SEC Petition Evaluation Report
Petition SEC-00188

Report Rev #:0 Report Submittal Date: 02/21/2012

Subject Expert(s):	Tim Adler, Jim Bogard, Paul Ruhter
Site Expert(s):	N/A

Petition Administrative Summary

Petition Under Evaluation

Petition #	Petition Type	Petition Receipt Date	Qualification Date	DOE/AWE Facility Name
SEC-00188	83.13	July 18, 2011	October 21, 2011	Sandia National Laboratories-Albuquerque

Petitioner-Requested Class Definition

All Security Inspectors, Security Clerks, Firemen, Non-regular Recurrent Security Inspectors, Security Officers, Security Police Officers I, Security Police Officers II, Security Police Officers III, and Central Alarm System Operators that worked in any area at SNL-A for the period from January 1, 1963 through May 21, 2011.

Class Evaluated by NIOSH

All personnel that worked in any area at Sandia National Laboratories in Albuquerque, New Mexico for the period from January 1, 1963 through May 21, 2011.

NIOSH-Proposed Class(es) to be Added to the SEC

All employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked in any area at Sandia National Laboratories in Albuquerque, New Mexico, from January 1, 1963 through December 31, 1994, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

Related Petition Summary Information

SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
SEC-00162	83.13	Sandia National Laboratories, Albuquerque	Class added to the SEC for January 1, 1949 through December 31, 1962

Related Evaluation Report Information

Report Title	DOE/AWE Facility Name
SEC Petition Evaluation Report for Petition SEC-00162	Sandia National Laboratories-Albuquerque

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Peer Review Completed By:	[Signature on File] *Sam Glover*	2/21/2012 *Date*
SEC Petition Evaluation Reviewed By:	[Signature on File] *J. W. Neton*	2/21/2012 *Date*
SEC Evaluation Approved By:	[Signature on File] *Stuart L. Hinnefeld*	2/21/2012 *Date*

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Evaluation Report Summary: SEC-00188, Sandia National Laboratories

This evaluation report by the National Institute for Occupational Safety and Health (NIOSH) addresses a class of employees proposed for addition to the Special Exposure Cohort (SEC) per the *Energy Employees Occupational Illness Compensation Program Act of 2000*, as amended, 42 U.S.C. § 7384 *et seq.* (EEOICPA) and 42 C.F.R. pt. 83, *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort under the Energy Employees Occupational Illness Compensation Program Act of 2000*.

Petitioner-Requested Class Definition

Petition SEC-00188 was received on July 18, 2011, and qualified on October 21, 2011. The petitioner requested that NIOSH consider the following class: *All Security Inspectors, Security Clerks, Firemen, Non-regular Recurrent Security Inspectors, Security Officers, Security Police Officers I, Security Police Officers II, Security Police Officers III, and Central Alarm System Operators that worked in any area at SNL-A for the period from January 1, 1963 through May 21, 2011.*

Class Evaluated by NIOSH

NIOSH incurred internal monitoring data retrieval problems while processing individual claims and performing data capture work. The data retrieval issues appeared to affect much of the time period within the petitioner-requested class definition and impacted all types of workers (not just workers associated with the Security Police Association). Considering this information, NIOSH expanded the petitioner-requested class to include all personnel. NIOSH evaluated the following class: All personnel that worked in any area at Sandia National Laboratories in Albuquerque, New Mexico for the period from January 1, 1963 through May 21, 2011.

NIOSH-Proposed Class to be Added to the SEC

Based on its current research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked in any area at Sandia National Laboratories in Albuquerque, New Mexico, from January 1, 1963 through December 31, 1994, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort. The period from January 1, 1963 through December 31, 1994 was included (see Section 3.0) primarily due to the lack of internal monitoring program documentation, compounded by the lack of internal monitoring data and process information applicable to this period. For the purposes of timeliness, NIOSH is issuing this report covering available data sufficiency and feasibility conclusions now, but will continue to review and evaluate internal exposure reconstruction feasibility for the 1995 through 2011 period when applicable databases become available. If NIOSH finds information indicating that doses cannot be bound for the January 1, 1995 through May 21, 2011 period, NIOSH will proceed with an 83.14 report, recommending an additional class.

Feasibility of Dose Reconstruction

NIOSH finds it is not feasible to estimate internal exposures with sufficient accuracy for all workers at the site from January 1, 1963 through December 31, 1994. This period was included primarily due to the lack of internal monitoring program documentation, compounded by the lack of internal monitoring data and process information. For the purposes of timeliness, NIOSH is issuing this report covering available data sufficiency and feasibility conclusions now, but will continue to review and evaluate internal exposure reconstruction feasibility for the 1995 through 2011 period when applicable databases become available. If NIOSH finds information indicating that doses cannot bound for the January 1, 1995 through May 21, 2011 period, NIOSH will proceed with an 83.14 report, recommending an additional class.

The NIOSH dose reconstruction feasibility findings are based on the following:

- Principal sources of internal radiation for members of the proposed class included exposures to plutonium, tritium, uranium, americium, and fission and activation products. Potential exposure pathways could have involved the handling of these radionuclides during waste-burial operations or exposure to surface or air contamination associated with reactors and/or accelerators work. NIOSH has found that source terms and associated exposures varied over the evaluated period. Considering the potential exposure scenarios, NIOSH finds it is unable to estimate these internal exposures with sufficient accuracy for the period from January 1, 1963 through December 31, 1994.

- Principal sources of external radiation for members of the proposed class included exposures to alpha, beta, gamma, and neutron radiation. Exposures could have occurred during waste-handling activities and hot cell work. Work with reactors and accelerators also involved exposure potential for workers. Samples obtained from blast experiments conducted at the Nevada Test Site and analyzed at Sandia National Laboratories-Albuquerque could have resulted in external exposure. Additionally, medical X-rays performed onsite as a condition of employment would have resulted in external exposures to the evaluated class. NIOSH finds that it is feasible to reconstruct all occupational external dose for Sandia National Laboratories-Albuquerque workers with sufficient accuracy for the entire evaluated period.

- Pursuant to 42 C.F.R. § 83.13(c)(1), NIOSH determined that there is insufficient information to either: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred under plausible circumstances by any member of the class; or (2) estimate the radiation doses of members of the class more precisely than a maximum dose estimate.

- Although NIOSH found that it is not possible to completely reconstruct internal radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Sandia National Laboratories-Albuquerque during the period from January 1, 1963 through December 31, 1994, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

Health Endangerment Determination

Per EEOICPA and 42 C.F.R. § 83.13(c)(3), a health endangerment determination is required because NIOSH has determined that it does not have sufficient information to estimate dose for the members of the proposed class from January 1, 1963 through December 31, 1994.

NIOSH did not identify any evidence supplied by the petitioners or from other resources that would establish that the proposed class was exposed to radiation during a discrete incident likely to have involved exceptionally high-level exposures. However, evidence indicates that some workers in the proposed class may have accumulated substantial chronic exposures through episodic intakes of radionuclides, combined with external exposures to gamma, beta, and neutron radiation. Consequently, NIOSH has determined that health was endangered for those workers covered by this evaluation who were employed for at least 250 aggregated work days either solely under their employment or in combination with work days within the parameters established for other SEC classes.

For the period January 1, 1995 through May 21, 2011, a health endangerment determination will be provided when dose estimation feasibility for this period has been completed.

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SEC Petition Evaluation Report for SEC-00188

ATTRIBUTION AND ANNOTATION: This is a single-author document. All conclusions drawn from the data presented in this evaluation were made by the ORAU Team Lead Technical Evaluator: Tim Adler, Oak Ridge Associated Universities. The rationales for all conclusions in this document are explained in the associated text.

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for all employees who worked in any area at Sandia National Laboratories, Albuquerque, New Mexico (often referred to as SNL-A throughout this report), from January 1, 1963 through May 21, 2011. It provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created SEC.

This report does not make any determinations concerning the feasibility of dose reconstruction that necessarily apply to any individual energy employee who might require a dose reconstruction from NIOSH. This report also does not contain the final determination as to whether the proposed class will be added to the SEC (see Section 2.0).

This evaluation was conducted in accordance with the requirements of EEOICPA, 42 C.F.R. pt. 83, and the guidance contained in the Division of Compensation Analysis and Support's (DCAS) *Internal Procedures for the Evaluation of Special Exposure Cohort Petitions*, DCAS-PR-004.[1]

2.0 Introduction

Both EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting that the Department of Health and Human Services (HHS) add a class of employees to the SEC. The evaluation is intended to provide a fair, science-based determination of whether it is feasible to estimate with sufficient accuracy the radiation doses of the class of employees through NIOSH dose reconstructions.[2]

42 C.F.R. § 83.13(c)(1) states: *Radiation doses can be estimated with sufficient accuracy if NIOSH has established that it has access to sufficient information to estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class, or if NIOSH has established that it has access to sufficient information to estimate the radiation doses of members of the class more precisely than an estimate of the maximum radiation dose.*

Under 42 C.F.R. § 83.13(c)(3), if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, then NIOSH must determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. The regulation requires

[1] DCAS was formerly known as the Office of Compensation Analysis and Support (OCAS).
[2] NIOSH dose reconstructions under EEOICPA are performed using the methods promulgated under 42 C.F.R. pt. 82 and the detailed implementation guidelines available at http://www.cdc.gov/niosh/ocas.

NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for at least 250 aggregated work days within the parameters established for the class or in combination with work days within the parameters established for one or more other SEC classes.

NIOSH is required to document its evaluation in a report, and to do so, relies upon both its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the petitioner(s) and the Advisory Board on Radiation and Worker Health (Board). The Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Board considers appropriate, in order to make recommendations to the Secretary of HHS on whether or not to add one or more classes of employees to the SEC. Once NIOSH has received and considered the advice of the Board, the Director of NIOSH will propose a decision on behalf of HHS. The Secretary of HHS will make the final decision, taking into account the NIOSH evaluation, the advice of the Board, and the proposed decision issued by NIOSH. As part of this decision process, petitioners may seek a review of certain types of final decisions issued by the Secretary of HHS.[3]

3.0 SEC-00188, Sandia National Laboratories Class Definitions

The following subsections address the evolution of the class definition for SEC-00188, Sandia National Laboratories-Albuquerque (SNL-A). When a petition is submitted, the requested class definition is reviewed as submitted. Based on its review of the available site information and data, NIOSH will make a determination whether to qualify for full evaluation all, some, or no part of the petitioner-requested class. If some portion of the petitioner-requested class is qualified, NIOSH will specify that class along with a justification for any modification of the petitioner's class. After a full evaluation of the qualified class, NIOSH will determine whether to propose a class for addition to the SEC and will specify that proposed class definition.

3.1 Petitioner-Requested Class Definition and Basis

Petition SEC-00188 was received on July 18, 2010, and qualified on October 21, 2010. The petitioner requested that NIOSH consider the following class: *All Security Inspectors, Security Clerks, Firemen, Non-regular Recurrent Security Inspectors, Security Officers, Security Police Officers I, Security Police Officers II, Security Police Officers III, and Central Alarm System Operators that worked in any area at SNL-A for the period from January 1, 1963 through May 21, 2011.*

The petitioner provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the SNL-A workers in question. NIOSH

[3] See 42 C.F.R. pt. 83 for a full description of the procedures summarized here. Additional internal procedures are available at http://www.cdc.gov/niosh/ocas.

determined that the petitioner-provided information supported the qualification of petition SEC-00188. Specifically, the affidavits supplied can be used to support the following:

- An F.1 basis, which includes the cases where potential radiation doses were not monitored through personal monitoring, as explicitly stated in the affidavits.

- An F.2 basis, which includes the cases where monitoring records were lost, falsified, or destroyed; or when there is no information regarding source, source term, or process from the site.

Based on its SNL-A research and data capture efforts, NIOSH determined that it has access to external monitoring data for SNL-A workers during the time period under evaluation. However, NIOSH also determined that access to internal monitoring data records is very limited. NIOSH concluded that there is sufficient documentation to support, for at least part of the requested time period, the petition basis that internal radiation exposures and radiation doses were not adequately monitored at SNL-A; that internal radiation monitoring records may have been lost or destroyed; and that there is potentially incomplete information regarding monitoring, source terms, or process information relating to SNL-A operations. The details of the petition basis are addressed in Section 7.4.

3.2 Class Evaluated by NIOSH

Based on its preliminary research, NIOSH expanded the petitioner-requested class to include all personnel because of internal monitoring data retrieval problems incurred while processing individual claims and performing SNL-A data capture work. The data retrieval issues appeared to affect much of the time period within the petitioner-requested class definition and included workers not associated with the Security Police Association. Therefore, NIOSH defined the following class for further evaluation: All employees who worked in any area at Sandia National Laboratories, Albuquerque, New Mexico, from January 1, 1963 through May 21, 2011.

3.3 NIOSH-Proposed Class to be Added to the SEC

Based on its research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked in any area at Sandia National Laboratories in Albuquerque, New Mexico, from January 1, 1963 through December 31, 1994, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort. NIOSH will continue to review and evaluate internal exposure reconstruction feasibility when applicable databases become available. If NIOSH finds information indicating that doses cannot bound for the period, NIOSH will proceed with an 83.14 report, recommending an additional class.

4.0 Data Sources Reviewed by NIOSH to Evaluate the Class

As is standard practice, NIOSH completed an extensive database and Internet search for information regarding SNL-A. The database search included the DOE Legacy Management Considered Sites database, the DOE Office of Scientific and Technical Information (OSTI) database, the Energy Citations database, and the Hanford Declassified Document Retrieval System. In addition to general Internet searches, the NIOSH Internet search included OSTI OpenNet Advanced searches, OSTI Information Bridge Fielded searches, Nuclear Regulatory Commission (NRC) Agency-wide Documents Access and Management (ADAMS) web searches, the DOE Office of Human Radiation Experiments website, and the DOE-National Nuclear Security Administration-Nevada Site Office-search. Attachment One contains a summary of SNL-A documents. The summary specifically identifies data capture details and general descriptions of the documents retrieved.

In addition to the database and Internet searches listed above, NIOSH identified and reviewed numerous data sources to determine information relevant to determining the feasibility of dose reconstruction for the class of employees under evaluation. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. The following subsections summarize the data sources identified and reviewed by NIOSH.

4.1 Site Profile Technical Basis Documents (TBDs)

A Site Profile provides specific information concerning the documentation of historical practices at the specified site. Dose reconstructors can use the Site Profile to evaluate internal and external dosimetry data for monitored and unmonitored workers, and to supplement, or substitute for, individual monitoring data. A Site Profile provides process history information, information on personal and area monitoring, radiation source descriptions, and references to primary documents relevant to the radiological operations at the site. As part of NIOSH's evaluation detailed herein, it examined the following Site Profile for insights into SNL-A operations:

- *Site Profile for Sandia National Laboratories in Albuquerque, New Mexico, and the Tonopah Test Range, Nevada*, ORAUT-TKBS-0037; Rev. 00; June 22, 2007; SRDB Ref ID: 32531

4.2 ORAU Technical Information Bulletins (OTIBs) and Procedures

An ORAU Technical Information Bulletin (OTIB) is a general working document that provides guidance for preparing dose reconstructions at particular sites or categories of sites. An ORAU Procedure provides specific requirements and guidance regarding EEOICPA project-level activities, including preparation of dose reconstructions at particular sites or categories of sites. NIOSH reviewed the following OTIBs and procedures as part of its evaluation:

- *OTIB: Dose Reconstruction from Occupational Medical X-Ray Procedures*, ORAUT-OTIB-0006, Rev. 03 PC-1; June 20, 2011; SRDB Ref ID: 98147

- *OTIB: Use of Coworker Dosimetry Data for External Dose Assignment,* ORAUT-OTIB-0020, Rev. 03; November 14, 2011; SRDB Ref ID: 104029

- *OTIB: External Coworker Dosimetry Data for the Sandia National Laboratory in Albuquerque, New Mexico,* ORAUT-OTIB-0072, Rev. 00; September 26, 2008; SRDB Ref ID: 49941

- *Procedure: Occupational Medical X-Ray Dose Reconstruction for DOE Sites,* ORAUT-PROC-0061, Rev. 03; March 3, 2010; SRDB Ref ID: 79758

4.3 Facility Employees and Experts

There have been multiple SNL-A worker interviews. Some of these interviews were completed by NIOSH for purposes other than support of this evaluation report, while others were older interviews performed by other organizations that were obtained by NIOSH during data capture trips. These interviews, plus three additional interviews of semi-retired SNL-A health physicists (conducted specifically for this evaluation) as well as one large meeting with current and former SNL-A personnel have been considered and referenced throughout this evaluation. Both interviews performed specifically for this SEC evaluation were conducted by phone and are referenced below:

- Personal Communication, 2011, *Personal Communication with SNL-A Employee*; Telephone Interview by ORAU Team; February 24, 2011, 12:00 PM EST; SRDB Ref ID: 93639 (Personal Communication, 2011a)

- Personal Communication, 2011, *Personal Communication with SNL-A Employee*; Telephone Interview by ORAU Team; February 24, 2011, 3:00 PM EST; SRDB Ref ID: 93640 (Personal Communication, 2011b)

- Personal Communication, 2011, *Personal Communication with Former SNL-A* Employee; Telephone Interview by ORAU Team; April 26, 2011; SRDB Ref ID: 105305 (Personal Communication, 2011c)

- Personal Communication, 2011, *Personal Communication with Multiple Former and Current SNL-A Employees*; Site meeting by NIOSH; November 15, 2011; SRDB Ref ID: TBD after classification review (Personal Communication, 2011d)

4.4 Previous Dose Reconstructions

NIOSH reviewed its NIOSH DCAS Claims Tracking System (referred to as NOCTS) to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. Table 4-1 summarizes the results of this review. (NOCTS data available as of December 14, 2011)

Table 4-1: No. of SNL-A Claims Submitted Under the Dose Reconstruction Rule

Description	Totals
Total number of claims submitted for dose reconstruction	367
Total number of claims submitted for energy employees who worked during the period under evaluation (January 1, 1963 through May 21, 2011)	323
Number of dose reconstructions completed for energy employees who worked during the period under evaluation (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval).	270
Number of claims for which internal dosimetry records were obtained for the identified years in the evaluated class definition	37
Number of claims for which external dosimetry records were obtained for the identified years in the evaluated class definition	256

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. Of the total of 323 claims submitted for energy employees who worked during the period under evaluation, SNL-A/Department of Energy (DOE) has responded to 320 claims. Of these 320 claims, SNL-A/DOE has indicated that "there is no record of internal measurements having been made" for 283 claimants (~ 88%). Of the 320 claims receiving SNL-A/DOE responses, 256 (81 %) contain external monitoring data.

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the assessment of the evaluated class. Two thousand five hundred ninety-six documents in this database were identified as pertaining to SNL-A. These documents were evaluated for their relevance to this petition. The documents include historical background on internal and external dosimetry programs and evaluations, monitoring summary reports, annual environmental reports, reviews and assessments of SNL-A, evaluations of specific buildings, site surveys, and facility and process descriptions.

4.6 Documentation and/or Affidavits Provided by Petitioners

In qualifying and evaluating the petition, NIOSH reviewed the following documents submitted by the petitioners:

- *Petition Form B for SEC-00188*; received October 7, 2011; OSA Ref ID: 114974 (Form B, 2011)
- *Petitioner Consult Call Response with Attachment*; October 7, 2011; OSA Ref ID: 114974, pdf pp. 1-7 (Consult Call Response, 2011)
- Affidavit, 2011; *Affidavit from SNL-A Security Police Officer*; October 4, 2011; OSA Ref ID: 114974, pdf pp. 8-10 (Affidavit, 2011a)
- Affidavit, 2011; *Affidavit from SNL-A Security Police Officer*; October 4, 2011; OSA Ref ID: 114974, pdf pp. 11-13 (Affidavit, 2011b)
- Affidavit, 2011; *Affidavit from SNL-A Security Police Officer*; October 4, 2011; OSA Ref ID: 114974, pdf pp. 14-18 (Affidavit, 2011c)

5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

The following subsections summarize both radiological operations at SNL-A from January 1, 1963 through May 21, 2011, and the information available to NIOSH to characterize particular processes and radioactive source materials. From available sources NIOSH has gathered some process and source descriptions, information regarding the identity of each radionuclide of concern, and limited information describing processes through which radiation exposures may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is intended only to be a summary of the available information.

5.1 Sandia National Laboratories Facilities and Process Descriptions

Sandia National Laboratories is located in Albuquerque, New Mexico on 8,642 acres. The workforce consisted of 7,146 workers in 1963 and 4,189 workers in 2010. The highest employee population occurred in 1992 with a little over 10,080 employees. SNL-A had its origin as a satellite support site for the Los Alamos Scientific Laboratory. In July 1945, the Los Alamos Scientific Laboratory Z-Division was established to handle weapons development, testing, and bomb assembly for the Manhattan Engineer District (Ullrich, 1998). In late fall of 1945, some units of Z-Division were moved to the current SNL-A site. In 1948, Z-Division became a separate branch of Los Alamos Scientific Laboratory. In 1949, "Sandia Corporation" was created and became completely separated from Los Alamos Scientific Laboratory. Sandia Corporation changed its name to Sandia Laboratories in 1971 and then again to its current name, Sandia National Laboratories in 1979.

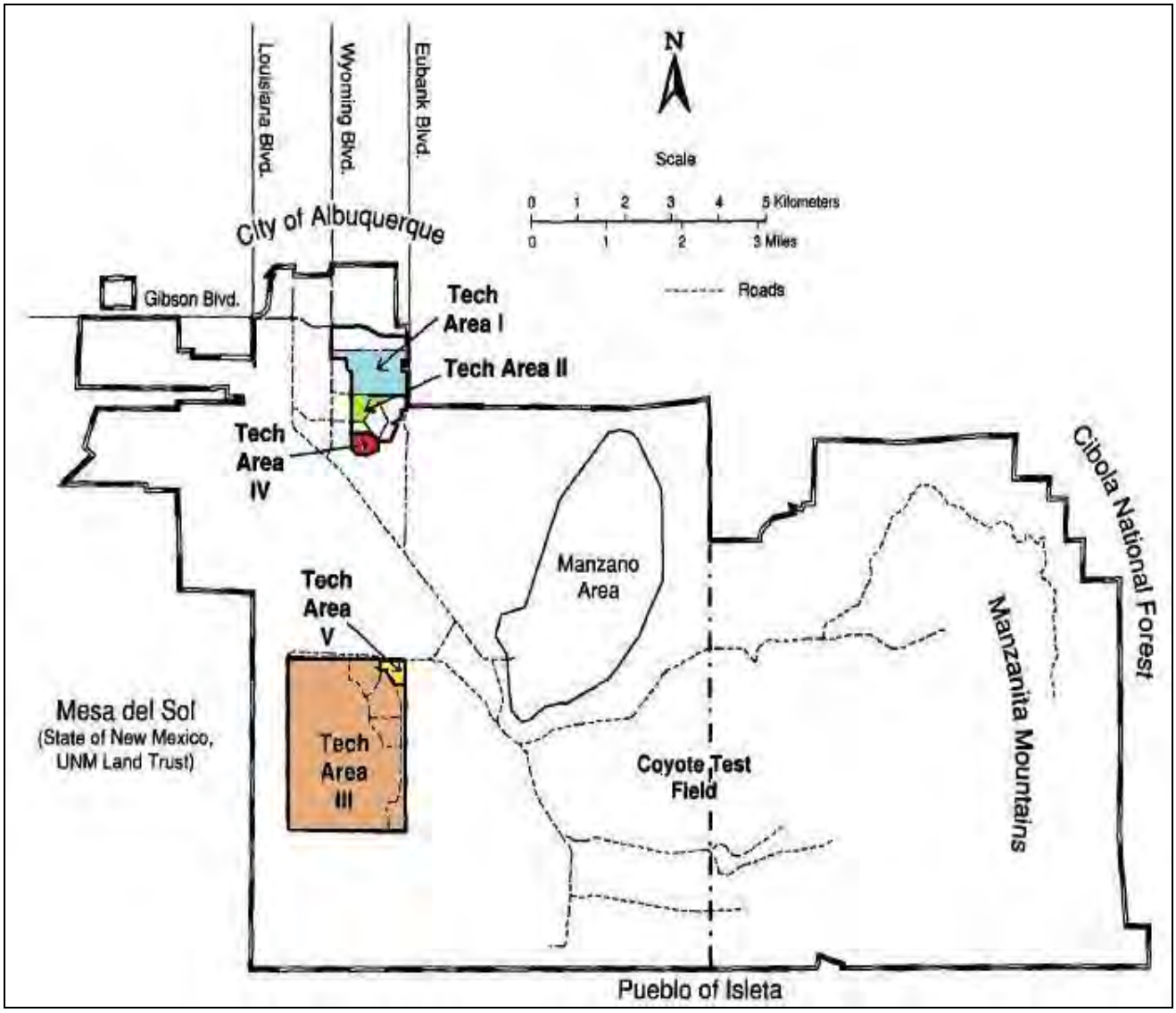
SNL-A's original focus was on weapons assembly, weapon ordinance engineering, and production coordination among various AEC contractors. By the early 1950s, a weapon production complex was in place and the focus was on weapons development, SNL-A also began field testing components and supported atmospheric tests sponsored by partner laboratories. Later in the 1950s, nuclear testing was halted temporarily due to the US/USSR test moratorium. Recognizing that flexibility was crucial in responding to rapidly changing national defense demands, SNL-A acquired accelerators and built reactors to test the responses of materials (including weapon components) to radiation and to conduct research in radiation physics and chemistry.

In the 1960s and early 1970s, the growing emphasis on research to strengthen the underpinnings of the engineering effort resulted in a concerted effort to hire more scientists and engineers to bolster and expand SNL-A's research efforts. In response to the Limited Test Ban Treaty of 1963, SNL-A worked with the National Aeronautics and Space Administration to enhance the safety of aerospace nuclear power systems and applied some techniques to the development of conventional weapons and intrusion sensors for use in the Vietnam War. National and international events, including the energy crisis and the terrorist acts at the Munich Olympics of the early 1970s, caused SNL-A to become involved in new areas of energy research and in the physical security and safeguards for facilities (Johnson, 1997).

Throughout the advance into new areas SNL-A maintained its responsibilities in developing new weapons and maintained the safety and reliability of the existing stockpile. As international arms control efforts increased in the late 1970s and throughout the 1980s, more emphasis was placed on treaty monitoring while improvements were made in methods of ensuring the safety, security, and control of the national stockpile. With the end of the Cold War in the late 1980s and the decision to stop developing new weapons in the early 1990s, SNL-A's role as stockpile steward took on new importance. Currently, ensuring the U.S. nuclear arsenal is safe, secure, reliable, and fully supportive of the Nation's deterrence policy is SNL-A's primary mission. SNL-A scientists and engineers design and integrate over 6,300 parts of a modern nuclear weapon's 6,500 components. Other current SNL-A mission areas include: Energy, Climate, Infrastructure Security, Nonproliferation, Defense Systems and Assessments, and Homeland Security and Defense (Johnson, 1997).

Sandia Technical Areas

There are five Technical Areas located on the SNL-A site as shown in Figure 5-1.



Source: This map is a modified version of the map in DOE, 1999.

Figure 5-1: Map of Sandia National Laboratories

Table 5-1: SNL-A Potential Exposure Areas and Processes
(*Table 5-1 and its associated notes span 3 pages*)

Building or Area/Description	Exposure Potential		Operational Dates
	External	Internal	
Technical Area-I (Electron/Ion Beam Accelerators)			
642/NERUES bremsstrahlung beam system	Y	N	1971+
672/Fexitron flash X-ray tube	Y	N	1970 - 1973+
672, 803/Heavy Ion/Proton Accelerators (~100 kV)	Y	N	1968+
803/Van de Graaff(s) electron generator/accelerator	Y	Y	1958 - present
884/Cockroft-Walton(s) electron generator/accelerator	Y	Y	Late 1950s - present (2006)
Technical Area-I (Manufacturing Facilities)			
802/Chemistry Labs; Radiochemicals to support research activities	Y	Y	1949 - present
802, 805, 870, 884/Kaman Neutron Generators Mfg. (NGMF)	Y	N	--- - present
805/LICA – Low Irradiation Calibrator Apparatus	Y	Y	>2003 - 2005
818, 828	Y	Y	1998 - present
858/Sealed sources used in microelectronics development	---	---	single incident
868/Machining uranium work (Received wastes from early weapons testing; stored stockpiled nuclear cores.)	Y	Y	1949 - 1968
869/Toxic Metals Machine Shop	Y	Y	~1959 - 1994
883/6-MeV Ion Generator	Y	N	1984 - 1996
891	---	Y	---
Technical Area-I (Medical Services)			
831, Rm 130/Medical X-ray (Picker GX325-PX350 tube) 300 mA @ 125 kVp	Y	N	1949 - present (registered in 1978)
Technical Area-II (Waste Handling/Burial, Weapons Assembly)			
TA-II Burial Pits/ Items buried included: contaminated tools, clothing, wastes from Sandia Pulse Reactor (SPR) and Sandia Engineering Reactor Facility (SERF), waste from weapons components, airplane sections, residue from processing plutonium samples in 829, bioassay and soil samples, RaBe and small cobalt-60 sources, irradiated material from rocket tests, and gap tubes containing cesium-137. Note: Records and logs have been destroyed	Y	Y	1949 - early 1960s
935/Neutron generator	Y	N	1969 - 1993
935	---	---	---
Technical Area-III (Waste Destruction/Disposal/Transfer)			
"Leaking Cask"	---	---	single incident
6583/Classified Destruction Facility	---	---	1957 - 1988
6920/Radiological and Mixed Waste facility	Y	Y	1949 - 1986
Technical Area-IV (Electron/Ion/X-Ray Beam Accelerators)			
961/TESLA	Y	N	1998 - present
961/MITE pulsed 6-MeV X ray (4 units)	Y	N	present

Table 5-1: SNL-A Potential Exposure Areas and Processes
(*Table 5-1 and its associated notes span 3 pages*)

Building or Area/Description	Exposure Potential		Operational Dates
	External	Internal	
970/HERMES III (Higher-energy version of HERMES II)(<20 MeV)	Y	Y	~1988 - 1998
970/SABRE, 6-12 MeV (Sandia Accelerator and Beam Research Experiment)	Y	Y	1998 - present
981/SATURN (Succeeded PBFA-I, preceded PBFA-II)	Y	Y	1967 - 1996+
981/SPEED (1.0 MeV)	Y	Y	1983 - 1986
981/SPHINX	Y	Y	1992 - present
981-983/Particle Beam Fusion Accelerator (PBFA)-1	Y	Y	1987 - 1995
983/ Particle Beam Fusion Accelerator (PBFA)-II (<30 MeV)	Y	Y	1993-present
983/Z-machine (Modified from PBFA-II)	Y	Y	1996-present
Technical Area-IV (Repair/Test Facility)			
905/Neutron Generator -Test Equipment	Y	---	1959 - 1997+
Technical Area-V (Electron/Ion Beam Accelerators			
6580/Proto-I (1st Generation high-powered short-pulse accelerator)	Y	Y	1972 - 1976
6580/Proto-II (2nd Generation high-powered short-pulse accelerator)	Y	Y	1976 - 1998
6580/Pelletron Facility – Variable-energy high-stability DC electron beam generator (1 MeV)	Y	Y	1968 - 1991
6580/HERMES-I, -II (Field emission electron beam or bremsstrahlung X-ray accelerator)	Y	Y	1968 - 1988
6580/Hydra-HydraMITE-I, -II (Dual transmission line for 1-MeV short-pulse electron, bremsstrahlung X-ray unit)	Y	Y	1977, 1984+
6580/REHYD (1.3-MV variable-energy Heavy Ion Accelerator; positive-ion combination of REBA and HydraMITE)	Y	Y	1988 - 1998+
6580/Relativistic Electron Beam Accelerator (REBA) = Z-machine (3.2 MV)	Y	N	1994 - present
6581/Febetrons (Flash X-ray System, < 2 MeV)	Y	N	1967+
Technical Area-V (Reactors)			
6580/SER Reactor	Y	---	1962 - 1969
6581/Sandia Engineering Research Facility (SERF). 5 MW; airborne potential after 1962 startup of operations.	Y	Y	1958 - 1979
6588/ ACRR (600 kW) also operated as Pulsed Reactor (ACPR) (<15,000 MW) [TRIGA-type]	Y	Y	1968 - 1998
6588/ACRR – Mo-99 Production (600 kW)	Y	Y	1998 - present
6590, 6591 /Sandia Pulse Reactor (SPR-I)[GODIVA type]	Y	Y	1961 - 1975
6590/SPR-II [GODIVA type] (<130,000 MW pk)	Y	Y	>1962 - present
6596/SPR-III (KIVA) [GODIVA type] (<170,000 MW pk)	Y	Y	2003 - present

Table 5-1: SNL-A Potential Exposure Areas and Processes
(*Table 5-1 and its associated notes span 3 pages*)

Building or Area/Description	Exposure Potential		Operational Dates
	External	Internal	
Technical Area-V (Irradiation and Calibration Support Laboratories)			
6580, 6581/ HCF - Hot Cell Facility support prior to reactor startup and Fizeau blast sample work	Y	---	1957 - 1959 1988 - Present
6591/GIF - Gamma Irradiation Facility; north and south cells (~900 Ci Co-60 and Cs-137 high activity sources for irradiation experiments) 1) Co-60 49 kCi (1985) and (2) Cs-137 163 kCi (1985) in north cell, and (1) 150 kCi Co-60 (upgraded to 300 kCi in 1985) in south cell	Y	---	1962 - 1998
6591-6598 Complex/NEW GIF – combined with LICA, more flexible sources (Co-60 and Cs-137 high activity sources for irradiation experiments)	Y	---	1998(?) - present
Other			
Lurance Canyon Burn Site, Uranium Burn Site	---	---	---
Near 9820/Animals from radiation studies buried in pits	---	---	1950s - early 1960s
Pendulum-site burial mounds	---	---	closed in the 1970s
Coyote Test Facility/Thunder Range–source metals after explosion and fire tests of weapons, containers	---	Y	1969 - 1994

Notes:
This table is a modified version of Table 2-2 in ORAUT-TKBS-0037.
--- Three hyphens (---) in a table cell denote a lack of information.

The potential for chronic intakes in most areas of SNL-A has historically been less than at DOE production sites because of the nature of the tasks performed at SNL-A. Certain areas of the site have always been non-nuclear. Nevertheless, the nature of the research environment at SNL-A during the evaluated period may have resulted in intake potentials that were often unique and of short duration, and the potential for monitored and unmonitored intakes has existed throughout the site's history.

5.2 Radiological Exposure Sources from Sandia National Laboratories Operations

The following subsections provide an overview of the internal and external exposure sources for the Sandia National Laboratories class under evaluation.

5.2.1 Internal Radiological Exposure Sources from Sandia National Laboratories Operations

Complete details of the internal exposure sources at Sandia National Laboratories have not been identified. However, internal dose potential during the evaluation period is associated with reactors, machine shops, accelerators, and other research and supporting activities, along with radioactive waste disposal. Technical Areas I and V, with electron- and ion-beam accelerators, generated tritium and

tritiated compounds, while the supporting laboratories and machine shops in Technical Area-I worked with uranium and plutonium. The radioactive gases N-13 and O-15 are associated with electron, ion, and beam accelerators in Technical Area-IV. Mixed waste (uranium, plutonium, and fission/activation products) disposal activities with internal exposure potential occurred at the Technical Area-II Burial Pits from 1958 to the early 1960s (presumably including a portion of the evaluation period), and in the Radiological and Mixed Waste facility of Technical Area-III from 1949 through 1986. Although specific areas where waste materials were generated and buried are not readily identifiable from documents available to NIOSH, a potential for internal intakes from these activities is assumed to exist.

Radionuclides with the widest application throughout the SNL-A facilities during the evaluation period are:

- Tritium,
- Uranium (U-238, U-234, U-235),
- Fission and activation products (e.g., Sr-90, Cs-137, Zn-65, Co-60, Ta-182) and, to a lesser degree,
- Plutonium (Pu-238, Pu-239, Pu-240, Pu-241),
- Americium (Am-241), both alone and as a contaminant in plutonium from the radioactive decay of Pu-241, and
- Thorium (Th-232).

5.2.1.1 Tritium

Tritium exposure potential has existed at SNL-A since its beginning and into present time because of the numerous accelerator facilities and neutron generators that use tritiated targets. Facilities in each of the Technical Areas have exhibited tritium exposure potential during the period of evaluation, as shown in Table 5-2. Activities in Technical Area-I have resulted in the potential for tritium intakes since 1949, and ambient environmental tritium in Technical Areas IV and V still results in exposure potential in 2011. Potential intakes may have resulted from operations with neutron generators, accelerator targets, and reactor operations. Surveys and air samples for tritium were routinely performed, as indicated by captured logbooks. Positive results have been noted for many samples within the logbooks (Monitoring Results, 1959-1970).

Table 5-2: SNL-A Facilities with Tritium Exposure Potential, By Year		
Technical Area	**Operations Using or Producing Tritium**	**Period**
Area I	Cockroft-Walton Accelerators	1959-2006
	Van de Graaff Accelerators	1958-2006
	[Redacted]	----
Area II	Neutron Generators	1969-1993
	Chemistry Labs	1949-2006
	Neutron Generators	1967-1993
	II Burial Pits	1949-early 1960s
Area III	Mixed Waste Landfill	1959-1988
Area IV	PBFA-I (HT)	1979-2006
	Neutron Generator	1959-1998
	SATURN	1959-1998[a]
	HERMES III	1987-1999
Area V	SER	1962-1969
	Pelletron	1968-1991
	HERMES I, II	1968-1988
	Proto-I	1972-1976
	Proto-II	1976-1998
	Hydra-HydraMITE-I, -II	1977-1984+
	REHYD	1988-1998+
	REBA	1994-Present
	SERF	1958-1979
	Febetrons	1967-?[b]
	SPR-I [GODIVA Type]	1961-1975
Ambient Environmental (Airborne)		
Area I		1948-1996
Area II		1948-1996
Area III		1953-1996
Area-IV		1979-2011
Area-V		1961-2011

Notes:

This table is a modified version from tables and information in ORAUT-TKBS-0037.

[a] Excluding 1990-1995

[b] Exposure potential identified, but not verified after 1967

Exposures to metal tritides and gaseous tritium are described in several NIOSH-obtained documents. Metal tritides have been used as components of neutron generators and are associated with specific locations in Technical Area-I (Building 891) (ORAUT-TKBS-0037, pdf p. 55). Time frames associated with metal tritide use in these locations have not been determined, however.

5.2.1.2 Uranium (U-238, U-234, U-235)

Some potential for internal deposition of uranium (primarily by inhalation of airborne particles) existed during the evaluation period at SNL-A, primarily in Technical Areas I and III, although Technical Areas II and IV are also implicated. The greatest potential is associated with activities in machine shops and burial grounds, which can result in the generation or resuspension of respirable particles. Specific facilities with internal exposure potential for uranium are shown in Table 5-3.

Table 5-3: SNL-A Operations with Uranium Exposure Potential

Technical Area	Potential	Period
Area I	Cockroft-Walton Accelerators	1956-2006
	Van de Graaff Accelerators	1958-2006[a]
	Machining[b]	1949-1968
	Toxic Metal Shop[c]	1959-1994
Area II	TA-II Burial Pits	1949-Early 1960s
Area III	Mixed Waste Landfill[d]	1959-1988
	Rad- and Mixed-Waste Facility[c]	1949-1986
	Chemical Waste Landfill	1954-1994
Area V	SER	1962-1969
	SERF	1958-1979
	SPR-I [GODIVA type]	1961-1975
Other	Lurance Canyon, Uranium Burn Site[c]	---
	Pendulum site burial mounds	Closed in 1970s
	Coyote Test Facility/Thunder Range[c]	1969-1994
Ambient Environmental (Airborne)		1948-2004

Notes:

This table is a modified version from tables and information in ORAUT-TKBS-0037.

[a] Also heavy-ion and proton accelerators from 1968

[b] U of unspecified enrichment and U depleted in U-235

[c] Depleted in U-235

[d] All enrichments: Natural, enriched in U-235, and depleted in U-235

5.2.1.3 Fission and Activation Products (Sr-90, Cs-137, Zn-65, Co-60, Ta-182)

Numerous nuclear reactors and particle accelerators at SNL-A have produced fission and activation products during the evaluation period. These radioactive byproducts become available for internal deposition when respirable particles are generated in processes such as machining or resuspended when waste is disposed of in landfills. The Sandia Pulse Reactor (SPR), KIVA, Sandia Engineering Reactor (SER), and other reactors in Technical Area-V have operated during most of SNL-A's history. Activation products were also produced by photoactivation of metals in accelerators such as

the Particle Beam Fusion Accelerator II (PBFA-II). The specific activities of photoactivated products in stainless steel at these facilities can be up to microcurie/gram quantities in localized areas. Handling can be delayed to permit the decay of short-half life products, such as isotopes of aluminum and copper. However, the ferrous isotopes (Fe-59, half life 45 days) and other activation products, such as manganese-54 (half life greater than 300 days), are more persistent and can become aerosolized when these parts are machined. Examples of fission and activation products that are contained in plant air samples, effluents, and primary coolant have been taken from various reports (ORAUT-TKBS-0037) and are shown in Table 5-4.

Table 5-4: Documented Fission and Activation Products at Sandia National Laboratories

Noble Gases	Fission Products	Activation Products
Kr-85m	Zr-95	W-187
Xe-133	I-131	Ag-110m
Xe-135	Ru-103	Ta-182
Ar-41[a]	Ru-106	Mn-54
	Ba/La-140	Mn-56[b]
	Te-132	Na-24[b]
	Y-94	Cu-64[b]
	Mo-99/Tc-99m	Cd-115[b]
	Zr-97/Nb-97	Al-28[b]
	Rb-89	Co-56
	I-132	Co-57
	I-133	Co-58
	I-134	Co-60[b]
	I-135	Zn-65
	Sr-91	Sb-122
	Y-91m	Ni-57
	Y-92	Sn-117m
	Cs-136	Sn-119m
	Cs-137	Ta-182
	Cs-138	Ta-183
	Ce-141	As-76
	Ce-144	Fe-59[b]
	Sb-124	Be-7

Notes:

This table is a modified version from tables and information in ORAUT-TKBS-0037.

[a] Main contributor to activity at the SER.

[b] From the SER and the PBFA.

Operations producing or handling reactor-generated nuclides and accelerator-produced nuclides are shown in Tables 5-5 and 5-6 below, along with the applicable time periods.

Table 5-5: SNL-A Operations Involving Reactor-Generated Nuclides		
Technical Area	**Facility or Operation[a]**	**Period**
Area III	Mixed Waste Landfill	1959-1988
	Classified Destruction Facility	1957-1988
	Rad & Mixed Waste Facility (Cs-137)	1949-1986
	CWL Chemical Waste Landfill (Co-60)	1949-1986
Area V	SER	1962-1969
	SERF	1958-1979
	SER	1958-1979
	ACRR/ACPR	1968-1998
	ACRR – Mo-99 Production	1998-Present
	SPR-I	1961-1975
	SPR-II	1962-2011
	SPR-III (KIVA) [GODIVA type]	2003-Present
Ambient Environmental (Airborne)		
All Areas		1967-1994

Notes:

This table is a modified version from tables and information in ORAUT-TKBS-0037.

[a] Workplace air sampling results have been obtained in all Technical Areas from 1957-2011, and ambient environmental results from 1967-1994.

Table 5-6: SNL-A Operations Involving Accelerator-Produced Nuclides		
Technical Area	**Facility or Operation**	**Period**
Area I	Cockroft-Walton Accelerators	1956-2006
	Van de Graaff Accelerators[a]	1958-2006
	HIPA, Fexitron	1968-1973
	Ion Beam	1984-1996
Area IV	HERMES III	1989-1999
	SABRE	1998-Present
	PBFA-I (HT)	1982-2006
	SATURN	1967-1996+
	SPEED	1983-1986
	SPHINX	1992-Present
	PBFA-II	1993-Present
	Z-machine (modified from PBFA-II)	1996-Present
Area V	Proto-I	1972-1996
	Proto-II	1976-1998
	Pelletron	1968-1991
	HERMES I, II	1968-1988
	Hydra-HydraMITE-I, -II	1977-1984+
	REHYD	1988-1998+
	Febetron	1967+

Notes:

This table is a modified version from tables and information in ORAUT-TKBS-0037.

[a] Including heavy ion/proton accelerators from 1968.

Some accelerator facilities, such as the High Energy Radiation Megavolt Electron Source (HERMES III), produce short-half-life air activation products O-15 and N-13, for which occupational exposure was controlled by ventilation prior to entry.

Removable contamination on surfaces provides a source for re-suspension of respirable aerosols containing radioactive materials. Examples of results from removable contamination surveys in selected areas during the period of evaluation are shown in Table 5-7 below. The maximum results in disintegrations per minute (dpm) are for a surveyed area of 1 ft^2. A re-suspension factor of 1×10^{-6} is usually applied in estimating the air concentration that could result from loose surface contamination.

Table 5-7: Example Contamination Survey Results for Selected Areas

Area	Date	Alpha dpm (max)	Beta dpm (max)	Location	Remarks
SER/6520	1976	75	7,500	Rm 212	Table top/Inside sink
SER/6520	1976	782	11,500	-	Hood/Berger Hut
SER/6520	1977	14	20,000	Rm 212	Disassembly area/work surfaces
SER/6520	1979	10.5	15	Rm 104-121	-
SER/6520	1978	16	1,900	Rm 212	-
SER/6520	1980	5	293	Rm 212	Open shelf
SER/6520	1981	200	2,800	-	Parts on shelf
TA-V 203	1986	249	112	203	Surfaces/ hot side
TA-1	1993	8350	2990	Industrial Hygiene Lab	Average

Notes:
This table is a modified version from tables and information in ORAUT-TKBS-0037.

5.2.1.4 Plutonium (Pu-238, Pu-239, Pu-240, Pu-241)

Plutonium in forms that could typically result in internal deposition resulted from operations in Technical Areas I, II, III and V. There is no definitive historical information on the atom ratios of SNL-A plutonium sources except for a 'pure' Pu-238 source term used in heat source technology with the following nominal isotopic composition (Holley 1967):

Isotope:	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
Weight Fraction:	81%	15%	2.9%	0.1%	0.3%
Specific Activity in Mixture (Ci/g):	1.4E01	9.2E-03	6.6E-03	1.1E-01	1.2E-05

There is also no information about how typical isotopic ratios varied with time and location. The dominant (by activity) isotope in most plutonium to which SNL-A workers might have been internally exposed is Pu-238. Plutonium used at SNL-A is presumed to be research grade (freshly separated, with minimal Am-241 in-growth), except for that encountered in building decommissioning and environmental restoration where the plutonium could have been in place for many years.

Activities at facilities that generate airborne particles, such as the Technical Area-I machine shops, waste disposal sites at the Technical Area-II burial pits, and the Technical Area-III Mixed Waste facility represent a significant potential source for internal deposition of plutonium. There is also the potential for internal exposure to plutonium at Technical Area-V Hot Cell and Reactor facilities, used for both experimental research and radiopharmaceutical production. Specific facilities with plutonium exposure potential are shown in Table 5-8 below. A 1984 memo (SNL-A, 1984, pdf p. 11) of safe operating procedures for the Building 869 Toxic Machine Shop states, "Plutonium metal or compounds or alloys of plutonium are not permitted in that area because of their toxicity and the complexity of their radioactive contamination potentials." It is not clear whether this reflects the implementation of a new policy in 1984, or when the policy was otherwise adopted, since other information suggests that plutonium was used in the Toxic Machine Shop during the period 1959-1994. These are sealed radioactive sources, and internal deposition of plutonium is possible only in the event that the source encapsulation is compromised.

Table 5-8: SNL-A Facilities with Internal Exposure Potential for Plutonium

Technical Area	Facility or Operation	Period
Area I	Toxic Metal Shop[a]	~1959-1994
	Kaman Neutron Generators Mfg. (NGMF)	?-Present
Area II	TA-II Burial Pits	1949-Early 1960s
	Neutron Generators[b]	1969-1993
Area III	Mixed Waste Landfill[c]	1959-1988
	Classified Destruction Facility	1958-1988
	Rad- and Mixed-Waste Facility	1988-2007
	Rad- and Mixed-Waste Facility	1988-2007
	Rad- and Mixed-Waste Facility	1988-2007
Area IV	Neutron Generator – Test Equipment	1959-1997+
Area V	SER	1962-1969
	SERF	1958-1979
	SPR-I [GODIVA type]	1961-1975

Notes:

This table is a modified version from tables and information in ORAUT-TKBS-0037.

[a] A 1984 memo of safe operating procedures for the Building 869 Toxic Machine Shop indicates that plutonium is not permitted.

[b] Only if damages so that encapsulation is compromised.

[c] Pu-contaminated waste and Nevada Test Site debris.

5.2.1.5 Americium (Am-241)

Americium-241 has always been included in the bioassay profile at SNL-A, but specific source terms driving the inclusion of Am-241 are not known (ORAUT-TKBS-0037). Documents have been found, however, indicating that a 'pure' Am-241 (i.e., americium not associated with plutonium) source term has historically existed at SNL-A. There is an indication that workers submitted samples for the americium bioassay program only if there was a potential for exposure to pure americium. The

potential for chronic exposure either to pure Am-241 or to Am-241 in plutonium at SNL-A is not routine but could have occurred in relation to certain experiments or due to handling leaking calibration sources.

The release of small quantities of Am-241 is assumed to apply to all years of operations for Technical Areas I and II. Early environmental monitoring reports indicate that the potential for radionuclide release in Technical Area-III was minimal, but no emission monitoring data are available prior to 1973. A building in Technical Area-III was cited as a small source of Am-241 in the mid-1990s. Americium-241 was among 21 radionuclides with the potential for contributing more than 0.01 mrem/year dose equivalent to workers for the maximum yearly airborne release at SNL-A, based on the evaluation of radioactive effluent monitoring results for 69 radionuclides from 1973-2004.[4] It was added to the list of radioactive air emissions in annual environmental monitoring reports starting in 1989. The maximum annual median intake for Am-241 in Technical Areas I and II is estimated to be 2E-09 Bq each year from 1948 to 2004. No maximum annual median intake for Am-241 in Technical Area-III is estimated prior to 1994.

Internal occupational exposure to Am-241 is a particular concern from handling damaged neutron generators in the Repair and Test facilities of Technical Area-II and Technical Area-IV. A building in Technical Area-IV was reported to a Tiger Team as a facility with Am-241 calibration sources in March 1991, but there is no quantitative information about the number of sources, their activities, or whether periodic leak tests were performed to verify the encapsulation integrity.

Records obtained by NIOSH document that positive bioassay results for Am-241 did occur. A January 1992, memo requesting follow-up whole-body counting for three SNL-A employees cited preliminary tissue burden estimates ranging from 0.14 nCi to 0.18 nCi (Monitoring Results, 1991). An October 27, 1992, memo (Hallman, 1992; Panel, 1992, pdf p. 2) describes a March 1992 example of a potential Am-241 exposure from a leaking Am-241 check source involving five SNL-A employees and an infant:

> This incident began in March 1992, when an Am-241 check source began leaking. Although the exact date this source began leaking is unknown, the earliest probable date of 26 March 1992 has been used as the potential intake date for all internal dosimetry calculations. This event took place in [Redacted] …The dose assigned to all individuals involved in this incident is 0.000 rem. Additional information concerning this incident is contained in the Internal Radiation Dosimetry Files.

One result of the exposure evaluation was that significant problems with background results at the Bioassay Lab (Atlan-Tech) invalidated all bioassay results previously provided by that lab.

Another potential exposure was identified on March 30, 1993. It involved the discovery of transferrable α contamination from Am-241 exceeding 10,000 dpm on a tray in a cabinet in which radioactive solutions were stored prior to disposal. The cabinet was not posted as a Controlled Area

[4] Identification of specific radionuclides released from various facilities in stack emissions are available in data from 1973 to 2004 and were used to characterize radionuclide emissions for all years. There are no radionuclide-specific data from earlier years.

(although it was posted for radioactive materials). The tray had been in use for 25 years, the first 15 of which were in other areas at SNL-A, and the source of contamination could not be identified. Bioassay samples from two SNL-A Industrial Hygiene staff were analyzed, with no detectable internally deposited Am-241 or uranium.

5.2.1.6 Thorium (Th-232)

The source term for thorium operations at SNL-A began in 1959 and, except for thorium in storage, apparently involved only small amounts used in research. Per a 1994 Defense Nuclear Facilities Safety Board memo on SNL-A low-level waste management (Helfrich, 1994, pdf p. 20), about 12,000 kg of thorium oxide was received by SNL-A in 1982 and stored in a bunker. Experiments were performed with small quantities of this material also. The remaining material was turned over to an SNL-A waste management organization in 1993. Little documentation has been obtained regarding thorium bioassay (e.g., documents only make references to thorium bioassay being performed).

The principal sources of Th-232 emissions from SNL-A during the period under evaluation are the Mixed Waste Landfill and Chemical Waste Landfill in Technical Area-III. The Mixed Waste Landfill operated from 1959 to 1988. Wastes disposed included thorium and a variety of other radioactive materials. It does not appear that any buildings in Technical Area-III, other than small buildings housing the operators and screening detectors to manage the waste disposal facilities, had significant sources of radioactivity present for normal operations.

No emission monitoring data are available prior to 1973 for Technical Area-III, but information in early environmental monitoring reports indicates that the potential for radionuclide release was minimal (ORAUT-TKBS-0037). Technical Area-III activities began in 1953; it is unclear if any radionuclides were involved during the earliest years. The Chemical Waste Landfill has been a diffuse source of small quantities of Th-232. Thorium-232 was among 21 radionuclides with the potential for contributing more than 0.01 mrem/year dose equivalent to workers for the maximum yearly airborne release at SNL-A, based on the evaluation of radioactive effluent monitoring results for 69 radionuclides from 1973 through 2004.[5] The maximum annual median intake for Th-232 in Technical Area-III is estimated to be 2E-04 Bq each year from 1953 to 2004.

5.2.2 External Radiological Exposure Sources from Sandia National Laboratories Operations

Work involving nuclear weapons components occurred at SNL-A throughout the entire evaluation period. The primary mission at SNL-A is to ensure the safety and reliability of the U. S. nuclear arsenal. This mission involves the design and engineering of weapons, including the radiation-hardened microelectronics, advanced simulation and computing capabilities, and large-scale testing to support these simulation capabilities. In support of this mission in the early history of SNL-A, a Van de Graaff and a Cockroft-Walton generator/accelerator were introduced in 1958. The SPR began operation in 1961, while the SER began operation in 1962. Other reactors were added, such as the HERMES in 1968, and the ACRR, also in 1968. The accelerators and reactors are discussed in

[5] Identification of specific radionuclides released from various facilities in stack emissions are available in data from 1973 to 2004 and were used to characterize radionuclide emissions for all years. There are no radionuclide-specific data from earlier years. Any uranium and thorium detected is assumed to originate from facility activities, even though it could be naturally occurring.

Section 5.1 above and Table 5-X, as well as in Section 2.4 of ORAUT-TKBS-0037 and are summarized in Tables 2.2 and 2.3 of that document. Many of these reactor facilities continued to operate into the 2000s and into the present period, including the Annular Core Research Reactor (ACRR/ACPR) and Sandia Pulse Reactors (SPR-II and SPR-III). Electron, Ion, and X-ray Beam accelerators were added throughout the years, with many of these operating into the present time, such as the Particle Beam Fusion Accelerator (PBFA-II), Sandia Accelerator and Beam Research Experiment (SABRE), and Relativistic Electron Beam Accelerator (REBA). Facilities with high-level sources also operated throughout this period, such as the Hot Cell Facility (HCF) and the Gamma Irradiation Facility (GIF). These accelerators and reactors were used to create radiation fields for the purpose of testing materials and system components associated with nuclear weapons.

Direct exposure to workers from the radiation fields created by operations of these machines was limited by shielding, access control, and interlock systems. Some exposure would have occurred during maintenance activities and experiment change-out operations. Some external exposure could also have potentially occurred during activities at hot cells and from radioactive waste-handling activities. Exposure sources associated with these work environments are described below. There were also procedures in place for procurement and control of radium and radium compounds; thus, these sources would also have been available as potentials for exposure to radiation. NIOSH has not located specific documents that explain how these sources were used.

5.2.2.1 Photon

As mentioned previously, several reactors and generators/accelerators were operational during the evaluated period. The generators/accelerators were originally located in Technical Area-I, but were then moved to Technical Area-V sometime after 1967. Radiation areas resulting from the operation of these facilities were typically evacuated and/or interlocked to prevent personnel exposures to the potential sources of radiation. An example of this design requirement for the SPR facility is stated in a report describing the SPR Facility. The report states (Burnett, 1962, pdf p. 4) that "Operation of the reactor in a normal manner does not expose any personnel to hazardous radiation. The nature of the reactor is such that the production of radioactive waste is minimal, and the spread of radioactive contamination is not a problem." However, residual radiation would potentially still exist for personnel entering to modify experimental setup, retrieve samples, or to perform maintenance. The energy ranges would have been typical of those associated with fission products or accelerator energies at other AEC/DOE facilities; these are discussed in Section 6.6 of ORAUT-TKBS-0037. Depending on the design of the accelerators, the accelerators would have produced beams of various radiations, electrons, ions, neutrons, or X-rays. However, exposure to these beams would not have occurred except under incident conditions caused by the failure of interlocks and alarms (See Section 5.2.3 Incidents). Small exposures would have been possible during maintenance or experimental change outs. During maintenance activities at the SPR, non-uniform fields could have been encountered that would have increased the potential for extremity exposures.

5.2.2.2 Beta

Known operations at SNL-A did not involve extensive handling of radioactive materials that would have resulted in significant sources of beta exposure. As discussed previously, the material was in a solid form and would not have resulted in skin contamination. However, NIOSH has located

documentation that indicates that beta radiation was involved (Unknown, 1952). After the introduction of accelerators and reactors, some exposure to beta radiation occurred during some operations. For example, maintenance at the Reactor facilities and/or during experimental change-outs resulted in small exposures to workers, as indicated from available exposure records. Energy values are detailed in Section 6.6 of ORAUT-TKBS-0037, specifying that the beta energies are greater than 0.15 keV.

5.2.2.3 Neutron

Neutron sources would have existed during reactor and accelerator operations, as well as during operations involving the handling of weapons components. However, neutrons from the reactors would have only been available near the reactor during operation; personnel access to these areas was prohibited during reactor operation. The Cockroft-Walton generator/accelerator, put into service in 1958 and still being used currently, would have produced primarily high-energy neutrons, but only while operating and only in the area where access was prohibited during operation. The configuration of the nuclear weapons and associated materials at SNL-A presented a very limited source of neutrons. Neutron sources used for instrument calibration would also be a source of potential exposure, but exposure would have been limited by access controls and interlocks. Any other operations associated with the evaluated class would have had very low potential for exposure to neutrons. The neutron energy values are discussed in more detail in Section 6.9 of ORAUT-TKBS-0037.

5.2.3 Incidents

SNL-A incidents are discussed in Section 2.5 of ORAUT-TKBS-0037. There was a single incident involving a serious overexposure in 1960. A single employee received a life-threatening exposure and serious hand injuries when the interlock protocol intended to prevent such situations was contravened. Additional monitoring equipment was installed and revised protocols were created; no similar events have occurred in the last 45 years (Incidents, 1960-1978, pdf p. 179. Documents available to NIOSH list incidents that occurred from 1960 through 1987 and provide investigation reports indicating that no other major incidents occurred at SNL-A during this time period (Incidents, 1960-1978; Incidents, 1978-1987). Many incident reports have been obtained, but none describing the high exposure levels that occurred in the 1960 incident.

6.0 Summary of Available Monitoring Data for the Class Evaluated by NIOSH

SNL-A's Health Physics Section was first established prior to the evaluation period in 1957 within the already existing Industrial Hygiene Division (Johnson, 1997). Because of the Industrial Hygiene Division's historical role in performing many analyses, internal monitoring records were frequently stored in files located within that Division for much of the evaluation period. The majority of these paper records have now been moved into offsite, inactive, record-storage boxes that are not easily, nor routinely searched. Similarly, data such as surveys and air monitoring results are also predominantly stored within inactive record-storage boxes. Approximately 50,000 boxes of records now exist within the inactive record-storage area; the area consists of caves in the nearby "Monzano Area."

Occupational external radiation monitoring records have historically been more centralized and readily available than internal monitoring data. External monitoring records are typically found within worker files and are also available in summary fashion within AEC and DOE annual summary reports, as described below in Section 6.2. SNL-A's electronic monitoring record databases applicable to the evaluated period do not contain records prior to approximately 1993 for internal monitoring data and 1989 for external monitoring data.

Microfilm and Microfiche Records

In January 2010, NIOSH requested SNL-A to perform additional data searches to address known data gaps in information that SNL-A had been providing NIOSH in response to specific EEOICPA-records requests. In response to the identified gaps, SNL-A located a specific collection of records that holds additional worker radiological records and information. The identified data is primarily stored on microfiche, with some of the earliest records stored on microfilm. It is apparent from archived site newspaper articles and interviews with SNL-A employees that in the very early 1960s SNL-A made the decision to microfilm and microfiche records in an effort to conserve current and future onsite record storage space and presumably as a backup for the inactive record storage located in the mountain caves. According to discussion conducted with many site experts (Personal Communication, 2011d), it was normal practice during most of the evaluated period to convert monitoring records onto microfilm (very early years) and then onto microfiche media (later years) prior to transferring the paper records to inactive storage. According to several SNL-A employees, conversion of paper records to these media before sending offsite for storage was routine and ongoing from the early 1960s until approximately the year 2000, or 2001 (Personal Communication, 2011d). It is believed by site personnel that the microfilm/microfiche data collection should contain records of all occupational personal monitoring data collected at SNL-A for the time it was used. Actual contents of the microfilm/microfiche data collection are currently unverified. NIOSH is considering pursuing the task of incorporating this information into a database.

Although NIOSH has worked to determine data availability and sufficiency applicable to the entire 1963 through 2011 evaluation period, NIOSH is providing this report in the interest of providing timely support regarding the proposed 1963 through 1994 SEC period. NIOSH believes it will have access to sufficient documentation and data for the post-1994 period and intends to continue conducting its analysis of the contents and completeness of the various SNL-A monitoring record databases associated with the 1995 through 2011 period when they become available. Specifically, NIOSH intends to continue efforts to collect available electronically stored data applicable to this later period and will issue subsequent evaluation responses or reports as applicable based on the results of its reviews. The following subsections provide an overview of the state of the available internal and external monitoring data for the SNL-A class under evaluation.

6.1 Available Sandia National Laboratories Internal Monitoring Data

For much of SNL-A's operational history, using professional judgment, health physics representatives designated personnel for participation in internal dosimetry monitoring (primarily urinalysis for the evaluated period). Few *in vivo* (whole-body and lung counting) results have been obtained by NIOSH and almost no *in vivo* results have been found to have been measured prior to 1989, possibly indicating it was not routinely used prior to that period.

SNL-A's historical monitoring record management practices and lack of database availability preclude the summarization and presentation of the total internal personal monitoring data availability for the evaluated class period prior to the 1993 period when the Sandia Dosimetry System (SANDOS) was first used to store internal occupational doses. Pending a more complete analysis of the more recent electronically available results as described in Section 6.0 above, the presentation of internal monitoring data availability in this report reflects the data obtained from SNL-A during multiple data capture trips performed by NIOSH. Because *in vitro* (urinalysis) has been the primary internal monitoring technique used for the majority of the evaluated period and very few *in vivo* results have been obtained, only the captured urinalysis results are presented. It is expected that many more *in vivo* monitoring results will be available within SNL-A databases for the post-SEC period once the data are available to NIOSH.

NIOSH has extracted and electronically entered monitoring data found within the 2,600 documents obtained from the site and other sources during the course of this evaluation. Table 6-1 presents a summary of the urinalysis monitoring data pulled from these documents as applicable to the evaluated class period. Data obtained include bioassay results for gross beta/gamma, tritium, uranium, and plutonium as performed during the evaluated time period. In most cases, results do not contain enough detail to be confidently associated with specific source activities. While in some cases NIOSH can infer the activity the data were meant to be monitoring (from information coincident with data obtained), in most cases this level of detail cannot definitively be determined. Organizational units are historically identified in many cases. However, per a 1980 interview conducted with the then Supervisor of the Health Instrumentation Division, the "names for internal Sandia organizations do not accurately describe job function or potential exposure risk. Some employees worked for organizations different from their assigned organization" (SNL-A, 1980a). This situation seemed to be improved however with the association of specific "Worksite Codes" to employees in 1992 (Chavez, 1992). This latter system provided for much more specific work activity association including location, job title, facility, and hazard.

Currently, no urinalysis data after 1991 have been obtained. More recent internal monitoring data are available in SNL-A databases and presumably within the microfilm/microfiche data collection.

Table 6-1: Summary of Individual *In Vitro* Bioassay Results				
Year	**Tritium**	**Uranium[a]**	**Plutonium**	**Beta/Gamma[b]**
1963	281	23	2	32
1964	248	14	4	-
1965	224	-	13	-
1966	222	-	98	-
1967	540	41	85	-
1968	78	5	74	-
1969	187	17	46	-
1970	147	47	24	-
1971	281	85	6	-
1972	184	74	-	5
1973	193	110	-	8
1974	99	60	-	3
1975	46	62	-	-
1976	126	64	-	-
1977	83	50	-	-
1978	138	30	-	1
1979	155	24	-	1
1980	147	40	-	-
1981	213	40	-	-
1982	79	59	-	-
1983	26	26	-	-
1984	28	74	-	-
1985	25	29	-	-
1986	33	70	-	-
1987	24	29	-	-
1988	24	24	-	-
1989	10	-	-	-
1990	442	-	-	-
1991	281	-	-	-

Notes:

- Indicates no data.

[a] Number of results for total uranium, enriched uranium, and isotopic uranium are summed in the uranium column.

[b] Number of results for beta, beta/gamma, and gamma are summed in the beta/gamma column.

The number of results obtained by NIOSH show that although a site-wide documented internal monitoring program was not in place until 1992, *in vitro* bioassay was being performed for workers within the evaluated class. Tritium and uranium bioassay were most frequently captured for the evaluated time frame. Only a relatively small number of ambient and facility air sample results have been captured for the evaluated period. No databases are known to exist for air monitoring data and the data that are available are predominantly stored in the inactive archives located in the Monzano Area caves. As previously indicated, NIOSH believes it will have access to sufficient documentation

and data for the post-1994 period and intends to continue conducting its analysis of the contents and completeness of the various SNL monitoring record databases associated with the 1995 through 2011 period when they become available. Therefore, the specific analyses of the available data discussed below are limited to the 1963-1994 proposed class period.

6.1.1 Tritium

Documented urinalysis results for tritium have been obtained by NIOSH during the period 1959 through 1991. The total number of tritium urinalysis, number of positive results, and the highest values recorded during this period, from the records captured by NIOSH, are shown in Figure 6-1.

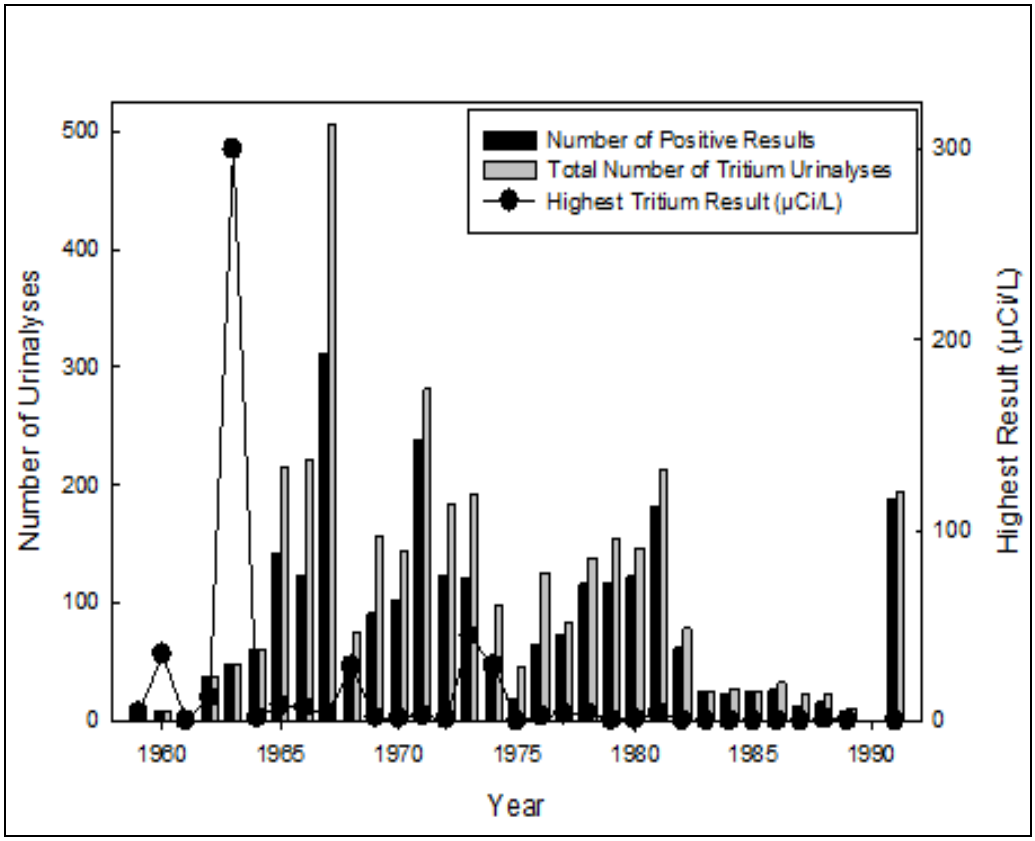


Figure 6-1: Urinalysis for Tritium Performed at Sandia National Laboratory, 1959-1991.

The largest number of both tritium urinalysis (505) and positive results (311) during the period 1959-1991 occurred in 1967, which is included in the period of evaluation. The highest result for tritium in urine obtained by NIOSH is 300 µCi/L in 1963, also occurring in the period of evaluation; all other results were <50 µCi/L.

6.1.2 Uranium

Documented urinalysis results for uranium have been found by NIOSH during the period 1959 through 1988. The total number of uranium urinalysis, number of positive results, and the highest values recorded during this period, from the records identified by NIOSH, are shown in Figure 6-2.

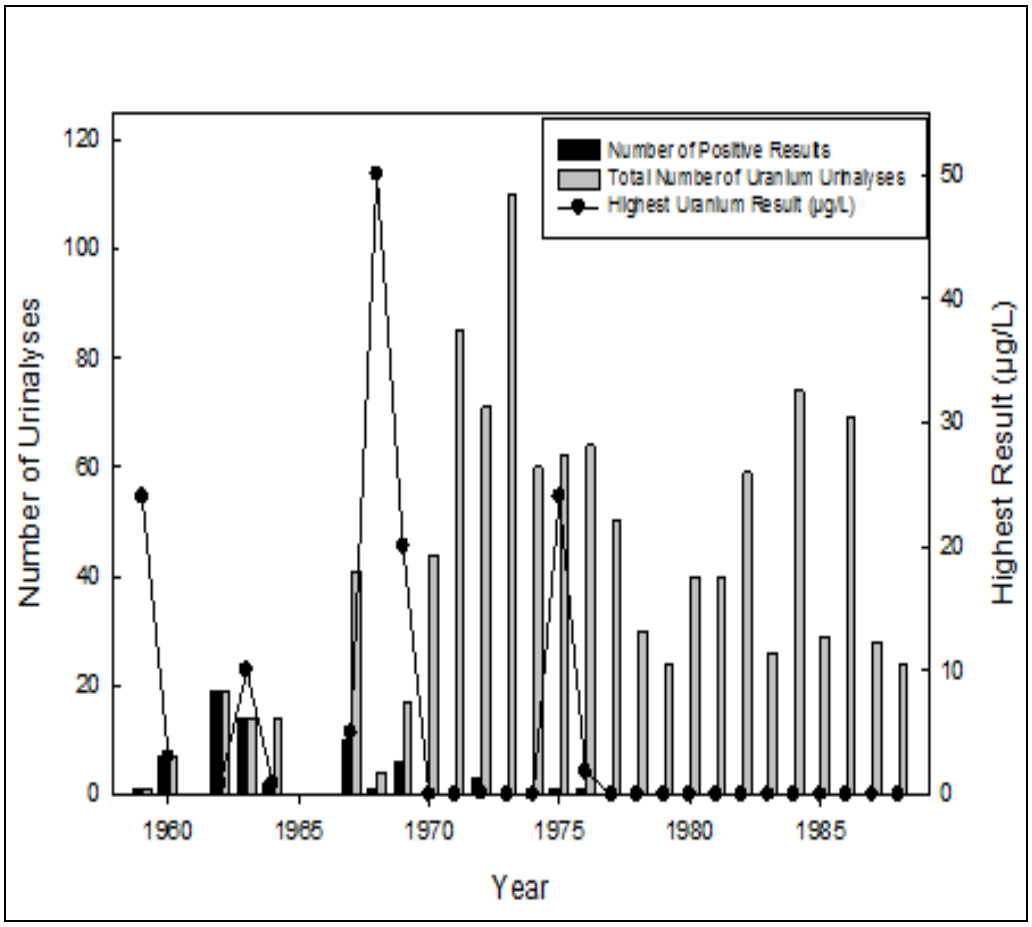


Figure 6-2: Urinalysis for Uranium Performed at Sandia National Laboratory, 1959-1988.

6.1.3 Fission and Activation Products

Very few fission and activation products bioassay data have been obtained by NIOSH.

6.1.4 Plutonium

Documented urinalysis results for total plutonium during the period from 1959 through 1971 have been obtained by NIOSH. The number of plutonium urinalysis, number of positive results, and the highest values recorded during this period, from the records identified by NIOSH, are shown in Figure 6-3. No data are available for 1963 and 1965.

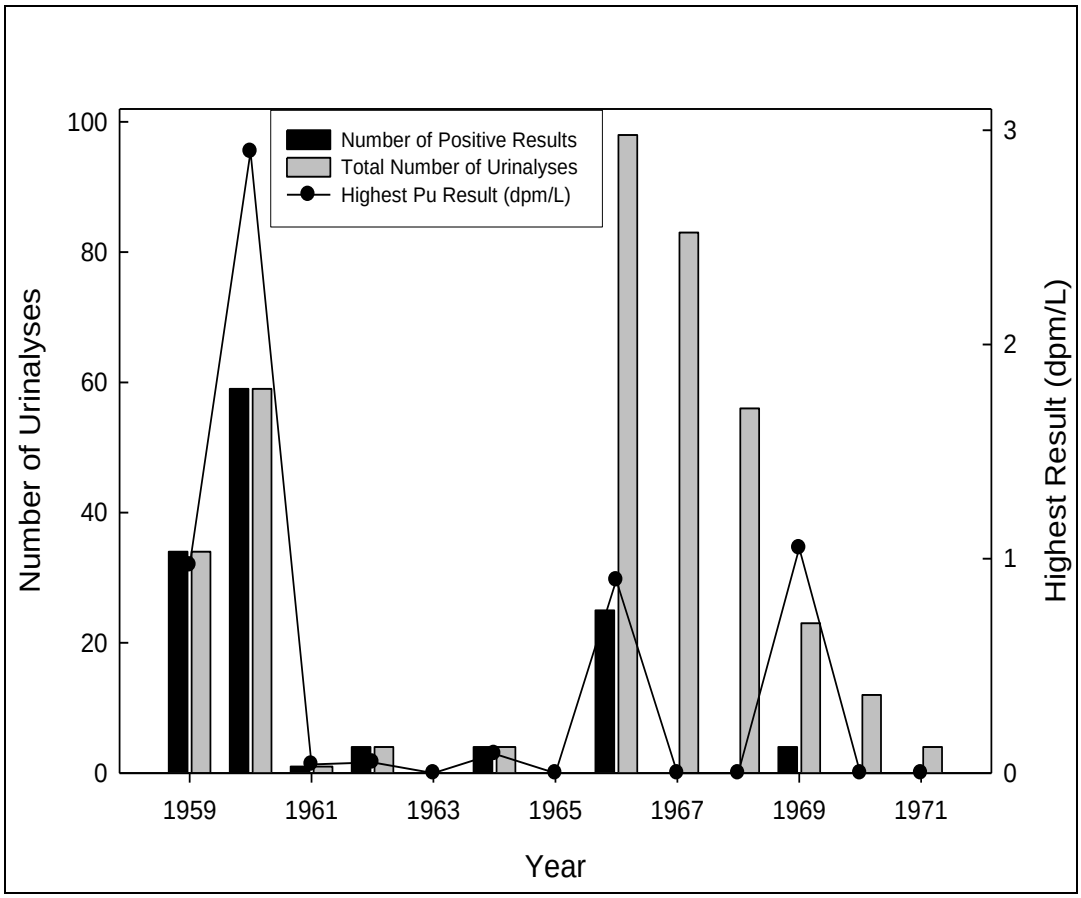


Figure 6-3: Urinalysis for Total Plutonium Performed at Sandia National Laboratory, 1959-1971.

6.1.5 Americium and Thorium

Very few (potential exposure related) data points have been obtained by NIOSH for Am-241. No thorium bioassay data have been captured by NIOSH.

6.2 Available Sandia National Laboratories External Monitoring Data

SNL-A employees assigned to operations involving radiation sources were monitored for exposure to radiation during the period evaluated. Sandia Corporation Instructions 2043 (SNL-A, 1957-1963) provided guidance and direction regarding the film dosimetry program during the early portions of the evaluated period. These instructions document that the Industrial Hygiene Division was "responsible for the overall administration of the film badge dosimetry program to insure, by centralized control, proper and uniform application of its provisions," including the decisions about which employees should be monitored and maintaining a permanent historical dosimetry record for each SNL-A employee (SNL-A, 1957-1963 pdf p. 24). Also documented is the 1957 designation of the Health Physics Section as well as that section's responsibilities to implement the Industrial Hygiene organizational goals. The scope of the radiation dosimetry program stipulated that all SNL-A employees working in locations designated as "Radioactive Areas" or working with radioactive materials were to wear film badges. It also stipulated that visitors were to be furnished with film badges accordingly. This practice was implemented throughout the organization as witnessed by a memo to all members of Section 1626-1 and 1626-3 (Radiation Effects and Radiation Special Studies Sections) dated June 25, 1957, stating that all who handled or were around radiation material were required to wear film badges (Colp, 1957, pdf p. 81). The memo further stated that "in the case of our two Sections, this applies to everyone assigned to work in our area" (Colp, 1957, pdf p. 81). These procedures were carried over into the period being evaluated, later being incorporated into the *Sandia Manual for Industrial Safety, Fire Prevention, and Environmental Health* (SNL-A, 1971). Multiple documents indicate that technically sound procedures were being used in the middle and late 1990s (SNL-A, 1994b, 1994c, 1995b, 1996a, 1997, 1996b, 1996c). NIOSH has access to documents that specify the requirements for using a radiation dosimeter at SNL in late 1990 (Stanley, 1990; Garcia, 1991). DOELAP accreditation was completed in 1991 (Loesch, 1991) and included all the categories for accurately monitoring the radiation fields at SNL-A, specifically, beta particles, low and high energy photons, and neutrons. Table 6-2 summarizes the various dosimeters used at SNL-A during the evaluated period.

Table 6-2: Dosimeters Used at Sandia National Laboratories	
Time Period	**Beta/Photon Dosimeters Used**
1963 to April 1971	Film Badge 2: Plastic holders had four windows: open window, 0.035-in. Al filter for beta/gamma, Tungsten/Cd and Sn filters for thermal neutrons. Used DuPont 558 film packets for the beta/gamma exposures based on calibrations with cobalt-60 and 70 keV Xrays. These packets contained DuPont 519 film (stated range 30 mR to 10 R) and 1290 film (stated range 10R to 3000 R).
May 1971 to ~1988	Harshaw Model 2271: The first TL badge had an open window and a 0.035-in. Al filter. The TLD card consisted of two TLD-100 elements, each also 0.035-in. thick.
~1989 to ~1994	Harshaw Model 8801 (7776-1141) cards in Model 8812 holder. 1: 0.015-in. thick TLD-700 under 600 mg/cm^2 ABS plastic (deep dose). 2: 0.015-in. thick TLD-700 under 242 mg/cm^2 ABS, 0.004-in. Cu (low-energy X-rays). 3: 0.0036-in. thick TLD-700 under open window, 0.0025-in. Mylar (shallow dose). 4: 0.015-in. thick TLD-600 under 600 mg/cm^2 ABS plastic (neutron dose).
~1995 to present	Harshaw/Bicron EXTRAD put into use 2nd quarter 1997 for extremity dose. Harshaw Model 8802 (7776-1161) or 8801 cards (see above) in Model 8812 holder 1: 0.015-in. thick TLD-700 under 600 mg/cm^2 ABS plastic (deep dose). 2: 0.015-in. thick TLD-700 under 242 mg/cm^2 ABS, 0.004-in. Cu (low-energy X-rays). 3: 0.006-in. thick TLD-700 under open window, 0.0025-in. Mylar (thicker shallow-dose chip than in the Model 8801) . 4: 0.015-in. thick TLD-600 under 600 mg/cm^2 ABS plastic (neutron dose).
Time Period	**Neutron Dosimeters Used**
1963 to April 1971	Film Badge 2: In a plastic holder with four windows: ones with cadmium and tin filters were used to measure thermal neutrons. Used DuPont film for thermal neutron dose and Kodak Personnel Monitoring Film, Type A film (NTA) for fast neutron dose based on calibrations with Van de Graaff generator/accelerator at energies of 1, 5, and 14 MeV.
May 1971 to ~1973	The first TL neutron badge consisted of three LiF elements: two LiF-600 that were sensitive to thermal neutrons and one LiF-700 that was insensitive to neutrons but was used to subtract any gamma contribution. The LiF elements were placed behind tin and cadmium filters to support determination of incident and scattered thermal neutrons.
~1973 to ~1990	First dedicated neutron dosimeter incorporated two cards, each with a TLD-600 and a TLD-700 element. One TLD-600 and TLD-700 were enclosed in a borated polyethylene pouch and one TLD-600 and TLD-700 were uncovered. The holder had an open window and three 0.035-in. Al filters. Deep and shallow measurements were made with the TLD-700 elements and bare and boron-filtered measurements of neutrons with the TLD-600 elements to discriminate energies near thermal.
July 1984	An albedo TLD was added for neutron dosimetry.
~1990 to 1994	Harshaw "Sandia Beta-Gamma-Neutron Configuration, Model 8812/8801" 1. 0.015-in. TLD-700 under 600 mg/cm2 ABS plastic (0.277-in.). 2. 0.015-in. TLD-700 under 242 mg/cm2 ABS and 0.004-in. copper. 3. 0.0015-in. TLD-700 under 0.0025-in. Mylar. 4. 0.015-in. TLD-600 under 600 mg/cm2 ABS (neutron dose).
~1995 to present	Harshaw -"Sandia Beta-Gamma-Neutron Configuration, Model 8812/8802" 1. 0.015-in. TLD-700 under 600 mg/cm2 ABS plastic (0.277-in.). 2. 0.015-in. TLD-700 under 242 mg/cm2 ABS and 0.004-in. copper. 3. 0.006-in. TLD-700 under 0.0025-in. Mylar. 4. 0.015-in. TLD-600 under 600 mg/cm2 ABS (neutron dose).

Source: The information for this table was extracted from Tables 6-1 and 6-2 of ORAUT-TBKS-0037 for the period under evaluation.

Data presented in Table 6-3 summarize the dose-related quantities that have been reported in SNL-A annual dose summaries for the period of interest. These data confirm that both beta and gamma exposures were monitored and reported, as well as thermal and fast neutron exposures. The data also confirm that extremity (wrist) exposures were also monitored.

Table 6-3: Dose Quantities Reported in SNL-A Annual Reports to AEC/DOE

Dose Quantities in Annual Dose Reports	1959-1965	1966	1967-1969	1970	1971-1976	1983-1987	1988-1991	1992-2011
"Total Body"						■	■	■
"Total Wrist"								
Total Dose (Total)								
Total This Period	■							
Total This Quarter	■							
Year to Date	■	■	■	■				
Cumulative Total	■	■	■	■				
Gamma	■	■	■	■	■	■		
Fast Neutron	■	■	■	■	■			
Thermal Neutron	■	■	■	■	■			
"Beta"	■	■						
Wrist	■	■						
Cumulative Beta		■						
Cumulative Wrist		■						
Cumul. Non-pen.			■		■			
Cumul. Extremity			■	■	■			
Extremity			■	■	■	■		■
Non-penetrating			■	■	■	■		
Ann. Penetrating					■			
Cumul. Penetrat.					■			
Annual Skin					■	■		■
Cumul. Skin					■			
Cumul. Gamma					■			
Cumul.Fast					■			
Cumul Thermal					■			
Annual Internal					■	■	■	■
Cumul. Internal					■			
Eye						■		■
Neutron						■	■	■
Deep							■	■
Shallow								■

Source: The information for this table (1959-1991) was extracted from Table 6-3 of ORAUT-TKBS-0037 for the period under evaluation. The final column (1992-2011) information was based on DOE reporting requirements and claims data provided by SNL-A during this period.

A memo dated August 21, 1996, specifically mentions that "film badge records have existed since Sandia came into existence" (Perez-Romo, 1996). It describes the storage location for these dosimetry records and indicates that data extracted from the gamma and neutron film were initially manually entered on index cards. Later in the process history, a semi-automatic system was developed to replace the index cards (Perez-Romo, 1996). Monitoring results are available for the period in question. A claim file review was conducted to determine the nature and amount of external radiation exposure data that had been returned by SNL-A in response to claims that had been submitted to SNL-A. The external monitoring records available appeared to be consistent with work histories. However, the records provided by SNL-A show some peculiarities that can complicate the dose reconstruction process. For example, some records from the evaluated period indicate specific badging periods, but the exposures are listed for an entire year rather than the badging period. Therefore, dose reconstruction requires making some judgments regarding which period the exposure actually occurred or how many "0" exposures occurred during the year. There are also gaps in the exposure records where not every badging period is represented by data. This requires that decisions be made regarding whether the worker was actually appropriately unmonitored, or if the worker was involved in work that should have been monitored, but for some unknown reason was not. This anomaly exists primarily prior to the late 1980s; after this period, the doses provided with the claims response are provided by wear period, making the decision process for individual dose reconstructions more straight-forward.

6.2.1 Photon Exposure Data

Table 6-4 lists whole-body gamma exposure data submitted as part of the annual radiation exposure reports to AEC. It is apparent that the external exposure reporting criteria required by AEC changed periodically; thus, the same external exposure information is not available for all the years in question. Generally, the data specify how many workers were monitored, sometimes an indication of how many were not monitored, the number of workers with exposures within specific ranges, and sometimes a listing of the maximum exposure for that particular year. The data show that exposures to the vast majority of the workers were typically low, generally less than 1 rem/year.

Table 6-4: Radiation Exposure Data Reported by SNL-A to AEC/DOE
Table 6-4 and its associated notes span two pages.

Year	No. Employees Monitored	No. Employees Not Monitored	<0.1 rem	0.1-0.25 rem	0.25-0.5 rem	< 1 rem	1-2 rem	2-3 rem	3-4 rem	4-5 rem	Max. Dose
1963	3094	4052				3078	14	2			<3
1964	3,380	3,833				3,372	4	4			<3
1965	3,696	3,428				3,685	10	1			<3
1966	3,920	3,161				3,896	17	7			<3
1967	2,692	5,316+25K [a]				2,669	13	8	2		<4
1968	3,135	5,121+25K				3,108	14	7	3	3	<5
1969	2,875	5,106+25K				2,852	11	6	6		<4
1970	2,952	4,755+25K				2,927	18	5	2		<4
1971	2,382	4,648+25K				2,356	19	3	3	1	<5
1972	2,408	4,506+25K				2,374	20	5	4	3	<5

Table 6-4: Radiation Exposure Data Reported by SNL-A to AEC/DOE
Table 6-4 and its associated notes span two pages.

Year	No. Employees Monitored	No. Employees Not Monitored	<0.1 rem	0.1-0.25 rem	0.25-0.5 rem	< 1 rem	1-2 rem	2-3 rem	3-4 rem	4-5 rem	Max. Dose
1973	2,802	3,648+25K				2,779	16	3	2	2	<5
1974	1,937	(987)[b]	721	157	45	12	10	4		1	<5
1975	3,880	(2,168)[b]	1,347	250	75	19	18	1		1	<9
1976	4,350	(2,232)[b]	1,848	195	30	30	6	4	4	1	
1977	4,631	(2,450)[b]	1,819	247	70	26	10	5	2	2	
1978	5,009	(3,443)[b]	1,334	150	38	18	14	7	3	2	
1979	4,721	(3,430)[b]	1,107	113	35	21	8	1	4	2	
1980	4,279	(3,338)[b]	805	90	20	18	5	1	2		
1981	4,764	(4,113)[b]	550	56	33	6	3	2	1		
1982	4,725	(3,920)[b]	653	80	39	14	10	4	2	3	
1983	4,935	(3,804)[b]	991	100	20	9	3	6	1	1	
1984	4,967	(4,243)[b]	634	56	13	13	4	2	2		
1985	3,561	(2,903)[b]	569	53	18	9	6	2	1		
1986	3,283	(2,849)[b]	368	34	15	10	5	2			
1987	989	(979)[b]	9	1							
1988	3,440	(2,788)[b]	544	65	21	15	5	2			
1989	3,906	(2,980)[b]	854	38	19	5	1	4			
1990	4,941	(4,087)[b]	805	30	11	5	3				
1991	5,152	(4,581)[b]	532	24	6	5	4				
1992	5,298	(4,782)[b]	481	21	10	4					
1993	4,285	(3,971)[b]	295	9	8	2					
1994	4,001	(3,751)[b]	225	16	5	4					
1995	3,750	(3,407)[b]	324	13	6						
1996	5,006	(4,521)[b]	465	7	7	6					
1997	3,406	(3,213)[b]	175	12	2	3					
1998	3,462	(3,281)[b]	167	7	2	5					
1999	3,246	(3,126)[b]	107	7	4	2					
2000	2,983	(2,878)[b]	83	13	8	1					
2001	2,886	(2,787)[b]	88	6	5						
2002	2,937	(2,828)[b]	96	11	2						
2003	3,024	(2,774)[b]	223	21	6						
2004	3,220	(2,903)[b]	269	36	10	1	1				
2005	3,345	(3,123)[b]	201	18	3						
2006	3,185	(2,917)[b]	229	15	12	11	1				
2007	2,998	(2,823)[b]	152	21	2						
2008	2,804	(2,644)[b]	136	22	2						
2009	2,469	(2,381)[b]	79	6	3						
2010	2,124	(2,065)[b]	50	8	1						

Notes:

[a] The value of 25K was submitted by SNL-A as the estimated number of construction workers that were not monitored.

[b] Numbers inside the ( ) in the third column show the number of employees with no measurable exposure, while the numbers not inside ( ) show the number of employees not monitored. Results for 1974 and later all refer to the number of employees with no measureable exposure.

Table 6-4 also indicates that not all employees were monitored, which is typical for operations such as those conducted at SNL-A. Not all employees performed jobs that caused them to potentially be exposed to external radiation. However, as indicated in NIOSH-obtained monitoring procedures, all employees who handled or were around radioactive materials were required to wear dosimetry devices. As discussed previously, this policy was carried forward into the *Sandia Manual for Industrial Safety, Fire Prevention, and Environmental Health* (SNL-A, 1971) and other more contemporary procedures (SNL-A, 1994b, 1994c, 1995b, 1996a, 1997, 1996b, 1996c). Table 6-4 also indicates that the vast majority of employees that were monitored did not receive measurable exposures, which can be seen by the difference between the number of employees monitored and the number receiving measurable exposure.

6.2.2 Beta Exposure Data

The radiation dosimetry devices in use at SNL-A during the period under evaluation had the capability to monitor beta exposures. The devices were also used as wrist badges to monitor for extremity exposures. Records of these exposures have been retained and appear in data request responses submitted by SNL-A for specific claims. Table 6-2 summarizes the dosimeters used during the evaluated period. Table 6-5 provides the potential annual missed dose for these dosimeters.

Table 6-5: Potential Annual Missed Doses

Period of Use	Dosimeter	Exchange Frequency	Annual Missed Deep Dose	Annual Missed Non-Penetrating Dose
1959 to April 1971	Film in plastic holder	Biweekly[a] Monthly Quarterly	520 240 80	520 240 80
May 1971 to ~1973	2271 TLD	Monthly Quarterly	120 40	228 76
1973 to ~1990	Two-Card Neutron TLD	Monthly Quarterly	120 40	228 76
~1990 to ~1994	8801 TLD	Monthly Quarterly	60 20	210 70
~1995 to Present	8802 TLD	Monthly Quarterly	30 16	30 20

Notes:

Source: The information for this table was extracted from Table 6-7 of ORAUT-TBKS-0037for the period under evaluation.

[a] Dosimeters in reactor areas and for organizations handling radioactive materials consistently were exchanged on a biweekly basis (every two weeks).

6.2.3 Neutron Exposure Data

Neutron monitoring began in 1958, which coincides with the beginning of accelerator operations. Neutron exposures were monitored as described in SNL-A procedures. Nuclear Track Emulsion Type-A film was used to measure fast neutrons; thermal neutrons were measured using the film density differences under the cadmium shielded versus tin shielded portions of the film badge. This protocol has been described in the "Capture Gammas for Neutron Dosimetry with a Film Badge" in Volume 10 of the 1964 *Health Physics* Journal (Caruthers, 1964). A 1962 document describes this calculation procedure as well as the process for determining gamma and beta doses from the film badge readings (Unknown, 1962). The requirements for use of radiation dosimetry and the related records are described in August 21, 1996, correspondence regarding film badge and TLD records (Perez-Romo, 1996). Neutron exposures were recorded in the records of the individual workers. The doses to workers were also reported to the AEC, as shown in *Annual, Semi Annual, and Quarterly Film Badge Exposure Summaries and Annual Summary Reports (1949-1984)* (Monitoring Results, 1949-1984).

7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

The feasibility determinations for the class of employees under evaluation in this report are governed by both EEOICPA and 42 C.F.R. § 83.13(c)(1). Under that Act and rule, NIOSH must establish whether or not it has access to sufficient information either to estimate the maximum radiation dose for every type of cancer for which radiation doses are reconstructed that could have been incurred under plausible circumstances by any member of the class, or to estimate the radiation doses to members of the class more precisely than a maximum dose estimate. If NIOSH has access to sufficient information for either case, NIOSH would then determine that it would be feasible to conduct dose reconstructions.

In determining feasibility, NIOSH begins by evaluating whether current or completed NIOSH dose reconstructions demonstrate the feasibility of estimating with sufficient accuracy the potential radiation exposures of the class. If the conclusion is one of infeasibility, NIOSH systematically evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might assure that NIOSH can estimate either the maximum doses that members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class. This approach is discussed in DCAS's SEC Petition Evaluation Internal Procedures which are available at http://www.cdc.gov/niosh/ocas. The next four major subsections of this Evaluation Report examine:

- The sufficiency and reliability of the available data. (Section 7.1)
- The feasibility of reconstructing internal radiation doses. (Section 7.2)
- The feasibility of reconstructing external radiation doses. (Section 7.3)
- The bases for petition SEC-00188 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of Sandia National Laboratories Data

This subsection answers questions that need to be asked before performing a feasibility evaluation. Data Pedigree addresses the background, history, and origin of the data. It requires looking at site methodologies that may have changed over time; primary versus secondary data sources and whether they match; and whether data are internally consistent. All these issues form the bedrock of the researcher's confidence and later conclusions about the data's quality, credibility, reliability, representativeness, and sufficiency for determining the feasibility of dose reconstruction. The feasibility evaluation presupposes that data pedigree issues have been settled.

Though workers at SNL-A have been monitored for radiation exposures since 1949, the site's first formally designated Health Physics Section was first formed within the Industrial Hygiene Division in 1957, approximately five years prior to the start of the SEC evaluation period. It was initially created to perform radiation safety for workers participating in atmospheric testing; it quickly expanded to provide radiation safety services throughout the site as needed. From 1957 forward, NIOSH has been able to obtain several Sandia Corporation Instructions that detail various health and safety oriented roles and responsibilities, including proper handling of radioactive material and the dosimetry program. The Sandia Corporation Instructions documents show that the Industrial Hygiene Division had "overall administration of the Film Badge Program to insure, by centralized control, proper and uniform application of its provisions" (SNL-A, 1957-1963). Per the Sandia Corporation Instructions, within the Industrial Hygiene Division, the newly formed Health Physics Section was tasked with the day-to-day implementation of the program goals. This included furnishing consulting services on all aspects of radiation protection, surveillance of all radiation activities, distribution and processing of monitoring equipment, maintaining exposure records and submitting reports, scheduling urinalysis measurements, evaluating suspected overexposures assessing and eliminating hazards, supervision and coordination of the waste disposal program, etc. It is evident from available documentation and interviews that during the evaluation period monitoring requirements at SNL-A have been determined primarily within specific departments or divisions and based on work area and activity-specific bases. Health physicists determined monitoring requirements for workers under their purview based on their judgment of exposure potential. Organization supervisors were responsible for implementing the health physicists' recommendations. Often, air monitoring was used as a decision tool for determining worker protection needs and bioassay sampling requirements.

Certain aspects of the SNL-A's health physics oversight program were not well documented during much of the evaluation period however. A lack of program documentation is particularly applicable to internal exposure monitoring practices and internal monitoring record maintenance. This may be due in part to the relatively low internal exposure potential for much of the work performed at SNL-A, and the resultant ad hoc approach to internal monitoring. The first documented "Interim Internal Dosimetry Policy" was established in December 1993 (Stanley, 1993), following deficiencies noted during internal SNL-A and DOE Tiger Team assessments. Also in response to the assessments, SNL-A issued a comprehensive "Control of Radiological Records Procedure" in January 1994 (SNL-A, 1994a). This procedure's purpose was to "…establish and implement the controls for the systematic generation, distribution, control, and retention or disposition of official Radiation Protection Operations Department records and documents related to the radiological control at Sandia National Laboratories." The lack of documented internal monitoring procedures and requirements prior to 1993 undermines the ability to definitively support the supposition that internal monitoring was

performed whenever and wherever necessary, for all appropriate workers. Contrary to internal monitoring requirements, external monitoring requirements have been well documented. In addition to the Sandia Corporation Instructions described previously, NIOSH has obtained several other examples of SNL-A's external monitoring procedures applicable to the evaluated period.

Databases containing internal or external monitoring data do not cover the majority of the evaluated period. Existing SNL-A electronic monitoring record databases do not contain internal monitoring records prior to approximately 1993, or external monitoring records prior to 1989. Earlier records associated with the evaluated period were all originally on paper; the very early monitoring records were on Cardex cards (Personal Communication, 2007). Paper monitoring records (and apparently other records) were converted into and replaced with microfilm for a short time, and then to microfiche. Actual contents of the microfilm/microfiche data collection are currently unverified. NIOSH is considering pursuing the task of incorporating this information into a database but has not done so to date. A large portion of the original paper records created during the evaluated period have been archived in inactive records storage in mountain caves for long-term storage purposes. Currently, there are approximately 50,000 boxes of records in this long-term storage repository. Although these records are technically still available, there are currently no efficient search and retrieval methods for these records.

Active, current, or recently requested radiological records (non-electronically stored) are held in a centralized repository called the Environmental Safety and Health (ES&H) Records Center (also known as Customer Funded Records Center) on the first floor of Building 869. The Industrial Health Division is located on the first floor of the building as well. Health physics records stored in the ES&H Records Center include radiation monitoring, contamination surveys, and air sample data. The ES&H Records Center allows the originating organization to determine the content of the submissions. Documents are retained in the ES&H Records Center for three years from the date they are received, not from the date the documents were originated. Afterwards, the records holdings are archived into the long-term storage location (also referred to as inactive record storage). Currently there are three finding aids for inactive records. They include:

- The Versatile database, which is site-wide in scope;
- The Safety Health Environmental Automated Records System (SHEARS), which is unique to the ES&H Records Center; and
- The Inactive Record Transfer (IRT) binder, which catalogs stored records that were submitted prior to the establishment of the ES&H Records Center.

To conduct a thorough search for records it is necessary to know the name of the organization that created the record at the time of the record's creation. Many records applicable to the evaluated period and kept in long-term storage, are searchable via the index within the IRT binder listed previously. This index however does not provide the detail needed for targeted data capture nor determining total data availability. In addition to the ES&H Records Center and inactive records holdings, non-electronic employee records may be located within medical records and industrial hygiene records.

More recent SNL-A monitoring records are maintained electronically. The Sandia Dosimetry System (referred to as SANDOS) was first created as two separate, independently-operated applications in approximately 1989/1990. The external dosimetry SANDOS system came first, followed approximately three years later by the radiobioassay SANDOS system. External SANDOS was used to manage the SNL-A TLD inventory through the various stages of the TLD life cycle (from issue to return of dosimeters, to uploading group files from the dosimeter reader's application**,** processing data, calculation of doses, and storage of occupational doses). Internal SANDOS was used to issue radiobioassay kits, track kits/assignments, log kits back in upon return, store laboratory results reported for each kit, and store doses calculated outside of the system associated with laboratory results. Various reports were generated using data from SANDOS, including dose histories and annual occupational exposure reports.

External and internal SANDOS applications were combined into one integrated application under a "PowerBuilder" platform sometime in 2003. All data and doses in the previously existing, separate SANDOS applications were migrated into the newer SANDOS application. This application included a new function to calculate air sample doses using ICRP dose conversion factors and user-supplied air sample data. All other radiobioassay doses continued to be calculated outside the system and inserted manually as appropriate. The SANDOS (PowerBuilder) application was a stand-alone internal and external occupational dose electronic database from its inception in 2003 until June 2009 when the external dosimetry portion of SANDOS and all associated TLD data/doses were migrated into a new web-based Java application called WebDose developed at SNL-A. WebDose is the current external occupational dose database. It also functions as the internal and external dose reporting tool. Annual dose reports, REMS reports, and other official dose reports are generated using WebDose. Since June 2009, SANDOS has been used exclusively for internal dosimetry purposes, as described above.

7.1.1 Internal Monitoring Data Pedigree Review

As noted in Subsection 6.1, NIOSH has obtained relatively few internal monitoring data for the evaluated period. Bioassay data for the evaluated period have occasionally been returned during EEOICPA claimant data requests, found in NIOSH-obtained documents, and found in records selected from inactive storage during data capture efforts. Additionally, initial reviews of the microfilm/microfiche data (see Section 6.0 of this report) indicate the presence of *in vitro* bioassay data within that set.

Radiochemical and chemical analysis of *in vitro* bioassay samples was generally performed in-house during the period under evaluation. Although no analytical procedures have been obtained, a retired health physics manager stated that historically most of the sampling protocol and analytical techniques were based on Los Alamos Scientific Laboratory procedures (Personal Communication, 2011a). Beginning in 1992, the Santa Fe company Controls for Environmental Pollution (CEP) was contracted to provide part of SNL-A's bioassay analytical services. CEP tested approximately 500 employee urine samples for SNL-A between 1992 and 1994. SNL-A officials stopped using CEP's services in 1994 because quality control testing raised questions about the reliability of CEP's reports. It is NIOSH's policy that all data provided by CEP are unacceptable for EEOICPA dose reconstruction use.

Difficulty retrieving and receiving SNL-A occupational internal monitoring data has been an ongoing problem while processing EEOICPA claimant records requests. To address data gaps identified during claims processing, NIOSH requested monitoring data searches to be repeated for 164 SNL-A claimants. A comparison of data obtained by NIOSH during its own data capture efforts to data resupplied by SNL-A for the EEOICPA claimant data requests has been performed. The results highlight the ongoing retrievability issues associated with data collected and stored prior to the advent of the first electronic storage systems being put in place (i.e., Internal SANDOS in approximately 1993). Through data capture efforts, NIOSH retrieved internal monitoring data reports associated with 20 current SNL-A claimants employed within the evaluated period and for whom EEOICPA monitoring data requests had already been processed. Comparing the two, it was apparent that NIOSH has obtained 24 different urinalysis reports that were not provided by SNL-A during the processing of these claims. These reports are associated with various decades as noted in Table 7-1 below.

Table 7-1: Urinalysis Reports Obtained by NIOSH

Decade	1960s	1970s	1980s	1990s
No. of Reports	6	15	1	2

The total sample size and data collection method are not conducive to making conclusions regarding data retrievability comparisons over time periods. The results do however sufficiently highlight internal monitoring data retrievability problems existing from the beginning of the evaluated period up into the early 1990s at a minimum. The total quantity of internal monitoring data potentially available from SNL-A is likely low, due to the ad hoc nature of the monitoring performed. Difficulty locating detailed work process and internal radiation protection program information for the earlier years, as well as data retrievability problems known to exist for records not stored within electronic media create uncertainty regarding the ability to confidently bound internal doses that might have occurred. Access to air monitoring data appears just as difficult as access to personal monitoring data. Regardless of data availability issues, the lack of documented internal monitoring procedures and requirements prior to 1993 prevents the ability to definitively support a premise that internal monitoring was performed as necessary for all appropriate workers.

Based upon NIOSH's assessment of the SNL-A internal monitoring program, the results of its extensive data capture efforts and document reviews, and interviews with SNL-A personnel NIOSH concludes that the SNL-A internal monitoring data pedigree is insufficient to support bounding internal doses for members of the class under evaluation during the January 1, 1963 through December 31, 1994 period. This is due primarily to the absence of internal monitoring program documentation for this period and compounded by the lack of source term information, data retrieval problems known to exist into the very early 1990s, and the use of CEP analytical services for bioassay well into 1994. Evaluation of internal monitoring data pedigree post 1994 (after electronic databases storage systems were becoming the norm) is still ongoing. Completion of this work is dependent upon acquiring access to SNL-A's other electronic data storage media.

7.1.2 External Monitoring Data Pedigree Review

There was external radiation exposure monitoring throughout the evaluated period at SNL-A. External radiation exposure data were supplied to AEC/ERDA/DOE annually in accordance with reporting requirements and these reports are available to NIOSH. External monitoring records for monitored SNL-A workers within the evaluated period are typically available within EEOICPA claims as well; SNL-A has supplied data for 256 of 367 workers from this period. This monitoring ratio is consistent with the data supplied by SNL-A to the AEC during this period, generally indicating external records have been properly retained in repositories in a retrievable manner.

NIOSH has also determined that the external exposure data were obtained from badges with known, sufficient performance characteristics and that the data exist as either primary data records or as photo copies (microfilm or microfiche) of the primary data. The dosimeters in use were properly calibrated with radiations that were appropriate for the fields that were likely to exist at SNL-A. Neutron monitoring began in 1958 (prior to the evaluated period), which coincides with the introduction of an accelerator that had the potential to produce neutrons.

Program procedures are available from 1957 forward and they detail an effort to ensure that all workers who should have been monitored were monitored; that is, any worker that entered a "radiation area." It is also known that there were a large number of workers at SNL-A that would not have entered a radiation area and would not have been monitored, due to the remote nature of the areas which contained reactors and accelerators. Given the availability of monitoring program documents and the continuity and consistent availability of external records throughout the evaluated time period, NIOSH believes that an appropriate external monitoring program has also been in place for the entire evaluated period.

Based upon NIOSH's assessment of the SNL-A external dosimetry program, the results of its extensive data capture efforts and document reviews, and interviews with SNL-A personnel NIOSH concludes that the SNL-A external monitoring data pedigree is sufficient to support bounding external dose for the entire period for the class evaluated (January 1, 1963 through May 21, 2011).

7.2 Evaluation of Bounding Internal Radiation Doses at Sandia National Laboratories

The principal sources of internal radiation doses for members of the class under evaluation were likely associated with waste handling and with machining that supported reactor and accelerator operations. Other potential internal doses could have been received from neutron generator work (if damaged) and from handling accelerator targets. Most urinalysis data with relevant contextual information obtained by NIOSH are related to incidents, however. There is no information to indicate that SNL-A had routine and documented bioassay programs prior to about 1993, and records of radiological incidents are not available in any comprehensive way. Consequently, NIOSH has obtained only relatively few results overall. Lack of access to complete, detailed information creates uncertainty regarding the presence of other potential internal exposure sources. The following subsections address the ability to bound internal doses and the feasibility of internal dose reconstruction.

7.2.1 Evaluation of Bounding Process-Related Internal Doses

The following subsections summarize the extent and limitations of information available for reconstructing the process-related internal doses of members of the class under evaluation.

7.2.1.1 Urinalysis Information and Available Data

NIOSH data capture efforts have identified several documents containing urine bioassay results for a portion of the evaluated period. NIOSH currently has no means, however, of efficiently accessing internal monitoring data (prior to 1993) within individual personnel files or in the long-term record storage repository. Therefore, determining total internal monitoring data availability for any of the bioassay analytes for the 1963 through 1994 period is not possible. Similarly, obtaining efficient access to complete potential internal dose source-term documentation is not possible, and internal monitoring program documentation is nonexistent prior to 1993. As a result, data sufficiency for determining the feasibility of bounding internal doses for the evaluated period must be based on program and bioassay data currently available for this portion of the evaluation period. NIOSH has concluded that sufficient bioassay data are not currently available to bound internal dose for the January 1, 1963 through December 31, 1994 portion of the evaluated class. NIOSH intends to continue its assessment of the January 1, 1995 through May 21, 2011 period when it has access to the internal monitoring data contained within SNL-A electronic databases covering this latter period. If NIOSH finds information indicating that it cannot bound for the period, NIOSH will present an additional SEC class in an 83.14 ER.

7.2.1.2 Airborne Levels

NIOSH has obtained very little air monitoring data for the evaluated period. Documentation for assessing and monitoring the workplace for airborne exposure potential has not been obtained for years prior to 1995. NIOSH is aware that Revision 01 of an Operational Air Monitoring Assessment procedure (ORAUT-TKBS-0037) describing parameters used to identify areas requiring air sampling, CAM alarm set-point determinations, air flow pattern studies, placement of air monitoring equipment, air sampling line design, and air monitoring in environmental restoration activities was completed in 1996, but the date of implementation for the original procedure is not clear. Similarly, Revision 01 of an Airborne Radioactivity Sampling and Monitoring procedure (SNL-A, 1995a; ORAUT-TKBS-0037) appears to have been issued in 1995, but the implementation of the original procedure is unknown. Airborne concentration measurement results are not available for all years of operation, especially for fission products, and reported results often do not include critical information such as the volume of air through the filter.

Engineered controls to prevent intakes are emphasized in the radiation protection program records. Modifications in the SPR facility, for instance, reduced airborne gross alpha activity levels after a burst from >1 $\mu Ci/m^3$ in 1961 to <0.1 $\mu Ci/m^3$ in 1964. Modifications in the SPR II facility were implemented to prevent the leakage of fission products after an incident in 1968 resulted in evacuation of the Reactor Control Room.

In most cases, sampling and analysis parameters necessary for proper interpretation of the little data available are not known. As such, NIOSH has concluded that sufficient air monitoring data prior to 1994 are not currently available to estimate a bounding internal dose.

NIOSH believes that data are available to bound operational internal doses incurred from January 1, 1995 through May 21, 2011. NIOSH intends to continue its assessment when it has access to the internal monitoring data within SNL-A electronic databases covering this latter period. If NIOSH finds information indicating that it cannot bound for the period, NIOSH will present an additional SEC class in an 83.14 ER.

7.2.1.3 Alternative Data Sources for Bounding Internal Dose

Annual reports to AEC and DOE state that no workers received greater than 50% Maximum Permissible Body Burden for the years 1964 through 1974, 1976 through 1984, and 1989 (Monitoring Results, 1949-1985; DOE, 1992). Later DOE annual reports summarizing radiation doses do not report internal dose separately by site. Missed doses based on the limiting values in the years available could technically be calculated and used as a significant overestimate of the dose applied to members of the evaluated class. However, because NIOSH does not have access to limiting values in all years, nor to the relevant supporting data, validation of these reported results is currently not possible. NIOSH has concluded that sufficient alternative data sources are not available to support the assessment of bounding internal dose for the proposed class.

7.2.2 Evaluation of Bounding Ambient Environmental Internal Doses

Because NIOSH has determined that internal monitoring program information and data are insufficient to bound operational internal dose, an exhaustive analysis of ambient environmental internal dose reconstruction has not been pursued for the 1963 through 1994 portion of this evaluation. NIOSH intends to continue its assessment of the January 1, 1995 through May 21, 2011 period when it has access to all data within SNL-A electronic databases covering this latter period in a separate review or evaluation, as applicable, to support expediting the evaluation of the proposed SEC class as presented in this report. NIOSH intends to use any available data and applicable methods/assessments as defined in the Technical Basis Documents (including environmental dose assessments) for the purpose of partial dose reconstructions for the proposed SEC class period.

7.2.3 Methods for Bounding Internal Dose at Sandia National Laboratories

NIOSH has determined that monitoring program documentation and data are insufficient to bound operational internal dose prior to 1994, thus methods for bounding internal doses have not been developed for this time period. Based on its initial evaluation of available information, NIOSH believes that monitoring program documentation, data, and methods are available to bound operational doses incurred from January 1, 1995 through May 21, 2011. However, to be certain, NIOSH intends to continue its assessment when it has access to internal monitoring data within SNL-A electronic databases covering this latter period in a separate review or evaluation, as applicable, to support expediting the evaluation of the proposed SEC class as presented in this report. However, NIOSH intends to use any available data and applicable methods/assessments as defined in ORAUT-TKBS-0037 or other NIOSH documents (including environmental dose assessments) for the purpose of partial dose reconstructions for the proposed SEC class period.

7.2.4 Internal Dose Reconstruction Feasibility Conclusion

NIOSH has determined that bioassay monitoring program documentation, workplace monitoring data, and process information are insufficient to support bounding EEOICPA internal doses for the January 1, 1963 through December 31, 1994 portion of the evaluated class. Additional internal monitoring data are known to exist that allegedly cover this period (microfilm/microfiche record set), but these data are not readily searchable as of the time of this evaluation report. Based on a lack of internal monitoring program documentation and source term information data for the January 1, 1963 through December 31, 1994 period, NIOSH feels it cannot establish a bounding approach even when the microfilm/microfiche records become available.

Based on its initial evaluation, NIOSH believes that monitoring program documentation, data, and methods are available to bound EEOICPA operational internal doses incurred from January 1, 1995 through May 21, 2011. However, to be certain, NIOSH intends to continue its assessment when it has access to internal monitoring data within SNL-A electronic databases covering this latter period. If NIOSH finds information indicating that it cannot bound for the period, NIOSH will present an additional SEC class in an 83.14 ER.

Although NIOSH found that it is not possible to reconstruct internal radiation doses for the period from January 1, 1963, to December 31, 1994, NIOSH intends to use any internal monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures) for the purpose of partial dose reconstructions for the proposed SEC class period. Therefore, dose reconstructions for individuals employed at SNL-A during the period from January 1, 1963, through December 31, 1994, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

7.3 Evaluation of Bounding External Radiation Doses at Sandia National Laboratories

The principal sources of external radiation doses for members of the evaluated class were reactors and accelerators being used to provide radiation environments for testing components and systems. The following subsections address the ability to bound external doses, methods for bounding doses, and the feasibility of external dose reconstruction.

7.3.1 Evaluation of Bounding Process-Related External Doses

The following subsections summarize the extent and limitations of information available for reconstructing the process-related external doses of members of the class under evaluation.

7.3.1.1 Personnel Dosimetry Data

From the beginning of site activities in 1949, employee radiation monitoring was an integral part of the SNL-A Radiation Protection program. Radiation exposure data have been provided for claimants employed during the 1963 through 2011 evaluation period. Additionally, information presented in Section 6.2 indicates that external dosimetry records exist for the evaluation period. Table 6-4 lists the data submitted annually to AEC, demonstrating that a significant number of personnel were monitored each year. A review of the NOCTS claims also indicates in general terms that such data

have been successfully retained over the years, is retrievable, and is being provided by SNL-A when requested.

Photon

External radiation exposure data have been provided for claimants employed during the entire evaluated period. Data presented in various documents/records (Monitoring Results, 1949-1984; Monitoring Results, 1964; Monitoring Results, 1972; Monitoring Results, 1981; Monitoring Results, 1982; Monitoring Results, 1983) and the DOE REMS database are summarized in Table 6-4 of this document. The data confirm that a significant fraction of SNL-A personnel were monitored and also indicate the maximum exposure occurring each year. These records are available, and when adjusted for missed dose and the dosimeter uncertainty correction factor (as described in ORAUT-TKBS-0037), are of sufficient quality to represent an appropriate basis for bounding external SNL-A radiation exposures.

Based on the information available to NIOSH regarding the SNL-A monitoring program and the available monitoring data, NIOSH concludes that sufficient data are available to bound external photon doses for the entire class under evaluation.

Beta

The preceding general discussion about personnel dosimetry and record-keeping applies equally well to the beta component of the dosimeter data. Non-penetrating exposures were monitored during the evaluated period as well as extremity exposures using wrist badges. The dosimeters were calibrated with uranium slabs, which would be appropriate for the radiation fields that may have been encountered at SNL-A. For unmonitored personnel with a work history indicating that the worker should have been monitored, the information in Table 6-5 can be used to assign a beta exposure.

The occupational external monitoring records for beta exposures have been retained and are available in summary format from annual reports and in employee files. The missed dose, bias, and uncertainty factors described in ORAUT-TKBS-0037 should be applied. With these adjustments, the data available should be sufficient to establish a bounding shallow dose estimate for the evaluated period.

Neutron

Neutron exposures have been monitored at SNL-A since 1958 and continued for the duration of the evaluated period, with the resulting data available in personnel files. There should not typically be significant neutron exposure to unmonitored workers since the necessary source for neutrons only existed within reactor areas or near neutron sources that would have been designated as radiation areas (e.g., Area V). Radiation dosimetry was required for all workers entering such areas. If there is a need to estimate neutron exposures for an unmonitored worker, Section 6.7 of ORAUT-TKBS-0037 provides a protocol.

Monitoring records have been available in employee files based upon review of DOE-provided records for claims. The missed dose and bias/uncertainty factors derived in ORAUT-TKBS-0037

should be applied. With these adjustments, the available data should be sufficient to establish a bounding neutron dose estimate for the entire class under evaluation.

7.3.1.2 Area Monitoring Data

Environmental monitoring data are available for the period beginning in 1980 and extending into the end of the evaluated period. An evaluation of the ambient external radiation exposures is discussed in Section 4.4.1 of ORAUT-TKBS-0037. The values provided in Table 4-2 of ORAUT-TKBS-0037 are sufficiently bounding values for occupational exposures that could be used for unmonitored workers. However, the availability of personnel monitoring data obviates the need for area monitoring data as a substitute.

7.3.2 Evaluation of Bounding Ambient Environmental External Doses

Ambient environmental external exposures would be included in the occupational external exposures determined for the workers. Consequently, additional assessment of ambient environmental doses is not necessary.

7.3.3 Sandia National Laboratories Occupational X-Ray Examinations

Although NIOSH has not located specific parameters associated with occupational medical X-rays, discussions with former SNL-A X-ray technologists demonstrate a reasonably clear account of the frequencies and types of radiographs taken during the evaluated period (Personal Communication, 2005; SNL-A, 1978) and SNL-A occupational medical records are being made available through the EEOICPA claims process. Because individual worker X-ray exams and historical technical data regarding the X-ray machine and program are available, NIOSH believes it can reasonably reconstruct dose for medical procedures at SNL-A. Additionally, conservative default values and dose reconstruction techniques are detailed in ORAUT-TKBS-0037 and may be used in the absence of medical records if deemed necessary. The default values in ORAUT-TKBS-0037 are upper limit values developed from review of patient doses as reported in literature, machine characteristics, and knowledge of X-ray procedures used during different time periods. Therefore, NIOSH concludes that it is feasible to reconstruct X-ray occupational medical dose for SNL-A workers with sufficient accuracy for the evaluated class.

7.3.4 Methods for Bounding External Dose at Sandia National Laboratories

There is an established protocol for assessing external exposure when performing dose reconstructions (these protocol steps are discussed in the following subsections):

- Photon Dose
- Beta Dose
- Neutron Dose
- Medical X-ray Dose (as applicable per Section 7.3.3)

7.3.4.1 Methods for Bounding Operational Period External Dose

Photon, Beta, and Neutron Dose

Photon, beta, and neutron exposures for monitored workers have been measured with sensitive dosimeters throughout SNL-A's history. The dosimetry used to monitor neutron exposures reflected the state-of-the-art technology available for the SNL-A operations during the evaluated period. Available external monitoring program procedures state SNL-A workers were required to wear dosimetry badges when entering a "radiation area." The resultant monitoring data have been retained for the class period under consideration and are available to NIOSH.

The following are examples of period-specific information describing monitoring devices and brief summaries of the known adjustments needed. A document issued in May 1962 (Unknown, 1962) describes the calculations used to evaluate the four-window film badge in use during the period from 1963 through 1971. Calculation procedures are included for gamma exposures, beta exposures, and thermal neutron exposures. The thermal neutron exposure was evaluated by using the differential exposure density under the cadmium filter, which was being commonly used throughout the AEC complex at that time. The technical basis for this process was published in "Capture Gammas for Neutron Dosimetry with a Film Badge" in Volume 10 of the 1964 *Health Physics* Journal (Caruthers, 1964). If the exposure estimate from the cadmium filter portion of the film was 1.25 times greater than the exposure estimate under the lead filter portion of the dosimeter's film, a thermal neutron determination was completed. The determination was made by subtracting the cobalt-60 equivalent exposure under the lead filter from that measured under the cadmium filter and assigning half the difference as the thermal neutron dose. The document *Personnel Dosimetry Records Survey*, dated May 1980 (SNL-A, 1980b) provided the following information about the 2-Chip Harshaw dosimeter that was in use at SNL-A during from 1971 through 1988 (as shown in Table 6-2). Note that dosimeters used after 1988 to present were accredited by the DOE Laboratory Accreditation Program (DOELAP) and the results need no special adjustments.

- The dosimetry records did not record hire date, date of birth, job class, or gender.
- Internal and external doses were not added together, because the internal exposures were too small.
- The dosimetry records did not record fast and slow neutron dose, just total neutron dose using the appropriate QF for the energies observed.
- Deep dose was measured at 2 cm.
- Shallow dose was measured at 15 mg/cm^2, which corresponded to the depth of the filter over the open window of the dosimeter.

This information would have the following impact:

- The neutron dose in a claimant file should be accurate since the recorded value was adjusted for the energies observed. The use of n/p ratios should not be necessary.
- The deep dose being reported at 2 cm would be slightly smaller than what would have been reported had the more normal depth of 1 cm been used. This would necessitate a correction to 1 cm before adjusting to the depth of the specific organ of interest.
- The shallow dose would also have been under reported, since the 15 mg/cm^2 depth is greater than the traditional shallow depth of 7 mg/cm^2. This, too, would indicate the need for an adjustment to the shallow dose, based upon the assumed energy of the beta radiation, if this exposure route were critical.

With the methods described in ORAUT-TKBS-0037, including the missed dose and bias corrections, available data permit adequate estimation of bounding photon, beta, and neutron exposures for monitored workers with complete monitoring records. Although unmonitored externally exposed workers should not exist, if work history records indicate exposure, then potential maximum values adjusted for bias and uncertainty as discussed in ORAUT-TKBS-0037 provide bounding values that could be used. In addition, the data in ORAUT-OTIB-0072 can be used to assign dose for any gaps in the dosimetry record where a missed dose approach appears inappropriate. If neutron exposures were possible from stockpiled nuclear cores, n/p ratios from similar components measured at other facilities should be used for the suspected time of exposure. For unmonitored workers who did not enter radiation areas, the bounding approach would be to assign the environmental external dose which is specified in Table 4-2 of ORAUT-TBKS-0037.

Medical X-ray Dose

SNL occupational medical records are being made available through the EEOICPA claims process. Because individual worker X-ray exams and historical technical data regarding the X-ray machine and program are available, NIOSH believes it can reasonably reconstruct dose for medical procedures at SNL-A. In the absence of medical records, the dose associated with medical X-ray exams, if required as a condition of employment, can be bounded by using the assumptions and methodology in ORAUT-TKBS-0037. The default values detailed in ORAUT-TKBS-003 are upper limit values developed from review of patient doses as reported in literature, machine characteristics, and knowledge of X-ray procedures used during different time periods. NIOSH believes the ORAUT-TKBS-0037 methodology supports its ability to bound the occupational medical X-ray doses for the entire SNL-A EEOICPA class under evaluation.

7.3.5 External Dose Reconstruction Feasibility Conclusion

The data sources for photon, beta, and neutron doses, as well as occupational X-ray examinations and ambient environmental external doses have been examined and found to be adequate for bounding EEOICPA external doses for monitored SNL-A workers for the entire evaluated period. NIOSH notes that although documentation identifying all potential source terms and program specifics has not been obtained, it appears, based on available monitoring documentation, appropriate external monitoring procedures have been in place for the entire evaluation period using suitable monitoring devices with

the resultant monitoring data being available to NIOSH. Therefore, NIOSH concludes that external dose reconstruction for monitored workers for the January 1, 1963 through May 21, 2011 evaluation period is feasible.

The assessment of doses for unmonitored workers can be determined from the ambient environmental external dose methods defined in ORAUT-TKBS-0037. Based on NIOSH's assessment of the available external data and the dose calculation methods available in ORAUT-TKBS-0037, NIOSH concludes that it is feasible to bound external dose for all members of the class under evaluation.

7.4 Evaluation of Petition Basis for SEC-00188

The following subsection evaluates the assertion made on behalf of petition SEC-00188 for SNL-A.

7.4.1 Internal Monitoring Associated with SNL-A Security Guards

Assertion: *The petitioner asserted that Security Guards working at SNL-A were tasked with working in and around radioactive hazard areas and machines. Duties listed included the protection of special nuclear materials and weapons. He (and two other employees via affidavit) asserted that at times external monitoring devices were not properly worn and that no internal monitoring was performed. Additionally, results of requests for external monitoring records have been incomplete.*

Response: NIOSH found support for the petition basis that: (1) radiation exposures and radiation doses potentially incurred by members of the proposed class initially proposed in this petition were not monitored, either through personal monitoring or through area monitoring; (2) radiation monitoring records for members of the proposed class may have been lost, falsified, or destroyed; and/or (3) there is limited program information regarding internal monitoring and potential source terms at SNL-A. Based on problems identified during NIOSH's review of SNL-A's monitoring program prior to receipt of this petition, and upon review of the supporting documents provided for SEC-00188, NIOSH found that the issues identified by the petitioner required further evaluation and that an expansion of the evaluated class was justified. During the course of the current evaluation NIOSH has found that potential internal doses associated with work conducted at SNL-A are not completely known and access to internal monitoring data and program information is limited, as described in Sections 6.0 and 7.0 of this report.

7.5 Other Potential SEC Issues Relevant to the Petition Identified During the Evaluation

During the feasibility evaluation for SEC-00188, a number of issues were identified that needed further analysis and resolution. The issues and their current status are:

- ISSUE: *Potential Shortcomings Exist in Completeness and Adequacy of Dosimetry Records*

  RESPONSE: SNL-A does not have an electronic database containing occupational monitoring records for the evaluated class prior to 1990 for external data, and approximately 1993 for internal data. *In vitro* bioassay records prior to this time period are found in paper and microfilm/fiche format in archives. Currently, the records are often not located and incorporated by SNL-A as a part of claimant files and difficult to access. Data provided to NIOSH for EEOICPA dose reconstruction may be limited to summary reports, including dose information in some years for tritium, plutonium, and uranium.

- ISSUE: *Inaccurate Dose Record for Pulse Reactor Personnel*

  RESPONSE: Inaccurate dose records for SPR operators resulted from the under-recording of external gamma/neutron dose received during shutdown maintenance activities. This under-recording resulted from inadequate dosimetry at the time for a severe gradient of exposure levels experienced by personnel working beneath the reactor vessel. Workers in this area experienced higher exposures to the head than would have been properly monitored by the badge located on the chest. Survey data from 1961 (paired gamma and neutron measurements) for various locations in the SPR facility have been obtained by NIOSH. The data's usefulness for determining actual worker exposures has been assessed and corrections can be made enabling conservative estimation of bounding exposures. It is noteworthy that wrist badges were used, ostensibly to measure the non-uniform fields. The primary issue associated with severe gradients/non-uniform fields is unmonitored exposure to extremities (normally hands); the wrist badges were likely used to measure that exposure. Additionally, "head" badges were provided to the workers to more accurately monitor the exposure to the head and enable a more accurate determination of eye exposure (Stanley, 1982; Thompson, 1982).

- ISSUE: *Site-Wide Workers Not Bioassayed for Potential Internal Intakes Before 1992*

  RESPONSE: NIOSH has found no documentation supporting the existence of a routine, site-wide internal monitoring program prior to 1993. Internal monitoring for much of the evaluated class was performed on an ad hoc basis. Information used to determine monitoring needs, as well as the actual monitoring results have predominantly not been located prior to 1993. Details regarding potential internal source-term information are also unavailable for all years. As a result, NIOSH concludes that workers in areas containing radioactive materials may have had the potential for internal exposures that were not monitored. Additionally, assigning potential missed dose by work location is questionable, particularly in the absence of complete work history records. Therefore, NIOSH concludes that it cannot bound internal doses for the period from January 1, 1963 through December 31, 1994.

- ISSUE: *Use of Air Monitoring Data in Dose Estimation is Problematic*

  RESPONSE: Worker bioassay monitoring was often dependent on air monitoring results. However, only limited air monitoring data have been obtained. No centralized or easily accessed repository exists. With only limited air monitoring data availability for many periods and areas of operation, using air monitoring data as a substitute for bioassay sampling is not possible for the 1963 through 1994 period. NIOSH intends to continue its assessment of the post-1994 period when it has access to SNL-A electronic databases covering this latter period. If NIOSH finds information indicating that it cannot bound for the post-1994 period, NIOSH will present an additional SEC class in an 83.14 ER.

- ISSUE: *Inadequate Identification of Potential Radiological Exposure Sources*

  RESPONSE: NIOSH is unable to be certain complete source term information has been obtained for the evaluated period. Examples of obstacles for determining the existence as well as the retrievability of all source term information include: (1) multiple large and vaguely indexed SNL-A records repositories, (2) limited access to classified electronic and hard copy repositories, (3) inability to efficiently redact information collected from classified repositories, and (4) inability to definitively demonstrate all SNL-A activities involving exposure potential were documented and that those documents were retained.

- ISSUE: *Some Claimant Data Supplied by SNL has been Incomplete*

  RESPONSE: This issue is primarily applicable to internal monitoring data. NIOSH has compared internal monitoring data obtained during site visits to data that were supplied by SNL-A for EEOICPA claims monitoring-data requests. The results are presented in Subsection 7.1.1 of this report. The comparison demonstrates that efficient, complete retrieval of internal monitoring data for SNL-A employees remains problematic for data collected prior to approximately 1994. NIOSH intends to continue its assessment of the post-1994 period when it has access to SNL-A electronic databases covering this latter period. If NIOSH finds information indicating that it cannot bound for this period, NIOSH will present an additional SEC class in an 83.14 ER.

7.6 Summary of Feasibility Findings for Petition SEC-00188

This report evaluates the feasibility for completing dose reconstructions for employees at SNL-A from January 1, 1963 through May 21, 2011. NIOSH found that the available monitoring records, process descriptions, and source term data available are not sufficient to complete EEOICPA internal dose reconstructions for the evaluated class of employees from January 1, 1963 through December 31, 1994. A lack of internal monitoring data has precluded a detailed assessment for each radionuclide during that time period; therefore, a specific feasibility finding for each is not presented. For the purposes of timeliness, NIOSH is issuing this report covering available data sufficiency and feasibility conclusions now, but will continue to review and evaluate internal exposure reconstruction feasibility for the 1995 through 2011 period when applicable databases become available. If NIOSH finds information indicating that doses cannot bound for the January 1, 1995 through May 21, 2011 period, NIOSH will proceed with an 83.14 report, recommending an additional class.

Table 7-2 summarizes the results of the feasibility findings at SNL-A for each exposure source during the time period from January 1, 1963 through December 31, 1994 and from January 1, 1995 through May 21, 2011.

Table 7-2: Summary of Feasibility Findings for SEC-00188
January 1, 1963 through December 31, 1994;
January 1, 1995 through May 21, 2011

Source of Exposure	January 1, 1963 through December 31, 1994		January 1, 1995 through May 21, 2011[1]	
	Reconstruction Feasible	**Reconstruction Not Feasible**	**Reconstruction Feasible**	**Reconstruction Not Feasible**
Internal		**X**	[1]	[1]
External	**X**		**X**	
- Gamma	X		X	
- Beta	X		X	
- Neutron	X		X	
- Occupational Medical X-ray	X		X	

Note:
[1] To expedite the presentation of the infeasibility and proposed SEC class, NIOSH is issuing the current recommendation now, but will continue to review and assess the January 1, 1995 through May 21, 2011 period when applicable electronic data become available. If NIOSH finds information indicating that it cannot bound for this period, NIOSH will present an additional SEC class in an 83.14 ER.

As of December 14, 2011, a total of 323 claims have been submitted to NIOSH for individuals who worked at SNL-A during the period under evaluation in this report. Dose reconstructions have been completed for 270 individuals (~84%).

Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at SNL-A during the period from January 1, 1963 through December 31, 1994, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

8.0 Evaluation of Health Endangerment for Petition SEC-00188

The health endangerment determination for the class of employees covered by this evaluation report is governed by both EEOICPA and 42 C.F.R. § 83.13(c)(3). Under these requirements, if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, NIOSH must also determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. Section 83.13 requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for a number of work days aggregating at least 250 work days within the parameters established for the class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

Based on the sum of information available from available resources, NIOSH's evaluation determined that it is not feasible to estimate radiation dose with sufficient accuracy for members of the NIOSH-evaluated class for the time period from January 1, 1963 through December 31, 1994. Therefore, the resulting NIOSH-proposed SEC class must include a minimum required employment period as a basis for specifying that health was endangered for this time period.

For the period January 1, 1995 through May 21, 2011, a health endangerment determination will be provided when dose estimation feasibility for this period has been completed

9.0 Class Conclusion for Petition SEC-00188

Based on its current research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked in any area at Sandia National Laboratories in Albuquerque, New Mexico, from January 1, 1963 through December 31, 1994, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

NIOSH has carefully reviewed all material sent in by the petitioner, including the specific assertions stated in the petition, and has responded herein (see Section 7.4). NIOSH has also reviewed available technical resources and many other references, including the SRDB, for information relevant to SEC-00188. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

These actions are based on existing, approved NIOSH processes used in dose reconstruction for claims under EEOICPA. NIOSH's guiding principle in conducting these dose reconstructions is to ensure that the assumptions used are fair, consistent, and well-grounded in the best available science. Simultaneously, uncertainties in the science and data must be handled to the advantage, rather than to the detriment, of the petitioners. When adequate personal dose monitoring information is not available, or is very limited, NIOSH may use the highest reasonably possible radiation dose, based on reliable science, documented experience, and relevant data to determine the feasibility of reconstructing the dose of an SEC petition class. NIOSH contends that it has complied with these standards of performance in determining the feasibility or infeasibility of reconstructing dose for the class under evaluation.

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Attachment One: Data Capture Synopsis

Table A1-1: Summary of Holdings in the SRDB for Sandia National Laboratories			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
Primary Site/Company Name: Sandia National Laboratories, New Mexico (SNL-A/NM) Primary Point of Contact: [Name and Contact Information Redacted] Physical size of the site: The physical size of Sandia National Laboratories, NM is 8642 acres. The site contains 847 buildings with a total of 5,822,908 square feet under roof. Size of the workforce during the SEC related periods: In 1960 the site population, as reported to the AEC, was 6,778, of which 5,509 were not monitored for radiation exposure. The most recent site population number is 10,419 FTEs in FY-11.	Routine and special dosimetry reports, neutron spectra, research, dosimetry, tritium, uranium, polonium, and actinide bioassay reports, internal dosimetry results, procedures, technical basis documents, environmental reports and dosimetry, Technical area descriptions, SAND reports, incident reports, facility safety analyses, special facility surveys, dosimetry calibrations, descriptions of radiological monitoring, counting, and detection systems and equipment, waste management documentation, inactive records storage box inventories, health physics logs, Tiger Team appraisals and responses, Operation Gumdrop plans and procedures, DOELAP documentation, site history, process knowledge interview notes, Reactor Division search results, tritide research reports, Technical Area V radiation survey data, laboratory surveys, Ross Aviation aircraft and shipment surveys performed by SNL, NM, a 1957-1962 Reactor Division individual telephone listing, Area V log books, health physics SPR log books, inactive records transfers, SERF health physics log books, 1992-2006 in-vivo and in-vitro spreadsheets, waste management data inventories, factors relating to portable survey instruments, an approximation of radiation dose from a tritium release, and Sandia's symposium on instrumentation and health physics tritium control. NOTE: NIOSH and the ORAU Team are awaiting the identification of site repositories for Reactor Division exposure data from 1957-1962.	Ongoing	1969
State Contacted: [Name Redacted], Bureau Chief, Radiation Control Bureau	The State of New Mexico has never regulated Sandia National Laboratories and does not hold records regarding the site.	09/27/2010	0
Cincinnati Public Library	The history of the Atomic Energy Commission from 1953-1963.	02/18/2009	1
Colorado State University Library	Site environmental reports and a 1993 environmental monitoring plan.	04/10/2006	5
Department of Energy (DOE)	The DOE's guide for good occupational radiological protection practices at plutonium facilities.	05/11/2007	1
Department of Labor / Paragon	A 1952 Tonawanda area progress report which indicates that 30 radium sources were imported for Sandia.	12/30/2008	1
DOE Albuquerque Operations Office	Internal dosimetry programmatic documents, 1982 Technical Area V safety appraisal, 1982 dose reduction proposal for SPR-III, 1972 exemption request for plutonium storage facilities, and fallout measurements from the	07/12/2010	7

Table A1-1: Summary of Holdings in the SRDB for Sandia National Laboratories			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
	Gravel Gertie test.		
DOE Brookhaven National Laboratory	Description of air monitoring parameters at DOE facilities, an assessment of external dosimetry services, 1992 annual exposure report to DOE, 1950 report of Brookhaven personnel who worked on other AEC projects, and urinalysis reports.	10/24/2008	5
DOE DOELAP Office, Idaho National Laboratory	Listing of Albuquerque Operations Office facilities applying for DOELAP accreditation.	06/11/2009	1
DOE Germantown	A 1949 report on difficulties with RaBe sources, a plea agreement from the CEP case, and the Manhattan District history section detailing the establishment of Sandia.	03/12/2008	3
DOE Hanford	The 1978 guidelines for diagnostic X-rays, 1958 Hanford report which mentions a visit by Sandia personnel on vacuum etching, and a description of destructive testing of neutron sources performed by Sandia personnel at Pantex.	07/31/2008	3
DOE Lawrence Livermore National Laboratory (LLNL)	Nevada Test Site external exposures 1957-1958, Sandia temporary film badge records 1959, exposure records for Lawrence Berkeley National Laboratory personnel visiting Sandia 1970, external exposure of Sandia personnel at Livermore 1958, and tritium results for Sandia personnel at Livermore 1962.	05/18/2007	8
DOE Legacy Management - Grand Junction Office	A 1982 Fernald long range plan which mentions supplying depleted uranium to Sandia, 1952 Tonawanda area progress reports which mention radium sources being imported for Sandia, notes on early Middlesex Sampling Plant operations which mention Sandia, NIOSH interview notes, a 1990 decontamination and decommissioning monthly status report, and a 1959 summary of fuel types and enrichments from various reactors.	08/25/2011	9
DOE Legacy Management - Morgantown	A 1988 DOE site summary of environmental, safety, and health needs and a report which documents the shipment of normal UO_3 to Sandia.	05/24/2011	8
DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database)	Complex-wide waste management and effluent discharge reports, unusual occurrence reports, report of the DOE precious metals program, a metallographic examination of a milli-watt generator manufactured for Sandia, a report of a bioassay and analytical chemistry conference sponsored by Sandia, and a description of destructive tests Sandia performed on Galileo and Ulysses heat sources.	02/02/2009	14
DOE Los Alamos National Laboratory (LANL)	Sandia environmental monitoring reports, radioactive waste disposal	12/06/2007	6

Table A1-1: Summary of Holdings in the SRDB for Sandia National Laboratories			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
	correspondence, descriptions of DOE mixed waste streams, and reconfiguration of the Nuclear Weapons Complex.		
DOE Los Alamos National Laboratory / LAHDRA	Process knowledge interview, 1949 progress reports, an environmental impact statement for storage and disposition of weapons-usable fissile material, and guidelines for the disposal of contaminated personal property.	12/06/2007	6
DOE Lovelace Respiratory Research Institute	Descriptions of analysis of thorotrast solutions at Sandia, correspondence and results, and Lovelace dosmetry services provided by Sandia.	09/09/2008	2
DOE Nevada Test Site	Shipping documents with smear results for radioactive materials shipments from Sandia to Nevada Test Site.	06/03/2009	12
DOE Office of Scientific and Technical Information (OSTI)	Surveys of irradiation facilities including the Sandia Pulsed Reactor and 1993 DOE site maps and facilities listings.	05/17/2007	5
DOE Paducah Gaseous Diffusion Plant	Film badge work sheets including visitors from Sandia.	01/25/2005	1
DOE Pantex	Records transfer forms, report on Tweezer Operations, and a request from Sandia for Pantex to irradiate rocket motors.	12/31/2008	3
DOE Sandia National Laboratories / California	Dosimetry results from 1965, 1970, 1989, 1992, 1993, 1997, a draft external dosimetry program manual, procedure for the assembly and testing of the rapid deployment test payload, positive exposure reports, and a procedure for the Co-60 Calibration Facility.	03/28/2007	25
DOE Sandia National Laboratories / SC&A	The 1962 health physics study of the Sandia Pulsed Reactor Facility, 1959 and 1960 reports of environmental airborne radioactivity, and a health physics report for Operation Roller Coaster.	03/28/2006	4
Dr. Henry Spitz	The 1983 Pacific Northwest Laboratory performance comparison of personnel dosimetry systems.	08/17/2003	1
Federal Records Center (FRC) - Denver	Finding of no significant environmental impact from heat source testing on the Sandia sled track, finding of no significant environmental impact from the new gamma irradiation facility, safe operating procedures for the Gamma Irradiation Facility, and a LANL request for Sandia to participate in an external dosimetry survey.	06/15/2010	4
General Atomics	Radioactive material shipments from Sandia to General Atomics and a radiation exposure report cover letter with limits and definitions.	11/02/2005	2
Interlibrary Loan	Proceedings of a 1973 criticality safety short course.	11/30/2006	1
Interlibrary Loan / SC&A	Environmental radioactivity levels at Sandia during 1971.	01/21/2010	1
Internet	Environmental monitoring reports, an NRC information notice on accuracy of bioassay and environmental sample results, brief history of the site,	11/16/2009	14

Table A1-1: Summary of Holdings in the SRDB for Sandia National Laboratories			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
	report on the need to develop source term estimates for sabotaged spent fuel casks, and parameter and pathway analysis for residual contamination from decommissioning activities.		
Internet - Defense Technical Information Center (DTIC)	A 1959 Sandia bibliography of radiation effects publications.	01/03/2012	1
Internet - DOE	Analysis of experimental airborne release data from nonreactor facilities.	12/04/2008	1
Internet - DOE Comprehensive Epidemiologic Data Resource (CEDR)	No relevant data identified.	05/27/2010	0
Internet - DOE Hanford Declassified Document Retrieval System (DDRS)	No relevant data identified.	05/27/2010	0
Internet - DOE Legacy Management Considered Sites	Tonawanda area progress report that mentions radium sources imported for Sandia. NOTE: This document was added by Site Association Review.	05/27/2010	1
Internet - DOE National Nuclear Security Administration (NNSA) - Nevada Site Office	No relevant data identified.	05/27/2010	0
Internet - DOE OpenNet	Sandia monthly progress reports and R&D board minutes, a Z-Division report, descriptions of radiation and fusion research facilities, Armed Forces Special Weapons Project, and history of the Nuclear Weapons Program. NOTE: 4 documents were added by Site Association Review.	09/10/2010	18
Internet - DOE OSTI	Environmental monitoring reports, environmental assessment for Technical Area IV, tritium in soils at the Technical Area III mixed waste landfill, and health physics programs for the HP-41CV calculator.	11/30/2009	8
Internet - DOE OSTI / SC&A	The production of specialty glass for Sandia at Pinellas.	03/02/2004	1
Internet - DOE OSTI Energy Citations	A report on the characterization and segregation of legacy mixed waste, a citation for the characterization plan for the Sandia Livermore Tritium Research Laboratory, a report on contaminated concrete, a Pinellas report which documents plutonium shipments from Sandia, and a 1995 waste minimization and pollution prevention program report. NOTE: 4 documents were added by Site Association Review.	05/27/2010	5
DOE-OSTI Information Bridge	Environmental reports, 1991 Tiger Team assessment, source characterizations, personal accident dosimetry, radioactive material package testing, site history, waste packaging reports, remediation of Technical Area II uranium calibration pits, ERDA radioisotope production and customer lists, transuranic and mixed waste reports, nuclear facility decommissioning reports, complex-wide reports on environmental dose	11/18/2011	58

Table A1-1: Summary of Holdings in the SRDB for Sandia National Laboratories			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
	models and personnel dosimetry, and a report on starting production of neutron generators. NOTE: 32 documents were added by Site Association Review.		
Internet - Google	Environmental reports and planning, safety bases corrective actions, epidemiologic surveillance, site histories and descriptions, nuclear materials storage report, long term stewardship plan, Z-Division progress report, site capabilities descriptions, complex-wide reports on site clean-up, transuranic waste management and disposal, nuclear materials management, Congressional budget information on site clean-up costs, workforce transition report, clean-up standards, Sandia's WIPP waste stream profiles, and a neutron generator facility safety information document. NOTE: 47 documents were added by Site Association Review.	11/12/2011	154
Internet - Health Physics Journal	Behavior of plutonium aerosols, neutron dosimetry at the Sandia Pulsed Reactor and Potter's review of internal dosimetry.	09/28/2010	4
Internet - Journal of Occupational and Environmental Hygiene	No relevant data identified.	09/27/2010	0
Internet - National Academies Press (NAP)	A citation for The Nuclear Weapons Complex: Management for Health, Safety, and the Environment.	05/27/2010	1
Internet - National Institute for Occupational Safety and Health (NIOSH)	The petition evaluation report for Petition SEC-00162 Sandia.	09/29/2011	1
Internet - NRC Agencywide Document Access and Management (ADAMS)	The 1991 and 1992 U.S. spent fuel and radioactive waste inventories, projections, and characteristics, environmental impacts of highly enriched uranium disposition and stockpile stewardship, reviews of shipping casks, and management of radioactive sources at Sandia. NOTE: 9 documents were added by Site Association Review.	10/29/2011	20
Internet - USACE/FUSRAP	No relevant data identified.	05/27/2010	0
Internet - Washington State University (U.S. Transuranium and Uranium Registries)	No relevant data identified.	05/27/2010	0
Iron Mountain	Operating manual for the Jordan Radector.	09/12/2006	1
Missouri Department of Natural Resources	A draft environmental impact statement on stockpile stewardship and plutonium working group reports.	10/01/2008	3
Mound Museum	Milli-watt generator and heat sources proposals submitted to Sandia, 1959-1964 plutonium shipments, plans for Sandia to test Apollo Thermal Energy Application assemblies, Mound newsletter articles regarding items	05/18/2010	17

Table A1-1: Summary of Holdings in the SRDB for Sandia National Laboratories			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
	designed by Sandia and produced at Mound, and Mound newsletter articles that mention Sandia.		
NARA / SC&A	Radiation doses received by Sandia personnel at Pinellas, neutron source information, neutron source shipments to Sandia, tritium stack releases, and a research proposal for the dissolution of metal tritides in biological systems.	06/10/2004	7
National Archives and Records Administration (NARA) - Atlanta	Radiation doses received by Sandia personnel at Pinellas, 1989 radioactive material shipments, controlatron/zetatron contamination surveys, shipping surveys of a contaminated accelerator, a truck contamination survey, directories of AEC consultants, and a research proposal for the dissolution of metal tritides in biological systems.	07/01/2006	16
National Archives and Records Administration (NARA) - College Park	Researcher notes documenting the presence of Sandia correspondence in the Oak Ridge Series 6 collection and a listing of box contents.	07/26/2010	3
National Institute for Occupational Safety and Health (NIOSH)	Worker outreach meeting sign-in sheets, minutes, correspondence, and emails, SC&A data capture plan with associated emails, and Sandia records retention and disposal schedules.	03/22/2011	26
NIOSH / SC&A	Working group reports on highly enriched uranium.	02/16/2006	3
Nuclear Regulatory Commission Public Document Room (NRC PDR)	Neutron pulsed generator reports, and a report on the dissociation of cesium iodide in radiation fields.	09/02/2011	3
Oak Ridge Library for Dose Reconstruction	Manhattan Project history and an Oak Ridge National Laboratory (ORNL) report which notes the similarities between the ORNL Health Physics Research Reactor and the Sandia Pulsed Reactor.	04/01/2011	2
ORAU Team	Radiation exposure reports 1977-1986, 2005 data capture notes, a Project spreadsheet, Project analyses of dose results and neutron/photon ratios, site profile and technical basis documents, external coworker dosimetry technical information bulletin, a neutron/photon spreadsheet, process knowledge expert documented communications, notes on records box contents, and the DOE adoption of 1990 ICRP recommendations on neutron weighting factors.	01/05/2012	36
RETN, Inc.	Correspondence with Sandia personnel and process knowledge expert regarding internal dosimetry issues.	03/10/2008	6
SAIC	Radiation exposure summaries for 1960, 1961, 1964, 1972, and 1973.	09/02/2004	5
S. Cohen & Associates (SC&A)	Tritide studies, tritium studies, DOELAP reports, urinalysis intercomparison, environmental radiation dosimetry reports, dosimetry	03/31/2010	48

Table A1-1: Summary of Holdings in the SRDB for Sandia National Laboratories			
Data Capture Information	**Data Capture Description**	**Completed**	**Uploaded into SRDB**
	blind audit results, internal dosimetry TBD, records information and reports, 1997 ESH report, 1994 incident data sheet, and neutron response testing of Harshaw Model 8801 TLD.		
SC&A / Idaho National Laboratory (INL)	Idaho National Laboratory inventory statements including Sandia material.	06/24/2010	9
SC&A / NARA - Atlanta	A Pinellas report which includes the results of Sandia's testing of RTG shipping containers.	08/09/2004	1
SC&A / NIOSH	A highly enriched uranium working group report, a plutonium working group report, and a Pantex ES&H progress assessment which details Sandia's participation at Pantex.	06/01/2001	3
SC&A / Santa Susana Field Laboratory (SSFL)	A trip report to a tritium symposium.	06/24/2010	1
Southern Illinois University	AEC construction cost differentials report and a description of the AEC cryptographic telecommunications network.	10/16/2008	2
University of Colorado - Norlin Library	Environmental monitoring plans and report, characterization of low-level waste, a study of increasing the film badge exchange interval, Sandia performance indicators, and a 1977 ERDA workshop on neutron dosimetry.	04/18/2006	9
University of Rochester - Miner Library	Dose estimates from the accidental exposure at the Van De Graaff Facility.	10/14/2008	1
University of Tennessee Library Stannard Papers	Report of the Operation Plumbbob field release of plutonium aerosols.	03/15/2010	1
Unknown	Environmental monitoring reports, history of Technical Area II, Operations Grommet and Toggle radiological safety reports, Linking Legacies excerpt, Operation Gumdrop re-entry instructions, and beryllium reports.	01/25/2006	34
Total			**2,632**

Table A1-2: Database Searches for Sandia National Laboratories			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
NOTE: Database search terms employed for each of the databases listed below are available in the Excel file called “Copy of Sandia NM Data Capture Rev 02 01-19-12.”			
DOE CEDR http://cedr.lbl.gov/	See Note above	4	0

Table A1-2: Database Searches for Sandia National Laboratories			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
COMPLETED 05/27/2010			
DOE Hanford DDRS http://www2.hanford.gov/declass/ COMPLETED 05/27/2010	See Note above	38	0
DOE Legacy Management Considered Sites http://csd.lm.doe.gov/ COMPLETED 05/27/2010	See Note above	0	0
DOE OpenNet http://www.osti.gov/opennet/advancedsearch.jsp COMPLETED 05/27/2010	See Note above	113	14
DOE OSTI Energy Citations http://www.osti.gov/energycitations/ COMPLETED 05/27/2010	See Note above	1,121	1
DOE OSTI Information Bridge http://www.osti.gov/bridge/advancedsearch.jsp COMPLETED 05/27/2010	See Note above	2,393	26
Google http://www.google.com COMPLETED 05/27/2010	See Note above	2,787,919	107
HP Journal http://journals.lww.com/health-physics/pages/default.aspx COMPLETED 09/28/2010	See Note above	146	4
Journal of Occupational and Environmental Health http://www.ijoeh.com/index.php/ijoeh COMPLETED 09/27/2010	See Note above	0	0
National Academies Press http://www.nap.edu/ COMPLETED 05/27/2010	See Note above	2,229	1
NNSA - Nevada Site Office www.nv.doe.gov/main/search.htm COMPLETED 05/27/2010	See Note above	0	0
NRC ADAMS Reading Room http://www.nrc.gov/reading-rm/adams/web-based.html	See Note above	4,267	11

Table A1-2: Database Searches for Sandia National Laboratories			
Database/Source	**Keywords**	**Hits**	**Uploaded into SRDB**
COMPLETED 10/17/2011			
USACE/FUSRAP http://www.lrb.usace.army.mil/fusrap/ COMPLETED 05/27/2010	See Note above	0	0
U.S. Transuranium & Uranium Registries http://www.ustur.wsu.edu/ COMPLETED 05/27/2010	See Note above	0	0

Table A1-3: OSTI Documents Requested			
Document Number	**Document Title**	**Requested Date**	**Received Date**
SAND96-2152C REF ID 89687	Thar's Gold in Them Thar Notebooks: Benefits of Laboratory Notebooks in the Government Archive	10/25/2010	10/26/2010
RHO-HS-ST-5 REF ID 77087	Seven Health Physics Calculator Programs for the HP-41CV, 1984	08/18/2009	11/30/2009
SAND-78-0620 REF ID 77102	Environmental Monitoring Report, Sandia Laboratories, 1977, Health Physics Division 3312 dated 1978	08/18/2009	10/08/2009
SAND-81-0566 REF ID 77091	1980 Environmental Monitoring Report, Sandia National Laboratories, Albuquerque, New Mexico, Environmental Health Department 3310, April 1981	08/18/2009	10/08/2009
SAND-83-0789 REF ID 77089	1982 Environmental Monitoring Report, Sandia National Laboratories, Albuquerque, New Mexico, Environmental Health Department 3310, April 1983	08/18/2009	10/08/2009
SAND-84-0429 REF ID 77100	1983 Environmental Monitoring Report, Sandia National Laboratories, Albuquerque, New Mexico, Environmental Health Department 3310, April 1984	08/18/2009	10/08/2009