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DCAS-PER-038, SUBTASK 4

REVIEW OF THREE ADVISORY BOARD-SELECTED CASES REASSESSED FOR THE EVALUATION OF HOOKER ELECTROCHEMICAL COMPANY TBD REVISIONS

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S. Cohen & Associates: ***Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. DCAS-PER-038, Subtask 4 Review Effective Date: Draft – October 16, 2014
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Task Manager: _____ Date: _____ U. Hans Behling, PhD	Supersedes: N/A
Project Manager: _____ Date: _____ John Stiver, MS, CHP	Reviewer: John Stiver

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	10/16/2014	Initial issue.

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ABBREVIATIONS AND ACRONYMS

Advisory Board	Advisory Board on Radiation and Worker Health
AP	anterior/posterior
CATI	Computer-Assisted Telephone Interview
DCAS	Division of Compensation and Analysis Support
DCF	dose conversion factor
DOL	(U.S.) Department of Labor
dpm/day	disintegrations per minute per day
DR	dose reconstruction
EE	Energy Employee
HCl	hydrochloric acid
IMBA	Integrated Modules for Bioassay Analysis
IREP	Interactive RadioEpidemiological Program
keV	kilo electron volt, 1,000 electronvolts
LLI	lower large intestine
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
ORAUT	Oak Ridge Associated Universities Team
PA	posterior/anterior
PER	Program Evaluation Report
POC	Probability of Causation
PRSC	Procedures Review Subcommittee
rem	Roentgen equivalent man
SC&A	S. Cohen and Associates (SC&A, Inc.)
TBD	technical basis document
TIB	technical information bulletin
ULI	upper large intestine
/y or /yr	per year

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1.0 RELEVANT BACKGROUND INFORMATION

S. Cohen and Associates (SC&A) was tasked by the Advisory Board to conduct a review of DCAS-PER-038, *Hooker Electrochemical TBD Revisions* (DCAS 2012). DCAS-PER-038 was issued to determine the number of claims impacted as a result of several revisions to the Hooker Technical Basis Document (TBD). A history of NIOSH reports that have been prepared in behalf of the Hooker Electrochemical facility is presented below:

- *Site Profiles for Atomic Weapons Employers that Refined Uranium and Thorium – Appendix AA Hooker Electrochemical Company.* Battelle-TBD-6001, Appendix AA. June 15, 2007 (Battelle 2007).
- *Technical Basis Document for the Hooker Electrochemical Company*, Rev. 0. DCAS-TKBS-0009. April 4, 2011 (DCAS 2011a).
- *Technical Basis Document for Hooker Electrochemical Company*, Rev. 1. DCAS-TKBS-0009. June 17, 2011 (DCAS 2011b).

Hooker Electrochemical Company manufactured fluorinated and chlorinated organic chemicals beginning in 1943. One of the byproducts associated with this process was hydrochloric acid (HCl), which could be used to process uranium-bearing slag as a precursor of uranium recovery. The processing of uranium-contaminated slag began on July 11, 1944, and ended on January 15, 1946 (operational period). A period of residual radioactivity exposure is also assumed from January 16, 1946, to October 11, 1976.

On May 20, 2013, SC&A submitted to the Procedures Review Subcommittee (PRSC) our review of NIOSH's program evaluation report (PER), DCAS-PER-038 (SC&A 2013). In conducting a PER review, SC&A is committed to perform five subtasks, as specified below:

Subtask 1: Assess NIOSH's evaluation/characterization of the "issue" and its potential impacts on dose reconstruction (DR). Our assessment intends to ensure that the "issue" was fully understood and characterized in the PER.

Subtask 2: Assess NIOSH's specific methods for corrective action. In instances where the PER involves a technical issue that is supported by document(s) [e.g., white papers, technical information bulletins (TIBs), procedures] that have not yet been subjected to a formal SC&A review, Subtask 2 will include a review of the scientific basis and/or sources of information to ensure the credibility of the corrective action and its consistency with current/consensus science. Conversely, if such technical documentation has been formalized and previously subjected to a review by SC&A, Subtask 2 will simply provide a brief summary/conclusion of this review process.

Subtask 3: Evaluate the PER's stated approach for identifying the universe of potentially affected DRs, and assess the criteria by which a subset of potentially affected DRs was selected for re-evaluation. The second step may have important implications in instances where the universe of previously denied DRs is very large and, for reasons of practicality, NIOSH's re-evaluation is confined to a subset of DRs that, based on their scientific

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judgment, have the potential to be significantly affected by the PER. In behalf of Subtask 3, SC&A will also evaluate the timeliness for the completion of the PER.

Subtask 4: Conduct audits of DRs affected by the PER under review. The number of DRs selected for audit for a given PER will vary. (It is assumed that the selection of the DRs and the total number of DR audits per PER will be made by the Advisory Board.)

Subtask 5: Prepare a written report that contains the results of DR audits under Subtask 4, along with our review conclusions.

SC&A's review of DCAS-PER-038 identified no findings. Specifically, our review found that (1) NIOSH's selection criteria in the PER properly identified the population of claims requiring re-examination, and (2) SC&A agrees with the NIOSH corrective action approach taken in the PER.

This report fulfills the requirement defined in Subtask 4, "Conduct audits of DRs affected by the PER under review." Under Section 2.0 of DCAS-PER-038, NIOSH indicated that although Revision 01 of DCAS-TKBS-0009 (DCAS 2011b) did not introduce any increase in radiation doses, there were some increases in both external and internal exposures in Revision 00 (DCAS 2011a) as compared to Appendix AA, Hooker Site Profile, of Battelle-TBD-6001 (Battelle 2007). Therefore, this PER compares Appendix AA to Revision 1 of the TBD and identified that increased dose assignments include the following:

- Uranium intakes during the operational years (1944–1946) for all workers other than Operators (label Plant Floor High in Appendix AA)
- Shallow dose rate during the residual period (1946–1976) for all job categories

Section 3.0 of DCAS-PER-038 developed two sets of criteria to screen claims that had been reviewed prior to the publication of DCAS-TKBS-0009, Revision 00. These criteria included:

Criteria #1:

- < 50% POC
- DR approved by DCAS on or prior to April 4, 2011 (issue date of Revision 00 of TBD)
- Employment at Hooker between 1946 and 1976 (residual period)
- Diagnosed with skin cancer (only shallow dose increased)

Criteria #2:

- < 50% POC
- DR approved by DCAS on or prior to April 4, 2011 (issue date of Revision 00 of TBD)
- Employment at Hooker between July 11, 1944, and January 15, 1946 (operational period)

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These case selection criteria resulted in the identification of the following:

- 53 claims met screening criteria requiring further review
- 33 of these claims were eliminated due to assignment of "Plant Floor High" intake rate, which was slightly lower in Revision 01 of the TBD
- Probability of Causation (POC) recalculated for 20 claims
- POCs for all recalculated claims below 50%

During the meeting of the PRSC held on February 13, 2014, SC&A was authorized to review three DRs as part of our review of DCAS-PER-038. It was determined that SC&A's review should be limited to evaluating only those methods and corrective actions introduced in the re-evaluated doses that relate strictly to issues addressed in DCAS-PER-038.

It should also be noted that, for all the cases impacted by revisions to the Hooker TBD, NIOSH simply performed an internal evaluation of the cases (which was documented in a one-page MS Word file) and determined that none of the original DRs would result in a POC of equal to or greater than 50%. Therefore, no formal DR reworks were performed and no revised DRs were submitted to the Department of Labor (DOL). This information was relayed to the PRSC and our Project Officer (also the Designated Federal Official); and it was decided that SC&A would perform a re-analysis of impacted doses for the three DRs, calculate a POC based on these revised doses, and compare our results to NIOSH's internal evaluation.

Presented in Sections 2.0 through 4.0 below is SC&A's focused review to determine whether the applicable external doses and the internal doses associated with the three selected cases were re-evaluated by NIOSH in accordance with DCAS-PER-038.

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2.0 REVIEW OF DCAS-PER-038 ISSUES FOR CASE #[REDACTED]

2.1 BACKGROUND INFORMATION FOR CASE #[REDACTED]

Case #[redacted] represents an energy employee (EE) who worked at Hooker Electrochemical (Hooker) from [redacted], through [redacted]. Therefore, the EE was employed during the operations period (i.e., 1944–1946) and for a portion of the residual period. According to the DOL records, the EE's job position was "unknown." However, the Computer Assisted Telephone Interview (CATI) indicated that the EE worked as a [redacted] while employed at Hooker, and the EE's primary work location was the main #[redacted]. There are no records that indicate the EE was monitored for external or internal radiation exposure. The EE was diagnosed with a lung cancer/undifferentiated carcinoma (ICD-9 Code 162.9) in April 1979.

In November 2008, NIOSH performed a DR in behalf of this case using the Battelle-TBD-6001, Appendix AA, Hooker Electrochemical Company TBD. In the original DR, NIOSH calculated a total dose to the lung of 10.324 rem. Based on this assigned dose estimate, the DOL determined the POC to be 17.12% and the claim was denied.

Using Revision 01 of the Hooker TBD (DCAS 2011b), NIOSH recalculated a dose of 14.312 rem to the lung. Based on this reassessed dose, a POC of 23.88% was derived. Exhibit #1 shows NIOSH's one-page DR reassessment form, which provides a comparison of the total original and re-evaluated doses and a summary of changes considered in the revised external, internal, and x-ray dose estimates.

Table 2-1 presents a comparison of the original DR and NIOSH's re-evaluated doses for external, internal and occupational medical exposures.

Table 2-1. Comparison of NIOSH-Derived External/Internal Dose Estimates Assigned for the Lung Cancer in the Original DR and Re-evaluated Screening Doses

Dose Categories		External	Medical X-Ray	Internal	Total	POC
Lung (April 1979)	Original DR	2.247	0.084	7.993	**10.324**	**17.12%**
	NIOSH Re-evaluation	0.018	0.084	14.21	**14.312**	**23.88%**

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EXHIBIT #1: NIOSH's REASSESSMENT REPORT FOR CASE #[REDACTED]

Claim [redacted]

Total assigned dose

Total Dose Assigned	
Previous DR	10.324 rem lung
PER DR	14.312 rem lung

PoC

PoC	
Previous DR	17.12%
PER DR	23.88%

Internal

1. Applied values from page 10 of the new TBD – new internal values for inhalation are higher and new internal values for ingestion are higher than old TBD for production years.
2. Residual dose applied from Table 6 of the new TBD page 14. The new values in this table are the same as the values from the old TBD.

External

1. The exposure values in Table 5 (page 13) applied – The dose values in Table 5 are lower than the dose values from old TBD.
2. Residual period added in new TBD. The exposure values in Table 6 (page 14) applied.

X-rays

1. Doses remain the same with the new TIB 6 for lung.

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2.2 SC&A'S REVIEW OF EXTERNAL AND INTERNAL DOSES IMPACTED BY DCAS-PER-038 FOR CASE #[REDACTED]

Since NIOSH's dose re-evaluation for the Hooker Electrochemical TBD revisions addressed under DCAS-PER-038 includes changes to external and internal DR methodologies, SC&A reviewed the dose assignments for all exposure pathways in behalf of this case.

2.2.1 Assessment of External and Internal Doses Assigned in the Original DR

In the **original**, it was determined that the EE was not monitored for external or internal exposures. Therefore, using overestimating assumptions and the technical guidance documents available at the time of the DR [i.e., Battelle-TBD-6001 (Battelle 2007)], external and internal doses were assigned as specified below.

Modeled External Dose. Since records were not available to determine if the EE was exposed to radioactivity as a [**redacted**] at Hooker, NIOSH assumed that the EE was chronically exposed to the source (i.e., uranium-bearing slag) and assigned doses associated with the job category of "Plant Floor Low." Annual organ doses were calculated for the operations period (1944–1946) and the residual period (1946–1975), as specified in Table AA.3 of Battelle-TBD-6001, Appendix AA. Values from Table AA.3 were multiplied by an anterior/posterior (AP), 30–250 keV, 'Exposure to Organ Dose' dose conversion factor (DCF) of 0.986. This resulted in the assignment of a total dose of 0.072 rem/yr for the operations period and total residual period dose of 0.068 rem/yr. These doses were entered into the Interactive RadioEpidemiological Program (IREP) as 100% photons with energy ranges of 30–250 keV and with a constant distribution. As shown in Table 2-1 above, this resulted in the assignment of a total external dose from photons of 2.247 rem in the original DR.

Occupational Medical Dose. External doses estimated in the original DR also included one "pre-employment" diagnostic x-ray, as specified in Battelle-TBD-6001, Appendix AA. Using the occupational medical x-ray dose for a posterior/anterior (PA) view from Table 6-5 of ORAUT-OTIB-0006, Rev. 03 PC-1 (ORAUT 2005), a lung dose of 0.084 rem was assigned in the original. This value was entered into IREP as a mean of a normal distribution with an uncertainty of 30%.

Modeled Internal Dose. There were no records of bioassay monitoring for the EE. Therefore, NIOSH calculated internal dose assuming that the EE was directly involved in uranium operations and the source material was inhaled and ingested. Using the Integrated Modules for Bioassay Analysis (IMBA) program, inhalation/ingestion dose was calculated based on intake values cited in Table AA.1 of Battelle-TBD-6001, Appendix AA, for the job category "Plant Floor Low," and assuming Type S solubility. This resulted in the assignment of a total internal dose of 7.993 rem to the lung.

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2.2.2 Assessment of External and Internal Dose Assigned in NIOSH's Re-evaluation of the Doses

In the **reassessment** of doses for this case, NIOSH estimated external and internal doses using guidance in DCAS-TKBS-0009, Revision 1. In addition, the dose reassessment utilized the most current technical documents, which included a revised ORAUT-OTIB-0006, Revision 04 (ORAUT 2011), for determining the occupational medical dose. Details regarding the recalculation of external and internal doses, which are summarized in Exhibit #1 above, are presented below.

Modeled External Dose. External dose rates in DCAS-TKBS-0009, Revision 1 (DCAS 2011b), for both the operational and residual periods were significantly reduced from those cited in Battelle-TBD-6001, Appendix AA (Battelle 2007). In addition, the Appendix AA job categories of "Plant Floor High" and "Plant Floor Low" were changed in DCAS-TKBS-0009 to "Operator" and "Laborer," respectively. These changes are reflected in Table 5 (Operational Period) and Table 6 (Residual Period) of DCAS-TKBS-0009.

Using the values cited in Table 5, NIOSH derived photon doses from (1) handling of source material and (2) contamination during the operational period as shown below:

Photons (material dose) = Table 5 'Operator' Dose × Exposure to Organ DCF
= 1.43 mrem/yr × 0.986
= 1.41 mrem/yr or 0.00141 rem/yr

Photons (contamination) = Table 5 'Operator' Dose × Exposure to Organ DCF
= 4.55E-01 mrem/yr × 0.986
= 0.448 mrem/yr or 0.000448 rem/yr

Residual period doses were calculated based on values cited in Table 6 of DCAS-TKBS-0009 as shown below:

Photons (residual period) = Table 6 'Operator' Dose × Exposure to Organ DCF
= 4.55E-01 mrem/yr × 0.986
= 0.448 mrem/yr or 0.000448 rem/yr

All photon doses were entered into IREP with an energy range of 30–250 keV and as a constant dose distribution. This resulted in a total photon dose of 0.018 rem.

Occupational Medical Dose. Since ORAUT-OTIB-0006 had been revised since the initial DR was completed, NIOSH also reassessed the occupational medical dose. It was determined that the PA chest exam dose for the lung cited in Table A-7 of ORAUT-OTIB-0006, Revision 04 (ORAUT 2011), was the same value cited in Revision 03 PC-1 (ORAUT 2005) and used in the original DR. One pre-employment x-ray dose of 0.084 rem was entered into IREP as a photon energy of 30–250 keV and as a mean of a normal distribution with a 30% standard deviation.

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Modeled Internal Dose. Internal dose was recalculated based on inhalation and ingestion intake values cited on page 10 of DCAS-TKBS-0009, Rev. 01. These updated intaks values of 340 dpm/calendar day during operations, 2.2 dpm/day during the residual period, and 5.9 dpm/day from ingestion are significantly higher than those recommended in Battelle-TBD-6001, Appendix AA. Using these values, NIOSH's reassessment ran for both solubility Types S and M, with Type S resulting in the higher dose. Annual doses from alpha radiation were entered into IREP as constants.

Reassessment Summary. NIOSH entered the above-described external and internal doses into IREP and re-evaluated the POC. Using the reassessed doses, a POC of 23.88% was derived, which was an increase from the 17.12% POC resulting from doses calculated in the initial DR.

2.2.3 SC&A's Conclusions Regarding Assignment of External and Internal Doses

SC&A's review compared guidance for modeling external and internal doses cited in the applicable Hooker Electrochemical TBDs to the re-evaluated doses calculated by NIOSH as summarized in Exhibit #1. Our evaluation found that both external and internal doses were appropriately calculated. This resulted in a decrease in external doses and an increase in internal doses, with an overall outcome of adding nearly 4.0 rem to the total dose, due to changes in the TBD, as outlined in DCAS-PER-038.

We also verified that all doses were entered into IREP with the appropriate exposure parameters and dose distributions. It should be noted that, for external doses calculated for exposure to contamination during the operational period, the TBD recommends entering this dose into IREP as a constant distribution with energies distributed as 80.3% <30 keV, 12.3% 30–250 keV, and 7.5% >250 keV. However, NIOSH entered these doses into IREP as 100% 30–250 keV. Although this is inconsistent with TBD guidance, it is a claimant-favorable assumption that had only a small increase in the resultant POC.

Lastly, SC&A re-ran IREP with NIOSH's reassessed doses and was able to verify that the POC of 23.88% is correct.

SC&A has no findings with NIOSH's methodology for reassessing Case #[**redacted**] doses.

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3.0 REVIEW OF DCAS-PER-038 ISSUES FOR CASE #[REDACTED]

3.1 BACKGROUND INFORMATION FOR CASE #[REDACTED]

Case #[redacted] represents an EE who worked at Hooker from [redacted], through [redacted]. This employment period coincides with the Hooker operational period (i.e., 1944–1946) and a portion of the residual period (i.e., 1946–1952). According to the DOL records, the EE's job position was an [redacted]. There are no records that indicate the EE was monitored for external or internal radiation exposure. The EE was diagnosed with a lung cancer, left lower lobe poorly differentiated adenocarcinoma (ICD-9 Code 162.5) in September 1978.

NIOSH performed a DR in behalf of this case in March 2008, using the Battelle-TBD-6001, Appendix AA, Hooker Electrochemical Company TBD. In the original DR, NIOSH calculated a total dose to the lung of 0.775 rem. Based on this assigned dose estimate, the DOL determined the POC to be 3.97% and the claim was denied.

Using Revision 1 of the Hooker TBD (DCAS 2011b), NIOSH recalculated a dose of 13.331 rem to the lung. Based on this reassessed dose, a POC of 44.08% was derived. Exhibit #2 shows NIOSH's one-page DR reassessment form, which provides a comparison of the total original and re-evaluated doses and a summary of changes considered in the revised external, internal, and x-ray dose estimates.

Table 3-1 presents a comparison of the original DR and NIOSH's re-evaluated doses for external, internal, and occupational medical exposures.

Table 3-1. Comparison of NIOSH-Derived External/Internal Dose Estimates Assigned for the Lung Cancer in the Original DR and Re-evaluated Screening Doses

Dose Categories		External	Medical X-Ray	Internal	Total	POC
Lung (Sept. 1978)	Original DR	0.030	0.090	0.655	**0.775**	**3.97%**
	NIOSH Re-evaluation	0.004	0.084	13.243	**13.331**	**44.08%**

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EXHIBIT #2: NIOSH's REASSESSMENT REPORT FOR CASE #[REDACTED]

Claim [redacted]

Total assigned dose

Total Dose Assigned	
Previous DR	0.775 rem lung
PER DR	13.331 rem lung

PoC

PoC	
Previous DR	3.97%
PER DR	44.08%

Internal

3. Applied values from page 10 of the new TBD – new internal values for inhalation are higher and new internal values for ingestion are higher than old TBD for production years.
4. Residual dose applied from Table 6 of the new TBD page 14. The new values in this table are the same as the values from the old TBD.

External

3. The exposure values in Table 5 (page 13) applied – The dose values in Table 5 are lower than the dose values from old TBD.

X-rays

2. Doses remain the same with the new TIB 6 for lung.

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3.2 SC&A'S REVIEW OF EXTERNAL AND INTERNAL DOSES IMPACTED BY DCAS-PER-038 FOR CASE #[REDACTED]

Since NIOSH's dose re-evaluation for the Hooker Electrochemical TBD revisions addressed under DCAS-PER-038 includes changes to external and internal DR methodologies, SC&A reviewed the dose assignments for all exposure pathways in behalf of this case.

3.2.1 Assessment of External and Internal Doses Assigned in the Original DR

In the **original**, it was determined that the EE was not monitored for external or internal exposures. Therefore, using claimant-favorable assumptions and the technical guidance documents available at the time of the DR (i.e., Battelle-TBD-6001, Rev. 0), external and internal doses were assigned as specified below.

Modeled External Dose. Since records were not available to determine if the EE was exposed to radioactivity as an #[redacted] at Hooker Electrochemical, NIOSH assumed that the EE was chronically exposed to the source (i.e., uranium-bearing slag) and assigned doses associated with the job category of "Clerical." Annual organ doses were calculated for the operations period (1944–1946) and the residual period (1946–1975), as specified in Table AA.3 of Battelle-TBD-6001, Appendix AA. Values from Table AA.3 were multiplied by an AP, 30–250 keV, 'Exposure to Organ Dose' DCF of 0.986. This resulted in the assignment of a total dose of 0.006 rem for the operations period and a total residual period dose of 0.024 rem. Annual doses were entered into IREP as 100% photons with energy ranges of 30–250 keV and with a constant distribution. As shown in Table 3-1 above, this resulted in the assignment of a total external dose from photons of 0.030 rem in the original DR.

Occupational Medical Dose. External doses estimated in the original DR also included one "pre-employment" diagnostic x-ray, as specified in Battelle-TBD-6001, Appendix AA. Using the occupational medical x-ray dose for a PA view, female lung, from Table 6-5 of ORAUT-OTIB-0006, Rev. 03 PC-1 (ORAUT 2005), a lung dose of 0.090 rem was assigned in the original. This value was entered into IREP as a mean of a normal distribution with an uncertainty of 30%.

Modeled Internal Dose. There were no records of bioassay monitoring for the EE. Therefore, NIOSH calculated internal dose assuming that the EE was directly involved in uranium operations and the source material was inhaled and ingested. Using the IMBA program, inhalation/ingestion dose was calculated based on intake values cited in Table AA.1 of Battelle-TBD-6001, Appendix AA, for job category "Clerical," and assuming Type S solubility. This resulted in the assignment of a total internal dose of 0.655 rem to the lung.

3.2.2 Assessment of External and Internal Dose Assigned in NIOSH's Re-evaluation of the Doses

In the **reassessment** of doses for this case, NIOSH estimated external and internal doses using guidance in DCAS-TKBS-0009, Rev. 1 (DCAS 2011b). In addition, the dose reassessment utilized the most current technical documents, which included a revised ORAUT-OTIB-0006, Rev. 04 (ORAUT 2011), for determining the occupational medical dose. Details regarding the

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recalculation of external and internal doses, which are summarized in Exhibit #2 above, are presented below.

Modeled External Dose. External dose rates in DCAS-TKBS-0009, Rev. 1, for both the operational and residual periods were significantly reduced from those cited in Battelle-TBD-6001, Appendix AA. These changes are reflected in Table 5 (Operational Period) and Table 6 (Residual Period) of DCAS-TKBS-0009 (DCAS 2011b).

Using the values cited in Table 5 and assuming a contamination dose associated with operators/ laborers, NIOSH derived photon doses during the operational period as shown below:

Photons (contamination) = Table 5 'Operator/Laborer' Dose × Exposure to Organ DCF
= 4.55E-01 mrem × 0.986
= 0.448 mrem/yr or 0.000448 rem/yr

Residual period doses were calculated based on values cited in Table 6 of DCAS-TKBS-0009 as shown below:

Photons (residual period) = Table 6 'Operator/Laborer' Dose × Exposure to Organ DCF
= 4.55E-01 mrem × 0.986
= 0.448 mrem/yr or 0.000448 rem/yr

All photon doses were entered into IREP with an energy range of 30–250 keV and as a constant dose distribution. This resulted in a total photon dose of 0.004 rem.

Occupational Medical Dose. Since ORAUT-OTIB-0006 had been revised since the initial DR was completed, NIOSH also reassessed the occupational medical dose. It was determined that the PA chest exam dose for the lung cited in Table A-7 of ORAUT-OTIB-0006, Rev. 04 (ORAUT 2011), was the same value cited in Revision 03 PC-1 (ORAUT 2005). NIOSH's reassessment also assumed one pre-employment x-ray; however, NIOSH selected the male, rather than female, lung dose of 0.084 rem, which was entered into IREP as a photon energy of 30–250 keV and as a mean of a normal distribution with a 30% standard deviation.

Modeled Internal Dose. Internal dose was recalculated based on inhalation and ingestion intake values cited on page 10 of DCAS-TKBS-0009, Rev. 01. The updated intake values for all worker categories are significantly higher than those recommended in Battelle-TBD-6001, Appendix AA. NIOSH's reassessment used IMBA to calculate the lung dose for three intake regimes (i.e., operational period inhalation, residual period inhalation, and operational ingestion). This assessment compared solubility Types S and M, with Type S resulting in the higher dose of 13.243 rem. Annual doses from alpha radiation were entered into IREP as constants.

Reassessment Summary. NIOSH entered the above-described external and internal doses into IREP and re-evaluated the POC. Using the reassessed doses, a POC of 44.08% was derived, which was an increase from the 3.97% POC resulting from doses calculated in the initial DR.

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3.2.3 SC&A's Conclusions Regarding Assignment of External and Internal Doses

SC&A's review compared guidance for modeling external and internal doses cited in the applicable Hooker TBDs to the re-evaluated doses calculated by NIOSH as summarized in Exhibit #2. Our evaluation found that NIOSH's reassessed external dose was calculated using claimant-favorable doses associated with Operators/Laborers, which is a conservative assumption since the EE was a clerical worker. Using these assumptions, SC&A was able to match the re-evaluated external doses. It should be noted that, for external doses calculated for exposure to contamination during the operational period, the TBD recommends entering this dose into IREP as a constant distribution with energies distributed as 80.3% <30 keV, 12.3% 30–250 keV, and 7.5% >250 keV. However, NIOSH entered these doses into IREP as 100% 30–250 keV. This inconsistency with TBD guidance is claimant favorable and had an insignificant impact on the resultant POC for this case.

SC&A considers NIOSH's internal dose assumptions appropriate, and we were able to match the internal doses using IMBA. Internal doses increased by a factor of 17, which is consistent with changes to the TBD, as outlined in DCAS-PER-038.

Lastly, SC&A re-ran IREP with NIOSH's reassessed doses and was able to verify that the POC of 44.08% is correct.

SC&A has no findings with NIOSH's methodology for reassessing Case #[**redacted**] doses.

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4.0 REVIEW OF DCAS-PER-038 ISSUES FOR CASE #[REDACTED]

4.1 BACKGROUND INFORMATION FOR CASE #[REDACTED]

Case #[**redacted**] represents an EE who worked at Hooker from #[**redacted**], through #[**redacted**], and #[**redacted**], through #[**redacted**]. This employment period coincides with less than 1 month during the Hooker operational period in 1946 and the entire residual period (i.e., 1946–1952). According to the DOL records, the EE was employed as a #[**redacted**]. There are no records that indicate the EE was monitored for external or internal radiation exposure. In August 1996, the EE was diagnosed with a squamous cell carcinoma (SCC) [**redacted**] (ICD-9 Code 232.5) and a metastatic carcinoma of the liver (with the primary cancer **unknown**) (ICD-9 Code 197.7) in November 2001.

NIOSH performed a DR in behalf of this case in September 2010 using the Battelle-TBD-6001, Appendix AA, Hooker Electrochemical Company TBD. In the original DR, NIOSH calculated a total dose to the skin of 4.052 rem and a dose to the stomach of 5.377 rem. Based on these assigned dose estimates, the DOL determined the POC to be 20.12% and the claim was denied.

Using Revision 1 of the Hooker TBD (DCAS 2011b), NIOSH recalculated a dose of 1.512 rem to the skin. In addition, the primary cancer associated with the carcinoma of the liver was changed from stomach to the lung and a lung dose of 2.054 rem was calculated. Based on these reassessed doses, a POC of 15.73% was derived. Exhibit #3 shows NIOSH's one-page DR reassessment form, which provides a comparison of the total original and re-evaluated doses and a summary of changes considered in the revised external, internal, and x-ray dose estimates.

Table 4-1 presents a comparison of the original DR and NIOSH's re-evaluated doses for external, internal, and occupational medical exposures.

Table 4-1. Comparison of NIOSH-Derived External/Internal Dose Estimates Assigned for the Skin and Stomach/Lung Cancer in the Original DR and Re-evaluated Screening Doses

Dose Categories		External	Medical X-Ray	Internal	Total	POC
Skin (August 1996)	Original DR	3.778	0.270	0.004	**4.052**	**20.12%**
Stomach (Nov. 2001)		5.283	0.090	0.004	**5.377**	
Skin	NIOSH Re-evaluation	1.240	0.270	0.004	**1.512**	**15.73%**
Lung (New Primary Cancer)		0.014	0.084	1.956	**2.054**	

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EXHIBIT #3: NIOSH's REASSESSMENT REPORT FOR CASE #[REDACTED]

Claim #[redacted]

Total assigned dose

Total Dose Assigned	
Previous DR	4.052 rem skin
Previous DR	5.377 rem stomach
PER DR	1.512 rem Skin
PER DR	2.054 rem Lung

PoC

PoC	
Previous DR	20.12%
PER DR	15.73%

External

5. (Hooker) The exposure values in Table 5 (page 13) applied – The dose values in Table 5 are lower than the dose values from old TBD.
6. (Hooker)The exposure values in Table 6 (page 14) applied – The dose values in Table 6 are lower than the dose values from old TBD.

X-rays

1. No changes.

Internal

1. (Hooker)Applied values from page 10 of the new TBD – new internal values for inhalation and ingestion are higher than old TBD for production years.
2. (Hooker)Residual dose applied from Table 6 of the new TBD page 14. The values in this table are the same as the values from the old TBD.

Note: New values made a change in the primary cancer from stomach to lung.

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4.2 SC&A'S REVIEW OF EXTERNAL AND INTERNAL DOSES IMPACTED BY DCAS-PER-038 FOR CASE #[REDACTED]

Since NIOSH's dose re-evaluation for the Hooker TBD revisions addressed under DCAS-PER-038 includes changes to external and internal DR methodologies, SC&A reviewed the dose assignments for all exposure pathways in behalf of this case.

4.2.1 Assessment of External and Internal Doses Assigned in the Original DR

In the **original**, it was determined that the EE was not monitored for external or internal exposures. Therefore, using claimant-favorable assumptions and the technical guidance documents available at the time of the DR (i.e., Battelle-TBD-6001, Rev. 0), external and internal doses were assigned as specified below.

Modeled External Dose. Since records were not available to determine if the EE was exposed to radioactivity as a [**redacted**] at Hooker, NIOSH assumed that the EE was chronically exposed to the source (i.e., uranium-bearing slag) and assigned doses associated with the job category of "Plant Floor High." Annual organ doses were calculated for 13 days during the operations period (January 3 through January 15, 1946) and the entire residual period (1946–1976), as specified in Table AA.3 of Battelle-TBD-6001, Appendix AA. Since the metastatic carcinoma of the liver was identified as a secondary cancer with an unknown primary cancer site, all likely primary cancers must be assessed in accordance with guidance in ORAUT-OTIB-0005, Rev. 03 (ORAUT 2010), Table 3-2. Based on this assessment, the original DR selected the **stomach** as the primary cancer site. Values from Table AA.3 were multiplied by an AP, 30–250 keV, 'Exposure to Organ Dose' DCFs of 0.892 for the skin and 1.251 for the stomach. This resulted in the assignment of a total operational/residual period dose to the skin of 3.778 rem and a total operational/residual period dose of 5.283 rem to the stomach. Annual doses were entered into IREP as 100% photons with energy ranges of 30–250 keV and with a constant distribution.

Occupational Medical Dose. External doses estimated in the original DR included one "pre-employment" diagnostic x-ray, as specified in Battelle-TBD-6001, Appendix AA. Using the occupational medical x-ray dose for a PA view from Table 6-5 of ORAUT-OTIB-0006, Rev. 03 PC-1 (ORAUT 2005), a skin dose of 0.270 rem and a stomach dose of 0.090 rem was assigned in the original. This value was entered into IREP as a mean of a normal distribution with an uncertainty of 30%.

Modeled Internal Dose. There were no records of bioassay monitoring for the EE. Therefore, NIOSH calculated internal dose assuming that the EE was directly involved in uranium operations and the source material was inhaled and ingested. Using the IMBA program, inhalation/ingestion dose was calculated based on intake values cited in Table AA.1 of Battelle-TBD-6001, Appendix AA, for the job category "Plant Floor High," and assuming Type M solubility. This resulted in the assignment of a total internal dose to the skin and stomach of 0.004 rem.

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4.2.2 Assessment of External and Internal Dose Assigned in NIOSH's Re-evaluation of the Doses

In the **reassessment** of doses for this case, NIOSH estimated external and internal doses using guidance in DCAS-TKBS-0009, Rev. 1 (DCAS 2011b). In addition, the dose reassessment utilized the most current technical documents, which included a revised ORAUT-OTIB-0006, Rev. 04 (ORAUT 2011), for determining the occupational medical dose. Details regarding the recalculation of external and internal doses, which are summarized in Exhibit #3 above, are presented below.

Modeled External Dose. This case was reassessed by NIOSH, since external dose rates during the residual period increased in DCAS-TKBS-0009, Rev. 1 (DCAS 2011b), for all worker categories with skin cancer from those cited in Battelle-TBD-6001, Appendix AA. In addition, the Appendix AA job categories of "Plant Floor High" and "Plant Floor Low" were changed in DCAS-TKBS-0009 to "Operator" and "Laborer," respectively. These changes are reflected in Table 5 (Operational Period) and Table 6 (Residual Period) of DCAS-TKBS-0009, Rev. 01.

Consistent with the original DR, NIOSH assessed doses for all likely primary cancers in accordance with guidance in ORAUT-OTIB-0005, Rev. 03 ORAUT 2010), Table 3-2. NIOSH's re-evaluation compared doses for primary cancer sites that included the stomach, colon, lower large intestine (LLI), upper large intestine (ULI), pancreas, and lung. It was determined that the **lung** produced the highest dose (rather than the stomach, which was used in the original DR) and was used as the primary cancer site.

Using the values cited in Table 5 (DCAS 2011b) and assuming a contamination dose associated with operators, NIOSH derived photon doses to the skin and lung during the operational period (i.e., 13 days in 1946) as shown below:

Skin (material dose) = Table 5 'Operator' Dose × DCF/days per yr × workdays/yr
= 1.43 mrem/yr × 0.892/365 × 13 days/yr
= 0.0454 mrem/yr or 4.54E-05 rem/yr

Skin (contamination) = Table 5 'Operator' Dose × DCF/days per yr × workdays/yr
= 0.455 mrem/yr × 0.892/365 × 13 days/yr
= 0.0145 mrem/yr or 1.45E-05 rem/yr

Lung (material dose) = Table 5 'Operator' Dose × DCF/days per yr × workdays/yr
= 1.43 mrem/yr × 0.986/365 × 13 days/yr
= 0.0502 mrem/yr or 5.02E-05 rem/yr

Lung (contamination) = Table 5 'Operator' Dose × × DCF/days per yr × workdays/yr
= 0.455 mrem/yr × 0.986/365 × 13 days/yr
= 0.016 mrem/yr or 1.60E-05 rem/yr

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Residual period doses were calculated based on values cited in Table 6 of DCAS-TKBS-0009, Rev. 01, as shown below:

Skin (residual period) = Table 6 'Operator/Laborer' Dose × Exposure to Organ DCF
= 4.55E-01 mrem × 0.892
= 0.406 mrem/yr or 0.000406 rem/yr

Lung (residual period) = Table 6 'Operator/Laborer' Dose × Exposure to Organ DCF
= 4.55E-01 mrem × 0.986
= 0.448 mrem/yr or 0.000448 rem/yr

All photon doses were entered into IREP with an energy range of 30–250 keV and as a constant dose distribution. This resulted in a total photon dose of 0.004 rem.

In addition to the assessment of photon doses, NIOSH evaluated electron doses for the skin cancer. Operational and residual period doses were calculated as shown below:

Skin (material dose) = Table 5 'Operator' Skin Dose/days per yr × workdays/yr
= 29.4 mrem per yr/365 × 13 days/yr
= 1.047 mrem/yr or 0.001047 rem/yr

Skin (contamination) = Table 5 'Operator' Skin Dose × DCF/days per yr × workdays/yr
= 40.5 mrem per yr/365 × 13 days/yr
= 1.44 mrem/yr or 0.00144 rem/yr

Skin (residual period) = Table 6 'Operator' Skin Dose
= 40.5 mrem/yr or 0.0405 rem/yr

This resulted in a total external skin dose from photons of 0.012 rem and 1.22 rem from electrons. For the lung, a total external dose of 0.014 rem was calculated.

Occupational Medical Dose. Since ORAUT-OTIB-0006 had been revised after the initial DR was completed, NIOSH also reassessed the occupational medical dose. It was determined that the PA chest exam dose for the skin of 0.270 rem, cited in Table A-7 of ORAUT-OTIB-0006, Rev. 04 (ORAUT 2011), was the same value cited in Rev. 03 PC-1 and assigned in the original DR. NIOSH's reassessment also assumed one pre-employment x-ray for the lung, which resulted in a dose of 0.084 rem. The occupational medical doses were entered into IREP as a photon energy of 30–250 keV and as a mean of a normal distribution with a 30% standard deviation.

Modeled Internal Dose. Internal dose was recalculated based on inhalation and ingestion intake values cited on page 10 of DCAS-TKBS-0009, Rev. 01. Contrary to statements cited under NIOSH's reassessed dose sheet shown in Exhibit #3 above, the operational period intakes for operators are slightly lower than those recommended in Battelle-TBD-6001, Appendix AA. However, the intakes were reassessed for the lung as the primary cancer site rather than the stomach. NIOSH's reassessment used IMBA to calculate the skin and lung doses for three

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intake regimes (i.e., operational period inhalation, residual period inhalation, and operational ingestion). This assessment compared solubility Types S and M, with Type M resulting in the higher dose of 0.004 rem to the skin and Type S, which produced a dose of 1.956 rem to the lung. Annual doses from alpha radiation were entered into IREP as constants.

Reassessment Summary. NIOSH entered the above-described external and internal doses into IREP and re-evaluated the POC. Using the reassessed doses, a POC of 15.73% was derived, which was a decrease from the 20.12% POC resulting from doses calculated in the initial DR.

4.2.3 SC&A's Conclusions Regarding Assignment of External and Internal Doses

SC&A's review compared guidance for modeling external and internal doses cited in the applicable Hooker TBDs to the re-evaluated doses calculated by NIOSH, as summarized in Exhibit #3. Since the liver carcinoma was a secondary cancer with an unknown primary cancer, we also reviewed all files and spreadsheets for determining the appropriate primary cancer site. It was noted during this review that, although the original DR selected the stomach as the primary cancer, it was actually the combined external and internal doses associated with the lung that resulted in the highest radiation dose. This was corrected during NIOSH's reassessment of the case.

Our evaluation of NIOSH's reassessed external doses found that they were calculated using claimant-favorable assumptions associated with Operators. Using these assumptions, SC&A was able to match the re-evaluated external photon and electron doses. It should be noted that, for external photon doses calculated for exposure to contamination during the operational period, the TBD recommends entering this dose into IREP as a constant distribution with energies distributed as 80.3% <30 keV, 12.3% 30–250 keV, and 7.5% >250 keV. However, NIOSH entered these doses into IREP as 100% 30–250 keV. This inconsistency with TBD guidance is claimant favorable and had an insignificant impact on the resultant POC for this case.

SC&A considers NIOSH's internal dose assumptions appropriate and consistent with guidance in DCAS-TKBS-0009, Rev. 01 (DCAS 2011b). In addition, we were able to match the internal doses using IMBA.

Lastly, SC&A re-ran IREP with NIOSH's reassessed doses and was able to verify that the POC of 15.73% is correct.

SC&A has no findings with NIOSH's methodology for reassessing doses associated with Case #[**redacted**].

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5.0 SUMMARY CONCLUSIONS

Under SC&A's *A Protocol to Review NIOSH's Program Evaluation Reports (PERs)*, SCA-TR-PR2009-0002, Rev. 1 (SC&A 2009), Subtask 4 requires the audit of DR cases reworked as a result of the PER under review. After SC&A's review of DCAS-PER-038 "Hooker Electrochemical TBD Revisions," it was determined by the PRSC that SC&A be tasked with reviewing three reworked claims.

This report satisfies the Subtask 4 requirement. For this review, SC&A compared external and internal doses assigned in the original DR to the NIOSH reassessed doses, since the TBD revisions associated with DCAS-PER-038 affected both exposure pathways. As noted above, based on NIOSH's reassessment of doses and resulting POCs for all Hooker cases impacted by the TBD revisions, there was no need to request that the DOL return any of the claims for a formal re-evaluation.

For each of the three claims, SC&A reviewed all applicable files, spreadsheets, and tools employed for assessing external and internal doses. In all cases, we considered NIOSH's assumptions to be reasonable, and we were able to match their revised internal and external doses. Lastly, we verified that all data were correctly entered into IREP and re-ran IREP to ensure that the POC values agreed with those reported by NIOSH.

This review did not identify any findings associated with the reassessment of cases due to changes in the Hooker Electrochemical TBD as outlined in DCAS-PER-038.

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