REPORT TO THE ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute of Occupational Safety and Health

Audit of Case PIID* from the Rocky Flats Plant

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SCA-TR-TASK4-CN PIID*

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Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program</td><td>Document No.
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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). This dose reconstruction was for an energy employee that worked at the Rocky Flats Plant for almost **PIID*** years, from **PIID***, through **PIID***. This period included the time when the Rocky Flats Plant produced plutonium triggers for nuclear weapons and processed weapons for plutonium recovery.

Because of claimant's employment as an instrumentation engineer in the plutonium recovery and waste treatment buildings, the worker likely experienced internal exposures due to the intake of particles of plutonium oxide in the workplace and outside environment, and external exposures from working near the production operations.

The employee was diagnosed with rectal cancer on **PIID***. NIOSH judged that the probability of causation (POC) would be very low for this individual because of the cancer type, the short latency period between exposure and diagnosis, and the relatively short exposure time. In cases like this one, with low causation probabilities, NIOSH intentionally overestimates the dose using, in some cases, very unrealistic assumptions. Using the colon as a surrogate to the rectum, they quantified doses from measured and missed external exposures, missed internal exposures, and occupational medical x-rays, and determined that the POC was 0.45%.

Table 1 presents an overall summary of NIOSH dose reconstruction.

Table 1. Summary of Exposure as Estimated by NIOSH

	Appendix A Exposure Entry No.	Dose (rem)
External Dose:		
▪ Photon Dosimeter Dose	1 – 3	0.48
▪ Photon Missed Dose	22 – 26	1.8
▪ Neutron Dosimeter Dose	NC*	—
▪ Neutron Missed Dose	NC*	—
▪ Occupational Medical	27 – 31	0.415
▪ Onsite Ambient	NC*	—
Internal Dose (Hypothetical):	4 – 21	8.68
Total		11.375

*NC – Not considered

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

- 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: 11.375 rem	POC: 0.45%

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: 11.375 rem	POC: 0.45%

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				12	✓		

[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

2.1 DOSE RECONSTRUCTION OVERVIEW

Dose estimates derived by NIOSH for various exposure categories that were used as input values for IREP are included as Appendix A of this report and summarized below. There were a total of 31 exposure data entries for the following exposure categories:

- Measured external dose from positive TLD results (Entries #1–#3 of Appendix A)
- Missed dose from internal alpha radiation (Entries #4–#9 of Appendix A)
- Missed dose from internal photon radiation (Entries #10–#15 of Appendix A)
- Missed dose from internal electrons (Entries #16–#21 of Appendix A)
- Missed external dose (Entries #22–#26 of Appendix A)
- Dose from medical x-rays (Entries #27–#31 of Appendix A)

2.2 RECORDED PHOTON DOSES

NIOSH found the external dose records to be sufficient to estimate the claimant's measured external dose. The reconstructor found positive TLD measurements for **PIID*** and **PIID*** that totaled 0.24 rem. NIOSH doubled this dose to account for uncertainty and assumed that the photon energy range was 30–250 keV to maximize the causation probability.

2.2.1 Reviewer's Comments

SC&A reviewed the TLD records and verified that the total individual year TLD measured dose was 0.24 rem. This dose represents the sum of two annual TLD reports dated **PIID***, and **PIID***. The reports listed the following doses:

Reporting Date	Quarter	Penetrating Dose (mrem)
PIID*	1	0
	2	0
	3	0
	4	37
	Total	37
PIID*	1	73
	2	53
	3	44
	4	28
	Total	203
	Grand Total	240

* Reporting date is the year following the measurements

Doubling this dose yields the 0.48 rem used in the IREP input and eliminates the need for uncertainty.

However, there is a discrepancy with a DOE record that shows the accumulated dose for the years including **PIID*** to be 0.277 rem, not 0.240 rem. This record was found on page 39 of 40 in the supplied .pdf file named DOE_Response_008121_D238. SC&A has no way to determine which value is correct or why there is this discrepancy between the summary printout and the individual yearly records.

Secondly, Appendix A shows that entry #3 corresponds to the identical **PIID*** dose of 0.074 rem as entry #1. Thus, entry #3 is either a redundant entry or entry #3 should have the assigned year of **PIID***.

Lastly, in compliance with guidance contained in ORAUT-OTIB-0008 (which identifies the Standard Overestimating Correction/Conversion Factor of 2 for recorded TLD values), doubling this dose yields the 0.48 rem and eliminates the need for uncertainty. However, ORAUT-OTIB-0008 also identifies a single generic $H_P(10)$-to-organ dose conversion factor (DCF_{max}) of 1.1, which was **not** applied to entries #1, #2, and #3. (The dose reconstructor either ignored the need for a DCF or assumed a value of 1.0.)

2.3 MISSED PHOTON DOSES

To estimate missed photon dose, NIOSH employed the following approach, as contained in the DR Report and reproduced below verbatim.

> *Missed dose was assigned to each actual or potential dosimeter cycle to maximize the external dose estimate. Missed dose represents the dose that may have been received but not recorded because of dosimeter detection limits or site reporting practices. Based on the Technical Information Bulletin: Overestimating External Doses Measured with Thermoluminescent Dosimeter,[8] the total number of dosimeter cycles assigned was 60 for photons. This number was based on a claimant-favorable assumption of 12 badge exchanges each full or partial year of employment to ensure that all possible instances of a zero badge reading were accounted for in this dose reconstruction. Based on information provided in the Technical Information Bulletin: Overestimating External Doses Measured with Thermoluminescent Dosimeter,[8] this results in a maximum missed dose of **3.600** rem from photons. For the purpose of calculating probability of causation, this value was divided by 2 in accordance with the External Dose Reconstruction Implementation Guideline.*[3] [Emphasis added.]

2.3.1 Reviewer's Comments

The above-cited explanation for estimating missed photon dose contains an erroneous interpretation of ORAUT and OCAS procedures, an erroneous interpretation of DOE dosimetry data, and a numerical error, as explained below.

- The dose reconstructor erroneously applied the standard overestimating C/C factor of 2 and derived the above-cited total of 3.600 rem:

  Total Missed Dose = (30 mrem/cycle)(12 cycles)(5 years)(2)
  = 3.600 rem

- Next the dose reconstructor **cancels** the first error (i.e., the misuse of the standard overestimating factor of 2) by dividing the dose estimate by 2 and explains this by the following statement ". . . for the purpose of calculating probability of causation, this value was **divided** by 2 in accordance with the External Dose Reconstruction Implementation Guideline.[3]" (Note: OCAS-IG-001 provides **standard** guidance for missed dose expressed as *n*LOD/2 and a GSD of 1.52 for uncertainty; OCAS-IG-001 is **not** intended to be combined with ORAUT-OTIB-0008.)

- The use of LOD (as opposed to LOD/2) for estimating missed dose per cycle represents the 95th percentile value and, therefore, precludes the need to incorporate uncertainty in the dose estimate. The dose reconstructor erroneously applied the GSD of 1.52 for uncertainty to a dose derived by LOD.

- The assumption of 12 cycles per year applies to situations in which data are lacking. Dosimetry records provided by DOE in behalf of Claim PIID* clearly indicate that the individual was monitored on a quarterly (**not** monthly) basis.

While the combination of procedural misinterpretations had only marginal impacts on assigned dose and clearly did not significantly affect the POC (and the compensability of the claim), it does demonstrate various difficulties associated with the implementation of this procedure.

2.4 MISSED NEUTRON DOSE

NIOSH did not estimate or discuss a neutron dose for this individual.

2.4.1 Reviewer's Comments

A review of DOE dosimeter records, however, indicates that claimant was, in fact, monitored for neutrons. The records reveal that all neutron dosimeter readings were recorded as zero. Based on procedural guidance, zero readings must be accounted for as missed dose. Given the history of neutron dose for the recovery facility (ORAUT-TKBS-0011-6, *Technical Basis Document for the Rocky Flats Plant – Occupational External Dosimetry*), ignoring the missed neutron dose is not in keeping with the idea of intentional overestimation. The TBD estimates the missed dose during the term of the claimant employment to be 30 mrem per TLD. This value includes a 30% uncertainty factor. Given the fact that the claimant was employed for **PIID*** calendar quarters, total missed neutron dose is estimated at 0.480 rem and should have been included in the dose reconstruction.

While the inclusion of 0.480 rem for missed neutron dose would neither significantly increase the total assigned dose nor the POC, its inclusion, however, does satisfy procedural guidance, as given in Section 3 of ORAUT-PROC-0006, Attachment D-2, which states the following:

> *In general, this instruction applies maximizing assumptions for both recorded and potentially unrecorded doses to ensure that the covered employee's dose and probability of causation (POC) are not underestimated. This approach is consistent with the external dose reconstruction IG and the principles outlined in 42 CFR 81 and 82. Unlike the approach for potentially >50% POC cases, this process does not allow a partial dose reconstruction as all potential sources of radiation dose must be evaluated.*

2.5 OCUPATIONAL MEDICAL EXPOSURES

NIOSH used ORAUT-OTIB-0006, *Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures,* to estimate the dose from medical x-rays. NIOSH used annual x-ray exams and a maximum default organ dose (lateral view of breast = 0.0638 rem per x-ray exam) in Table 4.0-1 of ORAUT-OTIB-0006 and multiplied by 1.3 to account for uncertainty, as recommended by the reference document. This resulted in a total dose of 0.415 rem, as follows:

0.0638 rem/exam x 1.3 x 1 exam/year x 5 years = 0.415 rem

2.5.1 Reviewer's Comments

SC&A reviewed the DOE records of the claimant and found no records for diagnostic x-ray exams. NIOSH's record request form is marked as "does not exist" by the DOE. Equally, the CATI report did not provide any information on the claimant having medical x-rays for employment. NIOSH's assumption of an annual chest x-ray is, therefore, inappropriately claimant favorable.

SC&A regards NIOSH's dose estimate to be procedurally and scientifically difficult to justify. Table 4.0-1 of ORAUT-OTIB-0006 clearly identifies the corresponding dose to the rectum, and there is no scientific justification for using the breast as a surrogate organ for rectal cancer. According to Table 4.0-1 of ORAUT-OTIB-0006, the value for the colon/rectum is 1.5E-04 rem/exam for the lateral view. This is the relevant organ for external exposures (OCAS-IG-001, *External Dose Reconstruction Implementation Guideline*. The colon/rectum value is about 425 times less than the value for the breast. This is not scientifically defensible, but is in keeping with intentionally overestimating the dose.

2.6 ONSITE AMBIENT DOSES

NIOSH did not include onsite ambient doses because the claimant was monitored during his employment, and because missed doses were assigned to dosimeter cycles. ORAUT-OTIB-0007, *Occupational Dose from Elevated Ambient Levels of External Radiation*, recommends that an ambient dose assessment need not be performed in cases like this. In addition, the site

measurement program did not subtract elevated background readings from the dosimeters, so the assigned missed doses exceed any onsite ambient levels.

2.6.1 Reviewer's Comments

Our audit finds NIOSH's reasoning not to include ambient doses scientifically defensible, especially since the missed external dose is overestimated.

3.0 AUDIT OF INTERNAL DOSES

According to NIOSH, there were no bioassay data, suggesting that claimant was unlikely to receive internal dose. Nevertheless, NIOSH used the hypothetical calculation based on ORAUT-OTIB-0002, *Maximum Internal Dose Estimates for Certain DOE Complex Claims*, to reconstruct any potential missed internal dose. Based on this calculation, NIOSH obtained a total missed internal dose of 8.684 rem.

3.1 REVIEWER'S COMMENTS

It was noted that ORAUT-OTIB-0002 recommends calculating the dose to the colon as a surrogate organ for the rectum. In SC&A's review of this document, ORAUT-OTIB-0005, and OCAS-IG-002, we found that Lower Large Intestine (LLI) is the correct surrogate for the rectum.

SC&A acknowledges, however, the difference between colon and LLI as surrogate organs for the rectum is small and, therefore, of limited relevance to the conservative assumptions surrounding the hypothetical internal dose model employed by NIOSH.

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4.0 CATI REPORT AND RADIOLOGICAL INCIDENTS

Our review of the CATI report reviewed no additional information useful and/or relevant to dose reconstruction.

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5.0 SUMMARY CONCLUSIONS

Our review of Case PIID* identified numerous minor deficiencies most of which involved a combination of misuse/misinterpretation of procedures for deriving maximized estimates of missed photon dose. This combination of nearly identical errors was also observed in behalf of two other cases (i.e., Case # **PIID*** and Case # **PIID***). The fact that these three cases represent the work of three different dose reconstructors suggest that the cause is rooted in procedural guidance that is ambiguous and difficult to interpret.

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REFERENCES

ACJ & Associates and the UK National Radiological Protection Board, Integrated Modules for Bioassay Analysis, (IMBA), Phase 1, Software produced for NIOSH-OCAS as part of the EEOICPA program, Version 1.0.63, UK, November 2002.

"NIOSH Report of Dose Reconstruction Under the Energy Employee Occupational Illness Compensation Program Act (EEOICPA)." NIOSH ID: 008121.

NIOSH. 2002. "External Dose Reconstruction Implementation Guideline, Rev 1," OCAS-IG-001. National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio, 2002.

NIOSH. 2002. "Internal Dose Reconstruction Implementation Guideline, Rev 0," OCAS-IG-002. National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio, August 2002.

ORAUT-TKBS-0011-6. 2004. "Technical Basis Document for the Rocky Flats Plant – Occupational External Dosimetry," January 20, 2004.

ORAUT –TKBS-0011-5 2004. "Technical Basis Document for the Rocky Flats Plant to be used for EEOICPA Dose Reconstruction," January 12, 2004.

ORAUT-OTIB-0008. 2003. "Standard Complex-Wide Conversion /Correction Factor for Overestimating External Doses Measured with Thermoluminescent Dosimeter," November 7, 2003.

ORAUT-OTIB-0007. 2003. "Occupational Dose from Elevated Ambient Levels of External Radiation," November 12, 2003.

ORAUT-OTIB-0006, "Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures," November 29, 2003.

ORAUT-OTIB-0002. 2004. "Maximum Internal Dose Estimates for Certain DOE Complex Claims," January 10, 2004.

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APPENDIX A: IREP INPUT

Table Below has been deleted – Please see hard copy labeled "#16 – Rocky Flats Plant"