production, neutron source production, and waste management.

The majority of the worker's radiation exposure was received during employment as a truck driver assigned to onsite construction. The claimant's spouse stated during the telephone interview that the claimant worked all over the site out of PIID*, including PIID*, PIID*, PIID*, PIID*, and the PIID*.

Records received from the DOE were found to be sufficient for the reconstruction of external doses for photons. DOE records show that for the duration of employment, the claimant was monitored monthly for external photon/electron exposure. The records also show that the claimant was not monitored for internal exposure, was not given any occupational medical exposures (e.g., chest x-rays), and was not involved in any radiological incidents that may have resulted in external/internal exposures.

In spite of the fact that the claimant was monitored for external radiation, NIOSH assigned an "onsite ambient" dose. Additional claimant-favorable assumptions included the assignment of an internal "hypothetical dose" and assignment of annual occupational medical exposures.

NIOSH performed a dose reconstruction that included a total of 39 doses for determining the probability of causation (POC). Appendix A of this report is a reproduction of the IREP input, which identifies these doses as exposure entries #1 through #39. Throughout this report, reference will be made to select portions of Appendix A; for example, exposure entry #1 identifies the measured external photon dosimeter results, while entries #2 through #33 correspond to assigned hypothetical internal doses.

Table 1 below provides a summary of organ dose estimates/assignments derived by NIOSH that correspond to data contained in Appendix A. Using the dose estimate derived by NIOSH, the POC was determined by the Department of Labor (DOL) to be 3.91% at the 99% confidence interval, and on this basis, the claim was denied.

Table 1. Summary of NIOSH-Derived External/Internal Dose Estimates

	Appendix A Exposure Entry No.	Dose (rem)
External Dose:		
▪ Photon Measured Dosimeter	1	0.011
▪ Photon Missed	34 – 35	0.23
▪ Occupational Medical	38 – 39	0.070
▪ Onsite Ambient	36 – 37	0.322
Internal Dose (Hypothetical):		
▪ Tritium	32 – 33	0.426
▪ All Other Radionuclides	2 – 31	1.181
Total:		2.24

1.1 AUDIT OBJECTIVES

SC&A's audit was performed with the following objectives:

- To determine if NIOSH assigned doses that are consistent with monitoring records provided by the DOE and with information contained in the CATI report
- To determine if the dose reconstruction process complied with applicable procedures that include generic procedures developed by NIOSH and ORAUT, as well as data/procedures that are site-specific to SRS
- In instances when procedure(s) provide more than one option or require subjective decisions, determine if the process is scientifically defensible and/or claimant favorable.

In pursuit of these objectives, a two-step process is followed in this audit. The first step is to independently duplicate and, therefore validate, doses derived by NIOSH. This step of the audit process is not only contractually mandated under Task 4, but provides NIOSH and the Advisory Board with a high level of assurance that the SC&A reviewer understands which procedures, models, site-specific data, and assumptions NIOSH used to perform its dose reconstruction. The second step of the audit critically evaluates whether the methods employed by NIOSH are scientifically defensible, consistent with applicable procedures, and claimant favorable.

Lastly, in compliance with the Privacy Act, this report makes no reference to the claimant's name, SSN, address, or any personal data that might reveal the identity of the claimant.

1.2 SUMMARY OF AUDIT FINDINGS

An overview of SC&A's audit findings for Case PIID* is provided in Table 2 in the form of a checklist. This checklist evaluates the data collection process, information obtained from the CATI interview, and all methods used in the dose reconstruction. When deficiencies are identified by the audit, such deficiencies are further characterized with regard to their impact(s) by means of the following definitions: (1) **low** means that the deficiency has only a marginal impact on dose; (2) **medium** means that the deficiency substantially impacts the dose, but is unlikely to impact the compensability of the case; and (3) **high** means that the deficiency substantially impacts the dose and may also impact the compensability of the case. A full description of deficiencies identified in the checklist is provided in the text of the audit that follows.

Table 2. Case Review Checklist

CASE PIID*	ASSIGNED DOSE: 2.24 rem	POC: 3.91%

No.	Description of Technical Elements of Review	Audit Response			If No, Potential Significance		
		YES	N/A	NO	LOW[1]	MEDIUM[2]	HIGH[3]
A. REVIEW OF DATA COLLECTION:							
A.1	Did NIOSH receive all requested data for the DOE or AWE site from any relevant data source?	✓					
A.2	Is the data used by NIOSH for the case adequate to make a determination with regard to POC?	✓					
B. REVIEW OF INTERVIEW AND DOCUMENTATION PROVIDED BY CLAIMANT							
B.1	Did NIOSH properly address all work history dates/locations of employment reported by claimant?	✓					
B.2	Did NIOSH properly address all incidents/occurrences reported by claimant?	✓					
B.3	Did NIOSH properly address monitoring/ personal protection/work practices reported by claimant?	✓					
B.4	Is the interview information consistent with data used for dose estimate?	✓					
C. REVIEW OF PHOTON DOSES							
C.1	Was the appropriate procedure used for determining:						
C.1.1	- Recorded Photon Dose?	✓					
C.1.2	- Missed Photon Dose?	✓					
C.1.3	- Occupational Medical Dose?	✓					
C.1.4	- Onsite-Ambient Dose?	✓					
C.2	Did the DR properly account for all:						
C.2.1	- Recorded Photon Dose?	✓					
C.2.2	- Missed Photon Dose?	✓					
C.2.3	- Occupational Medical Dose?	✓					
C.2.4	- Onsite-Ambient Dose?			✓	✓		
C.3	Is the recorded/assigned dose properly converted to the organ dose of interest for:						
C.3.1	- Recorded Photon Dose?	✓					
C.3.2	- Missed Photon Dose?	✓					
C.3.3	- Occupational Medical Dose?	✓					
C.3.4	- Onsite-Ambient Dose?	✓					
C.4	Is the organ dose uncertainty properly determined for:						
C.4.1	- Recorded Photon Dose?	✓					
C.4.2	- Missed Photon Dose?	✓					
C.4.3	- Occupational Medical Dose?	✓					
C.4.4	- Onsite-Ambient Dose?	✓					
D. REVIEW OF SHALLOW (i.e., 7 mg/cm^2)/ELECTRON DOSES							
D.1	Was the appropriate procedure used for determining:						
D.1.1	- Recorded Shallow/Electron Dose?		✓				
D.1.2	- Missed Shallow/Electron Dose?		✓				
D.1.3	- Onsite Ambient Dose?		✓				
D.2	Did the DR properly account for all:						
D.2.1	- Recorded Shallow/Electron Dose?		✓				
D.2.2	- Missed Shallow/Electron Dose?		✓				
D.2.3	- Onsite Ambient Dose?		✓				
D.3	Is the recorded/assigned dose properly converted to the organ dose of interest for:						
D.3.1	- Recorded Shallow/Electron Dose?		✓				

[1] **Low** means that the deficiency has only a marginal impact on dose.
[2] **Medium** means that the deficiency substantially impacts the dose, but is unlikely to impact the compensability of the case.
[3] **High** means that the deficiency substantially impacts the dose and may also impact the compensability of the case.

CASE PIID*	ASSIGNED DOSE: 2.24 rem	POC: 3.91%

No.	Description of Technical Elements of Review	Audit Response			If No, Potential Significance		
		YES	N/A	NO	LOW[1]	MEDIUM[2]	HIGH[3]
D.3.2	- Missed Shallow/Electron Dose?		✓				
D.3.3	- Onsite Ambient Dose?		✓				
D.4	Is the organ dose uncertainty properly determined for:						
D.4.1	- Recorded Shallow/Electron Dose?		✓				
D.4.2	- Missed Shallow/Electron Dose?		✓				
D.4.3	- Onsite Ambient Dose?		✓				
E. REVIEW OF NEUTRON DOSES							
E.1	Was the appropriate procedure used for determining:						
E.1.1	- Recorded Neutron Dose?		✓				
E.1.2	- Assigned Neutron Dose?		✓				
E.1.3	- Missed Neutron Dose?		✓				
E.2	Did the DR properly account for all:						
E.2.1	- Recorded Neutron Dose?		✓				
E.2.2	- Assigned Neutron Dose?		✓				
E.2.3	- Missed Neutron Dose?		✓				
E.3	Is the recorded/assigned dose properly converted to the organ dose of interest for:						
E.3.1	- Recorded Neutron Dose?		✓				
E.3.2	- Assigned Neutron Dose?		✓				
E.3.3	- Missed Neutron Dose?		✓				
E.4	Is the organ dose uncertainty properly determined for:						
E.4.1	- Recorded Neutron Dose?		✓				
E.4.2	- Assigned Neutron Dose?		✓				
E.4.3	- Missed Neutron Dose?		✓				
F. REVIEW OF INTERNAL DOSE: BASED ON HYPOTHETICAL MODEL							
F.1	Is the use of the selected hypothetical internal dose model appropriate, based on the likely POC value?	✓					
F.2	Is the use of a hypothetical internal dose model appropriate/conservative, based on claimant's available bioassay data,?	✓					
F.3	Was the hypothetical dose value correctly derived?	✓					
G. REVIEW OF INTERNAL DOSE: BASED ON BIOASSAY/IMBA							
G.1	Was the appropriate procedure (or section of procedure) used for determining likely (>50%), unlikely (<50%), or undetermined POC and compensability?		✓				
G.2	Are bioassay data sufficiently adequate for internal dose reconstruction?		✓				
G.3	Are assumptions pertaining to dates of uptake reasonable/conservative?		✓				
G.4	Are critical parameters (e.g., solubility class, particle size, etc.) used for IMBA organ dose estimates appropriate?		✓				
G.5	Are assigned uncertainties (measurement errors) for bioassay data (used as input to IMBA) appropriate?		✓				
H. Total Number of Deficiencies and Their Combined Potential Significance				1	✓		

[1] **Low** means that the deficiency has only a marginal impact on dose.
[2] **Medium** means that the deficiency substantially impacts the dose, but is unlikely to impact the compensability of the case.
[3] **High** means that the deficiency substantially impacts the dose and may also impact the compensability of the case.

2.0 AUDIT OF EXTERNAL DOSES

As part of this audit, 100% of all submitted DOE records were reviewed. These records include (1) lifetime exposure reports that summarized exposure data by year, (2) annual exposure data, which identified exposures for each monitoring cycle, (3) bioassay data, and (4) radiological incident reports/data.

2.1 RECORDED PHOTONS DOSES

DOE records show that the energy employee was monitored monthly, and the only measured deep dose occurred in the 4th cycle of PIID* with a recorded value of 10 mrem. For the purpose of maximizing the POC, the parameters selected were acute exposure, AP geometry, and 30–250 keV photon energies, with an organ dose conversion factor of 1.0.

Applying the selected parameters to the DOE-recorded dose of 10 mrem, entry 1 of Appendix A would have yielded a dose of 0.010 rem. However, entry 1 recorded the dose of 0.011 rem. This minor difference is due to the use of the $H_P(10)$ correction factor of 1.119, as given in Table 5.4.1 of ORAUT-TKBS-0003.

2.1.1 Reviewer's Comments

Given the low POC of this case, NIOSH's choice of parameters for external measured dose are consistent with procedural guidance, scientifically valid, and claimant favorable.

2.2 MISSED PHOTON DOSES

Potential missed photon doses correspond to five zero-dosimeter readings corresponding to the months of PIID* and PIID*, and PIID*, PIID*, and PIID*. NIOSH assigned a missed dose of 15 mrem for 1983 and 8 mrem for 1984, along with a geometric standard deviation of 1.52. The Dose Reconstruction (DR) Report, however, identifies a total missed photon dose of 0.045 rem (or 45 mrem).

2.2.2 Reviewer's Comments

Entries #34 and #35 of Appendix A for missed photon doses do not match the combined dose of 45 mrem cited in the text of the DR Report. It appears that the discrepancy involves the simple doubling of the Appendix A entries. If that was, in fact, done, entries #34 and #35 should have been doubled and entered as a constant (with no GSD value in Parameter 2). If the more standard protocol of LOD/2 had been followed for each cycle in which a zero dose was recorded, the total missed dose of (5 mrem/2)(5 cycles) would have yielded a total missed dose 12.5 mrem for PIID* and PIID* (see Table 5.5.1-1 of ORAUT-TKBS-0003).

In spite of the unresolved minor discrepancy pertaining to missed dose, either value can be viewed as procedurally "consistent" (since multiple options may be used), scientifically valid, and claimant favorable.

2.3 OCCUPATIONAL MEDICAL DOSE

NIOSH assumed that the claimant was given one annual chest x-ray for the years PIID* and PIID*. (DOE records provide no evidence that this individual was given an annual medical chest x-ray.) Entries #38 and #39 of Appendix A identify an organ dose of 35 mrem for each year.

Table 2.5.1-1 of ORAUT-TKBS-0003 identifies claimant-favorable, maximum-default organ doses for medical x-rays. Section 2.5.1 identifies the esophagus as an organ belonging to Group 2, and Table 2.5.1-1 identifies a dose of 35 mrem for each of the 2 years.

2.3.1 Reviewer's Comments

The total assignment of 70 mrem for occupational medical exposure is procedurally compliant, scientifically valid, and claimant favorable.

2.4 ONSITE AMBIENT DOSE

The SRS technical basis document (TBD) identifies locations with the highest average annual ambient onsite dose rates. For PIID* and PIID*, these maximum values of 166 mrem and 156 mrem, respectively, were assigned as organ doses to the energy employee. Because these doses are upper-bound values, they are entered as constants without an estimate of uncertainty.

2.4.1 Reviewer's Comments

The missed doses of 166 mrem and 156 mrem for PIID* and PIID*, respectively, could not be reproduced. Table 3.4-1 of ORAUT-TKBS-0003 cites maximum values (that furthermore account for a 50-hour workweek) of 69 mrem and 93 mrem, respectively. These values differ from the assigned values, and the discrepancy does not appear to involve a simple multiplier.

Independent of the unresolved discrepancy cited above, the assignment of an onsite ambient dose is claimant favorable for the following reasons:

- The energy employee had, in fact, been monitored, and there is no compelling reason to assume that an elevated ambient level of external radiation (EALER) had erroneously been recorded and subtracted by means of control badges.
- Maximum annual average ambient dose rates were employed, independent of energy employee's work location.
- A full annual ambient dose was used for PIID* and PIID*, even though the energy employee was employed for only PIID*.

It appears that a small error was made in calculating the onsite ambient dose. This error was clearly in favor of the claimant, which adds an additional level of conservatism to an already claimant-favorable dose calculation.

3.0 AUDIT OF INTERNAL DOSE (MISSED)

According to DOE records, the energy employee was not monitored for internal exposure by means of in vivo and/or in vitro bioassay measurements. Consequently, there are no records that the individual was whole-body counted or subject to bioassays that assessed body burdens for tritium or any other radionuclides.

Section 4.4.4 of ORAUT-TKBS-0003, however, states that ". . . If a worker wore a dosimeter, then the unrecorded dose would be no greater than that for a worker who was monitored but had no bioassay results exceeding reporting levels."

For non-compensable claims, Section 4.5.1 of ORAUT-TKBS-0003 provides an intake scenario that defines yearly doses starting with the first day of employment and ending with the year of cancer diagnosis for all relevant radionuclides, with the exception of tritium. Table 4.5.1-1 identified maximum alpha and electron doses, which are to be entered as point estimates or constants.

Entries #2 through #16 of Appendix A are the assigned annual alpha doses, and entries #17 through #31 are the annual electron doses for the years PIID* through PIID*.

Section 4.5.2 of ORAUT-TKBS-0003 provides separate guidance for estimating potential missed internal exposures to tritium. Due to the short biological (and therefore, effective) half-life of H-3, only the years of employment need to be considered. Table 4.5.3-1 identifies tritium doses of 355 mrem and 71 mrem for PIID* and PIID*, respectively.

3.1 REVIEWER'S COMMENTS

Default dose values for all radionuclides (other than tritium) representing entries #2 through #31 of Appendix A were checked against values cited in Table 4.5.1-1 of ORAUT-TKBS-0003; and tritium dose entries #32 and #33 were checked against values cited in Table 4.5.3-1.

All values cited in the DR Report match those of ORAUT-TKBS-0003. Thus, the assigned internal doses are fully compliant with applicable procedures and are likely to be scientifically valid and claimant favorable, with the noted exception as explained below.

The potential exception to scientific validity/claimant favorability reflects two issues. The first involves the unconfirmed assumption that all tritium exposures are those involving tritiated water. If intakes involved a significant fraction of organified tritium, with a biological/effective half-life that is about 2.3-fold higher, then the assigned doses herein may be too low.

The second issue is considerably more complex and involves the estimated yearly doses from all other internal radionuclides, as defined in Table 4.5.1-1 of ORAUT-TKBS-0003, which in turn were derived from data contained in ORAUT-OTIB-0001. In brief, ORAUT-TIB-0001 quantifies intakes that are based on ICRP 30 biokinetic models instead of the current ICRP 68 models, as required in 42 CFR 82. We believe that the use of ICRP 30 calculated intakes may

not be claimant favorable for several important radionuclides, and that ICRP 68 models should have been used to derive intakes.

Although the two issues cited above may impact both **recorded** internal dose (defined by bioassay data and IMBA) and **assigned** hypothetical doses, an agreement has been reached by the Advisory Board, SC&A, and NIOSH to evaluate these issues under Task 1 (i.e., Review of Site Profiles).

4.0 CATI REPORT AND RADIOLOGICAL INCIDENTS

The telephone interview for the claimant was conducted with the energy employee's survivor. There are several discrepancies between statements contained in the CATI report and DOE records/NIOSH assumptions. These include the following:

- The claimant indicated that the energy employee did participate in an in vitro (urinalysis) biological radiation-monitoring program. DOE records, however, did not identify any bioassay records.

- The claimant also stated that the covered employee was required to have a medical x-ray as a condition of employment. However, DOE records provide no evidence of any chest x-ray examinations.

- With regard to radiological incidents, the employee's survivor stated that the covered employee was involved in cleaning up spills when they happened and recalled several times when the employee had to be "scrubbed" due to contamination. There were no DOE records produced that identified any radiological incidents associated with the claimant.

4.1 REVIEWER'S COMMENTS

Although the DOE records did not identify any in vitro bioassays or medical x-rays, NIOSH's dose reconstruction calculated organ doses for both a hypothetical intake scenario and chest x-ray examinations for PIID* and PIID*, based on information provided in ORAUT-TKBS-0003. These organ dose calculations are based on worst-case assumptions and are considered claimant favorable.

Regarding the issue of potential radiological incidents, it is unclear whether NIOSH attempted to resolve this discrepancy by contacting the employee's supervisor, who, based on the interview, still works at the Savannah River Site. However, once again, the large assigned hypothetical internal dose can reasonably be assumed to exceed any potential unaccounted dose from radiological incident(s).

5.0 SUMMARY CONCLUSIONS

With the exception of minor errors, the dose reconstruction performed by NIOSH for the claimant complies with applicable procedures, is scientifically valid, and claimant favorable.

The two issues, which may require discussion/resolution, are generic issues that may not only affect this case, but potentially many SRS cases, including (1) the failure to consider tritium in organic form, and (2) the use of ICRP 30 biokinetic models for deriving hypothetical internal exposure to all radionuclides other than tritium.

Another generic concern that is not confined to this DR Report, but characterizes all 20 cases that SC&A has reviewed to date, is the brevity of the DR reports. In its current form, the NIOSH dose reconstruction report, at best, provides only a brief summary explanation for assigned doses. In some instances, the explanation is confined to a mere reference of a procedure/TBD.

The failure to explain how individual categories of internal/external exposures were derived, and the absence of a well-defined paper trail, pose limitations on NIOSH's internal QA review process. Similarly, these shortcomings force SC&A reviewers to engage in time-consuming speculations regarding the choice of procedures, methodology, and parameters selected by the dose reconstructor.

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APPENDIX A: IREP INPUT

Table below has been deleted – please see hard copy marked '#8 – Savannah River Site