REPORT TO THE ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute of Occupational Safety and Health

Audit of Case PIID* from Hanford

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

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1.0 RELEVANT BACKGROUND INFORMATION

This report presents an independent audit of a Dose Reconstruction (DR) Report performed by the National Institute of Occupational Safety and Health (NIOSH) for an energy employee who had worked at the Hanford Site's PIID* as a PIID* for a period of PIID* and PIID*, and as a PIID* from PIID* through PIID*. The claimant's job as a PIID* included PIID*. Work locations within the PIID*, and PIID*. The claimant was diagnosed with colon cancer in PIID*.

Throughout the employment period, the claimant was monitored for external exposure by means of film dosimeters or TLDs. External exposures included photon and neutron radiation. Claimant was also monitored for internal exposure by means of periodic in vivo and in vitro bioassay measurements that included whole-body counting, chest counting, and urinalysis.

NIOSH's dose reconstruction for this case included a total of 227 exposure data entries to be used for determining the probability of causation. These dose data entries are #1 through #227 and are reproduced herein as Appendix A. Throughout this report, reference will be made to select portions of Appendix A; for example, exposure entries #1 through #25 identify recorded external photon dosimeter results, while entries #26 through #35 correspond to external neutron exposures.

Provided in Table 1 below are dose estimates derived by NIOSH that correspond to data contained in Appendix A. Using the dose estimate derived by NIOSH, the probability of causation (POC) was determined by the Department of Labor (DOL) to be 40.54% 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 Dosimeter Dose	1 – 25	6.881
▪ Missed Photon Dose	165 – 168	0.680
▪ Neutron Dosimeter Dose	26 – 35	2.879
▪ Missed Neutron Dose	169 – 172	3.003
▪ Occupational Medical:		
- chest x-rays	200 – 226	0.213
- chest photofluorography	227	0.260
▪ Onsite Ambient	173 – 199	2.272
Internal Dose (Hypothetical):	36 – 164	16.986
Total:		30.902

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 Hanford

- 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 auditor understands which procedures, models, site-specific data, and assumptions NIOSH used to perform its dose reconstruction. The second step of the audit evaluates whether the methods employed by NIOSH are consistent with applicable procedures, scientifically defensible, 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.

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Table 2. Case Review Checklist

CASE PIID	ASSIGNED DOSE: 30.902 rem	POC: 40.45%

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 compensibility of the case.
[3] **High** means that the deficiency substantially impacts the dose and may also impact the compensibility of the case.

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CASE PIID		ASSIGNED DOSE: 30.902 rem			POC: 40.45%		
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				5			✓

[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 RECORDED PHOTON DOSES

As part of this audit, 100% of all DOE dose records were reviewed. These records include lifetime exposure reports that summarized exposure data by year and annual exposure data, which identified exposures for each month. SC&A's review of these data showed the following:

- With the **exception** of data for PIID*, and PIID*, data provided by the DOE were complete and **consistent** in that a summation of monthly exposures matched yearly/lifetime exposure data.
- Annual recorded doses provided by the DOE matched assigned doses by NIOSH as represented by exposure entries #1–#25 of Appendix A.

NIOSH's Report of Dose Reconstruction stated that for exposure geometry and radiation energies, values were selected to **maximize** dose. Thus, ". . . To ensure that the estimate dose has been maximized, an organ dose conversion factor of 1 has been applied to both photons and neutrons. To maximize the probability of causation, a photon energy of range 100% 30–250 kev . . . [was] applied."

2.1.1 Potential Deficiencies in Dose Reconstruction Report Pertaining to Recorded Photon Doses

Failure to Include Uncertainty. While the applied value of 1 for the colon dose conversion factor is conservative (i.e., claimant favorable), the fact the all photon doses of record were entered as a constant with no estimate of dosimeter uncertainty is a deficiency that is not claimant favorable. The need to account for dosimeter uncertainty is a procedural requirement as specified in all applicable procedures, which include OCAS-IG-001 (see Section 2.1.1.33), ORAUT-PROC-0006 (see Section 6.1.1.2), and ORAUT-TKBS-0006-6 (see Section 6.3.4.3 and 6.6.2).

Missing DOE Dosimetry Data. Exposure entry #25 of Appendix A cites a deep dose of 80 mrem for PIID*, which also matches the deep dose value given in DOE's Radiological Exposure Individual Dosimeter History Report (enclosed below as Exhibit 1). However, this cannot be verified since the monthly dosimeter data, as given in Exhibit 2, only provides data for PIID* (i.e., there are no data for the remaining PIID*). It should be noted that Exhibit 2 identifies a total of four pages on the upper right-hand side of the report and states " . . . Historical Dose Report PIID*" It is assumed that the missing pages 3 and 4 provide monthly dosimetry starting PIID* and ending PIID*, which coincides with claimant's termination date of PIID*. It should be further noted that in Appendix A there is no dosimeter dose assigned for the year PIID*, which may be due to the fact that all dosimeter measurements for PIID* were below the detection limit. If such is the case, these zero measurements must, nevertheless, be accounted for under the category of missed dose, as discussed in Section 2.3.

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Exhibit 1

REXER77	RADIOLOGICAL EXPOSURE Individual Dosimeter History	Page 1 01/08/03

Deletions made to the following table – please see hard copies labeled '#6 – Hanford'

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Exhibit 1 (Continued)

REXER77	RADIOLOGICAL EXPOSURE Individual Dosimeter History	Page 2 01/08/03

Deletions made to the following table – please see hard copy labeled '#6 - Hanford'

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Exhibit 2

PNNL
External Dosimetry

01/07/2003

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Exhibit 2 (Continued)

2.2 MISSED PHOTON DOSES

NIOSH assigned missed photon doses for the years PIID* and PIID*. These are cited as entries #165 through #168 of Appendix A, and are based on LOD/2 multiplied by the number of zero deep dose recordings in a given year.

Our review of dosimeter records reveals potential discrepancies for the years PIID* and PIID*, as given in Table 5 and discussed below.

Table 3. Potential Dosimeter Record Discrepancies

Year	LOD/2 (mrem)	Assumed No. of Zero $H_P(10)$ Doses	Assigned Missed Dose (mrem)	Documented No. of Zero Doses
PIID*	20	11	220	11
PIID*	20	9	180	9
PIID*	10	22	220	?
PIID*	10	6	60	?
Total		48	680	

2.2.1 Deficiency 1: Misinterpretation of DOE's Dosimetry Records for PIID*

NIOSH's DR Report states that ". . . The total number of zero dosimeter readings assigned, based on the actual number of zeros reported in [energy employee's] dosimetry files, was 48 for photons. . ." Column 8 of Exhibit 2 does, in fact, identify that of the 36 dose entries, there were a total of 22 zero readings for PIID*. Thus, it must be assumed that the dose reconstructor simply counted the number of zero dose entries in Column 8 and assigned a missed dose, as shown in Table 5. Inspection of Exhibit 2, however, shows that, in general, three dosimeters were assigned concurrently for each month representing one monthly whole-body dosimeter and two finger ring dosimeters. Therefore, the correct number of zero dose readings for PIID* should have been 9 instead of the 22 that were assumed by NIOSH; and the correct missed photon dose for PIID* is 90 mrem instead of 220 mrem.

2.2.2 Deficiency 2: Misinterpretation of DOE's Dosimetry Records for PIID*

For PIID*, NIOSH assumed six zero readings. This value was apparently also taken from page 2 of Exhibit 2, Column 8, which identifies six zero readings; however, for PIID*, only data for PIID*and PIID*are provided. Thus, potential zero doses for PIID* through PIID* are not included as missed photon doses. It must be assumed that the dose reconstructor has also failed to realize that these entries represent concurrent dosimeters that included finger rings and were limited for the months of PIID*. Missing for PIID* are monthly data for the other 10 months. Due to incomplete DOE data (i.e., missing pages 3 and 4 of Exhibit 2), the actual number of zero dose readings for PIID* cannot be determined.

2.2.3 Deficiency 3: Misinterpretation of DOE's Dosimetry Records for PIID*

For PIID*, NIOSH assigned no photon doses in behalf of recorded dosimeter doses. Exhibit 1 verified that, for PIID*, there were no positive deep doses recorded. This would further imply that, for PIID*, there were likely 12 zero photon doses for which a missed dose should have been derived but which was not included in NIOSH's DR Report. (It is likely that monthly dosimeter data are also included in the missing pages 3 and 4 of Exhibit 2.)

2.2.4 Deficiency 4: Misinterpretation of DOE's Dosimetry Records for PIID* and PIID*

In addition to deficiencies pertaining to missed doses for the years PIID*and PIID*, SC&A reviewed monthly dosimeter records for the years PIID* through PIID*, and PIID* through PIID*. Inspection of Appendix A shows no entry for missed photon dose for these years, which would imply that there were no monthly monitoring periods with a zero reading for a total of PIID* years. SC&A reviewed the monthly deep dose readings for the above cited years and found numerous monitoring periods for which the deep dose was recorded as zero or left blank. Table 6 below summarizes missed photon doses that were not included in the dose reconstruction report.

Table 4. Summary of Missed Photon Doses Not Included in Dose Reconstruction Report

Year	No. of Zero Recordings for $H_P(10)$	LOD/2 (mrem)	SC&A's Estimate of Missed Dose (mrem)
PIID*	2	20	40
"	0	20	–
"	0	20	–
"	1	10	10
"	1	10	10
"	0	10	–
"	1	10	10
"	2	10	20
"	1	10	10
"	2	10	20
"	5	10	50
"	0	10	–
"	2	10	20
"	3	10	30
"	9	10	90
"	7	10	70
"	3	10	30
"	3	10	30
"	7	10	70
"	10	10	100
"	11	10	110
"	9	10	90
"	2 – 11 (?)	10	20 –110
"	12 (?)	10	120 (?)
Totals	~100		950 – 1,040

2.2.5 Deficiency 5: Procedural Deficiencies Pertaining to Missed Photon Doses

Current procedural guidance pertaining to "missed" photon doses is exclusively directed to dosimeter data submitted by the DOE for which the dosimeter reading(s) are documented as zero

(0) readings (see Section 2.1.2 of OCAS-IG-001). In brief, the guidance states that for zero measurements, the assigned annual missed dose is determined by dividing the lower limit of detection (LOD) of the dosimeter by two and multiplying the LOD/2 by the total number of zero measurements for that year.
While this is an appropriate approach for assigning missed dose in instances when DOE records reveal an assigned photon dose of zero, a significant deficiency that is claimant unfavorable results when the DOE record reveals "measured" doses **below** LOD/2.

The simplest way to demonstrate this procedural deficiency and unfavorable impact on claimants (including this claimant) is by way of the following illustration:

> At the Hanford Site, the lower limit of detection for personnel dosimeters up until PIID* was 40 mrem. Thus, a person who was monitored prior to PIID* on a monthly basis but had 12 zero measurements would be assigned a missed photon dose of 240 mrem for the year.
>
> However, at Hanford (and assumedly elsewhere), doses well below LOD were, in fact, recorded. Exhibit 3 shows monthly dosimeter doses for Case PIID for the year PIID*, and shows monthly assigned doses as low as 1 mrem. Because there were no zero measurements for Case PIID for PIID*, there was no assignment of missed dose. The obvious discrepancy is that for measured doses less than 20 mrem, the claimant actually receives less assigned dose than the monitored individual whose measured dose is zero. For example, Table 7 provides the measured deep dose data for Case PIID and the assigned annual dose as recorded in entry #4 of Appendix A. (Note: The 175 mrem dose given in Exhibit 3 was apparently rounded up to 180 mrem, as given in Appendix A.) All but 3 monthly doses were above LOD/2 (or 20 mrem) and corresponded to a yearly "measured" dose of 175 mrem. This is 65 mrem less than the 240 mrem dose that would have been assigned as "missed" dose if Case PIID had 12 zero measurements.

Table 5. Measured/Assigned Doses for Case PIID* for PIID*

Month	Measured Dose (mrem)
January	2
February	2
March	13
April	17
May	1
June	12
July	25
August	41
September	2
October	36
November	5
December	19
Total	175

Exhibit 3

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2.3 RECORDED NEUTRON DOSES

The principal work location for this claimant was PIID* of the PIID*, which is cited as an area with potential neutron exposure (Section 6.3.4.5, ORAUT-TKBS-0006-6). Exposure entries #26 through #35 of Appendix A cite neutron exposures for the years PIID* through PIID*, and for PIID*, and PIID*.

Attachment 6E of ORAUT-TKBS-0006-6 specifies that prior to implementation of the HMPD in PIID*, neutron doses are to be estimated by means of neutron to photon ratios. For the PIID*, the ratio of 2.47 was defined (Table 6E-5 of ORAUT-TKBS-0006-6). Table 6E-3 further defines a maximum neutron correction factor of 1.91. On the basis of these recommendations, the 95th percentile annual neutron doses were derived for the years PIID*– PIID* by multiplying the corresponding annual photon doses by 2.47 and 1.91, as shown in Table 3.

Table 6. Assigned Neutron Doses Based on Neutron to Photon Ratio

Year	Photon Dose of Record (mrem)	$\eta-\gamma$ ratio factor	Adjustment Factor	Assigned η Dose (mrem)
PIID*	80	2.47	1.91	377
PIID*	100	2.47	1.91	472
PIID*	110	2.47	1.91	519
PIID*	180	2.47	1.91	849
PIID*	20	2.47	1.91	94

For all years after PIID*, all neutron doses of record were adjusted by means of the 1.91 neutron correction factor; and for the years between PIID* and PIID*, the additional adjustment factor of 1.35 was applied, as recommended in Section 6E.4.2.3 (see Table 4).

Table 7. Assigned Neutron Doses Based on Recorded η Doses

Year	Photon Dose of Record (mrem)	Adjustment Factor	Assigned η Dose (mrem)
PIID*	80	1.91; 1.35	206
PIID*	10	1.91	19
PIID*	20	1.91	38
PIID*	120	1.91	229
PIID*	40	1.91	76

In summary, the assigned neutron doses for entries #26 through #35 of Appendix A comply with the procedural recommendations of Attachment 6E of ORAUT-TKBS-0006-6

2.4 MISSED NEUTRON DOSES

Missed neutron doses are identified in entries #169 through #172 of Appendix A and correspond to the years PIID*, and PIID*. (Note: the years for missed neutron doses cited by NIOSH are identical to the years of missed photon doses.)

Assigned missed neutron doses for the years PIID* and PIID* were derived as defined in Section 6E.4.2.6 of ORAUT-TKB-0006-6. Before PIID*, the procedure specifies that:

missed neutron dose = (missed photon dose)(neutron/photon dose ratio);

and, for deriving the maximum missed neutron dose, the 95th percentile neutron/photon ratio of 2.47 can be used. Additionally, there is a need to apply the neutron correction factor of 1.91.

Applying this approach for PIID* and PIID* yields the following 95th percentile missed neutron doses:

PIID* missed η dose = (220 mrem)(2.47)(1.91)
= 1,038 mrem

PIID* missed η dose = (180 mrem)(2.47)(1.91)
= 849 mrem

These values match those of entries #169 and #170 of Appendix A.

2.4.1 Issue of Concern No. 1: Inability to Duplicate Assigned Missed Neutron Doses

For the years PIID* and PIID*, missed neutron doses of 955 mrem and 191 mrem, respectively, were assigned, which SC&A could not reproduce (see entries #171 and #172 of Appendix A). For the post- PIID* time period, missed neutron doses were to have been derived by procedural guidance contained in Section 6.5.2.1 of ORAUT-TKSB-0006-6 and/or Attachment 6E, Section 6E.4.2.6 of ORAUT-TKBS-0006-6. (Admittedly, guidance provided in these two sections of ORAUT-TKBS-0006-6 for deriving missed neutron doses is inconsistent, as well as difficult to interpret. It also appears that the dose reconstructionist did <u>not</u> attempt to follow the procedural "guidance" provided in these sections for deriving missed neutron doses.)

Based on SC&A's "interpretation" of guidance provided in ORAUT-TKBS-0006-6, the missed neutron doses for 1992 and 1993 should have been calculated as follows:

Missed η dose (PIID*) = (No. of Zero η dose reads)(MDL/2)(η dose correction factor)

From the previous Exhibit #2, the data show a total of ten zero neutron readings for PIID*; and for PIID*, the DOE Radiological Exposure Individual Dosimeter History Report (Exhibit 1) shows a zero η dose for the year, which implies 12 months of zero neutron doses. Table 6-31 of ORAUT-TKBS-0006-6 identifies a neutron MDL value of 50 mrem and Table 6-29 identifies the neutron correction factor of 1.91. Thus, for PIID* and PIID*, SC&A calculates missed neutron doses of 478 mrem and 573 mrem, respectively. These values differ significantly from the values of 955 mrem and 191 mrem derived by NIOSH (see entries #171 and #172 of Appendix A).

PIID* Missed Neutron Dose = (10 zero η readings)(50/2 mrem)(1.91)
= 478 mrem

PIID* Missed Neutron Dose = (12 zero η readings)(50/2 mrem)(1.91)
= 573 mrem

2.4.2 Issue of Concern No. 2: Failure to Account for Missed Neutron Doses for the Remaining PIID* Years of Monitoring

As was previously pointed out for missed photon doses, the DR Report also implies that there were no zero recorded neutron doses for the PIID* years that include PIID* through PIID*, PIID* through PIID*, and PIID*. SC&A's review of monthly external monitoring records reveal zero neutron dose readings for nearly all years of claimant's employment. Table 8 summarizes the number of yearly zero neutron readings and derives estimates of missed neutron exposures. Based on monthly zero neutron readings, SC&A estimates a missed neutron dose 18.1 rem. This is more than 15 rem greater than the assigned dose of 3.0 rem by NIOSH.

Table 8. Missed Neutron Doses Estimated by SC&A

Before PIID*	**No. of Zero η Reading**	**$MDL_{Film}/2$**	**Neutron/Photon Ratio**	**Neutron Correction Factor**	**η Dose (rem)**
PIID*	12	40	2.47	1.91	2.264
PIID*	12	40	2.47	1.91	2.264
PIID*	12	40	2.47	1.91	2.264
After PIID*	**No. of Zero η Readings**	**$MDL_{TLD}/2$**	**Neutron/Photon Ratio**	**Neutron Correction Factor**	**η Dose (rem)**
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	10	25		1.91	0.477
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	11	25		1.91	0.525
PIID*	10	25		1.91	0.477
PIID*	6	25		1.91	0.286
PIID*	12	25		1.91	0.477
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
PIID*	10	25		1.91	0.477
PIID*	12	25		1.91	0.573
PIID*	12	25		1.91	0.573
			Total Missed Neutron Dose:		18.106

2.5 OCCUPATIONAL MEDICAL EXPOSURES

Estimates of occupational medical exposures for this claimant are cited in entries #200 through #227 of Appendix A. NIOSH assumed a yearly 14” x 17” PA chest x-ray for the years PIID* through PIID* and a single 4” x 5” chest photofluorographic examination in PIID* for a combined colon dose of 471 mrem (0.471 rem). The colon dose for individual 14” x 17” chest x-ray examinations varied from 13 mrem to 5 mrem; an organ dose of 260 mrem was assigned for the chest photofluoroscopic examination.

Table 2 of Attachment E of ORAUT-PROC-0006 contains organ doses for PA chest x-ray exams by year. Organs are categorized into three groups and doses cited in Table 2 are considered “high.” Nevertheless, for further maximizing organ doses, the dose reconstructor may multiply the given organ dose by a factor of 1.3 and enter this dose as a constant. For example, Table 2 identifies a colon dose of 10 mrem for PIID*, which when multiplied by 1.3 yields a point dose value of 13 mrem and concurs with entry #200.

For occupational medical exposure, the assigned dose of 471 mrem is scientifically valid, procedurally compliant, and claimant favorable.

2.5.1 Issue of Concern No. 1: Improper Reference Cited in the Dose Reconstruction Report

Under the heading of Occupational Medical Exposure on page 6 of the DR Report, the following statement appears: "Based on information in Attachment E of the External Dose Reconstruction procedure[6] . . . a total X-ray dose of 0.471 rem was assigned."

The cited Reference 6 in the DR Report identifies ORAUT-PROC-0006, External Dose Reconstruction, Rev. 00, June 27, 2003. Rev. 00, June 27, 2003 does **not** contain the cited "Attachment E." Attachment E was not added to ORAUT-PROC-0006 until November 2003, along with a subsequent revision in December. Reference #6 in the DR Report should, therefore, have identified ORAUT-PROC-0006 with an effective date of December 11, 2003, and a Revision No. 00 PC-2.

2.6 ONSITE AMBIENT DOSE

Although it is acknowledged that this claimant was routinely monitored for external radiation exposure, onsite ambient doses were nevertheless assessed, in order to account for any inadvertent subtraction of elevated ambient doses registered in "control badges." For the total employment period, NIOSH derived a time-integrated dose of 2.272 rem, with annual doses given in entries #173 through #199 of Appendix A.

For this calculation, NIOSH assumed a 50-hour workweek and selected the highest average external onsite radiation level at Hanford for each year, regardless of the actual work location of the energy employee. Maximum annual onsite doses for Hanford were taken from Table 4.3.1-1 of ORAUT-TKBS-0006-4.

SC&A verified the derived onsite ambient dose of 2.272 rem and concludes that the inclusion of an onsite dose and the methodology employed is procedurally correct and claimant favorable.

3.0 AUDIT OF INTERNAL DOSES

Internal dose monitoring records submitted by the DOE included both in vivo and in vitro bioassays. In vivo monitoring consisted of whole-body counting (WBC) for gamma emitting fission products and chest counting (CH) for Am-241, Th-234, and U-235. In vitro bioassays consisted of analysis of urine samples for uranium and Pu-238/-239 representing 12- or 24-hour collection periods. Table 9 summarizes the type of bioassay provided and the dates. Whole-body and chest counting were performed on a yearly basis for 17 out of the 27 years, with most of the unmonitored years occurring during the early years of employment. Similarly, routine urinalyses for Pu-238/-239 were performed on an annual basis, with 5 unmonitored years occurring before 1975.

Table 9. Summary of Bioassays Performed on Case PIID*

Year	In vivo WBC (date)	Chest (date)	Urinalysis	
			Uranium	Pu-238/-239
PIID*	PIID*	PIID*	—	—
PIID*	PIID*	PIID*	PIID*; PIID*	PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*				PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*				PIID*
PIID*	PIID*	PIID*		PIID*
PIID*	PIID*	PIID*		PIID*
PIID*				
PIID*	PIID*	PIID*		PIID*
PIID*				PIID*
PIID*	—	—		—
PIID*	—	—		—
PIID*	—	—	See footnote [1]	PIID*
PIID*	—	—	See footnote [2]	—
PIID*	—	—	PIID*[3]	—
PIID*	—	—		—

[1] In PIID*, Claimant was tested a total of 12 times; uranium concentration varied between 1.4E+00 to 5.12E+00; however, the unit is not defined.

[2] In PIID*, Claimant was tested a total of six times; uranium concentration varied between 1.15E+00 to 1.46E-01; however the unit is not defined.

[3] The unit for defining urine concentration is not defined.

For all whole-body counts, there were no radionuclides with significant body concentrations. For urinalysis, all data were below detection limits except for uranium levels found in urine for the years PIID* and PIID*. However, the DOE summary records do not identify the unit of concentration (e.g., nCi/l, µg/24-hr volume) for these results. For Pu-238/-239, the detection limit ranged between 0.02 and 0.05 dpm per sample.

3.1 NIOSH'S APPROACH FOR ESTIMATING POTENTIAL INTERNAL DOSE

Due to the long time intervals between annual in vivo and in vitro bioassays, missed years of internal monitoring, and uncertainty regarding the interpretation of historical uranium urinalysis data, there is a potential for undetected and/or unaccounted internal doses.

To account for such doses, NIOSH elected to assign an internal dose based on a hypothetical intake, as defined in procedure ORAUT-OTIB-0002, "Maximum Internal Dose Estimates for Certain DOE Complex Claims, Rev. 01," January 28, 2004. For DOE facilities with reactors, the procedure specifies a single acute inhalation of 28 radionuclides with specific activity levels. To maximize the time-integrated organ dose, the procedure further specifies that this "event" is assumed to take place on the first day of employment. Entries #36 through #164 of Appendix A identify annual doses to the colon based on radiation type.

SC&A independently verified the dose calculation by means of the Excel® Workbook, as specified in ORAUT-OTIB-0002 and verified the DR Report's organ dose of 16.986 rem. Based on available bioassay data and their limitations, the use of the hypothetical intake model is justified and is likely to be claimant favorable.

4.0 CATI REPORT AND RADIOLOGICAL INCIDENTS

Review of the CATI report showed one inconsistency with data presented in the dose reconstruction report. The DR Report identifies PIID*, as the energy employee's termination date, while the CATI report cites PIID*.

DOE's bioassay records, however, show a termination urinalysis (uranium) for PIID*, and termination whole-body and chest counts for PIID*. Based on termination bioassay dates, it is, therefore, concluded that the energy employee terminated employment on PIID*, as cited in the DR Report.

The CATI report indicates that the energy employee was restricted from the workplace or certain job duties because the employee had reached/exceeded a radiation dose limit. DOE records further show the following:

- In PIID*, the employee was placed on radiation work restriction due to lost finger ring dosimeter(s). The employee was reinstated as of PIID*.
- In PIID*, an unexpectedly high extremity dose of 4,740 was recorded. Following an investigation of the ring dosimeter, the extremity dose was reduced to 1,730 mrem. This, however, was still above the 900 mrem exposure control guide.
- In PIID*, an extremity exposure of 2,110 mrem was recorded, which exceeded the 900 mrem administrative exposure control guide.

These events/exposures are unlikely to have contributed to the organ dose of interest in this case and were, therefore, not factored into the dose reconstruction.

The CATI report also makes reference to a radiological incident involving skin contamination and torn gloves while handling plutonium. Regarding this event, the DR Report states the following:

> *The DOE files contain one "skin and clothing decontamination" record indicating that [the claimant's] right palm became contaminated as a result of a torn glove. The records show that his hand was successfully decontaminated. The monitoring records analyzed in this dose reconstruction, together with the claimant-favorable assumptions applied, would have accounted for any dose received from these types of exposures.*

SC&A's review of DOE files confirms one contamination event that was the result of a torn glove and resulted in the contamination of the employee's right hand. Enclosed as Exhibit 4 is a copy of DOE's record for this radiological incident. Because of the poor quality of this photocopy, comments that describe this event have been transcribed below:

> *PIID* worked in the PIID* to PIID* at ~1100 hrs.*
> ***~1115 hrs**. During survey of the PIID* (?) and PIID* in preparation of the tour – PIID* were found contaminated – the ones the PIID* had used right before the survey. The PIID* [i.e., claimant] had been using PIID* and when he took them off, he turned them inside out. He **re-used** the same PIID* when he resumed work **after lunch**. PIID* found he was contaminated when he couldn't get through Hand and Foot counter located near the change rooms.*
> [Emphasis added.]

4.1 ISSUE OF CONCERNS PERTAINING TO CONTAMINATION EVENT

Inspection of Exhibit 4 reveals the following:

- Exhibit 4 has a heavy smudge mark that conceals the date of this contamination event.

- Exhibit 4 also identifies alpha contamination levels for five locations, which include the hand. The "direct alpha measurement" of 1,750 is given for the hand. However, the measurement unit cannot be deciphered and it is not possible to determine if the unit is expressed in cpm, cps, dpm, or dps.

- Comments contained in Exhibit 4 (as reproduced above) provide no clear indication of the timeline or sequence of events that include (1) the tearing of glove, (2) contamination of hand, (3) lunch, and (4) resumption of work after lunch.

- Comments contained in Exhibit 4 do not mention a prompt and successful decontamination, as stated in the DR Report.

In summary, the DR Report statement that ". . . The records show that his hand was successfully decontaminated. The monitoring records analyzed in this dose reconstruction . . . accounted for any dose received from these types of exposures . . ." is, however, unsubstantiated for the following reason: Table 9 identifies the dates for all Pu-238/-239 urinalysis. Table 9 shows only one annual routine urinalysis. Although the data of this contamination event could not be determined, it would appear highly improbable if it coincided in time with one of the annual routine urinalysis. It is, therefore, reasonable to conclude that there was no follow-up urinalysis done as a result of this contamination event that had a high potential for internal contamination.

Although there appears to have been no follow-up bioassay performed that would assess potential internal exposure from the contamination event, SC&A does acknowledge the fact that a **hypothetical** internal dose was assigned. It is also reasonable to conclude that the assigned hypothetical dose is greater than the potential internal dose that may have resulted from the documented contamination event.

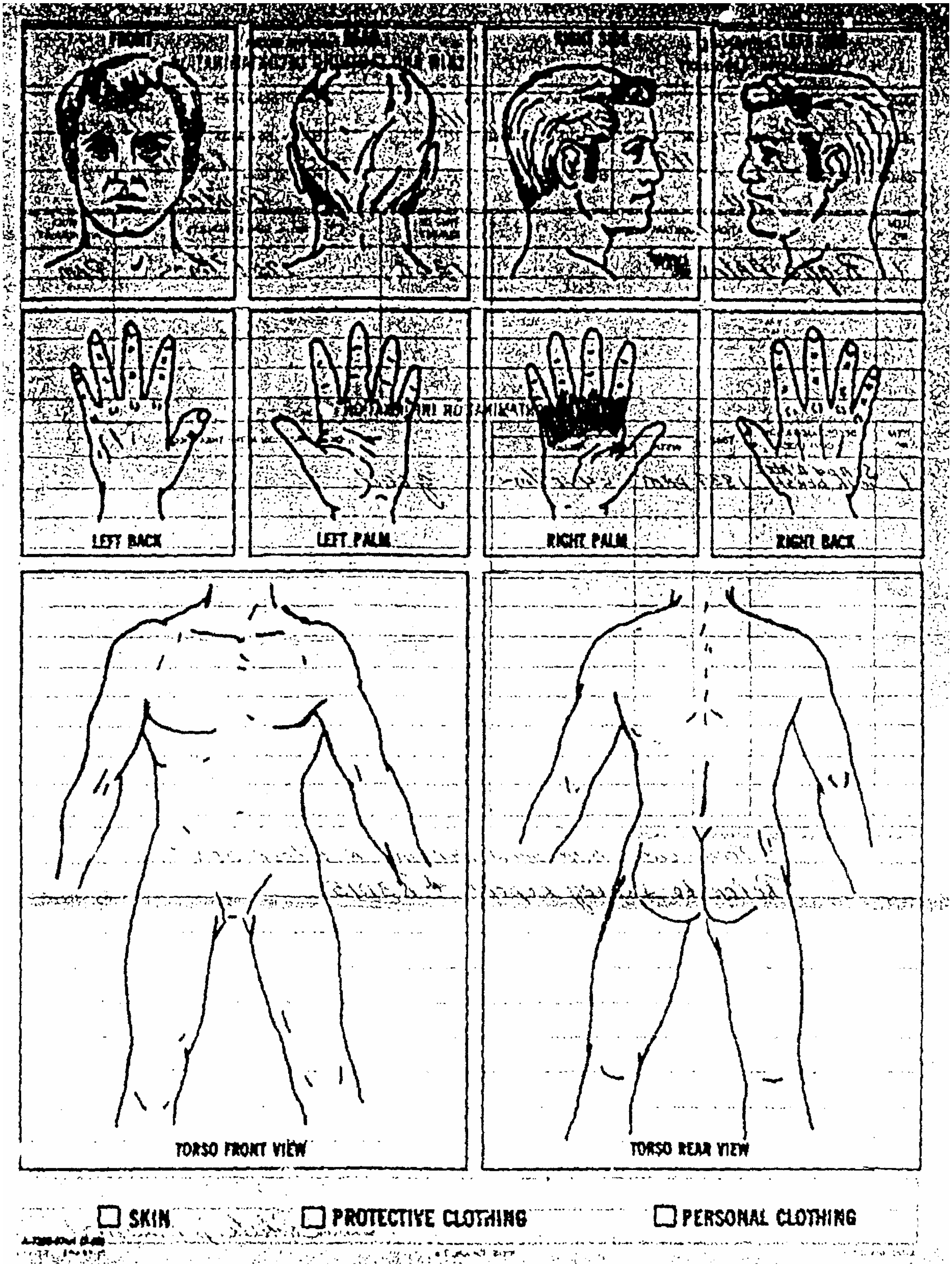
T

Exhibit 4

Deletion made to exhibit – please see hard copy labeled '#6- Hanford'

T

Exhibit 4 (Continued)



5.0 SUMMARY CONCLUSIONS

5.1 POTENTIAL DEFICIENCIES

SC&A's audit of the dose reconstruction for this case reveals that a substantial number of technical errors may have been made that could significantly change the organ dose and the associated probability of causation of cancer.

In the event that the issues of concern raised in this audit are validated, this may suggest one or more of the following:

- The dose reconstructor for this case is insufficiently familiar with the procedures needed to complete a dose reconstruction.

- Procedures used for dose reconstruction are too numerous, too fragmented in format, and in some areas, difficult to interpret. (Note: This comment reflects the opinion of this reviewer, who, under Task 3 of SC&A's contract with NIOSH, has thoroughly reviewed all procedures used for dose reconstruction.)

- NIOSH's review process for completed dose reconstructions is inadequate.

5.2 DOSE RECONTRUCTION REPORT CONTENT AND FORMAT

In its current form, the NIOSH Dose Reconstruction (DR) Report only provides brief summary explanations and dose data. For several categories of doses, the DR Report under review herein limits explanation/information regarding a derived dose estimate to a broad reference involving an entire Site Profile. The failure to explain how individual categories of internal/external exposures were derived and the absence of a well-defined paper trail for specific dose estimates poses severe limitations on NIOSH's internal QA review process. Similarly, these shortcomings force SC&A auditors to engage in time-consuming speculations regarding the choice of procedures, methodology, and parameters selected by the dose reconstructor for deriving dose estimates.

REFERENCES

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

ORAUT-PROC-0006. 2003. "External Dose Reconstruction," Rev. 00. Oak Ridge Associated Universities Team. Cincinnati, Ohio.

ORAUT-OTIB-0002. 2004. "Technical Basis Document – Maximum Internal Dose Estimates for Certain DOE Complex Claims," Rev. 01. Oak Ridge Associated Universities Team. Cincinnati, Ohio.

ORAUT-OTIB-0006. 2003. "Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures," Rev. 02. Oak Ridge Associated Universities Team. Cincinnati, Ohio.

ORAUT-TKBS-0006-3. 2004. "Technical Basis Document for the Hanford Site – Occupational Medical Exposure," Rev. 01. Oak Ridge Associated Universities Team. Cincinnati, Ohio.

ORAUT-TKBS-0006-4. 2004. "Technical Basis Document for the Hanford Site – Occupational Environmental Dose," Rev. 01. Oak Ridge Associated Universities Team. Cincinnati, Ohio.

ORAUT-TKBS-0006-6. 2004. "Technical Basis Document for the Hanford Site – Occupational External Dosimetry," Rev. 01. Oak Ridge Associated Universities Team. Cincinnati, Ohio.

APPENDIX A: IREP INPUT

CLAIMANT CANCER DIAGNOSIS						
	Primary Cancer #1	Primary Cancer #2	Primary Cancer #3	Secondary Cancer #1	Secondary Cancer #2	Secondary Cancer #3
Cancer Type	colon (153.1)	N/A	N/A	N/A	N/A	N/A
Date of Diagnosis	PIID*	N/A	N/A	N/A	N/A	N/A

EXPOSURE INFORMATION							
Number of exposures							
227							
Exposure #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
1	PIID*	acute	photons E=30-250keV	Constant	0.080	0.000	0.000
2	PIID*	acute	photons E=30-250keV	Constant	0.100	0.000	0.000
3	PIID*	acute	photons E=30-250keV	Constant	0.110	0.000	0.000
4	PIID*	acute	photons E=30-250keV	Constant	0.180	0.000	0.000
5	PIID*	acute	photons E=30-250keV	Constant	0.020	0.000	0.000
6	PIID*	acute	photons E=30-250keV	Constant	0.460	0.000	0.000
7	PIID*	acute	photons E=30-250keV	Constant	0.400	0.000	0.000
8	PIID*	acute	photons E=30-250keV	Constant	0.780	0.000	0.000
9	PIID*	acute	photons E=30-250keV	Constant	0.750	0.000	0.000
10	PIID*	acute	photons E=30-250keV	Constant	0.490	0.000	0.000
11	PIID*	acute	photons E=30-250keV	Constant	0.790	0.000	0.000
12	PIID*	acute	photons E=30-250keV	Constant	0.370	0.000	0.000
13	PIID*	acute	photons E=30-250keV	Constant	0.100	0.000	0.000
14	PIID*	acute	photons E=30-250keV	Constant	0.540	0.000	0.000
15	PIID*	acute	photons E=30-250keV	Constant	0.670	0.000	0.000
16	PIID*	acute	photons E=30-250keV	Constant	0.200	0.000	0.000
17	PIID*	acute	photons E=30-250keV	Constant	0.060	0.000	0.000
18	PIID*	acute	photons E=30-250keV	Constant	0.110	0.000	0.000
19	PIID*	acute	photons E=30-250keV	Constant	0.240	0.000	0.000
20	PIID*	acute	photons E=30-250keV	Constant	0.170	0.000	0.000
21	PIID*	acute	photons E=30-250keV	Constant	0.090	0.000	0.000
22	PIID*	acute	photons E=30-250keV	Constant	0.030	0.000	0.000
23	PIID*	acute	photons E=30-250keV	Constant	0.010	0.000	0.000
24	PIID*	acute	photons E=30-250keV	Constant	0.051	0.000	0.000
25	PIID*	acute	photons E=30-250keV	Constant	0.080	0.000	0.000
26	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.377	0.000	0.000
27	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.472	0.000	0.000
28	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.519	0.000	0.000
29	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.849	0.000	0.000
30	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.094	0.000	0.000
31	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.206	0.000	0.000
32	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.019	0.000	0.000
33	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.038	0.000	0.000

34	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.229	0.000	0.000
35	PIID*	chronic	neutrons E=100keV-2MeV	Constant	0.076	0.000	0.000
36	PIID*	chronic	alpha	Constant	0.769	0.000	0.000
37	PIID*	chronic	alpha	Constant	0.265	0.000	0.000
38	PIID*	chronic	alpha	Constant	0.259	0.000	0.000
39	PIID*	chronic	alpha	Constant	0.253	0.000	0.000
40	PIID*	chronic	alpha	Constant	0.249	0.000	0.000
41	PIID*	chronic	alpha	Constant	0.245	0.000	0.000
42	PIID*	chronic	alpha	Constant	0.243	0.000	0.000
43	PIID*	chronic	alpha	Constant	0.240	0.000	0.000
44	PIID*	chronic	alpha	Constant	0.238	0.000	0.000
45	PIID*	chronic	alpha	Constant	0.237	0.000	0.000
46	PIID*	chronic	alpha	Constant	0.236	0.000	0.000
47	PIID*	chronic	alpha	Constant	0.233	0.000	0.000
48	PIID*	chronic	alpha	Constant	0.232	0.000	0.000
49	PIID*	chronic	alpha	Constant	0.231	0.000	0.000
50	PIID*	chronic	alpha	Constant	0.230	0.000	0.000
51	PIID*	chronic	alpha	Constant	0.228	0.000	0.000
52	PIID*	chronic	alpha	Constant	0.227	0.000	0.000
53	PIID*	chronic	alpha	Constant	0.226	0.000	0.000
54	PIID*	chronic	alpha	Constant	0.225	0.000	0.000
55	PIID*	chronic	alpha	Constant	0.224	0.000	0.000
56	PIID*	chronic	alpha	Constant	0.222	0.000	0.000
57	PIID*	chronic	alpha	Constant	0.221	0.000	0.000
58	PIID*	chronic	alpha	Constant	0.220	0.000	0.000
59	PIID*	chronic	alpha	Constant	0.218	0.000	0.000
60	PIID*	chronic	alpha	Constant	0.217	0.000	0.000
61	PIID*	chronic	alpha	Constant	0.216	0.000	0.000
62	PIID*	chronic	alpha	Constant	0.215	0.000	0.000
63	PIID*	chronic	alpha	Constant	0.214	0.000	0.000
64	PIID*	chronic	alpha	Constant	0.212	0.000	0.000
65	PIID*	chronic	alpha	Constant	0.211	0.000	0.000
66	PIID*	chronic	alpha	Constant	0.211	0.000	0.000
67	PIID*	chronic	alpha	Constant	0.209	0.000	0.000
68	PIID*	chronic	alpha	Constant	0.208	0.000	0.000
69	PIID*	chronic	alpha	Constant	0.206	0.000	0.000
70	PIID*	chronic	alpha	Constant	0.206	0.000	0.000
71	PIID*	chronic	alpha	Constant	0.204	0.000	0.000
72	PIID*	chronic	alpha	Constant	0.203	0.000	0.000
73	PIID*	chronic	alpha	Constant	0.202	0.000	0.000
74	PIID*	chronic	alpha	Constant	0.201	0.000	0.000
75	PIID*	chronic	alpha	Constant	0.200	0.000	0.000
76	PIID*	chronic	alpha	Constant	0.199	0.000	0.000
77	PIID*	chronic	alpha	Constant	0.198	0.000	0.000
78	PIID*	chronic	alpha	Constant	0.197	0.000	0.000
79	PIID*	chronic	photons E>250keV	Constant	1.519	0.000	0.000
80	PIID*	chronic	photons E>250keV	Constant	0.152	0.000	0.000
81	PIID*	chronic	photons E>250keV	Constant	0.042	0.000	0.000
82	PIID*	chronic	photons E>250keV	Constant	0.016	0.000	0.000

83	PIID*	chronic	photons E>250keV	Constant	0.008	0.000	0.000
84	PIID*	chronic	photons E>250keV	Constant	0.005	0.000	0.000
85	PIID*	chronic	photons E>250keV	Constant	0.003	0.000	0.000
86	PIID*	chronic	photons E>250keV	Constant	0.002	0.000	0.000
87	PIID*	chronic	photons E>250keV	Constant	0.002	0.000	0.000
88	PIID*	chronic	photons E>250keV	Constant	0.001	0.000	0.000
89	PIID*	chronic	photons E>250keV	Constant	0.001	0.000	0.000
90	PIID*	chronic	photons E>250keV	Constant	0.001	0.000	0.000
91	PIID*	chronic	photons E>250keV	Constant	0.001	0.000	0.000
92	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
93	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
94	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
95	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
96	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
97	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
98	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
99	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
100	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
101	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
102	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
103	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
104	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
105	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
106	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
107	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
108	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
109	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
110	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
111	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
112	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
113	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
114	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
115	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
116	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
117	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
118	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
119	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
120	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
121	PIID*	chronic	photons E>250keV	Constant	0.000	0.000	0.000
122	PIID*	chronic	electrons E>15keV	Constant	4.458	0.000	0.000
123	PIID*	chronic	electrons E>15keV	Constant	0.193	0.000	0.000
124	PIID*	chronic	electrons E>15keV	Constant	0.091	0.000	0.000
125	PIID*	chronic	electrons E>15keV	Constant	0.065	0.000	0.000
126	PIID*	chronic	electrons E>15keV	Constant	0.052	0.000	0.000
127	PIID*	chronic	electrons E>15keV	Constant	0.043	0.000	0.000
128	PIID*	chronic	electrons E>15keV	Constant	0.036	0.000	0.000
129	PIID*	chronic	electrons E>15keV	Constant	0.030	0.000	0.000
130	PIID*	chronic	electrons E>15keV	Constant	0.025	0.000	0.000
131	PIID*	chronic	electrons E>15keV	Constant	0.021	0.000	0.000
132		chronic	electrons E>15keV	Constant	0.018	0.000	0.000

133	PIID*	chronic	electrons E>15keV	Constant	0.015	0.000	0.000
134	PIID*	chronic	electrons E>15keV	Constant	0.013	0.000	0.000
135	PIID*	chronic	electrons E>15keV	Constant	0.011	0.000	0.000
136	PIID*	chronic	electrons E>15keV	Constant	0.009	0.000	0.000
137	PIID*	chronic	electrons E>15keV	Constant	0.008	0.000	0.000
138	PIID*	chronic	electrons E>15keV	Constant	0.007	0.000	0.000
139	PIID*	chronic	electrons E>15keV	Constant	0.006	0.000	0.000
140	PIID*	chronic	electrons E>15keV	Constant	0.005	0.000	0.000
141	PIID*	chronic	electrons E>15keV	Constant	0.004	0.000	0.000
142	PIID*	chronic	electrons E>15keV	Constant	0.003	0.000	0.000
143	PIID*	chronic	electrons E>15keV	Constant	0.003	0.000	0.000
144	PIID*	chronic	electrons E>15keV	Constant	0.002	0.000	0.000
145	PIID*	chronic	electrons E>15keV	Constant	0.002	0.000	0.000
146	PIID*	chronic	electrons E>15keV	Constant	0.002	0.000	0.000
147	PIID*	chronic	electrons E>15keV	Constant	0.002	0.000	0.000
148	PIID*	chronic	electrons E>15keV	Constant	0.001	0.000	0.000
149	PIID*	chronic	electrons E>15keV	Constant	0.001	0.000	0.000
150	PIID*	chronic	electrons E>15keV	Constant	0.001	0.000	0.000
151	PIID*	chronic	electrons E>15keV	Constant	0.001	0.000	0.000
152	PIID*	chronic	electrons E>15keV	Constant	0.001	0.000	0.000
153	PIID*	chronic	electrons E>15keV	Constant	0.001	0.000	0.000
154	PIID*	chronic	electrons E>15keV	Constant	0.001	0.000	0.000
155	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
156	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
157	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
158	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
159	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
160	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
161	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
162	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
163	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
164	PIID*	chronic	electrons E>15keV	Constant	0.000	0.000	0.000
165	PIID*	acute	photons E=30-250keV	Lognormal	0.220	1.520	0.000
166	PIID*	acute	photons E=30-250keV	Lognormal	0.180	1.520	0.000
167	PIID*	acute	photons E=30-250keV	Lognormal	0.220	1.520	0.000
168	PIID*	acute	photons E=30-250keV	Lognormal	0.060	1.520	0.000
169	PIID*	chronic	neutrons E=100keV-2MeV	Lognormal	1.038	1.520	0.000
170	PIID*	chronic	neutrons E=100keV-2MeV	Lognormal	0.849	1.520	0.000
171	PIID*	chronic	neutrons E=100keV-2MeV	Lognormal	0.955	1.520	0.000
172	PIID*	chronic	neutrons E=100keV-2MeV	Lognormal	0.191	1.520	0.000
173	PIID*	chronic	photons E=30-250keV	Constant	0.350	0.000	0.000
174	PIID*	chronic	photons E=30-250keV	Constant	0.415	0.000	0.000
175	PIID*	chronic	photons E=30-250keV	Constant	0.225	0.000	0.000
176	PIID*	chronic	photons E=30-250keV	Constant	0.186	0.000	0.000
177	PIID*	chronic	photons E=30-250keV	Constant	0.186	0.000	0.000
178	PIID*	chronic	photons E=30-250keV	Constant	0.043	0.000	0.000
179	PIID*	chronic	photons E=30-250keV	Constant	0.040	0.000	0.000
180	PIID*	chronic	photons E=30-250keV	Constant	0.035	0.000	0.000

181	PIID*	chronic	photons E=30-250keV	Constant	0.035	0.000	0.000
182	PIID*	chronic	photons E=30-250keV	Constant	0.029	0.000	0.000
183	PIID*	chronic	photons E=30-250keV	Constant	0.029	0.000	0.000
184	PIID*	chronic	photons E=30-250keV	Constant	0.029	0.000	0.000
185	PIID*	chronic	photons E=30-250keV	Constant	0.038	0.000	0.000
186	PIID*	chronic	photons E=30-250keV	Constant	0.157	0.000	0.000
187	PIID*	chronic	photons E=30-250keV	Constant	0.127	0.000	0.000
188	PIID*	chronic	photons E=30-250keV	Constant	0.027	0.000	0.000
189	PIID*	chronic	photons E=30-250keV	Constant	0.025	0.000	0.000
190	PIID*	chronic	photons E=30-250keV	Constant	0.027	0.000	0.000
191	PIID*	chronic	photons E=30-250keV	Constant	0.027	0.000	0.000
192	PIID*	chronic	photons E=30-250keV	Constant	0.027	0.000	0.000
193	PIID*	chronic	photons E=30-250keV	Constant	0.030	0.000	0.000
194	PIID*	chronic	photons E=30-250keV	Constant	0.027	0.000	0.000
195	PIID*	chronic	photons E=30-250keV	Constant	0.035	0.000	0.000
196	PIID*	chronic	photons E=30-250keV	Constant	0.031	0.000	0.000
197	PIID*	chronic	photons E=30-250keV	Constant	0.030	0.000	0.000
198	PIID*	chronic	photons E=30-250keV	Constant	0.036	0.000	0.000
199	PIID*	chronic	photons E=30-250keV	Constant	0.026	0.000	0.000
200	PIID*	acute	photons E=30-250keV	Constant	0.013	0.000	0.000
201	PIID*	acute	photons E=30-250keV	Constant	0.013	0.000	0.000
202	PIID*	acute	photons E=30-250keV	Constant	0.013	0.000	0.000
203	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
204	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
205	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
206	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
207	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
208	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
209	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
210	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
211	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
212	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
213	PIID*	acute	photons E=30-250keV	Constant	0.007	0.000	0.000
214	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
215	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
216	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
217	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
218	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
219	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
220	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
221	PIID*	acute	photons E=30-250keV	Constant	0.009	0.000	0.000
222	PIID*	acute	photons E=30-250keV	Constant	0.005	0.000	0.000
223	PIID*	acute	photons E=30-250keV	Constant	0.005	0.000	0.000
224	PIID*	acute	photons E=30-250keV	Constant	0.005	0.000	0.000
225	PIID*	acute	photons E=30-250keV	Constant	0.005	0.000	0.000
226	PIID*	acute	photons E=30-250keV	Constant	0.005	0.000	0.000
227	PIID*	acute	photons E=30-250keV	Constant	0.260	0.000	0.000