
Draft

**ADVISORY BOARD ON
RADIATION AND WORKER HEALTH**

National Institute for Occupational Safety and Health

**UPDATE OF THE NEVADA TEST SITE (NTS) ISSUE
RESOLUTION MATRIX BASED ON THE SC&A REVIEW OF
THE NIOSH SITE PROFILE FOR THE NEVADA TEST SITE**

**Contract No. 200-2009-28555
SCA-SP-IM2012-0042**

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December 2012

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S. COHEN & ASSOCIATES: <i>Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program</i>	Document No. SCA-SP-IM2012-0042
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Update of the Nevada Test Site (NTS) Issue Resolution Matrix Based on the SC&A Review of the NIOSH Site Profile for the Nevada Test Site	Page 2 of 48
Task Manager: _____ Date: _____ Arjun Makhijani, PhD	Supersedes: Rev. 0
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Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	01/13/2006	Initial issue
1 (Draft)	12/14/2012	Updated issues matrix/text

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ABBREVIATIONS AND ACRONYMS

ABRWH or Advisory Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
DCF	dose conversion factor
DOE	(U.S.) Department of Energy
DTRA	Defense Threat Reduction Agency
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
GFP	Gross fission products
GI	gastro-intestinal
HTO	tritiated water
IMBA	Integrated Modules for Bioassay Analysis
keV	kiloelectron volt
km	kilometer
L/min	liter per minute
LLNL	Lawrence Livermore National Laboratory
LRL	Lawrence Radiation Laboratory
MDL	minimum detectable level
mR	milli roentgen
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
nm	nanometer
n/p	neutron-to-photon (ratio)
NOCTS	NIOSH OCAS Claims Tracking System
NRDL	Naval Radiological Defense Laboratory
NRDS	Nuclear Rocket Development Station
NTS	Nevada Test Site
ORAU	Oak Ridge Associated Universities
ORAUT	Oak Ridge Associated Universities Team
PHS	Public Health Service
R	RoentgenREECo Reynolds Electrical Engineering Company
rem	roentgen equivalent man

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RWMS	Radioactive Waste Management Site
SC&A	S. Cohen and Associates (SC&A, Inc.)
SEC	Special Exposure Cohort
SRDB	Site Research Database
TBD	Technical Basis Document
TLD	thermoluminescent dosimeter
TRU	transuranic
TTR	Tonopah Test Range
WBC	whole body count
WEF	Waste Examination Facility
WG	Work Group
μCi/cc	microcurie per cubic centimeter
μm	micrometer

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INTRODUCTION

At the June 2012 meeting of the Advisory Board on Radiation and Worker Health (ABRWH), SC&A was tasked with preparing an update of the Nevada Test Site (NTS) site profile issues matrix (SC&A 2006). The NTS Technical Basis Document (TBD or site profile) reviewed by SC&A was the 2004 version, which was issued as six volumes (Rollins 2004a through Rollins 2004f) numbered ORAUT-TKBS-0008-1 through ORAUT-TKBS-0008-6. SC&A sent its review of this version of the NIOSH site profile to the NTS Work Group (WG) on December 13, 2005 (SC&A 2005). A matrix of issues (SC&A 2006) was prepared based on the SC&A site profile review. This matrix was used mainly as a starting point for the review of Special Exposure Cohort (SEC) Petition SEC-00084. NIOSH's responses to this matrix were incorporated in a subsequent version of the matrix prepared by NIOSH (December 2007), in which its responses were included (NIOSH 2007b). NIOSH consolidated some matrix comments for the purpose of providing responses.

The WG review of the SEC petition resulted in closing some issues for SEC purposes or defining them as closed when NIOSH agreed to make changes to the site profile. SC&A did not review most of the site profile revisions that were in process while the SEC was being reviewed, though many issues, such as the intakes due to resuspension of previously deposited radionuclides, were discussed at length as part of the SEC review process.

The most recent versions of the six volumes of the NTS site profile are as follows:

- (1) Introduction: ORAUT-TKBS-0008-1, Vol. 1, Rev. 00-PC-1, July 20, 2006. (ORAUT 2006a)
- (2) Site Description: ORAUT-TKBS-0008-2, Vol. 2, Rev. 01-PC-1, May 27, 2008. (ORAUT 2008a)
- (3) Medical Dose: ORAUT-TKBS-0008-3, Vol. 3, Rev. 01, June 22, 2007. (ORAUT 2007a)
- (4) Occupational Environmental Dose: ORAUT-TKBS-0008-4, Vol. 4, Rev. 2, April 15, 2010. (ORAUT 2010a)
- (5) Occupational Internal Dose: ORAUT-TKBS-0008-5, Vol. 5, Rev. 2, April 15, 2010. (ORAUT 2010b)
- (6) Occupational External Dose: ORAUT-TKBS-0008-6, Vol. 6, Rev. 2, April 15, 2010. (ORAUT 2010c).

All six current volumes of the NTS site profile have been revised after the completion of the SC&A review of the original Rev. 0 version published in 2004. Two additions to the SEC were made since that time. The first was for the period January 27, 1951, when atmospheric testing began at NTS, to December 31, 1962 (SEC-00055); this addition was recommended by NIOSH in an SEC Evaluation Report dated April 10, 2006 (NIOSH 2006). The second addition to the SEC was recommended by NIOSH in its Evaluation Report (NIOSH 2007a) dated January 25,

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2010 (SEC-00084) covering the period January 1, 1963, to December 31, 1992. The most recent versions of three of the site profile volumes [Environmental Dose, Internal Dose, and External Dose (ORAUT 2010a, ORAUT 2010b, and ORAUT 2010c respectively)] were published after the 1963–1992 SEC was recommended. We note that SC&A did review part of an intermediate version of the External Dose volume of the site profile (SC&A 2007 and ORAUT 2007b) during the SEC review process. The issues that were reviewed and those that were not are noted in the various External Dose-related matrix items below.

This update of the site profile issues that are outstanding does not represent a full review of the most recent versions of the various parts of the NTS site profile. Rather, it reviews the status of previously identified site profile issues for their relevance to dose reconstruction for non-SEC cancers. It also provides preliminary SC&A conclusions for each matrix item; where appropriate, this includes preliminary SC&A recommendations on whether further review of that particular item appears to be warranted. The context overall is that NIOSH’s recommendation for SECs was made on specific grounds relating to the infeasibility of estimating occupational internal dose. Those aspects of dose cannot be estimated, and the corresponding issues are noted in the matrix below and designated as resolved. SC&A understands that NIOSH uses individual claimant internal monitoring data so far as it is available to estimate partial doses for non-covered cancers. SC&A agrees with this approach. Comments on other partial dose estimations, where relevant, are included.

The revised Evaluation Report also discusses some specific dose reconstruction issues that were identified as site profile issues during the SEC review process (NIOSH 2010, p. 85). These will also be covered in this update of the site profile matrix.

In the sections below, the comment number is from the original matrix (SC&A 2006), the finding number from the SC&A 2005 review. Both the matrix comment number and the finding number(s) are provided at the start of each section for tracking purposes. This is followed by the NIOSH response to each comment. Next, there is a discussion, followed by SC&A’s view of the status of each matrix comment, as well as preliminary conclusions for WG consideration. Some NIOSH responses relate to more than one comment; this is indicated and cross-referenced at the appropriate spots.

It should be noted that the initial SC&A site profile review did not “explicitly address the issue of radiation exposures to cleanup workers and decommissioning workers” in its site profile review, because the initial version of the NTS site profile did not cover those issues (SC&A 2005, p. 16). The revised NIOSH Evaluation Report for SEC-00084 states that NIOSH has the data to reconstruct doses from January 1, 1993, on, because “it has sufficient information to estimate dose for the members of the proposed class” (NIOSH 2010, p. 4). A new matrix comment relating to workers handling radioactive waste and to decommissioning has been added at the end of the existing list as a place-holder for WG discussion.

The summary table below shows the matrix comment statements as well as the status of each matrix comment and SC&A’s preliminary conclusions for consideration by the WG. The matrix items are discussed in more detail below the summary table.

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Table 1. Summary NTS Site Profile Matrix Update

Comment Number	Report Section	Issue Description	Status	SC&A Preliminary Conclusions
1	1	Some radionuclide lists are not complete. This is especially important for atmospheric testing and for early re-entry workers.	NIOSH has responded to the finding (except as related to Matrix Comment 5)	No further review of this item needed, except as related to issues in Section 5 below.
2	2	TBD does not provide adequate guidance for dose estimation to gonads, skin, and gastro-intestinal (GI) tract for early reactor test re-entry personnel. Large hot-particle doses to skin and GI tract have not been evaluated. Naval Radiological Defense Laboratory (NRDL) documents and models have not been evaluated, though one document is referenced.	NIOSH and SC&A agree that NRDL model could be used. NIOSH has been partially, but not fully, responsive to SC&A comments.	Some review of this issue appears to be warranted.
3	3	Doses from large (non-respirable) particles to GI tract and skin for workers in the early atmospheric test period have not been evaluated. These doses could be high. Hot-particle doses also need to be evaluated for early drillback and other early re-entry workers during underground testing periods.	Hot particle exposure as a result of nuclear weapon tests is still outstanding for external dose and for oro-nasal breathing.	It would appear useful to examine whether the NRDL model could also be used for weapons testing exposures to calculate partial doses.
4	4	Ingestion of non-respirable hot particles by reactor testing and nuclear weapons testing workers due to oro-nasal breathing needs to be evaluated.	It may be possible to calculate partial doses for certain non-presumptive cancers.	The investigation of this issue will depend on how the Work Group decides to address matrix comments 2 and 3 above.
5	5	Resuspension model and resuspension factor are not scientifically defensible or claimant favorable, due to a variety of factors. Doses may be underestimated by an order of magnitude or more. Mass-loading approach would be preferable for internal dose.	Matrix comments 6, 7, 15, and 23 are also covered here. NIOSH and SC&A are in agreement that occupational environmental dose can be estimated. NIOSH has not yet addressed some issues raised by SC&A.	Review of unaddressed items appears to be warranted.
6	5	The use of the site average air concentration values when worker location is not known is not claimant favorable. Largest value consistent with job-type data should be used in such cases.	See matrix comment 5 above.	See matrix comment 5 above.

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Table 1. Summary NTS Site Profile Matrix Update

Comment Number	Report Section	Issue Description	Status	SC&A Preliminary Conclusions
7	5	Resuspension doses to monitored workers, especially early re-entry workers, may be underestimated, due to the presence of short-lived radionuclides and higher resuspension expected in the days and months after a test (including safety tests). TBD does not specify procedures for estimating environmental internal doses in such cases.	See matrix comment 5 above.	See matrix comment 5 above.
8	6	Use of 1967 external dose data for 1963–1966 is not claimant favorable. There was no test in 1967 with measurable offsite fallout. Relatively short-lived radionuclides, which were likely present in 1963–1966, would have substantially decayed away by 1967.	NIOSH has pointed out that badging was required for all workers after 1957.	No further review of this comment appears to be needed.
9	6	Lack of environmental external dose data for 1968–1976 is puzzling. TBD has not specified an approach to estimating external environmental dose for this period. Venting in the 1968–1970 period likely made external dose in that period (and possibly beyond) higher than 1967.	See matrix comment 8 above.	See matrix comment 8 above.
10	7	The TBD does not provide any guidance for pre-1963 external environmental dose. Issues relating to unmonitored workers, as well as time of entry into contaminated areas, could be important.	SC&A has not reviewed the pre-1957 dose assignments suggested by NIOSH. Suggested dose assignments do not appear claimant favorable or compatible with the MDLs.	SC&A’s preliminary conclusion is that NIOSH values may reflect subtraction of the badge MDL. NIOSH clarification on how the values were derived is needed. Review of the proposed dose assignments appears to be warranted.

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Table 1. Summary NTS Site Profile Matrix Update

Comment Number	Report Section	Issue Description	Status	SC&A Preliminary Conclusions
11	8	Correction factors for external environmental dose due to geometry of organ relative to badge, and angular dependence of the dose conversion factor need to be developed.	NIOSH has provided a table of the photon energy spectra to be used. NIOSH's photon energy groupings may not apply to nuclear testing spectra. NIOSH concluded that the external dose conversion factors would not make a material difference and hence do not need to be applied.	NIOSH's photon energy groupings appear to need review. The correction factors for skin dose may be much greater than one. SC&A's preliminary view is that some aspects of NIOSH's conclusions of external environmental dose correction factors need review to assure that they are claimant favorable.
12	9	Radon doses in G-Tunnel are not claimant favorable. Gravel Gertie radon doses are not discussed, and could be substantial. (Site status of Gravel Gertie workers needs clarification.)	NIOSH has addressed G-Tunnel issue. Clarification is needed on Gravel Gerties.	NIOSH should clarify whether Gravel Gerties were entered in the post-1992 period. If not, this issue is resolved.
13	10	Environmental doses due to I-131 venting need to be taken into account for non-monitored workers.	NIOSH's method for estimating I-131 exposure due to Baneberry venting does not appear to be claimant favorable. A similar approach for other ventings may also underestimate dose.	Development of a method for assigning more claimant-favorable partial I-131 doses appears to be warranted.
14	11	There are no internal monitoring data until late 1955 or 1956; some Pu from then on; some tritium from 1958; Pu, T, and mixed fission products from 1961; and full radionuclide coverage established in about 1967. The TBD does not provide significant guidance for estimating internal dose for the pre-1967 periods for many radionuclides.	This issue has been resolved, due to granting of the SEC up to the end of 1992. NIOSH uses available individual internal dose data for partial dose estimation.	This issue can be closed.
15	12 (details in Section 5)	Resuspension of radionuclides by the blast wave, fractionation of relatively non-volatile radionuclides, and the variability of Cs-137 to Sr-90 ratios need to be taken into account in internal dose estimation.	See matrix comment 5 above.	See matrix comment 5 above.

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Table 1. Summary NTS Site Profile Matrix Update

Comment Number	Report Section	Issue Description	Status	SC&A Preliminary Conclusions
16	13	Use of photon dose, as done by Defense Threat Reduction Agency (DTRA), as the basis for estimating internal dose during periods when there are no data or scattered internal monitoring data has significant uncertainties. These uncertainties are compounded by the data integrity issue associated with NTS (see comment 20 below).	This issue has been resolved by the granting of the SEC.	This issue can be closed.
17	14	Ingestion doses need to be better evaluated.	NIOSH had suggested the use of ORAUT-OTIB-0018. This is not applicable to outdoor NTS work.	NIOSH should consider partial ingestion dose estimation based on resuspension models. See Section 5 above.
18	15	Recommended use of ORAUT-OTIB-0002 for post-1971 tunnel re-entry workers is contrary to guidance in that document, and its scientific validity has not been established. Its use may not be satisfactory even with restrictions, for instance for reactor testing early re-entry workers.	This issue has been resolved by the granting of the SEC.	This issue can be closed.
19	16	There are no beta dose data until 1966; the TBD does not specify a procedure for estimating pre-1966 beta dose. When the approach is developed, the large hot-particle issue will need to be taken into account.	NIOSH suggests the use of beta:gamma ratios. SC&A agrees in principle, but some suggested ratios may not be claimant favorable.	Review of the beta:gamma ratios suggested by NIOSH appears to be warranted.
20	17	There appears to have been intentional non-use of badges in some circumstances to avoid approaching or exceeding operational dose limits. The practice may have occurred until the mid-1960s or even extended into the 1970s. NIOSH has not investigated this problem, which raises questions on the integrity of the external dose record possibly into the 1970s, which need to be explicitly addressed.	This issue was extensively researched and discussed during the SEC review process.	In SC&A's view, this issue can be closed.
21	18	The TBD does not contain information about extremity dosimetry. Site status of bomb assembly workers is unclear.	According to NIOSH, there were no claims of device assembly workers involving extremity cancers as of 2007.	An update of claims with non-covered cancers to check whether there are still no extremity cancer claims through 2012 would be useful.

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Table 1. Summary NTS Site Profile Matrix Update

Comment Number	Report Section	Issue Description	Status	SC&A Preliminary Conclusions
22	19	There are no neutron dose data until 1966, and partial data until 1979. TBD assertion that neutron doses during atmospheric testing were negligible has not been substantiated and may be in error for some workers.	NIOSH's analysis regarding the low exposure potential for Department of Energy (DOE) and contractor test personnel appeared reasonable. There are still some outstanding questions, e.g. choice of n/p ratios.	Some further review of this issue appears to be warranted on specific points (e.g., n/p ratios for device assembly workers).
23	20 (Details in Section 5)	Adequacy of soil data for estimating resuspension doses needs to be evaluated, for instance in relation to hot spot detection and Pu soil data.	See matrix comment 5 above.	See matrix comment 5 above.
24	21	The presence of high-fired oxides resulting from atmospheric weapons testing and reactor testing needs to be investigated.	This issue has been resolved due to the granting of the SEC.	This issue can be closed.
25	22	NOISH documentation of site expert interviews is inadequate, and crucial site expert interviews have not been performed or performed in an incomplete manner, notably Barton Hacker and [Redacted]. Potentially critical archives and documents have not been reviewed, including the NRDL and Barton Hacker primary reference materials.	NIOSH has extensively modified its interview documentation approach.	This issue is now part of Worker Outreach review.
26	23	A number of issues in relation to waste handling, decommissioning, and other post-1992 site activities were reviewed by SC&A in SC&A 2005 or during the SEC review.	This is a new matrix comment. It has been added to this matrix update as a placeholder for WG discussion.	

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1.0 RADIONUCLIDE LISTS

1.1 MATRIX COMMENT 1, FINDING 1 IN SC&A 2005

Some radionuclide lists are not complete. This is especially important for atmospheric testing and for early re-entry workers. [SC&A 2006]

This matrix entry was based on Finding 1 in the SC&A TBD review. Details relating to this finding can be found in Section 5.1 of SC&A 2005.

1.2 NIOSH'S RESPONSE TO MATRIX COMMENT 1

NTS TBD Table 2-2 has been revised to include Cl-38, Al-28, and Sc-46. Other NTS TBD tables that identify radionuclides of concern were reviewed, but no additional changes were made to the TBD. [Addressed in NTS-2 Rev. 01, Table 2-2.]

REECo reported radionuclides for identification or dose concern versus the time after a test for various operations (REECo 1993). These radionuclide lists may not be comprehensive, but the lists have been reproduced in this TBD as published by REECo because they reflect REECo's historical account of the radionuclides of concern during the testing era.

Table 2-8 has been removed from the TBD. Because of the Special Exposure Cohort (SEC) petition for workers involved in atmospheric testing, NIOSH believes adding additional information to Tables 2-3 and 5D-13 is not appropriate at this time. [NIOSH 2007b]

1.3 DISCUSSION

A part of the SC&A review related to radionuclide lists needed for external dose (Table 2-2) and a part related to internal dose estimation. As noted in the NIOSH comment quoted above, the revised site description includes an expanded Table 2-2 of concern (ORAUT 2008a, Table 2-2, pp. 30–32). Specifically, NIOSH added the three radionuclides noted above in Section 1.2 in response to the SC&A site profile review.

NIOSH did not revise Tables 2-3 and 5D-13. The latter relates to internal dose. Infeasibility of internal dose estimation was the reason that NIOSH recommended the SEC for the atmospheric testing period (NIOSH 2006, pp. 3–4). Hence, it was appropriate to not revise it.

As noted in SC&A 2005, Table 2-3 is basically sound. Its use for external dose estimation only needs consideration of decay times, which can be considered by the dose reconstructor; it would have been helpful to add that information in the revised site profile, but not necessary.

NIOSH has not explained why it deleted Table 2-8 from the revised site profile. For comments on Table 2-8, see discussion on Comment 5 (Finding 6) below.

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1.4 PRELIMINARY STATUS AND CONCLUSION

NIOSH has responded to the SC&A finding, except as may relate to the environmental occupational dose, which is covered under Comment 5 below.

SC&A's preliminary conclusion is that no further work on this issue is needed and that any review should be in the context of Section 5 below.

2.0 HOT PARTICLES FROM REACTOR TESTING

2.1 MATRIX COMMENT 2 IN SC&A 2006 (FINDING 2, IN SC&A 2005)

TBD does not provide adequate guidance for dose estimation to gonads, skin, and GI tract for early reactor test re-entry personnel. Large hot-particle doses to skin and GI-tract have not been evaluated. Naval Radiological Defense Laboratory documents and models have not been evaluated, though one document is referenced. [SC&A 2006]

The above matrix entry was based on Finding 2 in SC&A 2005. Details on this finding can be found in Sections 5.2 and 7.1.1 of SC&A 2005. Section 5.2 contains the technical discussion; Section 7.1.1 refers to data sources that were used or not used in the preparation of the 2004 site profile. It includes some suggestions regarding additional NRDL data sources that could be reviewed.

2.2 NIOSH RESPONSE

The dose estimation methods and models described in Hazards To Personnel Re-entering the Nevada Test Site Following Nuclear Reactor Tests, NRDL-TR-68-149 (NRDL 1968), have been evaluated for their usefulness and application to the NIOSH dose reconstruction process for personnel participating in re-entry operations at the NTS. The dose models in the NRDL report are applicable only to the relatively small population of NTS workers that were involved in re-entry operation following a nuclear propulsion rocket test at the Nuclear Rocket Development Station (NRDS). The data are experiment specific and require knowledge of specific physical parameters. It would be difficult to use these models for other NRDS experiments/re-entries since the empirical data necessary to develop the curves and tables for other events would be intractable from existing NTS records.

The NRDL report provides methods of computing doses from both individual particles and infinite field contamination levels from the nuclear rocket tests. The model provides methods for calculating doses to the lungs, GI tract, skin, and gonads for particular exposure scenarios. If a claimant who participated in NRDS nuclear rocket re-entries has a covered cancer in a location where a hot particle exposure has been documented, and the claimant can be associated with a specific test, and the requisite physical parameters for the test are available from NTS records, Dose reconstructors may consider using the models and methods in the NRDL report. If this information is not available for NRDS

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workers, external exposures can be addressed through the procedures outlined in the Interpretation of Dosimetry Data for Assignment of Shallow Dose (ORAUT-OTIB-0017 [ORAUT 2005a]), the External Dose Reconstruction Implementation Guide (OCAS-IG-001 [OCAS 2007]), and the VARSKIN model. Internal exposures for these workers can be addressed through procedures outlined in the Internal Dose Reconstruction Implementation Guide (OCAS-IG-002 [OCAS 2002]) and the ORAU IMBA EXPERT codes.

When factual information is provided, in dosimetry records or the telephone interview, that a claimant who participated in NRDS nuclear rocket re-entries has a covered cancer in a location where a hot particle exposure has been documented, and the claimant can be associated with a specific test, and the requisite physical parameters for the test are available from NTS records, Dose reconstructors may consider using the models and methods in the NRDL report. Otherwise, NIOSH will not speculate on the potential internal exposure scenarios from large hot particles.

[Addressed in NTS-5 Rev. 01, Section 5.6.5.3 and NTS-6 Rev. 01, PC-1, Sections 6.5.1 and 6.5.2] [NIOSH 2007b]

NIOSH also cited the following from an expert interview:

NTS-6 Rev. 01 was in draft and was approved before the information could be added. The NRDS information regarding [word(s) missing here in the NIOSH original] was incorporated as a page change revision. An interview record with [EE], former NTS (NRDS) and DOE health physicist is also available. [The EE's] expert account clearly demonstrates that radiological monitoring (contamination surveys, whole body counting) methods were in place which would have easily detected hot particles and that stringent access control practices were implemented to protect personnel from external exposures. [NIOSH 2007b]

2.3 DISCUSSION

So far as internal dose is concerned, NIOSH recommended SECs (SEC-00055 and SEC-00084) based on infeasibility of internal dose reconstruction with sufficient accuracy. These SECs include the reactor testing period between 1959 and 1973 (ORAUT 2008a, pp. 46–47 and pp. 64–78). The Advisory Board accepted NIOSH's recommendations. However, NIOSH accepts the use of the NRDL model when it can be established that a worker participated in the reactor tests and when there was evidence of exposure. As a result, the possibility arises of estimating partial internal doses for non-presumptive cancers, such as cancer of the larynx, and partial external doses for non-presumptive cancers, such as skin cancer. However, in the procedure suggested by NIOSH, the worker's documentation would have to be sufficient to place them at a particular reactor test, as indicated by NIOSH's response quoted above. However, in Rev. 1 of the external occupational dose site profile, NIOSH indicated that worker records would not normally contain such information, barring exceptional circumstances:

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*Hot particle exposure is not easily identified because, in general, the dosimeter response cannot be used to distinguish between a hot particle exposure from a distributed radiation field exposure [11]. Because workers were normally monitored with hand-held survey instruments when leaving a radiation area, it was most likely that hot particles would be detected during this monitoring process. If such particles were detected, the worker would be asked to go through a decontamination procedure, including removal of outer clothing and showering as necessary (Allen and Schoengold 1995). **However, it is not likely that such incidents would be entered in the dosimetry record unless the conditions were unusual (e.g. very high count rates).***

Endnote [11]: Griffith, Richard V. ORAU Team. Principle [sic] Consultant. February 2007. *A hot particle is essentially a point source of radiation. If that particle is not deposited directly on the dosimeter, the radiation field from the particle spreads so that the dosimeter cannot distinguish between the radiation field from the particle and that from a distributed source. Therefore, a hot particle that was deposited on the body at even a small distance from the dosimeter could not be identified.*

Unless hot particles are detected shortly after deposition using survey instruments, they will be removed by normal washing or change of clothes, and their exposure will not be recorded. Without a specific entry in the dosimetry record, the only evidence, if the hot particle exposure is high enough, could be subsequent formation of a lesion at the deposition site [12].

Endnote [12]: Griffith, Richard V. ORAU Team. Principle [sic] Consultant. February 2007. *Hot particles will be removed in a short time (usually less than a day) after deposition on the body or clothing by washing or removal of the clothing. Once the particle has been removed, there is no way of knowing that it had been deposited unless associated radiation damage to the skin and underlying tissue manifested itself as an area of physical damage or a lesion.*

*The dose reconstructor should be aware of the possibility of external exposure from hot particle deposition and document positive indications in the claimant's dose or medical record that can be reasonably associated with hot particle deposition. Hot particle deposition issues should be addressed consistent with project guidance on assigning shallow dose. [ORAUT 2007b, pp. 24–25]
[Emphasis added]*

In its draft working paper, which reviewed some parts of Rev. 1 of the external occupational dose site profile, SC&A had made comments about the problem of a lack of records and the restriction of assignment of hot particle dose to workers who could be identified from their records as having had exposure:

The instruction to the dose reconstructor to rely on claimant dose records appears contradictory to the statement that those records are unlikely to contain the data required under most hot particle exposure conditions. Further, NIOSH has provided no examples of unusual conditions in which data would have been entered into employee records. [SC&A 2007, p. 3]

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NIOSH has not addressed in the post-SEC context how workers might be assigned partial internal and/or external hot particle doses in claimant-favorable ways, given that worker records may be incomplete in terms of placing them in hot particle fields during the tests.

Furthermore, in its 2005 review of the NTS site profile, SC&A had recommended review of NRDL documents as well as references provided in the official history of this testing period (Hacker 1994) – see Section 7.1.1 in SC&A 2005. However, Hacker 1994 was not referenced in Rev. 1 or Rev. 2 of the external occupational dose site profile (ORAUT 2007b; ORAUT 2010c).

SC&A also notes that the expert that NIOSH relied on regarding lack of hot particle contamination was there for only part of the reactor testing period (Rollins 2007a). Even if this expert interview presents a complete account of the period for which the expert had direct knowledge, some reactor tests occurred outside this period, such as those prior to 1966. Some of those tests had important failures, such as the fuel element ejection during the 1962 KIWI-B1B (ORAUT 2008a, p. 70).

2.4 STATUS AND CONCLUSIONS

NIOSH has been partially responsive to SC&A comments in that the potential utility of the NRDL model has been recognized. However, NIOSH has not yet fully addressed the issue of locating the workers in the hot particle fields of specific reactor tests. This issue could be particularly important for workers in reactor tests who have non-presumptive cancers, such as skin, larynx, and male genitalia. Some review of this issue to ensure that partial dose assignments are made in a claimant-favorable manner so far as possible appears to be warranted.

3.0 HOT PARTICLES FROM ATMOSPHERIC WEAPONS TESTING

3.1 MATRIX COMMENT 3 IN SC&A 2006 (FINDING 3 IN SC&A 2005)

Doses from large (non-respirable) particles to GI tract and skin for workers in the early atmospheric test period have not been evaluated. These doses could be high. Hot-particle doses also need to be evaluated for early drillback and other early re-entry workers during underground testing periods. [SC&A 2006]

This finding is discussed in Section 5.3 of SC&A 2005. We note here that SC&A did not evaluate the hot particle issue for nuclear weapons testing, but raised it by analogy with reactor testing and the potential for similar phenomena in nuclear weapons testing. In light of that, SC&A recommended “screening calculations by NIOSH to determine the relevance and scope of the issue.” (SC&A 2005, p. 30).

3.2 NIOSH RESPONSE

*As described in the NRDL 1968 report, models developed for re-entry personnel supporting nuclear propulsion reactor test at the NRDS **are not** applicable to dose estimates for workers associated with atmospheric nuclear tests, drillbacks and tunnel re-entries following underground nuclear tests, or the accidental venting of underground nuclear tests. The NTS sampling data, bioassay or*

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*environmental, does not indicate that hot particles were an issue at the NTS other than during the NRDS nuclear rocket test program. Historically the measurement of hot particles was not conducted at the NTS. Although insufficient or non-existent hot-particle data from the NTS makes dose calculations intractable, any **documented** hot-particle NTS external exposures can be addressed through the procedures outlined OTIB-0017, OCAS-IG-001, and the VARSKIN model. Any documented hot-particle internal exposures for these workers can be addressed through the procedures outlined in OCAS-IG-002 and the ORAU IMBA EXPERT codes.*

[Addressed in NTS-5 Rev. 01, Section 5.6.5.3 and NTS-6 Rev. 01, PC-1, Sections 6.5.1 and 6.5.2] [NIOSH 2007b; Emphasis in the original]

3.3 DISCUSSION

NIOSH's statements regarding hot particles due to atmospheric testing appear to be inconsistent. First, NIOSH states that hot particle measurements were "not conducted at the NTS." Second, NIOSH has concluded that, "NTS sampling data does not indicate that hot particles were an issue at the NTS other than during the NRDS nuclear rocket test program." But this statement that hot particles appear associated only with nuclear rocket tests is contradicted by a statement in the most recent revision of the external dose site profile, which states that hot particles were produced during atmospheric testing:

*Highly radioactive particles are produced by some of the operations at NTS (e.g. **atmospheric testing** or reactor operations such as nuclear rocket tests) (NRDL 1968, NCRP 1990). The size of **hot particles contained in nuclear fallout** ranges from 10 nm to 20 μ m for the worldwide fallout (NCRP 1990). Local fallout particles are significantly bigger (100 μ m to several millimeters) (NCRP 1990). **When deposited on skin or clothing, they can produce high levels of localized exposure primarily from beta or alpha particles** (NRDL 1968; NCRP 1990). [ORAUT 2010c, p. 27; Emphasis added]*

It appears to SC&A that the statement about hot particles in atmospheric testing fallout can also be extended to underground tests with serious ventings, such as Baneberry in December 1970.

3.4 STATUS AND CONCLUSIONS

It appears that the issue of hot particle exposure as a result of nuclear weapon tests (notably atmospheric tests and underground tests that vented) is still outstanding for external dose and for oro-nasal breathing, since this would affect some non-presumptive cancers. It would appear useful to examine whether the NRDL model could also be used to calculate partial doses for claimants with non-presumptive cancers.

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4.0 HOT PARTICLE INGESTION

4.1 MATRIX COMMENT 4 IN SC&A 2006 (FINDING 4 IN SC&A 2005)

*Ingestion of **non-respirable** hot particles by reactor testing and nuclear weapons testing workers due to oro-nasal breathing needs to be evaluated. [SC&A 2006]*

This issue is discussion in Section 5.4 of SC&A 2005.

4.2 NIOSH RESPONSE

The health physicist from NRDS (Bruce Church) was interviewed and indicated that no hot particles were ingested during the rocket testing experiments. This health physicist was responsible for the radiological controls programs during the rocket testing period and operated the whole body counter.

The dose estimation methods and models for nuclear reactor tests in the NRDL report (NRDL 1968) have been evaluated for their usefulness and application to the NIOSH dose reconstruction process for personnel participating in re-entry operations at NTS. The dose models in the NRDL report are applicable only to the relatively small population of NTS workers that were involved in re-entry operation following a nuclear propulsion rocket test at the NRDS. The data are experiment specific and require knowledge of specific physical parameters.

The NRDL report provides methods of computing doses from both individual particles and infinite field contamination levels from the nuclear rocket tests. The model provides methods for calculating doses to the lungs, GI tract, skin, and gonads for particular exposure scenarios. If a worker who participated in NRDS nuclear rocket re-entries has a covered cancer in a location where a hot particle exposure has been documented, and the worker can be associated with a specific test, and the requisite physical parameters for the test are available from NTS records, Dose reconstructors may consider using the models and methods in the NRDL report. If this information is not available for NRDS workers, internal exposures can be addressed through OCAS-IG-002 and the IMBA EXPERT codes.

[Addressed in NTS-5 Rev. 01, Section 5.6.5.3.] [NIOSH 2007b]

4.3 DISCUSSION

The discussion of this issue is the same as that in Sections 2.3 and 3.3 above.

4.4 STATUS AND CONCLUSIONS

It may be possible to calculate partial doses for certain non-presumptive cancers, such as oral cavity cancers, as discussed in Sections 2 and 3 above, even though the SEC has been granted on internal dose grounds. The investigation of this issue will depend on how the WG decides to address matrix comments 2 and 3 above.

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5.0 RADIONUCLIDE RESUSPENSION

5.1 MATRIX COMMENTS 5, 6, 7, 15, AND 23 IN SC&A 2006 (FINDINGS 6 AND 12 IN SC&A 2005)

Three comments in the matrix are related to Findings 6 and 12 in SC&A 2005. A fourth comment, number 23, also related to the same finding, though it is not called out as such in the matrix. NIOSH responded to all four with the same comment in the matrix. NIOSH also included matrix comment 15 in this response, which related to a different SC&A finding (Finding 12). All five matrix items are discussed in this section.

Comment 5:

Resuspension model and resuspension factor are not scientifically defensible or claimant favorable, due to a variety of factors. Doses may be underestimated by an order of magnitude or more. Mass-loading approach would be preferable for internal dose. [SC&A 2006]

It was discussed in Section 5.5.2 of SC&A 2005.

Comment 6:

The use of the site average air concentration values when worker location is not known is not claimant favorable. Largest value consistent with job-type data should be used in such cases.

It was discussed in Section 5.5.2.5 in SC&A 2005.

Comment 7:

Resuspension doses to monitored workers, especially early re-entry workers, may be underestimated, due to the presence of short-lived radionuclides and higher resuspension expected in the days and months after a test (including safety tests). TBD does not specify procedures for estimating environmental internal doses in such cases.

It was discussed in Section 5.5.2.6 in SC&A 2005.

Comment 15 (Finding 12 in SC&A 2005):

Resuspension of radionuclides by the blast wave, fractionation of relatively non-volatile radionuclides, and the variability of Cs-137 to Sr-90 ratios need to be taken into account in internal dose estimation. [SC&A 2006]

It was discussed in Section 5.6.3 of SC&A 2005.

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Comment 23 (Finding 6, SC&A 2005):

Adequacy of soil data for estimating resuspension doses needs to be evaluated, for instance in relation to hot spot detection and Pu soil data

It was discussed in Sections 5.5.2.1, 5.5.2.2, and 6.1 in SC&A 2005.

5.2 NIOSH RESPONSE

A white paper Ambient Environmental Intakes at the Nevada Test Site Based on Air Sampling and Soil Contamination Data was prepared by Gene Rollins [Rollins 2007b] and has been incorporated into the TBD. Fission and activation product correction factors by year are included.

[Addressed in NTS-4 Rev. 01, Sections 4.2.1.2.6 and 4.2.2] [NIOSH 2007b]

The relevant attachment (Attachment A) to Rev. 1 of the Occupational Environmental Dose section of the site profile (ORAUT 2008b) was carried over into Rev. 2 (ORAUT 2010a, Attachment A).

5.3 DISCUSSION

The intake due to resuspension of previously deposited radionuclides was among the issues discussed in great detail during the 2006–2009 review of site profile and SEC issues. This review included preparation of papers by SC&A and NIOSH, as well as revisions of the environmental occupational dose section of the site profile. The following list summarizes the major points in the discussions, which are documented in papers, as well as in the transcripts of the NTS WG meetings in the 2006–2009 period.

- SC&A prepared a paper on resuspension elaborating on the problems found in the site profile and recommending approaches to intake estimation (Anspaugh 2006). In particular, this paper suggested that a mass loading model was more appropriate than using resuspension coefficients for times more than 2 years after the initial radionuclide deposition.
- NIOSH developed and published a mass loading model in response to SC&A's review of the issue (NIOSH 2007c). SC&A prepared a brief response (Anspaugh 2007).
- NIOSH also developed a model based on estimating resuspension intakes using measured air concentration data (Rollins 2007b). This new model replaced the mass loading model and was incorporated into Rev. 1 of the Occupational Environmental Dose volume of the site profile (ORAUT 2008b, Attachment A).
- SC&A published a review of ORAUT 2008b (Anspaugh 2008). This was discussed extensively at the NTS WG meeting held on October 29, 2008 (ABRWH 2008).
- NIOSH revised its occupational environmental dose site profile (ORAUT 2010a) to reflect the fact of the SEC having been granted, but mostly left Rev. 1 (ORAUT 2008b) unchanged. The air concentration model was carried over into Rev. 2 of the document (ORAUT 2010a, Attachment A).

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NIOSH responded to a number of SC&A comments made during its review or during WG discussions, such as adjusting for decay and selective deposition of refractory radionuclides. During the WG discussions, SC&A raised some questions about the choice of soil contamination values and, for some situations, such as the omission of Area 30 soil data (ABRWH 2007a, p. 20, for instance) and higher values for resuspension with higher mass loading values for short periods of time (ABRWH 2007b, p. 46, for instance) that are still not fully addressed.

During WG discussion of SC&A's review of Rev. 1 of the occupational environmental dose site profile (ORAUT 2008b), NIOSH stated that occupational environmental doses were not meant to be applied to workers in the field. For these cases, NIOSH proposed to apply an occupational internal dose, either by using bioassay measurements or applying a coworker model. Occupational environmental dose was meant to be applied to situations where workers were not in areas where testing or test preparations were being carried out (ABRWH 2008, pp. 150–184).

Finally, SC&A notes that the revised ER stated that environmental occupational dose could be calculated on a claimant-favorable basis for NTS workers (NIOSH 2010, pp. 65–66).

5.4 STATUS AND CONCLUSIONS

The NTS SEC-00084 for the period January 1, 1963, to December 31, 1992, was granted on the grounds of infeasibility of estimating internal dose with sufficient accuracy (NIOSH 2010). In reviewing the extensive and complex record, it appears to SC&A that NIOSH and SC&A were in agreement that occupational environmental dose can be estimated. Therefore, it appears to SC&A that this is a site profile issue that could be used to calculate partial doses for non-covered cancers.

The most recent version of the occupational environmental dose site profile does not address some of the issues raised in Anspaugh 2008 and the subsequent WG discussion in October 2008 (ABRWH 2008) for estimating partial doses for non-SEC cancers. It would therefore appear to merit review.

6.0 EXTERNAL DOSE ESTIMATION FOR 1963–1966 AND 1968–1976

6.1 MATRIX COMMENTS 8 AND 9 IN SC&A 2006 (FINDING 7 IN SC&A 2005)

There were two matrix comments relating to Finding 7 in SC&A 2005 that NIOSH responded to with a single comment. They are covered together in this section.

Matrix comment 8 stated:

Use of 1967 external dose data for 1963–1966 is not claimant favorable. There was no test in 1967 with measurable offsite fallout. Relatively short-lived radionuclides, which were likely present in 1963–1966, would have substantially decayed away by 1967.

It was discussed in Section 5.5.3.3 in SC&A 2005.

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Matrix comment 9:

Lack of environmental external dose data for 1968–1976 is puzzling. TBD has not specified an approach to estimating external environmental dose for this period. Venting in the 1968–1970 period likely made external dose in that period (and possibly beyond) higher than 1967.

It was discussed in Section 5.5.3.4 in SC&A 2005.

6.2 NIOSH RESPONSE

Unexposed control films and thermoluminescent dosimeters (TLDs) were processed with personnel dosimeters and the readings from these control dosimeters were subtracted from the personnel dosimeter readings to obtain a net reading for determining exposure. Beginning on April 1, 1957, all employees entering the NTS were required to wear dosimeters while inside the NTS. Because the control dosimeters were maintained in environmentally controlled, low background areas (e.g., Building 111 in Mercury), exposure resulting from elevated ambient environmental levels from testing activities in other areas of the site would have been included in the individual exposure records. The assignment of ambient external dose will be consistent with ORAUT-PROC-0060, Occupational Onsite Ambient Dose Reconstruction for DOE Sites. With regard to additional analysis, NIOSH does not believe that a test-specific analysis is required to assure that ambient environmental dose has not been underestimated for noncompensable cases and would also be of little values [sic] for best estimate and compensable cases. Ambient doses no longer assigned after 1957 due to capture by universal badging/personal dosimetry.

[Addressed in NTS-6 Rev. 01, PC-1, Section 6.3.1.] [NIOSH 2007b]

Note that the pre-1963 external dose issue is covered in the next section.

6.3 DISCUSSION

NIOSH issued a revision of its external dose site profile for NTS in July 2007 (ORAUT 2007b). SC&A provided the WG with a review of this document in October 2007 (SC&A 2007). However, SC&A’s review did not cover all external dose issues. Specifically, it did not cover matrix comments 8 and 9 being discussed in this section.

However, as noted by NIOSH above, occupational environmental dose is not assigned after 1957 “due to capture by universal badging/personal dosimetry.” This is reaffirmed in the most recent external dose volume of the site profile (ORAUT 2010c, p. 45).

6.4 STATUS AND CONCLUSIONS

It appears that the NIOSH statement that all workers had external monitoring coverage after 1957 resolves this issue. SC&A checked an AEC reference from 1961 to verify this and it does state that “[a]ll personnel entering NTS must wear a current gamma-measuring film badge”

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(AEC 1961, pdf p. 11). Therefore, the issue of assignment of external environmental dose would appear to be covered; no further review appears to be needed. [The issues of (1) exposure geometry and (2) workers removing their badges or leaving them behind are addressed in Sections 8 and 17 below, respectively].

7.0 PRE-1963 EXTERNAL DOSE

7.1 MATRIX COMMENT 10 IN SC&A 2005 (FINDING 7 IN SC&A 2005, SECTION 5.5.3.5)

The TBD does not provide any guidance for pre-1963 external environmental dose. Issues relating to unmonitored workers, as well as time of entry into contaminated areas, could be important. [SC&A 2006]

7.2 NIOSH RESPONSE

All personnel entering the NTS were badged after April 1, 1957. Because the control dosimeters were maintained in environmentally controlled, low background areas (e.g., Building 111 in Mercury), exposure resulting from elevated ambient environmental levels from testing activities in other areas of the site would have been included in the individual exposure records after this date. NIOSH agrees that guidance for pre-1957 external environmental dose is needed for unmonitored workers with cancers that are not covered in the SEC petition. NTS-6, Rev. 00, PC-2 incorporated coworker data to assist in the estimation of external dose prior to universal badging in April 1957 for unmonitored workers. NTS-6, Rev. 01, PC-1 extends the coworker beyond 1957.

[Addressed in NTS-6 Rev. 00, PC-2, Section 6.4.1.1 and NTS-6 Rev. 01, PC-1, Section 6.4.1.1.] [NIOSH 2007b]

7.3 DISCUSSION

As noted in Section 6.3, this issue is addressed for the period from 1957 to 1962 by the requirement of universal badging. Prior to this period, NIOSH proposes to assign the 50th percentile of monitored worker external dose to unmonitored workers (ORAUT 2010c, p. 45 and Table 6-11 on p. 46). However, Table 6-11 would assign doses as low as 0.001 rem (in 1954 and 1957). The underlying reference, Allen and Schoengold 1995, provides the range of detection for the various film badge elements used in the period up to 1957. The film element with the lowest range was the DuPont film element 502 with a range of 0.05 to 10 R in the first tests (1951) and 0.02 to 10 R in the tests after that (Allen and Schoengold 1995, pp. 6-7). It is difficult to reconcile the suggested dose assignments, notably for 1954, 1955, and 1957, with the minimum detection limits specified for dosimetry at the time. Specifically, film badge dosimetry used in atmospheric nuclear tests was extensively evaluated in a 1989 National Research Council publication (NRC 1989). For example, during Operation UPSHOT-KNOTHOLE (NRC 1989, p. 132), the Type 502 film badge was assessed with the MDL of 0.04 R (or 40 mR) and with a 95% confidence limit for deep-dose equivalent of 0.00 to 0.08 rem (0 to 80 mrem).

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Given the MDL of 40 mrem, it appears that the reported 50% values in Table 6-11 correspond to recorded values from which the MDL value of 40 mrem had been subtracted. For example, SC&A interprets this to mean that for the 50% dose of 1 mrem identified for 1957, a monthly unmonitored dose of 41 mrem ($1 + 40 = 41$) should be assigned and for 1956, 66 mrem ($26 + 40 = 66$).

7.4 STATUS AND CONCLUSIONS

SC&A has not reviewed the pre-1957 dose assignment suggested by NIOSH. The preliminary review that was done for preparing this matrix update indicates that the NIOSH values may reflect subtraction of the MDL, though this is not a definitive conclusion. A NIOSH clarification on how the values were derived is needed. Review of the values may be warranted to ensure that the values in Table 6-11 of ORAUT 2010c are claimant favorable.

8.0 EXTERNAL ENVIRONMENTAL DOSE CORRECTION FACTORS

8.1 MATRIX COMMENT 11 IN SC&A 2006 (FINDINGS 7 AND 13, SECTIONS 5.5.3.6 AND 5.7.6 IN SC&A 2005).

Correction factors for external environmental dose due to geometry of organ relative to badge, and angular dependence of the dose conversion factor need to be developed. [SC&A 2006]

8.2 NIOSH RESPONSE

Correction factors for external environmental dose were evaluated with respects [sic] to 1) angular or directional dependence of the dosimeter, 2) angular or directional dependence of the dosimetric quantity used for monitoring purposes, and 3) the dose of specific organs relative to the dosimeter. Results of the calculations show that the correction factors for external exposure environmental radiation fields found at the NTS are not significantly different from unity. For most organs, these values are less than 1. Given the low environmental external exposure rates at NTS, it appears that the new DCFs would not have a significant impact on the assigned environmental doses, in comparison to the NIOSH claimant-favorable dose estimates. NIOSH has evaluated the time dependence of the photon energy spectrum for certain cohort groups involved in early re-entry activities. However, NIOSH does not believe that development of time dependence of the photon energy spectrum for individuals not included in these cohort groups would be of value. Therefore, the claimant favorable assumption is made that the photon energy range is 100% 30 to 250 keV in non-compensable cases. When minimizing or providing a best estimate dose, the photon energy range assumption is 25% 30 to 250 keV and 75% >250 keV. Summary guidance was added to the TBD. [Addressed in NTS-6 Rev. 01, Sections 6.3.5.1 and 6.4.1.6 and Attachment B.]

NIOSH agrees that an assessment of job types may be necessary to determine which ones need correction factors for angular dependence and geometry

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considerations. A worker category job matrix was added to the TBD. [Addressed in NTS-2 Rev. 01, Attachment C.] [NIOSH 2007b]

8.3 DISCUSSION

NIOSH has provided a table of the photon energy spectra to be used by job type in the external dose site profile volume (ORAUT 2010c, Attachment B). Our initial review indicates that NIOSH's groupings of photon fractions and adjusted photon fractions in the energy groupings in Attachment B are based on OCAS-IG-001 (NIOSH 2007d). However, fallout from weapons tests contains a complex mixture of gamma/x-ray energies that range up to 1800 keV and do not necessarily correspond with the groupings in NIOSH 2007d. As a result, SC&A questions NIOSH's selection of photon energy groupings and assumptions regarding their adjustment factors.

NIOSH has also addressed the effect of geometry of exposure for underground tests with significant venting of radioactivity by referring to the calculations in Griffith 2007. NIOSH concluded that these calculations indicated that the correction factors would "not have a significant impact on assigned dose." NIOSH has restated what is in the quote above in the most recent version of the external dose site profile:

Results of these calculations (Griffith 2007) show that the correction factors for external exposure environmental radiation fields found at the NTS are not significantly different from unity for most organs, and, in most cases, these values are less than 1. Given the low environmental external exposure rates at NTS, it appears that the new DCFs would not have a significant impact on the assigned environmental doses in comparison to the NIOSH dose estimates that are favorable to claimants. [ORAUT 2010c, p. 50]

While the NIOSH statement quoted above is generally true, the correction factors for skin dose are significant and would increase dose by several fold in many cases, and by more than a factor of 10 in some cases for ground plane geometry. The highest correction factor, for the Buster Charlie test, was estimated in Griffith 2007 to be 54 (Griffith 2007, Table 6). Since skin cancer is a non-covered cancer, the use of the correction factors during the atmospheric testing period and for tests with significant venting may make a material difference to estimated dose.

Furthermore, NIOSH has not provided a comparable set of correction factors to those in Griffith 2007 for the atmospheric testing period by test. In reviewing the correction factors for skin dose for underground tests that vented, it is possible that the correction factors for atmospheric tests would also be significant for skin dose.

Finally, NIOSH has not yet assessed job types, "to determine which ones need correction factors for angular dependence and geometry considerations." In the quote above, NIOSH noted that such an assessment "may be necessary."

8.4 STATUS AND CONCLUSIONS

Our initial review of NIOSH's photon energy spectra and groupings indicates that these groupings and the corresponding dose conversion factors (DCFs) selected by NIOSH may need

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review. Furthermore, NIOSH's conclusion that correction factors for external environmental dose would not make a significant difference does not appear to be valid in some cases, notably for skin dose. As a result, SC&A concludes that some aspects of NIOSH's conclusions of external environmental dose need review.

9.0 G-TUNNEL RADON DOSE

9.1 MATRIX COMMENT 12 IN SC&A 2006 (FINDING 8 IN SC&A 2005)

Radon doses in G-tunnel are not claimant favorable. Gravel Gertie radon doses are not discussed, and could be substantial. (Site status of Gravel Gertie workers needs clarification.) [SC&A 2006]

9.2 NIOSH RESPONSE

Radon doses and guidance to dose reconstructors regarding Gravel Gerties were updated in the TBD. [Addressed in NTS-4 Rev. 01, Sections 4.4.3 and 4.4.4.] [NIOSH 2007b]

9.3 DISCUSSION

Section 4.4.4 of the latest environmental dose volume of the NTS site profile discusses radon doses (ORAUT 2010a). NIOSH has fully addressed SC&A's concerns in its revised analysis for the G-Tunnel, as well as for workers whose location is not known.

NIOSH has also discussed the issue of radon concentrations in the Gravel Gerties. No radon measurements were made:

Although radon measurements are not available inside the NTS Gravel Gerties, because of the similarities of construction, application of the radon concentrations measured inside the Pantex Gravel Gerties is assumed to be appropriate. [ORAUT 2010a, p. 39]

The use of surrogate data from another site for radon exposure is questionable, since radon concentrations are highly variable even within a relatively small area, let alone from one state to another. However, this point may not be material in the present instance, since radon essentially affects only lung dose and lung cancer is covered under the SEC that has been granted. Furthermore, NIOSH has noted that, "with the cessation of testing in 1992, these Gravel Gerties have not been activated for device assembly" (ORAUT 2010a, p. 39).

9.4 STATUS AND CONCLUSIONS

This issue appears to have been rendered moot by the SEC and by the cessation of testing. NIOSH should clarify that the term, "have not been activated for assembly," means that workers did not enter the Gravel Gerties after the cessation of testing. If they did enter the Gravel Gerties, then the radon issue would remain open for the post-SEC period.

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10.0 I-131 ENVIRONMENTAL DOSES

10.1 MATRIX COMMENT 13 IN SC&A 2006 (FINDING 10, SC&A 2005 SECTION 5.5.5)

Environmental doses due to I-131 venting need to be taken into account for non-monitored workers. [SC&A 2006]

10.2 NIOSH RESPONSE

NIOSH has developed guidance for workers that bounds potential organ doses from I-131 exposures. Based on the ratios found in NTS-5 Rev. 01, Table 5-13 and the highest concentration measured in Area 12 Camp after the Baneberry release, an example calculation was incorporated in the TBD. These values can be assigned to an individual identified as being present during Baneberry. Similar calculations can be performed for other test releases where air concentration data are available and when an I-131 intake is suspected based on the records provided by DOE.

[Addressed in NTS-5 Rev. 01, Section 5.3.3.1.] [NIOSH 2007b]

NIOSH carried forward the same calculation to the latest version of the internal dose volume of the site profile (ORAUT 2010b, p. 40).

10.3 DISCUSSION

Iodine internal exposures mainly affect the thyroid and thyroid cancer is a covered cancer. External doses from tests that vented have been covered under a different matrix comment (see Section 8 above). Since there is a measurement available, partial I-131 doses could be assigned for non-covered cancers. NIOSH's description of the calculation is as follows:

A calculation based on the maximum iodine concentration for any event (i.e. Baneberry venting December 1970) provides an indication of the potential dose during a release. A concentration of 1.85E-12 $\mu\text{Ci/cc}$ was measured at Camp 12 on December 24, 1970, resulting in a calculated value of 3.1E-12 $\mu\text{Ci/cc}$ on December 18, 1970, the day of the venting. Assuming a breathing rate of 20 L/min and an exposure of 2 hours during the evacuation of the site, an intake of 7.44E-6 μCi is reasonable and results in a dose of less than 1 mrem to the thyroid. [ORAUT 2010b, p.40]

However, this NIOSH calculation for Baneberry appears to significantly underestimate the concentration that would have been experienced by workers who were caught in the event. The radioactive cloud would have long since passed over the NTS by December 24, 1970, since the test was conducted on December 18, 1970. NIOSH has not made any adjustment for this fact, though it has made an adjustment for decay (from the measured 1.85E-12 $\mu\text{Ci/cc}$ to 3.1E-12 $\mu\text{Ci/cc}$). The thyroid dose calculated by NIOSH on this basis is very low—less than 1 millirem. Furthermore, specific attention needs to be given to the fact that the workers who were exposed during the Baneberry event were accidentally caught in the fallout cloud

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(Anspaugh 2008, p. 21 and p. 23). Even potable water was contaminated. SC&A's recommendation in view of these facts was that it would be better to treat Baneberry exposure as an occupational environmental dose (Anspaugh 2008, p. 23).

NIOSH's approach for Baneberry intake estimation is not claimant favorable and does not properly reflect the exposure conditions. It could be revised based on other available information about that event. For instance, an air sample taken at Orange Road on December 18, 1970, was 3.48E-7 $\mu\text{Ci/cc}$ (SRDB 9627). This value is five orders of magnitude greater than the concentration calculated by NIOSH, based on the December 24, 1970, air sample. Another air sample at Gate 300, also taken on December 18, 1970, was 1.17E-7 $\mu\text{Ci/cc}$ (SRDB 9627). This same document, which is untitled and contains only sample data sheets, shows that samples taken on December 24, 1970, were somewhat higher, but clearly much closer to the value of 1.85E-12 $\mu\text{Ci/cc}$ cited NIOSH for that date.

10.4 STATUS AND CONCLUSIONS

This NIOSH dose assignment for I-131 exposure due to Baneberry venting does not appear to be claimant favorable and significantly underestimates doses for those exposed at the time or close to the time of the venting. If a similar method is used for other ventings, doses may be similarly underestimated, depending on the specific measurements proposed to be used. The WG may want to consider whether to review this issue, so that more claimant-favorable environmental intake values may be developed for underground tests that vented large amounts of radioactivity to enable better dose estimates for non-covered cancers.

11.0 INTERNAL MONITORING DATA UNTIL 1967

11.1 MATRIX COMMENT 14, SC&A 2006 (FINDING 12, SC&A 2005, SECTION 5.6.3)

There are no internal monitoring data until late 1955 or 1956; some Pu from then on; some tritium from 1958; Pu, T, and mixed fission products from 1961; and full radionuclide coverage established in about 1967. The TBD does not provide significant guidance for estimating internal dose for the pre-1967 periods for many radionuclides. [SC&A 2006]

11.2 NIOSH RESPONSE

As stated in the SEC petition for workers involved in atmospheric testing, because of the lack of early internal monitoring data, inter alia, NIOSH is unable to estimate with sufficient accuracy, the internal exposures and resulting doses for workers onsite from January 27, 1951, through December 31, 1962. NIOSH also believes that future studies would be unlikely to increase the accuracy of dose reconstruction for individuals involved in atmospheric testing to levels sufficient under EEOICPA and Title 42 CFR 83. Therefore, NIOSH does not intend to conduct investigations related to the lack of internal monitoring data during the early years of atmospheric testing at this time. At the working group meeting, it was agreed upon that our resolution for the NTS internal dose reconstruction

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methodology would be limited to the 1963–1967 timeframe when the available information is limited. Guidance for interpreting gross fission product bioassay and gross alpha bioassay data was added to the TBD. [NIOSH 2007b]

11.3 DISCUSSION

This issue has been rendered moot by the additions to the SEC, which now covers the entire period discussed in this comment.

11.4 STATUS AND CONCLUSIONS

This issue has been resolved.

12.0 BLAST WAVE RESUSPENSION OF RADIONUCLIDES

12.1 MATRIX COMMENT 15 IN SC&A 2006 (FINDING 12, SC&A 2005)

This issue was covered along with matrix comments 5 to 7 and matrix comment 23 in Section 5 above, since NIOSH provided a single response to all resuspension comments.

13.0 USE OF DTRA METHOD FOR INTERNAL DOSE

13.1 MATRIX COMMENT 16 IN SC&A 2006 (FINDING 12 IN SC&A 2005, SECTION 5.6.3)

Use of photon dose, as done by DTRA, as the basis for estimating internal dose during periods when there are no data or scattered internal monitoring data has significant uncertainties. These uncertainties are compounded by the data integrity issue associated with NTS (see comment 20 below). [SC&A 2006]

13.2 NIOSH RESPONSE

This option for assigning internal dose has not been pursued for this compensation program. [NIOSH 2007b]

13.3 DISCUSSION

No discussion is needed.

13.4 STATUS AND CONCLUSIONS

This issue is resolved.

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14.0 INGESTION DOSES

14.1 MATRIX COMMENT 17 IN SC&A 2006 (FINDINGS 11 AND 12 IN SC&A 2005, SECTIONS 5.5.6 AND 5.6.5)

Ingestion doses need to be better evaluated. [SC&A 2006]

14.2 NIOSH RESPONSE

Current project guidance, Internal Dose Overestimates for Facilities with Air Sampling Programs (ORAUT-OTIB-0018 [ORAUT 2005b]), includes consideration of the ingestion pathway. For a reasonable estimate of internal occupational environmental dose, an intake factor for ingestion (f_1) can be assigned when the diagnosed cancer implies more significant dose to the GI tract.

[Addressed in NTS-5 Rev. 01, Section 5.6.1.] [NIOSH 2007b]

14.3 DISCUSSION

ORAUT-OTIB-0018 [ORAUT 2005b] provides a method for overestimating internal doses, but it only applies to facilities with thorough air monitoring programs:

Sites or facilities that rigorously sampled particulate air concentrations in areas of risk and controlled exposure to intakes according to the measured concentrations. [ORAUT 2005b, p. 8]

The NTS did not have such a program consistently and the procedure would therefore not apply to it. Moreover, exposures at NTS were outdoors and OTIB-0018 applied indoors. This is also the case with the NIOSH ingestion dose estimation guidance (NIOSH 2004). We note that ingestion doses are a component of internal dose and therefore covered by the infeasibility finding in the NIOSH Evaluation Report for the SEC. However, NIOSH could calculate partial ingestion doses based on intakes derived from resuspension of radionuclides (see Section 5 above).

14.4 STATUS AND CONCLUSIONS

The NIOSH internal dose guidance for ingestion dose estimation in ORAUT 2005 and NIOSH 2004 does not apply to NTS outdoor work. NIOSH should consider partial ingestion dose estimation based on resuspension models. See Section 5 above.

15.0 USE OF ORAUT-OTIB-0002 FOR POST-1971 TUNNEL WORKERS

15.1 MATRIX COMMENT 18 (FINDING 12 IN SC&A 2005, SECTION 5.6.7)

Recommended use of ORAUT-OTIB-0002 [ORAUT 2004] for post-1971 tunnel re-entry workers is contrary to guidance in that document, and its scientific validity has not been established. Its use may not be satisfactory even with restrictions, for instance for reactor testing early re-entry workers. [SC&A 2006]

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15.2 NIOSH RESPONSE

Current project guidance, Internal Dose Overestimates for Facilities with Air Sampling Programs (ORAUT-OTIB-0018), includes consideration of the ingestion pathway. For a reasonable estimate of internal occupational environmental dose, an intake factor for ingestion (f_1) can be assigned when the diagnosed cancer implies more significant dose to the GI tract.

[Addressed in NTS-5 Rev. 01, Section 5.6.1.] [NIOSH 2007b]

15.3 DISCUSSION

This is an internal dose issue and has been addressed by the granting of the SEC on the infeasibility of its estimation with sufficient accuracy.

15.4 STATUS AND CONCLUSIONS

This issue has been addressed by the granting of the SEC for the entire underground testing period.

16.0 BETA DOSES UNTIL 1966

16.1 MATRIX COMMENT 19 (FINDING 13, SC&A 2005, SECTION 5.7.2)

There are no beta dose data until 1966; the TBD does not specify a procedure for estimating pre-1966 beta dose. When the approach is developed, the large, hot-particle issue will need to be taken into account. [SC&A 2006]

16.2 NIOSH RESPONSE

Time-dependent beta-gamma ratios have been developed and were added to the TBD. In addition, a proposed method to evaluate the beta dose by re-reading the original films has been developed. However, the method involves a significant amount of effort, and would have to be well justified on a case-by-case basis. Hot-particle issues are addressed in Response 2. [Addressed in NTS-6, Rev. 01, PC-1, Sections 6.4.2.2 and 6.4.2.3 and Attachment C.]

Approximately 200 claimant external dosimetry files were examined for positive neutron, beta, and gamma results. Of the 200 claimant files reviewed, only one positive neutron result, for one individual (Claim [XXX]) was located. This result was recorded as being associated with work in Building 1000.

Twenty-three of the 200 claimant external dosimetry files contained a total of 140 positive beta/shallow dose results. What was readily apparent from the review was that even when there were positive beta results in a file, they were not the norm. There were a total of 256 positive photon results for the years in which positive beta results were located. The most common situation was a preponderance of non-positive results with several positive beta results, usually

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associated with positive photon results. These results were analyzed to identify the associated beta-to-photon ratio.

The beta-to-photon ratios were based on the annual external dosimetry totals for the years in which positive beta results were available. A review of the 50 annual ratios found 25 to be less than 1, another 13 ratios were between 1 and 2, and only 3 of the 50 ratios were equal to or greater than 4.0. The largest annual beta-to-photon ratio was 4.14. [NIOSH 2007b]

16.3 DISCUSSION

NIOSH provided an extensive discussion and a model for calculating pre-1966 beta doses in Rev. 1 of the external occupational dose site profile (ORAUT 2007b). SC&A reviewed this model and provided initial comments for the purposes of discussion of the SEC petition (SC&A 2007). While SC&A was in agreement with the general approach of using beta:gamma ratios for most circumstances, a number of comments were provided for further development of the method.

A full review of the issue has not been done by SC&A. This issue is especially relevant for some non-covered cancers, such as skin cancer. It also partly overlaps with the hot particle issues already discussed in Sections 2.0 and 3.0 above.

16.4 STATUS AND CONCLUSIONS

SC&A and NIOSH are in agreement that external beta doses can be estimated for the pre-1966 period. The WG may want to consider a review of this issue for development of a more claimant-favorable approach for non-covered cancers.

17.0 INTENTIONAL NON-USE OF BADGES

17.1 MATRIX COMMENT 20 (FINDING 13, SECTION 5.7.3 AND SECTION 7.1.1 IN SC&A 2005)

There appears to have been intentional non-use of badges in some circumstances to avoid approaching or exceeding operational dose limits. The practice may have occurred until the mid-1960s or even extended into the 1970s. NIOSH has not investigated this problem, which raises questions on the integrity of the external dose record possibly into the 1970s, which need to be explicitly addressed. [SC&A 2006]

17.2 NIOSH RESPONSE

The NIOSH position is that in the 1963 through 1966 timeframe there was no systematic incentive for workers to misuse their dosimeter by not wearing them in radiation areas. To validate this position, NIOSH examined 160 of the highest exposed NTS claimant file[s]. 94 of these claimants were within the 1963–1966 time period. This time period was chosen as the period between the existing atmospheric NTS SEC and the time when the dosimeter and security credential

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were integrated into one system in 1967. This period seems most relevant since after this time period the security credential would have has [sic] to be removed in order to prevent the dosimeter from being exposed. This action being such a serious offense, it is highly unlikely to have happened.

The only plausible reason that a large group of workers would misuse their dosimeter was if they were likely to be excluded from radiation work due to high doses and therefore lose their income potential. The applicable dose limits then were 3 rem per quarter and 5 rem per year. There were no administrative controls levels in place at NTS at that time. Only those workers approaching the legal limits would have had an incentive to hide their true dose and the risk of being disciplined. If a worker was found violating procedures and not wearing dosimeters, that could not be discounted, and if the worker was not approaching a limit, it was in their interest to follow the rules and wear dosimeters. The data (1880 data points) presented here, representing all claimants who worked at NTS during that time frame, show that no workers exceeded the quarterly or annual exposure limits and that only a very few people even had a potential to exceed limits. In cases where over-exposures occurred (none in this data set) it can be shown that those over-exposures that did occur in one or two days – not weeks or months, so there would not have been time to develop a pattern of improper behavior.

The statistics of data from this subset of workers are interesting. Note that the Median is “ZERO,” which means that more than half the workers monitored received ZERO dose and the 95th percentile range from approximately 1/5 of the quarterly exposure limit to 2/5 annual exposure limit, respectively. This validates the assertion that most workers at the NTS received no exposures at all.

In conclusion, the analysis of the data clearly demonstrates that there was no systemic pattern or reason for NTS personnel to remove their dosimeters in order to continue working in radiation areas.

[Addressed in NTS-6 Rev. 01, PC-1, Section 6.3.1.5.2.] [NIOSH 2007b]

17.3 DISCUSSION

This issue was extensively researched and discussed both for the atmospheric testing period and for later underground testing activities. In the former case, the issue was whether workers systematically took off their badges to avoid an overexposure registering on their badges. In the latter case, the main issue appeared to be a belief that there would be negative employment consequences if workers returned damaged badges too often [an unwritten “three strikes and you’re out” policy was mentioned in interviews (see SC&A 2009, p. 46)].

Limited investigations comparing pencil dosimeter readings to badge readings did not reveal a pattern of badges being systematically lower than pencil dosimeters. Hence, while workers may have taken off their badges to prevent damaging them, this did not appear to have a detectable effect on external dose readings (see for instance the transcript of the October 29, 2008, WG meeting, ABRWH 2008, pp. 15–108)

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In light of the above, SC&A agrees with the implication of NIOSH's response that no adjustment of the external dose readings is needed to use the badge data to reconstruct dose.

17.4 STATUS AND CONCLUSIONS

In SC&A's view, this issue can be closed.

18.0 EXTREMITY MONITORING

18.1 MATRIX COMMENT 21 (FINDING 13, SECTION 5.7.5 IN SC&A 2005)

The TBD does not contain information about extremity dosimetry. Site status of bomb assembly workers is unclear. [SC&A 2005]

18.2 NIOSH RESPONSE

Extremity dosimetry is used when required and is incorporated into any dose reconstruction involving skin cancer of an extremity in accordance with ORAUT-OTIB-0017. [Addressed in NTS-6 Rev. 01 Section 6.4.2.6.]

Assembly workers were usually laboratory personnel and access to the device was highly restricted by safeguards and security. Device assembly was episodic with a discrete number of devices assembled in any given year; assembly was not a production line operation. This information was corroborated by [EE and EE]. A search of NOCTS revealed two device assembly workers (both were lab employees), neither of which had a cancer of the extremity; hence, extremity doses will not need to be reconstructed or considered further for these individuals. [Addressed in NTS-6 Rev. 01, Sections 6.3.5.3.1 and 6.5.3.] [NIOSH 2007b]

18.3 DISCUSSION

While it is true that extremity doses will not need to be reconstructed for the two claimants who did device assembly, neither of whom had a cancer of the extremity, it still does represent a site profile issue. Some NTS extremity monitoring data do exist, as noted in the latest revision of the external occupational dose volume of the site profile:

Extremity dosimetry has been used at NTS to assess exposure to the finger, hand, forearms and even the head (on rare occasions) that might have occurred during operations in proximity to, or involving the manual manipulation of, radioactive material and radiation-emitting objects. Extremity monitoring might be required, for example, when radiation technicians were involved in handling post-test core samples.

The dosimeter (film or TLD) was worn in a position that was intended to represent the highest exposure to the extremity, usually on the inside of the wrist in the case of film, or on the finger near the finger tip. The extremity being

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monitored is normally identified in the dose record using the codes shown in ORAUT (2008c, Table A-2). [ORAUT 2010c, p. 33]

The data could be used to create a coworker model if needed.

18.4 STATUS AND CONCLUSIONS

The WG may want to discuss whether it is worthwhile addressing this issue in the absence of any relevant claims. An update of claims with non-covered cancers to check whether this is still true near the end of 2012 would be useful, since the NIOSH response quoted above in Section 18.2 was written in 2007.

19.0 NEUTRON DOSES

19.1 MATRIX COMMENT 22 (FINDING 13, SECTIONS 5.7.7 AND 5.7.8 IN SC&A 2005)

There are no neutron dose data until 1966, and partial data until 1979. TBD assertion that neutron doses during atmospheric testing were negligible has not been substantiated and may be in error for some workers. [SC&A 2006]

19.2 NIOSH RESPONSE

The TBD has been revised to include a detailed discussion of neutron doses from atmospheric nuclear tests and states that neutron doses at distance beyond 6 km from an atmospheric test would have been < 1 mrem. (The closest workers were at the control point in Area 6). These distances are clearly much greater than 6 km (3.6 miles) from the test points. The one exception would have been the flight crews who conducted aerial monitoring, but even in that case, the separation distance would have been sufficient.

Personnel neutron exposures were not likely at NRDS, given the separation of the workers from the reactor test stand. If a worker were in closer proximity to the reactor during the test, any neutron doses would be accompanied by concomitant gamma exposures of significance. The NTS NRDS RadSafe reports contain information on personnel gamma and neutron dosimetry, as well as gamma and neutron surveys at numerous locations surrounding the reactors. [EE's] expert account clearly demonstrates that stringent access control practices were implemented to protect personnel from external exposures. NTS-2 Rev. 01, Attachment B also indicates the distance from the test stands to the control area was about 2 miles. [Addressed in NTS-6 Rev. 01, Sections 6.3.5.3.1, 6.3.5.3.3, and 6.5.3 and Attachment D.] [NIOSH 2007b]

19.3 DISCUSSION

The revision of the external occupation dose section of the site profile in 2007 (ORAUT 2007b) provided considerable information and analysis as well as suggested dose reconstruction approaches for workers not monitored for neutron exposure, but whose work indicated such

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potential. SC&A reviewed this in 2007 and had extensive comments on NIOSH's analysis (SC&A 2007, Section F).

Specifically, SC&A found that NIOSH's analysis regarding the low exposure potential for DOE and contractor test personnel appeared reasonable. There was one comment, however; some further work to verify that DOE and contractor test personnel were not present in closer proximity on occasion (together with armed forces test personnel) appeared to be warranted.

Regarding test device assembly workers and workers who handled neutron sources, SC&A had made a number of comments and raised some questions regarding the choices of neutron-to-photon (n/p) ratios suggested by NIOSH for use in specific circumstances. SC&A also raised a question of whether it was appropriate to use Pantex n/p ratios for NTS assembly workers in the absence of device specific data on n/p ratios. The Pantex data indicate that n/p ratios vary a great deal and tend to be device-specific.

19.4 STATUS AND CONCLUSIONS

There are still some outstanding questions regarding the selection of n/p ratios for unmonitored workers with neutron exposure potential, such as device assembly workers, TRU waste handlers, and workers who handled neutron sources. Further review of these outstanding issues appears to be warranted. There is some overlap of this issue with the post-1992 matrix comment (number 26) that has been added below, notably for waste handlers.

20.0 ADEQUACY OF SOIL DATA FOR ESTIMATING RESUSPENSION DOSES

20.1 MATRIX COMMENT 23

This issue has been covered in Section 5 above.

21.0 HIGH-FIRED OXIDES

21.1 MATRIX COMMENT 24

The presence of high-fired oxides resulting from atmospheric weapons testing and reactor testing needs to be investigated. [SC&A 2006]

21.2 NIOSH RESPONSE

NTS-5, Table A-29 includes a range of solubilities for most radionuclides of concern. To assure that organ doses are not underestimated, dose reconstructors are instructed to use the most claimant favorable solubility type possible for the given exposure situation when the actual type is not known. High-fired plutonium oxides are known to be less soluble than other oxides, and are therefore retained for longer periods in the lungs than more soluble forms. Estimating Doses for Plutonium Strongly Retained in the Lung (ORAUT-OTIB-0049 [ORAUT 2008c]) addresses doses due to intakes of extremely insoluble materials such as high-fired

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plutonium oxides. Any new guidance would apply to NRDL activities. The atmospheric timeframe is covered under the SEC petition.

[Addressed in NTS-5 Rev. 01, Section 5.6.3.2] [NIOSH 2007b]

21.3 DISCUSSION

This issue has been rendered moot by the granting of the SEC based on the inability to reconstruct internal dose.

21.4 STATUS AND CONCLUSIONS

This issue is resolved.

22.0 INTERVIEW DOCUMENTATION AND LITERATURE REVIEW

22.1 MATRIX COMMENT 25 (SECTION 7.1.1 IN SC&A 2005. NO FINDING NUMBER)

NIOSH documentation of site expert interviews is inadequate, and crucial site expert interviews have not been performed or performed in an incomplete manner, notably Barton Hacker and [Redacted]. Potentially critical archives and documents have not been reviewed, including the Naval Radiological Defense Laboratory and Barton Hacker primary reference materials. [SC&A 2006]

22.2 NIOSH RESPONSE

NIOSH has documented almost five hours of discussion with [Redacted] in early 2004. Mr. Hacker has not been interviewed by NIOSH, but other site experts have been interviewed including [Redacted] (REECo Retired), [Redacted] (REECo, Bechtel Nevada), [Redacted] (Bechtel Nevada), [Redacted] (NTS, LLNL), [Redacted] (Lawrence Radiation Laboratory (LRL) 1961 to 1966 (predecessor of LLNL) Retired), [Redacted] (REECo Retired), [Redacted] (REECO Retired), [Redacted] (REECo Retired), [Redacted] (REECo Retired), [Redacted] (NTS, LLNL), [Redacted] (Nevada Operations Office), [Redacted] (LLNL, DOE Retired), [Redacted] (LLNL/LANL Retired), [Redacted] (LLNL), [Redacted] (REECo, LLNL), [Redacted] (NTS, LLNL), and [Redacted] (PHS, NTS, AEC, and DOE retired). NIOSH may conduct additional interviews with site experts to address specific issues as they arise. [NIOSH 2007b]

22.3 DISCUSSION

NIOSH has made extensive changes to its interview documentation procedure. Further review of this issue is now under the purview of the Worker Outreach Work Group, which is reviewing NIOSH documentation of and responses to worker and public comments more generally. So far as NTS is concerned, this issue is now moot, except as noted in Section 2 of this report.

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22.4 STATUS AND CONCLUSIONS

This issue is now moot so far as NTS is concerned, except as noted in Section 2 of this report regarding review of Hacker 1994 and the associated archive of documents.

23.0 DRAFT OF POST-1992 PLACEHOLDER MATRIX COMMENT (ADDED BY SC&A IN OCTOBER 2012 FOR WG CONSIDERATION)

23.1 NEW MATRIX COMMENT NUMBER 26

There were no explicit matrix comments for the post-1992 period in SC&A 2005. This section is a place holder for the WG to consider and decide what, if any, review it might want to initiate for the post-1992 period.

There are some ongoing activities in the post-1992 period that may involve exposure potential including subcritical tests, waste handling and disposal, and decommissioning areas of the site. These activities and the associated exposure potential have not been reviewed by SC&A.

23.2 SOME NIOSH SITE PROFILE AND ER STATEMENTS

In its 2010 Evaluation Report, NIOSH stated that it had data to estimate doses for NTS workers after 1992:

Based on its preliminary research, NIOSH expanded the petitioner-requested class to the end of 1992 to ensure that all testing activities that ended in 1992 were included in the evaluated class and possible proposed SEC class. This later end date also coincides with the implementation of the DOE Radiological Control Manual (DOE, 1992), which was implemented in 1993, and the implementation of the 1993 NTS internal technical basis document that demonstrates NTS compliance with 10 C.F.R. 835 (NTS, 1993). [NIOSH 2010, p. 3]

NIOSH has provided some information on continuing activities in the latest version of the site profile. For instance, NIOSH has stated that Area 3 waste disposal activities are associated with potential for exposure to several radionuclides, which are listed in ORAUT 2010b (Table a-16, p. 90). The waste disposal exposure potential is described, in part, as follows:

Areas 3 and 5 contain sites for the disposal of low-level radioactive waste, and Area 5 contains sites for storage of transuranic and mixed transuranic wastes, as well as the Greater Confinement Disposal Test Unit and 12 accompanying boreholes (only a few contain waste). Disposal occurs in pits and trenches; concrete pads provide temporary storage of certain wastes. Area 5 is for packaged waste disposal only. The Waste Examination Facility (WEF) houses a glovebox with high-efficiency particulate air filtration that is used to examine and repack transuranic (TRU) waste drums. No contamination has been released

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from glovebox operations to the environment. The drums, which have been sent to NTS from Lawrence Livermore National Laboratory (LLNL) in past years, are stored inside the TRU Pad Cover Building. Repacked drums will be sent to the Waste Isolation Pilot Plant. The facility is a diffuse source of radiological effluents. The only radioactive effluent that has been detected by the various types of samplers around the site is HTO in atmospheric moisture. The Area 3 low-level waste site is in a location where surface soil has been contaminated by deposited plutonium, and resuspension of this soil by wind and vehicular activity has resulted in detection of above-background levels of plutonium in nearby air samples. [ORAUT 2010a, p. 15]

According to the NIOSH environmental dose section of the site profile, the potential for resuspension doses continues in the post-1992 period:

Because the low-level Area 3 RWMS is in a location where the surrounding surface soil has been contaminated by past nuclear tests, the resuspension of this soil by wind or vehicular activity results in the detection of above-background levels of plutonium in air samples collected inside and outside the perimeter fence (DOE 2002a). [ORAUT 2008a, p. 47]

NIOSH also states that internal monitoring has been carried out:

Routine bioassay was to collect quarterly urine samples and conduct annual WBCs. Urine samples were analyzed for gamma emitters, sampled for ³H, and analyzed for GFPs, Pu, and Am. [ORAUT 2010b, p. 90]

For external exposure, downhole well logging is one of the items listed as having potential for neutron exposure (ORAUT 2010c, p. 42)

There were also some decommissioning activities in the post-1992 period:

Operation Roller Coaster was an experimental series of plutonium dispersal tests that were conducted in 1963 at the TTR. The purpose of these tests was to evaluate storage and transportation issues. The DOUBLE TRACKS site was remediated in 1995 and 1996 and the CLEAN SLATE I corrective actions were performed in 1997. Contaminated soil was transported to the NTS Area 3 RWMS. Corrective actions for CLEAN SLATE II and III are pending an agreement between the State of Nevada and the Federal government on the level of cleanup. [ORAUT 2008a, p. 38]

23.3 DISCUSSION

None is needed pending WG discussion of this placeholder item.

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23.4 STATUS AND CONCLUSIONS

A number of issues in relation to waste handling, decommissioning, and other post-1992 site activities have not been reviewed by SC&A in terms of data available for dose reconstruction. This matrix comment has been added as a placeholder for WG discussion.

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