
Draft

**ADVISORY BOARD ON
RADIATION AND WORKER HEALTH**

National Institute for Occupational Safety and Health

**REVIEW OF REMAINING INTERNAL DOSE TOPICS
RELATED TO THE EVALUATION OF SEC-00235 AT THE
SANTA SUSANA FIELD LABORATORY**

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SC&A, INC.:

Technical Support for the Advisory Board on Radiation and Worker Health Review of NIOSH Dose Reconstruction Program

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ABBREVIATIONS AND ACRONYMS

ABRWH	Advisory Board on Radiation Worker Health
Am	americium
BZ	breathing zone
CAM	continuous air monitor
Ce	cerium
CEP	Controls for Environmental Pollution
Ci	curie
Co	cobalt
cpm	counts per minute
Cs	cesium
D&D	decontamination and decommissioning
DAC	derived air concentration
DOE	U.S. Department of Energy
dpm	disintegrations per minute
EE	energy employee
ETEC	Energy Technology Engineering Center
Eu	europium
GA	general air
GM	Geiger Muller
HEPA	high-efficiency particulate air
HPGe	high-purity germanium
MPC	maximum permissible concentration
mrem	millirem
μCi	microcurie
μR	micro roentgen
NIOSH	National Institute for Occupational Safety and Health
pCi	picocurie
Pu	plutonium
RIHL	Rockwell International Hot Laboratory
RMDF	Radioactive Material Disposal Facility
RMHF	Radioactive Materials Handling Facility

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SEC Special Exposure Cohort
SNAP Systems for Nuclear Auxiliary Power
Sr strontium
SRDB Site Research Database
SSFL Santa Susana Field Laboratory
Th thorium
TRUMP-S Transuranic Management by Pyropartitioning-Separation
USEPA United States Environmental Protection Agency
WBC whole body count

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1 INTRODUCTION AND BACKGROUND

In May 2017, the National Institute for Occupational Safety and Health (NIOSH) issued an evaluation report for Special Exposure Cohort ((SEC) Petition SEC-00235 for Area IV of the Santa Susana Field Laboratory (SSFL) for the period of August 1, 1991, to June 30, 1993 (NIOSH 2017). SEC-00235 qualified for evaluation because of compromised bioassay samples from the vendor laboratory, Controls for Environmental Pollution (CEP), during this time period (the evaluated period is referred to as the “CEP period” in this report). NIOSH did not use the bioassay results from CEP because they were implicated in data falsification at another site (not SSFL affiliated). NIOSH found that, despite the lack of roughly 2 years’ worth of in vitro bioassay data, there was no dose reconstruction infeasibility for the evaluated period and did not recommend that a class be added to the SEC. To perform internal dose reconstruction during this period, NIOSH recommended use of the coworker models developed for Area IV and documented in ORAUT-OTIB-0080, Revision 00, *Internal Coworker Dosimetry Data for Area IV of the Santa Susana Field Laboratory and the De Soto Avenue Facility* (NIOSH 2014). However, two SEC-related issues subsequently arose:

- Issue 1: The possible presence of thorium and americium isotopes that could potentially represent a significant internal exposure hazard.
- Issue 2: The evaluation and comparison of air sampling data during the operational period and CEP period to demonstrate that the general radiological conditions during the CEP period are sufficiently bounded by the operational conditions.

These two issues were discussed during the Area IV SSFL Work Group meeting held on December 4, 2017, at which time NIOSH was tasked with evaluating both concerns (ABRWH 2017). NIOSH delivered two separate white papers on these subjects to the Area IV SSFL on November 6, 2018 (NIOSH 2018a, 2018b). This report represents SC&A’s review of those two white papers¹ based on currently available documentation. On January 28, 2019, the SEC-00235 petitioner informed NIOSH that approximately 1,463 boxes of U.S. Department of Energy (DOE) records related to SSFL are scheduled to be made available no later than fall 2019. Therefore, this report may be considered an interim review contingent on future work group deliberations and potential actions in the evaluation of SEC-00235.

Sections 1.1 and 1.2 of this report describe the original work group discussion of these issues and give a summary of the NIOSH white paper conclusions for the two remaining SEC issues, respectively. Section 2 presents the results of SC&A’s interim review, and Section 3 discusses these results in the context of the individual SEC issues. SC&A’s summary conclusion is presented in Section 4.

¹ Although NIOSH issued two separate white papers on these subjects, due to the general overlap of these two issues, SC&A elected to combine its review into this single report.

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1.1 DESCRIPTION OF ISSUE 1 PRESENCE OF THORIUM AND AMERICIUM POST-1988

During the work group discussion on December 4, 2017, the work group noted that thorium and americium were not discussed as possible source terms for worker exposures for the residual period (post-1988) (ABRWH 2017). For the previous SEC evaluation (SEC-00234), a class was recommended to be added to the SEC because NIOSH found an infeasibility to reconstruct internal doses from thorium and americium radionuclides for the operational period of 1965–1988 (NIOSH 2016). NIOSH was tasked by the work group to provide more detail and relevant references on the nature of the source term for thorium and americium after 1988 at Area IV SSFL (ABRWH 2017). Upon further research and evaluation of additional data, NIOSH prepared the white paper, *Status of Operations Involving Thorium and Americium at Area IV SSFL during the Remediation Period (1988 – present)* (NIOSH 2018a). NIOSH presented this white paper to the Area IV SSFL Work Group on December 3, 2018 (ABRWH 2018a) and the Advisory Board on Radiation Worker Health (ABRWH) on December 12, 2018 (ABRWH 2018b).

NIOSH concluded that by the end of the operational period, all of the highly radioactive fuel had been removed from the site, thus removing fission products and transuranics in the reactor fuel from SSFL by 1988. The NIOSH review noted that the SSFL facilities under remediation after 1988 did not pose a “radiation exposure potential similar to the operational period” (NIOSH 2018a, p. 7), and that the remaining radionuclides of concern at Area IV during the evaluated SEC period were cesium-137 (Cs-137), strontium-90 (Sr-90), cobalt-60 (Co-60), and plutonium-239 (Pu-239). NIOSH further concluded that “only Cs-137 and Sr-90 were present in sufficient quantity to be readily dispersed for inhalation by workers, and Cs-137 was considered the most important radionuclide of concern during this period” (NIOSH 2018a, p. 7). NIOSH 2018a also stated that, “it is believed that the facility had at that point a state-of-the-art radiation protection program that was capable of detecting relevant radionuclides, and that those data are available for dose reconstruction” (NIOSH 2018a, p. 7). NIOSH, therefore, does not believe that the exposure potential to thorium-232 (Th-232) and americium-241 (Am-241) outlined in the SEC-00234 evaluation report continued during the remediation period (1989–present) (NIOSH 2018a).

In this evaluation, SC&A addressed this conclusion in terms of whether it is possible that thorium and americium could be present during the remediation period (1989–present) and pose a potential internal exposure hazard to workers that may present a similar dose reconstruction infeasibility as the operational period. To accomplish this task, SC&A screened over 2,000 records to determine their potential relevance to this issue and reviewed in detail hundreds of records contained in the Site Research Database (SRDB) for Area IV of the Santa Susana Field Laboratory – Ventura County, CA. SC&A reviewed a number of different types of records, dated 1988 and later, including air sampling results, contamination survey results, general air (GA) and breathing zone (BZ) data, air emission reports, environmental reports, accident/incident reports, engineering evaluations of facilities undergoing decontamination and decommissioning, and other relevant planning/occurrence reports. SC&A reviewed this relevant documentation for evidence of thorium and americium to determine the extent of the presence of these radionuclides and their potential impact on dose reconstruction.

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1.2 EVALUATION AND COMPARISON OF AVAILABLE AIR SAMPLING DATA DURING THE SEC EVALUATION PERIOD

During the work group discussion on Area IV SSFL pertaining to SEC-00235 on December 4, 2017, NIOSH was tasked by the work group to provide more information on the available air sample data for the period where in vitro bioassay data cannot be used (ABRWH 2017). The purpose of evaluating the air sampling data is to provide a meaningful comparison of the radiological conditions experienced by workers in both the operational period and CEP period. This comparison aids in establishing that the coworker intakes developed in ORAUT-OTIB-0080 are sufficiently representative and/or bounding of the potential intakes experienced during the CEP period. Upon further research and evaluation of additional data, NIOSH prepared the white paper, *Air Sample Data at Area IV SSFL in Support of SEC-00235* (NIOSH 2018b). NIOSH presented this white paper to the Advisory Board Work Group on Area IV of the SSFL on December 3, 2018 (ABRWH 2018a) and to the ABRWH on December 12, 2018 (ABRWH 2018b).

NIOSH found some additional BZ and GA data for Area IV during the period of August 1, 1991, to June 30, 1993, but no complete data sets for all quarters. NIOSH stated that data for the Rockwell International Hot Laboratory (RIHL) is available and can be considered bounding for the other facilities being decommissioned during this time period (the Systems for Nuclear Auxiliary Power (SNAP) reactor facility (T059) and the Radioactive Material Disposal Facility (RMDF)). Regarding the additional data that were found, NIOSH concluded that:

There is no clear evidence that the general air and breathing zone data are in any way unusual, given the operational status of the facilities at the time. Elevated air samples and whole body count results are in line with the work that was being completed then. There were a few localized elevated samples observed during the 1993 period, when bioassay are not useable for the first half of the year, but there is no indication that between the WBC and the bioassay sampling taking place in August would have led to significant missed exposures. Whole body counts and BZ samples were collected for workers in locations likely to receive an intake. Not all air and BZ data is available for all quarters and facilities, but it is believed this is because it has not been captured, not because it does not exist. There is no evidence that additional data capture for remaining quarters and facilities will lead to a different conclusion on the status of the air data or the feasibility to assess internal doses for Area IV SSFL using available data or the coworker model.
[NIOSH 2018b, p. 15]

NIOSH reiterated during the December 3, 2018, meeting of the work group that there are sufficient data available to conduct dose reconstructions (ABRWH 2018a).

In this evaluation, SC&A addresses this conclusion in terms of whether the available air sampling data demonstrate that radiological conditions are sufficiently representative or bounding to allow for the appropriate application of operational coworker data to the CEP period. Sections 2.1 and 2.2 of this report provide an overview of documentation relevant to exposure conditions after the operational period and include specific references during the CEP period. Section 2.3 presents SC&A's evaluation and comparison of the available air sampling

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data for RIHL, which had the most complete dataset for comparison and was undergoing significant decontamination and decommissioning (D&D) activities during the CEP period.

2 SUMMARY OF SC&A REVIEW

This section presents the results of SC&A’s review of the two currently outstanding SEC issues for SEC-00235. Section 2.1 describes SC&A’s review of available documentation found in the SRDB. Section 2.2 evaluates the incident/accident reports found in the petitioner-supplied Boeing Database. Section 2.3 presents SC&A’s evaluation and comparison of the GA sampling data for the occupational period and CEP period.

2.1 SRDB DOCUMENTATION REVIEW

SC&A used the documentation review summarized in this section for both SEC issue evaluations. Specifically, SC&A reviewed the SRDB documentation to determine if the presence of thorium and americium post-1988 represents a significant internal exposure hazard such that it represents an infeasibility similar to the operational period (Issue 1). SC&A also reviewed source documentation to determine if significant radiological conditions were likely to exist such that use of operational coworker data would not bound internal dose potential during the CEP period (Issue 2). In the context of Issue 2, and given the nature of the D&D work occurring during the CEP period, SC&A focused on noted incidents of contamination. Table 1 summarizes the results of SC&A’s document review.

Table 1 Summary of Document Reviews on the Site Research Database

SRDB No.	Title	Summary of Contents Related to Thorium and Americium
SRDB 22140	<i>Energy Technology Engineering Center – Site Description</i> (NIOSH 2006)	P. 24: “As a result of the work in the Hot Lab, the interior of the Hot Cells and the equipment they contain have been contaminated by small amounts of uranium, plutonium, thorium, and fission and activation products.... This radioactivity will be removed when the Hot Lab is decontaminated and decommissioned.” The only mention of americium is associated with the TRUMP-S program, but these materials were transported offsite prior to 1988 (p. 26). It should be noted that Am-241 was also present in sealed sources as well as contained in industrial smoke detectors at multiple facilities at the Energy Technology Engineering Center (ETEC).

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SRDB No.	Title	Summary of Contents Related to Thorium and Americium
SRDB 157608	<i>Radioactive Materials Handling Facility Decontamination and Decommissioning Engineering Evaluation/Cost Analysis</i> (Boeing 2007)	Section 2.1, page 7, states that Th-232 and Am-241 have the potential to be present at the Radioactive Materials Handling Facility (RMHF).
SRDB 166494	<i>Estimation of Radioactive Contents of RIHL Liquid Waste Tank Sludge</i> (Rockwell 1994)	The report describes the measured activity of the sludge contained inside an onsite tank. Th-232 activity concentration was within background. Am-241 total activity in the sludge was 2.14 μ Ci out of a total of 1,026.324 μ Ci (or about 1 Ci) for all radionuclides.
SRDB 73536	<i>U.S. Department of Energy Radionuclide Air Emissions Annual Report for Calendar Year 1995</i> (Rockwell 1996)	RMHF. Annual air emissions (after HEPA filter 99.97% efficient): Am-241 = 1.4E-10 Ci.
SRDB 170399	<i>U.S. Department of Energy Radionuclide Air Emissions Annual Report for Calendar Year 1991</i> (Rockwell 1992a)	Section 2 of the report states that thorium and Am-241 are present at the RMDF, but it does not specify if the material is in the form of contamination or packaged waste material. Section 3, paragraph 9, shows Th-232 and Am-241 as both being omitted from the dose evaluation because they were less than the detection limit. Th-232 is not associated with T059 (SNAP) in the report, but Am-241 is associated with SNAP but at less than detectable quantities. However, Section 4 of the report provides calculated doses to an offsite receptor and indicates that Th-232 and Am-241 represented 2.9% and 0.6% of the total dose, respectively.
SRDB 170364	Radioactive Material Handling Facility Sample Analyses January 1998–April 2001 (Teledyne Brown 1998–2001)	There are results for Th-232 on filter media on the order of 0.01 to 4 pCi, but the error was larger than the values except for five instances when the values were about 1 pCi. For Am-241, the majority of filter sample results were less than detectable, with one smear reading of 130 pCi.

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SRDB No.	Title	Summary of Contents Related to Thorium and Americium
SRDB 170373	Radioactive Materials Handling Facility Reviewed Surveys Area and Smear Surveys and Air Data December 1998, 1999, and January 2000 (Boeing 2000a)	Radiation surveys of controlled area boundaries included investigation for alpha contamination with all surveys being less than detectable. Smears for alpha contamination on departing transportation vehicles were likewise less than detectable. There are some air sampling records showing alpha readings on the order of E-14 to E-17 $\mu\text{Ci/cc}$ in the vault, decontamination room, and package room. These values are much lower than the DAC for Am-241 (3E-12 $\mu\text{Ci/cc}$) and Th-232 (1E-12 $\mu\text{Ci/cc}$).
SRDB 170375	Radioactive Materials Handling Facility Air and BZ Data April – May 2000 (Boeing 2000b)	Air sampling records showing alpha readings on the order of E-14 to E-16 $\mu\text{Ci/cc}$. These values are much lower than the DAC for Am-241 (3E-12 $\mu\text{Ci/cc}$) and Th-232 (1E-12 $\mu\text{Ci/cc}$).
SRDB 170391	Decontamination and Decommissioning T020 CAM, BZ and HEPA Exhaust Air Sample Logs (Boeing 1998a)	Air sampling records from 1998 showing alpha readings on the order of E-13 to E-15 $\mu\text{Ci/cc}$. These values are much lower than the DAC for Am-241 (3E-12 $\mu\text{Ci/cc}$) and Th-232 (1E-12 $\mu\text{Ci/cc}$).
SRDB 114216	<i>Summary Site Environmental Report Radiological Doses and Releases 1990 – 1994</i> (DOE 2001)	Table 3.1, p. 3-8: Most of the air emissions are from fission products (E-5 to E-6 Ci). Total strontium and total uranium were measured at levels of E-6 to E-10 Ci. Other actinides varied by several orders of magnitude (E-9 and E-16 Ci). Table 3.3, p. 3-20: There were no liquid releases containing radionuclides. There is no indication in the report that these air emissions resulted from activities that represented an internal exposure hazard to workers at SSFL.
SRDB 169468	Radiological Incidents in the 1980s (Rockwell 1989d)	PDF p. 213: October 4, 1989. In RIHL (Building 20), an employee bumped a “Unistrut” brace with sharp burr and punctured [REDACTED] in a glovebox for plutonium handling with possible Pu-239 contamination. A survey meter and smears showed background levels of contamination. There is no indication that Am-241 or Th-232 were also present in the glovebox, though it is worth noting that the puncture incident immediately triggered a [REDACTED].

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SRDB No.	Title	Summary of Contents Related to Thorium and Americium
SRDB 169468	Radiological Incidents in the 1980s (Rockwell 1989d)	PDF pp. 214–216. November 9, 1989. Equipment arrived from Stanford University that had radiation levels up to 60 μ R. The contamination was evaluated and determined to be Co-60. There was no indication of transuranic activity also present on the contaminated equipment.
SRDB 169476	Historical Rad Incidents ETEC-SSFL 1990s (Rockwell 2017)	PDF p. 4: April 18, 1990. RIHL (T020) Cell 2. Incident involving a puncture [REDACTED] contaminated to 120 pCi, which cut [REDACTED]. Bioassay was requested but no indication of alpha survey measurements was indicated. The document notes “see attachment,” but no attachment is provided in the file. There was no observed evidence in the incident report that indicates transuranic activity might have been involved.
SRDB 169476	Historical Rad Incidents ETEC-SSFL 1990s (Rockwell 2017)	PDF p. 7: July 17, 1990. RIHL (T020). [REDACTED] and was contaminated [REDACTED]. Nothing other than the 300 cpm exit survey was noted. However, a bioassay follow-up was recommended.
SRDB 169476	Historical Rad Incidents ETEC-SSFL 1990s (Rockwell 2017)	PDF p. 8: August 9, 1990. Power tool incident involving a cut in the RMDF. Only beta-gamma surveys were made, which is likely indicative of no alpha/transuranic material likely to be present. Report indicates bioassay as “results pending,” but it is unclear what type of bioassay. However, since the incident occurred within the CEP period, any subsequent bioassay would likely be invalid.
SRDB 169476	Historical Rad Incidents ETEC-SSFL 1990s (Rockwell 2017)	PDF p. 21: SNAP (T059) Test Cell 1. September 2, 1992. Shoe became contaminated during a torching operation; only beta-gamma surveys are indicated, which may indicate insignificant transuranic/alpha contamination was present.
SRDB 169476	Historical Rad Incidents ETEC-SSFL 1990s (Rockwell 2017)	PDF p. 54: T373 roof. August 22, 1995. Radioactive filters discovered. It appears only beta surveys were taken, and the contamination was determined to be predominantly Cs-137. No indication of worker exposures was observed in the incident report.
SRDB 169476	Historical Rad Incidents ETEC-SSFL 1990s (Rockwell 2017)	PDF p. 18: SNAP (T059) restricted area. Date redacted. Airborne Co-60 detected during “open tent torching in the test cell area.” The EEs involved were referred for bioassay analysis. There was no indication in the report of transuranic activity also being present.

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SRDB No.	Title	Summary of Contents Related to Thorium and Americium
19124	<i>Rocketdyne Propulsion & Power DOE Operations Annual Site Environmental Report 1996 (Boeing 1997)</i>	Refers to thorium only in the context of naturally occurring radioactivity. Americium not mentioned.
19125	<i>Rocketdyne Propulsion & Power DOE Operations Annual Site Environmental Report 1997 (Boeing 1998b)</i>	Refers to thorium only in the context of naturally occurring radioactivity. Americium not mentioned.

In addition to the documents described in Table 1, the SRDB contained an interview with a former SSFL worker who worked as the [REDACTED] beginning in 1992. The EE stated the following about the source term of concern at SSFL during D&D operations:

Our source-term inventory was overwhelmingly Cs-137/Sr-90. Building 59 was Co-60 and some other activation products (that had mostly disappeared when we started D&D). In most cases, Cs-137 or Co-60 were reliable indicators for the overall inventory (i.e., if Cs-137, Co-60 values were in range, one could be comfortable that the other possible isotopes were in range as well)...

As the various ETEC activities were terminated, the potential exposures to alpha-emitters reduced significantly. As mentioned above, the primary isotopes of concern became Cs-137 and Co-60. While alpha-emitters were also part of the source-terms in Building 20 and the RMHF, these were at very low levels and were not routinely found in the contamination surveys of these locations. Thus, Whole Body Counting became a very viable screening methodology for the site. [Documented Communication 2017, pp. 5–7]

Furthermore, an interview with the former [REDACTED] D&D and environmental radiation remediation beginning in 1990 stated the following about americium and thorium exposure potential:

It is my opinion that Am-241 and thorium would have been minor contributors, if any, to internal dose. It is likely that this rationale is why there were relatively few bioassay requests made historically for these radionuclides.

If Am-241 and thorium had been a significant internal dose contributor in the workplace of SSFL or De Soto, then it would logically have also been a potential environmental contaminant. This is not the case as demonstrated by the USEPA. The USEPA Area IV Radiological Study (2009–2012) took 3,735 soil and sediment samples at surface and subsurface analyzing all samples for 54 radionuclides, including Am-241 and thorium isotopes. Only 3 of 3,735 soil samples contained americium-241 that exceeded background, by only several

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hundredths of a picocurie. Only 5 of 3,735 soil samples had thorium-232 and 228 that exceeded background (at only 10% over background). So, neither americium nor thorium are or were an environmental issue. One could arguably extrapolate back and imply that it was also not a workplace issue at SSFL or at De Soto, or at least, less so than uranium, plutonium, and mixed fission products, for which we had more than adequate bioassay data. [Documented Communication 2018, pp. 5–6]

2.2 REVIEW OF BOEING INCIDENT DATABASE

In addition to captured documents contained in the SRDB, the petitioner for SSFL supplied NIOSH with a number of documents collectively known as the “Boeing Incident Database” during the ABRWH meeting on December 13, 2018.² There are approximately 1,500 files contained in the database, a portion of which are relevant to the period after 1988. SC&A reviewed the relevant files to determine if there are any indications of accidents/incidents that were related to inhalation or contamination involving americium and/or thorium. In addition, SC&A evaluated the available incident files to characterize the health physics oversight program in place during the CEP period. Table 2 summarizes the contents of these accident and incident reports. Note that all files in the Boeing Database described as “occurrence reports” were related to non-radiological incidents and thus are not discussed further in this report.

Table 2 Summary of Accident and Occurrence Reports Pertaining to Environmental and Personnel Contamination

ID No.	Title	Summary of Relevant Contents
A0665	Radiological Incident Report (Rockwell 1995a)	August 29, 1995: Contaminated soil at Area IV G Street. Radiation levels from the two hottest spots were 244 µR/hr contact, 40 µR/hr at 1 meter; and 73 µR/hr contact, 31 µR/hr at 1 meter. The report determined there was no impact on personnel at SSFL.
A0663	Radiological Incident Report (Rockwell 1995b)	August 8, 1995: Page 1 of the file. Soil contamination found in T064 side yard. Identified as Cs-137 (271 pCi/g). Spot is scheduled for remediation. The report determined there were no safety concerns, as the surface radiation is only 3 times background and the Cs-137 concentration is too low to be an inhalation concern.
A0580	Radiological Safety Report (Rockwell 1993a)	August 6, 1993. In the RMDF T021 laundry room, Cs-134, Cs-137, and Co-60 contamination was found on the room intake grill associated with the air conditioner. A survey of the room indicated no detectable activity.

² NIOSH subsequently made these accident and occurrence reports available to SC&A and the work group. They can be found on the Division of Compensation Analysis and Support internal server at aspp-dcas-files\ABRWH\AB Document Review\Santa Susana\Boeing_FlashDrive.

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ID No.	Title	Summary of Relevant Contents
A0575	Radiological Safety Report (Rockwell 1993b)	September 15, 1993. In RIHL T020, [REDACTED] drain piping found [REDACTED] dosimeter off scale. [REDACTED] in a High Radiation Area. [REDACTED] measured dose from the dosimeter was calculated to be 182 mrem. The source of radiation was not specified; however, no indications of alpha contamination were observed in the incident report.
A0571	Radiological Safety Report (Rockwell 1993c)	June 17, 1993. In Building 20 basement (RIHL). Contamination found on [REDACTED] from a vent duct that had serviced Cell 3. Contamination found on [REDACTED]. HP found 1,000–2,000 cpm using a survey meter. A bioassay was requested; however, since this incident occurred during the CEP period, any such bioassay would likely be invalid. The nature of the contamination was not specified, so it is not known if any transuranic material might have been present.
A0307	Radiological Safety Report (Rockwell 1992b)	December 3, 1992. In SNAP (T059), a worker discovered [REDACTED] dosimeter was off scale [REDACTED] in test cell L. The report indicates the exposure was potentially due to exposure of activated steel behind the wall being removed. The dose rate at the wall was about 300 μ Ci/hr. No bioassay was performed; however, activated steel contained in a facility wall would not contain transuranic material but rather would consist of fission and activation products.
A0217	Radiological Safety Report (Rockwell n.d.-b)	Date redacted. A radiological survey of the internal Respirator Lab washer at Building T100 in Room 130 using a GM survey meter that showed no detectable activity. A smear wipe was taken and counted on a Tennelec 5100 counter, showing 173 dpm/100 cm^2 beta. Gamma spectrometry indicated 254 dpm/100 cm^2 of Cs-137. Report recommends better decontamination practices and routine surveying of the respirators. No indication of alpha or transuranic contamination was indicated in the report.
A0212	Radiological Safety Report (Rockwell 1991)	January 17, 1991. In SNAP electrical room, floor sweepings found with a trace of Co-60 (0.85 pCi/g). No worker exposures were identified. As a result, the penetrations into the high bay were taped over to prevent possible migration of radionuclides into the room.

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ID No.	Title	Summary of Relevant Contents
A0211	Radiological Safety Report (Rockwell n.d.-a)	November 15, 1990. In the RMDF, found contaminated [REDACTED] at about 30,000 dpm beta/gamma direct reading. Gamma spectroscopy of Ce-144, Cs-137, and Co-60. A bioassay was recommended for the EE.
A0209	Radiological Safety Report (Rockwell 1990a)	October 2, 1990. In the T021 Decon Room, a worker detected contamination on [REDACTED] up to 2,000 cpm on an exit survey after unloading equipment from a storage box. Cause was from handling cables and body perspiration from working in a full-face respirator. Radionuclides included Co-57, Cs-137, Cs-134, and Co-58. A bioassay was recommended for the EE.
A0206	Radiological Safety Report (Rockwell 1990b)	May 8, 1990. In T059 (SNAP), [REDACTED]. Fixed contamination of 300 cpm was found, and the [REDACTED] were disposed of. [REDACTED] decontaminating vacuum equipment room shield blocks. The contamination was identified as Co-60. A bioassay was recommended for the EE.
A0199	Radiological Safety Report (Rockwell 1989a)	June 29, 1989. In Building 20 (RIHL) Cell #2 and Decon #I, [REDACTED] (7,000 cpm and 1,000 cpm) while electropolishing. Believed the contamination came from the red line laundry. [REDACTED]. No bioassays were recommended. The report does not specify the type of contamination.
A0198	Radiological Safety Incident Report (Rockwell 1989b)	June 6, 1989. In Building 20 (RIHL) Cell #1, two workers were contaminated during decontamination and decommissioning operations. [REDACTED]. A survey meter measured 6,000 cpm and 12,000 cpm beta/gamma for the two workers, respectively. No bioassays were recommended. There is no indication of measurable alpha contamination indicated in the report.
A0197	Radiological Safety Incident Report (Rockwell 1989c)	April 6, 1989. In the lower level of SNAP (T059), during the changing of exhaust filters, a worker noticed a cloud of dust from the box of filters when it fell to the ground. [REDACTED] (4,350 dpm) and [REDACTED] (5,800 dpm) were decontaminated. Dust was analyzed on a T100 HPGe detector (700 dpm/100 cm ²). Nasal smears were taken (132 dpm). The report identified Co-60 as the radionuclide involved.

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ID No.	Title	Summary of Relevant Contents
A0190	Radiological Safety Incident Report (Rockwell 1988a)	September 30, 1988. Building 20 (RIHL) Cell #1. An employee found contamination on [REDACTED] with a maximum of 3,500 dpm beta/gamma using a “T/A pug IA.” ^a No bioassay was recommended. There is no indication of measurable alpha contamination mentioned in the report.
A0189	Radiological Safety Incident Report (Rockwell 1988b)	August 19, 1988. In SNAP (T059), an employee was [REDACTED]. No radioactivity from nasal and facial smears. The work area air sample indicated 1.5E-11 µCi/cc, below the MPC level of 9E-9 µCi/cc for airborne beta/gamma contamination. Bioassay was recommended for the worker involved. Co-60 is noted as the contaminant of interest in the report.
A0188	Radiological Safety Incident Report (Rockwell 1988c)	August 15, 1988. In the RMDF (T075), there was an accidental release of about 40 grams of radioactivated sand from waste drums (24,000 dpm beta/gamma) due to a forklift puncturing the drum. No bioassay was recommended. There is no indication of measurable alpha contamination mentioned in the report. Activated sand is not likely to contain transuranic material.
A0187	Radiological Safety Incident Report (Rockwell 1988d)	August 12, 1988. In the SNAP (T059) pipe chase room, a worker was contaminated with 17,500 dpm beta/gamma/100 cm ² . Identified radionuclides included Co-60, Eu-152, and Eu-154. Bioassay was recommended for the EE. Nasal smears showed up to 12 dpm. There is no indication of measurable alpha contamination mentioned in the report.
IR01684	Incident Report (Boeing 2003)	February 26, 2003. Area IV, Building 4057. During a routine records search of file cabinet drawer F-25C, a package of air samples was discovered that had measurable internal contamination using a Ludlum 3 frisker that indicated approximately 2–3 times background. The envelopes had been put in the file cabinet in September 1976. The package was transferred to the RMHF.

^a SC&A believes “T/A put IA” to represent the Technical Associates Survey Meter: pug IA.

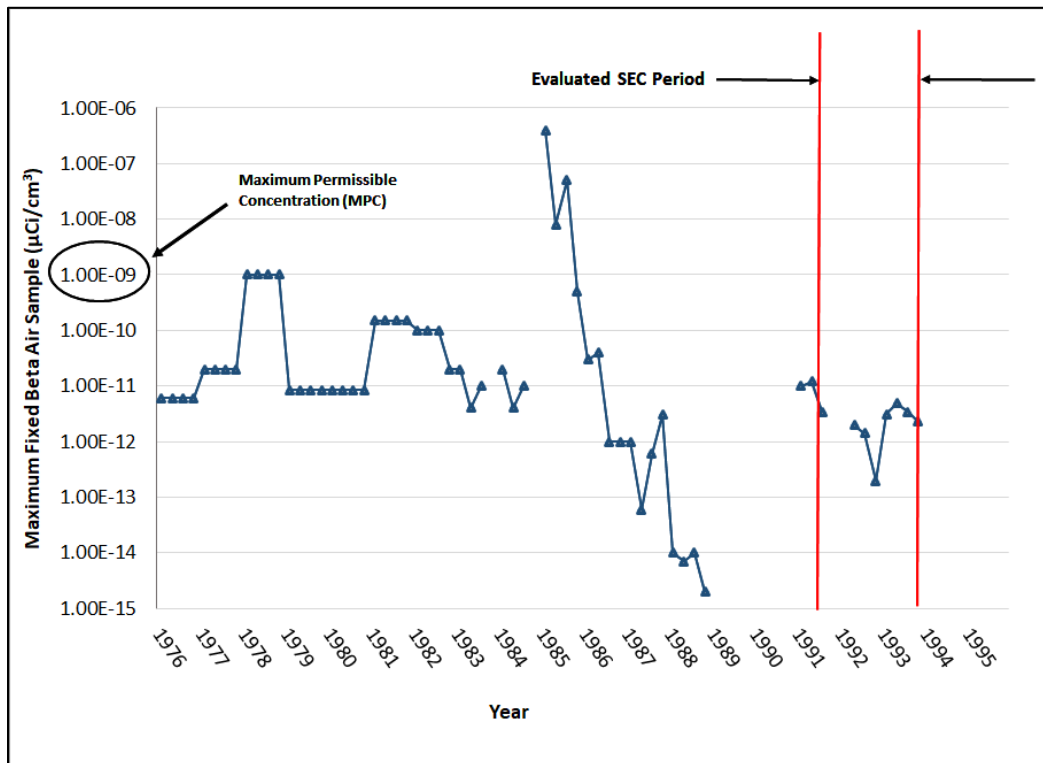
2.3 COMPARISON OF GENERAL AIR SAMPLING RESULTS

To evaluate the relative internal exposure potential between the operational period (pre-1989) and CEP period (approximately 1991–1993), SC&A compiled and analyzed the GA sampling reports for RIHL from 1975 through 1993. SC&A chose RIHL due to the relative amount of data

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available for that location as well as the nature and extent of D&D activities occurring during the CEP period.³ SC&A examined both the average and maximum quarterly air sampling values for gross alpha and gross beta activity, when available, to compare the two periods. Figures 1–4 show the results of this comparison; Section 3.2 discusses the air sampling analysis.

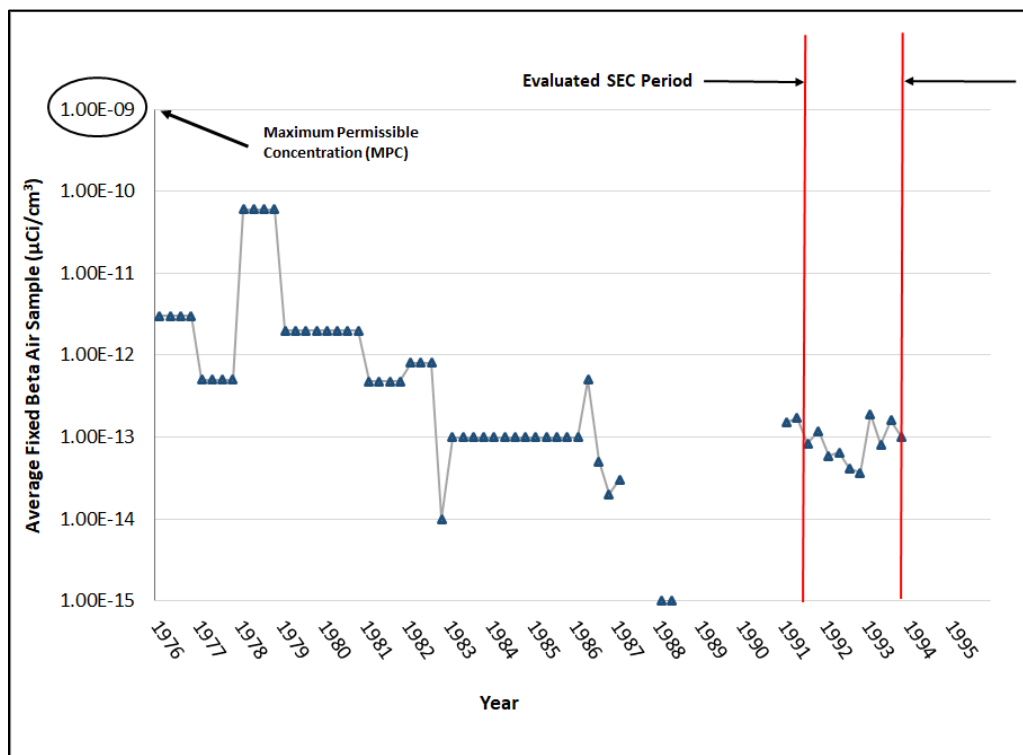
Figure 1. Maximum General Air Beta Air Sampler Results for RIHL (1976–1993)



Source: Rockwell 1980a, p. 18; 1980b, p. 17; 1980c, p. 13; 1980d, p. 13; 1983, p. 13; 1985, p. 17; 1984, p. 14; 1986a, p. 20; 1986b, p. 17; 1986c, p. 18; 1988e, p. 17; 1988f, p. 15; 1989e, p. 25; 1993d, pp. 18–20, 57–59, 97–98, 146–147, 173–174, 189–197, 246–254, 295–303, 364–372, 429–437, 483–492, 531–539.

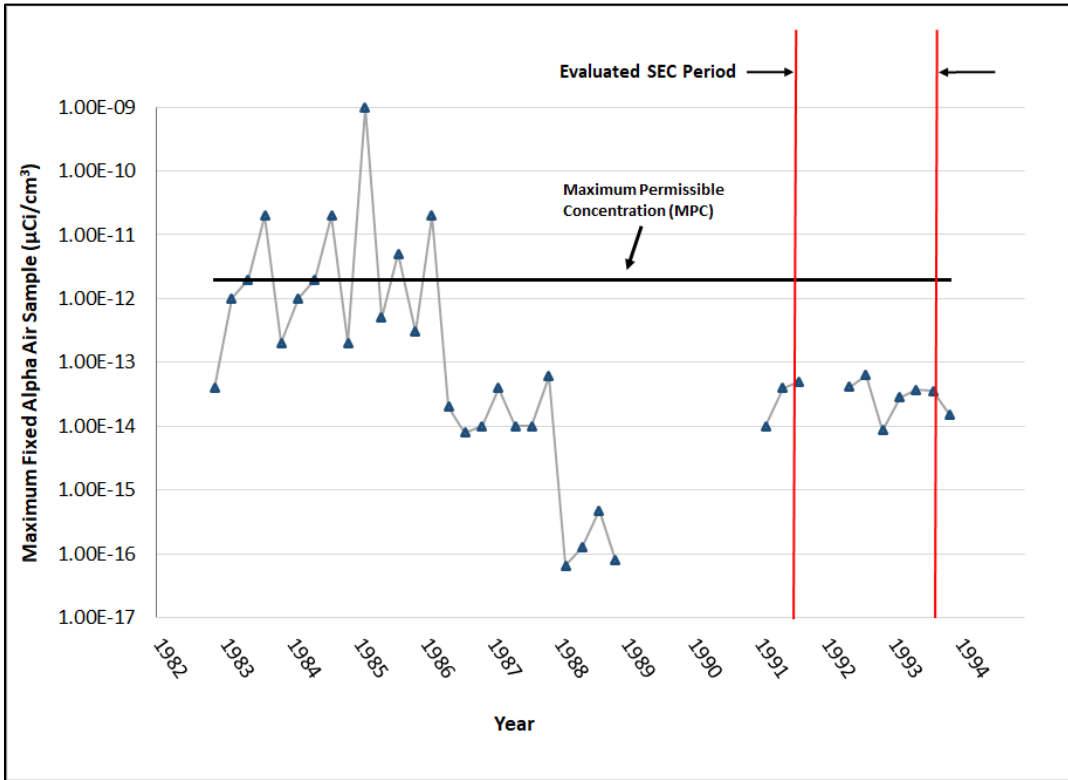
³ As noted in NIOSH 2006, the radioactive material license for RIHL was modified in 1990 to include only D&D activities.

Figure 2. Average General Air Beta Air Sampler Results for RIHL (1976–1993)



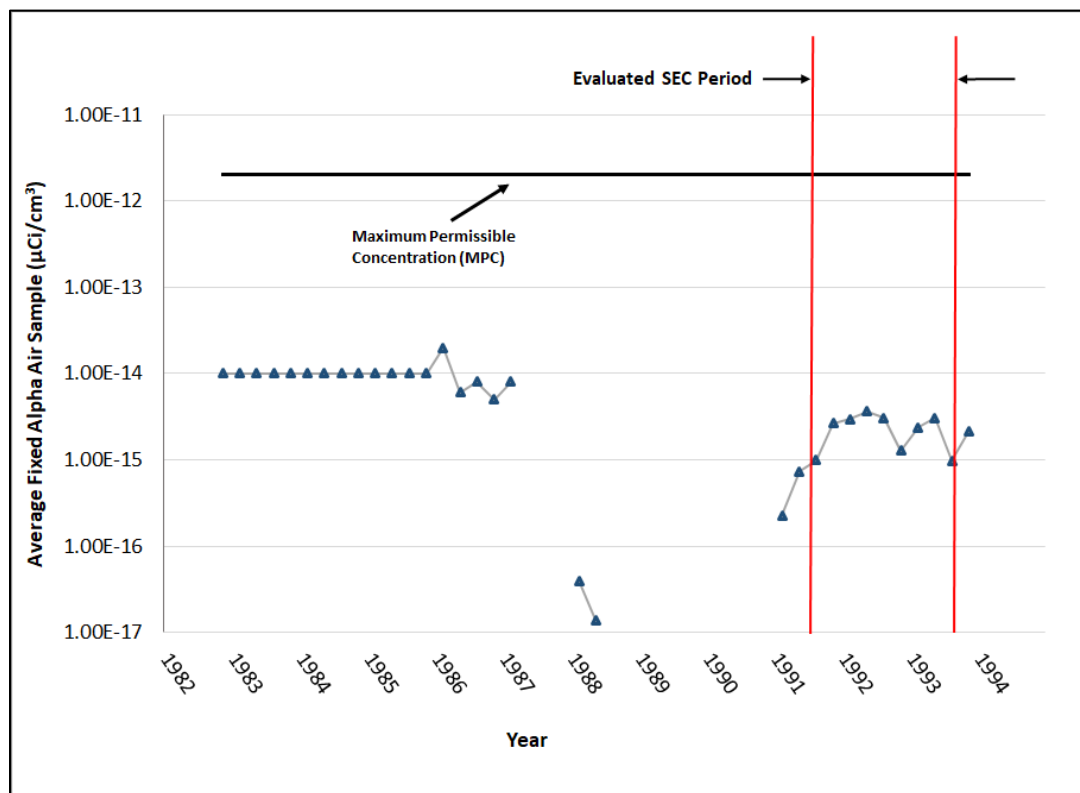
Source: Rockwell 1980a, p. 18; 1980b, p. 17; 1980c, p. 13; 1980d, p. 13; 1983, p. 13; 1985, p. 17; 1984, p. 14; 1986a, p. 20; 1986b, p. 17; 1986c, p. 18; 1988e, p. 17; 1988f, p. 15; 1989e, p. 25; 1993d, pp. 18–20, 57–59, 97–98, 146–147, 173–174, 189–197, 246–254, 295–303, 364–372, 429–437, 483–492, 531–539.

Figure 3. Maximum General Air Alpha Air Sampler Results for RIHL (1982–1993)



Source: Rockwell 1980a, p. 18; 1980b, p. 17; 1980c, p. 13; 1980d, p. 13; 1983, p. 13; 1985, p. 17; 1984, p. 14; 1986a, p. 20; 1986b, p. 17; 1986c, p. 18; 1988e, p. 17; 1988f, p. 15; 1989e, p. 25; 1993d, pp. 18–20, 57–59, 97–98, 146–147, 173–174, 189–197, 246–254, 295–303, 364–372, 429–437, 483–492, 531–539.

Figure 4. Average General Air Beta Air Sampler Results for RIHL (1982–1993)



Source: Rockwell 1980a, p. 18; 1980b, p. 17; 1980c, p. 13; 1980d, p. 13; 1983, p. 13; 1985, p. 17; 1984, p. 14; 1986a, p. 20; 1986b, p. 17; 1986c, p. 18; 1988e, p. 17; 1988f, p. 15; 1989e, p. 25; 1993d, pp. 18–20, 57–59, 97–98, 146–147, 173–174, 189–197, 246–254, 295–303, 364–372, 429–437, 483–492, 531–539.

3 DISCUSSION

This section discusses the documentation review and data analysis presented in the previous section in the context of the two remaining SEC issues. Specifically, Section 3.1 discusses the potential presence of americium and thorium during the D&D period and the implications for dose reconstruction feasibility. Section 3.2 discusses the comparison of air sampling data between the operational and CEP periods in order to evaluate the relative internal exposure potential during the two periods.

3.1 PRESENCE OF THORIUM AND AMERICIUM POST-1988

SC&A reviewed the documents shown in Tables 1 and 2 above to determine if there were significant quantities of thorium (Th-232) and americium (Am-241) present post-1988 at Area IV to determine the feasibility of dose reconstruction to these potential contaminants. Boeing 2007 (see Table 1) states that both thorium and americium could be present at RMHF based on process history. This conforms to statements in the ETEC site description technical basis document (NIOSH 2006) that thorium could be present in RIHL. However, NIOSH 2006 goes on to state that americium associated with the Transuranic Management by Pyropartitioning-Separation (TRUMP-S) program was shipped to SSFL but was later removed to

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the University of Missouri. It has not been established that TRUMP-S work was ever actually undertaken at SSFL; therefore, it is likely the material was only stored at the site. The DOE radionuclide air emissions annual report for calendar year 1991 (Rockwell 1992a) states that thorium and americium are present at the RMDF, but no additional information is provided about the form in which these radionuclides would exist (packaged, encapsulated, etc.). Rockwell 1992a appears to contradict itself in that Section 3 of that report states that americium and thorium have been omitted from the offsite receptor dose evaluation because the calculated releases were below the level of detection. However, Section 4 of Rockwell 1992a indicates that Th-232 and Am-241 contributed 2.9% and 0.6% of the total dose to an offsite receptor (the calculated doses were several orders of magnitude less than 1 mrem). Two interviews with former workers with technical expertise⁴ and direct involvement in [REDACTED] of D&D operations at SSFL did not indicate that significant exposure potential to americium and/or thorium during those operations was likely (Documented Communication 2017, 2018).

SC&A reviewed radiological surveys, incidents involving area and personnel contamination, and process descriptions and could not find thorium or americium mentioned as being present as an internal exposure hazard, although other radionuclides were identified (e.g., cesium-137). Surveys were predominantly for beta-gamma, although SC&A did find measurements of alpha contamination in SRDB 170373, SRDB 170375, and SRDB 170391. However, these measured values were much less than the derived air concentration (DAC) for Am-241 and Th-232 (3×10^{-12} and 1×10^{-12} microcuries per cubic centimeter ($\mu\text{Ci/cc}$), respectively). SC&A reviewed the incident and accident reports provided by the SSFL petitioner, and none of these reports identified thorium or americium as being present in any measurable quantity (see Table 2). The only mention of an incident involving alpha activity involved a glovebox that was contaminated with plutonium. SC&A identified two annual environmental reports (Boeing 1997, 1998b). Both reports referred to thorium as being present in the surrounding environment of Area IV in naturally occurring amounts, and neither identified the presence of americium.

3.2 COMPARISON OF RADIOLOGICAL CONDITIONS DURING OPERATIONAL AND CEP PERIOD

As noted in Section 2.2, several incidents of contamination that may represent an internal exposure potential are documented during the post-1988 period. However, in these cases health physics follow-up occurred, and in most cases bioassay was recommended. Although follow-up bioassay would not be valid during the CEP period, a routine in vivo monitoring program was also in place during this period that would detect any intakes of gamma-emitting fission and activation products likely to be present at SSFL during the evaluated period. The sole incident identified involving alpha contamination was a [REDACTED] incident in a plutonium glovebox. Follow-up bioassay for the incident occurred in 1989 when a viable bioassay program was in place, although the results of the bioassay are not known at this time.

A comparison of GA air samples at both the maximum and average quarterly levels demonstrates that the measured values for controlled areas during the CEP period were bounded by the operational period for both gross beta and gross alpha measurements. Furthermore, quarterly GA air samples during the CEP period were all several orders of magnitude below the maximum

⁴ Interviewees included the [REDACTED] during the period of interest.

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permissible concentration (MPC) for both alpha and beta airborne contamination. SC&A did not identify any evidence in the available air sampling data to suggest that internal exposure potential to the radionuclides of concern at SSFL would not be bounded by the operational bioassay data.⁵

4 SUMMARY CONCLUSION

Based on the review of relevant available documentation in the SRDB, as well as relevant incident documentation found in the Boeing Incident Database provided by the petitioner, SC&A did not identify evidence of internal exposure potential to americium and/or thorium sources that would preclude dose reconstruction feasibility. However, the operational history of americium and thorium exposure was clearly established in SEC-00234 and then described in Boeing 2007 as decontamination and decommissioning contaminants of interest. NIOSH 2006 and Rockwell 1992a indicate that thorium and americium could be present as potential sources of exposure. NIOSH 2010 reaffirms americium and thorium as a potential source of exposure and provides environmental intakes of both radionuclides based on stack emissions at ETEC. Given the uncertainty related to off-normal work conditions associated with decontamination and decommissioning activities, NIOSH might consider establishing an occupational exposure model, in place of an environmental intake model, that uses available air sampling results (BZ and GA) or some fraction of the administrative limits in place at the time. This might be particularly important if BZ data is not generally provided in a claimant's dosimetry file. This would assure a claimant favorable and bounding dose assignment for thorium and americium.

With regard to Item 2, SC&A found no evidence in either the available documentation or GA air sample data that radiological conditions were significantly different from the operational period that would preclude the use of coworker intake models developed for uranium, plutonium, and fission/activation products (strontium and cesium) during the CEP Period. Although, there are several outstanding findings/observations associated with the SSFL coworker model that are still under consideration by the ABRWH (SC&A 2014), SC&A does not consider these outstanding findings/observations to be SEC issues at this time. SC&A believes the remaining coworker issues can be resolved via the site profile review process.

Finally, it must be noted that the SEC petitioner notified NIOSH on January 28, 2019, that approximately 1,463 boxes of DOE records relevant to SSFL are scheduled to be made available no later than fall 2019. Therefore, the analysis and conclusions contained in this report may be considered an interim evaluation pending future work group deliberations and/or SEC-00235 action concerning the discovery of these records.

⁵ It should be noted that 15 findings and 10 observations from SC&A's 2014 review of the SSFL coworker model remain open (SC&A 2014). However, several of these findings and observations have been obviated by SEC-00234, and the remaining issues are not considered items that might preclude dose reconstruction.

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