NIOSH Draft White Paper

NIOSH Investigation into the Issues Raised in Comment 2 from SCA-TR-TASK1-005

Author- Brian Gleckler

Revision 0

September 3, 2013

This white paper has been generated to support the NIOSH Response to Comment 2 in SCA-TR-TASK1-0005

NIOSH Investigation into the Issues Raised in Comment 2 from SCA-TR-TASK1-005

1.0 PURPOSE

The purpose of this white paper is to summarize the results of an investigation that was performed by NIOSH in regards to the information presented in the 2003 SC&A report titled *Critical Review of Source Terms for Select Initial Engine Tests Associated With the Aircraft Nuclear Propulsion Program and INEL*. The results of this investigation are intended to assist NIOSH with its response to Comment 2 in SCA-TR-TASK1-0005 (SC&A 2006).

2.0 SUMMARY OF RESULTS

Based on the results of this investigation, NIOSH recommends that additional research be performed to assess the potential impact of the radioactive releases from the IET #10 runs on the workers' internal doses. In regards to the other issues being raised in Comment 2, NIOSH believes that the guidance in the *Technical Basis Document for the Idaho National Laboratory and Argonne National Laboratory West – Occupational Environmental Dose* for Revision 02 (ORAUT 2010) is sufficient.

3.0 BACKGROUND

Comment 2 was made in regards to the information provided in Revision 00 of the document titled *Technical Basis Document for the Idaho National Engineering and Environmental Laboratory (INEEL) – Occupational Environmental Dose* (ORAUT 2004). Even though the current version of this document is Revision 02, Comment 2 is still considered to be a valid comment, since no significant changes have been made to this document regarding how episodic releases are addressed in dose reconstructions (ORAUT 2004, 2010). However, it should be noted that the title of this technical basis document has been changed to *Technical Basis Document for the Idaho National Laboratory and Argonne National Laboratory West – Occupational Environmental Dose* for Revision 02 (ORAUT 2010). In addition, to simplify identifying and/or referring to this technical basis document (**TBD**) in the subsequent sections of this white paper, all versions of this document will be referred to as the ***environmental TBD***.

3.1 Summary of the Issue

Comment 2 as stated in the INL Issue Resolution Matrix for Findings and Key Observations (i.e. Attachment 5 of SCA-TR-TASK1-0005) (SC&A 2006).

Issue 2: (5.1.1.2) Episodic Airborne Release - The airborne releases associated with several of the Initial Engine Tests of the Aircraft Nuclear Propulsion (ANP) Program were likely to have been underestimated by factors ranging from **2 to 7**. Also, NIOSH did not evaluate the uncertainties associated with the deficiencies in air monitoring equipment.

Sections regarding Comment 2 that are in the main body of the INL site profile review (i.e. Sections 5.1.1.2.2 and 5.1.1.2.1 of SCA-TR-TASK1-0005) (SC&A 2006).

5.1.1.2.1 Completeness and Quality of Episodic Releases Data

The airborne releases associated with several of the Initial Engine Tests (IETs 3, 4, and 10) of the Aircraft Nuclear Propulsion (ANP) Program, as estimated by the INELHDE, were likely to have been underestimated as follows:

- IET 3 – underestimate of total radionuclide release by up to a factor of about 3
- IET 4 – underestimate of noble gases by up to a factor of about 16, halogens by up to a factor of about 7, and solids by a factor of up to about 2
- IET 10 – underestimate of total radionuclide releases by up to a factor of about 7

These concerns were cited in the SC&A report, *A Critical Review of Source Term for Select Initial Engine Tests Associated with the Aircraft Nuclear Propulsion Program at INEL* (SC&A 2003, -g. 2-24), which states the following:

> *The HDE Task Group acknowledged the absence of available raw effluent data as well as the deficiencies/limitations of summary data contained in the report by Thornton et al. (1962b). The HDE, therefore, modeled release estimates that were principally based on historical operating records and photographic evidence, which characterized the extent of fuel damage to the HTRE No. 1 reactor core. … Embedded in the HDE model of radioactive releases are several assumptions that potentially may have underestimated the true release quantities of fission products. Identified below are four key model parameters whose values may have differed significantly from those assumed by the HDE.*

5.1.1.2.2 Other Observations

Similar to the problem with routine releases, NIOSH should list the episodic airborne release activities for each INL facility used in the Occupational Environmental Dose TBD. Uncertainties associated with the release activities should also be provided. This data would be helpful for the dose reconstructors to assess whether the worker intakes are applicable to their claim. An example may be given showing how the worker exposure could be calculated using the release activities, uncertainty values, and weighting factors.

3.2 Actions from 2011 Working Group Meeting

NIOSH: Review SC&A report (*Critical Review of Source Terms for Select Initial Engine Tests Associated With the Aircraft Nuclear Propulsion Program and INEL*, 2003) on the Risk Assessment Corporation (**RAC**) modeling approach that was used for the Idaho National Laboratory (**INL**).

4.0 NIOSH INVESTIGATION RESULTS

The document *Critical Review of Source Terms for Select Initial Engine Tests Associated With the Aircraft Nuclear Propulsion Program at INEL* is a document that was written by SC&A, Inc. and SENES Oak Ridge, Inc., under a CDC contract. A 2005 version of the document *Critical Review of Source Terms for Select Initial Engine Tests Associated With the Aircraft Nuclear Propulsion Program at INEL* (Behling et al 2005) was reviewed instead of the 2003 version, because it was a newer version and because it was the only version of this document available on the CDC's website. This document was obtained from the CDC's Radiation Studies website at http://www.cdc.gov/nceh/radiation/brochure/profile_ineel.htm, and a copy is now in ORAUT's Site Research Database (SRDB) as Reference 103215.

Three other key documents were reviewed to address Comment 2, including a number of the relevant references for those documents. The following is a listing of those three documents.

1) *Idaho National Engineering Laboratory Historical Dose Evaluation* (***INEL-HDE***) Volumes I and II (DOE 1991a, DOE 1991b)
2) *Identification and Prioritization of Radionuclide Releases from the Idaho National Engineering and Environmental Laboratory* (***RAC Report No. 3***) (CDC 2002)

3) *Supplement to Technical Basis Document 4 for the Idaho National Engineering and Environmental Laboratory: INEEL Occupational Environmental Dose* (Peterson 2004)

In August 1991, the Department of Energy (**DOE**) published the *INEL-HDE*. After the publication of the *INEL-HDE*, a DOE review committee recommended a more detailed study using source documents and incorporating public involvement. The Governor of Idaho asked the Centers for Disease Control and Prevention (**CDC**) to perform a technical review of the methodology for the analyses used for the *INEL-HDE* report. As a result of that technical review, minor changes were recommended in some of the airborne source terms. Those minor changes did not change the total curies released, but added small amounts of other radionuclides and respective quantities to earlier years where detection had not been as 'lowlevel' as in the more recent years. In the course of the review, the Radiological Assessment Corporation examined the Radiological Safety Analysis Computer-4 (**RSAC-4**) program that defined the radiological doses for each of the releases (CDC 2002). That review stated: "The [National Council on Radiological Protection and Measurements (**NCRP**)] and RSAC results agreed very well, confirming that the [Council] methodology is an acceptable method to rank releases of radionuclides" (CDC 2002).

4.1 Releases from IETs #3, #4, and #10

The document titled *Critical Review of Source Terms for Select Initial Engine Tests Associated with the Aircraft Nuclear Propulsion Program at INEL* was written to address issues associated with offsite exposures to members of the public (Behling et al 2005). The document specifically addresses issues associated with previously estimated releases for Initial Engine Tests (**IETs**) #3, #4, and #10 (Behling et al 2005). This document does not address any issues associated with other episodic releases, onsite exposures, nor does it raise any issues about the atmospheric data that were used and the dispersion modeling that was performed.

Section 4.2.2.3 and Attribution 11 of the *environmental TBD* (ORAUT 2010) indicates that when the analysis of the *INEL-HDE* (DOE 1991) was completed the meteorological diffusion trajectories were reviewed to determine which INL facilities were affected. The result of those trajectory reviews was that only 16 releases had the potential to affect other INL facilities. As a result of those reviews, IETs #3, #4, and #10 were determined to not affect other INL facilities, and no onsite intakes for those episodic releases were calculated and included in the *environmental TBD*. Unfortunately, the original author of the *environmental TBD* that performed those reviews is now deceased (H. K. Peterson), and no detailed documentation of those reviews could be found. It is also worth noting that Mr. Peterson was also a member of the task group that created the *INEL-HDE*, and that he was involved with the meteorological

diffusion calculations used for that document. Therefore, Mr. Peterson was intimately familiar with the information provided in the *INEL-HDE* reference and the bases for that information.

The information that NIOSH has been able to capture regarding meteorological diffusion trajectories for IETs #3, #4, and #10 can at least partially substantiate the determinations that were made for the *environmental TBD*. The following sub-sections summarize the trajectory information that was found for IETs #3, #4, and #10.

4.1.1 Information for IET #3

Activities associated with IET #3 took place during the period of 02/11/56 - 02/24/56. **Figure 1** depicts the trajectory for the IET #3 releases that occurred during 02/11/56 - 02/14/56 (DOE 1991b, p. 262). **Figure 2** is a map of the dispersion isopleths which depict the release trajectory for the IET #3 releases that occurred during 02/11/56 - 02/24/56 (DOE 1991b, p. 262). This information indicates that none of the IET #3 releases were dispersed over other facilities at the INL and would not have affected the internal doses of the INL workers.

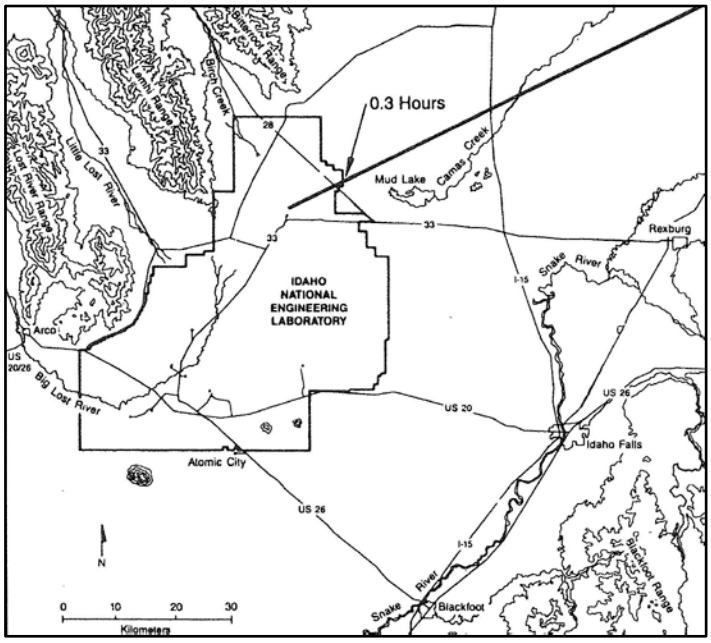

Figure 1 – IET #3 Release Trajectory for the 02/11 – 02/14/56 Release Period (DOE 1991b, p. 262)

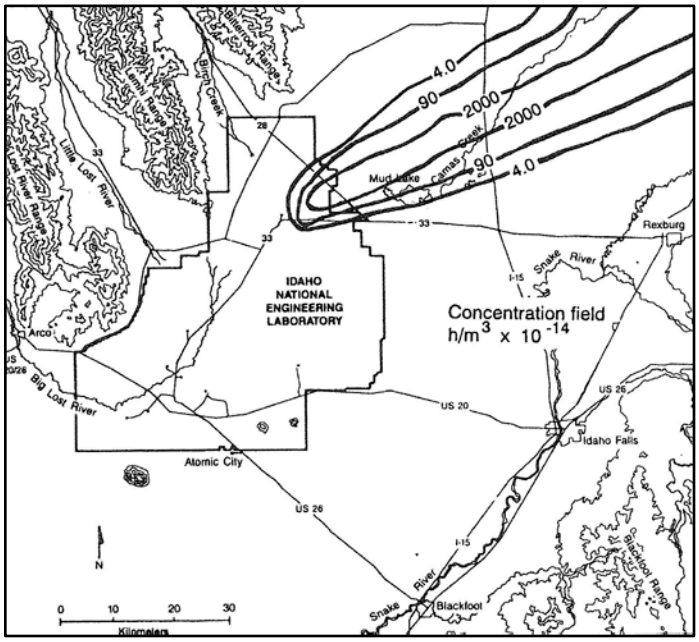

Figure 2 – IET #3 Release Trajectory for 02/11 – 02/24/56 Release Period (DOE 1991b, p. 262)

4.1.2 Information for IET #4

Activities associated with IET #4 have been divided into 3 different periods: IET #4(A) 05/01/56 – 05/23/56, IET #4(B) 05/24/56 – 06/26/56, and IET #4(C) 06/29/56. The document *Critical Review of Source Terms for Select Initial Engine Tests Associated with the Aircraft Nuclear Propulsion Program at INEL* only had an issue with the model for IET #4(C), and considered the model used for IET #4(A) and IET #4(B) logical and appropriate (Behling et al 2005). Therefore, only the IET #4(C) releases are addressed in this document.

For IET #4(C), **Figure 3** depicts the trajectory of the releases that occurred on 06/29/56, and **Figure 4** is a map of the dispersion isopleths which also depicts the trajectory for the IET #4(C) releases (DOE 1991b, p. 260). It should be noted that Figure B-30 in Volume II of the *INEL-HDE* has an incorrect date of 06/19/56. The release date for the IET #4(C) activities was limited to 06/29/56 (DOE 1991b, p. 260). The quality assurance file for the *INEL-HDE* also confirms that the date should have been 06/29/91 (DOE 1991c, p. 21). This information indicates that the IET #4(C) releases were not dispersed over other facilities at the INL and would not have affected the internal doses of the INL workers.

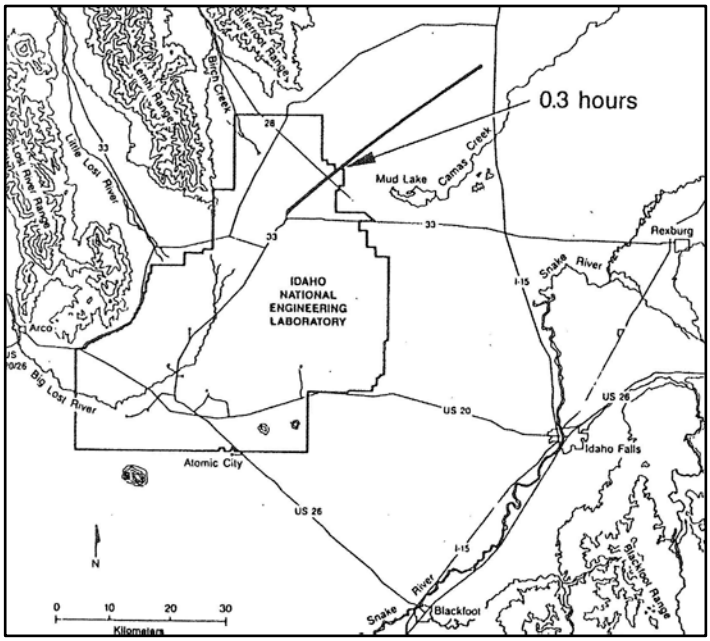

Figure 3 – IET #4(C) Release Trajectory for 06/29/56 Release (DOE 1991b, p. 260)

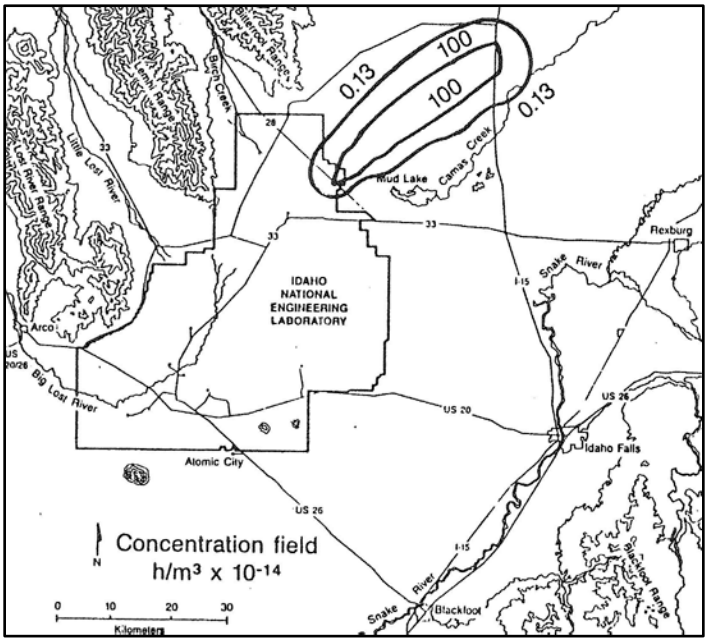

Figure 4 – IET #4(C) Release Trajectory for 06/29/56 Release (DOE 1991b, p. 260)

4.1.3 Information for IET #10

In the *INEL-HDE*, activities associated with IET #10 have been divided into 2 different periods: IET #10(A) 12/20/57 – 02/25/58 and IET #10(B) 03/01/58 – 03/06/58. Unlike IET #3 and IET #4, the *INEL-HDE* does not contain release trajectories and dispersion isopleths for IET #10. However, the quality assurance documentation for the *INEL-HDE* does provide dispersion factors and air concentration estimates for 16 offsite locations (DOE 1991d). Those 16 offsite locations are depicted in **Figure 5**. Dispersion factors and air concentration values were generated for the 32 runs associated with IET #10 (DOE 1991d). When the dispersion factors and air concentrations for the 4 downwind locations in the shaded portions of **Figure 5** are zero, the releases associated with that specific run would not have affected the INL workers. Of the 32 runs, 12 of the runs (i.e. runs 5, 9, 11, 19, 20, 26, 32, 38, 40, 48, 49, and 57) had air concentrations of zero for all 4 downwind locations, and thus did not have the potential to contribute to the internal doses of the INL workers. The dispersion factors and air concentrations for 20 of the runs indicate that 20 of the runs had the potential to contribute to the internal doses of the INL workers at varying degrees.

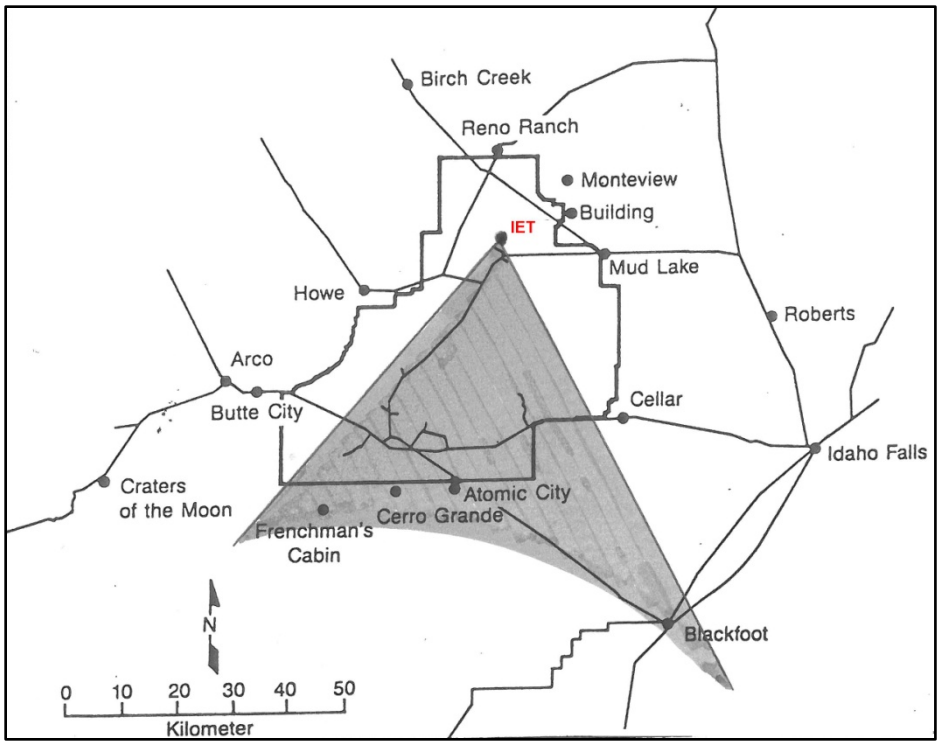

Figure 5 – Trajectory Area Affecting Other INL Facilities

IET #10 was divided into three phases (Foster et al 1958). Phase I consisted of the initial IET runs; Phase II started with the runs that occurred after January 17, 1958; and Phase III included the runs that occurred after February 4, 1958 (Foster et al 1958). The document *Critical Review of Source Terms for Select Initial Engine Tests Associated with the Aircraft Nuclear Propulsion Program at INEL* indicates that the radioactive releases from the Phase III runs (i.e. runs 37, 38, 40, 42, 43, 45, 46, 47, 48, 49, 52, 53, 54, 55, 56, and 57) were underestimated in the *INEL-HDE* (Behling et al 2005). After reviewing the information presented in that document, NIOSH agrees that the radioactive releases for those runs were likely underestimated in the *INEL-HDE*, but NIOSH does not necessarily agree with the magnitude of the underestimates. Further research is needed to determine the magnitude of those underestimates. It should also be noted that the review of the dispersion factors and air concentrations for the Phase III runs 38, 40, 48, 49, and 57 previously determined that these runs did not have the potential to contribute to the internal doses of the INL workers. Therefore, the releases from runs 38, 40, 48, 49, and 57 do not need to be reevaluated.

4.2 Uncertainties Attributable to Air Monitoring Equipment Deficiencies

It should be noted that no specific air monitoring deficiencies were identified as part of Comment 2. In addition, the environmental intake values provided in the *environmental TBD* for the episodic releases are based on the airborne releases provided in the *INEL-HDE* (DOE 1991a, DOE 1991b), with the exception of the 1978 criticality at the Idaho Chemical Processing Plant (ICPP). Releases for 1978 criticality were estimated by one of the original authors of the *environmental TBD* using the RSAC-6 computer code and an approach that was similar the approaches used for some of the other episodic releases. Because NIOSH did not assess those releases with only one noted exception, the uncertainties associated with any air monitoring equipment deficiencies that those releases were based on were not included in the *environmental TBD*. However, many of the uncertainties associated with the values used for the *environmental TBD* have been addressed in the *INEL-HDE*, *RAC Report No. 3*, and the references to those documents.

The *INEL-HDE* expended a substantial amount of effort in reconstructing the episodic releases for the INL site. Because of the complicated nature of reconstructing releases from these tests, NIOSH has relied on the work that was previously completed and reported, and the release estimates in those documents are considered to be the best values that are consistent with the available information. As an indication of the level of effort that went into the *INEL-HDE* and its complexity, the *INEL-HDE* (document number DOE/ID-12119 Vol. 1 and 2) and its 82 supporting documents (document numbers DOE/ID-12119-QAF-001 through DOE/ID-12119-QAF-082) include over 4,200 pages of documented information.

In the instances where releases were estimated based on air monitoring results and details of the air monitoring approach was used, NIOSH was able to determine that a number of the potential air monitoring deficiencies were accounted for by the INL personnel that originally processed that data. For example, systematic errors attributable to 1) collection efficiency of sampling media, 2) sampling line loss, 3) counting efficiency, and 4) augmentation of the effluent air were being accounted for in the air monitoring results that the IET releases were based on (Boone et al 1959, Pincock 1959). However, those uncertainties were not propagated with the reported release values and calculated air concentrations.

Potential uncertainties associated with the dispersion modeling that was performed for the *environmental TBD* have not been accounted for because they cannot be readily quantified. Because the uncertainties associated with modeling atmospheric conditions and dispersion can be large, one of the most significant sources of uncertainty in the environmental intakes cannot be accounted for. Therefore, NIOSH does not believe that a detailed uncertainty analysis is warranted for the environmental intake calculations and the discussions in the Uncertainty Section of the *environmental TBD* are sufficient. However, it should be noted that the uncertainties associated with the episodic release intakes are generically being accounted for by assigning those intakes as lognormal distributions with a geometric standard deviation (GSD) of 3.0 (ORAUT 2010, ORAUT 2012).

5.0 CONCLUSIONS & RECOMMENDATIONS

NIOSH confirmed that the *environmental TBD*'s determination that the radioactive releases from IET #3 and IET #4 did not have any significant effects on the INL workers doses was substantiated. Therefore, no environmental intakes from IET #3 and IET #4 need to be included in the *environmental TBD*.

NIOSH's review of the IET #10 information, determined that the radioactive releases from some of the IET #10 runs may have provided a significant contribution to the INL workers' unmonitored internal doses (i.e. a total dose $\geq$ 0.001 rem), and that some of the releases for the Phase III runs may have been underestimated in the *INEL-HDE*. Therefore, NIOSH recommends that additional research be performed to assess the potential impact of the IET #10 runs on the workers' internal doses. If the detailed dispersion data for the dispersion calculations presented in the *INEL-HDE* documentation can be located, the dispersion calculations could be rerun for the onsite facilities versus offsite locations. In addition, those calculations could be performed independently for the releases from each run. Given the magnitude of the total releases from some of the IET #10 run and the amount of time between the first and last runs with radioactive releases, dispersion calculations for each run would be preferred. If the detailed dispersion data for the dispersion calculations presented in the *INEL-HDE* documentation cannot

be located, redoing the dispersion calculations for each run could be very difficult if not impossible.

The uncertainties associated with the episodic release intakes are generically being accounted for by assigning those intakes as lognormal distributions with a geometric standard deviation (GSD) of 3.0 (ORAUT 2010, ORAUT 2012). For the reasons stated above, NIOSH doesn't believe that a detailed uncertainty analysis is warranted for the environmental intake calculations and the discussions in the Uncertainty Section of the *environmental TBD* are sufficient.

6.0 REFERENCES

Behling, U. H., Mauro, J., 2005, *Critical Review of Source Terms for Select Initial Engine Tests Associated with the Aircraft Nuclear Propulsion Program at INEL*, SC&A, Inc. and SENES Oak Ridge, Inc., under Centers for Disease Control and Prevention Contract No. 200-2002-00367, July. [SRDB Ref ID: 103215]

Boone, F. W., Lofthouse, J. H., VanVleck, L. D., 1959, *Gross Activity Stack Monitoring Results and Environmental Hazards Evaluation for the D101-L2A and D101-L2C Test Series*, DC 59-7-722, General Electric, Atomic Products Division, Aircraft Nuclear Propulsion Department, July 30. [SRDB Ref ID: 31951]

CDC (U.S. Centers for Disease Control and Prevention), 2002, *Identification and Prioritization of Radionuclide Releases from the Idaho National Engineering and Environmental Laboratory*, RAC Report No. 3-CDCTask Order 5-2000-FINAL, Department of Health and Human Services, October 8. [SRDB Ref ID: 1141]

DOE (U.S. Department of Energy), 1991a, *Idaho National Engineering Laboratory Historical Dose Evaluation*, DOE/ID-12119, Volume 1, Idaho Operations Office, Idaho National Engineering Laboratory, Idaho Falls, Idaho, August. [SRDB Ref ID 1107]

DOE (U.S. Department of Energy), 1991b, *Idaho National Engineering Laboratory Historical Dose Evaluation*, DOE/ID-12119, Volume 2, Idaho Operations Office, Idaho National Engineering Laboratory, Idaho Falls, Idaho, August. [SRDB Ref ID 1109]

DOE (U.S. Department of Energy), 1991c, *Idaho National Engineering Laboratory Historical Dose Evaluation Quality Assurance File – Summary of Dispersion Factors for IET #4, #6, #12, #13, #22, and #24 Tests*, DOE/ID-12119-QAF-090, Idaho Operations Office, Idaho National Engineering Laboratory, Idaho Falls, Idaho, May. [SRDB Ref ID 87576 p. 12-39]

DOE (U.S. Department of Energy), 1991d, *Idaho National Engineering Laboratory Historical Dose Evaluation Quality Assurance File –IET #10 Source Term Characterization*, DOE/ID-12119-QAF-026, Idaho Operations Office, Idaho National Engineering Laboratory, Idaho Falls, Idaho, March. [SRDB Ref ID 88731]

Foster, D.C., S.W. Gabriel, J.W. Highbert, and N.K. Sowards, 1958, *Power Testing Results from D 101 D2 Core (IET # 10)*, XDCL-58-7-715. [SRDB Ref ID 83589]

ORAUT (Oak Ridge Associated Universities Team), 2004, *Technical Basis Document for the Idaho National Engineering and Environmental Laboratory (INEEL) – Occupational Environmental Dose*, ORAUT-TKBS-0007-4, Rev 00, Oak Ridge, Tennessee, March 30. [SRDB Ref ID 19518]

ORAUT (Oak Ridge Associated Universities Team), 2010, *Technical Basis Document for the Idaho National Laboratory and Argonne National Laboratory West – Occupational Environmental Dose*, ORAUT-TKBS-0007-4, Rev 02, Oak Ridge, Tennessee, January 8. [SRDB Ref ID 78635]

ORAUT (Oak Ridge Associated Universities Team), 2012, *Site Profile and Technical Basis Document Development*, ORAUT-PROC-0031, Rev 04, November 5.

Peterson, H. K., 2004, *Supplement to Technical Basis Document 4 for the Idaho National Engineering and Environmental Laboratory: INEEL Occupational Environmental Dose*, March 9. [SRDB Ref ID 15451]

Pincock, G. D. (ed.), 1959, *Idaho Test Station – Test Engineering – Test Results from D 101 L2A-1 Power Testing, IET #14*, DC 59-8-728, August 19. [SRDB Ref ID 12732]

SC&A (S. Cohen & Associates), 2006, *Review of the NIOSH Site Profile for the Idaho National Laboratory, Idaho*, SCA-TR-TASK1-005, January 25.