SEC Petition Evaluation Report
Petition SEC-00093

Report Rev #: 1

Report Submittal Date: April 28, 2009

Subject Expert(s):	Ray Clark, Gene Potter
Site Expert(s):	NA

Petition Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition B Qualification Date	DOE/AWE Facility Name
SEC-00093	83.13	October 19, 2007	Santa Susana Field Laboratory-Area IV

Petitioner Class Definition
All employees who worked in all areas of Santa Susana Field Laboratory-Area IV during the time period from 1955 to the present (which incorporated the post-1987 remediation period).

Class Evaluated by NIOSH
All employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors who worked at Area IV of the Santa Susana Field Laboratory from January 1, 1955 through December 31, 1965.

NIOSH-Proposed Class(es) to be Added to the SEC
All employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors who worked in any area of Area IV of the Santa Susana Field Laboratory for a number of work days aggregating at least 250 work days from January 1, 1955 through December 31, 1958, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

Related Petition Summary Information			
SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
N/A	N/A	N/A	N/A

Related Evaluation Report Information	
Report Title	DOE/AWE Facility Name
N/A	N/A

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Peer Review Completed By:	[Signature on file] *Lara Hughes*	4/28/2009 *Date*
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Evaluation Report Summary: SEC-00093, Santa Susana Field Laboratory-Area IV

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

Petitioner-Requested Class Definition

Petition SEC-00093, qualified on October 19, 2007, requested that NIOSH consider the following class: *All employees who worked in all areas of Santa Susana Field Laboratory-Area IV during the time period from 1955 to the present (which incorporated the post-1987 remediation period).*

Class Evaluated by NIOSH

Based on its preliminary research, NIOSH reduced the petitioner-requested class to a class that includes the time period from January 1, 1955 through December 31, 1965. NIOSH evaluated the following class: *All employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors who worked at Area IV of the Santa Susana Field Laboratory from January 1, 1955 through December 31, 1965.*

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

Based on its full research, NIOSH modified the petitioner-requested class to define a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The revised NIOSH- proposed class includes *all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors who worked in any area of Area IV of the Santa Susana Field Laboratory for a number of work days aggregating at least 250 work days from January 1, 1955 through December 31, 1958, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.*

NIOSH cannot estimate internal exposures with sufficient accuracy during the period from 1955 through 1958 (which is a period with limited internal monitoring data). This includes the time from the beginning of Area IV radiological activities in 1955, to late 1958 (selected as December 31, 1958 for SEC evaluation purposes). This timeframe corresponds with the date after which an established bioassay program existed at SSFL and after which sufficient internal monitoring has been identified. With the exception of the class above, NIOSH has obtained sufficient information to support bounding doses for the entire evaluation period.

In its original evaluation report (Rev. 0) for SEC00093, the NIOSH proposed class definition to included *all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors who were monitored while working in any area of Area IV of the Santa Susana Field Laboratory for a number of work days aggregating at least 250 work days from*

January 1, 1955 through December 31, 1958, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

The class definition proposed by NIOSH in revision 0 was based on the infeasibility of reconstructing internal doses for the period from January 1, 1955 to December 31, 1958. Information available at the time Revision 0 of the report was completed indicated that all workers with the potential for internal exposures would have been monitored with a radiation dosimeter badge. The change in proposed class definition was triggered by additional information collected by NIOSH indicating that there was a possibility that not all workers who entered controlled areas were necessarily monitored for external radiation exposure. Because of this, NIOSH can not definitively rule out the possibility that some unmonitored workers could have incurred internal exposures.

Feasibility of Dose Reconstruction

NIOSH cannot estimate internal exposures with sufficient accuracy during the period from 1955 through 1958 (which is a period with limited internal monitoring data). This includes the time from the beginning of Area IV radiological activities in 1955, to late 1958 (selected as December 31, 1958 for SEC evaluation purposes). This timeframe corresponds with the date after which a routine bioassay program existed at SSFL and after which sufficient internal monitoring has been identified. With the exception of this class, 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 maximum dose. Information available from the site profile and additional resources is sufficient to document or estimate the maximum internal and external potential exposure to members of the evaluated class under plausible circumstances during the specified period from 1959-1965.

Health Endangerment Determination

Per EEOICPA and 42 C.F.R. § 83.13(c)(3), a health endangerment determination is required because NIOSH has determined that it lacks sufficient internal monitoring data for the period from January 1, 1955 through December 31, 1958, which prevents evaluating internal dose with sufficient accuracy for the members of the proposed class during this period.

NIOSH did not identify any evidence supplied by the petitioner or from other resources that would establish that members of the proposed worker class were exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. However, evidence indicates that some workers in the proposed class may have accumulated substantial chronic exposures through episodic intakes of radionuclides, combined with external exposures to gamma, beta, and neutron radiation. Consequently, NIOSH has determined that health was endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class or in combination with work days within the parameters established for one or more other classes of employees in the SEC (excluding aggregate work day requirements).

Table of Contents

Tables

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SEC Petition Evaluation Report for SEC-00093

ATTRIBUTION AND ANNOTATION: This is a single-author document. All conclusions drawn from the data presented in this evaluation were made by the ORAU Team Lead Technical Evaluator: Ray Clark, Oak Ridge Associated Universities. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for all employees who worked in any area of Santa Susana Field Laboratory-Area IV during the time period from January 1, 1955 to December 31, 1965. It provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created SEC.

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

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

2.0 Introduction

Both EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting that the Department of Health and Human Services (HHS) add a class of employees to the SEC. The evaluation is intended to provide a fair, science-based determination of whether it is feasible to estimate with sufficient accuracy the radiation doses of the class of employees through NIOSH dose reconstructions.[1]

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

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

[1] NIOSH dose reconstructions under EEOICPA are performed using the methods promulgated under 42 C.F.R. pt. 82 and the detailed implementation guidelines available at http://www.cdc.gov/niosh/ocas.

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

NIOSH is required to document its evaluation in a report, and to do so, relies upon both its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the petitioner(s) and to the Advisory Board on Radiation and Worker Health (Board). The Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Board considers appropriate, in order to make recommendations to the Secretary of HHS on whether or not to add one or more classes of employees to the SEC. Once NIOSH has received and considered the advice of the Board, the Director of NIOSH will propose a decision on behalf of HHS. The Secretary of HHS will make the final decision, taking into account the NIOSH evaluation, the advice of the Board, and the proposed decision issued by NIOSH. As part of this decision process, petitioners may seek a review of certain types of final decisions issued by the Secretary of HHS.[2]

3.0 Petitioner-Requested Class/Basis & NIOSH-Proposed Class/Basis

Petition SEC-00093, qualified on October 19, 2007, requested that NIOSH consider the following class for addition to the SEC: *All employees who worked in all areas of Santa Susana Field Laboratory-Area IV during the time period from 1955 to the present (which incorporated the post-1987 remediation period).*

The petitioner provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the Santa Susana Field Laboratory (SSFL)-Area IV workers in question. NIOSH deemed the following information and affidavit statements sufficient to qualify SEC-00093 for evaluation:

> As identified in Item F.1 of the SEC-00093 Form B and discussed in the July 30, 2007 call, the petitioner discussed the sodium burn pit, the lack of internal monitoring data, and indicated that no records were kept. The petitioner also discussed a Tiger Team report, indicating that the report detailed "inadequate air monitoring" and that "no internal monitoring was done."

The information and statements regarding the lack of pre-1959 internal monitoring data qualified the petition for further consideration by NIOSH, the Board, and HHS. NIOSH determined that the time period from 1955 to 1965 should qualify for the purposes of the SEC petition evaluation, which includes the employment period in the original SEC-00093 petition. The details of the petition basis are addressed in Section 7.4.

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

Based on its research, NIOSH reduced the petitioner-requested class to define a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The revised NIOSH-proposed class includes all employees who worked in all areas of Area IV of the Santa Susana Field Laboratory from January 1, 1955 through December 31, 1958. The petitioner-requested class was reduced in scope as a result of the petition qualification review discussed above and the feasibility evaluation documented in Section 7.0. With the exception of the class above, NIOSH has obtained sufficient information to support bounding doses for the entire evaluation period.

NIOSH cannot estimate internal exposures with sufficient accuracy during the period from 1955 through 1958 (which is a period with limited internal monitoring data). This includes the time from the beginning of Area IV radiological activities in 1955, to late 1958 (selected as December 31, 1958 for SEC evaluation purposes). This timeframe corresponds with the date after which an established bioassay program existed at SSFL and after which sufficient internal monitoring has been identified.

In its original evaluation report (Rev. 0) for SEC00093, the NIOSH proposed class definition to included all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors *who were monitored while working* in any area of Area IV of the Santa Susana Field Laboratory from January 1, 1955 through December 31, 1958.

The class definition proposed by NIOSH in revision 0 was based on the infeasibility of reconstructing internal doses for the period from January 1, 1955 to December 31, 1958. Information available at the time Revision 0 of the report was completed indicated that all workers with the potential for internal exposures monitored with a radiation dosimeter badge. The change in proposed class definition was triggered by additional information collected by NIOSH indicating that there was a possibility that not all workers who entered controlled areas were necessarily monitored for external radiation exposure. Because of this, NIOSH can not definitively rule out the possibility that some unmonitored workers could have incurred internal exposures.

4.0 Data Sources Reviewed by NIOSH

NIOSH identified and reviewed numerous data sources to obtain information relevant to determining the feasibility of dose reconstruction for the class of employees proposed for this petition. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. The following subsections summarize the data sources identified and reviewed by NIOSH.

4.1 Site Profile and Technical Basis Documents (TBDs)

A Site Profile provides specific information concerning the documentation of historical practices at the specified site. Dose reconstructors can use the Site Profile to evaluate internal and external dosimetry data for monitored and unmonitored workers, and to supplement, or substitute for, individual monitoring data. A Site Profile consists of an Introduction and five Technical Basis Documents (TBDs) that provide process history information, information on personal and area monitoring, radiation source descriptions, and references to primary documents relevant to the radiological operations at the site. The Site Profile for a small site may consist of a single document. As part of NIOSH's evaluation detailed herein, it examined the following TBDs for insights into SSFL-Area IV operations or related topics/operations at other sites:

- *Atomics International – Introduction*, ORAUT-TKBS-0038-1; Rev. 01; August 30, 2006; SRDB Ref ID: 30080

- *Energy Technology Engineering Center – Site Description*, ORAUT-TKBS-0038-2; Rev. 00; February 2, 2006; SRDB Ref ID: 22140

- *Area IV of the Santa Susana Field Laboratory, the Canoga Avenue Facility (Vanowen Building), the Downey Facility, and the De Soto Avenue Facility (sometimes referred to as Energy Technology Engineering Center)– Occupational Medical Dose*, ORAUT-TKBS-0038-3; Rev. 02; October 31, 2008; SRDB Ref ID: 53184

- *Area IV of the Santa Susana Field Laboratory, the Canoga Avenue Facility (Vanowen Building), the Downey Facility, and the De Soto Avenue Facility (sometimes referred to as Energy Technology Engineering Center [ETEC] or Atomics International) – Occupational Environmental Dose*, ORAUT-TKBS-0038-4; Rev. 01; March 8, 2007; SRDB Ref ID: 30622

- *Energy Technology Engineering Center – Occupational Internal Dose*, ORAUT-TKBS-0038-5; Rev. 00; February 22, 2006; SRDB Ref ID: 22287

- *Atomics International – Occupational External Dose*, ORAUT-TKBS-0038-6; Rev. 01; November 16, 2006; SRDB Ref ID: 30082

4.2 ORAU Technical Information Bulletins (OTIBs) and Procedures

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

- *OTIB: Estimating the Maximum Plausible Dose to Workers at Atomic Weapons Employer Facilities*; ORAUT-OTIB-0004; Rev. 03 PC-2; December 6, 2006; SRDB Ref ID: 29949

- *OTIB: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*; ORAUT-OTIB-0006; Rev. 03; August 2, 2005; SRDB Ref ID: 19422

- *OTIB: A Standard Complex-Wide Methodology for Overestimating External Doses Measured with Film Badge Dosimeters*; ORAUT-OTIB-0010; Rev. 01; June 5, 2006; SRDB Ref ID: 29953

- *OTIB: Interpretation of Dosimetry Data for Assignment of Shallow Dose*; ORAUT-OTIB-0017; Rev. 00; January 19, 2005; SRDB Ref ID: 19435

- *OTIB: Internal Dose Overestimates for Facilities with Air Sampling Programs*; ORAUT-OTIB-0018; Rev. 01; August 9, 2005; SRDB Ref ID: 19436

- *OTIB: Use of Coworker Dosimetry Data for External Dose Assignment*; ORAUT-OTIB-0020; Rev. 0; December 29, 2004; SRDB Ref ID: 19441

- *OTIB: Application of Internal Doses Based on Claimant-Favorable Assumptions for Processing as Best Estimates*; Rev. 00; ORAUT-OTIB-0033; April 20, 2005; SRDB Ref ID: 19457

- *OTIB: Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses*; ORAUT-OTIB-0054; Rev. 00; May 11, 2007; SRDB Ref ID: 31780

- *OTIB: Technical Basis for Conversion from NCRP Report 38 Neutron Quality Factors to ICRP Publication 60 Radiation Weighting Factors for Respective IREP Input Neutron Energy Ranges*; ORAUT-OTIB-0055; Rev. 00; June 5, 2006; SRDB Ref ID: 29980

- *Procedure: Occupational Onsite Ambient Dose Reconstruction for DOE Sites,* ORAUT-PROC-0060; Rev. 01; June 28, 2006; SRDB Ref ID: 29986

- *Procedure: Occupational X-Ray Dose Reconstruction for DOE Sites*, ORAUT-PROC-0061; Rev. 01; July 21, 2006; SRDB Ref ID: 29987

4.3 Facility Employees and Experts

To obtain additional information, NIOSH interviewed five former SSFL employees. The interviews were conducted by two ORAU team members and each interview lasted approximately one hour.

- Personal Communication, 2007, *Personal Communication with Fireman*; Telephone Interview by ORAU Team; November 15, 2007 9:00 AM PST; SRDB Ref ID: 37532

- Personal Communication, 2007, *Personal Communication with Health Physicist*; Telephone Interview by ORAU Team; November 15, 2007 10:30 AM PST; SRDB Ref ID: 37536

- Personal Communication, 2007, *Personal Communication with Health Physicist*; Telephone Interview by ORAU Team; November 20, 2007 11:00 AM PST; SRDB Ref ID: 37534

- Personal Communication, 2007, *Personal Communication with HP-Radiation Engineer*; Telephone Interview by ORAU Team; November 29, 2007 1:00 PM PST; SRDB Ref ID: 37537

- Personal Communication, 2007, *Personal Communication with Health and Safety Manager*; Telephone Interview by ORAU Team; November 30, 2007 9:00AM PST; SRDB Ref ID: 37538

4.4 Previous Dose Reconstructions

NIOSH reviewed its NIOSH OCAS Claims Tracking System (NOCTS) to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. Table 4-1 summarizes the results of this review. (NOCTS data available as of April 21, 2009)

Table 4-1: No. of SSFL-Area IV Claims Submitted Under the Dose Reconstruction Rule

Description	Totals
Total number of claims submitted for dose reconstruction	247
Total number of claims submitted for energy employees who meet the evaluated class definition for the time period evaluated in this report (January 1, 1955 through December 31, 1965)	171
Number of dose reconstructions completed for energy employees who meet the evaluated class definition criteria	118
Number of claims for which internal dosimetry records were obtained for the identified years in the evaluated class definition	28*
Number of claims for which external dosimetry records were obtained for the identified years in the evaluated class definition	63

Notes:
*** One claim with pre-1959 internal monitoring data (available for September 1958); no internal data available prior to the initiation of an internal monitoring program for Area IV of the SSFL (program initiated in August 1958).**

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. Of the 171 claims that are within the period of this report, 166 have received responses to requests for site data. Of the 118 claims where the associated individual dose reconstructions have been completed, all 118 cases have been submitted to DOL.

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database to locate documents supporting the evaluation of the proposed class. Six hundred eighty-eight documents in this database were identified as pertaining to Area IV of the Santa Susana Field Laboratory. These documents were evaluated for their relevance to this petition. The documents include historical background on internal and external monitoring, program descriptions, process materials, process descriptions, dust sampling results, air monitoring data, urinalysis data, as well as information about the radiological control program and medical monitoring.

4.6 Documentation and/or Affidavits Provided by Petitioners

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

- *Petition Form B*; June 22, 2007; OSA Ref ID: 103252
- *Letter to Substantiate SEC Petition Application for the Santa Susana Field Laboratory*; [Name One Redacted]; June 30, 2007; OSA Ref ID: 103255
- *Under Pressure, DOE Halts Field Lab Cleanup for 45 Days*, newspaper article submitted with petition; Kerry Cavanaugh; May 26, 2007; OSA Ref ID: 103253
- *Order Granting Plaintiffs' Motion For Summary Judgments*, Natural Resources Defense Council, Inc., Committee to Bridge the Gap, and City of Los Angeles (Plaintiffs) versus Department of Energy, Spencer Abraham, Secretary, Department of Energy, and Camile Yuan-Soo Hoo,

Manager, National Nuclear Security Administration, Oakland Operations (Defendants); United States District Court; May 2, 2007; OSA Ref ID: 103253

- *Declaration of Arjun Makhijani*, expert testimony in legal case; February 12, 2004; OSA Ref ID: 103253

- *Living on Earth*, email containing interview that aired the week of January 20, 2006— containing comments by Arjun Makhijani; March 6, 2006; OSA Ref ID: 103253

- *Declaration of Bernd Franke*, expert testimony in legal case; February 12, 2004; OSA Ref ID: 103253

- *Curriculum Vitae for Bernd Franke*; OSA Ref ID: 103253

- *Santa Susana Field Lab (SSFL) Closure Plan*, letter from Julia Brownley; Julia Brownley, Assembly Member of the 41st District; May 4, 2007; OSA Ref ID: 103253

- *Statement of the Honorable John N. Hostettler, Chairman of the Subcommittee on Immigration, Border Security and Claims for the December 5, 2006 Oversight Hearing on the Energy Employees Occupational Illness Compensation Program Act—Are we Fulfilling the Promise We Made to These Veterans of the Cold War when We Created the Program?*; OSA Ref ID: 103253

- *Monthly Report—March, 1960; Chemical Disposal—Activities at Pits, Inspections, Burning, Convoying, Etc.;* Inter-office letter from E. G. Addeo to R. J. Madden; E. G. Addeo; April 4, 1960; OSA Ref ID: 103253

- *Various Pages from Journal*, pictures and pages from article that was published in *Ecology and Environment, Inc*.; author not identified; July 19, 1989; OSA Ref ID: 103253

- *EPA Concludes Superfund Evaluation of ETEC Area IV*, United States Environmental Protection Agency; December 2003; OSA Ref ID: 103253

- *Energy Employees Occupational Illness Compensation Program Act of 2000*, letter from [Name One Redacted] to Congressman Elton Gallegly; [Name One Redacted]; March 1, 2006; OSA Ref ID: 103253

- *H. R. 2242*, copy of H. R. 2243; 110th Congress, 1st Session; May 9, 2007; OSA Ref ID: 103253

- *The U.S. EPA Announces Results of Rocketdyne's Off-Site Sampling Program for the Santa Susana Field Laboratory*, EPA update; U. S. Environmental Protection Agency; July 1999; OSA Ref ID: 103253

- *Dose Construction* [sic] *for [Name Two Redacted]*, letter from [Name One Redacted] to Mr. Larry Elliott; [Name One Redacted]; June 4, 2006; OSA Ref ID: 103253

- *Commendation Regarding Uranium Fire, Canoga Facility, May 17, 1967*, J. E. Stewart; May 19, 1967; OSA Ref ID: 103253

- *Employment History/Monitoring Record*; Santa Susana Field Laboratory; October 28, 2005; OSA Ref ID: 103253
- *Statement from [Name Three Redacted]*, regarding work experiences at Rocketdyne; date not identified; OSA Ref ID: 103253
- *Site Visit to Santa Susana Field Laboratory Operated by Rockwell/Rocketdyne*, site visit memo; Gregg D. Dempsey; July 28, 1989; OSA Ref ID: 103253
- *Letter Regarding Request to Evaluate the Need for an Epidemiological Study of Workers and Community Residents Potentially Impacted by the Operations at Rockwell International Corporation's Santa Susana Field Laboratories*, letter to Dr. Robert Goldsmith from the Department of Health Services; Department of Health Services of California; October 5, 1990; OSA Ref ID: 103253
- *Statement of the Potential Health Risks Identified in the Santa Susana Field Laboratory Exposure Assessment Study*; Charles M. Haskell; February 4, 1991; OSA Ref ID: 103253
- *High-Level Radioactivity Found in Groundwater at Rocketdyne Lab*; Kerry Cavanaugh; May 19, 2004; OSA Ref ID: 103253
- *Higher Tritium Levels Found in Water at Field Lab*; Kerry Cavanaugh; 2005; OSA Ref ID: 103253
- *Studies of Atomic Bomb Survivors—Understanding Radiation Effects*, Editorial in the *Journal of the American Medical Association*, John D. Boice; August 1, 1990; OSA Ref ID: 103253
- *Excerpts from Unknown Report*; unknown author; unknown date; OSA Ref ID: 103253, pages 151 and 154
- *Project History Excerpts from Unknown Report*; unknown author; unknown date; OSA Ref ID: 103253, pages 155 and 156
- *Dispute Surfaces on Rocketdyne Deaths Study*, newspaper article; Mack Reed; July 11, 1995; OSA Ref ID: 103253
- *Rocketdyne Worker Health Study Summary*; California Department of Health Services, Occupational Health Branch; date not identified; OSA Ref ID: 103253
- *Lab Linked to Cancer Risk*, article in the *Los Angeles Times*; Mack Reed and Thomas H. Maugh; September 12, 1997; OSA Ref ID: 103253
- *Incident Report Regarding Oxidation Reaction of Uranium*; D. E. Owens; October 27, 1964; OSA Ref ID: 103700

- *Radiation Safety Progress for November 1966*, regarding a sodium reactor experiment; author unknown; December 9, 1966; OSA Ref ID: 103701

- *Letter Regarding SSFL-Area IV Dose Reconstruction Case*, includes dose reconstruction with attached DR Report and handwritten statements/notes; [Name One Redacted]; September 6, 2007; OSA Ref ID: 103702

- *Interim Final RCRA Facility Assessment Report for Rockwell International Corporation*, TZ4-R09015-RN-M07933; Science Applications International Corporation, Technology Services Company; July 10, 1991; OSA Ref ID: 103715

- *Email from Petitioner*, sent to OCAS requesting document be added to petition; [Name One Redacted]; August 27, 2007; OSA Ref ID: 103666

- *Tiger Team Assessment—Energy Technology Engineering Center*, DOE/EH—0175; U.S. Department of Energy; April 1991; OSA Ref ID: 103714

- *Detailed Outline of Materials in Support of SEC-00093*, Email to OCAS; [Name One Redacted]; September 20, 2007; OSA Ref ID: 103808

- *The Rocket's Red Glare*, a short DVD from Rocketdynewatch.org

- *A Briefing for Elected Officials on the Health Risks to the Public from SSFL*, DVD submitted by petitioner, dated April 5, 2007

5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

Unless otherwise indicated, information for Section 5.0 and its subsections was obtained from *Historical Site Assessment of Area IV Santa Susana Field Laboratory Ventura County, California, Volume 1-Methodology*, *Nuclear Operations at Rockwell's Santa Susana Field Laboratory—A Factual Perspective*, or *Energy Technology Engineering Center – Site Description* (ORAUT-TKBS-0038-2).

The following subsections summarize both radiological operations at SSFL-Area IV and the information available to NIOSH to characterize particular processes and radioactive source materials. From available sources NIOSH has gathered process and source descriptions, information regarding the identity and quantities of each radionuclide of concern, and information describing both processes through which radiation exposures may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is intended only to be a summary of the available information.

For the purpose of providing a complete understanding of the history of SSFL-Area IV, Section 5.0 includes discussions about operations that occurred outside of the period being evaluated in this report.

5.1 SSFL-Area IV Plant and Process Descriptions

SSFL consists of a total of 2,850 acres and is located in the Simi Hills of Ventura County, approximately 30 miles northwest of downtown Los Angeles, California. Based on ownership and operations, SSFL is divided into four administrative and operational portions—Area I, Area II, Area III, and Area IV. DOE operations are conducted in Rockwell International-owned and DOE-owned facilities on a 290-acre westernmost administrative and operational portion designated as Area IV.

Following World War II, the potential of atomic energy captured the interest of the United States Government and many companies. This interest resulted in the need for Nuclear Research & Development (R&D) facilities. SSFL was initially established in 1947 by North American Aviation (NAA) to meet the requirements for a field test laboratory to static-fire large rocket engines; however, it also met NAA's need for a Nuclear Research facility. As a result, Area IV was established in 1953 at SSFL as a Nuclear Research and Development facility. Since then, SSFL-Area IV has housed both nuclear development and rocket development groups, albeit in distinct and separate locations. Atomic Energy Research Development (AERD) also conducted operations in SSFL-Area IV. In December 1955, the nuclear development and rocket development groups were transformed into separate divisions: Atomics International (AI) and Rocketdyne.

Two distinct AI groups were housed in Area IV and supported by DOE. One focused on development of civilian nuclear power, and the other was a center of excellence for research and testing of non-nuclear components related to liquid metals. These two groups were referred to as AI and Liquid Metal Engineering Center (LMEC), respectively. Nuclear R&D activities in Area IV increased rapidly from 1953 into the late 1960s, and then began to decline. AI was eventually merged into Rocketdyne in 1984 as a result of this decline.

The LMEC was created in 1966 as a government-owned and contractor-operated organization; its purpose was to provide development and non-nuclear testing of Liquid Metal Reactor (LMR) components and to establish the Liquid Metal Information Center (LMIC) for the AEC's Liquid Metal Fast-Breeder Reactor (LMFBR) program. The LMEC was renamed Energy Technology Engineering Center (ETEC) in 1978 to reflect DOE's desire to broaden its mission beyond the LMFBR program.

Several corporate mergers and organizational changes occurred over the years. In 1967, NAA merged with Rockwell Standard to become North American Rockwell. In 1973, the corporate name changed to Rockwell International (RI), with AI and Rocketdyne continuing to exist as independent divisions until 1984, when AI was absorbed by the Rocketdyne division. The Boeing Company purchased RI in 1996, and Rocketdyne is now a division of Boeing.

The DOE Office of Worker Advocacy defines the start of covered operations as 1955 for Area IV of the Santa Susana Field Laboratory; it identifies the Downey Facility, DeSoto Avenue Facility, and Canoga Avenue Facility (all located outside the boundary of the SSFL site) as separate covered facilities under EEOICPA. Therefore, this report only includes a review and evaluation of the covered periods and locations as defined by the DOE Office of Worker Advocacy for Area IV of the SSFL.

5.2 SSFL-Area IV Functional Areas

SSFL-Area IV operations included the following functional areas:

- Nuclear Reactor Development and Testing

- Nuclear Support Operations

Additional information regarding the functional areas of SSFL-Area IV can also be found in ORAUT-TKBS-0038-2.

5.2.1 SSFL-Area IV Nuclear Reactor Development and Testing

Between 1954 and 1980, several nuclear reactors were built, tested, and operated in Area IV. These included both nuclear reactors and critical test assemblies. Nuclear reactor programs focused on the development and operation of homogeneous water boiler-type reactors, sodium-cooled graphite moderated reactors, and uranium-zirconium hydride reactors.

Operation of a nuclear reactor creates three sources of radioactivity: fission, transuranic, and activation products. When part of the fissionable material in the fuel element is expended, or when a reactor is decommissioned, the fuel elements are removed. These spent fuel elements contain the fission products and transuranic materials generated by operation of the reactor, and the activation products in the cladding. The amount of radioactivity generated by a nuclear reactor depends in part on the amount of heat it generates. The heat generated is measured in thermal watts (Wt). The reactors at SSFL all operated at low-power levels. Six had power levels of less than 100 kWt, three had power levels of 600 to 1,000 kWt, and one was a 20-MWt test reactor.

A total of 135 million Ci of radioactivity was generated in the fuel from about 7,200 MWd of total reactor operation. Almost 90% of the total SSFL radioactivity was generated by the 20-MWt Sodium Reactor Experiment (SRE).

5.2.1.1 Homogeneous Water Boiler Reactors

The water boiler reactors were operated in Buildings 4073 and 4093. The water boiler reactors used a 93% enriched uranyl sulfate solution held in a critical configuration in a spherical vessel. Rather than actually boil, the neutron and gamma flux caused radiolytic decomposition of water into hydrogen and oxygen in the form of tiny bubbles, which gave the impression of boiling. Area IV contained two water boiler reactors: the Kinetics Experiment Water Boiler (KEWB) operated from 1956 until 1966 and the Water Boiler Neutron Source (WBNS), later called the L-85, operated from 1956 through 1980.

5.2.1.2 Sodium-Cooled Graphite-Moderated Reactor

The Sodium-Cooled Graphite-Moderated Reactor in Area IV of the SSFL was designated as the Sodium Reactor Experiment (SRE). The SRE included 12 structures on the SSFL site including the reactor building, office buildings, and support structures. Eight of these structures were directly involved in operations with radioactive materials:

- Reactor Building (Building 4143)

- Component Storage Building (Building 4041)

- Temporary Hot Waste Storage Building (Building 4686)
- Site Service Building (Building 4163)
- Cold Trap Vault (Building 4695)
- Liquid Radioactive Waste Vault (Building 4653)
- Interim Radioactive Waste Storage Area (Area 4654)
- Intermediate Contaminated Storage Area (Area 4689)

The SRE started in Area IV, Building 4143 in 1954 as part of an AEC program to develop a graphite-moderated sodium-cooled reactor for power application and to demonstrate the feasibility of such reactors as an energy source for power stations. Construction of the SRE reactor was completed in February 1957, with the reactor being brought to full power in May 1958; it operated until February 1964, when DOE terminated the program (having generated 37,000 MWhr of electrical power in more than 27,000 operating hours during this time). Decontamination and decommissioning (D&D) of the SRE began in 1974 and was completed in 1983.

5.2.1.3 Uranium-Zirconium Hydride Reactors

The Systems for Nuclear Auxiliary Power (SNAP) program operated from 1956 to 1971 to support the development and testing of small reactors designed to provide power for research missions in space. The SNAP reactors were uranium-zirconium hydride reactors that used fully-enriched (93%) uranium dispersed in fuel rods containing zirconium hydride. Seven SNAP reactors were tested and operated in Buildings 4010, 4024, 4028, and 4059. The seven SNAP reactors included the following: SNAP Experimental Reactor (SER), SNAP 8 Experimental Reactor (S8ER), SNAP 2 Development Reactor (S2DR), SNAP 10 Flight Simulation Reactor (S10FS3), Shield Test Reactor (STR), Shield Test and Irradiation Reactor (STIR), and SNAP 8 Development Reactor (S8DR).

SNAP Experimental Reactor (SER)—The SER operated from September 1959 through December 1960, when the reactor and the associated test equipment were removed, examined, and sent offsite for disposal.

SNAP 8 Experimental Reactor (S8ER)—The S8ER operated from May 1963 to April 1965, when the core and associated equipment were removed, examined at the Hot Lab, and sent offsite for disposal. Building 4010 D&D was completed in 1978 and the building demolished thereafter.

SNAP 2 Development Reactor (S2DR)—The S2DR operated from April 1961 through December 1962. The S2DR was tested at a nominal power level of 65 kWt without any power conversion system equipment. The reactor was tested in Vault 1 of the SNAP Environmental Test Facility, Building 4024[3].

[3] Building 4024 also contained the SNAP 10 Flight System 3 (S10FS3) reactor in a different vault. In addition, the SNAP Transient (SNAPTRAN) Reactor criticality tests occurred in this building.

SNAP 10 Flight Simulation Reactor (S10FS3)—The S10FS3 was a SNAP 10A reactor that operated between January 1965 and March 1966; it was used to test the reliability and performance of the reactors in space. Following completion of S10FS3 operations, the reactor was removed from the building and sent offsite for disposal. The D&D activities for Building 4024 were completed in 1978. However, some activated concrete shielding remains in the vaults and the test vaults remain restricted; they have been in surveillance and maintenance mode since 1978.

Shield Test Reactor (STR)—The STR operated from 1961 to 1964 and was fueled with SNAP reactor fuel elements. In 1964, the reactor was renamed the Shield Test and Irradiation Reactor (STIR).

Shield Test and Irradiation Reactor (STIR)—The STIR operated from 1964 to 1972. In 1972, fuel from the STIR was removed and disposed of; the facility was secured. D&D ended in March 1976.

SNAP 8 Development Reactor (S8DR)—Building 4059 was built during 1962 and 1963 for development testing of SNAP reactors. At the end of test operations, the reactor core and control system were removed and shipped offsite for disposal. At this time, sufficient D&D occurred to make a portion of the facility available for other use. Further D&D of the facility (except for the reactor cell and vacuum system) occurred between June and September, 1978. Upon completion of D&D in 1992, the entire facility was released for unrestricted use.

5.2.1.4 Critical Test Facilities

A criticality test operates at a very low-power level (up to a few hundred watts), and neutron levels are correspondingly very low (which results in the generation of correspondingly lower amounts of radioactivity and radioactive materials, as compared to production-scale operating reactor units that operate at much higher power levels and outputs). Therefore, a large number of criticality tests can occur in the same test facility without generating much activation product radioactivity. Almost the entire amount of generated radioactivity is contained within the fuel elements of the criticality test. When the fuel elements are removed, the radioactivity is also removed. There have been dozens of criticality tests at Area IV in seven different facilities (i.e., First and Second SNAP Critical Facility, SNAP Flight System Critical Facility, SNAP Transient Test Facility, Organic Moderated Reactor, Sodium Graphite Reactor, Advanced Epithermal Thorium Reactor, and the Fast Critical Experiment Laboratory). Use of some of these low-power reactors began in 1954 and continued until 1974.

SNAP Development Test Facilities—Test facilities in Area IV for the SNAP program included Buildings 4373, 4012, 4019, and 4024.

First SNAP Critical Facility, Building 4373—The First SNAP Critical Facility was a Critical Test Facility constructed in Building 4373. It was used for five SNAP reactor critical assembly tests (SCA-1, S2ERC, SCA-2, SCA¬3, and SCA-4C) between 1957 and 1963. The D&D activities in Building 4373 were completed in 1995. Demolition of the building was completed in 2003.

Second SNAP Critical Facility, Building 4012—Three SNAP reactor critical assemblies (SCA-4A, SCA-4B, and SCA-5) were tested between 1961 and 1967. Initial demolition efforts in Building 4012 were completed in 1986. Final D&D in the remaining portion of the building was performed in 1995. Demolition of the building was completed in 2003.

SNAP Flight System Critical Facility, Building 4019—The SNAP Flight System Critical Facility was built to test-qualify SNAP reactor power systems. Additionally, three reactors (FS-1, FS-4, and FS-5) were assembled and tested from 1964 through 1965. D&D activities for the SNAP Flight System Critical Facility were completed in 1965. Following additional decontamination in 1998, the building was released.

SNAP Transient Test Facility, Building 4024—The SNAP Transient Test Facility only operated in 1971.

Note: Information regarding the SNAP Transient Test Facility is included to provide a complete background of the processes at SSFL—Area IV. However, based on the operational timeframe of the facility, anything related to the SNAP Transient Test Facility is considered outside the scope of this evaluation.

Civilian Nuclear Power Test Facilities—Critical test facilities supporting the development of civilian nuclear power included Buildings 4009 and 4100.

Organic Moderated Reactor (OMR), Building 4009—The OMR was used from 1958 through 1967. D&D activities for the OMR were completed in 1967. When the program ended, all associated equipment was removed. Building 4009 is currently being used for non-nuclear R&D.

Sodium Graphite Reactor (SGR), Building 4009—The SGR operated from 1958 through 1967. D&D activities were completed in 1967. When the program ended, all associated equipment was removed. Building 4009 is currently being used for non-nuclear R&D.

Advanced Epithermal Thorium Reactor (AETR), Building 4100—The AETR operated from 1960 through 1974. D&D activities for the AETR were completed after the program was terminated in 1974.

Fast Critical Experiment Laboratory, Building 4100—The Fast Critical Experiment Laboratory was a licensed facility used between 1961 and 1974. The laboratory was decontaminated, decommissioned, and released for unrestricted use in 1980. The facility license was terminated October 1, 1980.

5.2.2 SSFL-Area IV Nuclear Support Operations

Starting in 1956, several operations were conducted in Area IV to support nuclear programs. Operations included reactor fuel manufacturing; disassembly and examination of reactors and used reactor fuel assemblies; fabrication, use, and storage of radioactive sources; preparation of radioactive material for disposal; research on reprocessing used reactor fuel; operation of particle accelerators; research using radioisotopes; and other miscellaneous operations, which included the conservation yard and sodium disposal facility. With the exception of the Radiation Materials Handling Facility, Fuel Storage Facility, and the Radiation Instrument Calibration Laboratory, operations were terminated by 1988. Operations were terminated at the Fuel Storage Facility and Radiation Instrument Calibration Laboratory in 1993 and 1996, respectively. The RMHF continues to operate in support of the DOE's cleanup efforts.

5.2.2.1 Reactor Fuel Manufacturing

As part of the nuclear reactor development work performed for the government, two different reactor fuel manufacturing operations occurred at SSFL-Area IV in Buildings 4003 and 4064 during the timeframe being evaluated in this report.

Note: Reactor fuel manufacturing and studies were also performed in Building 4055 (used as a Plutonium Fuel Manufacturing Facility) and Building 4005 (used as a Uranium Carbide Fuel Manufacturing Pilot Plant); however, radiological activities associated with both of these buildings were performed outside of the proposed class timeframe evaluated in this report. Therefore, further discussion of these facilities is not included here.

Engineering Test Building, Building 4003—The Engineering Test Building was built to support the SRE through assembly of SRE fuel elements; it operated between 1954 and 1964. D&D was completed in 1975. The facility has been released for unrestricted use.

Fuel Storage Facility, Building 4064—Fuel Storage Facility operations started in 1958. D&D activities for Building 4064 were completed in 1997.

5.2.2.2 Disassembly and Examination of Reactors and Used Reactor Fuel Assemblies

The Hot Lab operated in Building 4020 from 1959 through 1990 and was used to examine fuel and/or components from the SRE, SER, S2DR, S8ER, S8DR, and S10FS3 reactors, the OMR and SGR Criticality Test Facilities, and the Piqua reactor. When a reactor operation was complete and the reactor was no longer needed, the reactor was removed from its operating location, disassembled, its fuel removed, and the radioactive structure cut into pieces small enough to be shipped for disposal.

The Hot Lab was also used to declad fuel from the SRE, EBR-I, EBR-II, Hallam, Fermi, and Southwest Experimental Fast Oxide Reactor reactors. Additionally, the Hot Lab was used for work on radioactive materials generated outside SSFL; this consisted in large part of used reactor fuel from other nuclear reactors. The fuel elements were shipped to the Hot Lab and disassembled or separated from their cladding material, and the separated materials were then shipped offsite. Finally, the Hot Lab was also used for manufacturing sealed sources, for leak checks on sources, and for cutting and machining operations that involved cobalt-60. The license for this facility was changed in 1990 to limit operations to D&D work. D&D in Building 4020 was completed in 1999.

5.2.2.3 Fabrication, Use, and Storage of Radioactive Sources

Building 4029, the Radiation Measurements Facility, housed, stored, and used radioactive sources to calibrate radiation detection instruments for the SRE and other reactor tests. Building 4029 operated between 1959 and 1974, after which it was used for temporary storage of non-radioactive materials. In addition to calibrating nuclear instruments, radiation sources were used for some forms of radiography, irradiation testing, and other applications. Sources were manufactured in the Hot Lab and used in various facilities both at the SSFL and elsewhere. Approximately 140,000 Ci of radioactive material (primarily promethium-147) were fabricated into sources at the Hot Lab. These sources were stored in secured locations and used under carefully controlled conditions.

5.2.2.4 Preparation of Radioactive Material for Disposal

Radioactive waste from the operation of nuclear reactors, fuel fabrication, reactor and fuel examination, etc., was prepared for disposal at the Radioactive Materials Disposal Facility (RMDF) with support at the Interim Storage Facility (ISF) in Building 4654.

Radioactive Materials Disposal Facility (RMDF), Building 4021/4022—The RMDF was built in 1958 for storing fuel and processing solid and liquid waste for disposal in conjunction with the operation of the SRE. The RMDF began operations in 1959 (Sapere Consulting, 2005) and has subsequently been used to support all SSFL nuclear operations. The RMDF consisted of the following structures and/or areas:

- Building 4022—Radioactive material storage vault
- Building 4021—Decontamination and Packaging Facility
- Building 4075—Low specific activity waste storage
- Building 4621—Source storage
- Buildings 4034 & 4044—Offices
- Building 4665—Non-radioactive material storage
- Leach Field—Sanitary sewer septic tank

Interim Storage Facility (ISF), Building 4654—The ISF was built in 1958 and used from 1958 through 1964 to store SRE fuel elements inside 10 thimbles installed in holes drilled into bedrock (ORAUT-TKBS-0038-2). The ISF was also used for storing fuel shipping casks for other reactors (OMRE and SNAP). In 1964, the ISF was taken out of service, the thimbles removed, and the area decontaminated and released for unrestricted use.

5.2.2.5 Research on Reprocessing of Used Reactor Fuel

The Hot Cave in Building 4003 (Engineering Test Building) supported testing of nuclear reactor fuel reprocessing. From 1957 through 1964, Building 4003 was used to assemble fuel for the SRE. Until the termination of the SNAP program in 1973, Building 4003 was used for the analysis of SNAP fuel burn-up samples and the evaluation of irradiation experiments (Sapere Consulting, 2005). The used fuel assemblies from nuclear reactors contained unused fissionable material, fissionable transuranic products (mainly plutonium), and fission products. Rockwell developed a pilot-scale process to make a partial separation of used fuel by removing part of the fission products so that the material could be used again as reactor fuel. The experiments used up to kilogram quantities of unirradiated uranium and thorium, and up to 100-g quantities of highly irradiated materials.

5.2.2.6 Operation of Particle Accelerators

Besides nuclear fission, radioactivity was also generated by bombarding a target material with atomic particles accelerated to high speeds by means of a particle accelerator. Rockwell operated a Van de

Graaff generator in Building 4030 from 1960 through 1964, bombarding tritium targets with deuterons to produce neutrons (Sapere Consulting, 2005). A second Van de Graaff generator was operated at the SRE Facility for neutron activation analyses of materials (removed from the SRE Facility before the facility D&D). Accelerators were removed in 1966 and a radiation survey showed the facilities to be free of radioactive contamination. A follow-up survey performed in 1988 confirmed that there was no activation in the building.

5.2.2.7 Research Using Radioisotopes

Some SSFL-Area IV research required special radioisotopes. Small quantities of specially prepared radioisotopes were brought to SSFL-Area IV, used in laboratories under controlled conditions, and then either shipped back out or stored for reuse.

One research program associated with the use of radioisotopes that was planned at SSFL was the Transuranic Management by Pyropartitioning-Separation (TRUMP-S) program. The purpose of the TRUMP-S program was to develop fundamental thermodynamic and electrochemical data on various transuranic materials so that processes could be developed to separate long-lived radioactive isotopes from spent nuclear fuel. These long-lived radioactive isotopes could then be destroyed by fissioning them in a nuclear reactor or accelerator, thereby eliminating the long-term hazard associated with the disposal of spent nuclear fuel. The program used small quantities of transuranic materials (plutonium, neptunium, and americium). The TRUMP-S tests were originally planned to be performed in the Hot Laboratory at SSFL; however, the test program was transferred to and implemented at the University of Missouri.

Fuel Storage Facility, Building 4064—The Fuel Storage Facility contained the materials for the TRUMP-S tests, which were subsequently transferred to the University of Missouri when it was determined that the tests were not going to be performed at SSFL. The material that was shipped to Missouri included 75 g of depleted uranium, 5 g of plutonium, 4 g of neptunium, and 4 g of americium. Building 4064 was constructed in two phases. In 1958, a reinforced concrete structure with 11-inch thick walls was constructed. Construction of a second part in 1963 included a new bay to the north of the original structure. The facility operated from 1958 until 1993. It was demolished in 1997 and the waste was shipped offsite as clean waste (DOE, 2007).

Corrosion Testing Laboratory, Building 4023— Another radioisotope research program was the corrosion test program in the Corrosion Testing Laboratory, which ran from 1962 through 1986. A pumped sodium corrosion test loop was built to study the deposition behavior of activation products (manganese-54 and cobalt-60) in flowing sodium to develop more effective traps for these isotopes. An activated piece of fuel cladding containing these isotopes was used in these tests. The test specimens and the test loop were later removed from the building.

Mechanical Component Development and Counting Building, Building 4363—The Mechanical Component Development and Counting Building was transferred from the Rocketdyne Division to Area IV of the SSFL between 1956 and 1957 for the purpose of supporting expansion of the nuclear operations at SSFL. It was used for sodium systems in support of the SRE from before 1959 until 1963. It has been primarily used for storage since 1963.

5.2.2.8 Miscellaneous Operations

Neither the Conservation Yard nor the Sodium Disposal Facility was intended for use with radioactive materials, but both were inadvertently contaminated.

Conservation Yard—The Conservation Yard was an outdoor area used for storage and salvaging used equipment. In 1988, a 20-by-20-foot area of the surface of the Conservation Yard was found to be slightly contaminated by radioactivity. A total of 132 cubic feet of contaminated soil and asphalt was removed and shipped offsite for disposal. The Conservation Yard was released for unrestricted use in 1995.

Sodium Disposal Facility—Also called the sodium burn pit, the Sodium Disposal Facility consisted of a large, rectangular, concrete-lined pit filled with water, surrounded by a concrete slab with two water-filled basins, a small building (Building 4886), and steam lance cleaning equipment. The Sodium Disposal Facility was built to clean nonradioactive metallic sodium and NaK from various scrap test components (pumps, valves, etc.) before the components were disposed of. In addition, the facility was used to treat nonradioactive waste sodium and NaK, and was also used to burn nonradioactive combustible liquid waste (oils, etc.).

5.2.3 Summary of Key SSFL-Area IV Facilities

Table 5-1 summarizes the key facilities as well as the buildings and dates of operation.

Table 5-1: Key SSFL-Area IV Facilities, Operations, and Dates of Operation

Table 5-1and corresponding notes span two pages.

Operations	Buildings	Key Facilities	Dates[a]
Reactor	Building 4093	**WBNS or L-85 Reactor:** Water Boiler Neutron Source Reactor; 3 kWthr	1956-1980
Reactor	Building 4143*	**SRE Reactor:** Sodium Reactor Experiment Reactor; 20 MWthr	1957-1964
Reactor	Building 4010	**SER Reactor:** SNAP Experimental Reactor; 50 kWthr	1959-1960
		S8ER Reactor: SNAP 8 Experimental Reactor; 600 kWthr	1963-1965
Reactor	Building 4024	**S2DR Reactor:** SNAP 2 Development Reactor; 50 kWthr	1961-1962
		S10FS Reactor: SNAP 10 Flight Simulation Reactor; 7 kWthr	1965-1966
Reactor	Building 4028	**STR Reactor:** Shield Test Reactor; 50 kWthr	1961-1964
		STIR Reactor: Shield Test and Irradiation Reactor; 1 MWthr	1964-1972
Reactor	Building 4059	**S8DR Reactor:** SNAP 8 Development Reactor; 600 kWthr - 1 MWthr	1968-1969
Reactor	Building 4012	**SNAP Critical Test Facility:** Second SNAP Critical Test Facility	1962-1968
Reactor	Building 4373	**SNAP Critical Test Facility:** First SNAP Critical Test Facility	1957-1963
Reactor	Building 4019	**SNAP Flight System Critical Facility**	1964-1965
Reactor	Building 4009	**OMR Critical Facility:** Organic Moderated Reactor Low Power Critical Experiment	1958-1967
		SGR Critical Facility: Sodium Graphite Reactor Low Power Critical Experiment	1958-1967
Reactor	Building 4100	**AETR Test Facility:** Advanced Epithermal Thorium Reactor	1960-1974
		Fast Critical Experiment Laboratory: Used to study different reactor core configurations	1961-1980
Nuclear Support	Building 4003	**Engineering Test Building:** Reactor Fuel Manufacturing Facility to support Sodium Reactor Experiment	1954-1964
		Hot Cave: Hot cell for reprocessing used reactor fuel	1954-1964

Table 5-1: Key SSFL-Area IV Facilities, Operations, and Dates of Operation

Table 5-1and corresponding notes span two pages.

Operations	Buildings	Key Facilities	Dates[a]
Nuclear Support	Building 4654	**ISF:** Interim Storage Facility for SRE fuels	1958-1964
Nuclear Support	Building 4030	**Van de Graaff Accelerator:** Particle accelerator	1960-1964
Nuclear Support	Building 4020	**Hot Lab:** Hot Laboratory for disassembly and examination of used reactor fuel	1957-1988
Nuclear Support	Building 4023	**Corrosion Testing Laboratory:** Liquid Metals Component Testing Facility	1962-1986
Nuclear Support	Building 4029	**Radioactive Measurement Facility:** Used for storage and used radioactive sources to calibrate radiation instruments	1959-1974
Nuclear Support	Building 4064	**Fuel Storage Facility:** Fuel Storage Facility is a vault built to provide storage for fissionable fuel material (enriched uranium & plutonium)	1958-1993
Nuclear Support	Buildings 4021/4022**	**RMDF:** Radioactive Materials Disposal Facility-built for fuel storage and processing solid and liquid waste for disposal in conjunction with the SRE operation	1959-present
Nuclear Support	Building 4363	**Mechanical Component Development and Counting Building:** Used for sodium systems in support of SRE from before 1959 until 1963.	1956-1963

Notes:

[a] For reactors, refers to operation of the reactor rather than program duration dates

*** Includes Component Storage Building (Building 4041), Temporary Hot Waste Storage Building (Building 4686), Site Service Building (Building 4163), Cold Trap Vault (Building 4695), Liquid Radioactive Waste Vault (Building 4653), Interim Radioactive Waste Storage Area (Area 4654), and Intermediate Contaminated Storage Area (Area 4689)**

****Includes Radioactive Material Storage Vault (Building 4022), Decontamination and Packaging Facility (Building 4021), Low Specific Activity Waste Storage (Building 4075), Source Storage Buildings (Building 4621), Offices (Buildings 4034 & 4044), Non-Radioactive Material Storage (Building 4665), and Leach Field—Sanitary Sewer Septic Tank**

5.3 Radiological Exposure Sources from SSFL-Area IV Operations

There were many different types of facilities and processes at Area IV of the SSFL, which included reactors, critical test facilities, fuel preparation and post-irradiation examination facilities, accelerator and calibration facilities, and support facilities. Most reactors were low-power (a few kilowatts), with the maximum being 20 MWt, and all had relatively short operating histories. There was a Van de Graaff (Deuterium-Tritium) accelerator producing neutrons with a maximum energy of 14 MeV. The fuel examination and manufacturing facilities, reactors, and critical facilities handled fissionable fuels with various enrichments, mostly compounds of uranium including carbides. They also handled relatively small quantities of plutonium and thorium, with the exception of Buildings 4023, 4029, and 4030 where no thorium or plutonium was handled. Some fuel decladding took place in the hot cells of Area IV of the SSFL, which resulted in the release of considerable quantities of those fission products with high fission yields (e.g., strontium-90 and cesium-137) into the hot cell environment; also released were smaller amounts of europium-152, europium-154, and tritium (ORAUT-TKBS-0038-6). The separations of irradiated fuel consisted of pilot-scale operations conducted inside a hot cell; therefore, exposure potential as a result of these operations was fairly small.

<table>
<tr><th colspan="2">Table 5-2: Area Information and Parameters of SSFL-Area IV Nuclear Operations
Table 5-2 and corresponding notes span three pages.</th></tr>
<tr><th>Facility</th><th>Radioisotopes[a]</th></tr>
<tr><td>Building 4073:
KEWB Reactor (1 kWt)</td><td rowspan="4">Sr-90
Cs-137
U-234
U-235
U-238
Pu-238
Pu-239
Pu-240
Pu-241
Am-241</td></tr>
<tr><td>Building 4093:
L-85 Reactor (3 kWt)</td></tr>
<tr><td>Building 4143:
SRE Reactor (20 kWt)</td></tr>
<tr><td>Building 4010:
SER (kWt);
S8ER (600 kWt)</td></tr>
<tr><td>Building 4024:
S2DR (50 kWt);
S10FS (7 kWt)</td><td>Sr-90
Cs-137
U-234
U-235
U-238
Pu-238
Pu-239
Pu-240
Pu-241
Am-241
Co-60
Eu-152
Eu-154
Th-232
H-3</td></tr>
<tr><td>Building 4028:
STR (50 kWt); STIR (1 MWt)</td><td rowspan="3">Sr-90
Cs-137
U-234
U-235
U-238
Pu-238
Pu-239
Pu-240
Pu-241
Am-241</td></tr>
<tr><td>Building 4012:
Second SNAP Critical Test Facility</td></tr>
<tr><td>Building 4373:
First SNAP Critical Test Facility</td></tr>
<tr><td>Building 4019:
SNAP Flight System Critical Facility</td><td>Co-60
Eu-152
Eu-154
H-3</td></tr>
<tr><td>Building 4009:
OMR Critical Facility; SGR Critical Facility</td><td rowspan="2">Sr-90
Cs-137
U-234
U-235
U-238
Pu-238
Pu-239
Pu-240
Pu-241
Am-241</td></tr>
<tr><td>Building 4100:
AETR Test Facility;
Fast Critical Experiment Laboratory</td></tr>
</table>

<table>
<tr><th colspan="2">Table 5-2: Area Information and Parameters of SSFL-Area IV Nuclear Operations
Table 5-2 and corresponding notes span three pages.</th></tr>
<tr><th>Facility</th><th>Radioisotopes[a]</th></tr>
<tr><td>Building 4003:
Engineering Test Building;
Hot Cave</td><td rowspan="3">Sr-90
Cs-137
U-234
U-235
U-238
Pu-238
Pu-239
Pu-240
Pu-241
Am-241
Co-60
Eu-152
Eu-154</td></tr>
<tr><td>Building 4654
Interim Storage Facility</td></tr>
<tr><td>Building 4005:
Uranium Carbide Fuel Pilot Plant</td></tr>
<tr><td>Building 4030:
Van de Graaff Accelerator</td><td>Sr-90
Cs-137
U-234
U-235
U-238
Pu-238
Pu-239
Pu-240
Pu-241
Am-241
Co-60
Eu-152
Eu-154
Th-232</td></tr>
<tr><td>Building 4020:
Hot Laboratory</td><td>U-234
U-235
U-238</td></tr>
<tr><td>Building 4023:
Corrosion Testing Laboratory</td><td>Sr-90
Cs-137
U-234
U-235
U-238
Pu-238
Pu-239
Pu-240
Pu-241
Am-241
Co-60
Eu-152
Eu-154
Th-232</td></tr>
<tr><td>Building 4029:
Radioactive Measurement Facility</td><td>H-3</td></tr>
<tr><td>Building 4064:
Fuel Storage Facility</td><td>Sr-90
Cs-137
Co-60
Eu-152
Eu-154</td></tr>
</table>

Table 5-2: Area Information and Parameters of SSFL-Area IV Nuclear Operations *Table 5-2 and corresponding notes span three pages.*	
Facility	**Radioisotopes[a]**
Buildings 4021/4022: RMDF	Ra-226
Building 4363: Mechanical Component Development and Counting Building	Sr-90 Cs-137

Source: Modified version of Table 5-9 in ORAUT-TKBS-0038-5 and Table 2-3 in ORAUT-TKBS-0038-2
Notes:
[a] Assumed particle size of 5 *μm (AMAD)* for all listed radionuclides

5.3.1 Alpha

Alpha particle emissions from radioactive source materials presented the most significant internal radiological protection challenge (alpha particles do not present an external exposure hazard). The main alpha-emitting plutonium isotopes were plutonium-238, plutonium-239, plutonium-240, and plutonium-241. Plutonium-238 emits 5.50 MeV (71%) and 5.46 MeV (29%) alpha particles; plutonium-239 emits a 5.16 MeV (73%) alpha particle with lower-abundance 5.14 MeV (15%) and 5.11 MeV (12%) emissions. Similarly, plutonium-240 emits alphas at 5.17 MeV (73%) and at 5.12 MeV (27%) (DOE, 2006). In addition, uranium isotopes (in varying ratios depending on whether the uranium being handled was natural, depleted, or enriched) were a source of alpha radiation. Uranium-238 emits 4.20 MeV (77%) and 4.15 MeV (23%) alpha particles, and uranium-234 emits 4.78 MeV (72.5%) and 4.72 MeV (28.4%) alpha particles. There are smaller amounts of uranium-235 (approximately 1/20 of the activity levels of uranium-238 or uranium-234 in natural uranium, varying up or down depending on enrichment level or depleted uranium activities, respectively) with the most significant alpha particles of 4.60 MeV (5%), 4.56 MeV (4.2%), 4.40 MeV (55%), 4.37 MeV (17%), 4.22 MeV (5.7%), and others with lower energies and percent abundance (Shleien, 1992).

5.3.2 Beta/Photon

The fuel examination and manufacturing facilities, reactors, and critical facilities handled fissionable fuels with various enrichments, mostly compounds of uranium including carbides. They also handled relatively small quantities of plutonium and thorium. Area IV of the SSFL performed only pilot-scale separations of irradiated fuel; therefore, there were minimal gross fission product problems. AI did declad fuels in the hot cells, which resulted in the release of considerable quantities of those fission products with high fission yields (e.g., strontium-90 and cesium-137) into the hot cell environment. In addition, decladding resulted in some europium-152 and -154 releases, along with some tritium.

The decladding was performed in a facility (hot lab) designed for such use. Strontium-90 and cesium-137 are volatile and tend to migrate to the surface of the fuel, but are contained in the hot cell. The fuel remained contained in the hot cell until much of the short-lived activity had decayed. The facility was shielded and remote manipulators were used to minimize the potential for personnel exposures. This design reduced the external exposures from highly radioactive items to levels within occupational limits. A ventilation system kept the hot cells at negative pressure relative to the operators' positions. Filters decontaminated the air from the hot cells prior to exhaust from the building (Oldenkamp, 1989).

Beta/photon sources consisted of reactors as well as associated radioactive material work and processes in buildings 4143, 4010, 4010, 4024, 4028, 4059, 4009, and 4100 that housed the reactors. Table 5-3 indicates the beta and photon energies and percentages at reactors and critical facilities.

<table>
<tr><th colspan="7">Table 5-3: Beta and Photon Energies and Percentages at Reactors and Critical Facilities
Table 5-3 spans two pages.</th></tr>
<tr><th rowspan="2">Process/ Building</th><th rowspan="2">Description</th><th colspan="2">Operations</th><th rowspan="2">Radiation Type</th><th rowspan="2">Energy (keV)</th><th rowspan="2">Percentage</th></tr>
<tr><th>Begin</th><th>End</th></tr>
<tr><td rowspan="3">All</td><td rowspan="3">Reactors</td><td rowspan="3">1956</td><td rowspan="3">1980</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td rowspan="2">Photons</td><td>30-250</td><td>25</td></tr>
<tr><td>>250</td><td>75</td></tr>
<tr><td rowspan="3">4143</td><td rowspan="3">SRE Reactor</td><td rowspan="3">1957</td><td rowspan="3">1964</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td rowspan="2">Photons</td><td>30-250</td><td>25</td></tr>
<tr><td>>250</td><td>75</td></tr>
<tr><td rowspan="3">4010</td><td rowspan="3">SNAP Experimental Reactor and SNAP8 Development Reactor (S8ER)</td><td rowspan="3">1959</td><td rowspan="3">1965</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td rowspan="2">Photons</td><td>30-250</td><td>25</td></tr>
<tr><td>>250</td><td>75</td></tr>
<tr><td rowspan="3">4024</td><td>SNAP2 Development Reactor (S2DR)</td><td>1961</td><td>1962</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td>SNAP 10 Flight Simulation Reactor (S10FS3)</td><td>1965</td><td>1966</td><td rowspan="2">Photons</td><td>30-250</td><td>25</td></tr>
<tr><td>SNAP Test Facilities</td><td>1971</td><td>1971</td><td>>250</td><td>75</td></tr>
<tr><td rowspan="3">4028</td><td rowspan="3">Shield Test Reactor and Shield Test and Irradiation Reactor (STIR)</td><td rowspan="3">1961</td><td rowspan="3">1972</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td rowspan="2">Photons</td><td>30-250</td><td>25</td></tr>
<tr><td>>250</td><td>75</td></tr>
<tr><td rowspan="3">4059</td><td rowspan="3">SNAP 8 Development Reactor (S8DR)</td><td rowspan="3">1968</td><td rowspan="3">1969</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td rowspan="2">Photons</td><td>30-250</td><td>25</td></tr>
<tr><td>>250</td><td>75</td></tr>
<tr><td rowspan="3">4009</td><td rowspan="3">Organic Moderated Reactor (OMR) and Sodium Graphite Reactor (SGR)</td><td rowspan="3">1958</td><td rowspan="3">1967</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td rowspan="2">Photons</td><td>30-250</td><td>25</td></tr>
<tr><td>>250</td><td>75</td></tr>
<tr><td rowspan="3">4100</td><td rowspan="3">Advanced Epithermal Thorium Reactor (AETR)</td><td rowspan="3">1960</td><td rowspan="3">1974</td><td>Beta</td><td>>15</td><td>100</td></tr>
<tr><td rowspan="2">Photons (thorium)</td><td>30-250</td><td>25</td></tr>
<tr><td>>250</td><td>75</td></tr>
</table>

5.3.3 Neutron

In uranium-235-based nuclear reactors, such as were operated at SSFL, fission neutrons have an average energy of about 2 MeV. In order to sustain the nuclear chain reaction, the neutrons must be slowed by collisions in the moderator of the reactor to an energy level of 0.025 eV (thermal neutron energy). Depending on the reactor design, few fast neutrons will escape the shielding. Due to the gamma radiation produced in the fuel and from the neutron-gamma reactions in the shielding, neutrons from reactors are usually a minor concern for personnel exposure compared to gamma radiation (ORAUT-TKBS-0038-2).

Correspondence regarding a neutron survey report of the SRE Hot Cell containing a 14-MeV neutron generator lists dose rates of 75 mrem/hr fast and 11.8 mrem/hr thermal with “the assumption that all fast neutrons are 14 MeV” (Clow, 1966). This correspondence also states, “As further surveys are taken and the spectrum completely analyzed, the dose rates may be reduced” (Clow, 1966).

According to Clow, these surveys were performed on the roof of the facility and were higher than those taken at “a window” (62.2 mrem/hr fast and 7.1 mrem/hr thermal) or “at the console” (7.1 mrem/hr fast and 2.2 mrem/hr thermal). The Van de Graaff accelerator with its D-T reaction generates 14-MeV neutrons that are quite monoenergetic in the 0° and 180° directions (ORAUT-TKBS-0038-6, page 8).

Table 5-4 lists facilities with neutron radiation. Facilities include reactors, accelerators, and fuel storage facilities. However, these facilities are assumed to be a negligible contributor to neutron doses due to the limited quantities of fuel present at any one time (ORAUT-TKBS-0038-6, page 8).

Table 5-4: Facilities and Neutron Energies

Facility	**Source**	**Neutron energy (MeV)**
Reactors	Reactors	0.1-2.0, W_R^*=20
Plutonium Fuel Storage Building 4064	Spontaneous fission and alpha-neutron reactions	
4030 Van de Graaff Accelerator	D-T reaction	2-14 max, W_R^*=10

Notes:
*** The distribution of energies and International Commission on Radiological Protection Publication 60 radiation weighting factors**

5.3.4 Incidents and Fires

The most radiologically significant and notable incident at Area IV of the SSFL was associated with the SRE and occurred in July 1959. The SRE reactor underwent an accidental partial blockage of sodium coolant flow in some of the reactor coolant channels. This resulted in the partial melting of 13 reactor fuel assemblies and the release of some fission products, which contaminated the reactor cooling system. All of the reactor safety systems functioned, and the reactor was shut down. The reactor fuel assemblies were removed, inspected, and stored at the Radioactive Materials Disposal Facility (RMDF). They were later declad in the Hot Lab, and the fuel and cladding were shipped offsite (ORAUT-TKBS-0038-2).

Based on its research, NIOSH has identified other incidents with minimal (or no) radiological impacts; these other incidents are included in summary form in *Nuclear Operations at Rockwell’s Santa Susana Field Laboratory – A Factual Perspective* as well as in various site incident reports and documents collected by NIOSH (Oldenkamp, 1989). NIOSH obtained additional clarification regarding these types of incidents and radiological occurrences during discussions with former and current SSFL employees (Personal Communication with Fireman; Personal Communication with Health Physicist-November 15, 2007; Personal Communication with Health Physicist-November 20, 2007; Personal Communication with HP-Radiation Engineer; Personal Communication with Health and Safety Manager). While additional information regarding these incidents and occurrences has not been included in this report, it is available in the identified references and the SSFL Site Profile documents.

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

NIOSH has located personal and area monitoring data in the NIOSH Site Research Database (SRDB) and in NOCTS which have been used to estimate doses to individual employees in the proposed class. The results of NIOSH data reviews are provided in the following subsections.

6.1 SSFL-Area IV Internal Monitoring Data

Radionuclides of concern for the facilities and process at Area IV of the SSFL were primarily fission products. Exposure to fissionable material, transuranics, and activation products was also possible. Summaries of the available *in vitro* and *in vivo* data, as well as general overviews of sampling and analytical protocols, are provided in the following subsections. Additional details, including analytical methods, detectable activities, and reporting protocols can be found in ORAUT-TKBS-0038-5.

6.1.1 Internal Urinalysis Data

NIOSH has identified only limited amounts of internal personnel monitoring data for pre-1959 exposures; this is consistent with its findings that a SSFL routine bioassay program was not initiated until August 1958 (Kellehar, 1966). Therefore, NIOSH has concluded that pre-1959 workers will generally not have bioassay data prior to August 1958 (except in rare cases). After August 1958, routine bioassay was normally in the form of urinalysis at a three-month frequency. At first, gross alpha or gross beta measurements were made of the samples. Specific radionuclides could be determined "where required" by performing additional radiochemical separations and analyses (Lang, 1960). For the period 1959 to 1966, analyses were available for uranium (both fluorometric and radiometric), mixed fission products, polonium-210, plutonium, strontium-90, tritium, and thorium (ORAUT-TKBS-0038-5).

Table 6-1 lists the frequencies for *in vitro* monitoring.

Table 6-1: Internal Dose Control Program (*in vitro*)

Routine Monitoring Type	Period	Frequency
Urine, single void[a]	1958-1988	Quarterly, semiannual, annual, based on job
Urine, single void, tritium	1958-1966	Weekly, based on job

Notes:
[a] **Sample requested on Friday, first voiding on Monday morning requested. Positive samples were verified and followed with at least one 24-hr sample collected on Sunday.**

Table 6-2 lists the minimum detectable activities (MDAs) and reporting levels for periods corresponding to the bioassay methods discussed in this section. The reporting levels are listed in the units quoted in the references, which are generally the units of the results. However, various volumes were used to report the results. In general, the excretions assumed when reporting "per sample" or "per day" were 1,500 mL for urine samples and 135 g for fecal samples.

Table 6-2: Detection limits 1958–1966[a]
Table 6-2 and corresponding notes span two pages.

Radionuclide	Method/ description	MDA[b]	Reporting level[c]
Gross alpha	Urine	15 dpm/L (U. S. Nuclear) 4 dpm/sample (Nuclear Science and Engineering Corporation)	7.5 dpm/L 2 dpm/sample
Gross beta	Urine	150 dpm/L (U. S. Nuclear) 2 dpm/mL (Nuclear Science and Engineering Corporation)	75 dpm/L 1 dpm/mL
Gross beta (minus K-40)	Urine	0.4 dpm/mL (BioScience) 0.04 dpm/mL (U.S. Testing Inc.)	0.2 dpm/mL 0.02 dpm/mL
Tritium	Urine	4,440 dpm/mL (Nuclear Science and Engineering Corporation) 10,000 dpm/mL (BioScience) 10,000 dpm/mL (U.S. Testing Inc.)	2,220 dpm/mL 5,000 dpm/mL 5,000 dpm/mL
MFP (gross)	Urine	4 dpm/mL (Nuclear Science and Engineering Corporation) 60 dpm/sample (Hanford) 0.2 dpm/mL (BioScience) 0.04 dpm/mL (U.S. Testing Inc.)	2 dpm/mL 30 dpm/sample 0.1 dpm/mL 0.02 dpm/mL
Polonium-210	Urine	0.02 dpm/mL (BioScience) 0.02 dpm/mL (U.S. Testing Inc.)	0.01 dpm/mL 0.01 dpm/mL
Plutonium	Urine	0.0006 dpm/mL (U.S. Testing Inc.)	0.0003 dpm/mL
Strontium-90	Urine	0.2 dpm/mL (BioScience) 0.04 dpm/mL (U.S. Testing Inc.)	0.1 dpm/mL 0.02 dpm/mL
Thorium	Urine	0.4 μg/125 mL (Tracerlab) 0.0004 μg/mL (BioScience) 0.0004 μg/mL (U.S. Testing Inc.)	0.2 μg/125 mL 0.0002 μg/mL 0.0002 μg/mL
Uranium	UF-1A Urine	0.004 μg/mL (U. S. Nuclear) 0.0002 μg/mL (Controls for Rad.) 0.0004 μg/mL (Nuclear Science and Engineering Corporation) 0.0004 μg/mL (BioScience) 0.0004 μg/mL (U.S. Testing Inc.)	0.002 μg/mL 0.0001 μg/mL 0.0002 μg/mL 0.0002 μg/mL 0.0002 μg/mL
Uranium (enriched)	UR-1B Urine	15 dpm/L (U. S. Nuclear) 4 dpm/sample (Nuclear Science and Engineering Corporation) 0.012 dpm/mL (BioScience) 0.012 dpm/mL (U.S. Testing Inc.)	7.5 dpm/L 2 dpm/sample 0.006 dpm/mL 0.006 dpm/mL

Notes:

[a] **The date of the reference for the reporting levels, which are the best information available for the period 1958-1966.**

[b] **Assumed to be twice the sensitivity (see ORAUT-TKBS-0038-5 text). The reported sensitivity ("less than" values) in the claimant records should be used to determine MDA in lieu of the values listed in this table. These values should also be used for the in-house laboratory.**

[c] **Sheperd, 1959; O'Brien, 1959; Edelmann, 1959; and Lee, 1963. UST results that were considered to be less than detectable generally have the reporting level included with the result.**

NIOSH has access to urinalysis results and other supporting data for the period after the initiation of the routine bioassay program (as the routine bioassay program started in August 1958 and the initial collection frequency was three months, this corresponds to the end of 1958). The practice at the facility was to collect urine samples based on job assignments that required exposures to radioactive materials (Kopenhaver, 1986; Garcia, July 1, 1963; Alexander, 1959). Details regarding the various analyses used, and the associated minimum detectable activities, are presented in ORAUT-TKBS-0038-5.

6.1.2 Lung, Whole-Body, and Other Types of Internal or Bioassay Data

Routine lung-counting, using equipment and techniques specifically developed to measure lung deposits of uranium, did not start until 1968 (outside of the timeframe evaluated in this report). Whole-body counts for fission or activation products occurred sporadically from 1968 through 1983 (also outside of the timeframe evaluated in this report). Although there is an indication that fecal samples were included in the bioassay program in 1970, no evidence has been recovered of their use during the period being evaluated in this report. There is evidence that wound contamination was evaluated. However, because urinalysis data are available, further review and evaluation of wound contamination data are not being pursued in this report. Finally, SSFL was neither a storage nor a processing location for large quantities of uranium or thorium; most of this material was in the form of reactor fuel that had been processed elsewhere to remove any long-lived radon- or thoron-producing progeny.

Based on the timeframe of the monitoring as compared to the proposed worker class time period evaluated in this report, these data were not evaluated for the dose reconstruction feasibility evaluation. Therefore, further discussion or evaluation of lung or whole-body counts (*in vivo*), fecal sampling, wound contamination evaluations, or evaluations of radon or thoron exposures is considered outside the scope of this SEC petition evaluation.

6.2 SSFL-Area IV External Monitoring Data

The external dose received by workers was a function of the physical location of the workers on the site, the processes taking place, the types and quantities of material present, and the time spent in each location. The radiation contributing to external dose was primarily beta, photon (including X-rays) and neutron. Information associated with the radiological external monitoring program at Area IV of the SSFL available to NIOSH has been reviewed as a part of this SEC (Badger, 1965-1987; Various authors, 1970-1987).

AI used a two-element dosimeter to measure and account for the photon and beta exposures in the early years (1954-1962) at Area IV of the SSFL; the two-element dosimeter was very similar to the film dosimeters used at the Y-12 plant (ORAUT-TKBS-0014-6) and the Hanford Site (ORAUT-TKBS-0006-6) that were based on the design developed by Pardue, Goldstein, and Wollan (Pardue, 1944). In addition to the two-element film badges, the SSFL also incorporated the use of pocket ionization chambers (PICs or *pencil dosimeters*). In 1963, AI started using commercial vendors (Landauer) who supplied a multi-element dosimeter to measure and account for photon and beta exposures; this practice continued throughout the rest of the facility's operating life (ORAUT-TKBS-0038-6). On occasion, workers wore special dosimeters to monitor non-routine work such as "hot jobs" or cell entries. NIOSH has not determined whether the special dosimeter procedure was in operation before 1963 (ORAUT-TKBS-0038-6).

In terms of dosimeter exchanges at SSFL, Lang (1960) states, "Normally film badges are to be worn for monthly periods except where the possibility of exceeding 100 mrem/week of exposure is expected. Then the badges are to be analyzed more frequently." Starting in 1963, most dosimeters were processed by the vendor (Garcia, April 5, 1963). Personnel doses from Landauer before 1985 were reported in milliroentgen as either penetrating (photon) or non-penetrating (beta) exposure. The reported total dose values included any special dosimeter results sent by AI for that exchange period.

AI used Nuclear Track Emulsion, Type A (NTA) film to measure neutron exposures over the history of operations at Area IV of the SSFL (beginning with the start of reactor operations and the use of the Van de Graaff accelerators). Both fast and thermal neutrons were measured and recorded as whole-body dose in rem. The routine exchange frequency (biweekly or monthly) and evaluation of the neutron dose is described further in the SSFL site program data, procedures, and in ORAUT-TKBS-0038-6 (Badger, 1965-1987; Various authors, 1970-1987). NIOSH has also identified and located area neutron surveys associated with the operations where potential neutron exposures existed, which can be used to supplement and evaluate the personnel external neutron monitoring data (ORAUT-TKBS-0038-6). Table 6-3 lists the time periods, types of dosimeters, exchange periods, MDLs, and estimated missed doses for the AI dosimeters used at Area IV of the SSFL.

Table 6-3: Estimated Exchange Frequencies, MDLs, and Annual Missed Doses

Radiation Type	Time Period[a]	Dosimeter	Exchange Period	MDL (rem)[b]	Estimated Annual Missed Dose (rem)[c]
Photon - Beta	1954-1962	Site-specific two element film PIC	Daily	0.005	0.625
			Weekly	0.04	1.04
			Bi-weekly	0.04	0.52
			Monthly	0.04	0.24
	1963-1979	Landauer multi-element film	Monthly	0.04	0.24
			Quarterly	0.04	0.08
	1980[d]-Present	Landauer multi-element film	Quarterly	0.01[e]	0.02
Neutron	1954-Present	NTA film	Bi-weekly	<0.05	0.650
			Monthly	<0.05	0.30

Notes:

[a] **The pre-Landauer start dates for the dosimeter time period are estimated based on the earliest entries in the available records. Landauer or its predecessor was the vendor in 1963 (Garcia, April 5, 1963).**

[b] **Estimated MDLs for each dosimeter in the workplace, although many doses were reported at less than the MDL.**

[c] **Estimated annual missed dose calculated using MDL/2 from OCAS-IG-001.**

[d] **Neutron dosimeters continued monthly exchanges (Badger, 1965-1987; Various authors, 1970-1987).**

[e] **Yoder, 2005.**

NIOSH has access to photon, beta, and neutron external dosimetry results, as well as other supporting data for the entire period evaluated in this report (available for all years of site operation). The policy at SSFL was to assign the applicable dosimetry to anyone with the potential for photon, beta, or neutron exposure; it was assigned based on job assignments that required exposure to radioactive materials (Badger, 1965-1987; Various authors, 1970-1987; ORAUT-TKBS-0038-6). Details regarding the various analyses used, and the associated minimum detectable activities, are presented in ORAUT-TKBS-0038-6.

6.3 SSFL-Area IV Air Sampling Data

The SSFL Area IV health physics program records include a number of air samples for alpha- (in limited cases) and beta-emitters. Measured air concentrations can be useful for estimating maximum doses, when bioassay data are unavailable either because the worker was unmonitored or in cases of non-radiological workers (both cases are associated with individuals with lower exposure potentials as compared to the radiological workers at Area IV of the SSFL). If needed, air concentration measurements are used to assign internal doses from radioactive material in the general environment, in accordance with ORAUT-TKBS-0038-4.

An environmental monitoring program, including air emissions and ambient air monitoring, was established at Area IV of the SSFL in May 1954, prior to completion of the first radiological facility (Sapere Consulting, 2005). From 1955 to present, ambient gross beta activity in air has been measured continuously in Area IV of the SSFL, but there are very few, if any, radionuclide-specific data for the years being evaluated in this report. In all cases, the gross beta concentrations were attributed to natural background plus fallout from aboveground nuclear weapons tests. Because of this, potential worker environmental inhalation intakes from onsite atmospheric radionuclide concentrations can be estimated using average annual concentrations of facility stack emissions (ORAUT-TKBS-0038-4). Specific radionuclides released from various facilities in stack emissions are identified in data from 1988 through 1999; these data were used to characterize radionuclide emissions for all years (ORAUT-TKBS-0038-4). The radionuclide-specific data showed that naturally-occurring radionuclides were major constituents of radionuclide emissions, with polonium-210 a main constituent of the gross alpha concentration and potassium-40 and beryllium-7 major constituents of the gross beta detected. Any uranium and thorium detected is assumed to originate from facility activities (albeit it could be naturally occurring).

The available stack and air monitoring data at SSFL-Area IV have not been found to be sufficiently process-related or facility-specific to support the evaluation of pre-1959 internal doses where other internal monitoring data are lacking. Because internal monitoring is available for the period after 1958, further discussion or evaluation of air sampling will not be included in this SEC petition evaluation.

7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

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

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

- The sufficiency and reliability of the available data. (Section 7.1)
- The feasibility of reconstructing internal radiation doses. (Section 7.2)
- The feasibility of reconstructing external radiation doses. (Section 7.3)
- The bases for petition SEC-00093 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of SSFL-Area IV 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.

A centralized radiological records program was established at SSFL at the beginning of nuclear operations in 1955. The radiological safety program began with the first proposal to secure radioactive material and continued to expand with the level of operations. All health physics records have been maintained in a centralized location at SSFL-Area IV and are readily available to NIOSH. They consist of personnel monitoring records (external exposure and bioassay), meteorological monitoring, environmental monitoring, and effluent monitoring records (Lang, 1960; Various authors, 1960-1966). The availability and extent of the health physics records was corroborated in November, 2007 in a telephone interview with the SSFL Manager of Radiation Safety and in a subsequent data capture trip to the site to do additional research on the data in the available files. Since revision 1 of this evaluation report, 458 documents have been added to the NIOSH Site Research Data Base as a result of additional data capture efforts.

Examination of the internal and external dosimetry data available for SSFL employees indicates that the data are of sufficient accuracy and represent the range of exposures associated with the work performed during the covered period. The type of monitoring was well-suited for the type of work performed at the facility and was comparable to what was used by other facilities doing similar work at that time.

In addition to health physics records, the available source term and process information includes the types and quantities of specific radionuclides and sources present, their chemical and physical form, and the types and frequency of operations (including controls) in which these sources were utilized. NIOSH has determined that there is a lack of meaningful source term information (such as isotopic and curie content) for the 1955-1958 period, which limits the development of a reliable source term for the SSFL-Area IV. However, sufficient information is available to support the evaluation of dose for the post-1958 employment periods using internal and external monitoring data.

7.1.1 Internal Monitoring Data Review

The routine *in vitro* bioassay program was established in August 1958 (Kellehar, 1966). The practice at SSFL was to collect urine samples based on job assignments that required exposure to radioactive materials. Prior to August 1958, NIOSH has found only limited personnel bioassay data or associated internal monitoring-related information for the worker class being evaluated in this report. However, NIOSH does have access to original urinalysis results and other supporting program data for the period after the initiation of a bioassay program in August 1958.

NIOSH reviewed the internal monitoring data analyses performed as part of a mortality study as well as a comprehensive dose reconstruction methodology study at Rocketdyne/Atomics International (Boice, 2006; Boice, May 2006). These documents and studies demonstrate the availability of the internal monitoring data collected over the operational period evaluated in this report and that the site collected and appropriately analyzed samples from individuals with the potential for internal radiological exposures. In addition, these documents include data for the highest exposed individuals for post-1958 periods, and the data are of sufficient quality and quantity to support radiological dose reconstruction and/or coworker studies/analyses for the post-1958 period (Alexander, 1959; Boice, 2006; Garcia, July 1, 1963; Garcia, July 15, 1963; Boice, May 2006; Kellehar, 1966; Lang, 1960; Lee, 1963; O'Brien, 1959; Sheperd, 1959; Various Authors, 1960-1966).

Throughout the history of the site, bioassay samples were also analyzed by commercial laboratories. These commercial laboratories incorporated the same practices and procedures required by SSFL (Rocketdyne/Atomics International) bioassay programs and generally incorporated state-of-the-art equipment and analysis techniques, kept abreast of the latest AEC/DOE requirements and regulations, and incorporated the latest quality control and assurance methods (which would be expected as internal monitoring was their business and would support retaining additional AEC/DOE-related business). During the large-scale studies by Boice (2006, May 2006), 200,000 records in 14,189 worker folders were reviewed, and 2,232 workers were determined to have been internally monitored. A total of 27,023 records of internal monitoring data were compiled (Boice, 2006; Boice, May 2006).

Based on this information, NIOSH has concluded that SSFL policies for the collection and maintenance of employee monitoring data are sufficient for dose reconstruction in terms of the pedigree parameters described previously. As discussed with former and current employees from the site, and later confirmed during data captures (including the most recent data capture in December 2007), physical records are available in hardcopy form and are stored onsite in file cabinets. Upon request, the SSFL provides original hardcopy records for individual claimants; these records have been used by NIOSH and support NIOSH's ability to confirm data. The lack of available internal monitoring data for the pre-1959 period prevents the performance of an internal consistency and data pedigree check for the Area IV SSFL data for the period from 1955 through 1958. Having the original Area IV records of SSFL personnel and the associated radiological program information eliminates the need for a separate internal consistency check of the internal data for the period from 1959 through 1965.

7.1.2 External Monitoring Data Review

When operations began at Area IV of SSFL, the site used its own dosimeter to monitor photon and beta exposures. The dosimeter design was very similar to the film dosimeters used at the Y-12 plant and the Hanford site, which were based on the design developed by Pardue, Goldstein, and Wollan

(Pardue, 1944). During this time period, AI supplemented their film dosimetry with pencil dosimeters and NTA film that was used to monitor neutron exposures. Both penetrating and non-penetrating doses were documented in personnel records (ORAUT-TKBS-0038-6).

AI started using commercial vendors for its dosimetry needs in the early 1960s and continued that practice to the end of its operating life. Original individual external dosimetry records are available for SSFL workers, and all workers shown to have a potential for radiation exposure were monitored over the period evaluated in this report (and for the entire operational period of Area IV of the SSFL). The exchange frequencies for personnel at the site were based on the potential to exceed the administrative exposures limits for the applicable period in the radiological program (Lang, 1960; ORAUT-TKBS-0038-6). Having the original personnel records and the associated radiological program information for Area IV of SSFL eliminates the need for a further consistency check of the external data for the period from 1955 through 1965.

As discussed in a mortality study and a comprehensive dose reconstruction methodology study at Rocketdyne/Atomics International (Boice, 2006; Boice, May 2006), radiation workers (workers routinely assigned to areas where exposure was likely) were assigned a dosimeter. During the early years of the external monitoring program, all employees were assigned a radiation folder (to store any radiological monitoring data collected for each individual) regardless of whether or not they were designated as radiation workers (which resulted in the identification of a multitude of empty radiation folders during the studies). Based on the reviews performed as part of the studies, it was confirmed that the radiation workers who had the potential to receive routine external radiological exposures were monitored using dosimeters for all years evaluated in this report (and for all years of site operations). Therefore, NIOSH has concluded that the available information includes data for the highest exposed individuals for the period evaluated in this report (and for the operations of the site), and that these data are of sufficient quality and quantity to support radiological dose reconstruction and/or coworker studies/analyses for the entire evaluated period. As discussed in the dose reconstruction methodology study and the available information describing the external monitoring and dosimetry program during the period evaluated in this report, sufficient information exists (including quality control information and data to support uncertainty analyses) to support interpreting the external monitoring data for the entire period evaluated in this report (Badger, 1965-1987; Boice, 2006; Clow, 1966; DOE, 1986; Garcia, April 5, 1963; Garcia, July 1, 1963; Garcia, July 15, 1963; Boice, May 2006; Lang, 1960; Pardue, 1944; Various Authors, 1970-1987). Boice (2006, May 2006) reviewed over 200,000 records in 14,189 worker folders, and determined that 5,743 workers were externally monitored (Boice, 2006; Boice, May 2006).

7.2 Internal Radiation Doses at SSFL-Area IV

The principal sources of internal radiation doses for members of the evaluated class were airborne alpha and beta-gamma particulate materials. Alpha-emitting radionuclides were associated with fissionable materials and transuranics in reactor fuel. They include plutonium-238, plutonium-239, uranium-234, uranium-235, uranium-238, thorium-228, thorium-230, thorium-232, and americium-241. Reactor operations produced beta-gamma-emitting mixed fission products and activation products. These include cobalt-60, strontium-90, cesium-137, and tritium. Workers were potentially exposed to these radionuclides during reactor operations as well as during shutdowns, modifications, and refueling. Dust containing radionuclides could be inhaled by individuals and then deposited in the respiratory tract. The dust would also settle on surfaces and become resuspended in the air, where it could again be inhaled or ingested by transfer from contaminated surfaces via hand-to-mouth. The majority of the exposures over the history of SSFL-Area IV operations are considered to be chronic in nature. There were a number of incidents that could have resulted in higher short-term exposures for a limited number of employees. The incidents are well-documented in the site records (ORAUT-TKBS-0038-5).

In addition to particulate matter, reactor operations also produced some short-lived gaseous (xenon-133 and krypton-85) and volatile fission products (radioiodines). Workers could have inhaled this material, although generally there were systems designed to confine or absorb this material until it decayed or was disposed of as waste (Sapere Consulting, 2005).

7.2.1 Process-Related Internal Doses at SSFL-Area IV

The following subsections summarize the extent and limitations of information available for reconstructing the process-related internal doses of members of the evaluated class. Most of the information summarized below is provided in greater detail in the individual TBDs and other document sources.

7.2.1.1 Urinalysis Information and Available Data

As discussed in Section 6.1, NIOSH has identified only limited amounts of internal personnel monitoring data for pre-1959 exposures. The routine *in vitro* bioassay program was established in August 1958 (Kellehar, 1966). NIOSH has access to urinalysis results and other data for the post-1958 period evaluated in this report. Quarterly urinalysis was normally used for routine bioassay during the early years of the program. Initially, gross alpha or gross beta measurements were analyzed and specific radionuclides could be determined “where required.” Should significant activity be detected, more detailed radiometric analysis could be performed with suitable body-burden determinations (Lang, 1960). For the period of 1958 through 1966, analyses were performed for uranium (both fluorometric and radiometric), mixed fission products, plutonium, strontium-90, tritium, and thorium (Alexander, 1959). In addition, NIOSH has access to the internal monitoring program data and radiological source term information associated with all radiological operations performed during (and after) this time period. For the operational period prior to 1959, NIOSH only has access to limited internal monitoring data, and lacks access to sufficient program data or a developed source term evaluation.

The urinalysis practice at SSFL-Area IV for the period after 1958 included collecting urine samples based on job assignments that required exposure to radioactive materials. Workers who were not monitored by urinalysis were considered to be at little or no risk of exposure. Special urine samples were requested when an intake was suspected, or if a routine sample exceeded 10% of the urinary excretion expected from a single maximum permissible body burden. Special samples were analyzed by the onsite laboratory, commercial labs, or both (Kellehar, 1966).

Based on limited pre-1959 internal monitoring data and associated program or source term information, NIOSH has concluded that there is insufficient information to support establishing a bounding internal exposure scenario for the proposed worker class that worked in Area IV of the SSFL from 1955 through 1958. NIOSH has identified post-1958 radiological internal monitoring program data and has access to the original monitoring data for individuals working in the potential exposure areas at Area IV of the SSFL. Therefore, NIOSH has concluded that there are sufficient data to bound the dose (reconstruct dose with sufficient accuracy) for the remainder of the evaluated worker class for the period from 1959 through 1965.

7.2.2 Ambient Environmental Internal Radiation Doses at SSFL-Area IV

Ambient environmental air sampling data exist for the period evaluated in this report; however, no stack effluent concentration data are available for the period prior to 1965. The facilities operating during the pre-1965 period were mainly small reactor facilities. The SRE, the largest reactor at SSFL, operated from 1957 (full-power by May 1958) to 1964 in Area IV.

The SSFL ambient air monitoring data through 1999 are reported as gross alpha and gross beta without identification of specific radionuclides. In all cases, the gross alpha and gross beta concentrations are a small fraction of the applicable limits and are indistinguishable from background. Because of this, stack emission data were used as the primary basis for inhalation intake estimates from onsite atmospheric radionuclide concentrations. Furthermore, the average percentage that each radionuclide contributed to the gross alpha or gross beta concentration was determined from 1988-to-1999 data that were applied to earlier years to estimate radionuclide-specific stack concentrations. Any uranium and thorium detected was assumed to originate from facility activities, even though it could be naturally occurring (ORAUT-TKBS-0038-4).

The facility effluent concentrations for each year were summed and worker exposure hours and rates were estimated (ICRP, 1975). Because the stack effluent concentrations were at the point of release, a further reduction factor of 0.01 was applied to account for the decreased overall intake due to contributions from facility spacing, atmospheric dispersion, and building wake effects (ORAUT-TKBS-0038-4).

Noble gases were not included in inhalation estimates because they were not included in emission monitoring data. The potential dose from radioactive noble gases is very small. Acute release events that would contribute negligibly to the annual average radionuclide concentration are not included in the annual average effluent concentrations (ORAUT-TKBS-0038-4).

The use of facility ambient air monitoring data for assessing internal radiation doses was evaluated for performing EEOICPA dose reconstructions. However, NIOSH has concluded that the ambient environmental method (described above) does not support a bounding internal exposure evaluation method for the pre-1959 time period, when the facility lacked a routine urinalysis program. These data could be applied to support partial internal dose reconstructions (for non-presumptive cancers in the pre-1959 era or cases in the pre-1959 era with less than 250 days employment). For the post-1958 timeframe, personnel ambient exposure/dose is accounted for within the available urinalysis monitoring data for those personnel, and these available bioassay data can be used to bound the post-1958 ambient/environmental doses. Based on this information, further evaluation of these exposures was not performed or required for this evaluation report.

7.2.3 Internal Dose Reconstruction

When Area IV was established at SSFL in 1953, some existing structures were converted for use in nuclear research and development, but many new buildings had to be specifically constructed to house the small reactors and critical assemblies that were the main focus of the early years. Many of the early facilities were not operational until after 1955 (Sapere Consulting, 2005). Small reactors and critical assemblies could produce high external doses in unshielded areas and could have presented some possibility of exposure to enriched uranium; however, in general these did not operate at high enough power levels to produce large quantities of fission products or transuranics (Sapere Consulting, 2005). This is consistent with the lack of a bioassay program during this time at Area IV of the SSFL and the logic for initiation of a bioassay program at the site in August 1958 (as operations were ramping up).

It is important to note that the 1959 SRE incident occurred after the start of routine bioassay and that some of the highest exposure-potential facilities, such as the Hot Laboratory (Building 4020), the Nuclear Materials Development Facility (Building 4055), and Uranium Carbide Fuel Pilot Plant (Building 4005), were not active until after the start of the routine bioassay program (Sapere Consulting, 2005).

The following subsections summarize the methods available to dose reconstructors to either estimate the maximum internal radiation dose or estimate the internal radiation doses to members of the class more precisely than a maximum dose estimate.

Workers employed prior to 1959—Radionuclides of concern were primarily fission products and uranium. Some exposure to fissionable material, transuranics, and activation products was also possible (Sapere Consulting, 2005). Since the routine bioassay program was not initiated until August 1958, many of these workers will not have bioassay data prior to that date. In the rare case that pre-1959 bioassay results do exist for an individual, this data may be applied to support a partial internal dose reconstruction if there is information available to support interpreting the data and/or results. For workers without bioassay results, a partial reconstruction or estimation of their dose is possible through evaluation of their post-1958 internal monitoring data (if available) and/or application of the ambient environmental dose estimates.

Workers employed from 1959-1965—Radionuclides of concern were primarily fission products. Exposure to fissionable material, transuranics, and activation products became more likely as the number, variety, and power levels of the small reactors increased and new facilities for handling unsealed radioactive materials came online (Sapere Consulting, 2005). Doses to the organ of interest for the majority of these workers can be calculated from bioassay results. Although some early bioassay results are recorded only in terms of gross activity, ORAUT-OTIB-0054 provides guidance on the assignment of radionuclide-specific intakes of mixed fission and activation products when air sampling or urinalysis data associated with reactors or reactor fuels are available only as gross or total beta activity or gross or total gamma activity. The availability of actual bioassay results (and associated program data and documentation/information that support the ability to interpret the internal data) for members of the evaluated worker class who were considered radiation workers (and therefore have post-1958 bioassay results available), supports NIOSH's ability to reconstruct dose for those members of the evaluated class with sufficient accuracy. Because these data would include the worst-case exposure scenarios for the evaluated worker class, as discussed in Section 7.1.1, NIOSH contends that the availability of these data also supports its ability to establish a bounding exposure scenario for the entire evaluated worker class. Although research by NIOSH has indicated that those radiation workers who had an internal exposure potential were monitored, NIOSH has deemed it useful to investigate the feasibility of an internal coworker model based on the entirety of the abstracted internal dose records collected by Boice et al. (2006, May 2006). Data from the coworker model could be applied in cases where a worker was not monitored, but by today's standards should have been monitored for internal exposure or for a worker for whom the internal data are incomplete or were lost.

7.2.4 Internal Dose Reconstruction Feasibility Conclusion

NIOSH has established that unmonitored intakes of radionuclides associated with reactor operations (and associated operations) may have occurred in Area IV of the SSFL prior to 1959 and that these exposures may have resulted in unmonitored doses to site workers and workers incidentally exposed in these facilities. NIOSH has also determined that there was no established routine bioassay program for Area IV of the SSFL prior to August 1958. There is insufficient information associated with the source terms for the operations during this timeframe to support developing a method to estimate or bound internal radiological exposures based on source term (or any currently available) information or data. For this reason, NIOSH has concluded that it cannot bound or reconstruct pre-1959 internal doses with sufficient accuracy for any member of the evaluated worker class. NIOSH has established that it can provide a partial estimate of dose for the pre-1959 workers (for non-presumptive cases or for < 250-work day cases in the time period) using any available data in the period, the available monitoring data after 1958 (back-extrapolating the potential intake/dose), or ambient environmental dose reconstruction information.

For the period after 1958 (from 1959-1965), NIOSH has established that it has access to sufficient internal dose information to either: (1) estimate the maximum internal 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 internal radiation doses to members of the class more precisely than a maximum dose estimate.

7.3 External Radiation Doses at SSFL-Area IV

There were many different types of facilities and processes at Area IV of the SSFL with sources of external exposure, including reactors, critical test facilities, fuel preparation and post-irradiation examination facilities, accelerator and calibration facilities, and support facilities. The major accelerator was a Van de Graaff generator that produced neutrons. The fuel facilities, reactors, and critical facilities handled fissionable fuels with various enrichments, mostly compounds of uranium (including carbides). They also handled relatively small quantities of plutonium and thorium. Small-scale fuel decladding operations also resulted in releases of fission products and tritium within the hot cell environment (ORAUT-TKBS-0038-6)

The principal source of external radiation doses for members of the evaluated class included exposure to beta particles, gamma rays, and neutrons. The radiation sources contributing to these exposures have been identified as:

- Operations involving the reactor research and nuclear operations,
- Operations involving nuclear support (fuel, disassembly and examination of reactors, fabrication of sources, waste disposal, etc.), and
- Periodic X-ray examinations.

In terms of isotopes of concern, Table 5-2 identifies the potential radiological contaminants associated with the specific nuclear operations at SSFL-Area IV.

7.3.1 Process-Related External Radiation Doses at SSFL-Area IV

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

7.3.1.1 Beta and Photon Radiation Dosimetry and Source Term

Beta and photon monitoring data are available for Area IV of the SSFL in the form of personnel individual dosimetry records and area monitoring surveys. From the beginning of operations at Area IV of the SSFL, potential exposure to workers, particularly in reference to skin or extremity dose, was routinely considered. Exposure to beta radiation was typically accompanied by photon radiation exposures in SSFL-Area IV work areas. The summary of the beta and photon exposure evaluations, as discussed in this report and as reviewed and characterized in ORAUT-TKBS-0038-6, are included below.

The beta spectrum from uranium is highly dependent on the quantity of daughter products in the uranium, which in turn depends on the enrichment level of the uranium. In some cases, the personnel dosimetry information includes extremity dosimeter results that can be considered in combination with the shielded dosimeter results to evaluate shallow or beta dose. The personnel beta exposures and doses can be reconstructed through an evaluation of the associated individual's personnel monitoring records and application of dose reconstruction methods. Because dosimeter results are available for the radiation workers working at SSFL-Area IV, which would include the most highly exposed individuals, NIOSH has concluded that sufficient information exists to permit bounding the beta exposures for the evaluated class.

In addition to the analysis of the beta exposures, low-energy photons also contribute to personnel shallow dose. Plutonium produces very few highly-penetrating gamma rays because they occur at such a low emission probability. Most photons from plutonium are from low-energy X-rays that are easily shielded. The primary source of external photon exposure is the decay of americium-241, which produces a 60 keV photon with 37% probability of emission per alpha disintegration. Americium-241 is the beta decay progeny of plutonium-241. The americium-241 in-growth in the plutonium increases with time, and hence increasingly contributes its higher-energy photon component to the total exposure. The plutonium-241 decay beta is of low energy (0.022 MeV) and is completely shielded by thin rubber gloves and various other materials (DOE, 2006). Based on the available source term information associated with these exposures, NIOSH has concluded that sufficient information exists to permit bounding the low-energy photon exposures for the SSFL-Area IV evaluated worker class.

High-energy photon exposures also resulted from SSFL-Area IV routine radiological operations with uranium and other high-energy photon sources (as discussed in the SSFL Technical Basis Documents and this evaluation report). Enriched uranium has much less in-growth of protactinium-234m, but uranium-235 and its decay products emit a 185.7 keV photon 57% of the time and a 143.8 keV photon 11% of the time. These two photons dominate the measured photon energy spectra. It is appropriate to assume that the entire photon dose from enriched uranium is a result of exposure in the 30 - 250 keV photon energy range. For enriched uranium, the reconstruction assumes that all photon doses were a result of exposure to the 30 – 250 keV photon energy range, which provides a bounding dose estimate for external dose reconstruction (DOE, 2006). Because dosimeter results are available for the radiation workers working at SSFL-Area IV, which would include the most highly exposed individuals, NIOSH has concluded that sufficient information exists to permit bounding the beta exposures for the evaluated worker class.

7.3.1.2 Neutron Radiation Dosimetry and Source Term

Facilities at Area IV of the SSFL with the potential for neutron radiation exposures include the reactors, accelerators, and fuel storage facilities. AI operated a Van de Graaff generator in Building 4030 to bombard tritium targets with deuterons to produce neutrons. A second Van de Graaff generator operated at the SRE Facility to generate neutrons for neutron activation analyses of materials (1960 through 1964). The Water Boiler Neutron Source (WBNS), a small low-power research reactor, was used for reactor operator training and as a neutron source for many different tests from 1956 through 1980 (ORAUT-TKBS-0038-2). From the perspective of personnel neutron exposures, the accelerators were the major source of neutrons.

Because of strict criticality controls at the site, no neutron-induced multiplication from plutonium would be expected at Area IV of SSFL. Induced fission seems to be a problem only in metal (1 kg or more) or in very large, high-density arrays of plutonium oxide with an additional moderator. The spontaneous fission neutron fields associated with plutonium at Area IV of SSFL varied based on the amount of shielding (or moderator material) around the plutonium. Most spontaneous fission neutrons produced by plutonium have energies less than 20 MeV, with the majority of energies being less than 5 MeV (DOE, 2006).

Beginning with the start of reactor operations and the use of Van de Graaff accelerators, neutron doses were measured using NTA film. Neutron doses were recorded as whole-body dose in rem and are included in the records submitted to NIOSH for those claimants with the potential for neutron exposures. The general trend in recorded neutron dose for SSFL workers is available in the DOE CEDR external dosimetry analysis file for the epidemiologic study conducted by Boice, et al. (2006). The earliest positive neutron dose occurred in 1954, and neutron doses were measured in all years until 1987. NTA is known to have limitations for lower-energy neutrons (<~0.5 MeV). Because most, if not all, of the neutron energies that existed at Area IV of SSFL were >0.5 MeV (ORAUT-TKBS-00038-6), the available NTA measurement results are expected to be a reasonable representation of the SSFL neutron exposures and associated doses.

In the case that it becomes necessary to evaluate exposures to, and doses from, lower-energy neutrons at Area IV of SSFL, it would be possible to evaluate the neutron-to-photon ratio to account for and assign a neutron dose (considering that it was the AI practice at Area IV of the SSFL to assign beta/photon personnel dosimeters to all workers entering a radiologically controlled area; therefore, any significant photon radiation dose would have also been measured in tandem with the neutron dose). NIOSH also has access to area monitoring data that could be used to supplement and verify any neutron-to-photon ratios, as necessary.

Because NTA dosimeter results are available for all applicable members (radiation workers who worked in areas where neutron exposures were expected) of the SSFL-Area IV worker class evaluated in this report, and NIOSH has knowledge of the associated source terms that result in appreciable neutron exposures, NIOSH has concluded that sufficient information exists to permit bounding the neutron exposures for the evaluated class.

7.3.1.3 Application of Coworker Data for External Dose Reconstruction

In cases of lost or damaged dosimeters, dose results are derived from past results of similar work, coworker results, or the product of instrument measurements and time spent in the radiation zone. These practices are typical of sites with similar circumstances.

Coworker data may be used for cases not having complete monitoring data and may fall into one of several categories including:

- The worker was unmonitored, and even by current standards did not need to be monitored (e.g., a non-radiological worker)
- The worker was unmonitored, but by current standards would have been monitored
- The worker may have been monitored, but the data are not available for dose reconstruction
- The worker has partial information, but it is insufficient to complete a dose reconstruction

Although a significant dosimetry data deficiency has not been identified for the evaluated worker class timeframe, NIOSH has proceeded to complete an external coworker model based on the available digitized data available to NIOSH from the study by Boice et al. (2006, May 2006). The coworker model is deemed useful for cases such as outlined in the paragraph above.

7.3.2 Ambient Environmental External Radiation Doses at SSFL

NIOSH has determined that ambient environmental external dose information is not available during the period evaluated in this report (sufficient data are not available until the mid-1970s). Using the available data, NIOSH estimated that the baseline dose above background in Area IV is 20 mrem/year, to account for reactor operations during the period from 1955 through 1965. Facility-specific dose for the RMDF during these years was estimated to be elevated to 80 mrem/year. During the years of SRE operations, a facility-specific dose of 40 mrem/year was estimated for Building 4143 (ORAUT-TKBS-0038-4).

The use of facility ambient external monitoring data for purposes of assessing external ambient environmental radiation doses was evaluated for purposes of performing EEOICPA dose reconstructions. However, NIOSH has concluded that the ambient environmental method (described above) does not support a bounding external exposure evaluation method for the 1955-1958 timeframe, in support of radiological dose reconstructions for the proposed worker class. However, the available data including the external coworker model can be used to bound the external ambient doses for unmonitored workers during the remainder of the evaluation period (1959-1965). Therefore, further evaluation of the ambient environmental external doses is not included in this evaluation report.

7.3.3 SSFL-Area IV Occupational X-Ray Examinations

AEC-funded work at SSFL-Area IV began in 1948. Clinicians prescribed chest X-ray examinations, and in some cases lumbar-spine X-ray examinations. These examinations caused exposure to the lungs and other tissues of the body. Exposure came from the primary X-ray beam and from scattered and leakage radiation. Radiation safety standards dating back to 1966 required “pre-exposure examinations” for radiation workers (Garcia, 1965). This examination was to include a chest X-ray. It is reasonable and claimant-favorable to assume that this practice has been in effect for radiation workers since the start of operations in Area IV.

A review of randomly selected X-ray films dating back to 1956 provided insight into the occupational medical program (Morris, 2005). Individual medical charts do not contain X-ray films. If an old film is to be reviewed, the separate X-ray record must be retrieved. Three boxes of archived radiographs representing approximately 300 individuals were reviewed. The boxes contained an envelope for each individual; each envelope contained films for that person. The outside of each file storage envelope describes the contents; thus, it is possible to determine the number and kind of radiograph, and whether the radiograph represents a pre-employment examination, periodic re-examination, or a workup following an industrial injury. Radiographs associated with an industrial injury are often identified as “IND;” these are not pertinent to dose reconstruction.

Lacking specific information in a claimant record, a reasonable and claimant-favorable assumption is that all employees had a pre-employment examination consisting of the following:

• PA chest film,

• LAT chest film,

• AP lumbar spine film, and

• AP lumbar spine spot film.

7.3.4 External Dose Reconstruction

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

- Photon Dose
- Electron Dose
- Neutron Dose
- Unmonitored Individuals Working in Production Areas
- Medical X-ray

7.3.4.1 Photon Dose

Standard external dose reconstruction practices can be employed by using the actual individual dosimeter results and by assigning missed dose to each non-positive dosimeter cycle (ORAUT-TKBS-0038-6; ORAUT-OTIB-0004; ORAUT-OTIB-0020).

7.3.4.2 Electron Dose

As discussed in Section 5.0, although it is not expected that beta radiation would be a significant exposure concern or contributor to the personnel dose for the worker class evaluated in this report, dosimeters used during the time period under evaluation included an open window for assessing shallow dose from electrons. Actual individual dosimeter results may be used to reconstruct skin dose when applicable (ORAUT-TKBS-0038-6; ORAUT-OTIB-0017).

7.3.4.3 Neutron Dose

Facilities with the potential for exposure to neutron radiation included reactors, accelerators, and fuel storage facilities. NTA film was incorporated into the film dosimeters if there was a potential for exposure >100 mrem in those facilities where neutron exposures were possible (recorded in the dose record, under the “n” column). It is assumed that the dose recorded was the result of fast neutron exposure (ORAUT-TKBS-0038-6, pages 8-10). The distribution of energies and International Commission on Radiological Protection (ICRP) Publication 60 conversion correction factors (ICRP, 1991; ORAUT-OTIB-0055) are listed in ORAUT-TKBS-0038-6. The correction factor for the 2- to 14-MeV energy group was calculated from data in ORAUT-TKBS-0014-6, based on the similarities in the badges used at the two facilities.

7.3.4.4 Medical X-ray

The records provided by DOE typically include adequate information to define the date, type, and count of X-ray examinations that were administered to each employee as a condition of employment. Assumptions regarding radiographic exposure frequency are used only for screening or when specific claimant records are not available.

In accordance with ORAUT-OTIB-0006 and ORAUT-PROC-0061, NIOSH has data and information to support bounding the medical X-ray dose.

7.3.5 External Dose Reconstruction Feasibility Conclusion

NIOSH has established that it has access to sufficient information to either: (1) estimate the maximum external 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 external radiation doses to members of the class more precisely than a maximum dose estimate.

7.4 Evaluation of Petition Basis for SEC-00093

The following subsections evaluate the assertions made on behalf of petition SEC-00093 for SSFL-Area IV.

7.4.1 Evaluation of Specific Petitioner Statements in SEC-00093

This subsection presents general concerns made by workers on behalf of petition SEC-00093. The italicized statements are from the petition; the comments that follow are from NIOSH.

7.4.1.1 SRE Incident and Release of Core Gases

The petitioner indicated that based on information about the SRE partial meltdown of fuel rods, it was the petitioner's intent to maintain this incident as part of their petition basis that monitoring records do not exist. On the Continuation page of Form B—under See Enclosures— the petitioner listed "release of core gases."

In addition to reference documents located in the SRDB, NIOSH has reviewed several documents that specifically evaluate the environmental releases resulting from this incident (Christian, 2005; Lochbaum, 2006; Hart, 1962, Rutherford, 2005). Although there is not a consensus on the exact amount of gaseous radioactive materials released to the environment following the incident, all pertinent scientific reports conclude that a significant amount of fission products was released from the fuel into the primary sodium coolant, with a percentage of that inventory being released to the reactor's cover gas system, and subsequently released into the atmosphere through reactor building vent systems and from gaseous storage tanks. The type and range of releases to the environment following the fuel damage run from less than 1 Ci of iodine-131 (Christan, 2005) to a conservative upper-bound estimate of ~ 3000 Ci of iodine-131 (Lochbaum, 2006). Based on documented stack releases during the incident, AI concluded that since no iodine-131 was detected in the cover gas, only about 28 Ci of the noble gases krypton-85 and xenon-133 were released from the stacks to the environment (Rutherford, 2005).

Based on its review of claims in NOCTS, NIOSH concludes that personnel monitoring does exist for members of the evaluated class (both internal monitoring and external monitoring) during the timeframe of the SRE event. In addition to the personnel monitoring, some air monitoring measurements from the reactor area and stack monitoring also exist. The availability of actual bioassay results (and associated program data and documentation that support the ability to interpret the internal data) post-1958 for affected and/or associated members of the evaluated worker class supports NIOSH's ability to reconstruct dose for those members of the evaluated class with sufficient accuracy. Because these data would include the worst-case exposure scenarios for the evaluated worker class, NIOSH contends that the availability of these data also supports its ability to establish a bounding exposure scenario for the entire evaluated worker class after 1958. At this point NIOSH has completed the development of an external coworker model to assess potential doses to workers who were not monitored, but should have been monitored based on their employment location or potential unplanned involvement in the incident response. NIOSH is currently in the process of developing an internal coworker model for the same purpose.

7.4.1.2 Radiation Badges

The petitioner discussed a Tiger Team report indicating that it detailed "inadequate radiation badges."

The Tiger Team Report cited by the petitioner does not state that the dosimeters were inadequate, but that they were not Department of Energy Laboratory Accreditation Program (DOELAP)-accredited, and it specifically focuses on the D&D period versus the period being evaluated in this report. As it relates to the program being discussed in the Tiger Team report, it was common practice (and is noted as an option in Section 7 of DOELAP Administrative Standard DOE-STD-1111-98) for smaller programs to be exempted from DOELAP accreditation, contingent upon using a National Voluntary Laboratory Accreditation Program (NVLAP)-accredited commercial service (DOE, 2006). However, this is pertinent only beginning in 1986 when the DOELAP requirements were implemented. Therefore, as discussed previously, the period cited in the petition is after the period of the evaluation and does not impact this Evaluation Report.

7.4.1.3 Tritium Plumes

On the Continuation Page of Form B—under See Enclosures—the petitioner listed "tritium plumes."

Available data indicate that onsite water supply wells were the primary water source from 1949 to 1964. No detectable (>1000 pCi/l) tritium has ever been found in any of the water supply wells. The primary supply wells (WS-5, WS-6, WS-12, and WS-13) were in Areas I, II, and III at SSFL. One well (WS-7) was in Area IV and was a minor source compared to the other wells. Recent sampling indicates that the source of the tritium is in the vicinity of Building 4010. None of the sampling wells between the source and the historical water supply wells has shown detectable levels of tritium (>1000 pCi/l) (Haley & Aldrich, 2007). Based on the available data, NIOSH can bound occupational exposure to tritium in the groundwater by assuming that the concentrations in the shallow sampling well RD-34A are related to concentrations in the drinking water wells in the 1950s and 1960s. It should be noted that sampling well RD-34A has never been a source of drinking water for the site and is down-gradient from the source of the tritium (Building 4010). Since 1991, the mean concentration in this well has been 2,940 pCi/l. For the purpose of establishing a bounding approach to reconstructing dose from this exposure source to the evaluated worker class evaluated in this report, it can be assumed that the tritium instantaneously built up in the soil and was transported to the groundwater. This would result in a concentration of 30,000 pCi/l in the 1950s and 1960s (accounting for radioactive decay). Exposures would be considered incidental after the point that bottled drinking water was delivered to the site (1962 and later).

Starting in 1964, offsite water was imported into the pipelines (public water supply), and by 1965 the majority of the water supplying the restrooms, kitchens, etc. was from an offsite source. All supply wells were sampled for tritium in the 1980s and 1990s, and none was detected. Around 2000, the imported water that supplied the restrooms, etc. was completely separated from the supply wells onsite (Haley & Aldrich, 2007; Rutherford, 2007).

7.4.1.4 Uranium Fires

On the Continuation Page of Form B—under See Enclosures—the petitioner listed "uranium fires."

Documentation supporting the petitioner's claim cites two incidents of a sodium explosion while cleaning a valve, and a uranium carbide oxidation incident. NIOSH has assumed that the petitioner has provided these as examples of incidents without monitoring data. The documents submitted contain data indicating that radiological surveys of Building 064 Vault and the CERF (Building 163) were performed following each of these events. Monitoring consisted of survey meters and smears that indicated beta contamination levels of 726 d/m – 57,762 d/m-100cm^2 for Building 163 and 5 x 10^3 d/m-100 cm^2 for Building 064. Building 163 had air monitoring data with concentrations of 2 x 10^{-9} µCi/cm^3 following the events (Name One, September 6, 2007). Based on the available information for these incidents, coupled with the available personnel monitoring data, NIOSH contends that it can bound the dose associated with these exposures for the evaluated worker class evaluated in this report. A review of 38 additional uranium fire incident reports indicate that the areas were checked after the incidents for contamination, and those individuals involved in the incidents went through decontamination and medical checks with no injuries reported.

7.4.1.5 Air Monitoring

On the Continuation Page of Form B—under See Enclosures— the petitioner listed "no air monitoring."

Based on NIOSH's review of the information available in the SRDB, the Site Profile, and the personnel monitoring data in NOCTS, NIOSH concurs that there is an apparent lack of area air monitoring for the period at SSFL-Area IV prior to 1958, which does impact the feasibility of estimating internal radiation doses with sufficient accuracy for the proposed worker class during that time period.

After 1958, NIOSH will base its dose reconstructions primarily on bioassay data. The availability of actual bioassay results (and associated program data and documentation that supports the ability to interpret the internal data) for members of the evaluated worker class supports NIOSH's ability to reconstruct dose for those members of the evaluated class with sufficient accuracy. Because these data would include the worst-case exposure scenarios for the evaluated worker class, NIOSH contends that the availability of this data also supports the ability to establish a bounding exposure scenario, regardless of the availability of air sample data, for the evaluated worker class after 1958, when bioassay data became routinely available.

7.4.1.6 The Sodium Burn Pit

As identified in Item F.1 of the SEC-00093 Form B, the petitioner discussed the Sodium Burn Pit and indicated that no records were kept.

The Sodium Burn Pit was used to clean sodium from equipment parts before disposal and was not intended to be used for disposal of radioactive material. The site profile does not evaluate the potential emissions from these operations (due to contamination of the sodium with fission products). However, it does state that "several small scrap test components containing radioactivity were found and removed" (ORAUT-TKBS-0038-2).

The *Interim Final RCRA Facility Assessment Report for Rockwell International Corporation* states that the Sodium Burn Pit had soil contamination, but it was unknown if radioactive waste had been burned there. In October 1978, three contaminated sodium barrels were found in the sodium burn pit. The barrels had a maximum exposure rate of 1 mrad/hour. The barrels were removed and taken to the RMHF for disposal (Sapere Consulting, 2005). After the discovery of contaminated items at the site, periodic radiation surveys and soil samples were performed from 1978 through 1983. Based on process history, the contaminants of concern are cesium-137, strontium, and thorium. Results indicated low levels (56 pCi/g maximum) of radioactive contamination (principally cesium-137), primarily in the lower pond. Contamination was not identified in areas outside the ponds.

The Sodium Burn Pit was an outdoor area, neither continuously occupied nor continuously used. Because the pit was not an operations area, exposures for individuals that may have intermittently occupied the Sodium Burn Pit would have been lower than exposures for individuals who performed operations work with the source materials that were delivered to this location. In addition, significant radiological exposures resulting from worker activities in the vicinity of the Sodium Burn Pit are unlikely because of the controls in place at this location. For example, workers were required to maintain a safe distance from the pits (including lined and unlined pits/ponds) because of the potentially violent reactions that could occur in the case of sodium or potassium making contact with water.

The availability of actual bioassay results after 1958 (and associated program data and documentation that support the ability to interpret the internal data) supports NIOSH's ability to reconstruct dose for those workers who might have been affected by or associated with burn pit operations. Because the data would include the most highly exposed individuals , NIOSH contends that the availability of these data also supports the ability to establish a bounding exposure scenario for any exposures to personnel at the burn pit, or for any member of the worker class evaluated in this report and who worked after the 1955-1958 time period.

7.5 Other Issues Relevant to the Petition Identified During the Evaluation

During the feasibility evaluation for SEC-00093, a number of issues were identified that required further analysis and resolution. The issues and their current status are as follows:

- ISSUE: The identification of workers with blank radiation exposure record sheets in their file (a sheet with no entries).

  APPROACH: In an interview with a current Radiation Safety Officer at the SSFL, the interviewee stated that each AI worker (both radiation and non-radiation workers) had a blank record sheet in his/her file called a "blue card." If they were assigned to a controlled area, they were required to have a film badge and any exposure was entered into their file (Personal Communication with Health Physicist, November 20, 2007). This information was corroborated in random individual record reviews performed by NIOSH as well as in documented reviews of personnel records (Boice, 2006; Boice, May 2006); therefore, NIOSH has concluded that individuals that had no record (or blue card) are considered non-radiological workers at Area IV of the SSFL.

  Based on information included in documented reviews (Boice, 2006; Boice, May 2006), during the early years at the site all personnel were issued a radiation dose folder/record; however, only radiological workers (who were issued dosimeters) received recorded dose information in those records. Based on this information, NIOSH has concluded that individuals with blank radiological folders/records are also non-radiological workers (at Area IV of SSFL), and individuals with recorded information in their radiological files are considered SSFL-Area IV radiological workers. As previously discussed, the availability of personnel records for monitored individuals supports NIOSH's ability to reconstruct dose with sufficient accuracy for the evaluated worker class members for the period after 1958. Because the available data also include a representation of the maximum potential exposures (a bounding exposure scenario) for the evaluated worker class, NIOSH contends that this supports its ability to bound the associated dose for all members of the evaluated worker class after 1958, including any unmonitored individual or any individual with potentially missing dosimetry data (this approach will be handled on an individual case basis).

- ISSUE: When firemen from other sites were involved in fires or events at SSFL Area IV, how was it recorded?

  APPROACH: Based on interviews and reviews of dosimetry information for this evaluation, NIOSH has determined that firemen typically wore film badges when working in areas with the potential for radiological exposures. In one case, an individual that worked as a fireman did not have monitoring records in his file. During interviews, interviewees indicated that all firemen wore film badges regardless of where they were assigned for a shift. One interviewee stated that "During the 30 years I was there (1962 through 1993), there were no radiation fires" (Personal Communication with Fireman). Based on the information from interviews, it is clear that each individual claim will have to be reviewed and processed on a case-by-case basis; it is possible that the fireman without monitoring records was not expected to receive any exposures while on the job and was not required to enter radiological areas during his employment. However, this does not prevent NIOSH from establishing a bounding exposure scenario for the evaluated worker class. As previously discussed and stated, the availability of personnel records for monitored individuals supports NIOSH's ability to reconstruct dose with sufficient accuracy for workers after 1958. Because the available data also include a representation of the maximum potential exposures (a bounding exposure scenario), NIOSH contends that this supports its ability to bound the associated dose for all members of the evaluated worker class after 1958, including dose associated with the exposure scenarios presented by/for these firemen.

7.6 Summary of Feasibility Findings for Petition SEC-00093

This report evaluates the feasibility for completing dose reconstructions for employees at SSFL-Area IV from January 1955 through December 1965. Based on the limited pre-1959 internal monitoring data and associated program or source term information, NIOSH has concluded that there is insufficient information to support establishing a bounding internal exposure scenario for the proposed worker class that worked in Area IV of the SSFL from 1955 through 1958. NIOSH has identified post-1958 radiological internal monitoring program data and the original monitoring data for individuals working in the highest-exposure areas at Area IV of the SSFL. Therefore, NIOSH has concluded that there are sufficient data for it to bound the dose (reconstruct dose with sufficient accuracy) for the class evaluated for the period from 1959 through 1965.

Table 7-1 summarizes the results of the feasibility findings at SSFL-Area IV for each exposure source during the time period of January 1955 through December 1965.

Table 7-1: Summary of Feasibility Findings for SEC-00093

January 1955 through December 1965

Source of Exposure	Reconstruction Feasible	Reconstruction Not Feasible
Internal[1]	X (January 1, 1959 – December 31, 1965)	X (January 1, 1955 – December 31, 1958)
- All Radionuclides	X	X

Table 7-1: Summary of Feasibility Findings for SEC-00093 January 1955 through December 1965		
	(January 1, 1959 – December 31, 1965)	(January 1, 1955 – December 31, 1958)
External	X	
- Beta, Photon, and Neutron	X	
- Occupational Medical X-ray	X	

Notes:
[1] Internal includes an evaluation of urinalysis (in vitro) and airborne dust data.

8.0 Evaluation of Health Endangerment for Petition SEC-00093

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

Per EEOICPA and 42 C.F.R. § 83.13(c)(3), a health endangerment determination is required because NIOSH has determined that it lacks sufficient internal monitoring data for the period from January 1, 1955 through December 31, 1958, which prevents evaluating internal dose with sufficient accuracy for the members of the proposed class during this period.

NIOSH has determined that members of the class were not exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. However, evidence indicates that some workers in the proposed class may have accumulated substantial chronic exposures through episodic intakes of radionuclides, combined with external exposures to gamma, beta, and neutron radiation. Consequently, NIOSH is specifying that health was endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class or in combination with work days within the parameters established for one or more other classes of employees in the SEC (excluding aggregate work day requirements).

9.0 NIOSH-Proposed Class for Petition SEC-00093

Based on its research, NIOSH reduced the petitioner-requested class to define a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors who worked in any area of Area IV of the Santa Susana Field

Laboratory for a number of work days aggregating at least 250 work days from January 1, 1955 through December 31, 1958, or in combination with work days within the parameters established for one or more other classes of employees in the SEC (excluding aggregate work day requirements).

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 Site Research Database (SRDB), for information relevant to SEC-00093. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to this 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 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 that it would not be feasible to reconstruct the internal dose for the class proposed in this petition.

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