SEC Petition Evaluation Report
Petition SEC-00056

Report Rev # 0

Report Submittal Date: 2/20/2007

Subject Expert(s):	Robert Coblentz, Roger Gard, Timothy Adler
Site Expert(s):	Not Applicable

Petition Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition B Qualification Date	DOE/AWE Facility Name
SEC-00056	83.13	August 29, 2006	Bethlehem Steel Corporation

Petitioner Class Definition
Millwrights, welders, electricians, bricklayers, carpenters, all maintenance, testers, rollers, supervisors, crane operators, hookers, clean-up crews, and grinders who worked in the 10-Inch Bar Mill and Blooming Mill from the years 1949 through 1952.

Proposed Class Definition
All Atomic Weapons Employer personnel at the Bethlehem Steel Corporation who were monitored or should have been monitored for exposure to uranium during uranium rolling activities at the Bethlehem Steel, Lackawanna, New York facility from January 1, 1949 through December 31, 1952.

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
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Peer Review Completed By:	[Signature on file] *Sam Glover*	2/20/2007 *Date*
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Evaluation Report Summary: SEC-00056, Bethlehem Steel Corporation

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-00056, qualified on August 29, 2006, requested that NIOSH consider the following class: *Millwrights, welders, electricians, bricklayers, carpenters, all maintenance, testers, rollers, supervisors, crane operators, hookers, clean-up crews, and grinders who worked in the 10-Inch Bar Mill and Blooming Mill from years 1949 to 1952.*

NIOSH-Proposed Class Definition

Based on its research, NIOSH expanded the petitioner-requested class to define a single class of employees for which NIOSH can estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all Atomic Weapons Employer personnel at the Bethlehem Steel Corporation who were monitored or should have been monitored for exposure to uranium during uranium rolling activities at the Bethlehem Steel, Lackawanna, New York facility from January 1, 1949 through December 31, 1952. The class was expanded because NIOSH determined that the available information does not allow NIOSH to definitively link all individuals to their specific work title/function or work location for the proposed time period and because NIOSH can estimate close with sufficient accuracy for this class.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.13(c)(1), NIOSH has established that it has access to sufficient information to: (1) estimate the maximum radiation dose incurred by any member of the class; or (2) estimate radiation doses more precisely than a maximum dose estimate. 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 proposed class under plausible circumstances during the specified period, and that NIOSH has sufficient information to reconstruct dose for the broader class.

Health Endangerment Determination

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

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SEC Petition Evaluation Report for SEC-00056

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for all Atomic Weapons Employer personnel at the Bethlehem Steel Corporation who were monitored or should have been monitored for exposure to uranium during uranium rolling activities at the Bethlehem Steel, Lackawanna, New York facility from January 1, 1949 through December 31, 1952. 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, NIOSH must also then determine whether or not 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 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

[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.

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 petitioners 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, petitioner(s) 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-00056, qualified on August 29, 2006, requested that NIOSH consider the following class for addition to the SEC: *Millwrights, welders, electricians, bricklayers, carpenters, all maintenance, testers, rollers, supervisors, crane operators, hookers, clean-up crews, and grinders who worked in the 10-Inch Bar Mill and Blooming Mill from years 1949 through 1952.*

The petitioner provided information and affidavit statements in support of the petitioner’s belief that accurate dose reconstruction over time is impossible for the Bethlehem Steel Corporation workers in question. NIOSH deemed the following information and affidavit statements sufficient to qualify SEC-00056 for evaluation:

> The original submission and supplemental supporting documents included 25 documents to support the petition for including the above stated class of workers into the Special Exposure Cohort (SEC). The supporting documentation included various letters, production reports, trip reports, articles, and 69 affidavits. The basis of the petition is that: 1) radiation monitoring records for the proposed class have been lost, falsified, or destroyed; 2) there is no information regarding monitoring, source, source term, or process for uranium rolling activities at Bethlehem Steel; and 3) one or more unmonitored, unrecorded, or inadequately monitored or recorded exposure incidents occurred.

The information and statements provided by the petitioner qualified the petition for further consideration by NIOSH, the Board, and HHS. The details of the petition basis are addressed in Section 7.4.

Based on its research, NIOSH expanded the petitioner-requested class to define a single class of employees for which NIOSH can estimate radiation doses with sufficient accuracy. The NIOSH-

[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.

proposed class includes all Atomic Weapons Employer personnel at the Bethlehem Steel Corporation who were monitored or should have been monitored for exposure to uranium during uranium rolling activities at the Bethlehem Steel, Lackawanna, New York facility from January 1, 1949 through December 31, 1952. The class was expanded because NIOSH determined that the available information does not allow NIOSH to definitively link all individuals to their specific work title/functions or work locations for the proposed time period; and, that NIOSH has sufficient information to reconstruct dose for the broader class.

4.0 Data Sources Reviewed by NIOSH

NIOSH identified and reviewed numerous data sources to determine the availability of 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 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 consistently evaluate internal and external dosimetry data for monitored and unmonitored workers, and to supplement, or substitute for, individual monitoring data. A Site Profile may consist 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. As part of NIOSH’s evaluation of this petition, it examined the following TBDs for insights into Bethlehem Steel Corporation operations or related topics/operations at other sites:

- *Technical Basis Document: Basis for Development of an Exposure Matrix for Bethlehem Steel Corporation, Lackawanna, New York; Period of Operation: 1949-1952*; OCAS-TKBS-0003, Rev. 1; July 27, 2006; SRDB Ref ID: Not available in SRDB

- *Technical Basis Document: Basis for Development of an Exposure Matrix for Bethlehem Steel Corporation, Lackawanna, New York; Period of Operation: 1949-1952*; ORAUT-TKBS-0001, Rev. 1; June 29, 2004 (superseded by OCAS-TKBS-0003 Rev. 0); SRDB Ref ID: Not available in SRDB

- *Technical Basis Document: Basis for Development of an Exposure Matrix for Bethlehem Steel Corporation, Lackawanna, New York; Period of Operation: 1949-1952*; ORAUT-TKBS-0001, Rev. 0; June 29, 2004 (superseded by ORAUT-TKBS-0001, Rev. 1); SRDB Ref ID: 19475

- *Technical Basis Document: Site Profile for Simonds Saw and Steel Company, Lockport New York;* ORAUT-TKBS-0032; Rev. 0; May 31, 2005; SRDB Ref ID: 20181

4.2 ORAU Technical Information Bulletins (OTIBs)

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. NIOSH reviewed the following OTIBs as part of its evaluation:

- *OTIB: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*, Revision 03 PC-1, ORAUT-OTIB-0006; December 21, 2005; SRDB Ref ID: 20220

- *OTIB: Estimating the Maximum Plausible Dose to Workers at Atomic Weapons Employer Facilities*, Revision 03, ORAUT-OTIB-004; August 12, 2005; SRDB Ref ID: 19421

4.3 Facility Employees and Experts

To obtain additional information, NIOSH attended three worker outreach meetings and one Town Hall meeting: 1) a May 4, 2004 public meeting; 2) a July, 1, 2004 meeting with the Bethlehem Steel Claimants Action Group; 3) a January 12, 2005 Town Hall meeting to discuss modifications and updates to the Bethlehem Steel Site Profile and to hear public comment; and 4) a June 21, 2006 second meeting with the Bethlehem Steel Claimants Action Group. NIOSH also conducted telephone interviews with two former site employees. The following subsections describe the worker outreach meetings and telephone interviews in more detail.

4.3.1 Worker Outreach

Three worker outreach meetings were conducted. A public meeting was held on May 4, 2004 to provide information to former Bethlehem Steel employees about the EEOICPA program. In addition, two meetings were conducted with the Bethlehem Steel Claimants Action Group: one on July 1, 2004 and one on June 21, 2006. A Town Hall meeting was also conducted on January 12, 2005. All meetings were conducted to solicit questions and/or comments from former Bethlehem Steel employees or survivors, and for NIOSH to gather first-hand information about uranium rolling activities at Bethlehem Steel.

In addition to the meetings, members of the public have provided numerous comments and questions through written correspondence on behalf of former Bethlehem Steel workers, primarily through the representative (also the designated representative for the Bethlehem Steel Special Exposure Cohort claim petition) of the Bethlehem Steel Claimants Action Group (Petition Form B, 2006, Submitted Comments[3]). NIOSH also corresponded with the SEC petition representative, who explained various issues related to the Bethlehem Steel dose reconstructions. Specific issues raised during these activities are briefly cited in Section 4.3.4 and further evaluated in Section 7.4.

[3] Submitted comments can be located at http://www.cdc.gov/niosh/ocas/bethst.html under the *Comments on Bethlehem Steel Company Documents* heading

4.3.2 Advisory Board on Radiation and Worker Health

The Advisory Board on Radiation and Worker Health held several meetings in various cities across the country, for which the Board's agendas[4] included the Bethlehem Steel Site Profile. These efforts focused on addressing concerns from members of the public and discussing proposed updates to the site profile. Advisory Board meetings are open to the public and provide an opportunity for members of the public to observe the review process and make comments; former Bethlehem Steel workers attended several of these ABRWH meetings. Verbatim transcripts of these public meetings can be found at www.cdc.gov/NIOSH/OCAS.

4.3.3 Telephone Interviews

Due to extensive prior interaction with former Bethlehem Steel workers, NIOSH conducted fewer telephone interviews for this evaluation than usual. NIOSH interviewed two former Bethlehem Steel employees: the Bethlehem Steel SEC petition designated representative and another individual who was present during uranium rolling activities at Bethlehem Steel. Interview questions focused on the following issues: cobble cutting activities, conditions in the cooling bed sub-basement, protective equipment/practices, and accidents or incidents. Interviewees confirmed that uranium rod cobble-cutting was performed by torch-cutting. Interviewees also stated that the cooling bed sub-basement was cleaned once or twice a month by using air hoses to blow debris from inaccessible areas, then using shovels, brooms, and wheelbarrows to clean the debris off of the sub-basement floor. Interviewees also stated that no personal protective equipment was used during uranium rolling activities.

- *Personal Communication with Don Lotocki and Ed Walker*; Telephone Interview by Jack Beck and Libby Gilley; October 26, 2006; SECIS Document ID: 112 and 113

4.3.4 Bethlehem Steel Corporation Worker Issues

Former Bethlehem Steel Corporation employees have expressed concerns regarding dose reconstructions for Bethlehem Steel workers. The issues were expressed in public meetings, phone interviews, and written correspondence. The following is a brief list of those issues. Further details can be found in Section 7.4.

- Information from Simonds Saw and Steel is not a valid comparison to Bethlehem Steel Corporation.

- Other buildings were involved [in uranium work], including the Blooming Mill.

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[4] The following meetings included conversations related to the Bethlehem Steel Site Profile: January 2003; ABRWH Working Group, March 2004; ABRWH, June 2, 2004; ABRWH, June 3, 2004; ABRWH, December 2004; ABRWH, February 7, 2005; ABRWH, February 8, 2005; ABRWH, July 2005; ABRWH, August 2005; ABRWH, October 6, 2005; ABRWH, October 17, 2005; ABRWH, October 18, 2005; ABRWH, November 2005; ABRWH, January 2006; ABRWH, June 2006; ABRWH, September 2006

- NIOSH did not consider [exposures from working in] the sub-basement under the Cooling Bed, nor the Cooling Bed above.
- There are no records for the time period from 1949 through 1950.
- Workers were not supplied with personal protective equipment.
- Thirteen ton of radioactive materials were left at the Bethlehem Steel site.
- The amount of uranium rolling could not have been done in a 10-hour day.
- The work at Bethlehem Steel involved more manual labor than at Simonds Saw and Steel.
- The government admits to destroying records.
- The work areas could not have been cleaned in one day.
- NIOSH initially stated that the highest dust levels were at the rollers, and then later, NIOSH stated the highest exposures were somewhere else.
- Grinding was not recognized or incorporated in the Bethlehem Steel Technical Basis document.
- Workers ate and drank in dusty areas and could have ingested uranium.
- Workers wore contaminated coveralls.

4.4 Previous Dose Reconstructions

NIOSH reviewed its NOCTS dose reconstruction database to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. Table 4-1 summarizes the results of this review for the period of January 1, 1949 through December 31, 1952 (NOCTS data available as of December 14, 2006).

Table 4-1: Number of Bethlehem Steel Claims Submitted Under the Dose Reconstruction Rule
(January 1, 1949 through December 31, 1952)

Description	Totals
Total number of claims submitted for energy employees who meet the proposed class definition criteria	732
Number of dose reconstructions completed for energy employees who were employed during the years identified in the proposed class definition	634
Number of claims for which internal dosimetry records were obtained for the identified years in the proposed class definition	0
Number of claims for which external dosimetry records were obtained for the identified years in the proposed class definition	0

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for each employee. At the time that dose reconstructions were performed, NIOSH was not able to obtain personnel dosimetry records for any employee represented in an individual claim submitted for dose reconstruction under EEOICPA for the time period of January 1, 1949 through December 31, 1952. It is apparent to NIOSH that personal radiation monitoring information was not collected for Bethlehem Steel workers. As a result, prior dose reconstructions have relied on available monitoring data, source term information, production rate records, and air sampling data from a site with similar processes.

As part of the dose reconstruction process, NIOSH conducts Computer Assisted Telephone Interviews (CATIs) with claimants to obtain additional information relevant to each dose reconstruction, including work locations, hours, job titles, and other information. NIOSH carefully reviewed the CATI summary reports to identify information relevant to this evaluation, with particular attention given to those interviews with former employees. The interviews provided information regarding the number of hours worked and typical working conditions that existed during the covered period. Most interviewees reported that no radiological monitoring of any sort was performed. Other individuals reported that they did not know if monitoring had been performed.

4.5 NIOSH Site Research Database

NIOSH also reviewed its Site Research Database to locate documents supporting the evaluation of the proposed class. Currently, there are 141 documents in this database that were identified as pertaining to Bethlehem Steel Corporation. These documents were evaluated for their relevance to this petition. The documents include historical background on process information for experimental rolling of uranium rods, trip reports, and air dust sampling data sheets. There are post-production documents that include surveys for residual contamination, Formerly Utilized Site Remedial Action Program (FUSRAP) elimination reports, and memos concerning the availability of records.

4.6 Documentation and/or Affidavits Provided by Petitioners

In qualifying and evaluating the petition, NIOSH reviewed the following documents submitted by the petitioners (received 03/13/06):

- *Wayne Range Letter*, submitted to support the lack of monitoring data, Wayne Range/Bethlehem Steel Corporation; June 7, 1976; SECIS Document ID: 9576

- *69 affidavits*, submitted to support the lack of monitoring data, Workers and Survivors/Bethlehem Steel Corporation; SECIS Document ID: 9576

5.0 Radiological Operations Relevant to the Proposed Class

The following subsections summarize both radiological operations at the Bethlehem Steel Corporation from January 1949 to December 1952, 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.

5.1 Bethlehem Steel Corporation Plant and Process Descriptions

Bethlehem Steel Corporation, one of the largest steel manufacturers in U.S. history, acquired the Lackawanna facility in 1922. By the end of World War II, the Lackawanna facility was a large complex employing over 20,000 workers with a broad range of production capabilities. In 1947, work was completed on a continuous rolling mill known as the 10-Inch Bar Mill. This state of the art mill was chosen by the Atomic Energy Commission to assist with experimental uranium rolling work (Range, 1976; LaMastra, 1976; Summary 1950-1951). The purpose of this experimental uranium rolling work was to assist in the design of the Fernald facility, which was to be based on a continuous rolling mill technology such as that used at Bethlehem Steel Corporation. The Atomic Energy Commission contracted with Bethlehem Steel Corporation, and records indicate that Bethlehem Steel Corporation participated in both experimental and production uranium rolling runs.

AEC programmatic goals associated with uranium rollings included the following:

- To evaluate the continuous rolling mill as a source of uranium rods for the plutonium production program at Hanford and Savannah River;
- To gain information during the uranium rollings that would be used for the design of the Fernald plant;
- To evaluate technological improvements leading to reduced oxidation of uranium metal through the use of lead bath and salt bath heating (using a combination of lithium and potassium carbonate salts) which would reduce losses during rolling; and
- To evaluate the metallurgical implications of heat treatments for the purpose of improving quality during irradiations.

The specific purpose of the contract with Bethlehem Steel included the following:

- To finish rolling of bars rough-rolled at Simonds Saw or Aliquippa Forge (Summary 1950-1951);
- To compare lead bath versus salt bath heating on product and process quality;
- To heat treat rods and billets (rolled or to be rolled at other facilities), which in some cases also included grinding as part of this preparation; and
- To produce finish-rolled uranium rods from rough-rolled billets.

The uranium billets were prepared by Mallinckrodt Chemical in St. Louis, Missouri, shipped to the rough-rolling mill (Simonds Saw or Aliquippa Forge), and then shipped to Lackawanna in freight cars for finish-rolling. The work only involved the 10-Inch Bar Mill and associated billet preparation and handling equipment (LaMastra, 1976; Thornton, 1977; DOE, 1985; Range, 1976; ORNL, 1980), and generally took place only on weekends because the mills were in full use five days per week for normal steel production.

According to some accounts, material accountability practices for the project included collection of scale, residue, fine debris, and cropped ends. Workers reported the use of vacuum cleaners to assist in the cleanup in many areas. These materials were packaged and returned to the AEC, which had a documented scrap recovery program (Range, 1976; LaMastra, 1976; ORNL, 1980). Most uranium metal accountability records, however, were apparently destroyed (Range, 1976; Fletcher, 1976; LaMastra, 1976; ORNL, 1980). A memorandum from the Tonawanda sub-office titled *Monthly Progress Report for November* and dated November 1951, accounts for thirteen bundles of cobbled rods and four drums of scrap from the last Bethlehem rolling, occurring in October 1951, that were transferred to storage at the Lake Ontario Ordinance Works (LOOW) by personnel from the Bethlehem Steel Corporation (Malone, 1951).

A number of documents provide varied information regarding the time period during which the rollings occurred. Some reference memos and reports indicate that all work, which could have included rolling work, occurred between 1949 and 1952 (LaMastra, 1976; Summary 1950-1951; ORNL 1980; Range, 1976; NLO, 1952). However, NIOSH has only been able to substantiate that rollings were performed in 1951 and 1952 (NLO, 1952). Although NIOSH was unable to substantiate that uranium rollings were performed in 1949 and 1950, to ensure claimant-favorability in individual dose reconstructions, it has been assumed that one rolling occurred per month in the years 1949 and 1950. NIOSH also obtained a letter from a labor representative in October 1979 asserting that six to eight rollings took place in 1955. NIOSH was unable to locate any historical documentation to corroborate that rollings were performed on these dates (Kosanovich, 1979) and therefore, did not include 1955 in the operational period that was evaluated. The rolling work at Bethlehem Steel Corporation was used in the design of a rolling mill at the National Lead Company plant in Fernald, Ohio, and by all indications, uranium rolling was transferred to the Fernald Plant around September 1952 when Fernald began pilot-operations (Range, 1976; NLO,1952; NLO, 1985; LaMastra, 1976).

Several documents report that AEC personnel were present during all rolling operations, and several site-visit reports document these visits. AEC personnel conducted air and surface radioactivity monitoring and checked personnel involved in the rolling for contamination during some of the uranium rollings (LaMastra, 1976; DOE, 1985; ORNL, 1980). Although some reports indicate that no records are available regarding these monitoring activities (Range, 1976; LaMastra, 1976; ORNL, 1980), a review of AEC historical records has produced several documents containing air sampling data from the Health and Safety Laboratory (HASL) and National Lead Company for eight of the fourteen rollings from April 1951 through October 1952 at Bethlehem Steel. These documents, supplemented with data collected at Simonds Saw and Steel, (which performed similar work), along with source-term information gained from AEC uranium rolling production reports (Summary 1950-1951; OCAS-TKBS-003, Table 1)[5], provide the basis for worker dose estimation methodology.

[5] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source documents: AEC, 1951-1952 Sample Sheets; AEC, 1952 Sample Sheets; Bowman, 1952; Gardner, 1952; Hershman, 1952; Kattner, 1951; Kattner, 1952a; Kattner, 1952b; Kattner, 1952c; NLO, 1952; Reichard, 1951; Riches, 1951; Schneider, No date; Stewart, 1952

Radiological surveys were performed in 1976 and in 1980; the radiological surveys identified no residual contamination above natural background levels in the original facility or in the equipment; (DOE, 1985; LaMastra, 1976; ORNL, 1980; OCAS-TKBS-0003)[6].

Table 5-1 summarizes the site development.

Table 5-1: Bethlehem Steel Company Development Chronology

Years	Buildings	Comments	Plant Population
1949-1950	10-Inch Bar Mill	Although no documentation or records have been found to substantiate that rolling operations were actually performed in this period, uranium rolling is assumed to have been performed. Simonds Saw and Steel is used as a surrogate, with no protective coatings or ventilation methods applied. (**This data includes Simonds Saw and Steel's rough-rolling activities.)**	All workers are assumed affected at the 95th percentile value of the maximum dose potential data set, with the cobble-cutting dose model added for suspected cobble-cutters.
January 1951 - September 1951	10-Inch Bar Mill	Lead and salt bath technologies were utilized. General area air monitoring was mainly performed. A breathing zone/general area ratio from Simonds Saw & Steel air monitoring data was applied to Bethlehem Steel general area air monitoring results to derive surrogate breathing zone levels at Bethlehem Steel.	All workers are assumed affected at the 95th percentile value of the maximum dose potential data set, with the cobble-cutting dose model added for suspected cobble-cutters.
September 1951-1952	10-Inch Bar Mill	Salt bath technology was fully employed, significantly reducing airborne uranium levels at the rollers. Hence, grinding operations became the task with maximum dose potential.	All workers are assumed affected at the grinding airborne level, with the cobble-cutting dose model added for suspected cobble-cutters.

5.2 Bethlehem Steel Corporation Functional Areas

Bethlehem Steel Corporation uranium rolling operations were limited to the 10-Inch Bar Mill, which included the following components:

- Heating furnace and molten lead/salt vats
- Multi-stage continuous bar rollers

[6] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: Kattner, 1952

- Rotary Shear
- Rod Cooling Bed/Racks (North Side and South Side)
- North and South Shears
- North and South Scale Mounted Cradles and Stop-blocks
- Packaging Area

Rough-rolled billets were brought to Bethlehem Steel by railcar and were stored during the week for finish rolling on the weekends at the 10-Inch Bar Mill. The billets were heated to approximately 1,200 degrees by submersion into molten lead or salt vats, and then rolled into approximately 1-inch diameter rods. Rough ends were cropped, and then the rods were cooled on a two-sided cooling bed/rack. Once cooled, the rods were sheared to specified lengths, and bundled for shipment. Hand-grinding was sometimes necessary to correct surface imperfections. Occasionally, the rods were misfed while passing from one roller stage into the next; the incorrect feeding resulted in the rod bending and twisting into what was referred to as a cobble. The cobbles were then, according to worker reports, torch-cut into pieces small enough for placement into scrap barrels. These scraps were recovered as part of the AEC's scrap recovery program, which also included other scrap such as vacuumed slag and scale. Additional information regarding Bethlehem Steel Corporation uranium rolling operations can also be found in OCAS-TKBS-0003.

5.3 Radiological Exposure Sources from Bethlehem Steel Operations

The Bethlehem Steel Corporation had only one process involving radioactive material: rolling natural uranium metal. This process included receipt of rough-rolled uranium billets, lead or salt bath heating of the billets, finish-rolling the billets into approximately one-inch diameter bars, shearing off rough ends, air-cooling the bars, grinding off surface imperfections, cutting the rods into four-inch and eight-inch slugs, and packaging slugs for shipment. Also included was scrap recovery, in which slag, debris, and cobbles (produced when rods did not feed correctly into the successive rollers) were collected and cut into pieces and collected in drums. The scrap materials were then packaged for shipment.

5.3.1 Alpha Particle Emissions

Alpha particle emissions from natural uranium processed at Bethlehem Steel presented the greatest potential for internal radiation exposure through internal deposition via inhalation and ingestion (alpha particles do not present an external exposure hazard). Processed natural uranium consists of approximately equal activities of uranium-238 [4.20 MeV and 4.15 MeV alpha particles] and uranium-234 [4.77 MeV and 4.73 MeV alpha particles] (Radiological Health, 1970). There are smaller amounts of uranium-235 (approximately 1/20 of the activity levels of uranium-238 or uranium-234) with alpha particles of 4.40 MeV and 4.36 MeV.

5.3.2 Beta Radiation Fields

Beta particle radiation was the dominant source of external radiation exposure associated with uranium rolling activities at Bethlehem Steel. The dominant beta radiation from natural uranium is from the uranium-238 decay products. The most energetic of these beta particles is from protactinium-234m [2.29 MeV]. The surface beta dose rate from a uranium slab is approximately 230 millirad (mrad) per hour.

5.3.3 Neutron Exposures

Neutron exposures were not evaluated for Bethlehem Steel because they are negligible for natural uranium metal-handling facilities (ORAUT-OTIB-0004).

5.3.4 Photon Exposures

The majority of photons from natural uranium metals are in the 30 to 250 keV energy range. In contrast, solid uranium objects provide considerable shielding of the lower-energy photons and "harden" the spectrum, causing the majority of photons emitted from a solid uranium object (e.g., a billet or rod) to have energies greater than 250 keV. While it is recognized that solid uranium sources have a hardened photon spectrum, exposure to a thin layer of uranium results in a larger fraction of exposure to lower-energy photons. Therefore, for the purposes of this evaluation, deep dose estimates from the uranium sources at Bethlehem Steel are evenly distributed between photons with E=30-250 keV and photons with E>250 keV, which is consistent with the Bethlehem Steel Technical Basis Document (OCAS-TKBS-0003).

6.0 Summary of Available Monitoring Data for the Proposed Class

Dose estimates for workers at Bethlehem Steel are based on a compilation of data sources. The available sources of monitoring data are listed below:

- Simonds Saw and Steel work area and breathing zone air monitoring (surrogate data for Bethlehem Steel for years 1949 through 1950)
- Bethlehem Steel work area air monitoring for years 1951 through 1952
- Simonds Saw and Steel surface contamination monitoring for 1948
- Bethlehem Steel surface contamination monitoring for 1952
- Source term and process information; information from contract language and production reports

Work area air monitoring was performed at Bethlehem Steel during the years 1951 through 1952, but no records of air monitoring for Bethlehem Steel for the years 1949 through 1950 have been located. However, work area and breathing zone air monitoring was performed at Simonds Saw and Steel from 1949 through 1950, and due to the similarities of the work processes for Simonds Saw and Steel and Bethlehem Steel Corporation, data from Simonds Saw and Steel were deemed appropriate for bounding dose determinations for uranium rolling operations at Bethlehem Steel during the years 1949 and 1950. Data from work area air monitoring performed at Bethlehem Steel during the years

1951 and 1952 and the application of a derived work area/breathing zone ratio from the Simonds Saw and Steel data, present a reasonable approach for determining bounding airborne radioactivity levels during the years of 1951 through 1952.

Surface contamination monitoring was performed at Simonds Saw and Steel in 1948, and also at Bethlehem Steel Corporation in 1952. These data were utilized in the Bethlehem Steel Technical Basis Document to establish a correlation between surface contamination and airborne contamination levels. This correlation was then used to develop a dose model relating worker ingestion rates to airborne concentrations.

Production reports for the uranium rolling activities at Bethlehem Steel are available for the years 1951 and 1952 and provide a means for determining source term data, which are beneficial for determining bounding dose estimates for internal and external exposure to residual contamination and from direct handling of uranium metal.

6.1 Bethlehem Steel Corporation Internal Monitoring Data

NIOSH reviewed AEC historical records and found no evidence of personnel internal monitoring at Bethlehem Steel. Therefore, personnel internal dose estimates will be based on air monitoring, surface contamination monitoring, and source term data.

6.2 Bethlehem Steel Corporation External Monitoring Data

No external dosimetry data are available for Bethlehem Steel. However, dose rates from submersion in a cloud of uranium dust, direct exposure to uranium metal, exposure to workers from residual contamination, or from re-use of contaminated work clothing can be estimated by application of the rolling information, residual contamination estimates, and exposure rate constants for uranium materials.

6.3 Air Sampling Data

Records show that work area air monitoring was performed at Bethlehem Steel for the years 1951and 1952; but, no records of air monitoring at Bethlehem Steel for the years 1949 through 1950 have been located (this is consistent with the absence of documentation of uranium rolling in 1949 and 1950). NIOSH has assumed, for claimant favorability that rollings occurred in 1949 and 1950. Simonds Saw and Steel was then considered as a source for surrogate air monitoring data for the years 1949 and 1950 because extensive air monitoring had been performed at Simonds Saw and Steel and Simonds had work processes that were similar to those at Bethlehem Steel. The air monitoring at both Bethlehem Steel Corporation and Simonds Saw and Steel was performed by representatives from Health and Safety Laboratory (HASL). A detailed discussion of the application of Simonds Saw and Steel air monitoring data to work performed at Bethlehem Steel is provided in Section 7.4.1.

6.3.1 Simonds Saw and Steel Air Sampling

Simonds Saw and Steel began rolling uranium in February 1948 and continued serving as a principal source of rolled uranium for several years. In October 1948, prior to the implementation of any air control measures, AEC collected a variety of air and urine samples from Simonds Saw and Steel workers; these included 22 breathing zone samples and 15 general area samples. Several controls and a sample from the stack were also collected (OCAS-TKBS-0003). AEC's next visit, December 1, 1948, found improvements in the air control measures, including exhaust ventilation over each of the operating rolls, the central vacuum cleaner was discharged outside, and a temporary enclosure was provided over the de-scaling device (OCAS-TKBS-0003)[7]. Although improvements in ventilation were later made and documented in various reports, the Simonds Saw and Steel data from October 1948 (before ventilation changes) is the only Simonds Saw and Steel data used to support the internal dose estimates for Bethlehem Steel's Lackawanna facility. It is important to note that the Simonds Saw and Steel data exceeds that directly measured at Bethlehem Steel by approximately 100% and that a number of factors described in Section 7.4.1 indicate that the Simonds Saw and Steel data represent claimant-favorable exposure levels.

6.3.2 Bethlehem Steel Corporation Air Sampling

Several documents report that AEC personnel were present during all rolling operations, and several site visit reports document these visits. During some of these rollings, AEC personnel conducted air and surface radioactivity monitoring and checked personnel involved in the rolling for contamination (OCAS-TKBS-0003; ORNL 1980). NIOSH's review of AEC historical records, however, showed several documents containing air sampling data from HASL and National Lead Company for the rollings shown in Table 1 of the Bethlehem Steel TBD (OCAS-TKBS-0003). These records document 203 legible results for air samples which were taken at various locations during eight of the fourteen rollings during 1951 and 1952. Five of these samples were quality control samples and were not used in data analyses for dose reconstruction purposes.

7.0 Feasibility of Dose Reconstruction for the Proposed Class

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 was 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 (discussed in Section 9.0). 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 enable NIOSH to 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 as summarized in Section 7.6. This approach is discussed in OCAS's SEC Petition Evaluation Internal Procedures

[7] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: AEC, 1948

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-00056 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of Data

This subsection answers questions that must be asked before a feasibility evaluation is performed. 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.

7.1.1 Internal Data Review

As mentioned previously, the monitoring data available for performing Bethlehem Steel dose reconstructions are primarily air sample data collected from Bethlehem Steel Corporation and Simonds Saw and Steel. The AEC Health and Safety Laboratory provided a detailed description of the methods and background on air monitoring and exposure assessment utilized at these sites (DOE, 1982). This assessment was provided in a 1973 HASL manual. The detailed description of the concept of representative workplace monitoring was written by A. J. Breslin, Director, Health Protection Engineering Division, HASL. (Note that Mr. Breslin was one of the sample collection scientists for the Bethlehem Steel Corporation's uranium dust monitoring data.) Breslin's write-up provides a detailed discussion of the type of samples taken, how they were taken, how they were analyzed, and how the results should be interpreted. The discussion of sampling locations, designation of sampling sites and the job task analysis sheets contained in this document are consistent with the sampling strategy employed at both Simonds Saw and Steel and Bethlehem Steel Corporation. The following text, as excerpted from (DOE, 1982), provides a summary description of the various sample types and methodologies used by HASL to evaluate representative exposure. Please also note that from the early days of operation, HASL relied on time-weighted average exposure measurements to assess inhalation hazards in the workplace (OCAS-TKBS-0003).

> ***Breathing Zone Samples*** *- Typically, a worker performs a few operations in which he may come into close or direct contact with the hazardous material. Examples of these operations are operating a machine tool, charging a furnace, working at a chemical hood, changing the glove on a dry box, or any one of a hundred maintenance tasks that involve the dismantling of or entrance to equipment. At jobs such as these, dust concentrations are apt to be much greater than in the general area. Therefore, these activities may influence the average exposure far out of proportion to their duration. To measure accurately the concentration to which a worker is exposed while*

performing such a task, a breathing zone (BZ) sample must be collected. The sampling instrument is held in the vicinity of the worker's breathing area for the duration of the task. It should be held as close to his nose as possible short of interfering with his freedom of movement, because in situations where dust is escaping from a small aperture, concentration gradients around a source can be sharp. In one uranium plant, samples collected one foot apart at certain operations have shown concentration differences of twenty-fold. On the other hand, a sample collected so close as to interfere with the worker's movements is invalid because the job cannot be performed in the normal fashion. A small deviation in work habit may alter the dust concentration markedly.

***General Air Samples** - Usually, the total time spent by a worker on operations requiring BZ samples constitutes a small fraction of the day. There are, of course, exceptions… Worker exposure during the balance of the work day may be characterized by samples collected of the general air (GA) in the area that he occupies. A GA samples is one that is collected at a fixed location during a sustained sampling period. To be meaningful, the sample must be collected within an occupied area but also it must be away from dust sources except those that may dominate the area. Customarily, the sampling instrument is placed at a height from four to six feet from the floor although in a heavily trafficked area, the instrument must be placed over the heads of the workers to avoid interference with the normal work routine….*

***Process Samples** - There is yet another kind of air sample that is often useful, the process sample. It is used to identify sources of air contamination or to determine the relative strengths of two or more sources. Process samples are distinguished from BZ and GA samples by the fact that they are taken in and around process equipment at locations where employees normally are not exposed. For this reason they should never be used in the evaluation of occupational exposure.*

As an example, a process sample might be collected directly over a furnace to determine the amount of radioactivity that is carried by convection from the furnace to the room. The concentration at that point is not representative of an employee's exposure.

The sampling methods, as listed above, meet the most current recommendations from ICRP Publication 75 for collecting representative samples to determine exposure (OCAS-TKBS-0003)[8]. The breathing zone samples collected by HASL were held in a position to represent the breathing zone and are not associated with a fixed sampler. General area samples were taken with the expressed purpose of evaluating non-localized releases to which an employee could be exposed during the course of the day. Finally, process samples that were obtained during the measurement period were to assess source terms and are not indicative of concentrations to which workers may have been exposed.

While the standards and requirements for radiological counting and sampling equipment have changed significantly over the history of health physics and industrial hygiene, it is clear that the variation in the instrument calibration data over this time have contributed to a relatively small variation in air sample data uncertainty as compared to large changes in air concentration (as a function of time and

[8] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: ICRP, 1998

location). Though OCAS-TKBS-0003 does not use time-weighted averages to determine exposure to uranium dust, HASL reported that time-weighted averages of exposure were consistent with results obtained from personal lapel-mounted air samplers (after the lapel sample data became available in the late 1960s) (OCAS-TKBS-0003)[9]. This consistency provides additional support for the reliability of the data and the use of time-weighted average air sample results to estimate exposure.

7.1.2 External Data Review

No external dosimetry data are available for Bethlehem Steel. External exposures to workers can be estimated, however, by using uranium rolling information, residual contamination estimates, and exposure rate constants for uranium materials. Uranium rolling reports indicate the amount of uranium materials processed and provide a means for determining source-term estimates. Air monitoring and surface contamination monitoring data can be used to determine an upper-bound estimate of residual contamination levels. External dose rates from uranium metals have been studied and documented, and provide a means, when coupled with source-term estimates, of estimating external dose from direct contact with uranium metal. External dose is further described in Section 7.3.

7.2 Internal Radiation Doses at Bethlehem Steel Corporation

The principal source of internal radiation doses for members of the proposed class includes inhalation and ingestion of various uranium oxides that resulted from the production of uranium metal rods. Intake of these contaminants could have resulted from either routine or non-routine events. Routine operations that could directly cause airborne radioactivity or release contamination to work surfaces where it could be re-suspended included heating, rolling, cutting, and grinding (by machine and hand).

7.2.1 Process-Related Internal Doses at Bethlehem Steel

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

Because exposure potentials were process-specific and varied over time, and because the availability of site-specific air monitoring data also varied with time, evaluation of the feasibility of dose reconstruction for the proposed class is divided into specific timeframes and activities and is presented accordingly in following subsections. For example, no records of any air sampling are known to exist for 1949 or 1950 at Lackawanna. Additionally, NIOSH has not discovered any documentation that confirms that uranium rolling occurred in 1949 or 1950. Thus, this time period was evaluated using the data collected at Simonds Saw and Steel on October 27, 1948, prior to the implementation of any ventilation controls. Data from 1951 and 1952 were divided into two periods to reflect changes that occurred in the processing technologies (e.g., the change from lead bath and salt bath heating to only using salt bath heating). In summary, evaluation of internal dose from inhalation of contaminants was split into three periods: (1) January 1949 through December 1950 (Subsection 7.2.1.1); (2) January 1951 through September, 1951 (Subsection 7.2.1.2); and (3) October 1951 thru December 1952 (Subsection 7.2.1.3). A special exposure scenario for workers who participated in the cutting of

[9] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: Breslin, 1967

cobbles was established and is described in Subsection 7.2.1.4. Evaluation of internal doses due to ingestion and residual contamination is presented in Subsections 7.2.1.5 and 7.2.1.6.

7.2.1.1 Evaluation of Inhalation Exposure: January 1949-December 1950

NIOSH has not located any production, monitoring, or inspection records indicating that Bethlehem Steel processed uranium for DOE or its predecessors prior to 1951. However, the *Technical Basis Document: Basis for Development of an Exposure Matrix for Bethlehem Steel Corporation, Lackawanna, New York; Period of Operation: 1949-1952* indicates that a 1976 memo from the Energy Research and Development Administration (ERDA), which provides details recalled by retirees of the AEC who had knowledge of the company's operations; a memo by a plant radiological control engineer who used the 1976 memo from Range as a source along with discussions with plant personnel(Range, 1976); and a 1977 memo from Thornton (Thornton, 1977) as part of the ERDA resurvey program who based the time estimates on a discussion with LaMastra, have all been used to justify the 1949 to 1950 timeframe (Range, 1976; LaMastra, 1976; Thornton, 1977). Because there are no records documenting rollings at Bethlehem Steel for the 1949 through 1950 time period, and because the use of Bethlehem Steel data for uranium dust exposure assessment prior to 1951 may be inappropriate (lead bath heating may not have been performed), data from Simonds Saw and Steel will be used as a surrogate for the determination of dose for the 1949 through 1950 time period at Bethlehem Steel Corporation. The appropriateness of using Simonds Saw and Steel as a surrogate facility (discussed earlier in this document) is discussed at greater length in the *Technical Basis Document: Basis for Development of an Exposure Matrix for Bethlehem Steel Corporation, Lackawanna, New York; Period of Operation: 1949-1952*, and was the subject of significant review by the Advisory Board on Radiation and Worker Health (ABRWH or the Board).

HASL visited Simonds Saw and Steel on October 27, 1948 and collected 37 particulate air samples that were used to evaluate the time-weighted average exposure to various job categories at the plant. These samples included 22 breathing zone samples and 15 general area samples. Several controls and a sample from the stack were also collected. The median length of time of collection for a breathing zone sample was 0.71 minutes (range 0.5 to 2.5 minutes) while general area samples typically were collected over a much longer time (median 15 minutes, range 3 to 45 minutes). To prevent severe dust loading of the filters, the shorter sampling times were used by HASL in areas with high expected dust concentrations. To improve statistics associated with sample counting, longer sampling times were used in areas of expected low dust concentrations.

The data include various locations throughout the mill areas. Some of these locations represent higher air concentrations than others. Therefore, assigning the distribution could underestimate an individual's intake for someone located in one of the higher air concentration areas for extended periods of time. Thus, in order to prevent a dose from being underestimated, the 95th percentile of this distribution will be assumed for exposure estimates. This value will be assumed to be present in the breathing zone 100% of the time and be assigned as a constant. Figure 7-1 plots the distribution of uranium concentrations observed at Simonds Saw and Steel during this period of no ventilation. The 95th percentile of this distribution, 553 MAC (38,710 dpm m^{-3} of natural uranium), will be used as the basis for evaluation of inhalation exposure during the 1949 through 1950 time period (TKBS-OCAS-0003).

Figure 7-1 demonstrates the distribution and fit of uranium dust concentration data taken from Simonds Saw and Steel on October 27, 1948 (MAC=70 dpm m-3).

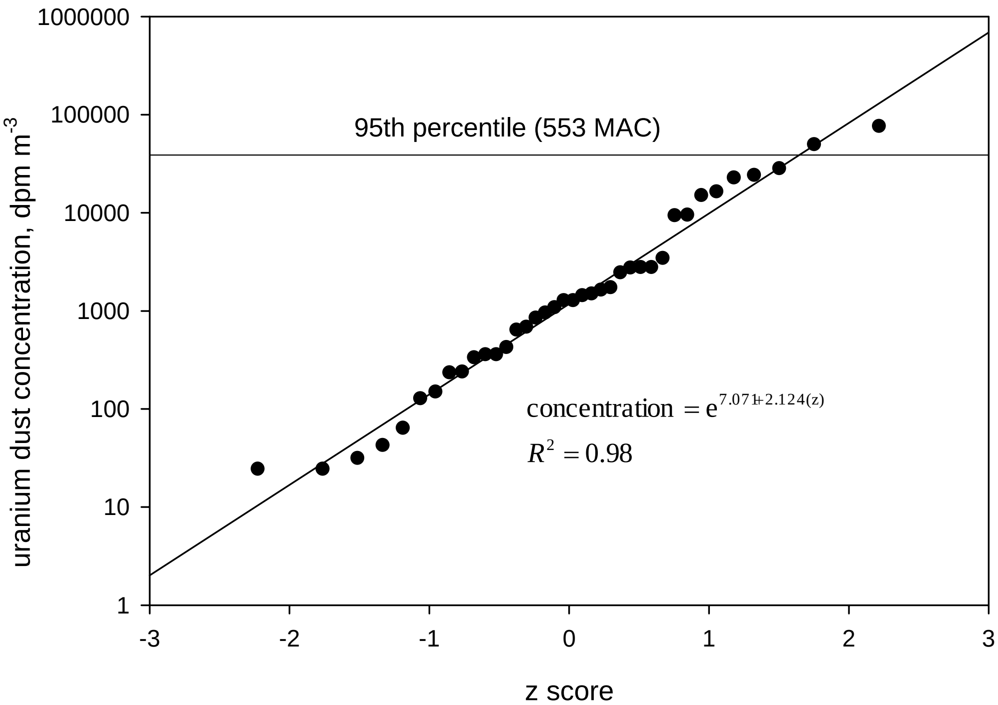

Figure 7-1: Uranium Dust Data from Simonds Saw and Steel: October 27, 1948

7.2.1.2 Evaluation of Inhalation Exposures: January 1951-September 1951

As previously discussed, the air sample data from Bethlehem Steel consist of a total of 204 air sample results, drawn and analyzed by HASL and National Lead. Personnel from National Lead were originally from HASL and used the same approaches and time weighted averages. These samples were collected on various days of rolling in 1951 and 1952. Sample types included general area (GA), breathing zone (BZ), and process samples. Of the 204 samples, one sample was found to be illegible (after reviewing the original records) and five were quality control samples; these six samples were not used in this analysis. Evaluation of the 204 samples found that changes in the process methods clearly impacted the air concentration data. This was reflected in both the monthly HASL reports and reports written by Hanford personnel who participated in those process changes.

The period from January 1951 to September 1951 was identified by NIOSH as the phase in which lead and salt bath technologies were both being evaluated at Bethlehem Steel. It was recognized that the number of breathing zone samples was a much lower fraction of the total samples as compared to the Simonds Saw and Steel measurements used to evaluate the 1949 to 1950 time period. For this reason, a breathing zone sample surrogate (BZ-GA) was developed to evaluate the breathing zone-to-general air sample concentrations at Simonds Saw and Steel, and to apply this factor to the general air samples gathered during this early 1951 period.

Both section 7.4.6 of this document and OCAS-TKBS-0003 discus the role that the Bethlehem Steel Corporation Lackawanna Rolling Mill played in the development of continuous rolling experiments for Hanford. Both documents also discuss the comparison of lead and salt bath heating. Only the first four experimental runs conducted in 1951 were known to have used the lead bath heating. Air sampling was conducted on three of those experimental runs. While it is known that the salt produced a more effective coating for reducing oxidation hence uranium dust, the data have been evaluated together to determine the 95% air concentration data.

Figure 7-2 graphically analyzes data from this time period prior to augmentation. Figure 7-3 shows the analysis of the augmented data set (which includes BZ-GA samples). The 225 MAC (15750 dpm m^{-3}) air concentration represents the 95% level, which can be used for analysis of uranium air concentration during rolling days for this early 1951 period.

Figure 7-2 displays the distribution and fit of uranium dust concentration data, prior to augmentation with BZ-GA samples, obtained at Bethlehem Steel from January 1951 through September 1951 (MAC=70 dpm m^{-3}).

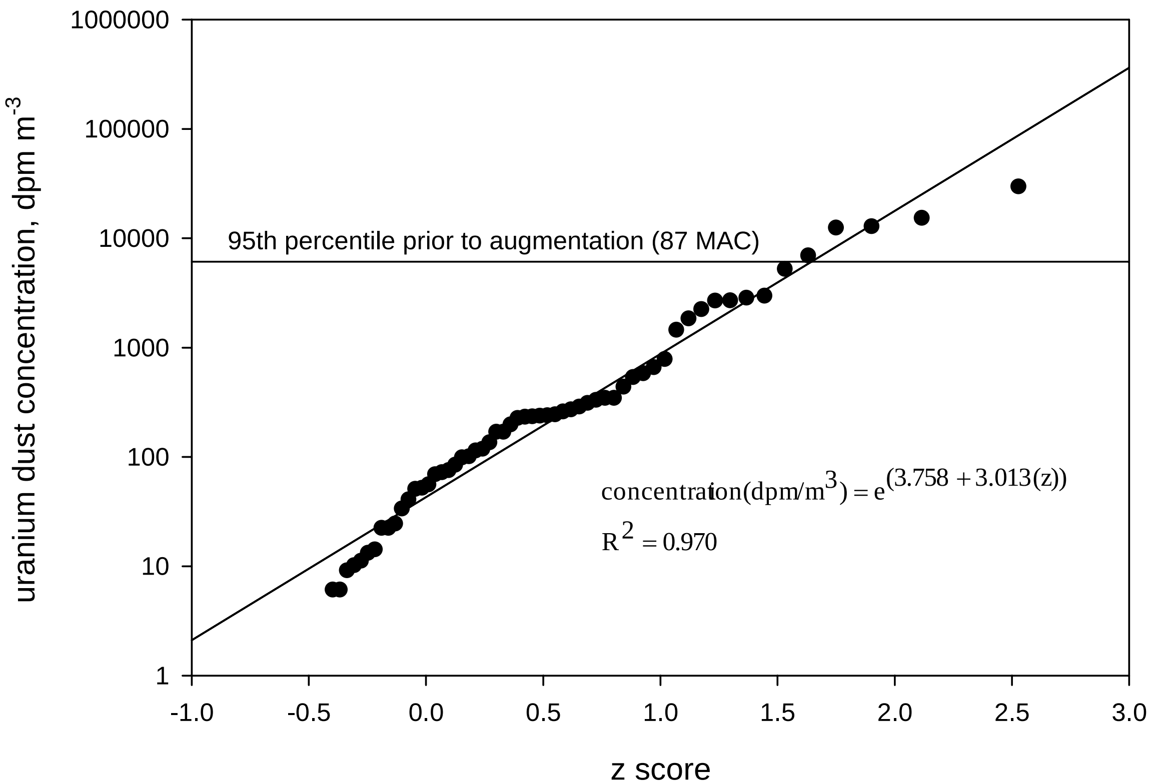

Figure 7-2: Uranium Dust Data from Bethlehem Steel: Jan.–Sept. 1951 (prior to augmentation)

Figure 7-3 displays the distribution and fit of uranium dust concentration data obtained at Bethlehem Steel from January 1951 through September 1951—augmented to include BZ-GA samples (MAC=70 dpm m^{-3}), with 225 MAC (1575 dpm m-3) as the air concentration level to be used for the assessment of rolling day intakes for this period.

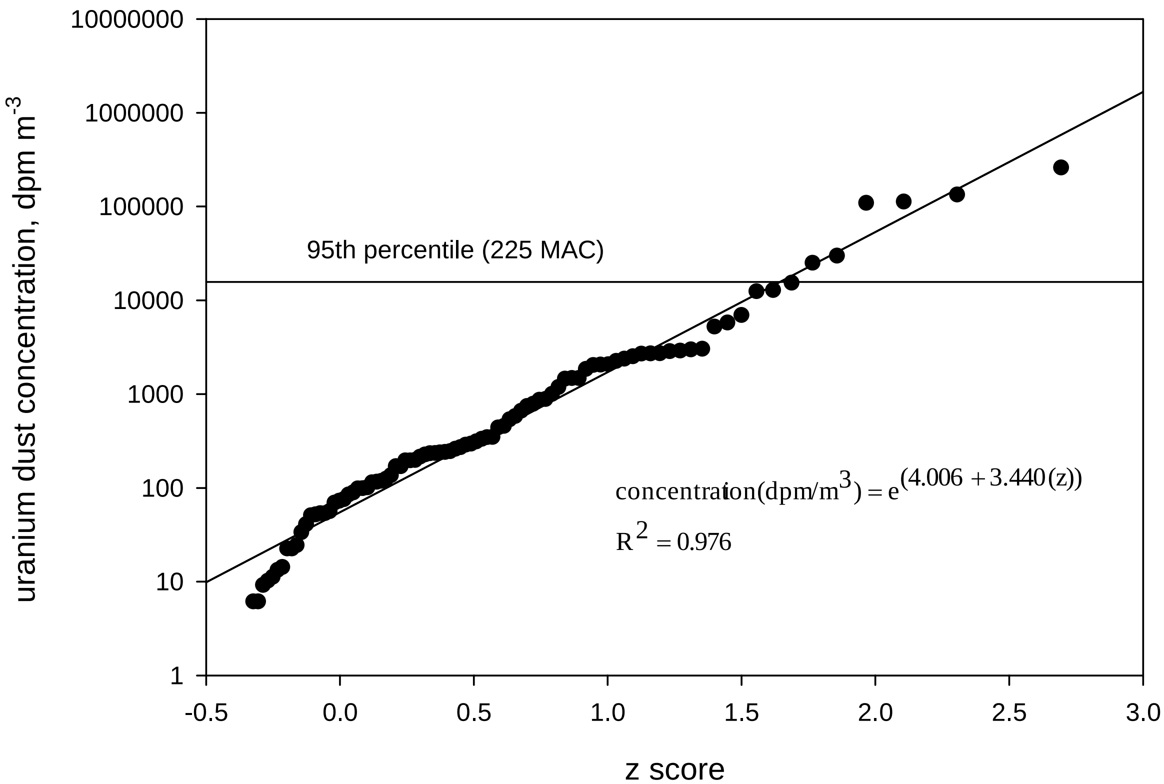

Figure 7-3: Uranium Dust Data from Bethlehem Steel: Jan.-Sept. 1951 (after augmentation)

7.2.1.3 Evaluation of the Inhalation Exposure: October 1951-December 1952

The majority of uranium airborne contamination in the early period at Bethlehem Steel was caused by the actual rolling of uranium metal. However, after the salt bath furnace was utilized, airborne contamination from the rolling operations greatly decreased. The median value of all the air samples collected from the rolling operations areas from late 1951 through 1952 is slightly less than 0.2 MAC. This means that other previously minor sources of airborne contamination are now accounted for the highest exposure potentials at the plant. Air monitoring data from these other areas, therefore, provide the airborne contaminant concentrations necessary for bounding worker exposures.

Grinding of the uranium billets to remove surface imperfections for some of the rollings was one such documented operation at Bethlehem Steel. A single process air sample was obtained for this operation. The air sample (70 MAC) was actually the highest recorded at Bethlehem Steel during the 1951 through 1952 time frame. This value can be used to estimate the air concentrations for the later period at Bethlehem Steel.

As with previous time periods, NIOSH has assumed that the operators inhaled the 70 MAC concentration continuously for a 10-hour work day (on days when uranium rolling occurred). Based on measurements taken at the Joslyn Steel plant while grinding on uranium metal (both breathing zone and general air samples), air concentration ranged from 0.4 MAC to 17 MAC (OCAS-TKBS-0003). These concentrations indicate that the 70 MAC concentration, which was determined from a process sample, provides a reasonable and claimant favorable upper bound dose to the operation.

While there may have been other sources of airborne contamination, it is likely that this estimate, with the exception of an exposure category of workers (cobble cutters) discussed below, is a bounding estimate. For other sources to be bounding, they would have to produce greater than 700 MAC-hours of exposure per day (70 MAC times 10-hours per day). This would require any other operation to not only create higher air concentrations, but to do so routinely. The most likely routine source of elevated airborne activity that has been postulated at Bethlehem Steel is the cutting of cobbles (OCAS-TKBS-0003)[10].

7.2.1.4 Evaluation of Intakes to Cobble Cutters: 1949-1952

In brief, cobbles are bent rods that are formed when a bar of metal is misfed from one stand into the next. Workers indicated that cobbles would have been removed from the mill in the most expeditious manner possible, utilizing an overhead crane whenever possible (OCAS-TKBS-0003). Worker information was confirmed in the documentation NIOSH reviewed on cobbles, which indicates that there was a fairly short time-span between a cobble being removed and the next sample passing through the stand. The short time-span was a result of workers cutting the cobbles at the stands only if it were necessary for their removal from the mill. Analysis of the time required for each rod rolled shows that cobbling did not grossly impact the production rate; this is further indication of the efficiency of the removal process. After removal, the cobbles were taken elsewhere for any additional cutting to return them to scrap (OCAS-TKBS-0003).

Test and production records indicate that during initial testing, a higher percentage of cobbles occurred during the initial testing than later in the production process. However, an evaluation of Bethlehem Steel records indicates that this initially higher rate of cobbling was offset by a lower total number of billets rolled. That is, despite a general increase in the numbers of billets rolled/day over time, the number of cobbles encountered per day remained relatively constant (~3.5 cobbles/day).

Based on interviews with workers, the time required to cut uranium cobbles varied between five minutes and one hour (Summary Notes, 2006; NIOSH, 2006). Potential methods of cutting uranium cobbles included using a torch, power saw, and/or shears. Worker accounts from several meetings indicate that torch cutting was the method used at Bethlehem Steel Corporation. NIOSH has

[10] The Bethlehem Steel Site Profile referenced Transcript November 28, 2005 as the source document. We were unable to locate this specific source document. However, related source document include Conference Call Notes, 2005a ; Conference Call Notes, 2005b

previously expressed reservations that, while torch cutting might have been used to cut steel cobbles, it would not necessarily be the best method to cut uranium. This is due to the pyrophorric nature of uranium, which would have a tendency to ignite while being cut with a torch. However, NIOSH has included an approach to estimate cobble cutters' exposures from torch cutting of uranium as a claimant-favorable assumption (OCAS-TKBS-0003).

The exposure to the cobble worker can be evaluated based on an average of two-hours per day engaging in torch cutting of cobbles. The time is based on an average reported during worker interviews and compared to published values for the cutting of stainless steel with acetylene torch. The latter values reported cutting time for stainless steel ranging from 2 to 4.2 minutes (3.6 minute mean) per cut of a 5-centimeter stainless steel pipe of 0.4 cm wall thickness (OCAS-TKBS-0003)[11]. Air concentrations are based on expected sustainable levels of contamination of 600 MAC, which is higher than both the largest air concentration documented at Bethlehem Steel and higher than the air concentration used to evaluate exposures at Bethlehem Steel during the 1949 to 1950 time-span. This air concentration is based on estimated bounding levels of sustainable airborne contamination concentrations over the course of this two-hour period from torch cutting (OCAS-TKBS-0003)[12].

7.2.1.5 Evaluation of Ingestion Dose

Ingestion intakes can be most closely related to surface contamination values. Very few measurements exist for surface contamination. However, airborne contamination levels and surface contamination levels are generally related. To evaluate the relationship between air contamination and surface contamination, NIOSH reviewed the available air and surface contamination measurements at Simonds Saw and Steel and Bethlehem Steel.

Air and surface contamination measurement data for Bethlehem Steel data were available for a rolling that took place on September 14, 1952. The Bethlehem Steel surface contamination data were obtained by smears wiped over a 100 cm^2 area. As such, the smears represent only the removable portion of the contamination.

At Simonds Saw and Steel, air and surface contamination measurements were taken during a uranium rolling campaign that took place on October 27, 1948. The Simonds Saw surface contamination data were direct measurements made with a portable instrument called a Zeuto. This type of instrument has an active surface measurement area that is three inches by four inches, or approximately 75 cm^2.

Each rolling stand at both Bethlehem Steel Corporation and Simonds Saw and Steel was evaluated. In addition, the shear at Bethlehem Steel Corporation was also evaluated. Stand Number Six at Bethlehem Steel was not evaluated because the surface smear indicated no detectable activity. Where more than one sample was taken, the results were averaged. Table 7-1 and Table 7-2 show the average air and surface contamination measurements for various locations. The surface contamination measurements at Simonds Saw were normalized to 100 cm^2 (OCAS-TKBS-0003).

[11] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: Newton, 1987

[12] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source documents: Conference Call Notes, 2005a ; Conference Call Notes, 2005b; SC&A, 2005

Table 7-1: Simonds Saw and Steel-Air and Surface Contamination Values

Table 7-1: Simonds Saw and Steel-Air and Surface Contamination Values			
Air sample	**Air concentration (dpm/m^3)**	**Surface Contamination Location**	**Surface Contamination Value (dpm/100 cm^2)**
L709	49,000	-	-
L710	75,000	East Roller 1	50,000
L711	22,400	West Roller 1	35,000
Average	48,800	Average	42,500
L718	14800	-	-
L719	23800	-	-
L720	27900	-	-
L721	943	-	-
L722	836	-	-
L723	418	West Roller 2	15,000
Average	11,449.5	Average	15,000

Notes:
Source of data is OCAS-TKBS-0003
- indicates no data available

Table 7-2: Bethlehem Steel Corporation-Air and Surface Contamination Values

Table 7-2: Bethlehem Steel Corporation-Air and Surface Contamination Values			
Air sample	**Air concentration (dpm/m^3)**	**Surface Contamination Location**	**Surface Contamination Value (dpm/100 cm^2)**
Q921	2,076	-	-
Q922	2,973	Shear	679
Q923	1,080	Shear	404
Average	2,043	Average	541.5
Q903	3	-	-
Q905	10	Stand 1	2
Average	6.5	Average	2

Table 7-2: Bethlehem Steel Corporation-Air and Surface Contamination Values			
Air sample	**Air concentration (dpm/m^3)**	**Surface Contamination Location**	**Surface Contamination Value (dpm/100 cm^2)**
Q906	10	-	-
Q908	12	Stand 2	9
Average	11	Average	9
Q909	18	-	-
Q911	14	Stand 3	6
Average	16	Average	6
Q912	13	-	-
Q913	10	-	-
Q920	6	Stand 4	5
Average	9.7	Average	5
Q914	12	-	-
Q915	3	-	-
Q919	12	Stand 5	9
Average	9	Average	9

Notes:
Source of data is OCAS-TKBS-0003
- indicates no data available

As in Tables 7-1 and 7-2, Figure 7-4 demonstrates the observed air concentration and surface contamination levels at Simonds Saw and Steel and Bethlehem Steel Corporation. Plotting the average surface and air concentrations shown in the above two tables, Figure 7-4 clearly indicates that the surface contamination is proportional to the air contamination. It should also be noted that this proportional relationship is internally consistent at the two facilities. That is, high airborne activity is predictive of high surface contamination levels, and vice versa. This means that if any large particle surface contamination that does not add to the air concentrations exists, the fraction of surface contamination represented by this is consistent across locations, sites, and concentrations. Using this relationship, NIOSH developed a model that relates the ingestion rate to air concentrations. This model can then be used to conservatively estimate internal doses due to ingestion (see OCAS-TKBS-0003 for model application details).

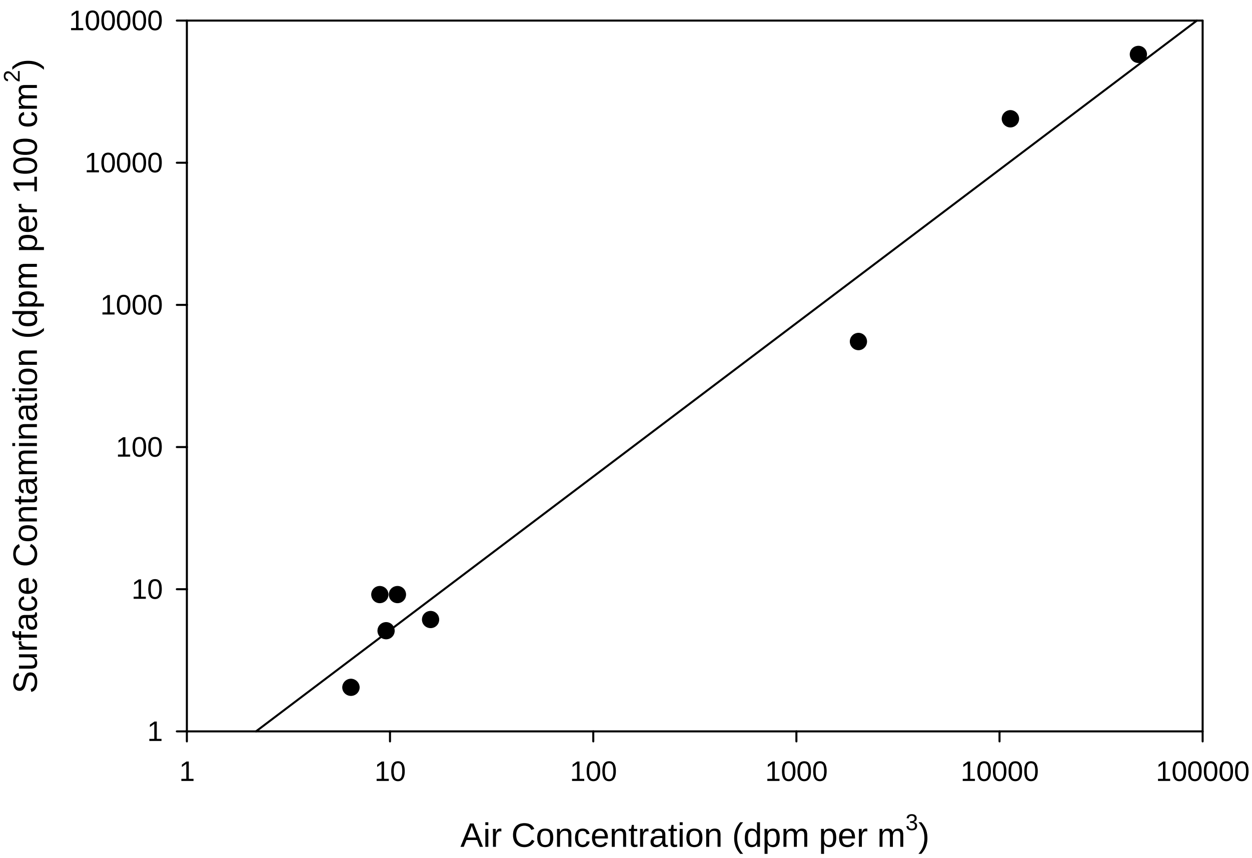

Figure 7-4: Air Concentration and Surface Contamination Levels at Simonds Saw and Steel and Bethlehem Steel

7.2.1.6 Evaluation of Inhalation and Ingestion Doses due to Residual Contamination

Following rolling operations, residual contamination would have been present in the form of uranium oxide dust on the floor and on other horizontal surfaces. While no surface or airborne contamination surveys could be found from Bethlehem Steel during days in which only steel was processed, NIOSH noted that because the 10-Inch Bar Mill was being fully utilized for steel production during the week, uranium rolling occurred primarily during weekends.

The principal product of Bethlehem Steel's Rolling Mill, measured in thousands of tons per year, was steel. On days in which Bethlehem Steel was not rolling uranium, steel was being produced. Because the production of steel generates large quantities of dust and debris and because as steel is rolled, a coating of this dust is likely to settle on top of any uranium contamination, the debris from the steel would have acted as a protective layer, making it less likely that the uranium would be re-suspended. However, as uranium contamination is re-suspended in the air, it settles back to horizontal surfaces and essentially forms a mixture of uranium and steel. This mixture would then allow uranium to continue to be re-suspended, but only as part of a mixture. The re-suspension of the material would have required some mode of force, such as ventilation, foot or vehicular traffic, etc. It is likely the same type of forces exist whether the mill was rolling steel or uranium. It is therefore likely that the same mass of material may be re-suspended at any given time. As the steel debris builds up, this re-suspended material is composed of fractionally less uranium and more steel.

The dose from residual contamination can be determined based on the above operations, which result in the re-suspension of contamination. NIOSH has assumed the uranium contamination to be diluted by additional rollings of steel occurring between uranium rollings. For the purposes of this model, NIOSH has also assumed that an equal mass of steel is added to the uranium each day. This is a conservative estimate because the steel production was measured in thousands of tons per year while uranium was rolled only on a limited basis (on the order of a few hundred tons). The material available for re-suspension one day after uranium rolling would therefore be one part uranium and one part steel. On the following day, the material would be one part uranium and two parts steel, and so on.

While rolling operations could result in high localized air concentrations, air concentrations from re-suspension of residual contamination would be more consistent throughout the area. Therefore, the median general air concentrations are used as the starting point. This value is then assumed to decrease in the days following uranium rolling as described above. The average air concentration due to re-suspension of residual contamination can be estimated using the following expression:

$$C_{Avg} = C_{Int.} * \frac{\int_{1}^{30} dt/t}{29} = C_{Int.} * \frac{\ln(t)_{1}^{30}}{29} = C_{Int.} * 0.117$$

Where:
CAvg. = the average air concentration through the 29 days following a rolling operation;
CInt. = the median general air concentration on the day of rolling; and
t = the number of days following the day of rolling.

The median general area air sample concentrations for the three time periods are listed in Table 7-3.

Table 7-3: Median General Area Air Sample Concentrations	
Site	**Median General Area Air Samples (MAC)**
Simonds Saw and Steel (1949-1950)	4.13
Bethlehem Steel (early 1951)	0.215
Bethlehem Steel (1951-1952)	0.081

The same method can be used for ingestion; however, the initial concentration factor is replaced by the daily ingestion rate on rolling days.

7.2.2 Ambient Environmental Internal Radiation Doses at Bethlehem Steel

Occupational environmental dose provides a mechanism to account for ambient dose on site that has not been either monitored or attributed to occupational exposure. The exposures of all employees of the Bethlehem Steel Corporation will be estimated based on the 95% air concentration at the Rolling Mill for a 10-hour day. This estimate precludes the use of environmental dose, which would be much lower than the exposures estimated. As such, any potential exposures to ambient environmental dose would be accounted for in the assigned occupational exposures at Bethlehem Steel Corporation.

7.2.3 Internal Dose Reconstruction Feasibility Conclusion

NIOSH found that available air monitoring records, process descriptions, and source term data are sufficient to complete internal dose reconstructions for the proposed class of employees. Though no records of any air sampling are known to exist for the 1949 through 1950 time period at Lackawanna, exposures during this period can be evaluated by using data collected at Simonds Saw and Steel prior to the implementation of any ventilation control measures at that site. The appropriateness of using Simonds Saw and Steel data as surrogate data is summarized earlier in this document, detailed in OCAS-TKBS-0003, and was subject to significant review by the Board.

Internal dose reconstructions for later years can be performed utilizing available Bethlehem Steel air monitoring data. Though the data contain only limited breathing zone measurements, a breathing zone sample surrogate can be calculated from Simonds Saw and Steel data and used to augment the Bethlehem Steel breathing zone data. These augmented data can then be used to bound inhalation doses associated with uranium metal rolling in early 1951 (prior to the established routine use of the salt bath furnace). After use of the salt bath furnace became a standard process procedure, airborne uranium contamination associated with the rolling of uranium metal was greatly reduced and was no longer the highest inhalation exposure potential activity. Instead, the single highest air sample result was obtained at a uranium billet grinding area; this result (70 MAC), can be used to calculate exposures from late 1951 through 1952. Doses to cobble cutters can be bounded by modeling an estimated air concentration of 600 MAC, which is higher than both the largest air concentration documented at Bethlehem Steel and the air concentration used to evaluate exposures during the 1949 through 1950 time period. Based on available air and surface contamination data, ingestion doses and doses from residual contamination can also be calculated.

7.3 External Radiation Doses at Bethlehem Steel Corporation

The principal source of external radiation dose for members of the proposed class was natural uranium metal. The primary exposure pathways were: 1) submersion in a cloud of uranium dust; 2) direct exposure to uranium metal; 3) external dose from residual contamination; and 4) external dose from wearing contaminated clothing (OCAS-TKBS-0003).

No external dosimetry data are available for Bethlehem Steel workers. However, external exposures to workers can be estimated by using uranium rolling information, air monitoring information, residual contamination estimates, and exposure rate constants for uranium materials.

7.3.1 Process-Related External Radiation Doses at Bethlehem Steel

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

7.3.1.1 External Dose from Uranium Dust

Derived air concentrations, combined with rolling times, number of rollings, and the dose conversion factors for uranium-238 with the daughter radionuclides thorium-234 and protactinium-234m, can be used to determine the external dose due to submersion in a natural uranium dust cloud (OCAS-TKBS-0003). However, only the skin should be reported, because all other doses are less than 1 mrem.

Table 7-4 indicates the annual external uranium skin dose due to submersion in air contaminated with natural uranium dust.

Table 7-4: Annual External Uranium Dose

Time Frame	Annual Skin Dose (Rem)
1949	0.002
1950	0.002
1951	0.001
1952	0.000

7.3.1.2 External Dose from Direct Contact with Uranium Billets

External doses from exposure to a uranium source were evaluated using extended (semi-infinite plane) natural uranium sources. Estimated surface dose rates of 230 mrad/hour at a depth of 7 mg/cm^2 and 2 mrad/hr at a depth of 1000 mg/cm^2 were obtained from a search of the literature (OCAS-TKBS-0003)[13]. Conservative values for the length of time workers were present near the source were based on descriptions of processes and different job types (OCAS-TKBS-0003)[14]. A triangular distribution for electron exposure from uranium was determined in the following manner:

- The minimum was estimated by assuming the worker was one meter from an extended uranium source for one hour (per 10-hour shift). The estimated dose rate for this scenario was 90 mrad/hour (OCAS-TKBS-0003)[15].

- Survey data of the Simonds facility were used to estimate the mode. The highest value measured during those surveys was 15 mrad/hour (OCAS-TKBS-0003)[16]. To be claimant-favorable, this dose rate was assumed for an entire 10-hour shift.

- A maximum value was estimated by assuming the worker was 0.3 meter (one foot) from an extended uranium source for six hours (150 mrad/hour) and one-meter away for four-hours (90 mrad/hour).

[13] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source documents: U.S. Army, 1989; Coleman, 1983

[14] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: AEC, 1948

[15] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: U.S. Army, 1989

[16] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: AEC, 1949

Table 7-5 summarizes annual values for estimated external shallow dose due to electron exposure from uranium. The target organs for this type of exposure are the skin, male genitals, and breast. In the case of male genital cancer or female breast cancer, additional evaluation might be needed to consider shielding and attenuation provided by clothing.

Table 7-5: Estimated External Shallow Dose Due to Electron Exposure from Natural Uranium Sources			
Time Frame	Annual Organ Dose (Rem)		
	Minimum	Mode	Maximum
1949	1.08	1.80	15.12
1950	1.08	1.80	15.12
1951	1.17	1.95	16.38
1952	1.35	2.25	18.90

7.3.1.3 External Dose from Residual Contamination

An estimate of surface contamination was calculated by using the terminal settling velocity of 0.00075 m s-1 multiplied by both the rolling day concentrations and the amount of time uranium was rolled in one year. The Simonds Saw and Steel concentration data were used for all years to simplify the calculations, as they overestimate the later rolling data. This calculation results in a contamination estimate of 12,500,000 dpm m-2 (1,250,000 dpm 100cm^2), which exceeds all the measured surface contamination levels. This calculation was then assumed to be constant for all years that rolling took place. The residual contamination value was converted to dose using the dose coefficients in the Federal Guidance Report Number 12 (OCAS-TKBS-0003)[17] for contaminated ground surfaces for uranium-238 and progeny protactinium-234m and thorium-234. The doses from contaminated sources are listed for skin, bone surfaces, and all other organs in Table 7-6. The "all other organ category" is the highest other organ rounded up to the nearest mrem.

Table 7-6: Annual Dose from Contaminated Surfaces at Bethlehem Steel, 1949 to 1952			
Timeframe	Skin (rem)	Bone Surfaces (rem)	All Other Organs (rem)
1949-1952	1.771	0.010	0.005

[17] The summary provided in the Bethlehem Steel Site Profile was based on the following primary source document: ORNL, 1993

7.3.1.4 External Dose from Reusing Contaminated Clothing

The average dose-rate data from contaminated clothing were documented at Mallinckrodt at an indicated level of 1.5 mrem/hour (HASL, 1958). Bethlehem Steel doses were estimated using these data as a bounding condition, based on the types and quantities of materials handled at Mallinckrodt. The dose was determined by assuming that the clothing was worn at Bethlehem Steel for two-work weeks prior to cleaning. Therefore, the annual dose to the skin was determined by assuming 1.5 mrem/hour multiplied by 50 hours per week, multiplied by two-weeks per month multiplied by 12-months per year. This results in an estimated annual dose to the skin of 1.8 rem per year.

7.3.2 Ambient Environmental External Radiation Doses at Bethlehem Steel

All significant sources of occupational external dose have been addressed in OCAS-TKBS-0003. As a result, ambient environmental dose is accounted for in the assessment of process-related dose.

7.3.3 Bethlehem Steel Corporation Occupational X-Ray Examinations

There is no information available with reference to whether occupationally-required medical X-ray examinations were performed at Bethlehem Steel. However, the AEC typically required both pre-employment and periodic medical examinations of workers involved in the larger uranium processing programs to include a preliminary and annual chest X-ray. For this analysis, it is assumed that all workers received both a pre-employment and annual X-ray examination, with exposure geometry assumed to be posterior-anterior. Annual X-ray data from OTIB-0006, *Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures*, and associated instructions should be used when evaluating occupational medical dose at Bethlehem Steel Corporation.

7.3.4 External Dose Reconstruction Feasibility Conclusion

Based on NIOSH's reviews and analyses of the available data, and the approach described in OCAS-TKBS-0003, there is 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 Specific Petitioner Statements in SEC-00056

Former Bethlehem Steel Corporation employees have expressed concerns regarding dose reconstructions for Bethlehem Steel workers. The issues were expressed in various forums/formats, including public meetings, phone interviews, and written correspondence. This section presents specific affidavit statements made by workers on behalf of petition SEC-00056. The italicized statements are from the petition; the comments that follow are from NIOSH.

7.4.1 Comparison between Bethlehem Steel Corporation and Simonds Saw and Steel

SEC-00056: *Simonds Saw and Steel Company information is not a valid comparison to the work done at Bethlehem Steel. Since Simonds was a much smaller facility, Simonds used different rolling* *equipment and procedures, Simonds implemented safety procedures and equipment which Bethlehem Steel did not use, and personal air monitoring was performed at Simonds and not at Bethlehem Steel.*

Simonds Saw and Steel represents a bounding case for Bethlehem Steel exposures to uranium based on the following:

- Data collected at Simonds in 1948 is used for years 1949 and 1950 at Bethlehem Steel, assuming that all workers at Bethlehem Steel were exposed to the 95th percentile of all air monitoring data. This level corresponds to the airborne level of the maximally exposed workers in these plants. While only a small fraction of the 20,000 workers at the Bethlehem Steel-Lackawanna plant were rolling mill operators, this claimant-favorable decision was made because of the difficulty of assessing the extent of other workers' involvement in and exposure to the rolling mill processes.

- Comparison of the exposure levels at Simonds Saw and Steel to those actually measured at Bethlehem Steel further show that these are bounding measurements. Assuming the 95th percentile level as a constant intake rate for 10 hours during rolling, the intake based on Simonds Saw and Steel data is over 26 times higher than that based on the Bethlehem Steel data. This is a claimant favorable decision to avoid underestimating the intake periods prior to 1951 when the use of protective coatings on the uranium cannot be confirmed.

- Simonds was a smaller facility and the processes were close to one another. Air concentration data for general area samples would tend to be higher because of the cross-talk between locations. Also, contamination would have remained more localized and thus more available for re-suspension. Thus, air concentration data from the much larger rollings quantity would have been greater.

- Simonds Saw and Steel processed bare metal uranium rods for the October 27, 1948 rollings and preceding rollings as well. Bare metal uranium is more susceptible to oxidation than lead bath-heated or salt bath-heated uranium and increases the uranium oxide dust production. All rollings which are known to have occurred at the Lackawanna plant were lead- or salt bath-heated.

- The dose reconstruction model being used by NIOSH for Bethlehem Steel is based on monitoring data taken at Simonds Saw and Steel prior to the installation of ventilation and floor gratings. NIOSH's calculations do not consider ventilation in Bethlehem Steel dose reconstructions.

- Simonds Saw and Steel was more labor-intensive and hands-on than the process conducted at the Lackawanna plant. Some of the highest air concentration levels at Simonds were observed during operations where rolled rods were dragged across the contaminated floor. The facilities at Lackawanna were state-of-the-art and designed to reduce the amount of labor involved in the production process.

- Air sampling data were collected and analyzed at Simonds Saw and Steel by the same organization, HASL, using the same methods as those which would have been used at Bethlehem Steel (see Section 7.1.1).

- Breathing zone samples collected at Simonds Saw and Steel on October 27, 1948 were taken during the worst part of the process for short durations (~1 minute) during peak episodes, and thus provide an upper bound to the overall breathing zone estimates.

- Simonds Saw and Steel became the rolling mill of choice for the AEC program; therefore, any rollings conducted at the Bethlehem Steel rolling mill in the 1949-1950 timeframe would have been small and experimental in nature compared to the volume rolled at Simonds. While rolling volume does not impact the breathing zone estimates, the amount of residual activity will be affected by the total amount of material rolled.

- The amount of material run at the Lackawanna plant was a small fraction of the plant's actual capacity. The application of a full 10-hour day for Bethlehem Steel at the monitored airborne levels associated with Simonds' higher production rate is a substantial but reasonable overestimate.

7.4.2 Blooming Mill Involvement

SEC-00056: *Other buildings were involved, including the Blooming Mill (Reference Wayne Range Letter of June 7, 1976). The purpose of the Blooming Mill was to reduce ingots to billets.*

The referenced letter states that a suitable Blooming Mill and Rolling Mill were present at Lackawanna; but the letter does not indicate or confirm the use of those facilities for uranium work. All documents reviewed by NIOSH describing uranium rollings indicate that all billets were rough-rolled at a separate facility (e.g., Simonds Saw and Steel).

7.4.3 Areas of High Uranium Concentration

SEC-00056: *NIOSH overlooked the 28,000 square feet of unmonitored high uranium concentrated area (sub-basement open under the Cooling Bed). They also overlooked the Cooling Bed above.*

While this area occupies a large portion of the facility, it does not represent a component that impacts the evaluation of dose at Bethlehem Steel. This area was evaluated as part of the updates to the Technical Basis Document, but was not found to be as limiting as the exposure models which were based on plausible worst-case occupational exposure conditions being assigned to all employees. Discussions with workers have also provided evidence that the occupation of this area was intermittent. The exposure model provides for a 10-hour exposure during rolling days and for exposure to residual contamination during non-rolling days. The dose model, therefore, accounts for exposures in all areas of the plant.

7.4.4 Lack of Records for 1949-1950

SEC-00056: *For 1949-1950, no records exist....NIOSH had no knowledge of what went on in 1949 through 1950.*

The covered period for Bethlehem Steel was based on a letter that indicated uranium rollings occurred between 1949 and 1951 (OCAS-TKBS-0003). Without the Range letter, there is no evidence of rollings occurring at Bethlehem Steel prior to 1951. However, NIOSH concluded that the recollection of monthly rollings beginning in 1949, as cited in the Range letter, cannot be refuted. Thus, the Bethlehem Steel Site Profile was written to assume rollings started in 1949.

7.4.5 Accurate Dose Reconstructions for Unprotected Workers

SEC-00056: *No personal protective equipment was issued at Bethlehem Steel, including: glovebox, masks, hoods, film badges, etc. How can accurate dose reconstructions be modeled without reliable air data or personal monitoring on workers?*

Dose reconstruction at Bethlehem Steel was based on modeling exposure conditions that used air monitoring results and production data. The Bethlehem Steel Site Profile provided consistent guidance to the dose reconstructor that no personal protective equipment was used at Bethlehem Steel.

7.4.6 Lost Uranium

SEC-00056: *Using NIOSH's figures to calculate the amount of lost uranium: lost uranium for 48+ rollings at eight-pounds per billet equals 13 tons of lost uranium in four years of rollings at Bethlehem Steel: 13 tons of radioactive material left on the site….*

Because scrap recovery was an important component of the AEC uranium program, NIOSH does not believe that 13-tons of material were left behind by the AEC at Bethlehem Steel. In fact, it has been consistently reported in various documents and in interviews with Bethlehem Steel workers that as a valuable metal, fines and scraps of uranium were picked up and vacuumed. In addition, the amount that was speculated to have been lost also includes the ends of cropped billets. These cropped ends were also recovered as part of the scrap program but did not contribute to material which could be used in Hanford's plutonium production program. The NIOSH exposure model accounts for the inhalation and ingestion of residual contamination after rollings, which in turn, accounts for the spread of uranium in the plant from rolling operations (OCAS-TKBS-0003).

7.4.7 Salt Bath Leak on September 22, 1952

SEC-00056: *There was a four-hour loss of time with a salt bath leak on September 22, 1952:*

- *303 billets rolled, 9 billets at a time to charge in the salt bath*
- *23 minutes average time to soak per charge*
- *759 minutes total time for soaking*
- *12.5 hours needed for soaking only*

It is impossible for this work to be done in a 10-hour working day based on the time requirements.

Fernald representatives reported in a document titled *Production Report on The Rolling of Two Hundred and Twenty-Two Uranium Billets at Bethlehem Steel Corporation's Lackawanna Plant on Saturday, April 12, 1952* that the rollers were running a billet every two minutes when they hit their stride (NLO, 1952). Because billets were removed one at a time and could be replaced to keep the process moving, soaking time is not likely to be the limiting factor. NIOSH has developed an exposure model assuming that the employees worked 10-hours at each of the rollings. Even if there was some deviation on one rolling day in the time required, the profile provides a very claimant-favorable estimate for days when only 30 billets were rolled.

7.4.8 Manual Labor at Bethlehem Steel

SEC-00056: *The manual labor at Bethlehem Steel, such as sledge-hammering uranium rods, moving rods across the salt bath with crowbars, and removing cobbles, far exceeds the rolling process at Simonds Saw and Steel.*

Manual processes were cited by the AEC as being one of the factors that elevated uranium exposures. And within that category, one of the largest factors involved dragging the rods between various stations and re-suspending the dust (this includes the example of reintroducing the rods). Simonds Saw and Steel rolled large quantities of uranium for long periods of time with no protective coating, resulting in significant amounts of uranium on the floor (this is why grating was later installed at Simonds). The application of the 95th percentile of the Simonds Saw and Steel air monitoring data for dose estimation during the early period at Bethlehem Steel, and the application of air monitoring data from the grinding of uranium at Bethlehem Steel for the latter period, present a bounding case for estimating dose at Bethlehem Steel. This estimate would exceed the dose potential at Bethlehem Steel from both sledge-hammering rods and moving rods across the salt bath with crowbars. Even so, NIOSH recognizes cobble removal and cutting as a valid exposure pathway and has included dose estimation methodologies for cobble-cutting in the Bethlehem Steel Technical Basis Document. Cobble-cutting dose methodology is described earlier in this document.

7.4.9 Destroyed Records

SEC-00056: *When doing experimental work, you are working with the unknown. The government admits to destroying these records.*

The government's admission that it destroyed records was provided in a letter from someone not involved in the program. In its own data capture efforts, NIOSH has obtained a significant number of documents regarding Bethlehem Steel from both HASL and Hanford. These documents indicate that the experimental work conducted at Bethlehem Steel occurred on a very limited basis. In spite of this, the Bethlehem Steel Site Profile has incorporated exposure conditions during which all employees are assumed to perform the highest exposure job for 10-hours per workday at the 95th percentile value. This assumptive exposure significantly overestimates the time required for an operation involving the small number of billets processed during the experimental phase. For the 1951 through 1952 period, air sample data, surface contamination data, and production records exist for the uranium rollings at Bethlehem Steel.

7.4.10 Exposure to Uranium throughout the Facility

SEC-00056: *The work areas could not have been cleaned in one day. Workers were exposed to uranium throughout the facility.*

The Bethlehem Steel Site Profile accounts for the re-suspension of uranium that was dispersed throughout the facility. It does not assume that the facility was decontaminated in one day. The Site Profile employs a model that accounts for both deposition and re-suspension of uranium dust from weekend uranium rollings and the added deposition of normal steel dust during the remainder of each week. As such, the amount of uranium available for re-suspension would be reduced over time by the dust generated during the normal steel manufacturing process.

7.4.11 Areas of Highest Exposures at the Bethlehem Facility

SEC-00056: *Initially NIOSH stated that the highest dust levels were at the rollers, then later it was somewhere else.*

NIOSH's extensive review of the rolling processes employed at Bethlehem Steel found that the salt bath technology employed during the later years significantly reduced air concentrations of uranium compared to the technology employed in the earlier period. The reduction was so significant that other operations became the bounding exposure scenario.

7.4.12 Absence of Grinding in the Technical Basis Document

SEC-00056: *No grinding was recognized or incorporated in the Bethlehem Steel Technical Basis Document.*

During NIOSH's extensive review of the rolling processes employed at Bethlehem Steel, it became obvious that the salt bath technology employed during the later years significantly reduced air concentrations of uranium over the technology employed in the earlier period. The reduction was so significant that other operations became the bounding exposure scenario. In keeping with the claimant-favorable assumptions used in the Bethlehem Steel Site Profile, NIOSH has adopted the highest exposure scenario for assigning intakes to workers in the later years. Based on its analysis of the measured air samples during this later period, grinding operations provide the highest potential for worker exposure. NIOSH will assume that all workers, regardless of job category, were exposed to these air concentrations 10-hours per day for each day of rolling. This exposure scenario is used to estimate maximum personnel doses for the later period of uranium rolling at Bethlehem Steel.

7.4.13 Ingestion of Uranium from Eating and Drinking

SEC-00056: *Workers ate and drank in dusty areas, and could have ingested uranium.*

While it is possible that a worker could have ingested uranium while eating and drinking in an area with uranium surface dust, this exposure would have been considerably lower than the exposure applied in the Bethlehem Steel Site Profile. The Bethlehem Steel Site Profile does not take into account breaks and lunch times; rather, the Bethlehem Site Profile assumes a full 10-hour exposure at the 95th percentile for the maximally exposed worker. The ingestion dose model in the Site Basis Document uses claimant-favorable heavy worker breathing rates (which maximizes the estimated amount of ingested uranium), uses a claimant-favorable gastrointestinal absorption value of two percent, and assumes that workers ingested moderately soluble forms of uranium. The Bethlehem Steel Site Profile also incorporates ingestion and inhalation of residual contamination during non-rolling days.

7.4.14 Contaminated Clothing

SEC-00056: *Workers wore contaminated coveralls without being laundered.*

Dose methodology for wearing contaminated clothing has been incorporated into the Bethlehem Steel Site Profile. The methodology is based on contaminated clothing dose rate data collected at Mallinckrodt Chemical Company (HASL, 1958). The data represent a bounding condition because Mallinckrodt processed greater quantities of radioactive materials than Bethlehem Steel, and because those materials included significant quantities of radium that produces higher dose rates than the natural uranium metal processed at Bethlehem Steel.

7.5 Other Issues Relevant to the Petition Identified During the Evaluation

As previously noted, the current Bethlehem Steel Technical Basis Document (OCAS-TKBS-0003) supersedes the previous Bethlehem Steel Technical Basis Document (ORAUT-TKBS-0001), also referred to as the Bethlehem Steel Site Profile. The Technical Basis Document was rewritten to address issues communicated during worker outreach meetings/correspondences and through extensive review by the Board and its technical support contractor, Sanford Cohen & Associates (SC&A). SC&A's review focused primarily on the first Bethlehem Steel Technical Basis Document (ORAUT-TKBS-0001). The objectives of the review were to evaluate the following:

- Completeness of data sources
- Technical accuracy
- Adequacy of data
- Consistency among site profiles
- Regulatory Compliance

SC&A's findings and observations can be found in the document titled *Review of NIOSH Site Profile for Bethlehem Steel Plant, Lackawanna, NY* (SCA-TR-TASK1-0001). Findings and observations based on those observations are addressed in the document titled *NIOSH Comments on the SC&A Review of the Bethlehem Steel Site Profile—Specific Responses to Findings, Observations and Procedural Non-Conformances, January 25, 2005*. Both documents can be found at NIOSH's website at: http://www.cdc.gov/niosh/ocas/bethst.html.

The current Bethlehem Steel Technical Basis Document (OCAS-TKBS-0003) is a result of these reviews and incorporates associated updates to dose reconstruction methodologies for former Bethlehem Steel workers.

7.6 Summary of Feasibility Findings for Petition SEC-00056

This report evaluates the feasibility for completing dose reconstructions for all Atomic Weapons Employer personnel at the Bethlehem Steel Corporation who were monitored or should have been monitored for exposure to uranium during uranium rolling activities at the Bethlehem Steel, Lackawanna, New York facility from January 1, 1949 through December 31, 1952. NIOSH found that the available monitoring records, process descriptions and source term data available are sufficient to complete dose reconstructions for the proposed class of employees.

Table 7-7 summarizes the results of the feasibility findings at Bethlehem Steel Corporation for each exposure source during the time period January 1949 through December 1952.

Table 7-7: Summary of Feasibility Findings for SEC-00056

January 1949 through December 1952

Source of Exposure	Reconstruction Feasible	Reconstruction Not Feasible
Internal[1]	**X**	
-uranium	**X**	
External	**X**	
-Gamma	**X**	
-Beta	**X**	
-Neutron	**X**	
-Occupational Medical x-ray	**X**	

[1] Internal includes an evaluation of potential inhalation or ingestion of uranium dust as detected in urinalysis (*in vitro*), airborne dust sampling data, and/or lung (*in vivo*) data

As of February 7, 2007, a total of 735 claims have been submitted to NIOSH for individuals who worked at Bethlehem Steel Corporation. Dose reconstructions have been completed for 634 individuals (~86%).

8.0 Evaluation of Health Endangerment for Petition SEC-00056

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.

NIOSH has determined that radiation doses can be estimated with sufficient accuracy using available monitoring data, surrogate monitoring data, and source term information. Our evaluation determined that it is feasible to estimate radiation dose for members of the proposed class with sufficient accuracy based on the sum of information available from available resources. A modification of the class definition regarding health endangerment and minimum required employment periods, therefore, is not required.

9.0 NIOSH-Proposed Class for Petition SEC-00056

Based on its research, NIOSH expanded the petitioner-requested class to define a single class of employees for which NIOSH can estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all Atomic Weapons Employer personnel at the Bethlehem Steel Corporation who were monitored or should have been monitored for exposure to uranium during uranium rolling activities at the Bethlehem Steel, Lackawanna, New York facility from January 1, 1949 through December 31, 1952. The class was expanded because NIOSH has determined that there is insufficient information available to determine, for the stated time period, every individual's work title/function or work location and because NIOSH can estimate dose with sufficient accuracy for this class.

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 Data Base, for information relevant to SEC-00056. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

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

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