SEC Petition Evaluation Report

Petition SEC-00188, Addendum 2 (1997-2011)

Report Rev Number:	Addendum 2 (1997-2011)
Report Submittal Date:	April 1, 2019
Subject Expert(s):	Tim Adler, Joe Guido
Site Expert(s):	N/A

Petition Administrative Summary

Petition Under Evaluation

Petition Number:	SEC-00188 Addendum 2 (1997-2011)
Petition Type:	83.13
Petition Receipt Date:	July 18, 2011
Qualification Date:	October 21, 2011
DOE/AWE Facility Name:	Sandia National Laboratories

Petition Class

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, 1997 through May 21, 2011.
NIOSH-Proposed Class(es) to be Added to the SEC:	None

Related Petition Summary Information

SEC Petition Tracking Number(s):	SEC-00162 and SEC-00188
Petition Type(s):	83.13
DOE/AWE Facility Name:	Sandia National Laboratories
Petition Status:	SEC-00162: Class added to the SEC for Jan. 1, 1949 through Dec. 31, 1962 SEC-00188: Class added to the SEC for Jan. 1, 1963 through Dec. 31, 1994 SEC-00188 Addendum (1995-1996): Class added to the SEC for Jan. 1, 1995 through Dec. 31, 1996

Related Evaluation Report Information

Report Title:	SEC Petition Evaluation Report Petition SEC-00162 SEC Petition Evaluation Report Petition SEC-00188 SEC Petition Evaluation Report Petition SEC-00188 Addendum (1995-1996)
DOE/AWE Facility Name:	Sandia National Laboratories

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Addendum 2 (1997-2011) to Sandia National Laboratories-Albuquerque (SEC-00188) Special Exposure Cohort Evaluation Report

Purpose and Scope of this Addendum 2 (1997-2011)

This Addendum 2 provides results from continued site and program assessments at Sandia National Laboratories in Albuquerque, New Mexico (SNL-A), that were previously unevaluated in the SEC Petition Evaluation Report for petition SEC-00188, covering 1963-1994 (NIOSH, 2012) and in an Addendum to that report, covering 1995-1996 (NIOSH, 2018). In these two evaluations, NIOSH defined classes of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. These previously-identified classes (combined) include all employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at Sandia National Laboratories in Albuquerque, New Mexico, from January 1, 1963 through December 31, 1996.

In the original SEC-00188 Evaluation Report, NIOSH established December 31, 1994 as the SEC class end date after considering data-retrieval problems known to exist into the very early 1990s, limited internal monitoring results, limited program documentation availability, the existence of a relatively-undeveloped internal monitoring record database during that period, and the use of Controls for Environmental Pollution (CEP) analytical services for bioassay well into 1994[1].

In the SEC-00188 Addendum (1995-1996), NIOSH extended the existing class to December 31, 1996 due to concerns with air monitoring data availability and uncertainties associated with the transitional and developmental nature of SNL-A's internal monitoring program. During 1996, significant changes to the internal dose monitoring program took place, including a requirement for internal dosimetry review and assignment of DAC-hrs, and a requirement to forward DAC-hr records to Internal Dosimetry if DAC fractions exceeded 0.1 DAC. Philosophical changes in the internal dosimetry program also took place in 1996, which included a change of emphasis from internal dosimetry to internal radiation protection, and reliance on other types of monitoring to indicate the need for bioassay.

This Addendum 2 presents conclusions from NIOSH's continued evaluation of SNL-A dose reconstruction feasibility for the remaining SEC-00188 petitioner-requested timeframe (January 1, 1997 through May 21, 2011).

[1] 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.

Evaluation Report Summary: SEC-00188 Addendum 2 (1997-2011)

Class Evaluated by NIOSH (in this Addendum 2)

All personnel that worked in any area at Sandia National Laboratories in Albuquerque, New Mexico, for the period from January 1, 1997 through May 21, 2011.

NIOSH Determination about the Proposed Class to be Added to the SEC (in this Addendum 2)

NIOSH has obtained information regarding post–1996 occupational monitoring as well as program policies and procedures related to implementation of 10 C.F.R. pt. 835. Based on its analysis of these available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.13(c) (1), NIOSH has established that it has access to sufficient information to: (1) 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 (2) estimate radiation doses of members of the class more precisely than an estimate of the maximum dose. Information available from the site profile and additional resources is sufficient to estimate the maximum internal and external potential exposure to members of the evaluated class under plausible circumstances during the specified period.

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

- As previously identified in the SEC-00188 Evaluation Report, NIOSH finds that it is feasible to reconstruct occupational medical dose for Sandia National Laboratories-Albuquerque employees with sufficient accuracy.

- As previously identified in the SEC-00188 Evaluation Report, 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. Considering the potential exposure scenarios, program policies, procedures, and monitoring data availability, NIOSH finds it is able to estimate these internal exposures with sufficient accuracy for the period from January 1, 1997 through May 21, 2011.

- As previously identified in the SEC-00188 Evaluation Report, principal sources of external radiation for members of the proposed class included exposures to beta, gamma, and neutron radiation. 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 sufficient 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.

Health Endangerment Determination

Per EEOICPA and 42 C.F.R. § 83.13(c) (3), a health endangerment determination is not required because NIOSH has determined that it has sufficient information to estimate dose for the members of the evaluated class.

Revised Excerpts of the SEC Petition Evaluation Report for SEC-00188

NOTE: FROM THIS POINT FORWARD, THIS SEC-00188 ADDENDUM 2 ONLY ADDRESSES THOSE SECTIONS IN THE SEC-00188 SANDIA NATIONAL LABORATORIES SEC PETITION EVALUATION REPORT THAT REQUIRE DISCUSSION REGARDING THE 1997-2011 PERIOD. THEREFORE, THE SECTION NUMBERING IS NOT CONTIGUOUS. WHEN DEEMED HELPFUL TO THE READER, ADDITIONAL ER TEXT IS SOMETIMES INCLUDED FOR CONTEXT.

3.2 Class Evaluated by NIOSH

This Addendum 2 presents conclusions from NIOSH's continued evaluation of SNL-A dose reconstruction feasibility for the remaining SEC-00188 petitioner-requested timeframe (January 1, 1997 through May 21, 2011).

3.3 NIOSH Determination about the Proposed Class to be Added to the SEC

NIOSH has obtained information regarding post-1996 occupational monitoring as well as program policies and procedures related to implementation of SNL-A's radiation protection program. Based on its analysis of these available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

4.0 Data Sources Reviewed by NIOSH to Evaluate the Class

As is standard practice, NIOSH completed extensive database and Internet searches for information regarding SNL-A. The database searches included the DOE Legacy Management Considered Sites database, the DOE Office of Scientific and Technical Information (OSTI) SciTech Connect database, the Defense Technical Information Center, and the Hanford Declassified Document Retrieval System. In addition to general Internet searches, the NIOSH Internet search included OSTI OpenNet Advanced searches, Nuclear Regulatory Commission (NRC) Agency-wide Documents Access and Management (ADAMS) web searches, and a DOE-National Nuclear Security Administration-Nevada Site Office-search. Attachment Three includes a summary of SNL-A documents. The summary includes data capture details and general descriptions of the documents retrieved.

In addition to the database and Internet searches listed above, NIOSH reviewed numerous other data sources to obtain information relevant to determining the feasibility of dose reconstruction for the class of employees under evaluation. This focused primarily on determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. This effort included three new official data capture requests submitted to SNL since the July 2018 issuance of Petition SEC-00188, Addendum (1995-1996). The first request (July 2018) pursued various clarifications regarding the site's "WebDose" monitoring data database (WebDose is a database used by SNL-A for bioassay monitoring record retention and as a radiation dose reporting tool). The second request (January 2019) further explored air monitoring data availability. The third request (also January 2019) focused on retrieval of radiological records for some interviewed SNL employees.

4.3 Facility Employees and Experts

Prior to this Addendum 2, twenty interviews were conducted with sixteen SNL personnel in support of the post-1994 evaluation work (some personnel were interviewed more than once). Workers interviewed included [job category redacted] staff members, a [program name redacted] manager, [function name redacted] department managers, security officers, an [job title redacted], a [function name redacted] manager, and a researcher (Personal Communication, 2013a-b; 2014a-m; 2017a-d; 2018a). That work culminated in the first ER Addendum and also provided insights for this current effort.

For Addendum 2, the following additional interview was conducted regarding monitoring for SNL's security force employees per the employees' request. A summary of this discussion is provided in Section 7.4

- Personal Communication, 2018b, *Personal Communication with Sandia National Laboratories Current or Former Employees*; Telephone interview by NIOSH and ORAU Team; December 20, 2018; SRDB Ref ID: 175475.

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 period from January 1, 1997 through May 21, 2011. Table 4-1 summarizes the results of this review. (NOCTS data available as of January 7, 2019.)

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

Description	Totals
Total number of claims submitted for dose reconstruction	747
Total number of claims submitted for energy employees who worked during the period under evaluation (January 1, 1997 through May 21, 2011)	275
Total number of claims submitted for energy employees who started their employment during the period under evaluation (January 1, 1997 through May 21, 2011)	67
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).	233
Number of claims for which internal dosimetry records were obtained for the time period in the evaluated class definition	11
Number of claims for which external dosimetry records were obtained for the time period in the evaluated class definition	120

NIOSH reviewed each claim that fell within the time period under evaluation to determine whether internal and/or external personal monitoring records could be obtained for the employee. As indicated in Table 4-1, of the total number of claims submitted for energy employees who worked within the period from January 1, 1997 through May 21, 2011, 11 (4%) contain internal monitoring data and 120 (44%) contain external monitoring data.

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents captured from the site supporting the assessment of the evaluated class. Over 5,500 documents in this database are identified as pertaining to Sandia National Laboratories in Albuquerque, New Mexico. Since the initial SEC Petition Evaluation Report for Petition SEC-00188 (February 21, 2012), more than 900 documents have been added to the SRDB; these documents were reviewed and evaluated for their relevance to this Addendum.

The focus of the post-1994 data capture efforts for SNL-A includes the following:

- Internal SNL-A procedures
- Facilities and process information
- Incident reports
- 10 C.F.R. pt. 835 compliance and self-assessment reports/memos
- Internally and externally-conducted Radiation Program audits and assessments
- Air monitoring records (breathing zone and general area)
- Internal and external monitoring records
- Radiation Worker Permits (RWPs) and Radiation Work Orders (RWOs)
- Specific word/radionuclide information searches

4.6 Other Technical Sources

NIOSH also investigated the following databases in an effort to assess available internal monitoring data, and compliance with 10 C.F.R. pt. 835 requirements:

- Extracts from SNL-A's "WebDose" database, which the site uses for bioassay monitoring record retention and as a reporting tool

- SNL-A databases and reports containing breathing zone and Derived Air Concentration (DAC)-hour tracking results

- The DOE Noncompliance Tracking System (NTS): This database was reviewed for 10 C.F.R. pt. 835 violations, site responses, and corrective actions. Out of a total of 171 documents listed, 72 were deemed potentially relevant, captured in full, and loaded into the SRDB for review.

- The DOE Occurrence Reporting System (ORPS): This database was also reviewed for 10 C.F.R. pt. 835 violations, site responses, and corrective actions. Out of a total of 1,498 documents listed, 194 were deemed potentially relevant, captured in full, and loaded into the SRDB for review.

5.1 SNL Plant and Process Descriptions

Descriptions of radiological operations and source terms relevant to the 1997-2011 evaluation can be found in Section 5.1 of the original SEC Petition Evaluation Report for Petition SEC-00188 (NIOSH, 2012). The 2012 Evaluation Report provides considerable scope and detail of SNL's potential exposure areas, processes, and source terms. NIOSH is nevertheless providing some additional process details in the subsections below regarding four areas considered to represent SNL's higher internal exposure potential concerns. These areas are the Radiological and Mixed Waste Management Facility (RMWMF), Annular Core Research Reactor (ACRR), Hot Cell Facility, and the Sandia Pulse Reactor (SPR). Notably, discussions with the SEC-00188 petitioner as well as other members of the Security Force revealed concerns with work they performed in the SPR area.

Radiological and Mixed Waste Management Facility (RMWMF)

From 1957 to 1988, low-level radioactive waste (LLW) and mixed waste (MW) generated by various programs at SNL-A were disposed of at the Mixed Waste Landfill (MWL) disposal site, located in Technical Area III at SNL-A. Beginning in 1988, this facility was no longer available to accept LLW or MW due to DOE requirements prohibiting further disposal. As a result, SNL-A needed a waste-handling facility.

Construction of the Radioactive and Mixed Waste Management Facility (RMWMF) began in 1989 and was completed in 1995 (ORAUT-TKBS-0037, PDF p. 40). The RMWMF serves as a centralized facility for receipt, characterization, compaction, treatment (if necessary), repackaging, certification, and storage of LLW, MW, and TRU (transuranic waste). The RMWMF is also used for extended storage until disposal and/or treatment sites are identified that can accept these materials. The facility enables SNL-A to handle and store the waste in compliance with applicable federal, state, and local environmental regulations, DOE Orders, and offsite waste acceptance criteria. In addition, the facility allows SNL-A to prepare the waste for shipment for treatment and disposal in accordance with specific requirements regarding waste certification, packaging, and transport (RMWMF, 1998a).

The RMWMF Compound, located in the southeastern portion of Technical Area III, consists of the following:

- Building 6920 (Waste Management Facility)
- Building 6921 (Waste Assay Facility)
- Building 6925 (Waste Storage Facility)
- Prefabricated skid-mounted storage building for reactive waste
- Prefabricated skid-mounted storage building for flammable waste
- Prefabricated building for compressed gas cylinder storage
- Paved outdoor LLW and MW storage area
- Unpaved (gravel) outdoor LLW storage area
- Lined retention pond designed to hold site surface-water run-off, sprinkler discharge from a design fire, and fire-hose streams
- Office trailers

- Building 6920 is designed to manage classified and unclassified waste. Waste processing in Buildings 6920 may include unpacking, sorting, repackaging, sampling, storing, staging, treatment, and preparing waste for offsite shipment to a permitted disposal site. Treatment may include dewatering, separation of select explosive devices, neutralization, solidification, stabilization, amalgamation, cutting, decontamination, and compacting.

Waste-processing operations in the Waste Assay Facility (Building 6921) are limited to characterization work conducted in the Counting Room. Personnel in Building 6921 evaluate samples, swipes, filters, and similar items collected during facility activities. The Assay Bay houses the radioassay equipment for characterizing waste packages. No more than two pallets or eight 55-gallon waste drums are permitted at any one time in Building 6921.

Building 6925 is the primary waste storage facility at the site. Waste is also stored in Building 6920, in the skid-mounted waste-storage sheds, and in "transportainers" on the paved and unpaved outdoor storage areas of the RMWMF site. The maximum storage capacity at the MWMF Compound is approximately 285,000 cubic feet (8,000,000 liters) (RMWMF, 1998a).

Annular Core Research Reactor (ACCR)

Located in Area V, the Annular Core Research Reactor (ACRR) pool-type reactor is a 2-MW reactor that can be operated in either a pulse or steady-state mode. The reactor uses cylindrical BeO-UO_2 fuel elements arranged in a close-packed lattice. The facility provides a large central irradiation cavity (23 cm diameter), a neutron radiography facility, and two large interchangeable fuel-ringed external cavities known as FREC I & II (38 and 51 cm diameter). The annular-shaped core is formed by single fuel elements with their longitudinal axes vertical, arranged in a hexagonal grid around the central cavity. The complete core assembly consists of the fuel elements, six fuel-followed control rods, two fuel-followed safety rods, and three void-followed transient rods. Depending on experimental requirements, the typical number of fuel elements varies between 200-250 (HCF, 1995, PDF p.18). The ACRR has been in operation since 1978 for defense radiation effects and other advanced nuclear technology experiment programs (SNL, 1998, PDF p. 444). The primary purpose for the ACCR during this evaluation period (1997-2011) was the production of medical isotopes such as Mo-99, whose daughter Tc-99m is used in nuclear medicine applications (Mo-99, 1998)

Sandia Pulse Reactor Facility (SPRF)

The Sandia Pulsed Reactor Facility (SPRF), which is also located in Area V, was built to supplement the Sandia Engineering Reactor Facility (SERF) in support of the radiation-effects testing program. Three reactors were used over the history of SPRF: SPR-I, SPR-II, and SPR-III. The reactors provided unique near-fission spectrum radiation environments for testing a wide variety of technologies that supported both defense and non-defense activities. The primary mission of the facility was to produce high-neutron fluence or pulsed high-neutron doses for the testing of electronic subsystems and components. Critical experiments were conducted in the facility to support other programs (SNL, 1998). The facility consisted of a heavily-shielded reactor building, a control room building, an instrumentation building, a beam-catcher building, and several vaults for the storage of the reactor and fissionable and radioactive materials. SPRF was located in TA-V, four miles due south of TA-I, the major installation of SNL-A (SPRF, 1961).

The first reactor, SPR-I, operated from 1961 until 1967 (HP Log, 1961-1962; HP Log, 1966-1967). Other than the potential for residual contamination and activation products, SPR-I is not relevant to this evaluation.

SPR-II operated from 1967 to 1978 as the sole SNL fast-burst reactor (FBR). In August 1978, SPR-III became the primary SNL FBR for irradiation service; however, infrequent operation of SPR-II continued until 1995 (SAR, 1995, PDF p. 9). The SPR-II reactor was a fast-pulse (or fast-burst) reactor with a bare, unreflected, and unmoderated cylindrical assembly of 93 percent enriched U-235 with 10 weight-percent molybdenum (U-10 Mo) (SNL, 1998). As with SPR-1, the SPR-II reactor is only relevant to this evaluation as a potential source of residual contamination and activation products.

SPR-III operations began in 1978. Operations were suspended in 2000, and the core was placed in secure storage (SPRF, 2005). In 2005, SPR-III came out of a five and a half-year storage. It operated safely for 159 days, conducting 563 operations from January through September 2006 (SPRF, 2007). Like SPR-II, SPR-III also used an unmoderated cylindrical assembly of solid uranium metal enriched to 93 percent U-235 with 10 weight-percent molybdenum. The SPR-III core consists of 18 stacked fuel rings mechanically fastened into two groups of nine rings each. The masses of the individual rings varied between 6.8 kg and 15.4 kg. The core support structure held the nine upper rings stationary, and high-strength bolts mechanically fasten together the nine lower rings. (SNL, 1998).

Fuel from SPR- II was sent to LANL for reprocessing. Fuel from SPR-III was sent to the Nevada Test Site for storage as part of the National Nuclear Security Administration's (NNSA) nuclear material consolidation and disposition effort (SPRF, 2007, PDF p. 2). Over 13,000 operations were performed at SPRF from 1961-2006 (SPRF, 2007, PDF p. 3).

Hot Cell Facility

Also located in Area V, the Hot Cell Facility (HCF) is used for post-irradiation examination of sealed experiments. Full contained packages irradiated in either SPR-III or ACRR are generally sent to the HCF for opening and evaluation. The HCF was in operation throughout this evaluation period (1996-2011).

The HCF, which includes the Hot Cell with Steel Containment Boxes (SCB), the Glove Box Laboratory (GBL), and ancillary equipment and instrumentation in the support area, was designed and developed to support SNL-A experimental programs in which Special Nuclear Material (SNM) and/or radioactive materials are used. Operations include the preparation of materials for testing, experiment assembly, post-testing disassembly, preparation of samples for post-testing examination, and post-testing microscopy and wet chemical analysis. The facility was used extensively to process medical isotopes, such as the Mo-99 produced at ACRR. In addition, the Hot Cell and GBL are used for the preparation and packaging of SNM for reprocessing and for the preparation and packaging of radioactive and contaminated waste for final disposition. The facility was designed with four separate ventilation zones; areas with the highest levels of radioactivity are isolated from other areas (HCF, 1995, PDF pp. 17-18).

5.2 Radiological Exposure Sources from SNL-A Operations

The radiological exposure sources relevant to the 1997-2011 evaluation, including sources from the RMWMF, ACRR, the SPRF, and the HCF described above, can be found in Section 5.2 of the original SEC Petition Evaluation Report for Petition SEC-00188 (NIOSH, 2012).

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

The following subsections provide an overview of the state of the available internal monitoring data for the SNL-A class under evaluation.

6.1 Available Sandia National Laboratories Internal Monitoring Data

Occupational internal monitoring data available for the 1997-2011 period include *in vitro* (primarily urinalysis), *in vivo* (whole-body and lung counting), personal air sample (PAS) data, and Derived Air Concentration-Hour (DAC-hour) tracking data.

6.1.1 SNL *In Vitro* Data Summary

The urinalysis summaries presented below were obtained from a WebDose database extract obtained by NIOSH from SNL-A. Table 6-1a below shows the number of urine sample results available and the number of persons sampled for the time period from 1997 through 2011. Note that each individual urine sample may yield multiple sample results, depending on the particular analytes associated with the sample (i.e., samples are often analyzed for multiple radionuclides).

Table 6-1a: Available WebDose Urine Bioassay Data: 1997-2011

Year	Non-H3 Sample Results	Persons Sampled (Non-H3)	H3 Sample Results	Persons Sampled (H3)
1997	111	45	238	100
1998	144	59	375	126
1999	187	67	440	83
2000	119	46	375	50
2001	90	39	426	58
2002	111	46	575	78
2003	160	55	679	78
2004	158	51	677	70
2005	172	60	647	69
2006	128	40	500	51
2007	115	35	438	47
2008	101	33	424	40
2009	121	42	435	40
2010	138	48	446	39
2011	165	47	534	54
Total	**2020**	**317**	**7209**	**362**

Table 6-1b shows the relative volume of available urine bioassay results by radionuclide. As shown, the predominant nuclides measured were H-3, Pu-238/239, Am-241, uranium, and thorium.

Table 6-1b: Available WebDose Non-H3 Urine Bioassay Data: 1997-2011 (Number of Urine Sample Results by Radionuclide)

Radionuclide	No. of Results
Am-241	759
Am-243	11
Cm-242	4
Cm-243	15
Cm-244	8
Co-60	9
Cs-137	10
I-125	3
I-126	1
K-40	6
Ni-63	1
Np-237	15
Pu-238	856
Pu-239	869
Pu-241	118
Pu-iso	26
Ra-226	5
Sr-90	746
Tc-99	8
Th-228	201
Th-230	201
Th-232	200
Th-iso	1
U	411
U-232	3
U-234	119
U-235	690
U-238	689
Total	**5985**

NOTE: The total number of results do not match the total number of samples from Table 6-1a above because samples are often analyzed for multiple radionuclides.

6.1.2 *In Vivo* Data Summary

Table 6-1c summarizes the frequency of *in vivo* bioassay measurements performed at SNL-A between 1997 and 2011. A total of 1115 measurements were performed involving a total of 207 individuals.

Table 6-1c: Available WebDose *In Vivo* Count Data: 1997-2011

Year	Measurements	Persons
1997	59	54
1998	66	55
1999	58	52
2000	265	40
2001	73	33
2002	54	43
2003	102	61
2004	60	46
2005	65	58
2006	61	54
2007	45	42
2008	29	28
2009	48	40
2010	40	39
2011	90	50
Total	1115	207

6.1.3 Air Monitoring Data Summary

During 1996, significant changes to the internal dose monitoring program took place, including a requirement for internal dosimetry review and assignment of DAC-hrs, and a requirement to forward DAC-hr records to Internal Dosimetry if DAC fractions exceeded 0.1 DAC. Philosophical changes in the internal dosimetry program also took place in 1996, which included a change of emphasis from internal dosimetry to internal radiation protection, and reliance on other types of monitoring (particularly air monitoring) to indicate the need for bioassay.

Personal air sampling (often called breathing zone (BZ) or lapel monitoring) was used extensively at Sandia during the period 1997 through 2011, with individual samples being analyzed for both gross alpha and gross beta/gamma activity. There are currently six sources of BZ monitoring data available within the site research database (SRDB). The contents of these datasets are categorized and summarized in Sections 6.1.3.1 – 6.1.3.6 below.

6.1.3.1 BZ Sample Records Contained in the WebDose Database Extract

Table 6-1d below is a summary of the available WebDose BZ monitoring data for the period 1997 through 2011 (WebDose, 2018). A total of 26 mrem CEDE was assigned to [number redacted] individuals; the maximum assigned dose was 10 mrem. As discussed below in Section 6.1.3.2, the WebDose entries represent a rollup of individual BZ samples associated with an individual during a defined period and do not necessarily represent the results of a single BZ sample. For this reason, it is not possible to relate the number of WebDose BZ entries.

Table 6-1d: Available WebDose Breathing Zone Air Monitoring Results: 1997-2011

Year	WebDose BZ Entries	WebDose BZ Persons	Total Associated CEDE (mrem)
1997	90	44	0
1998	89	53	10
1999	41	25	0
2000	24	19	0
2001	9	[number redacted]	0
2002	14	10	0
2003	16	[number redacted]	12
2004	0	[number redacted]	0
2005	0	[number redacted]	0
2006	0	[number redacted]	0
2007	0	[number redacted]	0
2008	1	[number redacted]	0
2009	0	[number redacted]	0
2010	1	[number redacted]	4
2011	0	[number redacted]	0
Total	**285**	**116**	**26**

NOTE: The sum total of WebDose BZ Persons is less than the sum of the WebDose BZ Persons for each year because the same individuals are often monitored in multiple years.

NOTE: For Column 3, numbers under 10 were redacted due to Privacy Act concerns.

6.1.3.2 DAC-hr Tracking Reports

There are nine SRDB files containing DAC-hr tracking reports spanning the time period January 1997 through November 2002 (Alpha BZ Analysis, 2019; DAC-hr, 1999; DAC-hr, 2000; DAC-hr, 2000-2001; DAC-hr, 2001a; DAC-hr, 2001b; DAC-hr, 2001c; DAC-hr, 2002a; DAC-hr, 2002b). These nine files contain records for 113 individuals (264 records) with a combined total of 86 DAC-hr (215 mrem). Individual sample values range from 0 to 6.78 DAC-hr (0 to 17 mrem). The total accumulated internal dose (per individual) for the three-year period covered ranges from 0 to 8.5 DAC-hr (0 to 21 mrem). These DAC-hr reports are the basis for the WebDose dose entries for BZ sampling. That is, each WebDose entry represents a rollup of the DAC-hr records for an individual over the applicable month and, accordingly, represents the results for multiple BZ samples for each entry.

6.1.3.3 WebDose 'PAS-Survey' Table Provided in Response to a NIOSH Data Request

The 'PAS-Survey' table was provided by Sandia in response to NIOSH data request Sandia-FY15-01 (PAS-Survey, 2015). The 'PAS-Survey' table contains 107 entries, with two from 2003, seven from 2012, and 97 from 2013. This data source does not allow one to determine the actual BZ result (e.g., filter activity, DAC-hr, etc.). However, most entries are accompanied by a comment stating that zero dose is assigned because the calculated dose did not exceed the Decision Level threshold of 10 mrem. This is consistent with the known Sandia practice of censoring BZ results at 10 mrem for a single BZ instance.

6.1.3.4 Listing of Lapel Surveys in VSDS

A spreadsheet contains 976 entries spanning 2008 through 2015, and represents radiological surveys that are indexed in the Visual Survey Data System (VSDS) survey system with 'lapel' in either the survey title or survey purpose (VSDS, 2015). There are no available quantitative data traceable to these entries. The existence of this spreadsheet is described here primarily because it is evidence of an active personal air sampling program during this time period.

6.1.3.5 MS Access Database from RWMWF

A Microsoft® Access® database ('HAZ summary data1.mdb') contains records for 704 samples, spanning the period 2009 to 2012 (Hazard Summary, 2015). The results are simply provided in cpm. Since there are no corresponding DAC or DAC-hr values presented, or sufficient data to compute them, these records have little quantitative value for the purposes of dose reconstruction. As with the VSDS spreadsheet, this database is described here primarily because it is additional evidence of an active personal air sampling program during this time period.

6.1.3.6 BZ Monitoring Raw Data Sheets

There is a collection of 11,283 pages of air sample data sheets contained within multiple sets of data files (BZ Data1, 2018; BZ Data2, 2018, BZ Data3, 2019). These data files contain individual General Area and Breathing Zone samples collected across the Sandia site. Samples were analyzed for gross alpha and gross beta/gamma radiation with results reported in either total filter activity or as activity per unit volume sampled. In a small number of instances, data were also reported for either tritium or low-energy beta-emitters (generally Pu-241). Breathing Zone samples contained demographic information on the individual wearing the sampler, the duration of the sampled activity, and whether respiratory protection was worn. Table 6-1e shows the availability of BZ monitoring results in the SRDB. Note that this tabulation does not necessarily represent the number of BZ samples actually collected by SNL-A in each year. It is a summary of sample results that are currently available to NIOSH. For example, it is likely that samples were collected for years 2003 and 2011; however, data for those years are not currently available to NIOSH. Additional information regarding data quality can be found in the Data Pedigree discussion (Section 7.1.1.3).

Table 6-1e: Available Breathing Zone Air Monitoring Results: 1997-2011

Year	BZ Sample Results
1997	357
1998	1583
1999	708
2000	336
2001	172
2002	585
2003	0
2004	274
2005	388
2006	208
2007	231
2008	445
2009	76
2010	26
2011	0
Total	**5389**

6.1.4 Summary of Internal Dose Assigned in WebDose

Internal dose assignment records are contained in the WebDose database extract provided by Sandia on May 2, 2018 (WebDose, 2018). Table 6-1f provides a summary of the total internal dose (CEDE) assigned for each year from 1997 to 2011 in units of mrem for each of the various monitoring methods employed.

Table 6-1f: Total Internal Dose (CEDE) Assigned (mrem): 1997 to 2011 by Monitoring Method

Year	H3 Urine	BZ Sample	Non-H3 Urine Sample	*In Vivo*	Total
1997	0	0	0	0	0
1998	0	10	0	0	10
1999	0	0	0	0	0
2000	0	0	0	5	5
2001	0	0	0	0	0
2002	0	0	0	0	0
2003	0	12	0	0	12
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	23	0	23
2010	0	4	19	0	23
2011	4	0	0	0	4
All	**4**	**26**	**42**	**5**	**77**

7.1 Pedigree of SNL 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.

7.1.1 Internal Monitoring Data Pedigree Review

In determining the pedigree of SNL monitoring data and the sufficiency of available data to bound worker doses, NIOSH evaluated the following:

- The overall suitability of SNL's Internal Dosimetry Monitoring Program;
- The use of bioassay sampling for specific groups of workers for confirmatory purposes;
- Incident response involving bioassay;
- Internal exposure potential of the workforce;
- Internal Exposure Monitoring Data (WebDose)
- Breathing Zone air monitoring data;
- Internal dose (CEDE) assigned by Sandia.

7.1.1.1 Internal Dosimetry Monitoring Program

Sandia implemented a radiation protection program that included baseline, termination, and routine internal monitoring (TBD, 1995). From the onset, the program identified "technology shortfall" radionuclides for which air monitoring would be employed as the primary means of internal monitoring (TBD, 1995, PDF p. 203). Interviews with the Internal Dosimetrist at the time indicated that initial selection for internal monitoring program participation was by individual department managers, and that, over time, this process was changed to focus monitoring on individuals with a higher risk of exposure (Personal Communication, 2017c). The reason for this change was noted by this same individual as being the high program cost relative to the low potential for internal exposure. A 1996 external assessment of the internal dosimetry program by a technical expert proposed the implementation of DAC-hr tracking (using personal air samples) as the primary method of internal exposure monitoring (with the exception of tritium, for which routine bioassay sampling was retained) (Assessment, 1996). Requirements for assigning DAC-hr equivalents based on air monitoring data, and the forwarding of these type of records to Internal Dosimetry for assignment as doses of record, appeared in procedures starting in the latter half of 1996 (SNL, 1996).

The following subsequent procedure revisions further refined the procedural requirements for documentation and retention of air monitoring records used to assess internal dose:

- RPO-04-420, *Air Sampling*, Issue 2 (3/18/1996), was revised to include requirements for internal dosimetry review and assignment of DAC-hrs (RPO, 1996)

- RPID-00-01, *Program Overview*, Issue 4 (8/27/96), indicates that results from personal air samplers are provided to the Radiation Protection Internal Dosimetry (RPID) group weekly. Those results are used to track exposure, and ultimately, to determine if bioassay monitoring is

required. It should be noted that the purpose of this revision was to: …*reflect philosophical changes in the internal dosimetry program. This includes change of emphasis from internal dosimetry to internal radiation protection and reliance on other types of monitoring to be indicative of the need for bioassay.* (RPID, 1996)

- RPID-20-04, *Personal Air Sampler Results Processing*, Issue 1 (7/16/1997), provided a mechanism for the electronic capture of PAS sample results as well as requirements for review by Internal Dosimetry staff (RPID, 1997).

- RPID-20-03, *Entering Internal Dose Equivalents in SANDOS*, Issue 3 (1/14/1999), was revised to provide instructions on entering dose from PAS samples into the dose tracking system (RPID, 1994).

- RPID-02-01, *Records Management Life Cycle*, Issue 3 (10/1/1999), was revised to include personal air sample results and dose records in the records series (RPID, 1999).

- The transition away from routine bioassay (except for tritium) was clarified in RPID-00-10, *Technical Basis Document: Internal Dosimetry*, Issue 3 (10/8/1998), which states: *Personal air sampling (PAS) is the primary indicator of intakes at SNL.* (RPID, 1995)

7.1.1.2 Confirmatory Sampling

Sandia maintained routine bioassay sampling for specific groups of workers based on work activity (i.e., job category) for confirmatory purposes.

A February 3, 1998 summary of an RMWMF Safety Committee discussion on the need for routine bioassay indicated the following (RMWMF, 1998b):

- RCTs at the RMWMF are on routine bioassay and results are reviewed to identify any trends. Furthermore: *If a trend developed indicating internal doses, RMWMF personnel would undoubtedly be asked to submit special bioassay samples to determine the scope of the problem.*

- *If trends developed indicating elevated air concentrations or increased surface contamination levels, special bioassay samples would be requested from appropriate facility personnel.*

- *Job-specific RWPs require bioassay, as appropriate, for those workers involved with tasks where significant levels of radionuclides, or certain specific radionuclides (e.g., 3H) are handled*.

Similarly, a May 30, 2001 memo documenting the routine bioassay program for Radiological Control Technicians (RCTs) at TA-V indicated the following (TA-V, 2001):

- Current schedule calls for annual whole-body counts and semi-annual urinalysis samples for U, Th, Am, and Pu.

- Furthermore: *The SNL bioassay program is confirmatory in nature. The Bioassay program confirms the results and effectiveness of contamination control and other personnel protection activities*.

- *Since Radiological Control Technicians (RCTs) must be present in all work activities where the possibility of meaningful intakes is credible, their bioassay serves as a good proxy indicator for potentially exposed line personnel…*

7.1.1.3 Incident Response

Although routine bioassay monitoring was not used as the primary means of internal dose monitoring, evidence was located indicating the implementation of bioassay monitoring in response to specific incidents. Table 7-1a provides a sample of incident responses that included bioassay monitoring.

Table 7-1a: Incident Response Actions Involving Bioassay Monitoring

Date	Triggering Event	Summary	Follow-up	SRDB Ref ID
02/07/97	Puncture wound	[Incident description redacted]	Bioassay Sampling	175709
03/20/97	Area survey	Unexpected surface contamination detected during post-job survey.	Bioassay Sampling	175706
04/16/97	Odor during opening drum	Upon opening drum, a strange odor was detected. Tritium contamination detected.	Bioassay Sampling	175707
05/29/97	Area monitor alarm	Tritium monitor alarmed during work.	Bioassay Sampling	175703
02/12/98	Area survey	Unexpected surface contamination detected during post job survey.	Bioassay Sampling	31028
07/23/98	Personnel contamination monitoring	Unexpected levels of contamination detected during work process. Work stopped, follow-up survey identified unexpected high levels of surface contamination.	Bioassay Sampling	23716
10/30/98	BZ air sample	Unexpectedly high air sample result during work.	WBC and Bioassay Sampling	23716
01/19/99	BZ air sample	Unexpectedly high air sample result during work.	Bioassay Sampling	23716
01/26/99	Area survey	Unexpected surface contamination detected during post-job survey.	Bioassay Sampling	23716
03/19/99	BZ air sample	Unexpectedly high air sample result during work.	Bioassay Sampling	23716

7.1.1.4 Internal Exposure Potential

As initially implemented in 1995, Sandia's Radiation Protection Program indicated that routine bioassay sampling would only be used to ensure that workplace controls were adequate. It further indicated that, because of effective engineering controls, the use of protective clothing and respiratory protection, as well as contamination surveys and air monitoring, routine bioassay samples would not be expected to contain any radioactive material indicative of a new intake (TBD, 1995). This assertion is consistent with external program reviews conducted in 1996 and 1999 (Assessment, 1996; Assessment, 1999), in which it was indicated that exposure to site personnel in excess of 100 mrem CEDE would be unlikely. In May 1999, the site Radiation Protection Plan was revised to indicate that it was not likely that individuals would receive greater than 100 mrem of internal exposure, and accordingly, a routine internal dosimetry program was not required (RPP, 1999).

7.1.1.5 Internal Exposure Monitoring Data (WebDose)

The current repository of all Sandia monitoring data is termed WebDose. The completeness of the urinalysis data contained in the WebDose system was assessed by comparing sample records from seven laboratory data files (captured by the ORAU Team in April 2007) to the records contained in a WebDose extract file provided to NIOSH in July 2014 (WebDose, 2014). ORAU identified 95 samples for which results were provided in the laboratory file but that were not in WebDose. A formal request was submitted to Sandia for resolution of the issue. It was subsequently determined that a change in the primary key used to associate individual names to monitoring records (i.e., from employee social security number to Sandia ID) resulted in the disconnection of some monitoring records from the record identifying the associated individual. Sandia determined that 548 records associated with 73 individuals were affected. This condition was corrected within Sandia's WebDose system and a new WebDose extract file was provided to NIOSH on May 2, 2018 (WebDose, 2018). The comparison between laboratory data files and the corrected WebDose extract was repeated using another set of laboratory data files (Urinalysis, 1994; 1995a; 1995b; 1995c; 1996; 1999). The only inconsistency found were instances in which a laboratory returned results for radionuclides that were not requested; such results were not input into WebDose (e.g., 22 instances in which isotopic thorium results were provided when total uranium results were requested).

Review of whole-body count records in WebDose indicate a lack of any 'result' associated with counts performed prior to 2000. It was confirmed that, prior to 2000, results for negative whole-body counts were not input into WebDose. In order to confirm this practice, hard copy records for 10% of the measurements performed between 1995 and 1999 (a total of 54 records) were requested and compared to corresponding WebDose entries. This comparison confirmed that the records with blank results were, in fact, non-detect measurements. It was also determined that there were three instances in which the whole-body count record in WebDose was not accurate (i.e., the record number for the WebDose record does not match the record on the raw data source). This discrepancy has not been resolved with the site, but it has been determined that a complete record of all whole-body counts associated with an individual could still be retrieved by the site using hard-copy record indexes.

The completeness of dose entries that originated from personnel air sample (BZ) results was assessed by compiling a list of individuals garnered from all known data sources (data sheets, WebDose, DAC-hr Tracking Reports, and RMWMF Database). Monitoring records were requested for these individuals. In total, data on 22 individuals were evaluated and compared. In 15 of the 22 instances, the monitoring data provided by Sandia was consistent with the raw data sources. In five instances, there were inconsistencies related to the assignment date; however, the results were consistent (albeit 0). The two instances in which the data were not consistent were for individuals sampled in 1995 and 1996.

7.1.1.6 Breathing Zone Air Monitoring Data

Air-monitoring data presented in Section 6.1.3 consists of raw field-monitoring data sheets that were obtained during data capture activities by the ORAU Team. This dataset is known to be incomplete, as follows:

- For some years, there are zero captured monitoring results: 2003 and 2011
- The data for the period 1997-2002 appear to represent data sheets that were sent to the Internal Dosimetry program office (as indicated by a "reviewed by _____" stamp on the majority of the pages). Interviews with site personnel indicate that air sample results exceeding threshold values were submitted to Internal Dosimetry; thus, it is reasonable to assume that the dataset represented by these sheets is biased high. The practice of only sending datasheets that exceed threshold values is consistent with air-monitoring procedures obtained from the site.
- The VSDS listing of lapel samples described in Section 6.1.4 indicates that a larger number of lapel surveys were performed than are currently represented by the datasheets obtained by data capture activities.
- Some of the captured datasheets have either missing or illegible data that renders them unusable for the purpose of assessing potential internal exposure to the associated individual (e.g., for 2002, 32 of 585 records contain no duration entry).

7.1.1.7 Internal Dose (CEDE) Assigned by Sandia

Internal dose data discussed in Section 6.1.4 was obtained from the WebDose extract file (an Excel formatted file) provided on May 2, 2018 (WebDose, 2018). The data were pulled from the various 'dose' sheets provided in the Excel file and are presumed to represent the dose records that are stored within Sandia's onsite record-keeping system. A query of the DOE REMS system (https://apps.orau.gov/CER/REMSQueryTool) indicates comparable, albeit not equivalent results (108 person-mrem accrued between 1997 and 2011 versus 77 person-mrem obtained from the WebDose extract file). However, there is 28 person-mrem noted in WebDose as received "offsite" (e.g., dose received by Sandia personnel at other sites). Once this 28 person-mrem is added in for these years (i.e., 77 + 28 = 105 person-mrem), the REMS and WebDose values agree favorably (i.e., 108 vs. 105 person-mrem).

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 exposures to plutonium, tritium, uranium, americium, and fission and activation products (NIOSH, 2012). The following subsections address the ability to bound internal doses, methods for bounding 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 Bioassay Data

As indicated previously in Section 6.1.3, by 1997 Sandia had shifted the emphasis of the internal monitoring program from reliance on bioassay monitoring to the use of breathing zone sampling as a primary method of monitoring. Sandia maintained the position that no individual was likely to receive an exposure in excess of 100 mrem; this is indicated in both internal technical basis documentation (RPP, 1999) as well as in external assessments performed in 1996 and 1999 (Assessment, 1996; Assessment, 1999). Program documentation indicates that radiation control technicians were maintained on routine bioassay programs as a confirmatory measure in the RMWMF and within Technical Area V (RMWMF, 1998b; TA-V, 2001).

Because of the confirmatory nature of Sandia's bioassay monitoring program, and the fact that breathing zone sampling was deemed the primary method of internal dose monitoring, it is not feasible to rely solely on bioassay monitoring to assess potential internal exposure to Sandia personnel.

7.2.1.2 Breathing Zone Sampling

The breathing zone sampling data discussed in Section 6.1.3.6, Table 6-1e, were primarily data for individuals who were wearing respiratory protection. These data were used to assess the potential exposure to co-located individuals who were not being monitored and were not wearing respiratory protection.

The internal dose associated with each BZ sample record was calculated as follows:

1. When the filter activity was provided, the intake quantity was calculated by multiplying the filter activity by the ratio of the breathing rate for Reference Man (20 L/m) to the sample flow rate (generally between 3 and 4 L/m).

2. When the filter concentration (activity per volume sampled) is provided, the filter activity was calculated by multiplying the filter concentration by the associated volume, and then the intake quantity was calculated as in Step 1 above.

3. The doses associated with the intake quantities calculated in either Steps 1 or 2 above were calculated by dividing the intake quantity by the stochastic ALI (based on the values listed in 10 C.F.R. pt. 835) and multiplying by 5000 mrem. NOTE: For this calculation, a conservative

(claimant-favorable) nuclide (Type S plutonium) was assumed, unless the associated survey indicated otherwise.

4. Steps 1 to 3 above were performed independently using gross alpha, gross beta/gamma, and H3 LSC results along with applicable ALI values.

As indicated in Section 7.1.1.6, there are a small number of instances during which insufficient information is available to arrive at the dose associated with an air sample filter record. For 2002, there are 32 instances (out of 585) for which there is insufficient information to perform a dose assessment. These samples were excluded from the final analysis; however, they represent a very small portion of the available data and are dosimetrically-insignificant (i.e., they have an average activity of less than 0).

BZ air sampling results, which give the dose in mrem for exposures to airborne radioactive materials, were analyzed to determine the distribution of the data grouped by event. An event is defined two ways: a radiological work task at a given location on a given day, and all radiological work on a given day.

Gross Alpha Analysis

The gross alpha air sample results were analyzed to determine the mean radiological doses from these data. Table 7-1b below shows the number of available alpha BZ sample results used in the analysis along with the number of samples grouped by work activity and work day.

Table 7-1b: Available Gross Alpha Data

Year	Available Alpha BZ Results	Number of Individual Work Activities	Number of Work Days with a Sample
1997	357	148	130
1998	1581	368	211
1999	708	186	120
2000	334	84	78
2001	172	90	82
2002	553	296	155
2004	131	53	44
2005	177	77	65
2006	75	33	32
2007	111	42	39
2008	189	68	63
2009	38	16	16
2010	23	6	6

Figure 7-1 is a QQ Plot of the individual dose (CEDE) in mrem associated with each BZ sample. This is a mixture of a normal distribution (the analytical noise) and a lognormal distribution (the real exposures). Note the negative (< 0) results. The parameters for the lognormal component of the distribution can be determined by censoring the results below 1 mrem and fitting a lognormal model to the remaining data. This lognormal dataset is then used to replace negative values in the original full dataset. This same method is used for analyzing censored bioassay data for co-worker models (ORAUT-RPRT-0053, *Analysis of Stratified Coworker Datasets*; ORAUT-RPRT-0071, *External*

Dose Coworker Methodology; and ORAUT-RPRT-0096, *Multiple Imputation Applied to Bioassay Coworker Models*).

The resulting revised dataset (with the negative values replaced) was used to compile a dataset representing the dose associated with individual work activities (i.e., all samples collected in a particular area during a particular time period) and all individuals working on a particular day (i.e., all samples collected on a particular day regardless of work location). The median dose for an event in this analysis was 0.48 mrem, with an associated geometric standard deviation of 5.8 for an event defined by particular area and time, and 0.51 mrem with a GSD of 5.2 for all individuals working on a particular day.

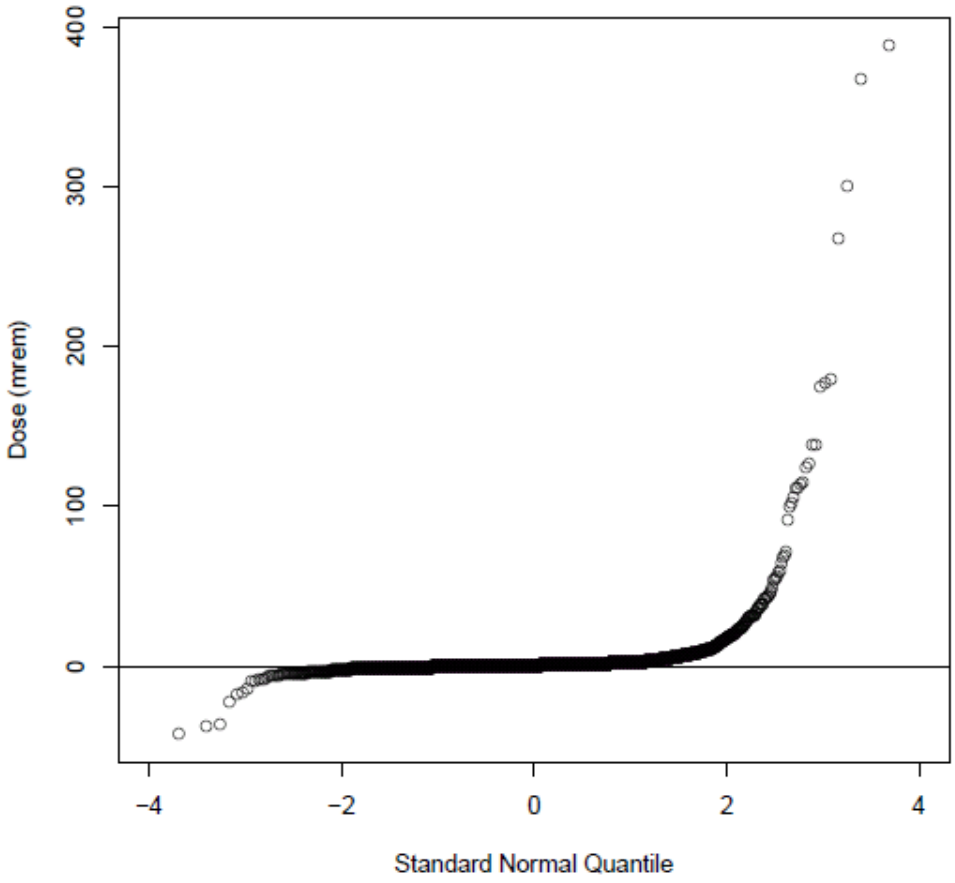

Figure 7-1: Normal QQ Plot of Alpha Dose Data

Gross Beta/Gamma Analysis

The gross beta/gamma air sample results were analyzed to determine the mean radiological doses from these data. Table 7-1c below shows the number of available alpha BZ sample results used in the analysis along with the number of samples grouped by work activity and work day.

Table 7-1c: Available Gross Beta/Gamma Data

Year	Available Beta/Gamma BZ Results	Number of Individual Work Activities	Number of Work Days with a Sample
1997	357	148	130
1998	1583	368	211
1999	708	186	120
2000	336	84	78
2001	172	90	82
2002	553	296	155
2004	137	53	44
2005	177	77	65
2006	72	32	32
2007	170	42	39
2008	358	68	63
2009	74	16	16
2010	26	6	6

Figure 7-2 is a QQ Plot of the individual dose (CEDE) in mrem associated with each BZ sample. This is a mixture of a normal distribution (the analytical noise) and a lognormal distribution (the real exposures). Note the negative (< 0) results. The parameters for the lognormal component of the distribution can be determined by censoring the results below 0.1 mrem and fitting a lognormal model to the remaining data. This lognormal dataset is then used to replace negative values in the original full dataset. This same method is used for analyzing censored bioassay data for co-worker models (ORAUT-RPRT-0053, *Analysis of Stratified Coworker Datasets*; ORAUT-RPRT-0071, *External Dose Coworker Methodology*; and ORAUT-RPRT-0096, *Multiple Imputation Applied to Bioassay Coworker Models*).

The resulting revised dataset (with the negative values replaced) was used to compile a dataset representing the dose associated with individual work activities (i.e., all samples collected in a particular area during a particular time period) and all individuals working on a particular day (i.e., all samples collected on a particular day regardless of work location). The median dose for an event in this analysis was 0.001 mrem with an associated geometric standard deviation of 8.0 for an event defined by particular area and time, and 0.001 mrem with a GSD of 7.0 for all individuals working on a particular day.

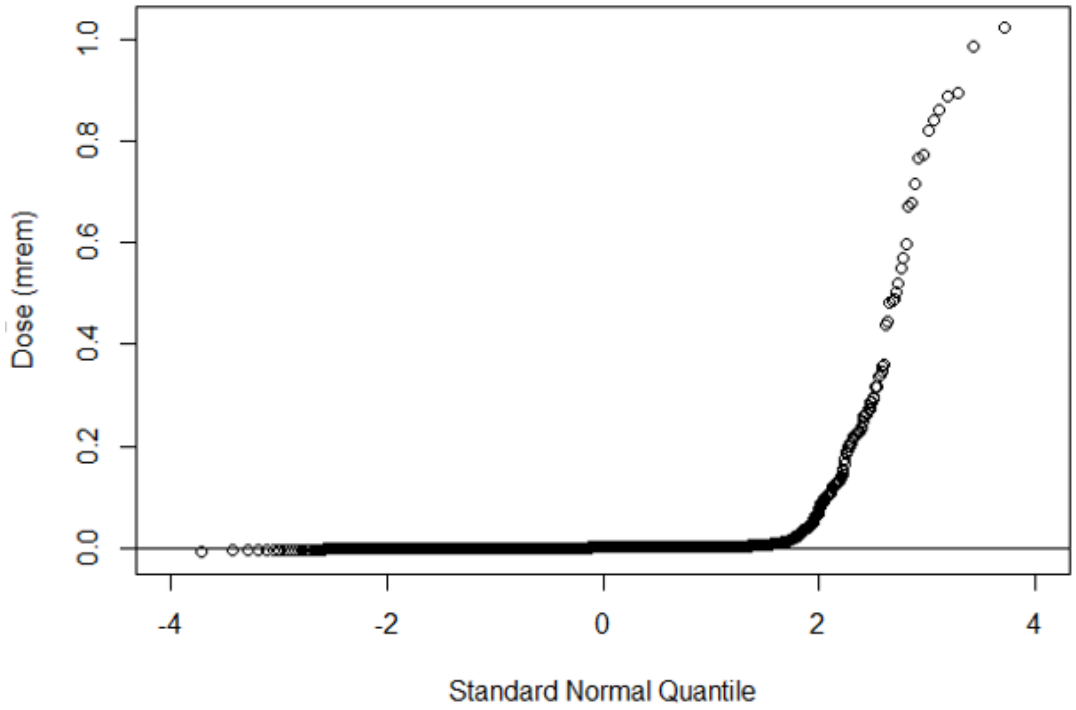

Figure 7-2: Normal QQ Plot of Beta/Gamma Dose Data

Tritium Analysis

The tritium air sample results were analyzed to determine the mean radiological doses from these data. Table 7-1d below shows the number of available alpha BZ sample results used in the analysis along with the number of samples grouped by work activity and work day. NOTE: When converting BZ results to dose, the dose conversion factor for Insoluble (Type S) Metal Tritides was assumed.

Table 7-1d: Available Tritium Data

Year	Available Tritium BZ Results	Number of Individual Work Activities	Number of Work Days with a Sample
2004	119	45	39
2005	165	67	57
2006	88	41	39
2007	52	20	19
2008	8	5	5

Figure 7-3 is a QQ Plot of the individual dose (CEDE) in mrem associated with each BZ sample. This is a mixture of a normal distribution (the analytical noise) and a lognormal distribution (the real exposures). Note the negative (< 0) results. The parameters for the lognormal component of the distribution can be determined by censoring the results below 0.2 mrem and fitting a lognormal model to the remaining data. This lognormal dataset is then used to replace negative values in the original full dataset. This same method is used for analyzing censored bioassay data for co-worker models (ORAUT-RPRT-0053, *Analysis of Stratified Coworker Datasets*; ORAUT-RPRT-0071, *External Dose Coworker Methodology*; and ORAUT-RPRT-0096, *Multiple Imputation Applied to Bioassay Coworker Models*).

The resulting revised dataset (with the negative values replaced) was used to compile a dataset representing the dose associated with individual work activities (i.e., all samples collected in a particular area during a particular time period) and all individuals working on a particular day (i.e., all samples collected on a particular day regardless of work location). The median dose for an event in this analysis was 0.007 mrem with an associated geometric standard deviation of 4.4 for an event defined by particular area and time, and 0.007 mrem with a GSD of 4.3 for all individuals working on a particular day.

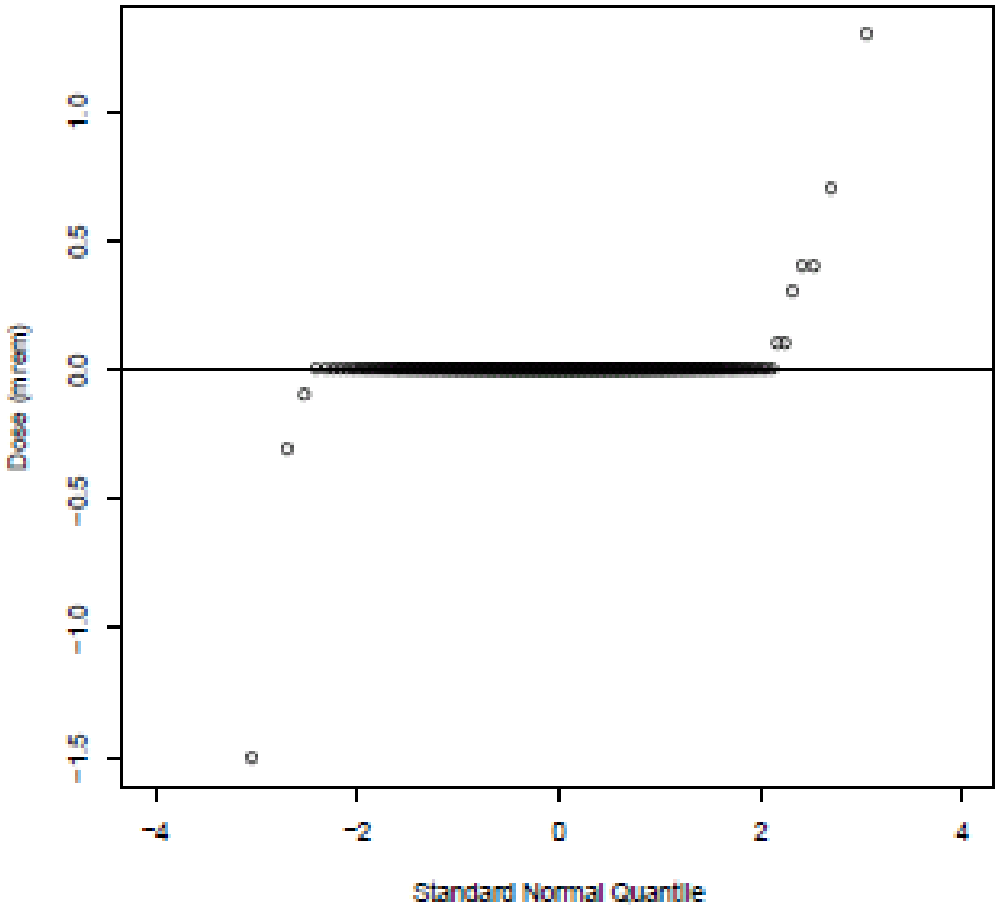

Figure 7-3: Normal QQ Plot of Tritium Dose Data

7.2.1.3 10 CFR 835 Regulatory Monitoring Threshold

10 C.F.R. pt. 835, *Occupational Radiation Protection*, specifies regulations that are pertinent to all DOE facilities. These regulations were issued on December 14, 1993 with an implementation deadline of December 31, 1995. These regulations contained specific requirements related to individual monitoring (§ 835.402) and recordkeeping (§ 835.702).

The original rule, dated December 14, 1993, states the following regarding individual monitoring (10 C.F.R. § 835.402):

> *§835.402 Individual monitoring.* [Original rule, 1993]
>
> *(c) For the purpose of monitoring individual exposures to internal radiation, internal dose evaluation programs (including routine bioassay programs) shall be conducted for:*
>
> *(1) Radiological workers who, under typical conditions, are likely to receive 0.1 rem (0.001 sievert) or more committed effective dose equivalent, and/or 5 rems (0.05 sievert) or more committed dose equivalent to any organ or tissue, from all occupational radionuclide intakes in a year.*

These monitoring thresholds correspond to 2% and 10%, respectively, of the occupational exposure limits for these categories of exposure for general employees (10 C.F.R. § 835.202). The requirement for monitoring based on organ and tissue committed dose equivalent (CDE) was removed in 1998, as explained in the Federal Register notice:

> *The monitoring threshold based upon committed effective dose equivalent obviates the need for this threshold because, through application of the weighting factors defined in §835.2(b), the committed effective dose equivalent always provides a more restrictive basis for individual monitoring*. (63 FR 59683)

The amended rule, dated November 4, 1998, states (10 C.F.R. § 835.402):

> *§835.402 Individual monitoring.* [Amended rule, 1998]
>
> *(c) For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) shall be conducted for:*
>
> *(1) Radiological workers who, under typical conditions, are likely to receive a committed effective dose equivalent of 0.1 rem (0.001 sievert) or more from all occupational radionuclide intakes in a year.*

Records of conducted monitoring were required to be maintained per § 835.702 in order to document compliance with 10 C.F.R. § 835.402:

> *§835.702 Individual monitoring records.*
>
> *(a) Records shall be maintained to document doses received by all individuals for whom monitoring was required pursuant to §835.402 and doses received during planned special exposures, accidents, and emergency conditions.*

DOE Occupational Radiation Exposure (DOE/EH-0575, 1997), Section 2.1, Radiation Protection Requirements, states:

> *10 CFR 835 became effective on January 13, 1994, and required full compliance by January 1, 1996. In general, 10 CFR 835 codified existing radiation protection requirements in DOE Order 5480.11. The rule provides nuclear safety requirements that, if violated, will provide a basis for the assessment of civil and criminal penalties under the Price-Anderson Amendments Act of 1988, Public Law 100-408, August 20, 1988 as implemented by 10 CFR 820 "Procedural Rules for DOE Nuclear Activities," August 17, 1993.*

Sandia-Albuquerque 10 C.F.R. pt. 835 Implementation Documentation

10 C.F.R. pt. 835 required all DOE sites to develop a radiation protection program (RPP) document outlining how compliance would be achieved and certifying compliance (or indicating elements that were not in compliance) by the December 31, 1995 deadline.

The initial version of the Sandia-Albuquerque 10 C.F.R. pt. 835 Radiation Protection Program (RPP) document, issued on December 29, 1994, includes the requirement for individual monitoring, as defined in 10 C.F.R. § 835.402(c) (RPP Plan, 1994). The RPP indicates that compliance with this section would be achieved upon revision of the site Internal Dosimetry Technical Basis Document (TBD). The revised site Internal Dosimetry TBD was issued on May 5, 1995 (TBD, 1995). Subsequent versions of the RPP document (RPP, 1999; RPP, 2011) issued in 1999 and 2011 characterize the Sandia bioassay monitoring program as 'confirmatory' with the assertions that: (1) no individual at Sandia is likely to receive an internal exposure exceeding 100 mrem CEDE; and (2) a routine internal dosimetry program is not required. A revision of the RPP issued between 1994 and 1999 is not available; however, other program documents issued in the 1996 and 1997 time frame (RPID, 1996; TBD, 1996) clearly indicate the internal monitoring program's shift from routine bioassay sampling to breathing zone air sampling while maintaining the 100 mrem monitoring threshold.

Internal and External Program Assessments

NIOSH reviewed 22 internal and external assessments of the radiological protection programs at Sandia generated between 1997 and 2008. Attachment One summarizes these assessments. The assessments were performed by Sandia personnel, SNL's "External Advisory Board," DOE's Independent Oversight and Performance Assurance (in 2003, 2005 and 2008), and the Inspector General's Office (in 2008). None of the findings in these assessments would likely affect NIOSH's ability to perform individual dose reconstructions.

DOE ORPS Reports

NIOSH reviewed the DOE Occurrence Reporting System (ORPS) for SNL-A 10 C.F.R. pt. 835 violations, as follows:

- NIOSH identified a total of 1,498 reports that were available.
- Of these 1,498 reports, 194 report titles were deemed potentially relevant and were selected for review.
- NIOSH found none of these reports to be problematic regarding dose reconstruction feasibility.

DOE Noncompliance Tracking System (NTS) Reports

NIOSH reviewed the NTS system for SNL-A 10 C.F.R. pt. 835 violations, site responses, and corrective actions, as follows:

- 171 SNL report titles were listed in the system.
- 72 were considered potentially relevant and were requested for review.

Of the 72 reviewed, [number redacted] were considered pertinent to compliance with 10 C.F.R. § 835.402(c)(1) or 10 C.F.R. § 835.702(a). A summary of these [number redacted] cases is provided in Appendix Two. None indicated either a failure to Identify/Monitor People with Potential to Exceed 100 mrem or Unavailable/Lost Personal Monitoring Records.

7.2.2 Evaluation of Bounding Ambient Environmental Internal Doses

NIOSH can bound ambient environmental doses to Sandia National Laboratory personnel using the methodology described in ORAUT-TKBS-0037, *Site Profile for Sandia National Laboratories in Albuquerque, New Mexico, and the Tonopah Test Range, Nevada.* Alternatively, the assignment of intakes that would result in doses of 100 mrem CEDE would be bounding for all sources of internal dose, including the relatively small (a few mrem) ambient environmental contribution.

7.2.3 Methods for Bounding Internal Dose at SNL-A

The following subsections summarize the methods for bounding internal dose at Sandia Albuquerque.

Based on its review of radioactive material use at Sandia-Albuquerque and the associated radiation protection programs, NIOSH has concluded that intakes for unmonitored workers with access to controlled areas were unlikely to have resulted in committed effective dose equivalents (CEDE) in excess of 0.1 rem per year. This conclusion is not wholly based upon the implementation of 10 C.F.R. § 835.402, but rather on a review of exposure monitoring records for individuals involved in high-risk radiological activities at the site during the period under evaluation. More specifically:

- The total assigned internal dose (CEDE) for all employees combined for the 15-year period from 1997 through 2011 is 77 mrem (Section 6, Table 6-1f).

- A review of available breathing zone bioassay data (Section 7.2.1.2) indicates that the median quantity of radioactive material available for internal uptake to individuals located alongside personnel performing high risk radiological work would correspond to an internal dose of 0.5 mrem per work event or per work day. This dose quantity assumes that the individual is present within the work area and is not wearing respiratory protection (which is typically the case). The fact that such individuals would be afforded a significant reduction in intake potential by the separation between the actual work and the area that can be occupied without the same level of radiological controls is not considered in this assessment. In any case, consistent with the recorded internal dose discussed above, it is not likely that an individual would be able to receive 100 mrem per year of internal exposure under these conditions (i.e., an individual would have to be present for 200 events, based on the median dose, to receive an exposure in excess of 100 mrem in a year).

Therefore, in the absence of internal dosimetry records indicating the contrary, NIOSH may assume that intakes by workers did not result in doses exceeding 0.1 rem CEDE.

Bounding intake quantities corresponding to a CEDE of 0.1 rem may be defined as 2% of the stochastic Annual Limit on Intake (ALI), or SALI. The ALI is defined in 10 C.F.R. § 835.2. The SALI is the value of intake of a given radionuclide in a year by the Reference Man (ICRP Pub. 23, 1975) that would result in a CEDE of 5 rem (0.05 sievert).

An unmonitored worker with access to controlled areas may be assumed to have been exposed to 2% of the SALI per year from any of these potential radionuclides. For purposes of bounding dose reconstruction, the radionuclide and lung clearance class selected for each year's intake would be the one resulting in the highest dose to the organ of interest at the time of cancer diagnosis. As indicated in Section 7.2.1.2, available air sample data indicate that the potential for exposure to airborne alpha activity is more than 100 times more likely than beta/gamma. For this reason, only alpha-emitting radionuclides need be considered when applying the 2% SALI intake.

Intakes of radon and their progeny by unmonitored workers with the potential for exposure may be bound by assuming an exposure of 40 DAC-hr per year. During the period under evaluation, 10 C.F.R. pt. 835 permitted the DAC values for Rn-220 and Rn-222 to be replaced by 1 working level (WL) and 1/3 WL, respectively. DCAS-TIB-011 provides a method for converting exposures expressed in working level months (WLM) into individual organ doses. A WLM is equivalent to 170 WL-hours. Therefore, 40 DAC-hrs is equivalent to 0.24 WLM for Rn-220 and 0.078 WLM for Rn-222.

7.2.4 Internal Dose Reconstruction Feasibility Conclusion

In the SEC-00188 Sandia-Albuquerque ER, NIOSH defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy (NIOSH, 2012). The class included all employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Sandia National Laboratory in Albuquerque, New Mexico from January 1, 1963 through December 31, 1994. A subsequent addendum dated July 26, 2018 extended that class through December 31, 1996 (NIOSH, 2018).

It is NIOSH's position that, regardless of whether Sandia could be shown to be in full compliance with 10 C.F.R. pt. 835, the salient sections of the regulation regarding monitoring and record retention (10 C.F.R. § 835.402 and 10 C.F.R. § 835.702) were in fact bounding of the actual exposure conditions at SNL-A for individuals without monitoring data indicating otherwise. Therefore, in the absence of internal dosimetry records, NIOSH may assume that intakes by workers lacking monitoring data to the contrary did not result in doses exceeding 0.1 rem CEDE.

In conclusion, for the period of this evaluation (January 1, 1997 through May 21, 2011), NIOSH finds that it has access to sufficient information to: (1) estimate the maximum radiation dose for every type of cancer for which radiation doses are reconstructed, and that could have been incurred in plausible circumstances by any member of the class; or (2) estimate radiation doses of members of the class more precisely than an estimate of maximum dose.

7.4 Evaluation of Petition Basis for SEC-00188

The following assertion was made on behalf of petition SEC-00188 for Sandia National Laboratories:

Assertion: *The petitioner asserted that [job title redacted] working at SNL-A were tasked with working in and around radioactive hazard areas and machines. Duties listed included the [job duties redacted]. 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. In addition, results received following requests for external monitoring records have been incomplete.*

Response: During the course of the previous evaluation (NIOSH, 2012) and the subsequent Addendum (NIOSH, 2018), NIOSH found that the issues identified by the petitioner required further evaluation and that an expansion of the evaluated class was justified. NIOSH found that from January 1, 1963 through December 31, 1994 (initial petition) and from January 1, 1995 through December 31, 1996 (addendum), potential internal doses associated with SNL-A work were not completely known and access to internal monitoring data and program information was limited. This current evaluation (covering the remaining petitioned period from January 1, 1997 through May 21, 2011) focuses only on internal monitoring because the prior evaluation determined that reconstruction of external dose was feasible.

Captured site memos document multiple [job category redacted] personnel concerns of exposure potential and inadequate monitoring dating back to mid-1992 (if not earlier). During the course of an exposure event investigation in April 1991 (Tritium, 1991), it was determined that [job category redacted] personnel unexpectedly had positive tritium bioassay results. The source of exposure was ultimately determined to be tritium [description redacted] (unrelated to the original event). Tritium bioassay samples were collected from all [job category redacted] and a total of 80 mrem was assigned to [number redacted] individuals. All other individuals were assigned a dose of 0 mrem.

A July 2, 1992 document describes meetings with [job category redacted] personnel to discuss exposure concerns associated with the movement of materials (Stanley, 1992). [Number redacted] individuals associated with the event were monitored via urine bioassay samples, whole-body and lung counting (whole-body and lung counts were performed at Los Alamos National Laboratory). Whole-body and lung counts indicated “no abnormal activities with respect to background” while uranium urine samples for [number redacted] individuals indicated low but detectable U-234 ([number redacted]) and U-238 ([number redacted]). Ultimately, less than 1 mrem CEDE was assigned. The observed contamination during the [work category] work was determined to be radon daughters trapped within clothing.

The leaking tritium [description redacted] events reinforced unmonitored [job category redacted] personnel’s concerns regarding their radiological exposure potential while executing their assigned tasks at SNL. Specific concerns noted by them at that time included wanting to know what measurements could be made immediately to evaluate possible uptake of radioactive materials by [job category redacted] personnel. In addition, there were concerns regarding a lack of adequate radioactive material-handling procedures.

Several follow-up memos from October, 1992 (Internal Dosimetry, 1992-1993, PDF pp. 6, 8, 12, 14) further document [job category redacted] personnel’s continued concerns for potential exposure and monitoring inadequacy. These documents note that a meeting was held on October 8th, 1992 to discuss [job category redacted] participation in the SNL’s Internal Radiation Dosimetry Program.

Topics on the agenda included:

- Current [job category redacted] guidance for entry into contaminated or airborne-activity areas
- [Job category redacted] concerns about internal radiation dosimetry
- Required bioassay monitoring for all [job category redacted] personnel
- When routine bioassay monitoring is necessary
- The Incident Sampling Procedure and suggested revisions

As a result of that meeting, a follow-up memo was issued on October 12, 1992 showing that [job category redacted] management and SNL Internal Dosimetry personnel agreed upon the following (Internal Dosimetry, 1992-1993, PDF p. 8):

- A baseline urinalysis and whole-body count would be required for all current and new [job category redacted] personnel.

- [Job category redacted] personnel were to inform their department manager of any suspected internal exposure to radioactive materials and of involvement in any radiological incident/accident, such as an inhalation, personal contamination, or skin break that could result in the intake of radioactive materials. Bioassay sampling may be required at that time. The "Incident Sampling" procedure (PRDP-21-04) would be followed in handling these incidents.

- [Job category redacted] personnel would participate in a routine bioassay program (i.e., whole-body counts and urinalysis would be required on an annual basis). Lead Internal Dosimetry personnel would calculate appropriate bioassay frequency if annual screening was not deemed sufficient. A termination whole-body count and urinalysis would be required for all [job category redacted] personnel.

- If routine bioassays of radiation workers who performed "hands-on" work indicated positive exposures, required bioassays would be expanded to include any [job category redacted] personnel who may have been present when the exposures occurred. Air sampling and contamination surveys would also be used in determining if special bioassays were needed.

- An Internal Dosimetry staff member would make arrangements with [designated [job category redacted] representatives] to accompany [job category redacted] personnel on routine duties in Area V. This would enable Internal Dosimetry staff to evaluate the necessity of a greater monitoring frequency in the routine bioassay program.

- The draft "Incident Sampling" procedure, PRDP-21-04 was reviewed by all present. The only necessary edit was a clarification of "skin break" guidance for individuals.

Another October 1992 memo (Internal Dosimetry, 1992-1993, PDF p. 12) from SNL's Radiation Dosimetry Program Lead confirmed the above agreements. It also reiterated that urinalysis and whole-body counting would be performed annually on all [department name redacted] personnel and that additional, appropriate bioassay would be performed if any personnel were directly involved in an incident or in the event that reportable dose was received by any non-Department monitored worker with whom that employee was involved. This memo also noted that the Fiscal year 1993 budgets would not cover total program costs and negotiations were still needed.

Following the aforementioned events and agreements, bioassay samples were submitted by 37 [job category redacted] individuals. However, these samples were all submitted to CEP[2] and, as such, the results were determined to be invalid. It does not appear that the individuals submitting these samples were ever resampled. An evaluation of the CEP incident (CEP, 1995) indicated that of the 533 total samples submitted to CEP:

1. 461 were baseline samples
2. 39 individuals sampled for cause but other sufficient data indicated no exposure
3. 24 individuals that were being resampled due to exposure potential at Sandia
4. 10 individuals that were being resampled due to exposure during [action redacted].

Individuals in category 1 and 2 were not resampled. It is likely that the [job category redacted] would have been in these categories.

During the period from January 1, 1997 to May 11, 2011, there are no internal monitoring records for any [job category redacted] personnel based on a comparison of the listing of [job category redacted] personnel provided by Sandia (Personnel, 2014) against the WebDose extract (WebDose, 2018). An interview with a [function name redacted] manager indicated that this is consistent with procedures and [job category redacted] work status during that period. While [job category redacted] workers are given general employee training (GERT), they are not considered radiological workers (Personal Communication, 2018a). As for all non-radiological workers, [job category redacted] personnel typically do not reside in close proximity to active radiological operations involving unsealed radioactive materials. [Description redacted] for radiological work are typically [description redacted] with [job category redacted] personnel occupying areas outside the [location redacted]. The analysis in Section 7.2.1.2 used air-monitoring data for individuals working inside radiological areas without considering any respiratory protection that was worn. [Job category redacted], who are stationed outside of these radiological work areas, would be subject to even lower exposure levels.

In summary, as indicated in Section 7.2.3, internal exposure to unmonitored individuals can be bounded by application of a presumptive annual exposure of 100 mrem CEDE consistent with the monitoring threshold contained in 10 C.F.R. pt. 835, and as supported by available radiological survey data.

[2] 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.

7.5 Other Potential SEC Petition Issues 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 that remain germane to this Addendum 2 evaluation are discussed below:

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

  RESPONSE: NIOSH acknowledges that retrieval of air-monitoring data continues to be problematic for the period under evaluation. However, the air-monitoring data that have been retrieved support the supposition in Section 7.2.3 that internal exposure to an individual in excess of 100 mrem per year is unlikely.

- ISSUE: *Some Claimant Data Supplied by SNL Has Been Incomplete*

  RESPONSE: Issues related to the irretrievability of claimant internal monitoring are discussed in Section 7.1.1.

- ISSUE: *Employee Concerns about Availability of Data Related to a Radiological Incident*

  RESPONSE: Two employee concerns were raised during the preparation of this addendum. They were both raised in a phone interview with NIOSH and ORAU Team personnel to specifically address these concerns (Personal Communication, 2018b). The concerns addressed are:

  - An individual with radiological worker training performed work (described as [nature of work redacted]) in [location redacted], but was not issued [description redacted]. NIOSH has requested this individual's exposure records and confirmed that the individual was issued [description and date ranges redacted]. The only exception was the period [date range redacted], during which time no [description redacted] was issued. The absence of issued [description redacted] between [date range redacted] would not preclude the performance of a claimant-favorable dose reconstruction because there is available co-worker data for this period that may be used (ORAUT-OTIB-0072).

  - During work on a [description redacted] system, a [action and consequence redacted]. The RCT monitored the release point with a swab and indicated that the swab 'set the meter off scale.' The RCT stopped the job and instructed the individuals to submit bioassay samples for seven days. Prior to the seven days passing, the RCT indicated that the meter was not calibrated correctly and that bioassay samples would no longer need to be collected. The concern raised was that the workers were never provided the results of the bioassay samples. NIOSH has obtained monitoring records for all [number redacted] individuals and confirmed the presence of closely-spaced tritium bioassay samples for all [number redacted] individuals in [date redacted] (which is consistent with the time frame indicated for the event). Sandia did not assign any internal dose based on these samples (i.e., they are indicative of exposure below the reporting levels). A claimant-favorable dose reconstruction would be able to be performed using these bioassay data.

7.6 Summary of Feasibility Findings for Petition SEC-00188

This report provides feasibility conclusions for completing dose reconstructions for employees at the SNL-A site from January 1, 1997 through May 21, 2011. NIOSH found that the available monitoring records, process descriptions, and source term data available are sufficient to complete dose reconstructions for the evaluated class of employees.

Table 7-2 summarizes the results of the feasibility findings at Sandia National Laboratories - Albuquerque during the period from January 1, 1997 through May 21, 2011.

Table 7-2: Summary of Feasibility Findings for the SEC-00188 Addendum 2

Source of Exposure	Reconstruction Feasible for January 1, 1997-May 21, 2011? (Yes or No)
Internal (all radionuclides)	Yes
External (Gamma, Beta, Neutron, Occupational Medical X-ray)	Yes*

* External dose reconstruction feasibility was previously evaluated and presented in the 2012 Evaluation Report (NIOSH, 2012). No information or materials captured since the 2012 evaluation alter its conclusions.

As of January 7, 2019, a total of 275 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 233 individuals (~85%).

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 employees 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.

This present evaluation is specific to internal dose reconstruction feasibility at SNL-A for the period from January 1, 1997 through May 21, 2011. NIOSH concludes that it has access to sufficient information to estimate the maximum radiation dose for every type of cancer for which radiation doses are reconstructed, and that could have been incurred in plausible circumstances by any member of the class for the period from January 1, 1997 through May 21, 2011.

NIOSH's evaluation determined that it is feasible to estimate radiation dose for members of the NIOSH-evaluated class with sufficient accuracy based on the sum of information available from available resources. Therefore, a health endangerment determination is not required.

9.0 Class Conclusion for Petition SEC-00188

Based on its full research of the class under evaluation, NIOSH found no part of said class for which it cannot estimate radiation doses with sufficient accuracy. This class includes all on-site personnel who worked at the Sandia National Laboratory-Albuquerque site from January 1, 1997 through May 21, 2011.

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 radiation dose for the class under evaluation.

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Attachment One: Summary of Internal and External Assessments

NIOSH reviewed 20 internal and external assessments of the SNL-A radiation protection programs generated between 1997 and 2008 (see Section 7.2.1.3). The assessments were performed by Sandia personnel, SNL's "External Advisory Board," DOE's Independent Oversight and Performance Assurance (in 2003, 2005 and 2008), and the Inspector General's Office (in 2008). Table A1-1 summarizes these assessments.

Table A1-1: Internal and External Assessments of the SNL-A Radiation Protection Programs

Document Title	Year	Findings and Comments	SRDB Ref ID
Area Monitoring Checklists	1997	Contains area and contamination monitoring checklists: Bldg. 870 (Room 1004); SPR Breezeway; HCF; Bldg. 905 Rm 1100G; PBFA-Z; Hermes III Exposure Cell; Bldg. 884 Rooms 1E and 10; Bldg. 805 Room 123. One issue with CAM placement is noted, but indicates that source term changes had diminished the necessity for that CAM.	146852
Monitoring in the Workplace Self-Assessment	1997	Internal assessment of Program Content and Program Implementation. For Program Content: unclear links noted between the Radiation protection Program Manual (RPPM) and 10 C.F.R. 835 requirements; out-of-date Quality Functional Deployment (QFD) matrix maintenance; inconsistent procedure information; RPOs lacking review cycles. For Program Implementation: required surveys being performed; improperly monitored operation in Bldg. 884 (promptly corrected); an air-sampling procedure that was not being implemented (i.e., no air samples taken) because it had not been distributed (poor RPO and RPRE integration); inappropriate waste accumulation in the HCF and Building 805 Room 123.	146864
Radiation Protection - Phase I Appraisal (98-I-002)	1998	Nine concerns and one observation were documented. All are generally related to weaknesses in program documentation and delineation of roles and responsibilities. Contains a memo addressing in detail an ES&H finding regarding discrepancies between airborne concentration monitoring requirements and 10 C.F.R. 835 DACs. The Dosimetry Subject Matter Expert (SME) pointed out the differences between stochastic and non-stochastic DACs, which resolved the issue originally raised.	35469
Interim Report - ES&H and Quality Appraisal of the Radiation Protection Program.	1998	Several Strengths were noted along with some non-critical Observations. One Issue: The current 3-year limitation on staff augmentation contractors has increased the difficulty of recruiting and maintaining critical RP personnel.	146863
Rad Ops Self-Assessment - Radiation Standards Facility, Building 818	1998	Used SNL's Radiological Operation Self-Assessment Checklist. The checklist "follows the SNL's RPPM." Series of questions answered Y/N/NA. Passed with no problems identified short of one minor labeling issue that was noted and slated for correction.	146869
Report of Assessment of SNL Radiation Protection Program	1998	Internal review of Sandia Radiation Protection Program. Identified issues with configuration management for procedures and traceability of requirements implementation.	146871

Document Title	Year	Findings and Comments	SRDB Ref ID
Radiation Protection Safety Committee Triennial Self-Assessment Report	1999	Forty-five (45) findings were identified as potential minor non-compliances. These were in the areas of Entry Control, Training, Monitoring, Posting and Labeling, and Records. Of the 13 monitoring findings, 10 were related to deficiencies in either area monitoring or individual monitoring not being performed. The other 3 were related to monitoring being performed, but inadequately. No areas of improvement were identified in the review of RPPM monitoring chapters. The majority of deficiencies were personnel error (inattention to detail) and the RPSC will communicate lessons learned back to the line. All 4 records findings were the result of either records being lost or not properly created and managed; the cause of these findings were not the RP Program documentation process, but rather personnel error (inattention to detail). No findings were categorized as PAAA-significant non-compliances.	146866
Self-Assessment of Department 7124, Radiation Protection Line Support Team	2000	One Finding and 7 Observations. Issues related to survey documentation and area postings.	146872
Radiation Protection Operations & Support Self-Assessment Checklist	2001	One of the line self-assessments. Review of entry requirements, postings and survey documentation. No significant findings.	146865
Triennial Self-Assessment of the Rad Protection Source and Device Program	2001	No findings were identified as non-compliant with the RPPM, 10 C.F.R. 835, or DOE N 441.1.	146874
Radiation Protection Safety Committee Triennial Self-Assessment Report	2002	Twenty-one (21) RPPM non-conformances identified, including: Work Planning and Controls (5); Training (5); Source Control (3); Radiation-Generating Device Control (5). All judged of minor consequence. No systemic or programmatic issues identified.	146867
External Advisory Board (EAB) Meeting of April 7-9, 2003	2003	Discussions and activities included: continuing efforts on retraining RCTs; shadowing visits with the RCTs; follow-up regarding internal audits and participation with the DOE-wide EFCOG Committee. EAB still concerned about the line organization in TA 4, the ES&H support team, and the RPP staff. The production on neutrons in the Z-machine facility became known to the Radiation Protection staff only in announcements in the Sandia Employee Newsletter and the local newspaper. The Board believes that these are examples of a less-than-proactive relationship between the TA 4 line organizations and the 3100 organization.	146855
External Advisory Board (EAB) Meeting of August 25-27, 2003	2003	Discussions and activities included: continuing efforts on retraining RCTs; shadowing visits with the RCTs; field visit to the sled track and the soil contamination area evaluation; continued follow-up regarding internal audits. Many favorable efforts noted regarding RCTs, RMWMF operations, and Hot Cell. Some suggestions and complaints, but nothing of a safety significance. The EAB is concerned about the line organization in TA 4, the ES&H support team, and the RPP staff; they should be strengthened and more proactive.	146856
External Advisory Board (EAB) Meeting of February 10-13, 2003	2003	Discussions and activities included: internal self-assessment program; ALARA review at the RMWMF facility; follow-up on instrumentation calibration training for RCTs; the project leaders meeting; and tour of the Monzano bunkers.	146857
External Advisory Board (EAB) Meeting of October 6-8, 2003	2003	Discussion included: the sled track soil contamination area evaluation; neutron dosimetry in accelerator facilities (suggestions made for better monitoring approach; however, no outright accusations of missed exposures); laboratory layout and design; data bias questions related to liquid-scintillation counting.	146858

Document Title	Year	Findings and Comments	SRDB Ref ID
Radiation Protection Safety Committee Triennial Self-Assessment Report	2005	Roll-up report of the line self-assessments. The most significant results were the large increase in training non-conformances. The report notes upfront that "the reported non-conformances have minor safety significance in and of themselves. Personnel did not receive unnecessary radiation exposure, radioactive contamination did not spread out of established boundaries, and there was no loss-of-control of radioactive material."	146862
EAB Visit of April 25-27, 2005	2005	Visit entailed: EAB Follow-up ALARA review of the RPLS Laboratory and Office Building; Building 1090 Design Review; Tech Area IV optimization of decisions regarding replacement or refurbishment of components for Z machine and RITS machine.	146853
External Advisory Board Visit of October 23-25, 2006	2006	Primarily called upon to investigate positive dosimeter readings. Actions included: review of glow curves; discussion of neutron exposures and dosimetry; Administrative Control Level (ACL) discussions held; status of ZR machine, ACRR, and SPR discussed.	146860
External Advisory Board Visit of August 20-22, 2007	2007	Discussions included: development of the electronic radiation survey system (VSDS); WebREMS software system implementation in TA-V; Neutron Dosimetry & Neutron Spectral Measurements Phantoms; update of DOELAP accreditation issues; implementation of new (2007) 10 C.F.R. 835 revisions; instrumentation funding; shadow visits; staff training; thoriated welding rods.	146859
Independent Oversight Inspection of Environment, Safety and Health Programs at the Sandia National Laboratory	2008	All findings were related to ES&H programs; there were no analyses specific to Radiation Protection Program elements.	80357

Attachment Two: Summary of Pertinent NTS Reports

NIOSH reviewed the DOE Noncompliance Tracking System (NTS) for SNL-A 10 C.F.R. pt. 835 violations, site responses, and corrective actions (see Section 7.2.1.3). Of the 171 SNL report titles listed, 72 were considered potentially relevant and reviewed. Table A2-1 summarizes the seven reports considered pertinent to compliance with 10 C.F.R. § 835.402(c)(1) or 10 C.F.R. § 835.702(a).

Table A2-1: Summary of NTS Reports Pertinent to 10 C.F.R. § 835.402(c)(1) or 10 C.F.R. § 835.702(a) Compliance

Title	Summary	SRDB Ref ID
Inspection of Environment, Safety and Health Management	The DOE Office of Independent Oversight reported 8 findings, one of which was the WM subcontractor did not have sufficient formality in the implementation of RC consistent with the ES&H manual (i.e., by not clearly identifying controls and job-specific RWPs that were documented and understood by the workers).	165468
Laboratories Wide Radiation Protection Self-Assessment for Compliance with 10 C.F.R. § 835.102	1999 tri-annual review was completed, which included Self-Assessment Requirements Documents (SARDs).	165473
NTS Report for PNOV EA-1999-03	The DOE Office of Enforcement and Investigation, EH-10, conducted a review of the SNL Price Anderson Amendments Act program in March 1999. EH-10 analyzed a series of SNL events and activities that occurred during 1997 and 1998, and identified potential violations of DOE nuclear safety requirements.	165480
Neptunium (Np) Oxide Spill in Building 819	Multiple issues with a spill of Np-oxide and poor RP controls before and after incident; no RWP sign in; improper monitoring. Radiological surveys conducted subsequent to the event indicated that there was no spread of contamination to uncontrolled areas. Bioassays conducted on personnel involved with the work indicated that there was no internal intake of radioactive material. Personnel dosimetry readings show that there was no measurable exposure to radiation during the event.	165491
Lapel Monitoring Not Performed during Waste Sorting Activities Radiological Work Permit Violations	On [date redacted], a waste-sorting team at the Radioactive Mixed Waste Management Facility (RMWMF) failed to wear lapel air monitors during one waste-sorting session, as required by the applicable Radiological Work Permit (RWP). The sorting team members, comprised of [numbers and job titles redacted], were wearing respirators. Based on room air sampling results, the team did not receive any internal exposure from the waste-sorting activity. The workers involved had previously worn lapel monitors along with their respirators during similar sorting evolutions.	165530
Internal Dosimetry Process	Failure to review 50 anomalous (unconfirmed positive) bioassays for 24 individuals from September 2009 to May 2012. Follow-up on these samples was not performed in a timely manner; however, a preliminary review conducted at the time the issue was identified indicated that no exposures in excess of the administrative control level (100 mrem) were likely. This discovery was made during a review of the Radiation Protection Dosimetry Project (RPDP) Internal Dosimetry Technical Basis Document (TBD).	165539
Repetitive Deficiencies in Radiological Work Control Practices and Control of Radioactive Materials	As a result of the SNL PAAA Review Committee screening, a number of events were documented via the SNL Radiological Process Improvement Reports (RPIRs). SNL submitted this NTS report to identify programmatic deficiencies associated with establishing and maintaining controls for radioactive materials, and the documentation, use, and adherence to technical work documents governing radiological work. Some deficiencies involved discovery of unlabeled radioactive materials stored outside radioactive materials areas. Exposure rates were very low.	165483

Attachment Three: Data Capture Synopsis

Attachment Three is a summary of SRDB holdings that pertain to the SEC-00188 Addendum evaluation efforts. Table A3-1 includes documents that were captured between January 26, 2012 and February 28, 2019 for the purpose of evaluating the post-1994 years. These efforts are in addition to the data capture efforts previously detailed in Attachment One of the SEC-00188 Petition Evaluation Report.

Table A3-1: Summary of Holdings in the SRDB for Sandia National Laboratories-Albuquerque Captured between January 26, 2012 and February 28, 2019

Data Capture Information	General Description of Documents Captured	Date Completed	Uploaded
Sandia National Laboratories - Albuquerque, New Mexico	Site and area-specific environmental reports, SANDOS and WebDose dosimetry databases, radiation protection and dosimetry procedures, bioassay requests, audits and assessments, a list of cancelled procedures, incident tracking, neutron measurements, air sample results, air sample DAC-hr and dose reports, bioassay reports, bioassay assignments, the technical basis for air-monitoring, specific bioassay procedures, DOELAP assessments, failure analyses, and accreditations, radiological technical work documents, radiological work permits, external Advisory Board meeting minutes, listings and bioassay results of selected personnel, radiological incident response, lapel sample results, the technical basis for implementing air sampling, and the response to Data Request Sandia-FY18-004, complete radiation dose histories for selected workers, analysis of a bioassay review deficiency, the interpretation of WebDose results, tallies of captured breathing zone air sampling results, and a list of SNL, NM assessments.	Ongoing (Additional BZ monitoring data have been requested.)	538
Cincinnati Public Library	Fission and activation product production, Mo-99 production and waste processing, improved accelerator shielding calculations, photoneutron production, and neutron effects in gallium arsenide laser diodes.	05/02/2012	6
DOE Germantown	A NIOSH researcher's notes from the review of classified documents.	03/18/2014	1
Internet - DOE Noncompliance Tracking System (NTS)	NTS radiological incident reports including program deficiencies, contamination events, radiation exposure events, radioactive material releases, discoveries of legacy material and contamination, unqualified personnel performing surveys, radiological work permit violations, loss of control of radioactive material, radioactive material spills, posting violations, radioactive material quantities exceeding authorization bases, survey and monitoring deficiencies, quality assurance deficiencies, and training deficiencies.	02/07/2017	73

Data Capture Information	General Description of Documents Captured	Date Completed	Uploaded
Internet - DOE Occurrence Reporting and Processing System (ORPS)	ORPS radiological reports including contamination events, unauthorized entries into radiological areas, procedural violations, failure to monitor shipping containers, radioactive material releases, radioactive material and contamination in uncontrolled areas, loose contamination found outside posted contamination areas, work conducted without required bioassay, unanticipated radiation exposures, loss of control of radioactive material, discoveries of legacy materials and contamination, identification of a previously unrecognized radiological area, radiological work permit violations, improper transfer and transportation of radioactive material, failures to follow procedures, tritium leaks from equipment, and a tritium stack release.	06/29/2017	187
Internet - DOE Office of Scientific and Technical Information (OSTI) Energy Citations	The fourth revision of Sandia acronyms, initialisms, and abbreviations.	05/07/2012	1
Internet - DOE Office of Scientific and Technical Information (OSTI) Information Bridge	Institutional plans, emergency preparedness approach, building hazard analyses, management of depleted uranium, a laboratory history, transportation technology, and the environmental baseline.	04/17/2013	9
Internet - DOE Office of Scientific and Technical Information (OSTI) SciTech Connect	The proceedings of a fast burst reactor workshop.	05/01/2018	1
Internet - Google	Z Machine fusion technology reports, a compliance self-assessment, occupational radiation exposure summaries, independent oversight audits, the FY 2014 ten-year site plan, the impact of switching to ICRP-74 neutron flux to dose rate conversion factors, the characterization of a neutron irradiation system, a preliminary notice of violation for 1997 and 1998 events, 1994 status reports on the implementation of the DOE radiological control manual, and the approach for determining the need for air sampling.	05/01/2018	22
Internet - National Institute for Occupational Safety and Health (NIOSH)	The February 2012 SEC-00188 Petition Evaluation Report, the May 2012 designation of a class of Sandia employees, minutes of the 70th meeting of the Advisory Board on Radiation and Worker Health, July 2018 Petition Evaluation Addendum Report, and the October 2018 HHS designation of additional members of the SEC.	01/20/2019	5
Internet - Sandia National Laboratories - Albuquerque, New Mexico	Security requirements for contracted escorts.	12/18/2018	1
NIOSH	A NIOSH Research Health Scientist's meeting and research notes, an ORAU Team Health Physicist's meeting notes, the tables list for the WebDose database, the tables list for the SANDOS database, a draft internal dosimetry database, and occupational dose records for 23 selected workers.	03/02/2016	11

Data Capture Information	General Description of Documents Captured	Date Completed	Uploaded
ORAU Team	The Sandia Site Profile, the report of a 2007 data capture trip, a 1995 to 2011 Nuclear Materials Management and Safeguards System report, documented communications with key Sandia personnel, and a radiation protection self-assessment listing.	12/20/2018	25
Personal Files – [Name redacted]	Office of Oversight radiological protection task team reports.	07/16/2018	1
Sandia National Laboratory - Livermore, California	Interview notes of SNL, CA personnel.	04/29/2013	1
TOTAL	Not applicable	Not applicable	**882**