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

Contract No. 200-2004-03805
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SCA-TR-TASK4-CNPIID*

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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 three periods of time; **PIID***. The worker was diagnosed with prostate 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 claimant's radiation exposure was received during employment as a **PIID***. As a **PIID***, the claimant performed work all over the site. Based on the Dose Reconstruction Telephone Interview, the claimant worked in various areas including **PIID***. About 50% of the time, the claimant was dressed out in protective clothing, including fresh-air suits. The claimant PIID*, and did general **PIID***.

The claimant was exposed to photon radiation fields and was monitored for ionizing radiation doses continuously during employment at the Savannah River Site. External dose records received from the Department of Energy were reviewed by NIOSH and found to be sufficient for the reconstruction of the external dose. A missed photon dose was assigned by NIOSH for all badge cycles when a zero dose was reported or when no information for a badge cycle was available.

Based on the information in the telephone interview, the claimant also worked at **PIID***. This facility presents the potential for neutron exposure. The energy employee was assigned a neutron dosimeter for 3 of the 12 badge cycles in **PIID*** and 2 of the 12 badge cycles in **PIID***To apply claimant-favorable assumptions that result in the highest probability of causation for neutron exposure, the 221F, **PIID***was used by NIOSH in the dose reconstruction for the years of potential neutron exposure. A missed neutron dose was assigned by NIOSH for all badge cycles when a zero dose was reported or when no information for a badge cycle is available.

Onsite ambient doses were assessed as part of the dose reconstruction. In addition, the photon doses due to annual x-ray procedures were evaluated.

From the telephone interview, the worker identified potential exposure to unknown quantities of tritium, Co, Pb, I, Rn, and enriched U. The worker was monitored for tritium. A potential missed dose for tritium was assigned by NIOSH for each year that an annual tritium dose was not reported. Additionally, the missed dose was assigned by NIOSH to the worker for any year in which the reported dose was less than the potential missed dose.

Internal dose monitoring records for radionuclides other than tritium were reviewed. All results of measurements for non-naturally occurring radionuclides showed an activity less than the minimum detection level for the given radionuclides and bioassay method. To account for any potential undetected dose for energy employees who participated in internal dose monitoring programs, internal dose was assigned by NIOSH based on a hypothetical intake. Assigned

internal doses for each radionuclide were based on a hypothetical acute intake on the first day of employment equal to the mathematical average of the largest five recorded intakes for that radionuclide documented at the Savannah River Site (referred to as the "high five" approach). The largest annual dose to a non-metabolic organ from these assumed intakes was calculated for each year from the first year of employment through the end of the year in which cancer was diagnosed. The high five approach is claimant favorable for workers who worked at the site in the **PIID*** and later, since it is unlikely that such workers would have been allowed to enter an area where they had the potential to experience high five exposures and not be properly monitored.

Table 1 summarizes the results of NIOSH's reconstruction of the doses to the energy employee's prostate gland for the purpose of deriving the probability of causation (POC) using IREP. Because the ICRP dosimetric model (ICRP 60, 1991) and IMBA do not provide the means to derive the doses to the prostate gland, NIOSH used the testes as a claimant-favorable surrogate for the prostate for external exposures, and the colon (maximum dose to any non-metabolic organ) for internal exposures. NIOSH's dose reconstruction included a total of 94 dose entries for determining the POC. Appendix A of this report is a reproduction of the IREP input, which identifies these doses as exposure entries #1 through #94. Throughout this report, reference will be made to select portions of Appendix A; for example, exposure entries #1 through #8 correspond to the measured external photon dosimeter results, as shown in Table 1 below.

The audit results are expressed in broad terms of whether we found the exposures to have been derived in compliance with applicable procedures, and in a scientifically valid and claimant-favorable manner. Using the dose estimate derived by NIOSH, the POC was determined by the Department of Labor (DOL) to be 3.19% at the 99% confidence interval, and on this basis, the claim was denied.

Table 1. Summary of Internal/External Exposures as Estimated by NIOSH

	Appendix A Exposure Entry No.	Dose (rem)
External Dose:		
▪ Photon Dosimeter Dose	1 – 8	0.174
▪ Photon Missed Dose	53 – 67	0.298
▪ Neutron Dosimeter Dose	9 – 10	0.175
▪ Neutron Missed Dose	68 – 70	0.848
▪ Occupational Medical	83 – 94	0.079
▪ Onsite Ambient	71 – 82	0.610
Internal Dose (Hypothetical):		
▪ Tritium	41 – 52	0.596
▪ All Other Radionuclides	11 – 40	1.181
Total		3.961

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 the 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 of this audit 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 technically 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: 3.961 rem	POC: 3.19%

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: 3.961 rem	POC: 3.19%

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

For external exposures to both photons and neutrons, NIOSH assumed that the exposure geometry was 100% anterior to posterior (AP). The testes were used as a surrogate organ for selection of the dose conversion factors (DCF) from Appendix B of the *External Dose Reconstruction Implementation Guideline* (OCAS-IG-001), which were applied based on energies for neutron and photons.

For photon radiation, 25% <30 keV and 75% 30–250 keV energy ranges were applied, yielding a photon DCF of 1.011. For neutron exposures, 100% 0.1–2 MeV energy range was applied, along with the 1.91 neutron correction factor, yielding a neutron DCF of 2.495 for the testes.

2.1 RECORDED PHOTON DOSES

For measured photon deep dose corresponding to the years **PIID***, NIOSH assigned a total dose of 174 mrem. SC&A reviewed the monthly DOE dosimeter records and was able to verify each of the dose entries, as given for entries #1 through #8 in Appendix A.

2.1.1 Reviewer's Comments

Based on information contained in the Dose Reconstruction (DR) Report and the CATI report, the claimant started employment on PIID*. Yearly dosimeter records submitted by the DOE, however, only provide data starting in **PIID***In fact, the only entry for **PIID*** is a 10 mrem dose recorded for cycle 9 (i.e., **PIID***). The absence of DOE dosimeter data for 1984 likely reflects the fact that zero measurements at SRS were not documented for the period **PIID***to 1988, as noted in OCAS-PER-001. It is noted, however, that NIOSH correctly accounted for this reporting deficiency by assuming the correct number of missed doses for **PIID***.

2.2 MISSED PHOTON DOSES

NIOSH assumed a 12-badge cycle per year for photons and estimated a total of 118 zero dose records for the full period of employment. The resultant total of missed photon doses of 298 mrem was derived by means of MDL values contained in Table 5.5.1-1 of ORAUT-TKBS-0003.

2.2.1 Reviewer's Comments

SC&A independently recalculated all TLD photon doses and verified annual assigned doses cited as entries #53 to #67 of Appendix A.

2.3 RECORDED NEUTRON DOSES

Measured neutron doses were recorded for the years **PIID***. A review of DOE dosimeter records shows neutron doses of 40 mrem and 30 mrem for years **PIID***, respectively. By means of the combined neutron dose correction factor and organ (testes) dose conversion factor of 2.495, neutron doses of 99.8 mrem and 74.85 mrem are derived.

2.3.1 Reviewer's Comments

Entries #9 and #10 of Appendix A match these derived values.

2.4 MISSED NEUTRON DOSES

NIOSH assigned missed neutron doses for the years **PIID***, when the claimant was working at the 221 F, B-Line. NIOSH assumed a total of 34 zero neutron recordings and estimated a total neutron dose of 848 mrem.

2.4.1 Reviewer's Comments

Our review of DOE dosimeter records for missed neutron doses (i.e., zero recordings) shows that this number is correct. In order to verify the above-cited dose, SC&A assumed that NISOH employed the following parameters for deriving the total missed neutron dose of 848 mrem:

Assumptions:

- Number of zeros found in neutron records: 34
- LOD for neutron dosimeter: 20 mrem
  (as given in Table 5.5.2-1 of ORAUT-TKBS-0003)
- (Neutron DCF)(Organ DCF) = 2.495

Calculation:

848 mrem = (34)(20 mrem/2)(2.495)

This dose estimate for missed neutron doses agrees with data for entries #68 to #70 in Appendix A. The methodology also complies with applicable procedures, is scientifically valid, and claimant favorable.

2.5 OCCUPATIONAL MEDICAL EXPOSURES

For occupational medical exposure, NIOSH assumed an x-ray organ dose for each of the **PIID*** years of employment. For all years other than **PIID***, the annual testicular dose of 6 mrem was assigned; for **PIID*** an annual dose of 8 mrem was assigned per x-ray examination. A total occupational medical exposure of 79 mrem was assigned.

2.5.1 Reviewer's Comments

SC&A reviewed default organ values for occupational medical x-rays, as given in Table 2.5.1-1 of ORAUT-TKBS-0003. This table segregates organ doses into three groupings, with Group 3 representing the testes. Based on data contained in Table 2.4.1-1, dose entries 83 to 94 comply with SRS default values.

When added, the annual doses for medical x-rays total 76 mrem, which is close to, but lower than, the stated value of 79 mrem cited in the text of the DR Report. Ignoring this minor discrepancy, the assigned doses comply with procedural data, are scientifically valid, and claimant favorable.

2.6 ONSITE AMBIENT DOSE

Although the claimant was monitored for external exposure, NIOSH, nevertheless, assigned an onsite ambient dose in order to account for any erroneous subtraction of elevated ambient levels of external radiation (EALER) that might have been recorded on control badges.

For onsite ambient doses, NIOSH employed default values, which represent the maximum annual onsite doses at SRS, and derived a total dose of 610 mrem.

2.6.1 Reviewer's Comments

SC&A reviewed maximum annual onsite doses for the corresponding years, as defined in Table 3.4-1 of ORAUT-TKBS-0003. Entries #71 through #82 of Appendix A match those of Table 3.4-1 for corresponding years. These dose entries, therefore, comply with the applicable procedure, are scientifically valid, and claimant favorable.

3.0 AUDIT OF INTERNAL DOSES (MISSED DOSE)

NIOSH only calculated internal doses in behalf of missed dose for tritium and for all nuclides other than tritium.

3.1 TRITIUM

An annual tritium dose was assigned to all years when a tritium dose was not reported or the reported dose was less than the default value for a missed tritium dose. Accordingly, NIOSH assigned 12 years of missed tritium doses spanning the years **PIID*** and totaling 596 mrem.

3.1.1 Reviewer's Comments

Review of DOE records shows that the claimant was monitored repetitively for tritium by means of urinalysis in the years **PIID***. Results of bioassays show levels consistently below 0.100 µCi/liter. In only two instances, urine levels of 0.7 and 0.3 µCi/liter were observed. These levels correspond to organ doses that are well below the organ dose assigned by default values.

Organ dose default values for SRS are defined in Table 4.5.3-1 of ORAUT-TKBS-0003. SC&A reviewed these values and matched them against dose entries #41 to #52 of Appendix A.

The reconstruction of missed tritium doses, therefore, complied with applicable procedures. The assigned doses are also likely to be scientifically valid and claimant favorable. This conditional judgment of scientific validity and claimant favorability rests with the assumption that tritium exist as tritiated water only. If tritium can be shown/assumed to be in organic form, the longer residency time of organified tritium in the body would raise the dose.

3.2 ALL OTHER NUCLIDES

For all other nuclides, assigned internal doses that may have gone undetected were also based on default values, as provided in Section 4.5.2 of ORAUT-TKBS-0003. Starting with the year of employment in **PIID*** until the year of cancer diagnosis in **PIID***, annual organ doses were assigned. These doses are defined by entries #11 to #40 of Appendix A and correspond to a total dose of 1.181 rem.

3.2.1 Reviewer's Comments

SC&A reviewed the default values cited in Table 4.5.1-1 of ORAUT-TKBS-0003 and verified that all entries in the DR Report matched those of Table 4.5.1-1.

It is concluded that NIOSH used the correct procedure and default values for missed internal doses for nuclides other than tritium.

A review of the method by which default values were derived, however, raises some concern about the scientific validity and claimant favorability of these default values. The following

provides a brief explanation and defines the potential magnitude of underestimated internal doses.

For radionuclides other than tritium, default values are based on the "high five" approach. Radionuclide-specific high five values were derived from data contained in ORAUT-OTIB-0001. In brief, ORAUT-OTIB-0001 models intakes that are based on ICRP 30 biogenetic models instead of 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 Profile).

4.0 CATI REPORT AND RADIOLOGICAL INCIDENTS

NIOSH briefly acknowledged two radiological incidents cited in the CATI report. While the CATI specifically identifies two separate radiological incidents – the first in **PIID*** and the second in **PIID*** – there is no mention/documentation of these incidents in the DOE records. It is, therefore, uncertain whether these incidents actually occurred or whether appropriate records are missing from the DOE files. (On the cover page of NIOSH's Request for Personnel Exposure Information, DOE checked the box indicating that these records do not exist.)

The NIOSH DR Report provides no insight as to whether there was any follow-up conversation/ communication with either the claimant or DOE to resolve this matter.

Based on the nature of the radiological incidents and the worker's claim that no investigation or bioassays were performed for either incident, the potential exists that internal exposures were not accounted for.

SC&A, however, does acknowledge that the NIOSH-assigned hypothetical internal doses for tritium and other nuclides are likely to be significantly greater than those that may have resulted from these incidents, which obviates the need for further investigation.

5.0 SUMMARY CONCLUSIONS

This dose reconstruction demonstrates the level of detail and extensive effort that NIOSH is required to satisfy the regulatory and procedural requirements in behalf of EEOICPA.

In general, the dose reconstruction was thorough, procedurally compliant, scientifically valid, and claimant favorable. The two issues that may require further discussion are generic issues that affect not only this case, but potentially many other SRS cases; these include (1) the failure to consider tritium in organic form, and (2) the use of ICRP 30 biogenetic models for deriving hypothetical internal exposure to radionuclides other than tritium.

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APPENDIX A: IREP INPUT

Deletions made to the following table -- please see hard copy labeled "#13 – Savannah River Site"

APPENDIX A (continued)

Deletions made to the following table -- please see hard copy labeled "#13 – Savannah River Site"