SEC Petition Evaluation Report
Petition SEC-00178

Report Rev #: 0 | Report Submittal Date: February 6, 2012

Subject Expert(s):	Jason Davis
Site Expert(s):	N/A

Petition Administrative Summary

Petition Under Evaluation

Petition #	Petition Type	Petition Receipt Date	Qualification Date	DOE/AWE Facility Name
SEC-00178	83.13	July 28, 2010	October 20, 2010	Clinton Engineer Works

Petitioner-Requested Class Definition

All guards and service workers who worked in any area at Clinton Engineering Works from January 1, 1943 through May 18, 1947.

Class Evaluated by NIOSH

All guards and service workers who worked in or around the warehouses at the Elza Gate area of Clinton Engineering Works from January 1, 1943 through December 31, 1949.

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

All employees of the Tennessee Eastman Corporation (1943-1947) and the Carbide and Carbon Chemicals Corporation (1947-1949) who were employed at the Clinton Engineer Works in Oak Ridge, Tennessee, from January 1, 1943 through December 31, 1949 for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more classes of employees included in the Special Exposure Cohort.

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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ORAU Lead Technical Evaluator: Jason Davis | **ORAU Peer Review Completed By:** Daniel Stempfley

Peer Review Completed By:	[Signature on File] *Lara Hughes*	2/8/2012 *Date*
SEC Petition Evaluation Reviewed By:	[Signature on File] *J. W. Neton*	2/8/2012 *Date*
SEC Evaluation Approved By:	[Signature on File] *Stuart L. Hinnefeld*	2/8/2012 *Date*

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Evaluation Report Summary: SEC-00178, Clinton Engineer Works

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-00178 was received on July 28, 2010, and qualified on October 20, 2010. The petitioner requested that NIOSH consider the following class: *All guards and service workers who worked in any area at Clinton Engineering Works from January 1, 1943 through May 18, 1947.*

Class Evaluated by NIOSH

Based on its preliminary research, NIOSH modified the petitioner-requested location description and extended the requested class period to the end of the EEOICPA-covered period for the site. NIOSH evaluated the following class: All guards and service workers who worked in or around the warehouses at the Elza Gate area of Clinton Engineering Works from January 1, 1943 through December 31, 1949. The petitioner-requested class location was modified (see Section 3.0). The evaluated worker definition was restricted to the Elza Gate area because the warehouses located there were the ones identified as storage locations for radioactive materials for the site. The petitioner-requested class time period was extended through 1949 because that is the end of the EEOICPA-covered period for the site.

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

Based on its full research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all employees of the Tennessee Eastman Corporation (1943-1947) and the Carbide and Carbon Chemicals Corporation (1947-1949) who were employed at the Clinton Engineer Works in Oak Ridge, Tennessee, from January 1, 1943 through December 31, 1949 for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more classes of employees included in the Special Exposure Cohort. The class under evaluation was modified (see Section 3.0). The proposed class definition was expanded to include all employees of the contractors listed above who carried out operations at the Clinton Engineer Works in the warehouse area near the Elza Gate. The Elza Gate warehouse area is the only area of CEW that has known operations involving radioactive materials and research by NIOSH has determined that the contractor that was operating the Y-12 plant also provided the workforce for the Elza Gate warehouse area at CEW. NIOSH found that it was infeasible to completely reconstruct internal and external doses for the class under evaluation due to insufficient monitoring data. The class period extends through 1949 because there was insufficient information and data to bound dose to the end of the EEOICPA-covered period for the site.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.13(c)(1), NIOSH has established that it does not have access to sufficient information to: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class; or (2) estimate radiation doses of members of the class more precisely than an estimate of maximum dose. Information available from related site profiles and additional resources is not sufficient to document or estimate the maximum internal and external potential exposure to members of the evaluated class under plausible circumstances during the specified period.
The NIOSH dose reconstruction feasibility findings are based on the following:

- NIOSH finds that it is likely feasible to reconstruct occupational medical dose for workers at the Clinton Engineer Works Elza Gate warehouse area with sufficient accuracy.

- Principal sources of internal radiation for members of the proposed class included exposures to uranium residues as well as African and domestic uranium ores through inhalation and ingestion of airborne uranium dust, and exposure from thorium, radium, radon and radon progeny.

- Based on the lack of thorium, radium, radon and uranium monitoring data for Clinton Engineer Works Elza Gate warehouse workers during the storage and/or repackaging operations conducted during the period from January 1, 1943 through December 31, 1949, internal dose reconstruction from all potential sources of exposure is not feasible.

- Principal sources of external radiation for members of the proposed class included exposures to uranium ore, UO_2 residues, uranium tailings, uranium slag, and uranium decay products that were stored at the Clinton Engineer Works Elza Gate warehouse site.

- NIOSH has not identified sufficient documentation to define and quantify the total external source term for the Clinton Engineer Works Elza Gate warehouse area during the period January 1, 1943 through December 31, 1949. Without additional documentation, NIOSH cannot make assumptions about the relative amounts of materials that would have been encountered at the site during this period.

- Limited external dosimetry data were found for 1945-1946. Without additional source term information, NIOSH is unable to determine whether the exposures monitored are representative of the maximally-exposed individual during the period under evaluation.

- NIOSH concludes that there is insufficient source term information and external monitoring data available to bound external exposures for the period from January 1, 1943 through December 31, 1949.

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

- Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Clinton Engineer Works in the area around the Elza Gate warehouses during the period from January 1, 1943 through December 31, 1949, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

Health Endangerment Determination

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

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

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SEC Petition Evaluation Report for SEC-00178

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

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for all guards and service workers who worked in or around the warehouses at the Elza Gate area of Clinton Engineering Works from January 1, 1943 through December 31, 1949. It provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created SEC.

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

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

2.0 Introduction

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

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

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

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

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

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

3.0 SEC-00178 Clinton Engineer Works Class Definitions

The following subsections address the evolution of the class definition for SEC-00178, Clinton Engineer Works. When a petition is submitted, the requested class definition is reviewed as submitted. Based on its review of the available site information and data, NIOSH will make a determination whether to qualify for full evaluation all, some, or no part of the petitioner-requested class. If some portion of the petitioner-requested class is qualified, NIOSH will specify that class along with a justification for any modification of petitioner's class. After a full evaluation of the qualified class, NIOSH will determine whether to propose a class for addition to the SEC and will specify that proposed class definition.

3.1 Petitioner-Requested Class Definition and Basis

Petition SEC-00178 was received on July 28, 2010, and qualified on October 20, 2010. The petitioner requested that NIOSH consider the following class: *All guards and service workers who worked in any area at Clinton Engineering Works from January 1, 1943 through May 18, 1947.*

The petitioner provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the Clinton Engineer Works workers in question. NIOSH deemed the following information and affidavit statements sufficient to qualify SEC-00178 for evaluation:

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

> "I have enclosed a document with information obtain [sic] from DOE that indicates that dad was not monitored for radiation exposure during his employment."

Based on its Clinton Engineer Works research and data capture efforts, NIOSH determined that it has access to a set of external dosimetry records and area monitoring surveys for some Clinton Engineer Works workers during the time period under evaluation. However, NIOSH also determined that internal and external dosimetry records are not complete for all time periods or for all radionuclides. NIOSH concluded that there is sufficient documentation to support, for at least part of the requested time period, the petition basis that internal and external radiation exposures and radiation doses were not adequately monitored at Clinton Engineer Works, either through personal monitoring or area monitoring. 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.

3.2 Class Evaluated by NIOSH

Based on its preliminary research, NIOSH modified and extended the petitioner-requested class. The location description was modified because there is no indication that radiological work was performed at Clinton Engineer Works outside the Elza Gate warehouses or outside the X-10, Y-12, K-25, and S-50 plants, or outside Oak Ridge Hospital and the Oak Ridge Institute for Science and Education (ORISE) which are considered separate sites under this program. The petitioner-requested class period was extended to through 1949 because that is the end of the EEOICPA-covered period for the site. Therefore, NIOSH defined the following class for further evaluation: all guards and service workers who worked in or around the warehouses at the Elza Gate area of Clinton Engineering Works from January 1, 1943 through December 31, 1949.

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

Based on its research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all employees of the Tennessee Eastman Corporation (1943-1947) and the Carbide and Carbon Chemicals Corporation (1947-1949) who were employed at the Clinton Engineer Works in Oak Ridge, Tennessee, from January 1, 1943 through December 31, 1949 for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more classes of employees included in the Special Exposure Cohort.

Based on its research, NIOSH modified the class under evaluation. The evaluated class definition was expanded to include all employees because warehouse operations data did not specify the job titles of all individuals who worked in the area. Based on research done during the evaluation, NIOSH determined that the same contracting company that operated the Y-12 plant also appeared to supply the workforce at the Elza Gate warehouse area. Therefore, the recommended class was defined using the operating contractor. NIOSH found that it was infeasible to completely reconstruct internal and external doses for the class under evaluation due to insufficient monitoring data. The class period extends through 1949 because there was insufficient information and data to bound dose to the end of the EEOICPA-covered period for the site.

4.0 Data Sources Reviewed by NIOSH to Evaluate the Class

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

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

4.1 Site Profile Technical Basis Documents (TBDs)

A Site Profile provides specific information concerning the documentation of historical practices at the specified site. Dose reconstructors can use the Site Profile to evaluate internal and external dosimetry data for monitored and unmonitored workers, and to supplement, or substitute for, individual monitoring data. As part of NIOSH's evaluation detailed herein, it examined the following related TBDs for insights into Clinton Engineer Works operations or related topics/operations at other sites:

- *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium*, Battelle-TBD-6000: PSWS-3738; Rev. F0; December 13, 2006; SRDB Ref ID: 30671
- *K-25 Site - Occupational Environmental Dose*, ORAUT-TKBS-0009-4, Rev. 01, Oak Ridge Associated Universities; June 22, 2007; SRDB Ref ID: 32526
- *Oak Ridge National Laboratory – Occupational Medical Dose*, ORAUT-TKBS-0012-3, Rev. 02, Oak Ridge Associated Universities; October 1, 2007; SRDB Ref ID: 35194
- *Oak Ridge National Laboratory – Occupational Environmental Dose*, ORAUT-TKBS-0012-4, Rev. 00, Oak Ridge Associated Universities; May 7, 2004; SRDB Ref ID: 20136
- *Y-12 National Security Complex – Occupational Medical Dose*, ORAUT-TKBS-0014-3, Rev. 01, Oak Ridge Associated Universities; June 18, 2006; SRDB Ref ID: 32461
- *Y-12 National Security Complex – Occupational Environmental Dose,* ORAUT-TKBS-0014-4, Rev. 01, Oak Ridge Associated Universities; July 20, 2006; SRDB Ref ID: 30042

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: Estimating the Maximum Plausible Dose to Workers at Atomic Weapons Employer Facilities*, ORAUT-OTIB-0004, Rev. 03 PC-2; Oak Ridge Associated Universities; December 6, 2006; SRDB Ref ID: 36191

- *OTIB: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*, ORAUT-OTIB-0006; Oak Ridge Associated Universities; December 21, 2005; SRDB Ref ID: 20220

- *OTIB: Estimation of Neutron Dose Rates from Alpha-Neutron Reactions in Uranium and Thorium Compounds*, ORAUT-OTIB-0024, Rev. 00; Oak Ridge Associated Universities; April 7, 2005; SRDB Ref ID: 19445

4.3 Facility Employees and Experts

To obtain additional information, NIOSH attempted to locate and interview former Clinton Engineer Works employees who worked in or around the warehouses at the Elza Gate area. No living employees meeting this criterion could be located. However, a Manufacturing Engineer who worked at DOE's Y-12 site and also served as a member of the Advisory Board on Radiation and Worker Health was contacted for historical knowledge. In addition, NIOSH interviewed two historians with expert knowledge of the Oak Ridge area.

Personal Communication, 2010, *Personal Communication with Current Manufacturing Engineer at Y-12*; Informal phone conversation with NIOSH staff member; November 29, 2010; SRDB Ref ID: 93103

Personal Communication, 2011, *Personal Communication with two Oak Ridge Historians,* December 12, 2011; SRDB Ref ID: 105919

4.4 Previous Dose Reconstructions

NIOSH reviewed its NIOSH DCAS Claims Tracking System (referred to as NOCTS) to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. Table 4-1 summarizes the results of this review. (NOCTS data available as of January 25, 2012)

Table 4-1: No. of Clinton Engineer Works Claims Submitted Under the Dose Reconstruction Rule	
Description	**Totals**
Total number of claims submitted for dose reconstruction	38
Total number of claims submitted for energy employees who worked during the period under evaluation January 1, 1943 through December 31, 1949.	34
Number of dose reconstructions completed for energy employees who worked during the period under evaluation (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval).	27
Number of claims for which internal dosimetry records were obtained for the identified years in the evaluated class definition	0
Number of claims for which external dosimetry records were obtained for the identified years in the evaluated class definition	0

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. Based on its review of the dose reconstructions completed for CEW employees and the available site documentation, NIOSH has identified a limited amount of personnel and area monitoring data for the CEW site. NIOSH's detailed review and assessment of the available records is provided in Sections 6.0 and 7.0 of this report.

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the assessment of the evaluated class. Four hundred twenty nine documents in this database were identified as pertaining to Clinton Engineer Works. These documents were evaluated for their relevance to this petition. The documents include historical background on the Clinton Engineer Works site, external monitoring data, limited air monitoring data, and radioactive material inventory for the Elza Gate warehouses.

4.6 Documentation and/or Affidavits Provided by Petitioners

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

- *Clinton Engineer Works Special Exposure Cohort Application: January 1, 1943 through May 18, 1947*, SEC Petition; received July 28, 2010; OSA Ref ID: 112238

- Excerpts from Covered Energy Employee's Personal Dose Reconstruction, National Institute for Occupational Safety and Health, Division of Compensation Analysis and Support; March 10, 2005; OSA Ref ID: 112238

- Excerpts from *SC&A Task Group Evaluation of ORAUT-TKBS-0012, "Technical Basis Document for the Oak Ridge National Laboratory*," SCA-TR-TASK1-0013, Sanford Cohen and Associates; September 29, 2006; OSA Ref ID: 112238 and 112615

- Internet Printouts from the *EEOICP Facilities List: Clinton Engineer Works and Oak Ridge National Laboratory*, United States Department of Energy, Office of Health, Safety and Security, Energy Employees Occupational Illness Compensation Program, URL: http://www.hss.energy.gov/healthsafety/fswp/advocacy/faclist/showfacility.cfm; accessed March 23, 2010; OSA Ref ID: 112238

- *Prostate Cancer and Exposure to Ionizing Radiation*, Citation of epidemiological studies that include data from workers employed at ORNL and Y-12, Center for Environmental Health Studies; July 23, 2010; OSA Ref ID: 112238

- *NIOSH Energy-Related Health Research Program: Previous DOE Studies*, National Institute for Occupational Safety and Health; unknown date; OSA Ref ID: 112238

- *Parameter Estimates for the Main Effects Model for Mortality from Selected Cancer Causes of Death Among White Males (N=67,197) Who Worked in Oak Ridge Between 1943 and 1984*, single-page table, unknown source; unknown date; OSA Ref ID: 112238

- *Single-page Executive Summary Presenting the Results and Analysis of a One-year Needs Assessment Study Evaluating Whether a Medical Monitoring and Risk Communication Program is Justified for Former and Current Workers at the Y-12 Plant and ORNL*, unknown source; unknown date ; OSA Ref ID: 112238

- Energy Citations Database listing for: *Advances in Dose Reconstruction at Oak Ridge*, F.O. Hoffman, and T. E. Widner; *Health Physics*, Volume 70, Issue S6; June 1996; OSA Ref ID: 112238

- Definition of a "Cancer Effect Level", unknown source; unknown date; OSA Ref ID: 112238

- *The Manhattan Project: Making the Atomic Bomb. Part IV: The Manhattan Engineer District in Operation*, single-page printout from The Atomic Archive internet site, URL: http://www.atomicarchive.com/History/mp/p4s22.shtml; accessed May 18, 2010; OSA Ref ID: 112615

- *External Coworker Dosimetry Data for the X-10 Site*, single-page excerpt from ORAUT-OTIB-0021, Oak Ridge Associated Universities; November 7, 2006; OSA Ref ID: 112615

- *Table AIV: Summary Results for White Males Ever Employed at X-10 or Y-12 by Dose Group Using Ten Year Lag*, single-page table, unknown source; unknown date; OSA Ref ID: 112615

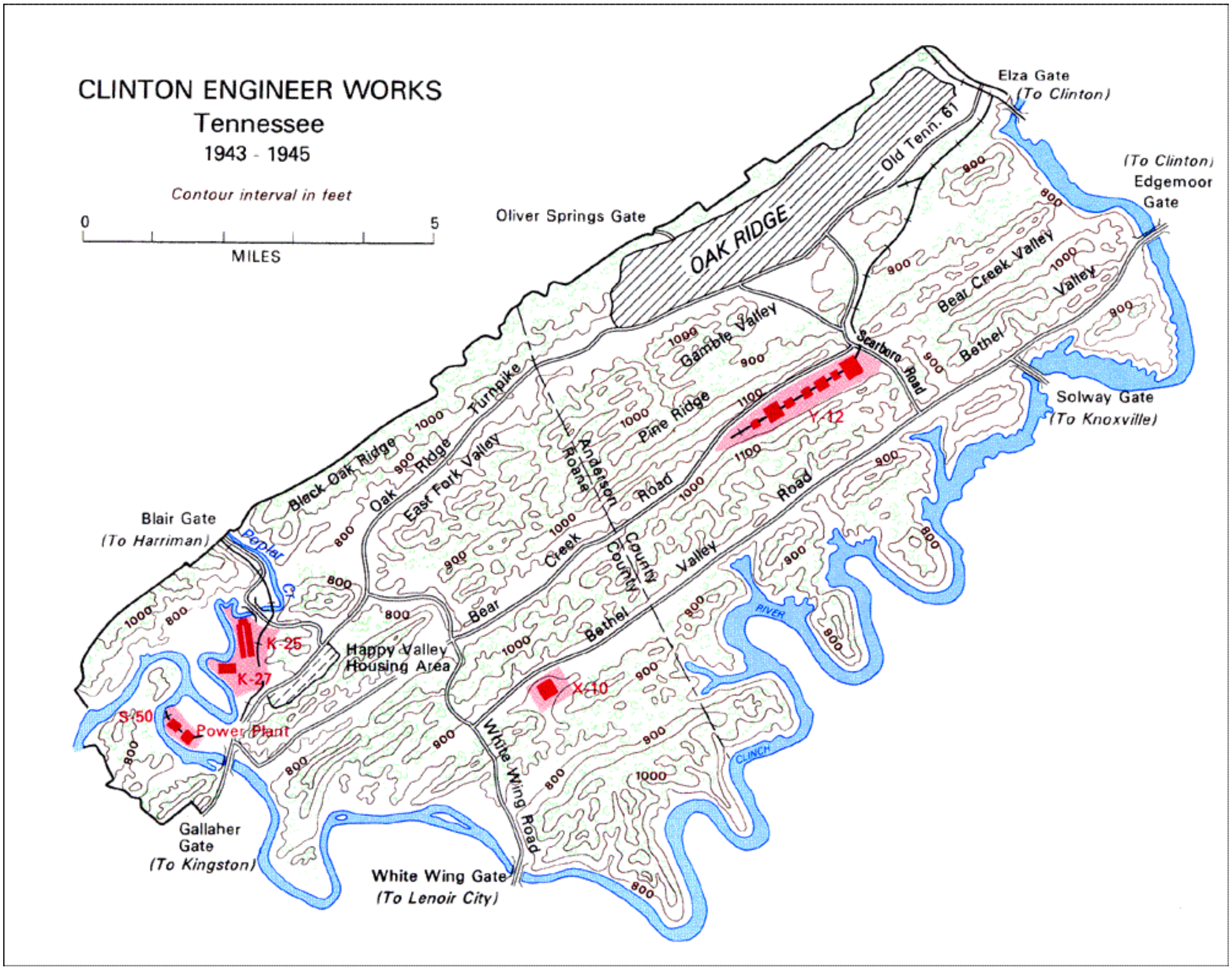
5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

The following subsections summarize both radiological operations at the Clinton Engineer Works from January 1943 through December 1949 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 of each radionuclide of concern, and information describing processes through which radiation exposures may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is intended only to be a summary of the available information.

5.1 Clinton Engineer Works Plant and Storage Descriptions

Clinton Engineer Works was located in both Roane and Anderson Counties, Tennessee. The facility was a 59,000-acre federal government area which hosted three main operating units concerned with atomic energy work (two U-235 production plants and a nuclear research center) as well as the community of Oak Ridge (see Figure 5-1). The population of CEW, concentrated chiefly in Oak Ridge, reached a peak of about 75,000 in the summer of' 1945. The employment peak of 82,000 was reached in May 1945. Thereafter, population and employment declined steadily; at the end of 1946, population was 42,465 and employment was 28,737. The primary contractor (Roane-Anderson Company) had a peak employment of nearly 10,000 in September 1945, declining to about 2,400 by September 1947 (Manhattan, 1947a, pdf p. 20).

The operating units within Clinton Engineer Works were the gaseous diffusion plant for the production of U-235 (K-25), operated for the Atomic Energy Commission by the Carbide & Carbon Chemicals Corporation; the electromagnetic plant for the production of U-235 (Y-12), operated from 1943-1947 by the Tennessee Eastman Corporation and after 1947 by the Carbide & Carbon Chemicals Corporation (also known as the Union Carbide and Carbon Corporation); and the Clinton Laboratories, now a nuclear research center (X-10), which served during the war as a pilot plant for the construction of the huge plutonium process buildings at Hanford Engineer Works in the State of Washington. Near the gaseous diffusion plant, there was also a high-temperature, high-pressure, variable-frequency steam power plant, which has generating equipment with a capacity of 238,000 kilowatts (equal to the capacity of Norris Dam of the TVA). Each of these facilities was fenced separately from the fence that surrounded the larger body of the Clinton Engineer Works (Bowman, 1949).



(Source: CEW Map, 1985)

Figure 5-1: Map of Clinton Engineer Works (1943-1945)

The site for Clinton Engineer Works was selected on Sept. 19, 1942, by representatives of the Manhattan Engineer District (MED) (established August 13, 1942) and the Stone & Webster Engineering Corporation of' Boston, which later had the contract for the construction of' the town of Oak Ridge and the electromagnetic plant (Manhattan, 1947a, pdf p. 28). The site was selected for these reasons: (1) it had to be isolated from large centers of population; (2) it had to be large enough to accommodate several huge plants to be built in flat building areas separated by natural barriers; (3) it had to have dependable electrical power in large quantities; (4) it had to be near a large body of' water; and (5) it had to be accessible to rail and motor transport.

The Clinton Engineer Works footprint was about 17 miles long at its greatest length, and about nine miles wide at its greatest width. The area is approximately eight miles from the town of Clinton, the town for which CEW was originally named, about 18 miles from the city of Knoxville, and about 20 miles from Norris Dam. The area runs generally in the northeast and southwest direction and is bounded on the east, southeast, and southwest by the Clinch River which provides a meandering 35-mile boundary.

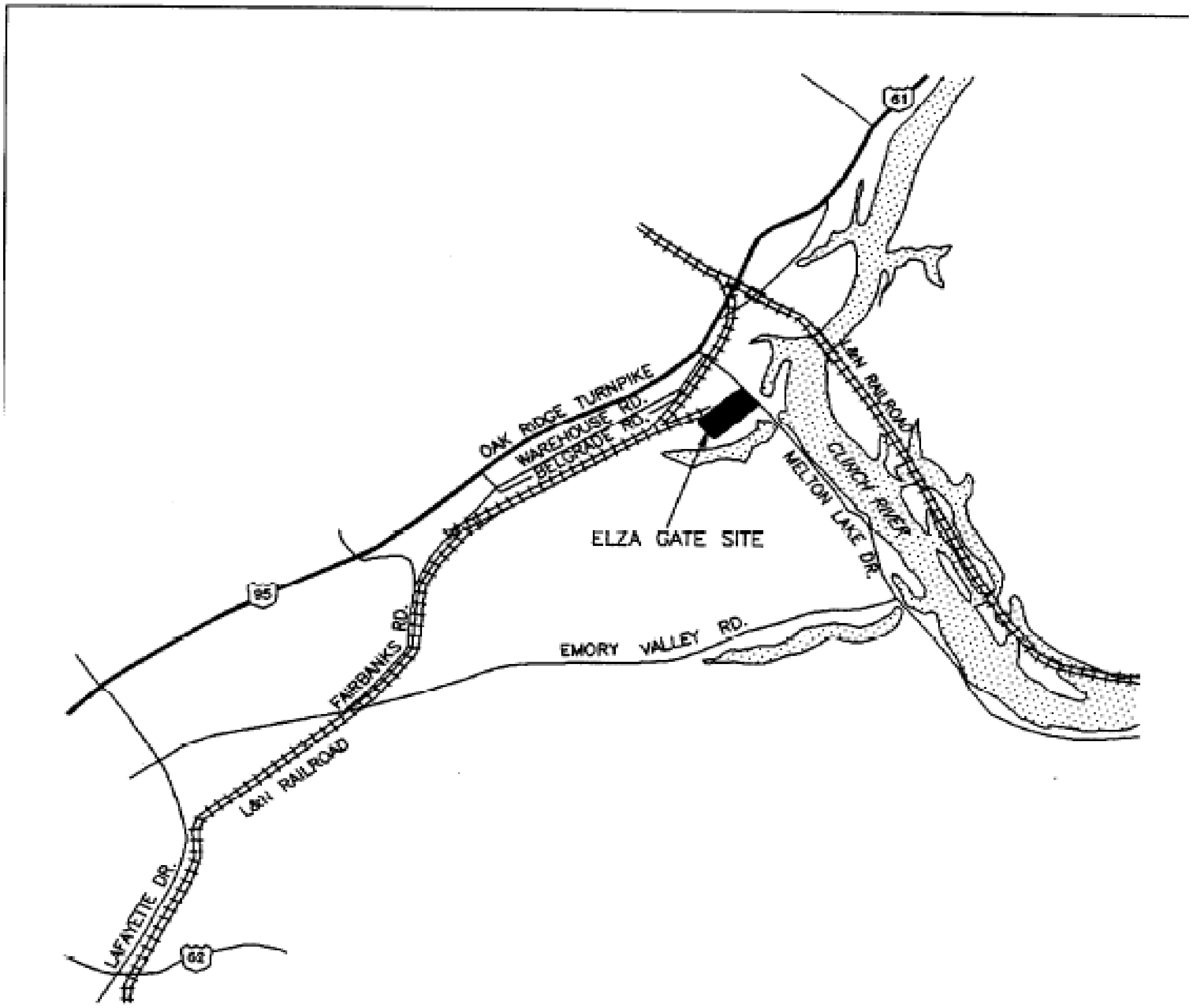
The city of Oak Ridge was constructed by the U.S. Government to provide living accommodations for CEW personnel. In general, the city is laid out on the long sloping side of a ridge that extends slightly to the northeast and southwest. The city occupied approximate1y eight square miles in the northeast corner of the CEW site. The city site is a hilly, wooded section 1.25 mi1es wide and 6.75 miles long bounded on the north by the ridge and on the south by the Oak Ridge Turnpike, the main artery through CEW. The turnpike was part of U.S. Highway 61 before the CEW project started (CEW Facts, 1947, pdf p. 18).

CEW reservation security was initially provided by forces from Stone and Webster. On October 11, 1943, responsibility for Y-12 plant security as well as the reservation guard houses, was transferred to Tennessee Eastman Corporation (Covington, 1943).

The Atomic Energy Commission took over jurisdiction of the Clinton Engineer Works from the Manhattan Engineer District on Jan. 1, 1947. The Manhattan Engineer District was abolished by the Corps of Engineers of the War Department on Aug. 15, 1947.

5.1.1 Elza Gate Warehouses

In the early 1940s, five warehouses were built in the northeastern portion of CEW for the storage of process-related materials. The 20-acre Elza Gate site is bounded by the L&N railroad tracks, Melton Lake Drive to the east, and the Clinch River (Melton Hill Reservoir) to the south and west (see Figure 5-2) (Elza Gate Survey, 1992). This site was variously known as “The Elza Gate Site,” “The Elza Gate Warehouses,” “Area 10,” “Parcel 228,” “Tennessee Storage,” “Tennessee Scrap Storage,” and “Area 0101” (Radon Results, 1944; Assessment, 1992; Sapirie, 1972; Monthly Reports, 1943-1945). Three of these warehouses (Warehouses #1, #2, and #3) were the only buildings within CEW boundaries, but outside the separately-fenced plant properties, where radioactive materials are known to have been stored or handled during the CEW covered period. Limited information is available on the affiliation of the workforce in the Elza Gate warehouses, such as a history report of the Tennessee Eastman Company from 1944 which indicated that by 1944 the warehouses at the Elza Gate area were operated by the company (History Report, 1944). In addition, five of the worker names available on the warehouse film badge result sheets were matched with employment rosters of the Tennessee Eastman Corporation available in the Oak Ridge Operations Records Holdings Area. This information was backed up by one of the Oak Ridge Historians interviewed. In his opinion, it was most likely TEC who would employ workers who would handle radioactive materials, and that the general CEW contractor (Roane Anderson Company) would be less likely to be involved in radioactive material operations (Personal Communication, 2011). It is assumed that the warehouse operations were continued in 1947 by the next contractor for the Y-12 plant, the Union Carbide and Carbon Corporation.



(Source: Elza Gate Survey, 1992)

Figure 5-2: Elza Gate Site at CEW

5.1.2 Stored Materials

NIOSH has found no documentation indicating that radiological materials were stored in Elza Gate Warehouses #4 and #5. Early documentary evidence indicates that Warehouse #1 was used for the storage of slag for recovery (Inspection, 1944). It was noted that some of the storage barrels were broken and leaking and would need repackaging. This same document states that high-grade ore, processing residues, and process tailings were stored in Warehouse #2. Low-grade ore was stored in Warehouse #3, with some of the ore in paper bags and some in burlap bags awaiting transfer to paper bags. NIOSH has discovered documents from other time periods that describe materials stored at the Elza Gate warehouses. The available documentation does not specify which materials were housed in which of the warehouses. The materials known to have been stored at the Elza Gate site during the period under evaluation are listed below. All listed materials are radiological except as noted.

- A was the storage code designation given to all uranium metal ores stored in Area 0101 at Clinton Engineer Works (Davies, 1944).

- B-1 was the waste designation for tuballoy (uranium) extraction tailings from the Point Hope and Vitro facilities. This material contained approximately 100 mg of radium per ton of tailings and varied from a semi-liquid to a consistency similar to damp sand. B-1 was stored in wooden whiskey barrels because it was caustic enough to corrode standard steel 55-gallon drums. These materials were received and unloaded from August 3, 1944 through February 24, 1945 (B1 Material, 1945).

- B-2/B-3 were code designations for non-radiological sludges. B-2 referred to sludges that contained other valuable materials; B-3 designated sludges of little value (Davies, 1944).

- C-1, C-2, and C-3 were various grades of scrap material and slag with uranium concentrations generally less than 20% (Davies, 1944).

- C-6 was a waste metal recovery designation given to sodium diuranate salts ($Na_2U_2O_7 \cdot 6H_2O$) that precipitated following the addition of sodium hydroxide to pitchblende solutions as part of the waste and neutralization cycle (Hanford Glossary, 1961).

- C-616 Residue was a code designation for uranium hexafluoride. This designation was used by both the Army Corps of Engineers and the K-25 plant operators (Codes, 1979).

- C-716 was used to describe two different non-radiological solvents. The Army Corps of Engineers used this code to describe hexadeca fluoroheptane (C_7F_{16}); K-25 operations used the code when discussing perfluoroheptane ($C_7H_2F_{14}$) (Codes, 1979).

- Chemical 42-17 was a designation used to describe a variety of uranium compounds, with the specific compound being indicated by a letter grade following the chemical number. Grade A was uranyl nitrate ($UO_2(NO_3)_2 \cdot 6H_2O$), grades B and C described uranyl oxide (UO_3), grades D and E indicated pitchblende (U_3O_8), and grades F and G indicated uranium dioxide (UO_2) (Hadlock, 1943). Of these, the only material known to be stored at the Elza Gate warehouses was the uranyl nitrate (Chemical 42-17, 1943).

- Chemical 264 is the code used to describe uranium trioxide (UO_3), also known as orange oxide. The orange oxide was generally stored in 2-½ gallon fiber drums that weighed seventy-five pounds when full (Shipment, 1945, pdf p. 3). Thirty-nine thousand pounds of this material was sent to Clinton Engineer Works between November 16, 1944 and December 19, 1944. Beginning on December 15, 1944, fifteen thousand pounds were shipped to CEW on a weekly basis (Shipment, 1945, pdf p. 7).

- Chemical 723 was a code designation for uranium trioxide (UO_3) prepared from uranium peroxide ($UO_4 \cdot 2H_2O$) and carried the alternate shipping designation of "PC-A" (Y-12 Glossary, 1946; Winters, 1945).

- Chemical 727 and Iron designated ammonium diuranate ($(NH_4)_2U_2O_7$) and iron residues precipitated by the addition of ferric aluminum oxalate ($(NH_4)_3Fe(C_2O_4)_3 \cdot 3H_2O$) to alpha "gunk" solutions, where alpha refers to the alpha calutron processes at Y-12 (Y-12 Glossary, 1946).

- Domestic Ore was alternatively termed "low-grade ore." Domestic sources of natural uranium were in the Colorado Plateau region of Colorado, Utah, and New Mexico. The uranium in this region occurred in carnotite ores, which would have been pre-processed in order to extract the vanadium present in the ore (Manhattan, 1985). Although the original carnotite ore had uranium concentrations of less than 1%, the tailings were shipped as a 20% sludge concentrate (Eisenbud, undated).

- E (B-1) Residue, also known as E-carbon, was a condensate from the first evaporation of solutions containing residues from the receiver end of the calutron (Y-12 Glossary, 1946). As one report notes, these residues may have contained large quantities of uranium because only 10-20% of the starting material was collected in the product pockets, while 80-90% of the charge was volatilized onto the liner and source and receiver parts, and had to be recycled to be reused as charge material (Banic, 1973).

- "E" End Ash Material was material remaining following the combustion of scrapings from the graphite liner and receiver on the receiver end of the calutron (Y-12 Glossary, 1946). This material was alternatively designated PC-2 (Winters, 1945). As with the E residues, the inefficiency of the pocket collection process likely resulted in this material containing significant quantities of uranium (Banic, 1973). Memos indicate that this material was essentially U_3O_8 (Morse, 1945).

- G-1 (non-radiological) was magnesium with natural impurities (Davies, 1944).

- G-2 was magnesium that had been contaminated with foreign matter. There is no documentation indicating whether these impurities may have been radiological (Davies, 1944).

- High-Grade Ore was pitchblende ore from the Belgian Congo (the so-called "Congo ore" or "African ore"), supplied by the Belgium-based African Metals Company. It had average concentrations of 25% (Eisenbud, undated) or 30% (Mason, 1977) uranium by weight, up to a maximum of 65-70% (Linking Legacies, 1997; Dupree-Ellis, 2000). Ores from the Belgian Congo had average concentrations of up to 100 mg of Ra-226 per ton of ore (Dupree-Ellis, 2000; Eisenbud, undated), possibly up to 135 mg per ton (Health Hazards, 1949). Thus, there could be a significant dose rate from the ore when it was in drums or when it was being loaded into other containers and hoppers.

- Iron Residues were precipitated by the addition of ferric aluminum oxalate ($(NH_4)_3Fe(C_2O_4)_3 \cdot 3H_2O$) to alpha "gunk" solutions, where alpha refers to the alpha calutron processes at Y-12 (Y-12 Glossary, 1946).

- Iron and Ammonium Precipitate is an alternative designation for ammonium diuranate ($(NH_4)_2U_2O_7$) and iron residues precipitated by the addition of ferric aluminum oxalate ($(NH_4)_3Fe(C_2O_4)_3 \cdot 3H_2O$) to alpha "gunk" solutions, where alpha refers to the alpha calutron processes at Y-12 (Y-12 Glossary, 1946).

- L.P. Solid Residues are residues from the liquid phase reaction used to convert UO_3 to volatile UCl_4 and UCl_5 using liquid CCl_4. These residues were known to contain phosgene ($COCl_2$); elemental chlorine (Cl_2); carbon tetrachloride (CCl_4) in vapor, liquid, and dry forms; nitrogen; uranyl oxide (UO_3); and uranium tetrachloride (UCl_4) (Y-12 Glossary, 1946).

- "M" End Ash Material is material remaining following the combustion of scrapings from the graphite liner of the source unit end of the calutron (Y-12 Glossary, 1946). This material was alternatively designated as PC-1 (Winters, 1945). As with the other ash and residue materials, this material likely contained significant quantities of uranium (Banic, 1973).

- Product-80, as manufactured by Harshaw Chemical Company, was a nickel-chromia catalyst with traces of iron, copper, sodium, sulfate, chlorine, calcium, and magnesium. In addition, this material may have contained trace amounts of cobalt, lead, manganese, and zinc. No information has been found to indicate that this material contained any radiological materials (deBethune, 1943).

- Q Material was a code for more than one material and was commonly used as a generic designation for tuballoy (uranium, and specifically, U-238). However, because this material is listed as having come from Y-12, it is likely that the appropriate definition of this code is residual material from the Q pocket of the receiving end of a calutron (Y-12 Glossary, 1946).

- Scrap Metal: NIOSH has not located any specific information describing what these materials are, but assumes that the materials were radiological in nature. This assumption is based on the materials' inclusion on an inventory of "special material" (Inventory, 1945). In general, uranium metal scraps during the MED era were collected at the machining sites in 30- or 55-gallon drums. The pieces would have been kept immersed in either water or oil to resist oxidation (Battelle-TBD-6000).

- Solid Gunk is a solidified form of the recovery solutions from the washing of calutron units using 4M nitric acid following the removal of the source, liner, and receiver assemblies. This material was filtered, dried, and finally run through an ion exchange resin in an attempt to extract useable heavy metals (Banic, 1973).

- Waffle Ash Material was the material remaining following the combustion of scrapings from the graphite liner and receiver of the receiver end of the calutron (Y-12 Glossary, 1946). This material was alternatively designated as "PC-2," "Q-face carbons," and "E face carbons" (Winters, 1945).

5.2 Radiological Exposure Sources from Clinton Engineer Works Operations

The following subsections provide an overview of the internal and external exposure sources for the Clinton Engineer Works class under evaluation.

5.2.1 Internal Radiological Exposure Sources from CEW Operations

Based on extensive data capture efforts and review of available information, NIOSH has concluded that the Clinton Engineer Works workers in and around the Elza Gate warehouses had the potential for internal radiation exposures from uranium residues as well as from African and domestic ores through inhalation and ingestion of airborne uranium dust, and exposure from radon and radon progeny while working at the site. The distinction between the two types of ore is important. The primary radiological hazards from an ore that contained only uranium and its short-lived progeny would be due to alpha and beta emissions. In contrast, radium and other progeny in the African ores would produce, in addition to the alpha and beta emissions, significant gamma emissions and elevated levels of radon.

5.2.1.1 Uranium

The radiological hazard presented by uranium metal or compounds results primarily from alpha particles emitted by U-238 (4.15 MeV and 4.20 MeV) and its isotopes U-235 (4.37 MeV, 4.40 MeV, and 4.58 MeV) and U-234 (4.27 MeV and 4.77 MeV). Naturally-occurring uranium is 0.71% (w/w) U-235 and 0.0055 (w/w) U-234. On an activity basis (i.e., dpm/gram), the U-235 will be present in negligible amounts at these enrichment levels, but the U-234 activity will be at a level that is essentially equal to U-238 due to its much shorter half-life (2.46×10^5 years for U-234, and 4.47×10^9 years for U-238). However, because many of the products stored at the Elza Gate warehouses were by-products from an enrichment process, NIOSH cannot assume that the uranium stored at this site was of natural enrichment.

5.2.1.2 Thorium

The uranium ores were reported to contain average concentrattions between 100 - 135 mg of Ra-226 per tom of ore. Since the progeny were likely in secular equilibrium with the parent nuclide, a significant amount of Th-230 could have also been present in the ores and residues. The main radiological hazard from Th-230 results from alpha particles, which are emitted at 4.68 MeV.

5.2.1.3 Radium

Ores from the Belgian Congo had average concentrations of up to 100 mg of Ra-226 per ton of ore (Dupree-Ellis, 2000; Eisenbud, undated), possibly up to 135 mg per ton (Health Hazards, 1949) and it is possible that workers could have been exposed to radium containing dusts while handling and re-bagging the ore materials. The internal radiological hazard from radium in the residues comes from alpha emissions at 4.78 MeV and 4.61 MeV.

5.2.1.4 Radon

Radon levels could exist where residues containing uranium daughter products were stored. It is likely that workers may have been exposed to short, high-level exposures when opening drums of stored uranium residues, opening rail cars used to ship drums to the site, or opening enclosed storage rooms containing residues. Radon levels were likely to have varied between warehouses based on different materials stored at Elza Gate Warehouses #1, #2, and #3. The major internal exposure hazard from radon and its short lived decay products stems from alpha emissions as listed below:

- Rn-222: 5.59 MeV
- Po-218: 6.12 MeV
- Po-214: 7.88 MeV

5.2.2 External Radiological Exposure Sources from CEW Operations

Based on the information and documentation available to NIOSH, the potential for external radiation doses from uranium ore, UO_2 residues, uranium tailings, uranium slag, and uranium decay products existed at the Clinton Engineer Works Elza Gate warehouses site. The following subsections provide an overview of the external exposure sources.

5.2.2.1 Photon

Uranium ore, residues, tailings, and slag were handled by CEW employees. External exposures to photon radiation would have resulted from the immediate daughter radionuclides in the uranium decay chain. The uranium progeny that result in the most significant photon exposures include Th-234 and Pa-234m (Rad Handbook, 1970). Note that these isotopes have relatively short half-lives and can be assumed to be in equilibrium with the parent U-238. Because of their short half-lives, the exposure potential from these isotopes would travel with the parent and will not be considered separately. The radium-226 and short lived decay products of radon-222 are also significant gamma emitters which are also part of the uranium chain.

Table 5-1 provides the gamma emission energies of the primary isotopes of concern at the Clinton Engineer Works.

Table 5-1: Gamma Emissions of Primary Interest

Radionuclide	Gamma Energy (MeV)	Gamma Yield Per Nuclide Disintegration (%)
Uranium-238	None	N/A
Thorium-234	0.063	3.5
	0.093	4
Protactinium-234m	0.766	0.2
	1.00	0.6
Uranium-235	0.144	11
	0.163	5
	0.186	54
	0.205	5
Thorium-231	0.026	15
	0.084	6.5

Table 5-1: Gamma Emissions of Primary Interest		
Radionuclide	**Gamma Energy (MeV)**	**Gamma Yield Per Nuclide Disintegration (%)**
Uranium-234	0.053	0.1
Radium-226	0.186	3.5
Lead-214	0.352 0.295 0.242	37.6 19.3 7.4
Bismuth-214	0.609 1.764 1.120 1.238 2.204	46.1 15.4 15.1 5.8 5.1

Source: Radiological Health Handbook, 1998. A more complete list for uranium progeny can be found in this document (Rad Handbook, 1998).

5.2.2.2 Beta

Exposure to beta sources for CEW employees would have resulted principally from uranium/radon decay products. In the uranium-series decay scheme, beginning with U-238, the short-lived isotope Pa-234m emits the most energetic beta particle (2.28 MeV). It is this beta particle that accounts for the shallow-dose hazard associated with handling uranium. Table 5-2 provides the beta emission energies of the primary isotopes of concern at the Clinton Engineer Works Elza Gate warehouses.

Table 5-2: Beta Emissions of Primary Interest		
Radionuclide	**Beta Energy (MeV, max.)**	**Beta Yield Per Nuclide Disintegration (%)**
Uranium-238	None	N/A
Thorium-234	0.10	19
	0.193	79
Protactinium-234m	2.28	99
Uranium-235	None	N/A
Thorium-231	0.205	15
	0.287	49
	0.304	35
Uranium-234	None	N/A

Source: Radiological Health Handbook, 1998. A more complete list for uranium progeny can be found in this document (Rad Handbook, 1998).

5.2.2.3 Neutron

Due to the low concentration of uranium in the stored materials, there is no credible source of neutron radiation exposure for CEW employees. However, neutrons could be emitted as a result of the α-n reaction with light elements, interactions of emitted alpha particles with the oxides, and through spontaneous fission. According to Battelle-TBD-6000, uranium oxides would be the most common generators of (α,n) reactions. Spontaneous fission yields and (α,n) yields in oxides are provided in Table 3.5 of Battelle-TBD-6000. Based on its analysis, NIOSH concludes that none of these sources would be sufficient to result in a significant neutron exposure.

5.2.3 Incidents

NIOSH did not identify any documented accidents at Clinton Engineer Works that resulted in exceptionally high personnel exposure levels (such as a criticality event). Therefore, further discussion or assessment of potential personnel exposures associated with incidents at Clinton Engineer Works is not included in this report.

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

Although NIOSH has been unable to locate any information on the work practices employed by CEW workers when loading and unloading materials at the Elza Gate warehouses, some documentation is available describing exposure conditions associated with these operations. The documentation available to NIOSH does not describe the work processes or exposure conditions associated with the Clinton Engineer Works repackaging of the AEC shipments involving uranium and uranium residues (B1 Material, 1945).

The following subsections provide an overview of the state of the available internal and external monitoring data for the Clinton Engineer Works class under evaluation.

6.1 Available Clinton Engineer Works Internal Monitoring Data

NIOSH has access to nineteen radon air samples collected in 1944. Seven of these air samples were taken on March 2, 1944 and the remaining twelve were taken on May 23. Of the twelve samples taken on May 23, 1944, three were taken in Warehouse #2 before the installation of new ventilation fans, and three were taken after the installation. Similarly, three samples were taken both before and after installation of fans in Warehouse #3 (Radon Results, 1944).

NIOSH also has records for sixteen radon air samples collected in 1945. On March 9, 1945, five samples were collected in Warehouse #2, four samples were collected in Warehouse #3, one sample was taken outside the warehouses, and one sample was taken at the nearby Elza Gate guard shack. On March 20, 1945, three samples were collected from Warehouse #2 and three were collected from Warehouse #3 (B1 Material, 1945).

Although weekly blood counts were recommended for workers at the Elza Gate warehouses as early as March 1945 (B1 Material, 1945), NIOSH has been unable to find any documentation indicating that CEW conducted a routine bioassay sampling program for its employees. NIOSH does not believe that uranium scrap presented an internal hazard at the Clinton Engineer Works Elza Gate warehouses because the scrap did not undergo further processing or machining at the site. Battelle-TBD-6000 indicates that the greatest potential for internal exposures from scrap material occurs during the processing of scraps into briquettes, releasing dust and fumes. NOISH has found no indication that such processing occurred at the Elza Gate warehouse site. However, uranium ores and residues did present a potential internal hazard, particularly when such materials were stored in leaky containers or when ore was transferred from burlap bags to paper bags (Inspection, 1944; Ferry, 1944). NIOSH has insufficient information to support evaluating the dose from those residues. Further information is discussed in Section 7.2.

6.2 Available Clinton Engineer Works External Monitoring Data

NIOSH has access to monthly summary exposure records for 20 men covering the time period from August 1944 through March 1945. NIOSH has also discovered 347 individual film badge records covering the time periods from March 12 through September 1, 1945 (B1 Material, 1945) and January 29 through March 31, 1946 (Film Badge Results, 1946). These badges are associated with a total of

182 control badges, some of which were stored in the guard shack at Elza Gate. Task-specific badges were issued to six men on October 29, 1945, six men on July 28, 1945, and nine men on July 31, 1945. These task-specific records contain descriptions of the types of work each individual was performing as well as how long each badge was worn (B1 Material, 1945).

NIOSH also has access to two sets of area gamma surveys. The first set was taken in August 1944 and contains four readings from Warehouse #2 and three readings from Warehouse #3 (Inspection, 1944, pdf p. 11). The second set of measurements was taken in March 1945 and is comprised of three measurements in Warehouse #2 and six measurements in Warehouse #3 (B1 Material, 1945, pdf p. 8).

7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

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

In determining feasibility, NIOSH begins by evaluating whether current or completed NIOSH dose reconstructions demonstrate the feasibility of estimating with sufficient accuracy the potential radiation exposures of the class. If the conclusion is one of infeasibility, NIOSH systematically evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might ensure that NIOSH can estimate either the maximum doses that members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class as summarized in Section 7.5. This approach is discussed in DCAS's SEC Petition Evaluation Internal Procedures which are available at http://www.cdc.gov/niosh/ocas. The next four major subsections of this Evaluation Report examine:

- The sufficiency and reliability of the available data. (Section 7.1)

- The feasibility of reconstructing internal radiation doses. (Section 7.2)

- The feasibility of reconstructing external radiation doses. (Section 7.3)

- The bases for petition SEC-00178 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of Clinton Engineer Works Data

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

7.1.1 Internal Monitoring Data Pedigree Review

As discussed in Section 6.1, NIOSH has not located any documentation indicating that routine air sampling or internal monitoring programs for uranium or radon were conducted during CEW operations. Therefore, an internal monitoring data sufficiency and pedigree evaluation is not possible for this internal monitoring data type.

Radon air sample results from MED surveys conducted in March and May 1944 and March 1945 are presented in report form and are recorded both in units of microcuries of radon per liter of air and in multiples of the tolerance limit (B1 Material, 1945; Radon Results, 1944). However, due to a lack of detailed inventory data spanning the entire period under evaluation, NIOSH could not draw a conclusion about the representativeness of the samples for the purpose of estimating personnel intakes.

7.1.2 External Monitoring Data Pedigree Review

NIOSH has access to monthly summary exposure records for 20 men covering the time period from August 1944 through March 1945. These reports list each individual's gamma and beta exposures and are in the form of original reports. NIOSH also has discovered 347 individual film badge records covering the time periods from March 12 through September 1, 1945 (B1 Material, 1945) and January 29 through March 31, 1946 (Film Badge Results, 1946). These badges are associated with a total of 182 control badges, some of which were stored in the guard shack at Elza Gate. Task-specific badges were issued to six men on October 29, 1945, six men on July 28, 1945, and nine men on July 31, 1945. These task-specific records contain descriptions of the types of work each individual was performing, as well as how long each badge was worn (B1 Material, 1945). Each of these records is in the form of original typewritten reports. Based on the format and context provided with the available film badge reports, it was possible to conclude that the University of Rochester provided the film badge service for the workers at the warehouses. Due to a lack of detailed inventory data spanning the entire period under evaluation, NIOSH could not draw a conclusion about the representativeness of the dosimetry results for the purpose of estimating personnel exposures.

NIOSH also has access to two sets of area gamma surveys. The first set was taken in August 1944 and contains four readings from Warehouse #2 and three readings from Warehouse #3 (Inspection, 1944, pdf p. 11). The second set was taken in March 1945 and is comprised of six measurements taken in Warehouse #3 and three measurements taken in Warehouse #2 (B1 Material, 1945, pdf p. 8). Both sets of results are in original typewritten reports. Due to a lack of detailed inventory data spanning the entire period under evaluation, NIOSH could not draw a conclusion about the representativeness of these samples for the purpose of estimating personnel exposures.

7.2 Evaluation of Bounding Internal Radiation Doses at CEW

The principal sources of internal radiation doses for members of the class under evaluation were uranium ore dust during the repackaging of materials shipped and initially stored in burlap bags and uranium residues that may have spilled from leaky drums (Inspection, 1944). The following subsections address the ability to bound internal doses, methods for bounding doses, and the feasibility of internal dose reconstruction.

7.2.1 Evaluation of Bounding Process-Related Internal Doses

Workers at the Elza Gate warehouse site were potentially exposed to uranium residues, uranium ore dust, and radon. NIOSH has found no indications that bioassay measurements were collected for the period under evaluation. NIOSH has also been unable to locate any records indicating that breathing zone or area air sampling was conducted during repackaging of uranium ore shipped and initially stored in burlap bags or during the clean-up of materials that may have spilled from leaking drums.

While NIOSH has obtained a limited number of radon air sampling results from 1944 and 1945, those results were found to be inadequate to bound internal intakes from radon during the period under evaluation (B1 Material, 1945; Radon Results, 1944). Radon air samples were taken on four occasions during these two years. On the first occasion, no information is provided on the precise location of the sampling. On the subsequent three occasions, each sample is listed along with information on the area being sampled. Due to the lack of detailed inventory records, NIOSH cannot determine the quantity of material present when the sampling was performed; therefore, the relevance or representativeness of those samples for the evaluated class cannot be established.

NIOSH has not identified sufficient documentation to define and quantify the total internal source term for the Elza Gate warehouse area during the period under evaluation. Without additional documentation, NIOSH cannot make assumptions about the relative amounts of materials that would have been encountered on site during this period. Thus, NIOSH finds that it is infeasible to completely reconstruct internal doses for the class under evaluation due to insufficient monitoring data as well as the inability to define who would have had occasion to work in and around the Elza Gate warehouses. Therefore, there is insufficient information available to NIOSH to bound internal exposures for the period from January 1, 1943 through December 31, 1949 (the end of the EEOICPA-covered period for the site).

7.2.2 Evaluation of Bounding Ambient Environmental Internal Doses

Ambient environmental internal exposures were possible from atmospheric releases of radionuclides from the large scale operations of the four plants located within CEW boundaries, as discussed below. Additional ambient environmental internal exposures were possible from radon released through the ventilation systems of the Elza Gate warehouses, although these exposures were likely small compared to environmental exposures from the four plants operating within the CEW boundaries.

K-25 Environmental Releases

Internal exposures to CEW employees were possible due to releases from K-25 stacks, individual building releases, and from the purge cascade and other operations at the Oak Ridge Gaseous Diffusion Plant. Releases of these radionuclides were studied from 1994 through 1999 as part of the Oak Ridge Dose Reconstruction, resulting in the development of a source term for airborne radionuclides (Dose Reconstruction, 1999; Shonka, 1997a; Shonka, 1997b; Shonka, 1997c). These source term data were combined with documented environmental monitoring data to estimate radionuclide specific airborne concentrations for U-234, U-235, and U-238. These values are tabulated in Tables A-1 through A-3 of the Occupational Environmental TBD of the K-25 Site Profile (ORAUT-TKBS-0009-4). These values may be used to bound ambient environmental internal exposures for CEW employees.

X-10 Environmental Releases

Releases from several processes at X-10 had the potential to contribute to ambient environmental exposures to CEW employees. The X-10 Graphite Reactor operated from November 1943 until November 1963. It was an air-cooled graphite pile; the cooling air exhaust was ventilated unfiltered via the 105 stack. The exhaust air system did not provide any hold-up or delay, so the effluent stream included short-lived fission gases, their particulate decay products, and air activation products, most notably Ar-41. In addition, particulate mixed fission product activity would be released following incidents of ruptured fuel slugs. The estimated Ar-41 emission rate from the 105 stack when the reactor was at its initial power level in 1944 was approximately 200 curies/day (Parker, 1944). The emission rate increased to approximately 500 curies/day in 1945 following an increase in the reactor's operating power level (Cheka, 1945).

Low volumes of high-activity offgases were produced from process vessels such as dissolvers, in which the initial chemical separations steps involving irradiated source materials were carried out. Examples of such operations include plutonium separations processes such as bismuth phosphate or PUREX and its variants, alternative fuel cycle processes such as Thorex, and production of radioisotopes such as I-131 or Ba-140/La-140 (i.e., the RaLa process). These high-activity offgas streams were ventilated via the 205 stack prior to completion of the ORNL central offgas-handling system about 1950 (Cheka, 1948).

High volumes of low-activity waste gases were produced by ORNL's numerous hot cells and fume hoods. Most of these sources were ventilated locally prior to completion of the central offgas-handling system about 1950. Other sources of airborne radioactive material in this era were hot chemistry work conducted in hoods in Building 706-A. These materials were exhausted via roof vents. In addition, the tank farm was considered a source of airborne material from spills that subsequently dried and became airborne (Cheka, 1948).

Initial air monitoring at X-10 focused on measurement of outdoor exposure rates from the radioiodine and noble gas emissions from stacks 105 and 205 via particulate air filters. It was noted that the principal effluents from stack 105 was Ar-41 and the principal effluents from stack 205 were xenon and iodine. Because the sampling methods at that time did not employ charcoal cartridges for sampling radioiodines, the results from the on-site air monitoring network may be considered reliable for mixed fission products but may not be accurate for I-131 concentrations.

Bounding values of dispersion coefficients coupled with release estimates and source term information derived from the Oak Ridge Dose Reconstruction project (Dose Reconstruction, 1999) have been used to calculate annual average airborne concentration data for I-131 and particulate mixed fission products for X-10. These values are tabulated in Attachment 4-B of the Occupational Environmental TBD of the X-10 Site Profile (ORAUT-TKBS-0012-4) and may be used to bound ambient environmental internal exposures for CEW employees.

Y-12 Environmental Releases

Releases from the electromagnetic separation and uranium salvage processes at Y-12 had the potential to contribute to ambient environmental exposures for CEW employees. The Y-12 calutron began operation in the fall of 1943 and ran until December 1946, when the gaseous diffusion process was selected as a less-costly alternative for uranium enrichment. After this time, electromagnetic operations continued for the purpose of researching new radionuclides for medical and industrial uses. In addition, the Y-12 plant was involved in the conversion of large quantities of UO_2, UO_3, and U_3O_8 for use in the calutrons (Dose Reconstruction, 1999).

An elaborate system of mechanical and chemical processes was used to recover and reclaim residual uranium feed and product material found on equipment and scrap material associated with the calutron operations as well as material shipped from the AEC's Weldon Spring (Missouri) Plant that had recoverable U-235. These operations included mechanical scraping and brushing, nitric-acid washing, and distillation and reclamation of solid uranium compounds adhering to surfaces. Uranium-contaminated materials included condensates, scrubber solutions, raffinates, destructive distillates, oils, and miscellaneous residues. These facilities handled mostly natural uranium (NU) and depleted uranium (DU).

Salvage operations involved EU recovery from all non-product components or by-products of operations. Uranium was reclaimed from materials not considered to be production equipment, such as liquid and solid waste materials from maintenance and clean-up activities (e.g., mop water, laundry washes, and floor drain residues). Other salvage operations included mechanical scraping and brushing, nitric-acid washing, and distillations and reclamation of solid uranium compounds (Dose Reconstruction, 1999). Combustible materials such as wood, rags, sponges, filter paper, and carbon solids were burned in muffle furnaces and incinerators to recover the uranium.
Release estimates for all buildings at Y-12 were previously estimated as part of the Oak Ridge Dose Reconstruction Project (Dose Reconstruction, 1999). These independent estimates were based on a reconstruction of releases from stack monitoring data. Estimates of uranium releases were reconstructed for individual exhaust stacks and vents and were based on available information on

individual buildings and uranium processes and from indoor air monitoring data. A compilation of these release estimates is presented in Table 4.2.4-1 of the Occupational Environmental Dose TBD of the Y-12 Site Profile (ORAUT-TKBS-0014-4). These values may be used to bound ambient environmental internal exposures for CEW workers.

S-50 Environmental Releases

Construction of the Liquid Thermal Diffusion Plant (S-50) began on July 9, 1944. Uranium enrichment began on September 16, 1944 (before construction was complete) and concluded on September 9, 1945 (S-50 Compilation, 2005). UF_6 losses were common during S-50 operations, with UF_6 often escaping into the air or cooling water (Manhattan, 1947b); such releases could have contributed to the ambient environmental exposures of CEW employees. From March through July 1945, monthly UF_6 losses ranged from 247 to 1,826 lbs (S-50 Compilation, 2005). This released UF_6 would rapidly oxidize and form uranyl fluoride (UO_2F_2), which could then exhaust through the building roof (S-50 Compilation, 2005). Accountability records showing losses for other months of operation are unavailable.

NIOSH has been unable to find any environmental monitoring data from S-50 operations. NIOSH determined in the SEC Evaluation Report for S-50 that there are insufficient personnel monitoring, air monitoring, or source term data to adequately reconstruct any internal or external occupational exposures at the plant (NIOSH, 2006). Consequently, NIOSH finds that it is not feasible to estimate with sufficient accuracy the radiation doses from internal or external ambient exposures at the S-50 plant for this current evaluation.

7.2.3 Methods for Bounding Internal Dose at Clinton Engineer Works

7.2.3.1 Methods for Bounding Operational Period Internal Dose

NIOSH has determined that the available bioassay, workplace monitoring, and source term data are inadequate to bound worker exposures to radon and uranium dust during the storage, transport, and/or repackaging of uranium ore and residue materials performed during the operational period at the Elza Gate warehouse site. Therefore, NIOSH has not identified a method for bounding internal doses at the Clinton Engineer Works Elza Gate warehouse site for the period from January 1, 1943 through December 31, 1949 (the end of the EEOICPA-covered period for the site).

7.2.3.2 Methods for Bounding Ambient Environmental Internal Dose

Although ambient environmental internal exposures were possible from radon released through the Elza Gate warehouses' ventilation systems, these exposures would be small compared to the environmental exposure resulting from operations of each of the four plants within the CEW boundary The environmental exposures resulting from the operations of the four plants located within the CEW boundary are considered bounding for any internal environmental exposure that may have been received by a worker at the Elza Gate Warehouse area.

Although NIOSH does not have Elza Warehouse area-specific internal monitoring data for the period from January 1, 1943 through December 31, 1949, NIOSH intends to use the information provided for each of the four plants within the CEW boundary, as well as any internal monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at CEW during the period from January 1, 1943 through December 31, 1949, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

K-25 Environmental Releases

Ambient environmental doses for individuals who worked at K-25 have been researched and assessed in the Occupational Environmental TBD of the K-25 Site Profile (ORAUT-TKBS-0009-4). Considering the effect that the additional distance between the K-25 plant and the other work locations within the CEW boundaries would have had on the dispersion of airborne radiological contaminants, the ambient environmental exposures assessed for workers in the K-25 Site Profile would have been considerably higher than those for individuals working at off-site (i.e., beyond K-25) locations. Therefore, the ambient environmental internal exposure assessment method defined in the K-25 Site Profile will serve to bound any ambient internal doses for individuals working within the CEW boundaries, but outside the fenced boundaries of the K-25 plant.

X-10 Environmental Releases

Ambient environmental doses for individuals who worked at X-10 have been researched and assessed in the Occupational Environmental TBD of the X-10 Site Profile (ORAUT-TKBS-0012-4). Considering the effect that the additional distance between the X-10 plant and the other work locations within the CEW boundaries would have had on the dispersion of airborne radiological contaminants, the ambient environmental exposures assessed for workers in the X-10 Site Profile would have been considerably higher than those for individuals working at off-site (i.e., beyond X-10) locations. Therefore, the ambient environmental internal exposure assessment method defined for X-10 workers in the X-10 Site Profile will serve to bound any ambient internal doses for individuals working within the CEW boundaries, but outside the fenced boundaries of the X-10 plant.

Y-12 Environmental Releases

Ambient environmental doses for individuals who worked at Y-12 have been researched and assessed in the Occupational Environmental TBD of the Y-12 Site Profile (ORAUT-TKBS-0014-4). Considering the effect that the additional distance between the Y-12 plant and the other work locations within CEW boundaries would have had on the dispersion of airborne radiological contaminants, the ambient environmental exposures assessed for workers in the Y-12 Site Profile would have been considerably higher than those for individuals working at off-site (i.e., beyond Y-12) locations. Therefore, the ambient environmental internal exposure assessment method defined for Y-12 workers in the Y-12 Site Profile will serve to bound any ambient internal doses for individuals working within the CEW boundaries, but outside the fenced boundaries of the Y-12 plant.

S-50 Environmental Releases

NIOSH has been unable to find any environmental monitoring data from S-50 operations. NIOSH determined in the SEC Evaluation Report for S-50 (NIOSH, 2006) that there are insufficient personnel monitoring, air monitoring, and source term data to adequately reconstruct any internal or external occupational exposures at the S-50 plant. Consequently, NIOSH finds that it is infeasible to estimate with sufficient accuracy the radiation doses from internal or external ambient exposures at the S-50 plant.

7.2.4 Internal Dose Reconstruction Feasibility Conclusion

NIOSH finds there are insufficient data, including bioassay results, air concentrations, or process information to estimate with sufficient accuracy internal exposures to radionuclides in the Elza Gate warehouse area of Clinton Engineer Works. Therefore, NIOSH finds that it is infeasible to completely reconstruct internal doses from the start of the class under evaluation (January 1, 1943) through the end of the EEOICPA-covered period (December 31, 1949) due to insufficient monitoring data.

Although NIOSH found that it is not possible to completely reconstruct internal radiation doses for the period from January 1, 1943 through December 31, 1949, NIOSH intends to use any internal monitoring data, including the ambient environmental monitoring data for the plants within the Clinton Engineering Works area, that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at Clinton Engineer Works during the period from January 1, 1943 through December 31, 1949, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

7.3 Evaluation of Bounding External Radiation Doses at CEW

The principal sources of external radiation doses for members of the evaluated class were uranium and uranium daughters found in the uranium materials and wastes located on the property. Domestic ores, African pitchblende, recoverable scrap materials, and various residues were stored on site. Radium and its progeny would produce gamma radiation. The following subsections address the ability to bound external doses, methods for bounding doses, and the feasibility of external dose reconstruction.

While the supporting documentation available to NIOSH states that some external monitoring was performed during the CEW operational period, NIOSH has been unable to locate a complete individual external monitoring data set for the class evaluated in this report. NIOSH has individual gamma and beta monitoring records spanning the time periods from August 1944 through September 1945 and January through March 1946 for employees who directly handled the radiological material at the warehouses; however, a lack of detailed inventory information precludes NIOSH from determining whether these data sets are representative of the exposures potentially received during the entire period under evaluation.

Although NIOSH has obtained a limited number of area gamma survey results from 1944 and 1945, these results were found to be inadequate to bound external exposures during the period under evaluation (B1 Material, 1945, pdf p. 8; Inspection, 1944, pdf p. 11). Each of the sample results includes information on the approximate sampling location. However, due to lack of detailed inventory records, NIOSH cannot determine the quantity of material present when sampling was performed; and therefore, cannot establish the relevance or representativeness of those samples to the class under evaluation.

NIOSH has not identified sufficient documentation to define and quantify the total external source term for Clinton Engineer Works during the period under evaluation. Without additional documentation, NIOSH cannot make reasonable assumptions about the relative amounts of materials that would have been encountered at the site during the specified period. Thus, NIOSH finds that it is infeasible to completely reconstruct external doses for the class under evaluation due to insufficient monitoring data. Therefore, there is insufficient information available to NIOSH to bound external exposures for the period from January 1, 1943 through December 31, 1949 (the end of the EEOICPA-covered period for the site).

7.3.2 Evaluation of Bounding Ambient Environmental External Doses

Area surveys performed in 1988 and 1989 (ORNL Survey, 1988; ORNL Survey, 1989) indicate that the concrete pads on which the warehouses once stood, as well as the soils surrounding the pads, contained radiological contaminants, suggesting a possible exposure pathway for ambient environmental external doses. NIOSH has not discovered any documentation describing when the structures were removed, thus exposing the concrete pads to the elements. Because the CEW area experiences an average annual precipitation of 140 cm (Assessment, 1992), it is infeasible to use the available data to estimate a soil or concrete pad contamination level for the time period under evaluation. However, any ambient environmental external exposures will be bounded by the atmospheric releases of radionuclides from the four plants located within CEW boundaries.

K-25 Environmental Releases

External exposures to CEW employees were possible due to releases from K-25 stacks, individual building releases, and from the purge cascade and other operations at the Oak Ridge Gaseous Diffusion Plant. Releases of these radionuclides were studied from 1994 through 1999 as part of the Oak Ridge Dose Reconstruction, resulting in the development of a source term for airborne radionuclides (Dose Reconstruction, 1999; Shonka, 1997a; Shonka, 1997b; Shonka, 1997c). This source term was combined with documented environmental monitoring data to estimate radionuclide specific airborne concentrations for U-234, U-235, and U-238. These values are tabulated in Tables A-1 through A-3 of the Occupational Environmental TBD of the K-25 Site Profile (ORAUT-TKBS-0009-4) and may be used to bound ambient environmental external exposures assuming a plume submersion scenario for CEW employees. In addition, ORAUT-TKBS-0009-4, Attachment A, lists average occupational environmental doses derived from gamma radiation levels measured at two perimeter monitoring stations.

X-10 Environmental Releases

As described in Section 7.2.2, releases from several processes at X-10 had the potential to contribute to ambient environmental exposures to CEW employees. By the late 1940s, ORNL had an established program of routine measurements to monitor the ambient “background” at the Laboratory. Measurements were made at approximately 50 specific locations in the Laboratory area using a portable GM counter and scaler. The measurements, referred to as “background checks,” were performed approximately monthly and were originally quantified in terms of count rate. Starting in February 1949, a radium source was used to determine a calibration factor in cpm per mR/hr for the detector used, and results from then on were reported in mR/hr. However, data for 1947 and 1948 have been found in which the results have been converted from cpm to mR/hr (Morgan, 1959).

Annual average site-wide exposure rate data are not available for 1944 through 1946. The annual site-wide average determined for 1947 was therefore assigned for 1944 to 1946 in the Site Profile (ORAUT-TKBS-0012-4). The largest contributor to elevated local exposure rates during that time was the RaLa process, both from exposure rates around the process building itself while runs were in progress, and from high-level liquid wastes eventually discharged to the settling basin. Data from the X-22 chambers from 1944 and 1945 show noble gas emissions to be only a minor contributor to on-site exposure rates. The number of short-decayed fuel slugs from the Graphite Reactor used in the RaLa program in 1944 and 1945 was much less than that for 1946, and the amount of material processed in 1946 was comparable to that processed in 1947 (Dose Reconstruction, 1999). Thus, applying the 1947 exposure rate for the prior years is a plausible upper bound.

Annual average exposure rate data for the X-10 site are summarized in ORAUT-TKBS-0012-4, Attachment 4C, for 1944 through 2003. The site-wide averages include measurement locations where exposure rates were chronically much higher than for other measurement locations and thus served to drive the average higher. These high-reading locations include the vicinity of the 706-D fan house (which operated until about 1950) and the vicinity of the settling basin. Other locations would raise the site-wide average depending on what activities were taking place, such as locations in the vicinity of Buildings 706-A or 706-C in the mid-to-late 1940s. The fact that these instances are included in the average exposure rate data means the site-wide averages should be sufficiently bounding for a CEW worker.

Y-12 Environmental Releases

As described in Section 7.2.2, releases from the electromagnetic separation and uranium salvage processes at Y-12 had the potential to contribute to ambient environmental exposures for CEW employees. ORAUT-TKBS-0014-4 uses the results of the 1987 outdoor scoping survey (Y-12 Survey, 1990a; Y-12 Survey, 1990b) for estimating external exposures for all years from 1948 to 2002. The scoping survey is a comprehensive assessment of radiation exposures and encompasses all areas of the site. There are 1787 grids; the resolution of the grids (100 feet x 100 feet to 200 feet x 200 feet) ensures that all localized hot-spots are included. The purpose of the scoping survey was to locate and prioritize areas of concern from both a worker health and safety standpoint and from an environmental assessment standpoint; therefore, this survey is very relevant to assessing worker exposure.

The Occupational Environmental Dose TBD for Y-12 workers (ORAUT-TKBS-0014-4) employs the highest direct exposure value from either the scans or the direct readings to ensure that exposures attributable to shine or localized hot-spots are taken into account. Data derived from these measurements are presented in Table 4.4.4-1 and converted to dose equivalent rates in Table D-7 of ORAUT-TKBS-0014-4. These values may be used to bound ambient environmental internal exposures for CEW employees.

S-50 Environmental Releases

Construction of the Liquid Thermal Diffusion Plant (S-50) began on July 9, 1944. Uranium enrichment began on September 16, 1944 (before construction was complete) and concluded on September 9, 1945 (S-50 Compilation, 2005). UF_6 losses were common during S-50 operations, with

UF_6 often escaping into the air or cooling water (Manhattan, 1947b); such releases could have contributed to the ambient environmental exposures of CEW employees. From March through July 1945, monthly UF_6 losses ranged from 247 to 1,826 lbs. (S-50 Compilation, 2005). This released UF_6 would rapidly oxidize and form uranyl fluoride (UO_2F_2), which could then exhaust through the building roof (S-50 Compilation, 2005). Accountability records showing losses for other months of operation are unavailable.

NIOSH has been unable to find any environmental monitoring data from S-50 operations. NIOSH determined in the SEC Evaluation Report for S-50 that there are insufficient personnel monitoring, air monitoring, or source term data to adequately reconstruct any internal or external occupational exposures at the plant (NIOSH, 2006). Consequently, NIOSH finds that it is not feasible to estimate with sufficient accuracy the radiation doses from internal or external ambient exposures at the S-50 plant for this current evaluation.

7.3.3 Clinton Engineer Works Occupational X-Ray Examinations

During the earliest construction periods of Clinton Engineer Works, individual construction companies operated their own field first-aid facilities and medical care programs (Radiology, 1966). A formal medical program for the CEW was developed under the guidance of the MED in April 1943. Under this program, all employees received a full physical examination, including a photofluorographic chest X-ray, before starting work (Radiology, 1966). In November 1943, Oak Ridge Hospital opened in Oak Ridge complete with emergency rooms, an outpatient facility, pathology laboratory, and diagnostic X-ray equipment (Hospital, 1951). An investigation of medical X-ray films contained in the ORNL Medical Records Vault indicates that the screening X-ray examinations for all of the CEW facilities were performed at Oak Ridge Hospital until the individual plants developed their own occupational medicine departments and began performing their own X-ray examinations (ORAUT-TKBS-0012-3; ORAUT-TKBS-0014-3).

No specific information regarding occupational medical dose has been identified for individual Clinton Engineer Works employees; however, the dose associated with on-site medical X-ray exams, required as a condition of employment, can be bounded by using the assumptions in the complex-wide TBD, *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (ORAUT-OTIB-0006). Therefore, NIOSH concludes that it is likely feasible to reconstruct occupational medical dose for Clinton Engineer Works workers with sufficient accuracy.

7.3.4 Methods for Bounding External Dose at Clinton Engineer Works

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

- Photon Dose
- Beta Dose
- Neutron Dose
- Medical X-ray Dose

7.3.4.1 Methods for Bounding Operational Period External Dose

Due to the low concentration of uranium in the stored materials, there is no credible source of neutron radiation exposure for CEW employees. NIOSH has determined that it lacks sufficient personnel monitoring data, area monitoring data, or source term data needed to bound external photon or beta doses that CEW workers potentially received from natural uranium, uranium residues, and uranium progeny. Therefore, NIOSH has not identified a method for bounding external doses at Clinton Engineer Works for the period from January 1, 1943 through December 31, 1949 (the end of the EEOICPA-covered period for the site).

Medical X-ray Dose

Although no specific information regarding occupational medical dose has been identified for individual Clinton Engineer Works employees, the dose associated with medical X-ray exams, if required as a condition of employment and administered onsite, can be bounded by using the assumptions in the complex-wide TBD, *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (ORAUT-OTIB-0006). NIOSH believes this methodology supports its ability to bound the occupational medical X-ray doses for the Clinton Engineer Works class under evaluation

7.3.4.2 Methods for Bounding Ambient Environmental External Doses

Although ambient environmental external exposures were possible from ground contamination around the Elza Gate warehouses, any exposures would be small compared to the environmental exposure resulting from operations of each of the four plants within the CEW boundary The environmental exposures resulting from the operations of the four plants located within the CEW boundary are considered bounding for any environmental exposure that may have been received by a worker at the Elza Gate Warehouse area.

Although NIOSH does not have Elza Gate Warehouse area-specific external-monitoring data for the period from January 1, 1943 through December 31, 1949, NIOSH intends to use the information provided for each of the four plants within the CEW boundary, as well as any external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at CEW during the period from January 1, 1943 through December 31, 1949, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

K-25 Environmental Releases

Ambient environmental doses for individuals who worked at K-25 have been researched and assessed in the Occupational Environmental TBD of the K-25 Site Profile (ORAUT-TKBS-0009-4). Considering the effect that the additional distance between the K-25 plant and the other work locations within the CEW boundaries would have had on the dispersion of airborne radiological contaminants, the ambient environmental exposures assessed for workers in the K-25 Site Profile would have been considerably higher than those for individuals working at off-site (beyond K-25) locations. Therefore, the ambient environmental external exposure assessment method defined for K-25 workers in the K-25 Site Profile will serve to bound any ambient external exposures for individuals working within the CEW boundaries, but outside the fenced boundaries of the K-25 plant.

X-10 Environmental Releases

Ambient environmental doses for individuals who worked at X-10 have been researched and assessed in the Occupational Environmental TBD of the X-10 Site Profile (ORAUT-TKBS-0012-4). Considering the effect that the additional distance between the X-10 plant and the other work locations within the CEW boundaries would have had on the dispersion of airborne radiological contaminants, the ambient environmental exposures assessed for workers in the X-10 Site Profile would have been considerably higher than those for individuals working at off-site (beyond X-10) locations. Therefore, the ambient environmental external exposure assessment method defined for X-10 workers in the X-10 Site Profile will serve to bound any ambient external doses for individuals working within the CEW boundaries, but outside the fenced boundaries of the X-10 plant.

Y-12 Environmental Releases

Ambient environmental doses for individuals who worked at Y-12 have been researched and assessed in the Occupational Environmental TBD of the Y-12 Site Profile (ORAUT-TKBS-0014-4). Considering the effect that the additional distance between the Y-12 plant and the other work locations within the CEW boundaries would have had on the dispersion of airborne radiological contaminants, the ambient environmental exposures assessed for workers in the Y-12 Site Profile would have been considerably higher than those for individuals working at off-site (beyond Y-12) locations. Therefore, the ambient environmental external exposure assessment method defined for Y-12 workers in the Y-12 Site Profile will serve to bound any ambient external doses for individuals working within the CEW boundaries, but outside the fenced boundaries of the Y-12 plant.

S-50 Environmental Releases

NIOSH has been unable to find any environmental monitoring data from S-50 operations. NIOSH determined in the SEC Evaluation Report for S-50 (NIOSH, 2006) that there are insufficient personnel monitoring, air monitoring, and source term data to adequately reconstruct any internal or external occupational exposures at the S-50 plant. Consequently, NIOSH finds that it is infeasible to estimate with sufficient accuracy the radiation doses from internal or external ambient exposures at the S-50 plant.

7.3.5 External Dose Reconstruction Feasibility Conclusion

NIOSH finds there are insufficient data, including film badge results, area surveys, or process information, to estimate with sufficient accuracy external exposures to radiological materials in the Elza Gate warehouse area of Clinton Engineer Works. Therefore, NIOSH finds that it is infeasible to completely reconstruct external doses from the start of the class under evaluation (January 1, 1943) through the end of the EEOICPA-covered period (December 31, 1949) due to insufficient monitoring data.

Although NIOSH found that it is not possible to completely reconstruct external radiation doses for the period from January 1, 1943 through December 31, 1949, NIOSH intends to use any external monitoring data, including the ambient environmental monitoring data for the plants within the Clinton Engineering Works area, that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at Clinton Engineer Works during the period from January 1, 1943 through

December 31, 1949, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

7.4 Evaluation of Petition Basis for SEC-00178

The following subsection evaluates an assertion made on behalf of petition SEC-00178 for the Clinton Engineer Works.

7.4.1 Lack of Monitoring Data

SEC-00178: *I have enclosed a document with information obtain* [sic] *from DOE that indicates that dad was not monitored for radiation exposure during his employment.*

Personal internal, external monitoring, and/or area monitoring data are not always required to develop an exposure model for a given facility. However, if these monitoring data are not available, NIOSH must have access to source term information and detailed process information in order to develop a sufficiently accurate exposure model. To date, NIOSH does not have access to Clinton Engineer Works personnel or area monitoring documentation that describes the extent of the storage and/or shipping activities that may have been performed with the uranium scrap, uranium ore, and uranium residues.

Due to the unknown radiological makeup of the uranium residues, NIOSH determined that intakes from potential uranium residue exposure cannot be reconstructed with sufficient accuracy. NIOSH also determined that it does not have adequate internal monitoring data for members of the class under evaluation, nor does it have enough source term or process information to develop a sufficiently accurate model for dose reconstruction for these exposures during the relevant timeframe.

7.5 Summary of Feasibility Findings for Petition SEC-00178

This report evaluates the feasibility for completing dose reconstructions for employees at the Clinton Engineer Works from January 1943 through December 1949. NIOSH found that the available monitoring records, process descriptions and source term data available are not sufficient to complete dose reconstructions from January 1, 1943 through the end of the EEOICPA-covered period (December 31, 1949).

Table 7-1 summarizes the results of the feasibility findings at Clinton Engineer Works for each exposure source during the time period January 1, 1943 through December 31, 1949.

Table 7-1: Summary of Feasibility Findings for SEC-00178
January 1, 1943 through December 31, 1949

Source of Exposure	Reconstruction Feasible	Reconstruction Not Feasible
Internal[1]		**X**
- U		X
- Rn		X

Table 7-1: Summary of Feasibility Findings for SEC-00178 January 1, 1943 through December 31, 1949		
Source of Exposure	**Reconstruction Feasible**	**Reconstruction Not Feasible**
- Ra		X
- Th		X
External		**X**
- Gamma		X
- Beta		X
- Neutron	N/A	N/A
- Occupational Medical X-ray	X	

[1] Internal includes an evaluation of airborne dust data.

As of January 25, 2012, a total of 38 claims have been submitted to NIOSH for individuals who worked at Clinton Engineer Works during the period under evaluation in this report. Dose reconstructions have been completed for 27 individuals (71%).

Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, NIOSH intends to use available ambient environmental monitoring data from the plants within the Clinton Engineer Works area as well as any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for individuals employed at Clinton Engineer Works during the period from January 1, 1943 through December 31, 1949, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

8.0 Evaluation of Health Endangerment for Petition SEC-00178

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 knowledge that radiological material were stored and repackaged in the area of the Elza Gate Warehouses of Clinton Engineer Works. NIOSH has limited survey and monitoring data, including limited information on total inventories of radiological materials in this location. NIOSH's evaluation determined that it is not feasible to estimate radiation dose for members of the NIOSH-evaluated class with sufficient accuracy based on the sum of information available from available resources. Therefore, the resulting NIOSH-proposed SEC class must include a minimum required employment period as a basis for specifying that health was endangered.

9.0 Class Conclusion for Petition SEC-00178

Based on its full research of the class under evaluation, NIOSH has defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class to be added to the SEC includes all employees of the Tennessee Eastman Corporation (1943-1949) and the Carbide and Carbon Chemical Corporation (1947-1949) who were employed at the Clinton Engineer Works in Oak Ridge, Tennessee, from January 1, 1943 through December 31, 1949, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

NIOSH has carefully reviewed all material sent in by the petitioner, including the specific assertions stated in the petition, and has responded herein (see Section 7.4). NIOSH has also reviewed available technical resources and many other references, including the Site Research Database (SRDB), for information relevant to SEC-00178. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

These actions are based on existing, approved NIOSH processes used in dose reconstruction for claims under EEOICPA. NIOSH's guiding principle in conducting these dose reconstructions is to ensure that the assumptions used are fair, consistent, and well-grounded in the best available science.

Simultaneously, uncertainties in the science and data must be handled to the advantage, rather than to the detriment, of the petitioners. When adequate personal dose monitoring information is not available, or is very limited, NIOSH may use the highest reasonably possible radiation dose, based on reliable science, documented experience, and relevant data to determine the feasibility of reconstructing the dose of an SEC petition class. NIOSH contends that it has complied with these standards of performance in determining the feasibility or infeasibility of reconstructing dose for the class under evaluation.

10.0 References

42 C.F.R. pt. 81, *Guidelines for Determining the Probability of Causation Under the Energy Employees Occupational Illness Compensation Program Act of 2000;* Final Rule, Federal Register/Vol. 67, No. 85/Thursday, p 22,296; May 2, 2002; SRDB Ref ID: 19391

42 C.F.R. pt. 82, *Methods for Radiation Dose Reconstruction Under the Energy Employees Occupational Illness Compensation Program Act of 2000*; Final Rule; May 2, 2002; SRDB Ref ID: 19392

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*; Final Rule; May 28, 2004; SRDB Ref ID: 22001

42 U.S.C. §§ 7384-7385 [EEOICPA], *Energy Employees Occupational Illness Compensation Program Act of 2000*, as amended

Assessment, 1992, *Postremediation Dose Assessment for the Elza Gate Site, Oak Ridge, Tennessee*, M. Nimmagadda, C. Yu; Argonne National Laboratory for U.S. Department of Energy, Oak Ridge Operations; October 1992; SRDB Ref ID: 78398

B1 Material, 1945, *Storage of B1 Material in 0101 Area*, Memorandum to the Files from J. L. Ferry (Medical Corps), U.S. Engineer Office, Manhattan District; April 16, 1945; SRDB Ref ID: 5920

Banic, 1973, *Radiation Safety and Control for the Electromagnetic Isotope Separation of the Heavy Elements in Building 9204-3, Y-12 Plant, Including Operational Procedures and Facility Layouts*, G. M. Banic, et al; prepared by the Isotopes Development Center, Oak Ridge National Laboratory, for the U.S. Atomic Energy Commission; March 1973; SRDB Ref ID: 42112

Battelle-TBD-6000, *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium*, PSWS-3738; Rev. F0; Battelle; December 13, 2006; SRDB Ref ID: 30671

Bowman, 1949, *Report on Oak Ridge Operation*, from H. L. Bowman (consultant) to S. Warren (Director, Division of Biology and Medicine); August 26, 1949; SRDB Ref ID: 8285

CEW Facts, 1947, *Basic Facts on Clinton Engineer Works, Its Operating and Research Units, and the Community of Oak Ridge*, U.S. Atomic Energy Commission; undated, but from content, likely 1947; SRDB Ref ID: 90645

CEW Map, 1985, *Clinton Engineer Works*, reprinted from V. C. Jones, Manhattan: The Army and the Atomic Bomb; U.S. Government Printing Office; 1985; www.atomicarchive.com/Maps/Images/oak_ridge_large.gif; SRDB Ref ID: 89564

Cheka, 1945, *Air Monitoring at Site "X,"* J. S. Cheka; Health Division, Health-Physics Section, Oak Ridge National Laboratory; June 31, 1945; SRDN Ref ID: 13254

Cheka, 1948, *Progress Report on the Particle Problem*, J. S. Cheka, H. J. McAlduff; Health Physics Division, Oak Ridge National Laboratory; September 10, 1948; SRDN Ref ID: 5499

Chemical 42-17, 1943, *Transfer of Chemical 42-17, Grade A*, transfer request from G. W. Russell (Corp of Engineers, Manhattan Engineer District) to the District Engineer, Clinton Engineer Works; September 8, 1943; SRDB Ref ID: 90788

Codes, 1979, *Visit from Mont Mason, 21-24 August 1979: Codes Used for Material at MCW*, Chemical and radionuclide codes used at Mallinckrodt Chemical Works; August 21-24, 1979; SRDB Ref ID: 13864

Covington, 1943, *Transfer of Responsibility for Guarding the Y-12 Area*, letter from P. T. Covington (Clinton Engineer Works, Tennessee Eastman Corporation) to W. E. Kelley (The Area Engineer office, Clinton Engineer Works); September 27, 1943; SRDB Ref ID: 90946

Davies, 1944, *Materials in 0101 Area, C. E. W.*, memorandum from J. L. Davies (Corps of Engineers, Madison Square Area) to B. W. Menke; July 18, 1944; SRDB Ref ID: 91992

deBethune, 1943, *Gas Velocity Relationships, Product 80 Reduction*, A. J. deBethune; Columbia University, Division of War Research; May 17, 1943; SRDB Ref ID: 31036

Dose Reconstruction, 1999, *Uranium Releases from the Oak Ridge reservation – a Review of the Quality of Historical Effluent Monitoring Data and a Screening Evaluation of Potential Off-Site Exposures*, J. E. Buddenbaum, et al; Reports of the Oak Ridge Dose Reconstruction, Vol. 5; The Report of Project Task 6; July 1999; Submitted to the Tennessee Department of Health by ChemRisk; SRDB Ref ID: 12715

Dupree-Ellis, 2000, *External Radiation Exposure and Mortality in a Cohort of Uranium Processing Workers*, E. Dupree-Ellis, et al; *American Journal of Epidemiology*, Vol. 152, No. 1, 2000; SRDB Ref ID: 9486

Eisenbud, undated, *Early Occupational Exposure Experience with Uranium Processing*, M. Eisenbud; New York University Medical Center; undated; from content, not earlier than 1970; SRDB Ref ID: 10629

Elza Gate Survey, 1992, *Verification Survey of the Elza Gate Site, Oak Ridge, Tennessee*, T. J. Vitkus, T. L. Bright; Oak Ridge Institute for Science and Education; ORISE 92/L-30; December 4, 1992; SRDB Ref ID: 40358

Ferry, 1944, *Inspection of Warehouses at Oak Ridge*, memo from J. L Ferry (U.S. Engineer Office, Manhattan District) to P. Merritt (The Area Engineer office, Madison Square Area, New York); August 12, 1944; SRDB Ref ID: 78413

Film Badge Results, 1946, *Results of Film Density Measurements in Area 0101*, J. R. Hayes; Clinton Engineer Works; various dates in January-March, 1946; SRDB Ref ID: 5495

Hadlock, 1943, *Letter to Columbia University Specifying Code Symbols for Compounds*, from C. Hadlock (Corps of Engineers, Manhattan Engineer District) to Dr. J. R. Dunning (Columbia University); September 29, 1943; SRDB Ref ID: 31030

Hanford Glossary, 1961, *Glossary of Hanford Terminology*, B. B. Lane; General Electric, Hanford Atomic Products Operation; February 1, 1961; SRDB Ref ID: 43651

Health Hazards, 1949, *Health Hazards in NYOO Facilities Producing and Processing Uranium (A Status Report – April 1, 1949)*, NYOO Medical Division, U.S. Atomic Energy Commission, New York Operations Office; April 18, 1949; SRDB Ref ID: 3931

History Report, 1944, *History Report,* Clinton Engineer Works Tennessee Eastman Corporation, October, 1944; SRDB Ref ID: TBD

Hospital, 1951, *Second Annual Report, Oak Ridge Hospital, Incorporated, Oak Ridge, Tennessee for the Year Ended June 30, 1951*, Oak Ridge Hospital; 1951; SRDB Ref ID: 64546

Inspection, 1944, *Inspection of Warehouses at Oak Ridge*, inspection report from J. L. Ferry (for the District Engineers) to the Area Engineer, Madison Square Area, Manhattan Engineer District; August 12, 1944; SRDB Ref ID: 8328

Inventory, 1945, *Inventory of Special Materials, 0101 Area*, Clinton Engineer Works, March 1, 1945; SRDB Ref ID: 46027

Linking Legacies, 1997, *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences*, Office of Environmental Management, U.S. Department of Energy; January 1997; SRDB Ref ID: 11930

Manhattan, 1947a, *Manhattan District History, Book I – General, Volume 12 – Clinton Engineer Works, Central Facilities*, U. S. Atomic Energy Commission; March 26, 1947; SRDB Ref ID: 44037

Manhattan, 1947b, *Manhattan District History, Book VI Liquid Thermal Diffusion (S-50) Projects*, U. S. Atomic Energy Commission; May 21, 1947; SRDB Ref ID: Export Controlled Information. A controlled copy can be obtained by contacting the COC Librarian.

Manhattan, 1985, *Manhattan: The Army and the Atomic Bomb*, V. C. Jones; Center of Military History, U. S. Army; *Chapter XIV: The Feed Materials Program*; 1985; SRDB Ref ID: 6603, pdf p. 195

Mason, 1977, *History & Background Relative to the Radiological Re-monitoring of Mallinckrodt by the Energy Research and Development Administration*, prepared for Mallinckrodt, Inc, by M. G. Mason; August 19, 1977; SRDB Ref ID: 15283

Monthly Reports, 1943-1945, *Monthly Accountability Reports for Various Sites (including Oak Ridge) for 1943-1945*, Memoranda to the Files, Corps of Engineers, Manhattan Engineer District; various authors and dates in 1943-1945; SRDB Ref ID: 30859

Morgan, 1959, *Waste Management Program at Oak Ridge National Laboratory*, K. Z. Morgan; Congressional Wastes Disposal Hearings, Washington, D.C.; January 28 – February 4, 1959; SRDB 13258

Morse, 1945, *Scrap Materials*, memo from R. D. Morse (Corps of Engineers) to L. R. Zumwalt (District Engineer Office, Manhattan District, Oak Ridge, Tennessee); January 3, 1945; SRDB Ref ID: 46642

NIOSH, 2006, *SEC Petition Evaluation Report for Petition SEC-00060, S-50 Oak Ridge Thermal Diffusion Plant*; National Institute for Occupational Safety and Health (NIOSH); August 4, 2006; SRDB Ref ID: 33588

OCAS-PR-004, *Internal Procedures for the Evaluation of Special Exposure Cohort Petitions*, Rev. 0, National Institute for Occupational Safety and Health (NIOSH); Cincinnati, Ohio; September 23, 2004; SRDB Ref ID: 32022

ORAUT-OTIB-0004, *Estimating the Maximum Plausible Dose to Workers at Atomic Weapons Employer Facilities*, Rev. 03 PC-2; Oak Ridge Associated Universities; December 6, 2006; SRDB Ref ID: 36191

ORAUT-OTIB-0006, *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*, Oak Ridge Associated Universities; December 21, 2005; SRDB Ref ID: 20220

ORAUT-OTIB-0024, *Estimation of Neutron Dose Rates from Alpha-Neutron Reactions in Uranium and Thorium Compounds,* Rev. 00; Oak Ridge Associated Universities; April 7, 2005; SRDB Ref ID: 19445

ORAUT-TKBS-0009-4, *K-25 Site - Occupational Environmental Dose*, Rev. 01, Oak Ridge Associated Universities; June 22, 2007; SRDB Ref ID: 32526

ORAUT-TKBS-0012-3, *Oak Ridge National Laboratory – Occupational Medical Dose*, Rev. 02, Oak Ridge Associated Universities; October 1, 2007; SRDB Ref ID: 35194

ORAUT-TKBS-0012-4, *Oak Ridge National Laboratory – Occupational Environmental Dose*, Rev. 00, Oak Ridge Associated Universities; May 7, 2004; SRDB Ref ID: 20136

ORAUT-TKBS-0014-3, *Y-12 National Security Complex – Occupational Medical Dose*, Rev. 01, Oak Ridge Associated Universities; June 18, 2006; SRDB Ref ID: 32461

ORAUT-TKBS-0014-4, *Y-12 National Security Complex – Occupational Environmental Dose,* Rev. 01, Oak Ridge Associated Universities; July 20, 2006; SRDB Ref ID: 30042

ORNL Survey, 1988, *Summary of October/November ORNL Survey*, Oak Ridge National Laboratory; November 1988; SRDB Ref ID: 78416

ORNL Survey, 1989, *Preliminary Site Survey report for the Former Elza Gate Warehouse Area, Oak Ridge, Tennessee,* Oak Ridge National Laboratory; September 1989; SRDB Ref ID: 40359

Parker, 1944, *Review of Air Monitoring Procedures at Clinton Laboratories*, H. M. Parker, possibly Argonne National Laboratory; September 1944; SRDB Ref ID: 13256

Personal Communication, 2010, *Personal Communication with Current Manufacturing Engineer at Y-12*; Telephone interview by NIOSH; November 29, 2010; SRDB Ref ID: 93103

Personal Communication, 2011, *Personal Communication with two Oak Ridge Historians*, Interview, December 12, 2011; SRDB Ref ID: 105919

Rad Handbook, 1970, *Radiological Health Handbook*, U.S. Department of Health, Education, and Welfare, Public Health Service; PHS-PUBL-2016; January 1970; SRDB Ref ID: 75017

Rad Handbook, 1998, *Handbook of Health Physics and Radiological Health*, 3rd Edition, B. Shleien, L. A. Slaback, Jr., B. K. Birky, editors; 1998; SRDB Ref ID: 22737 (commonly available from public resources)

Radiology, 1966, *Radiology in World War II*, Medical Department, U.S. Army; 1966; SRDB Ref ID: 10603

Radon Results, 1944, *Mz Concentrations in Warehouses at Oak Ridge*, memorandum from J. L. Ferry (Medical Corps) to S. L. Warren (U.S. Engineer Office, Knoxville, Tennessee); March 2, 1944; SRDB Ref ID: 5930

S-50 Compilation, 2005, *Compilation of Historical Document Reference Sources for Project S-50, Liquid Thermal Diffusion Plant*, R. P. Prince; Bechtel Jacobs Company LLC for the U.S. Department of Energy; ETTP-736; May 2005; SRDB Ref ID: 17169

Sapirie, 1972, *Disposal of Excess Real Property – Parcel 228*, approval letter from S. R. Sapirie (Manager, Oak Ridge Operations) to J. L. Smith (Director, Division of Contracts, HQS); February 3, 1972; SRDB Ref ID: 78415

Shipment, 1945, *Shipment Security Survey at Mallinckrodt Chemical Works*, Memorandum to the Officer in Charge from F. W. Simons, Intelligence and Security Division, Manhattan Engineer District; February 15, 1945; SRDB Ref ID: 9161

Shonka, 1997a, *The Atmospheric Master Release List and Atmospheric Source Term for K-25*, R. E. Burmeister; Shonka Research Associates, Inc.; Calc No. SRA-96-012, Rev. 1; February 11, 1997; SRDB Ref ID: 14012

Shonka, 1997b, *^{237}Np and ^{99}Tc Released to Air and Water from Historic Operations at the ORGDP and Y-12 Sites*, R. E. Burmeister; Shonka Research Associates, Inc.; Calc No. SRA-97-003, Rev. 0; May 14, 1997; SRDB Ref ID: 14013

Shonka, 1997c, *Per Annum Atmospheric Releases of Uranium from the K-25 Site from 1944 to 1995*, R. E. Burns, Jr.; Shonka Research Associates, Inc.; Calc No. SRA-97-011, Rev. 0; December 3, 1997; SRDB Ref ID: 14014

Winters, 1945, *Memo Identifying Shipped Materials*, from C. E. Winters (CEW Engineer) to K. T. McBee (Purdue University); April 11, 1945; SRDB Ref ID: 30742, pdf p. 9

Y-12 Glossary, 1946, *Glossary of Y-12 Coded Terminology and Nomenclature, Part II: Chemical Terms*, R. Beldock; Clinton Engineer Works – Tennessee Eastman Corporation; October 18, 1946; SRDB Ref ID: 8384

Y-12 Survey, 1990a, *The Outdoor Radiological and Chemical Surface Scoping Survey of the Y-12 Plant Site: Part 2 – The 1985-1987 Data Base*, R. D. Foley, R. F. Carrier; Y-12 Plant Remedial Action Program Environmental Management Department; Y/TS-600 PART 2; March 1990; SRDB Ref ID: 12531

Y-12 Survey, 1990b, *The Outdoor Radiological and Chemical Surface Scoping Survey of the Y-12 Plant Site: Part 3 – Recommendations*, R. D. Foley, R. F. Carrier; Y-12 Plant Remedial Action Program Environmental Management Department; Y/TS-600 PART 3; May 1990; SRDB Ref ID: 12526

Attachment One: Data Capture Synopsis

Table A1-1: Data Capture Synopsis for Clinton Engineer Works

Data Capture Information	General Description of Documents Captured	Date Completed	Uploaded to SRDB
Primary Site/Company Name Clinton Engineer Works DOE 1943-1949 Physical size of the site *(acres, sq miles, sq feet, # blocks, etc. and/or size of specific buildings if relevant)* The Clinton Engineer Works site includes all of the Oak Ridge Area, however SEC0178 pertains to guards and service workers who worked in or around the warehouse at the Elza Gate area. The combined area of concrete pads used for 5 warehouses (3 known to have housed radioactive materials) was approximately 84,000 square feet, however uranium soil contamination has been found throughout the 20-acre tract of land. Size of the workforce during the SEC related periods The class includes “all guards and service workers.” No records indicating specific work locations have been located. The peak employment number is 82,000 in May 1945, which includes the entire Oak Ridge complex i.e., Clinton Laboratory, Y-12, K-25, etc. Employment declined steadily after May 1945 to 28,737 at the end of 1946. If our focus becomes limited to the primary contractor (Roane-Anderson Company), then the peak employment figure is about 10,000 in September 1945 and declined to about 2,400 by September 1947. Other Site Names: Oak Ridge Area Oak Ridge Reservation	Note: This material located in the ORO Vault, was identified using DOE/OR's Records Holding Task Group (RHTG) database and was subsequently reviewed for classification. African Metals assays, purchase orders and invoices; security aspects of removal of the town of Oak Ridge from the controlled area; badge records; Y-12 plant progress report; Clinton Engineer Works employment records; film badge measurements; invoices for several agent for radioactive materials; machining of uranium; materials in 0101 area; production of 1% enriched uranium rods for Brookhaven National Laboratory; personal and portable radiation meters; removal of town of Oak Ridge from controlled area; medical and industrial hygiene problems; storage of U-235 from Los Alamos	01/25/2012	41
State Contacted: Radiological Health Director, [Name/phone number redacted] and [Name/phone number redacted]	No relevant data identified.	11/30/2010	0
Advisory Board on Radiation and Worker Health	Handwritten notes of Advisory Board Member [redacted]	11/30/2010	1

Table A1-1: Data Capture Synopsis for Clinton Engineer Works			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Atlanta NARA	Account of T- metal at Aluminum Company Of America, construction of new warehouses, film badge results, monthly accountability reports, monthly progress reports, plans for handling African ore, radon air sample results, Roane-Anderson company insurance information, and special shipments of X-containing materials; warehouses, storage, blood changes, transportation and medical considerations 1943-1945, CEW and contractor employee information, CEW contract information.	12/09/2011	32
College Park NARA	Production of fissionable materials, thorium fabrication, and a production report of the industrial hygiene section.	08/18/2010	7
Curtiss Wright	Methods of separating U233 from thorium.	06/18/2008	1
Department of Labor/Paragon	Uranium Ore Waste Residue Storage at LOOW.	12/30/2008	1
DOE Ames Laboratory	Industrial Medicine on the Plutonium Project.	07/25/2006	1
DOE Argonne National Laboratory - East	Organization of national nucleonics program, high temperature oxide pile, and an interim report on some manifold details for a P-9 pile.	04/02/2008	4
DOE Brookhaven National Laboratory	BNL personnel who have worked on other AEC projects.	10/21/2008	1
DOE Germantown	Safety program for Clinton Engineering Works, elimination report, monthly accountability, thorium information, site summary and history, Manhattan District history book, and a trip report to Mallinckrodt, St. Louis, Missouri.	05/09/2009	13
DOE Hanford	Note: Request based on results of data search has been submitted.	OPEN	0
DOE Legacy Management - Grand Junction Office	Atomic power in war and peace, grinding of thorium rods, U-235 and plutonium at various laboratories, fact sheet on Elza Gate, inspection of warehouses, radioactivity surveys, Manhattan District history book, activity of slugs from Clinton, accountability report of X metal, inventory of five types of material at C101 warehouse, shipment of tuballoy, type-II metal extrusion billets containing fission elements shipped to Revere, and uranium cleanup guidelines for the Elza Gate site.	11/22/2010	40
DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database)	Metallurgical Laboratory report, progress report, and epidemiology project summaries.	02/07/2007	5
DOE Los Alamos National Laboratory	Manhattan Project: Official History and Documents.	07/17/2007	1
DOE Oak Ridge National Laboratory	Machining of Uranium for Brookhaven Reactor.	04/12/2007	1
DOE Office of Scientific and Technical Information (OSTI)	Closed-cycle beta process, alpha II calutron development, and operation of receivers with enriched feed.	09/05/2008	4

Table A1-1: Data Capture Synopsis for Clinton Engineer Works			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Dr. Denise Degarmo	Biological research program at Clinton National laboratories, organization chart, purchase of workmen's insurance, and disposal of radioactive wastes in the Metropolitan St. Louis area.	11/24/2009	12
Hagley Museum	Clinton Engineer Works and Hanford history.	09/29/2010	17
Interlibrary Loan	The Dragon's Tail - Radiation Safety in the Manhattan Project.	04/01/2008	2
Internet - DOE Comprehensive Epidemiologic Data Resource (CEDR)	No relevant data identified.	10/27/2010	0
Internet - DOE Hanford Declassified Document Retrieval System (DDRS)	Effect of counting rate on operation of poor GM counter, effective area of a thin wall glass GM tube when used to count beta particles, H.I. section report, Hanford monthly report, and a report of visits to the radiation laboratories. Note: 13 documents added by site association.	11/08/2010	13
Internet - DOE Legacy Management Considered Sites	Survey of the Elza Gate site and special materials in 0101 area. Note: Three documents added by site association.	11/08/2010	3
Internet - DOE OpenNet	Manhattan District History Book I and Linking Legacies Appendix B. Note: Two documents removed by site association.	11/08/2010	4
Internet - DOE OSTI Energy Citations	Account of Oak Ridge National Laboratory's thirteen nuclear reactors and the modeling of Elza Gate contaminated material. Note: One document added by site association.	11/08/2010	4
Internet - DOE OSTI Information Bridge	Environmental baseline survey report, conversion of yellow cake to uranium hexafluoride, engineering evaluation/cost analysis for the proposed removal of contaminated materials from pad 1 at the Elza Gate site, environmental report, radioactivity and health information, and a radiological risk assessment. Note: Ten documents added by site association.	11/08/2010	19
Internet - Google	Remedial action at the Melton Lake Industrial Park (former Elza Gate area warehouse), cleanout of waste storage tanks at Oak Ridge National Laboratory, Clinton Engineer Works photo, designation investigations for warehouses, environmental monitoring report, first report of the U.S. Atomic Energy Commission, Operation Trinity and the Manhattan Project history, radionuclide releases, report of visit to Metallurgical Laboratories and Clinton Laboratories, reports on FUSRAP sites, Site X map, and surplus u-233 now "treasure" for new isotope technologies. Note: 49 documents were duplicates and/or removed by site association.	11/08/2010	85
Internet - HP Journal	No relevant data identified.	10/27/2010	0
Internet - Journal of Occupational and Environmental Health	No relevant data identified.	12/29/2010	0

Table A1-1: Data Capture Synopsis for Clinton Engineer Works			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Internet - National Academies Press (NAP)	No relevant data identified.	11/08/2010	0
Internet - National Nuclear Security Administration (NNSA) - Nevada Site Office	No relevant data identified.	11/08/2010	0
Internet - NRC Agencywide Document Access and Management (ADAMS)	Supplemental Responses to Petition Under 10 CFR 2.206 Snake River Alliance/Envirocare of Utah, Inc.	11/08/2010	1
Internet - US Army Corps of Engineers	No relevant data identified.	11/08/2010	0
Internet - Washington State University (U.S. Transuranium and Uranium Registries)	No relevant data identified.	11/08/2010	0
Kansas City NARA	The Federal Connection: History of the U.S. Military Involvement in the Toxic Contamination of Love Canal and the Niagara Frontier Region Volume I.	08/14/2008	1
National Institute for Occupational Safety and Health (NIOSH)	ORNL Review, A History of the Laboratory's First 25 Years.	10/30/2009	1
New York State Department of Health	Semi-monthly report.	02/25/2008	1
Oak Ridge Public Library	Alpha I-5 operating procedures, facts on Clinton Engineer Works operating and research units, and photographs of Oak Ridge production areas.	11/26/2010	10
ORAU Team	Documented communication.	03/02/2011	2
San Bruno Federal Records Center	Employee general information cards, beta run reports, and personnel assignment logs.	11/10/2010	6
Sanford Cohen & Associates (SC&A)	Documents Issued to SC&A by BWXT Y-12 in Concert with the Federal Advisory Board on Radiation and Worker Health at the Y-12 National Security Complex, Volume 2 of 4 (November 2005).	11/22/2005	1
Southern Illinois University	The Disposal of Radioactive Wastes in the Metropolitan St. Louis Area: The Environmental and Health Legacy of the Mallinckrodt Chemical Works	10/08/2008	1
University of Rochester	Radiotoxicity of Inhaled or Ingested Radioactive Products.	09/10/2008	1
University of Tennessee	Urinalysis results, instrument calibration, radiological incidents, history of Clinton Engineer Works and the Manhattan Project, radiological survey information, personnel exposure information, personnel monitoring at Clinton Laboratories, radiation protection practices, protective clothing sub-committee report, and monthly reports.	11/18/2010	41

Table A1-1: Data Capture Synopsis for Clinton Engineer Works			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Unknown	Atomic Energy Division records for Dupont, Hanford, and Clinton Engineer Works, Chemical Division operating manual, comparison of badge film readings, Manhattan District history, dust hazards, monthly status and progress reports, trip reports, and suggested tolerance for polonium.	10/08/2004	18
Viacom Records	Facility and process descriptions.	12/06/2004	1
TOTAL			**391**

Table A1-2: Databases Searched for Clinton Engineer Works			
Database/Source	**Keywords / Phrases**	**Hits**	**Uploaded to SRDB**
NOTE: Database search terms employed for each of the databases listed below are available in the Excel file called “Clinton Engineers Works Rev 01 (83.13) 03-03-11”			
DOE CEDR http://cedr.lbl.gov/ COMPLETED 10/27/2010	See Note above	0	0
DOE Hanford DDRS http://www2.hanford.gov/declass/ COMPLETED 11/08/2010	See Note above	0	0
DOE Legacy Management Considered Sites http://csd.lm.doe.gov/ COMPLETED 11/08/2010	See Note above	0	0
DOE OpenNet http://www.osti.gov/opennet/advancedsearch.jsp COMPLETED 11/08/2010	See Note above	112	6
DOE OSTI Energy Citations http://www.osti.gov/energycitations/ COMPLETED 11/08/2010	See Note above	666	3
DOE OSTI Information Bridge http://www.osti.gov/bridge/advancedsearch.jsp COMPLETED 11/08/2010	See Note above	634	13
Google http://www.google.com COMPLETED 11/08/2010	See Note above	135,058	134

Table A1-2: Databases Searched for Clinton Engineer Works			
Database/Source	**Keywords / Phrases**	**Hits**	**Uploaded to SRDB**
HP Journal http://journals.lww.com/health-physics/pages/default.aspx COMPLETED 10/27/2010	See Note above	0	0
Journal of Occupational and Environmental Health http://www.ijoeh.com/index.php/ijoeh COMPLETED 12/29/2010	See Note above	0	0
National Academies Press http://www.nap.edu/ COMPLETED 11/08/2010	See Note above	5,432	0
NNSA - Nevada Site Office www.nv.doe.gov/main/search.htm COMPLETED 11/08/2010	See Note above	0	0
NRC ADAMS Reading Room http://www.nrc.gov/reading-rm/adams/web-based.html COMPLETED 11/08/2010	See Note above	240	1
USACE/FUSRAP http://www.lrb.usace.army.mil/fusrap/ COMPLETED 11/08/2010	See Note above	0	0
U.S. Transuranium & Uranium Registries http://www.ustur.wsu.edu/ COMPLETED 11/08/2010	See Note above	0	0

Table A1-3: OSTI Documents Requested for Clinton Engineer Works			
Document Number	**Document Title**	**Requested Date**	**Received Date**
No documents requested.			