

SEC Petition Evaluation Report Petition SEC-00152

Report Rev #: 0

Report Submittal Date: September 28, 2009

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Petitioner Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition A Receipt Date	DOE/AWE Facility Name
SEC-00152	83.14	September 8, 2009	Hanford

NIOSH-Proposed Class Definition
All employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked at the Hanford site in Richland, Washington, from October 1, 1943 through June 30, 1972, 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 included in the Special Exposure Cohort.

Related Petition Summary Information			
SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
SEC-00057	83.13	Hanford	Two classes included in the SEC

Related Evaluation Report Information	
Report Title	DOE/AWE Facility Name
SEC Petition Evaluation Report for Petition SEC-00057-1	Hanford
SEC Petition Evaluation Report for Petition SEC-00057-2	Hanford

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Evaluation Report Summary: SEC-00152, Hanford

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*.

NIOSH-Proposed Class Definition

All employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked at the Hanford site in Richland, Washington, from October 1, 1943 through June 30, 1972, 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 included in the Special Exposure Cohort.

Feasibility of Dose Reconstruction Findings

NIOSH lacks sufficient information, which includes biological monitoring data, sufficient air monitoring information, or sufficient process and radiological source information, to allow it to estimate with sufficient accuracy the potential internal exposures to purified polonium, thorium, or neptunium to which the proposed class may have been subjected.

NIOSH finds that it is likely feasible to reconstruct occupational medical dose for Hanford workers with sufficient accuracy.

There are currently two classes of Hanford workers associated with two previous NIOSH evaluations of SEC petition SEC-00057. The earliest period currently designated for inclusion in the SEC begins October 1, 1943. The latest period currently designated for inclusion in the SEC ends on December 31, 1968.

Through the course of ongoing dose reconstruction and continued data capture efforts, NIOSH has determined that additional dose reconstruction infeasibilities exist due to work at Hanford with inadequately monitored radionuclides such as purified forms of polonium, thorium, and neptunium. These additional dose reconstruction infeasibilities envelop the time period of January 1, 1945 through June 30, 1972, and as such extend beyond the time period associated with the existing approved SEC classes for Hanford.

NIOSH has determined that reconstruction of internal dose is not feasible for the summative time period from October 1, 1943 through June 30, 1972, due to the lack of adequate biological monitoring data, sufficient air monitoring information, or sufficient process and radiological source term data.

NIOSH has further determined that there is insufficient information available to enable NIOSH to accurately assess whether an energy employee, or class of employees, did, or did not, potentially enter specific Areas of the Hanford site during the periods of time associated with both:

1. the previously designated SEC classes; and
2. the recently identified polonium, thorium, and neptunium dose reconstruction infeasibilities.

Due to the lack of access control and worker movement data, NIOSH has determined that it is necessary to remove the Area-specific parameters associated with the current Hanford SEC class definitions. Therefore, NIOSH finds it necessary to include all workers and all areas in the proposed SEC class definition for the period from October 1, 1943 through June 30, 1972.

Although NIOSH found that it is not possible to completely reconstruct radiation doses for the proposed class, the 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 the Hanford site during the period from October 1, 1943 through June 30, 1972, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

Health Endangerment Determination

The NIOSH evaluation did not identify any evidence supplied by the petitioners or from other resources that would establish that the class was exposed to radiation during a discrete incident likely to have involved exceptionally high-level exposures, such as nuclear criticality incidents or other events involving similarly high levels of exposures. However, the evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic radiation exposures through intakes of inadequately monitored radionuclides and from direct exposure to radioactive materials. Therefore, 42 C.F.R. § 83.13(c)(3)(ii) requires NIOSH to specify that health may have been endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

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SEC Petition Evaluation Report for SEC-00152

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: Michael Kubiak, MJW Technical Services. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for employees who worked at a specific facility during a specified time. It provides information and analysis 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, with the exception of the employee whose dose reconstruction could not be completed, and whose claim consequently led to this petition evaluation. The finding in this report is not the final determination as to whether or not the proposed class will be added to the SEC. This report will be considered by the Advisory Board on Radiation and Worker Health (the Board) and by the Secretary of Health and Human Services (HHS). The Secretary of HHS will make final decisions concerning whether or not to add one or more classes to the SEC in response to the petition addressed by this report.

This evaluation, in which NIOSH provides its findings both on the feasibility of estimating radiation doses of members of this class with sufficient accuracy and on health endangerment, was conducted in accordance with the requirements of EEOICPA and 42 C.F.R. § 83.14.

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 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 proposed class of employees through NIOSH dose reconstructions.¹

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

NIOSH is required to document its evaluation in a report, and to do so, relies upon both its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the petitioners and the Advisory Board on Radiation and Worker Health. The Board will consider the NIOSH evaluation report, together with the petition, comments of the petitioner(s) and such other information as the Board considers appropriate, 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 final decision process, the petitioner(s) may seek a review of certain types of final decisions issued by the Secretary of HHS.²

3.0 NIOSH-Proposed Class Definition and Petition Basis

The NIOSH-proposed class includes all employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked at the Hanford site in Richland, Washington, from October 1, 1943 through June 30, 1972, 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 included in the Special Exposure Cohort. During this period, employees at this facility were involved with fabrication of various reactor fuels, reactor operations and maintenance, and chemical separations involving various fission product and transuranic radionuclides.

The evaluation responds to Petition SEC-00152 which was submitted by an EEOICPA claimant whose dose reconstruction could not be completed by NIOSH due to a lack of sufficient dosimetry-related information. This claimant was employed as a laboratory technician and manager from 1968 through 2008. NIOSH's determination that it is unable to complete a dose reconstruction for an EEOICPA claimant is a qualified basis for submitting an SEC petition pursuant to 42 C.F.R. § 83.9(b).

There are currently two classes of Hanford workers associated with the previous NIOSH evaluations of SEC petition SEC-00057, for which the Secretary of Health and Human Services (HHS) has designated inclusion in the Special Exposure Cohort:

- Class added to the SEC effective October 12, 2007 (HHS, 2007): *Employees of the Department of Energy (DOE), its predecessor agencies, or DOE contractors or subcontractors who were monitored or should have been monitored for internal radiological exposures while working at the Hanford Engineer Works in: the 300 Area fuel fabrication and research facilities from October 1, 1943, through August 31, 1946; the 200 Area plutonium separation facilities from November 1, 1944 through August 31, 1946; or the 100 B, D, and F reactor areas from September 1, 1944, through August 31, 1946; for a number of work days aggregating at least 250 work days or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.*

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

- Class added to the SEC effective June 29, 2008 (HHS, 2008): All employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors or subcontractors who worked from:
 1. September 1, 1946 through December 31, 1961 in the 300 area; or
 2. January 1, 1949 through December 31, 1968 in the 200 areas (East and West) at the Hanford Nuclear Reservation in Richland, Washington, 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.

Detailed information associated with the worker classes added to the SEC in 2007 and 2008 can be found in the respective NIOSH evaluation reports, *SEC Petition Evaluation Report, Petition SEC-00057-1* (NIOSH, 2007), and *SEC Petition Evaluation Report, Petition SEC-00057-2* (NIOSH, 2008).

The earliest start date of the 2007 SEC class, October 1, 1943 for the 300 Area, was based on uranium (in the form of rods extruded off-site) being brought to Hanford in October 1943, and stored in the 300 Area (NIOSH 2007). The differing start dates for the 100 and 200 Areas were based on the start of the earliest radiological operations for those facilities. NIOSH proposed these area-specific class parameters based on the belief that sufficient data were available for NIOSH to adequately determine employees' work locations throughout their periods of employment. The end dates of the area-specific class parameters for the SEC class added in 2007 were based on the end of DuPont operations in August 1946, with NIOSH's intent to separately evaluate the subsequent years associated with the SEC petition SEC-00057.

The 2008 SEC class designation is also area-specific due to the NIOSH belief that enough data were available to enable NIOSH to determine the periods of time when a worker might have accessed, or not accessed, Areas 100, 200, or 300. The Area 200 class parameters were based on NIOSH's inability to assess with sufficient accuracy, the internal doses due to purified americium prior to 1969. The Area 300 class parameters were based on the inability to assess with sufficient accuracy, the internal doses due to purified thorium prior to 1962.

Through the course of ongoing dose reconstruction and continued data capture efforts, NIOSH has determined that additional dose reconstruction infeasibilities exist due to work with inadequately monitored radionuclides such as purified forms of polonium, thorium, and neptunium. As detailed in this evaluation, some of these recently identified dose reconstruction infeasibilities extend beyond the time period associated with the existing approved SEC classes for Hanford. Therefore, NIOSH has determined that it is necessary to propose the extension of the SEC time period for the Hanford site through June 30, 1972.

Further, through experience gained during dose reconstruction efforts, NIOSH has also determined that there is often insufficient information available to enable NIOSH to accurately assess whether an energy employee, or class of employees, did, or did not, potentially enter specific Areas of the Hanford site during defined periods of time. Due to the lack of access control and worker movement data, NIOSH has determined that it is necessary to remove the Area-specific parameters associated with the current Hanford SEC class definitions, and therefore include all workers and all Areas in the proposed SEC class definition for the specified time period. NIOSH has determined that expansion of the SEC class is warranted for the Hanford site in order to include all workers and all Areas from the date of the start of radiological operations, determined to be October 1, 1943 (NIOSH, 2007; HHS, 2007) through June 30, 1972.

4.0 Radiological Operations Relevant to the Proposed Class

The following subsections summarize the radiological operations at the Hanford site from the start of radiological operations on October 1, 1943 through June 30, 1972, and the information available to NIOSH to characterize particular processes and radioactive source materials. Using available sources, NIOSH has attempted to gather process and source descriptions, information regarding the identity and quantities of radionuclides of concern, and information describing processes through which the radiation exposures of concern may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is meant only to be a summary of the available information.

4.1 Operations Description

This section describes specific operations in the 100, 200, and 300 Areas of the Hanford site that are relevant to the NIOSH-proposed SEC class for all workers through June 30, 1972. The information presented in this section is not intended to be an exhaustive description of all radiological activities, but rather an example of major operations involving purified forms of polonium, thorium, and neptunium for which NIOSH has found dose reconstruction to be infeasible (see Section 6 for feasibility determinations).

Figure 4-1 shows the Hanford site during the Cold War era (around 1965) when the site was called Hanford Works (Hanford History, 2002, pdf p. 29).

4.1.1 Polonium Operations

Polonium-210, also called “chemical 14-92” or “postum,” was generated via the activation of bismuth metal (sometimes called “chemical 37-77,” “soda pulp,” or “B Metal”) in the Hanford reactors. On January 31, 1945, Robert Bacher reported to Robert Oppenheimer that a polonium-210/beryllium-9 implosion initiator (still to be designed) was possible. Initiator tests began in February 1945, causing demand for polonium to rise to 100 curies/month (AHF, 2009).

B-Reactor was already operating and F-Reactor came on-line in February. Plans were made for bismuth rods suitable for canning to be delivered by the government to Hanford, where the material was placed in cans suitable for exposure in the Hanford reactor pile. After completion of irradiation, the irradiated pieces were placed in containers and shipped to the Monsanto site in Dayton, Ohio (Tilley, 1945). In order to allow for assay of the polonium content of some of the early slugs, equipment was assembled for stripping the aluminum cans from the slugs prior to shipping (100 Area Monthly Report, February 1945). It is noted in a Health Instruments monthly report for March 1945, “The survey program... covered the handling of special bismuth slugs. Uncanned slugs were a potent beta source... in addition to the hazard of polonium contamination in the air. The canned slugs presented no handling problems” (HI Monthly Report, March 1945, p. 18). The opened slugs were subsequently shipped to Monsanto in hermetically-sealed shipping containers where Monsanto conducted three separate polonium-210 assays on bismuth material that had been irradiated at Hanford from February 23 through March 8, 1945 (Hanford Engineer Works Monthly Report, April, 1945, pp. 27-28).

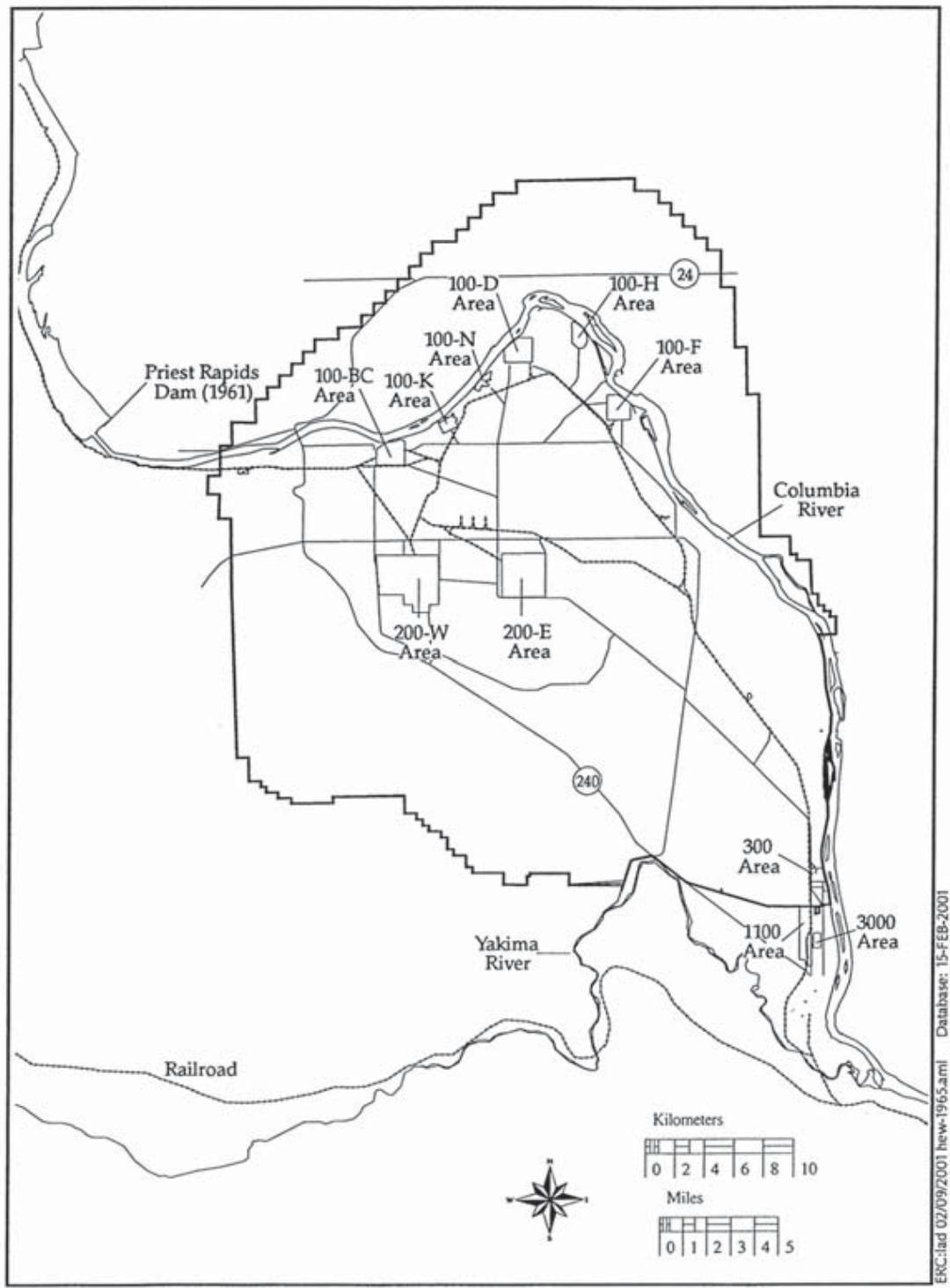


Figure 4-1: Hanford Site in 1965

Following these initial measurements, shipments of irradiated bismuth became routine. The first relatively large-scale shipment of soda pulp was made from the 100-B Area on May 5, 1945. The shipment consisted of seventy units of soda pulp, which had been charged in the 100-B pile on March 9, 1945 and discharged on April 26, 1945, with an estimated content of 210 curies of polonium (100 Area Monthly Report, May 1945).

Bismuth irradiation for polonium production continued as a routine part of Hanford operations through the 1950s, 1960s, and into the 1970s. Various Hanford and Mound polonium production documents illustrate the ongoing shipment of irradiated bismuth from Hanford, including plans to use the Hanford reactors and the Reduction Oxidation Plant (REDOX) to produce polonium through 1971 (Essig, 1965; Nason, 1966, p. 70; Essig, 1968, pp. 33-34; Monsanto, 1972, p. 24). Polonium research and production at Mound were eventually phased out in 1971 (GlobalSecurity, 2005).

Polonium experiments, such as study of polonium volatility from oxides, were performed in the 300 Area starting in 1963 and continuing through 1969. Worker interviews conducted by NIOSH indicate that much of the work was performed in the 325 Building where polonium-210 was purified in the 325 Building under a contract with the 3M Company (Personal Communication, 2008e). The polonium work was performed in glove boxes in the center hall of the 325 Building. Irradiated bismuth was de-jacketed, the metal was dissolved in hot caustic, and the polonium was then precipitated out of the caustic solution. NIOSH has found indications that complimentary studies were also being undertaken in the 200 Areas in 1965 and 1966, with small-scale engineering experiments on solvent extraction in the 200 Area Chemical Research and Development organization (200 Area Monthly Report, June 1966).

4.1.2 Thorium Operations

In October 1945, the first known activities with thorium at Hanford laboratories involved the use of small metallic pieces obtained from Oak Ridge, Tennessee for experiments on physical characterization (Gydesen, 1954). This work included machining two thorium slugs to standard size and performing trial canning (Smith, 1945). Similar metallic pieces were used to determine thorium's effects on reactor reactivity in the Building 305 Test Pile.

In January 1946, Hanford received a shipment of 150 pounds of thorium, which consisted of crooked four- to five-foot long rods that required straightening prior to machining (Smith, 1946; Gydesen, 1954). To prevent the rods from being contaminated with uranium from the contaminated equipment in Building 314, these thorium rods were straightened manually in the 300 Area Maintenance Shop with a 75-ton press. Following straightening, the rods were cut with a power hack-saw into 33 slugs, then machined on a small lathe in the 313 Tool Room. The slugs were then canned, welded, and tested for integrity by autoclaving in the 314 Building (Gydesen, 1954; Gerber, 1992). Airborne contamination readings within and near the 313 and 314 Buildings were frequently high, resulting from lathe and machining operations, extrusion press work, straightening, outgassing, and other fuel fabrication procedures. Radiation monitoring personnel often reported "metal dust" in building and vicinity air as being "over tolerance" for uranium with ventilation "not adequate." Autoclave explosions also contributed to the contamination (Gerber, 1992). The first production batch of 30 thorium (aka. myrnalloy) slugs was inserted into a Hanford reactor in 1946 (Wende, 1946a; Wende, 1946b).

The first major tests of metallic thorium elements in the Hanford reactors began with element fabrication using standard Hanford techniques on metallic thorium slugs in the 300 Area facilities in late 1951. Many problems connected with the rapid formation of a thick coat of oxide on the thorium metal targets led to experiments with a variety of bonding methods and coatings. These tests resulted in large-scale thorium contamination being introduced into the 313 Metal Fabrication Building and surrounding fuel warehouses. Thorium work in Building 313 continued until 1970 (Gerber, 1992).

Powdered thorium oxide fuel targets (wafers) were fabricated in the 3732 Building from 1965 to 1967. Sintering of the wafers was part of the process in the 3732 Building. A new technique involving pelletized targets replaced the 3732 Building operations. The pelletized targets were fabricated in the 3722 Building from 1968 through 1970. In addition, that building housed a furnace for the "recycling" (reduction) of depleted thorium oxide after it was processed in the Plutonium-Uranium Extraction (PUREX) Plant. When not recycled to the 3732 Building, the thorium nitrate was placed in the 241-WR Vault in the 200 West Area (Isochem, 1967); this was stand-alone storage area slightly northeast of Uranium Plant.

Thorium work was also conducted in Building 306 (alloy and fabrication test and development) from 1955 through 1970 (Rad Monitoring Unit Monthly Report, June 1955; Rad Monitoring Unit Monthly Report, August 1955); Building 3706 (radiochemistry in support of fuel fabrication) from 1954 through 1963; and Building 3722 (machining of thorium rods in the early years, and later the fabrication of pelletized fuel targets) from 1946 through 1970. The 3707-A and 3707-B change houses became contaminated due to contamination spread from the nearby fuel fabrication and scrap storage buildings (Gerber, 1992).

In the 306-W and 306-E Buildings, releases included the spread of airborne dust and particulate contamination, including uranium and thorium, and multiple leaks and fires that occurred in and around the building. The fires occurred in barrels and waste "load luggers" that contained uranium, thorium, heavy metals, and other fuel component scrap. The long-lived contamination settled in building sumps, crevices, and nearby soil. The area around the building has been paved and posted as having underground radioactive contamination (EPA, 2001).

The 3706 Building was contaminated as a result of operations and associated spills. Contamination resulted from inadequate containment systems, spills, overflows, vaporization, spreads of radioactive dusts and fines, and other incidents involving the loss of control of radioactive materials. In 1954, the building underwent a major decontamination and remodeling effort and many of the laboratories were converted into offices. Sampling laboratories for fuel fabrication operations continued until they were transferred to the 3720 Building in the mid-1960s (EPA, 2001).

The 321 Separation Building was constructed during World War II as Hanford's pilot-scale plant for testing chemical process improvements. The 321 Canyon provided support for 300 Area laboratory programs dedicated to the development of production reactor fuel. After irradiation, chemical separation of various forms of thorium-target fuel elements took place in the 321 Building using the Thorex separation process (Gerber, 1992; EPA, 2001).

By the end of 1953, thorium elements were being used in all Hanford reactors for use as flux-flattening poisons, replacing lithium-aluminum and bismuth (DeNeal, 1970). The first thorium element failure occurred in January 1954 in H reactor; a poorly-manufactured element ruptured (Brugge, 1954). Two more of these elements ruptured in B reactor in April and September 1954. These ruptures were repaired with standard maintenance techniques, which included removing the

tubes in which the slugs were stuck. NIOSH has found no evidence that any special precautions or other controls were used, other than the routine Hanford procedures.

Hanford received an order from the AEC for 110 kg of uranium-233 in mid-1964, which was subsequently increased to 140 kg in early 1965 (DeNeal, 1970). In addition to the 300 Area buildings previously used for thorium work in the 1950s, Building 3732 was used for fabrication of thorium-oxide fuel targets and was used as a furnace for recycling depleted thorium from 1965 through 1970. Powdered thorium-oxide fuel targets for uranium-233 production were fabricated at Building 3732 from 1965 to 1967. From 1968 through 1970, the program switched to pelletized targets that were canned. The processes spread fine and particulate contamination throughout the building. Decontamination practices included hosing down the facility floor and walls, which allowed contaminated liquid to be released into the surrounding soil (EPA, 2001).

The Hanford site conducted two campaigns to produce uranium-233 through irradiation of thorium-232-based target rods. These thoria elements were manufactured in the 300 Area and processed at PUREX in the 200 Area, with a Thorex process test in 1965 and two major thorium campaigns in 1966 and 1970 (Briggs, 2001). During 1965-1966, the PUREX facility processed powdered thorium-oxide fuel targets that had been irradiated for the production of uranium-233. However, the processing campaign caused plugging and other equipment and contamination problems within PUREX (Gerber, 1993). In 1970, a more successful campaign processed pelletized thorium-oxide targets. The PUREX thorium work recovered approximately 565 tons of thorium in the nitrate form from both campaigns (Gerber, 1992; Walser, 1978; ARHCO, 1971). No evidence has been found indicating that special health-physics precautions were taken during the manufacturing of the elements. The only obvious changes at PUREX were related to criticality safety (Gerber, 1993). The material was transferred in bottles to the pipe gallery of the 221-U Building prior to shipment. Some re-bottling of product occurred in a specially-constructed metal enclosure at the northeast end of the pipe gallery; this was ventilated with a blower-filter arrangement (ARHCO, 1971).

During 1965-1966, an experimental processing of commercial thorium nitrate into thorium-oxide powder was carried out in the 224-U Bulk Reduction Building, known as the UO₃ Plant, using the old electric pots. The goal of this work was to produce thorium-oxide powder suitable for fabrication into reactor target elements for uranium-233 production (Gerber, 1993). The task involved a few hundred pounds of thorium.

All known fuel-element failures in the single-pass Hanford reactors are summarized in the report titled, *Fuel-Element Failures in Hanford Single-Pass Reactors 1944-1971* (Gydesen, 1993). Just over 2000 leaks in the fuel cladding, of various degrees of severity, are reported. In the first years, a limited number of elements were manufactured using thorium metal, in a manner analogous to that used for uranium. A total of 27 fuel-element leaks occurred during the program to produce uranium-233 from thoria fuel during the period from 1965-1968. The thoria elements were manufactured in the 300 Area, irradiated in the 100 Area, and processed at PUREX in the 200 Area.

NIOSH has found no evidence that the thoria-related fuel failure remediation was accomplished with anything other than the routine Hanford processes and monitoring.

4.1.3 Neptunium Operations

Neptunium-237 was irradiated to produce plutonium-238, which was used as a heat source for thermal generators. The May 1948, 200 Area monthly report listed as activities for the month “preparation for and crude separation of neptunium from metal wastes of 385 g/ton material” (200 Area Monthly Report, May 1948, p. 52). The June 1948 monthly report states “170 liters of neptunium solution were shipped to Argonne National Laboratory” (200 Area Monthly Report, June 1948, p. 73).

In 1957, Hanford was investigating the amount of neptunium-237 contained and potentially extractable from weapons-grade spent fuel, and was investigating chemical procedures for extracting the neptunium at the fuel-separations facilities (Sheppard, 1957; Judson, 1958). The *Palm Recovery Progress Report* indicates that as early as November 1956, small, laboratory-scale samples were grabbed from the PUREX dissolution stream and analyzed for the neptunium-237 content (Sheppard, 1957, p. 4). Three small runs simulating the PUREX chemistry conditions were performed in February 1957 (Hanford Lab Operations Monthly Activities Report, February 1957, p. 63).

Extraction of neptunium-enriched nitrate solution from PUREX began on August 7, 1958, with two campaigns in 1958 (August and November) (Briggs, 2001, p. 28; Travis, 1958; Geier, 1961). Neptunium purification was performed in a special room at 222-S, called the 1-F Cubicle. During the period that the neptunium solution was purified at 222-S, the incoming material from PUREX and REDOX was highly contaminated. For instance, impurity data on runs numbered 12-58 (in 1958), and 40, 44, 46, 52, and 53 (circa 1961) show that the activity of plutonium, mostly plutonium-239+240, ranged from 3 to 81 times greater than the activity of neptunium-237 (Buckingham, 1959; Buckingham, 1961). However, the purified product had low levels of contaminants, with the activity of plutonium ranging from 0.3% to 4% of the neptunium activity for the 6 runs discussed above (Buckingham, 1959; Buckingham, 1961).

Starting in 1963, the purification of the neptunium was transferred to PUREX in J Cell and Q Cell, and purification at 222-S was stopped (Buckingham, 1963; Briggs, 2001, p. 30; Duckworth, 1963, pp. 12 & 19; Unknown author, 1963). NIOSH has found specifications for shipments of neptunium from PUREX from August 1963 through the last shipment in May 1972 (Various authors, 1962-1965; Various authors, 1966; Various authors, 1967-1972; Malody, 1971a; Malody, 1971b; Malody, 1971c; Malody, 1972a; Malody, 1972b). Production of neptunium nitrate in the 200 Areas ceased with the shutdown of PUREX in June 1972 (Hanford History, 1991; Hanford History, 2002, pdf p. 87; PUREX, 1993).

Fabrication of neptunium-target elements also involved handling the purified neptunium mixture. Workers interviewed by NIOSH indicated that nitrate or oxide was shipped to Oak Ridge National Laboratory and the Savannah River Site, and that the oxide was mixed with aluminum powder and sent to 231-Z for fabrication into neptunium-aluminum alloy target elements (Personal Communication, 2008a; Personal Communication, 2008d; Personal Communication, 2008l). Neptunium work in the 300 Area involved the target-element fabrication in the 308 Plutonium Fuels Pilot Plant beginning in 1966 (ORAUT-TKBS-0006-2; Gerber, 1992, p. 216), and manufacturing and canning of neptunium-oxide fuel targets in the 3708 Building in 1968 (Gerber, 1992, p. 71). According to a paper written by E. J. Wheelwright, irradiation and neptunium/plutonium separation occurred in 1969-1970 using a new dissolver in C Cell (Wheelwright, 1970). Decanning occurred at the Radiometallurgy Building (327 Building) (Wheelwright, 1970, p. 12). The remaining work occurred in the A, B, and C hotcells at the 325 Building, and the neptunium product was oxidized at the 325 Building (Wheelwright, 1970, p. 21).

4.2 Radiation Exposure Potential from Operations

The potential for internal and external radiation dose existed at the 100 Area, 200 Area, and 300 Area of the Hanford facility, as presented in Section 4.1 above. Based on the site operations outlined in Section 4.1, sources of exposure relevant to this SEC evaluation included internal exposures to purified forms of polonium, thorium, and neptunium. Based on the previous NIOSH evaluation of the early DuPont years at Hanford (NIOSH, 2007; HHS, 2007), additional sources of relevant exposure for the period from October 1, 1943 through August 31, 1946 include internal exposures to uranium brought on site in October 1943.

This evaluation responds to a petition based on NIOSH determining that internal radiation exposures could not be reconstructed for a dose reconstruction referred to NIOSH by the DOL. As such, it is not necessary for NIOSH to fully evaluate the feasibility of reconstructing external radiation exposures for the class of workers covered by this report; this report concentrates on the relevant aspects of internal exposures and internal exposure monitoring during the specified time period.

4.3 Time Period Associated with Radiological Operations

As presented in Section 4.1, the potential internal exposure scenarios associated with this proposed SEC class are as follows:

Polonium

- *Area 100 from January 1, 1945 through December 31, 1971*
Very early in 1945, prior to shipment to the Monsanto site, irradiated bismuth slugs containing polonium were processed in the Reactor Areas. NIOSH lacks sufficient information to assign an exact date early in 1945, and therefore assumes January 1, 1945 as the start date. Shipments of irradiated bismuth continued through 1971. NIOSH lacks sufficient information to assign an exact end date in 1971, and therefore assumes December 31, 1971 as the end date.
- *Area 200 from January 1, 1965 through December 31, 1966*
Engineering experiments on solvent extraction occurred in 1965 and 1966. NIOSH lacks sufficient information to assign exact start and end dates, and therefore assumes January 1 and December 31, respectively.
- *Area 300 from January 1, 1963 through December 31, 1969*
Polonium experiments and separations occurred in the 325 Building from 1963 through 1969. NIOSH lacks sufficient information to assign exact start and end dates, and therefore assumes January 1 and December 31, respectively.

Thorium

- *Area 100 from January 1, 1965 through December 31, 1968*
Fuel element failures associated with the irradiation of thorium fuel occurred during the 1965-1970 campaigns to produce uranium-233. NIOSH lacks sufficient information to assign exact start and end dates, and therefore assumes January 1 and December 31, respectively.

- *Area 200 from January 1, 1965 through December 31, 1970*
Major thorium operations in Area 200 began with a test of the Thorex process in 1965, and continued through the final major campaign to fabricate, irradiate, and process pelletized thorium-oxide targets in 1970. NIOSH lacks sufficient information to assign exact start and end dates, and therefore assumes January 1 and December 31, respectively.
- *Area 300 from October 1, 1945 through December 31, 1970*
Site thorium operations began with trial canning in October 1945 and continued through the final major campaign to fabricate, irradiate, and process pelletized thorium-oxide targets in 1970. NIOSH lacks sufficient information to assign exact start and end dates, and therefore assumes October 1 and December 31, respectively.

Neptunium

- *Area 200 from May 1, 1948 through June 30, 1972*
Area 200 neptunium-237 operations began with the crude separation of neptunium from metal wastes, first reported in May 1948. Production of neptunium nitrate in the 200 Area ceased with the shutdown of PUREX in June 1972. NIOSH lacks sufficient information to assign exact start and end dates, and therefore assumes May 1 and June 30, respectively.
- *Area 300 from January 1, 1966 through December 31, 1970*
Neptunium work in the 300 Area began with target-element fabrication beginning in 1966. Neptunium/plutonium separations continued into 1970. NIOSH lacks sufficient information to assign exact start and end dates, and therefore assumes January 1 and December 31, respectively.

As stated in Section 3.0, in 2007 HHS designated a class of Hanford employees for inclusion in the SEC. The earliest start date associated with the Area-specific 2007 SEC designation was October 1, 1943, for workers at the Hanford Engineer Works in the 300 Area fuel fabrication and research facilities. The existing 2007 SEC designation for Area 300 continues through August 31, 1946. The time period enveloped by the polonium, thorium, and neptunium operations detailed above is January 1, 1945 through June 30, 1972.

It is NIOSH's intent to remove the Area-specific class parameters from the periods associated with the existing SEC classes previously designated in 2007 and 2008. To accomplish such, in this evaluation NIOSH is combining the time periods associated with the 2007 and 2008 class designations with the periods of operations described in Section 4.1 of this report. Combining the time periods associated with the operations described in Section 4.1 with the time period of the SEC class already designated in 2007, yields a summative time period for this evaluation of October 1, 1943 through June 30, 1972.

Table 4-1 summarizes the preceding information in Section 4 on years, operational areas, and radionuclides as they relate to this evaluation (SEC-00152) and the two preceding evaluations performed for the Hanford site (SEC-00057-1 and SEC-00057-2), as explained in the Legend.

Table 4-1: Years, Operational Areas, and Radionuclides Associated with Hanford SEC-00152					
Year	100 Area		200 Area		300 Area
1943					57-1
1944		57-1		57-1	57-1
1945	Po	57-1		57-1	Th*
1946	Po	57-1		57-1	Th
1947	Po				Th
1948	Po		Np [#]	57-2	Th
1949	Po		Np	57-2	Th
1950	Po		Np	57-2	Th
1951	Po		Np	57-2	Th
1952	Po		Np	57-2	Th
1953	Po		Np	57-2	Th
1954	Po		Np	57-2	Th
1955	Po		Np	57-2	Th
1956	Po		Np	57-2	Th
1957	Po		Np	57-2	Th
1958	Po		Np	57-2	Th
1959	Po		Np	57-2	Th
1960	Po		Np	57-2	Th
1961	Po		Np	57-2	Th
1962	Po		Np	57-2	Th
1963	Po		Np	57-2	Po, Th
1964	Po		Np	57-2	Po, Th
1965	Po, Th		Np, Po, Th	57-2	Po, Th
1966	Po, Th		Np, Po, Th	57-2	Np, Po, Th
1967	Po, Th		Np, Th	57-2	Np, Po, Th
1968	Po, Th		Np, Th	57-2	Np, Po, Th
1969	Po		Np, Th		Np, Po, Th
1970	Po		Np, Th		Np, Th
1971	Po		Np		
June 30, 1972			Np		
Legend					
57-1	Year and operational area previously evaluated in SEC-00057-1, covered by the HHS 2007 SEC class designation, and now covered by SEC-00152				
57-2	Year and operational area previously evaluated in SEC-00057-2, covered by the HHS 2008 SEC class designation, and now covered by SEC-00152				
Po	Polonium operations associated with the SEC-00152 petition evaluation				
Th	Thorium operations associated with the SEC-00152 petition evaluation				
Np	Neptunium operations associated with the SEC-00152 petition evaluation				
*	Begins October 1, 1945				
#	Begins May 1, 1948				

4.4 Site Locations Associated with Radiological Operations

Through the course of ongoing dose reconstruction, NIOSH has determined that the Hanford site-specific and claimant-specific data available for the time period of this evaluation are insufficient to allow NIOSH to characterize worker movements across the site, or between the 100, 200, and 300 Areas. NIOSH is unable to accurately assess whether an energy employee, or class of employees, did, or did not, potentially enter specific Areas of the Hanford site during defined periods of time; therefore, NIOSH cannot define individual worker exposure scenarios based on Hanford site Areas.

4.5 Job Descriptions Affected by Radiological Operations

As stated in Section 4.4, through the course of ongoing dose reconstruction, NIOSH has determined that the Hanford site-specific and claimant-specific data available for the time period of this evaluation are insufficient to allow NIOSH to characterize worker movements across the site, or between the 100, 200, and 300 Areas. The data available to NIOSH on a claim-specific level are also often insufficient for NIOSH to limit a worker's potential exposure scenarios based on job titles and/or job assignments. The areas associated with this evaluation, as summarized in Section 4.3 above, include all areas of the Hanford site, and NIOSH is unable to eliminate any specific worker from any of the listed potential exposure scenarios based on worker job descriptions.

5.0 Summary of Available Monitoring Data for the Proposed Class

The primary data used for determining internal exposures are derived from personal monitoring data, such as urinalyses, fecal samples, and whole-body counting results. If these are unavailable, the air monitoring data from breathing zone and general area monitoring are used to estimate the potential internal exposure. If personal monitoring and breathing zone area monitoring are unavailable, internal exposures can sometimes be estimated using more general area monitoring, process information, and information characterizing and quantifying the source term.

This same hierarchy is used for determining the external exposures to the cancer site. Personal monitoring data from film badges or thermoluminescent dosimeters (TLDs) are the primary data used to determine such external exposures. If there are no personal monitoring data, exposure rate surveys, process knowledge, and source term modeling can sometimes be used to reconstruct the potential exposure.

A more detailed discussion of the information required for dose reconstruction can be found in OCAS-IG-001, *External Dose Reconstruction Implementation Guideline*, and OCAS-IG-002, *Internal Dose Reconstruction Implementation Guideline*. These documents are available at: <http://www.cdc.gov/niosh/ocas/ocasdose.html>.

5.1 Data Capture Efforts and Sources Reviewed

In addition to examining its Site Research Database (SRDB) to locate documents supporting the evaluation of the proposed class, NIOSH identified and reviewed numerous data sources to locate information relevant to determining the feasibility of dose reconstruction for the class of employees proposed for this petition. This included determining the availability of information on personnel monitoring, workplace monitoring, and radiological source term data.

NIOSH data capture efforts for the Hanford site focused on site and DOE data bases, DOE Office of Scientific and Technical Information (OSTI), DOE OpenNet, NRC Agencywide Document Access and Management (ADAMS), and worker interviews. NIOSH conducted eight organized site visits in 2007, and five in 2008, in an attempt to gather documents and data relevant to dose reconstruction of Hanford claims. NIOSH's SRDB currently contains over 18,000 documents and subdocuments associated with the Hanford site. Attachment One contains a summary of Hanford data gathering efforts and documents.

5.2 Worker Interviews

To obtain additional information, NIOSH interviewed and/or contacted 15 former Hanford employees. The purpose of the interviews was to gain additional first-hand information from people who worked at the Hanford facility.

- Personal Communication, 2008a, *Personal Communication with Retired Chemist and Shift Supervisor*; Telephone and email contact by ORAU Team; January 23-25 & 29-30, 2008; SRDB Ref ID: 41272
- Personal Communication, 2008b, *Personal Communication with Chemist*; Telephone and email contact by ORAU Team; January 14 & 17, 2008; SRDB Ref ID: 41268
- Personal Communication, 2008c, *Personal Communication with Retired Chemist and Program Manager*; Telephone Interview by ORAU Team; January 25, 2008; SRDB Ref ID: 41269
- Personal Communication, 2008d, *Personal Communication with Retired Hanford Employee*; Email contact by ORAU Team; September 4, 2008; SRDB Ref ID: 48378
- Personal Communication, 2008e, *Personal Communication with Retired Research Chemist*; In-person communication by ORAU Team; July 24, 2008; SRDB Ref ID: 46685
- Personal Communication, 2009a, *Personal Communication with Retired Chemist*; In-person communication by ORAU Team; March 5, 2009; SRDB Ref ID: 60977
- Personal Communication, 2009b, *Personal Communication with Retired Chemist and Manager*; Telephone communication by ORAU Team; April 24, 2009; SRDB Ref ID: 64482
- Personal Communication, 2008f, *Personal Communication with Retired Hanford Employee*; Telephone and email contact by ORAU Team; January 8-14, 2008; SRDB Ref ID: 41265

- Personal Communication, 2008g, *Personal Communication with Semi-Retired Operator and Engineer*; Telephone Interview by ORAU Team; January 14, 2008; SRDB Ref ID: 41266
- Personal Communication, 2008h, *Personal Communication with Retired Radiological Engineer*; Telephone Interview by ORAU Team; January 16, 2008; SRDB Ref ID: 41267
- Personal Communication, 2008i, *Personal Communication with Retired Program Manager*; Telephone and email contact by ORAU Team; January 7, 2008; SRDB Ref ID: 41263
- Personal Communication, 2008j, *Personal Communication with Retired Specialist from the Whole-Body Counting Program*; Telephone and email contact by ORAU Team; January 7, 2008; SRDB Ref ID: 41263
- Personal Communication, 2008k, *Personal Communication with Retired Westinghouse Hanford Company Employee*; Telephone Interview by ORAU Team; January 14, 2008; SRDB Ref ID: 41264
- Personal Communication, 2008l, *Personal Communication with Retired Hanford Employee*; Email contact by ORAU Team; September 5, 2008; SRDB Ref ID: 48446
- Personal Communication, 2008m, *Personal Communication with Retired Chemist and Manager from Hanford*; Telephone interview by ORAUT Team; December 16, 2008; SRDB Ref ID: 55669

5.3 Internal Personnel Monitoring Data

This section describes internal personnel monitoring data.

5.3.1 Polonium Internal Personnel Monitoring Data

A specific bioassay procedure for detection of polonium-210 in urine was developed at Hanford in 1948, upon the occasion of two workers becoming externally contaminated from a leaking PoBe source (Thorburn, 1948). There are no entries in the Radiological Exposure (REX) database for polonium bioassay until February 1968. Beginning in 1968 through July 1969, there are entries in REX associated with the Pacific Northwest Lab program for investigating polonium-210 microspheres. Following the cessation of the microsphere project, routine polonium bioassay results in the REX database were found for the period between September 1972 and January 1983.

5.3.2 Thorium Internal Personnel Monitoring Data

The August 1955 monthly report of the Radiological Sciences Department, Biophysics Section, states that "Improvements were made in the bioassay procedure for thorium in urine. . . . This and other improved techniques increased the precision of the results so that the detection limit (90% confidence) for duplicate analyses is 0.077 μg ..." (Rad Sciences Monthly Report, August 1955, p. 24). Although a urinalysis method was available for use prior and after this date, there is no evidence in the present REX database of thorium urinalyses samples being obtained from workers. NIOSH is unable to determine whether this is because no samples were obtained or because the results were not entered into the predecessor (to REX) electronic database.

Battelle Northwest Radiation Protection Department monthly reports were reviewed for months from 1965-1967 when thorium fuel failures occurred, and for months after fuel failures. These reports acknowledged “possible intake of other radioisotopes” (other than plutonium), but specific data were not found, so it is unknown whether these other isotopes may have been thorium. No other data were found in the reports that indicated any thorium monitoring or measuring was performed.

During 1964 through 1969, thorium-232 was specifically listed in the whole-body count records of some individuals (also one individual in 1962, and two individuals in 1963). Interviews of the Whole-Body Counting Program Manager circa 1958-63 and a specialist at the facility who started in 1969 did not provide any insight into how the thorium counts were performed (Personal Communication, 2008i; Personal Communication, 2008j). Literature and document searches for any documentation by others who worked at the Whole-Body Counting facility or for the Internal Dosimetry Program during the 1960s also provided no new information about *in vivo* counting for thorium.

5.3.3 Neptunium Internal Personnel Monitoring Data

There is no record of bioassay for neptunium-237 in the Hanford REX database prior to 1972 (four baseline samples in 1972). A letter from R. H. Wilson, dated July 6, 1960, to Jack Gillespie at Union Carbide Nuclear Company states that “we [Hanford] do not have a routine bioassay program for neptunium; however if bioassay sampling was necessary for this element we would probably carry out the following procedure: ...” (Wilson, 1960). A procedure was apparently attached to the letter (originally), but the attachment was not found by NIOSH. A procedure was developed in 1960, which may have been the one Wilson referred to; the procedure was described in the *Radiological Chemistry Operations Annual Report for 1960* (Rad Chemistry Operation Annual Report, 1960). The procedure used neptunium separation followed by electrodeposition and alpha-track counting in the same manner as was used for plutonium urinalysis samples, with essentially the same sensitivity (0.05 dpm/24-hr sample).

Extraction of neptunium-enriched nitrate solution from PUREX resulted in purified neptunium product having low levels of contaminants, with the activity of plutonium being only a small fraction of the neptunium activity. Therefore, during the part of the process involving conversion of neptunium nitrate to oxide, and especially loading the neptunium product into shipping containers, an intake of the neptunium would not have been readily detected by plutonium bioassay.

5.4 External Personnel Monitoring Data

This evaluation responds to a petition based on NIOSH determining that internal radiation exposures to purified polonium, thorium, and neptunium could not be reconstructed. In light of this conclusion, NIOSH did not perform an evaluation of external monitoring data for the period of October 1, 1944 through June 30, 1972. Although this evaluation draws no specific conclusions about the external data and the ability to bound external dose for the class under evaluation, NIOSH has drawn following general conclusion: available external monitoring data may be used in accordance with existing procedures on a case-by-case basis for the purpose of partial dose reconstructions.

5.5 Workplace Monitoring Data

This section describes workplace monitoring data.

5.5.1 Polonium Workplace Monitoring Data

A continuous aerosol monitor was installed in May 1968, expressly to sample for polonium (PNL Monthly Report, May 1968); however, NIOSH has been unable to locate the associated monitoring results. NIOSH has found no relevant workplace monitoring records specific to polonium during the period of this SEC evaluation.

5.5.2 Thorium Workplace Monitoring Data

Monthly and weekly reports beginning in 1946 were reviewed to determine the activities that were conducted at Hanford relevant to measuring and monitoring for thorium use in the 100, 200, and 300 Areas. Air samples were taken and reported in all areas over various times. Samples were reported in concentrations for plutonium or uranium. NIOSH found no sample results reporting thorium specifically.

In January 1954, when the fuel failure occurred in H reactor, there is no evidence that any special monitoring was performed for thorium. Routine and special radiological surveys were performed, as well as air monitoring, but NIOSH found no data to indicate that thorium was monitored. Airborne activity was reported in units of uCi/cc in several of the reports reviewed. The activity of the water leaving the retention basin was monitored, but those results are provided for average beta dose rate (mrep/hr); average gamma dose rate (mr/hr); and average total dose rate (mrep/hr). NIOSH has obtained no information regarding the instruments used for any of these measurements. The February 1954 monthly report indicated that bioassay measurements were made for plutonium, fission products, and uranium (Rad Sciences Monthly Report, February 1954). Contamination surveys were made and reported as dose rates in rads/hr at 1 inch. Personnel monitoring included the use of gamma pencils, slow neutron pencils, beta-gamma film badges, and fast neutron badges. Reactor effluent water studies were conducted, but NIOSH has found no data indicating that the presence of thorium was either tested for or identified.

During interviews with NIOSH, site health physicists who worked at the reactors did not recall monitoring for thorium (Personal Communication, 2008i, Personal Communication 2008j; Personal Communication, 2008k). They did state that when removing failed fuel, there were no workers on the back face of the reactors because the dose rates were so high. The dose rates on the front face of the reactor were also extremely high and the workers were generally limited to about thirty minutes of exposure. Respirators were worn during discharge of failed fuel; however, they were not required to be worn for normal discharge of fuel.

5.5.3 Neptunium Workplace Monitoring Data

NIOSH has found no relevant workplace monitoring records specific to neptunium during the period of this SEC evaluation.

5.6 Radiological Source Term Data

The source term information available to NIOSH that is relevant to this evaluation was presented in Section 4.1. NIOSH lacks sufficient source term information that would allow it to estimate all potential polonium, thorium, or neptunium exposures to which the proposed class may have been exposed.

6.0 Feasibility of Dose Reconstruction for the Proposed Class

42 C.F.R. § 83.14(b) states that HHS will consider a NIOSH determination that there was insufficient information to complete a dose reconstruction, as indicated in this present case, to be sufficient, without further consideration, to conclude that it is not feasible to estimate the levels of radiation doses of individual members of the class with sufficient accuracy.

In the case of a petition submitted to NIOSH under 42 C.F.R. § 83.9(b), NIOSH has already determined that a dose reconstruction cannot be completed for an employee at the DOE or AWE facility. This determination by NIOSH provides the basis for the petition by the affected claimant. Per § 83.14(a), the NIOSH-proposed class defines those employees who, based on completed research, are similarly affected and for whom, as a class, dose reconstruction is similarly not feasible.

In accordance with § 83.14(a), NIOSH may establish a second class of co-workers at the facility for whom NIOSH believes that dose reconstruction is similarly infeasible, but for whom additional research and analysis is required. If so identified, NIOSH would address this second class in a separate SEC evaluation rather than delay consideration of the claim currently under evaluation (see Section 10). This would allow NIOSH, the Board, and HHS to complete, without delay, their consideration of the class that includes a claimant for whom NIOSH has already determined a dose reconstruction cannot be completed, and whose only possible remedy under EEOICPA is the addition of a class of employees to the SEC.

This section of the report summarizes research findings by which NIOSH determined that it lacked sufficient information to complete the relevant dose reconstruction and on which basis it has defined the class of employees for which dose reconstruction is not feasible. NIOSH's determination relies on the same statutory and regulatory criteria that govern consideration of all SEC petitions.

6.1 Feasibility of Estimating Internal Exposures

NIOSH has evaluated the available personnel and workplace monitoring data and source term information and has determined that there are insufficient data for estimating internal exposures, as described below.

As presented in Section 5.3, NIOSH has no indications that the Hanford site implemented routine or special bioassay programs sufficient to detect intakes of purified polonium, purified thorium, or purified neptunium during the period being evaluated. In the absence of adequate *in vitro* or *in vivo* bioassay, NIOSH also lacks sufficient workplace monitoring or source term data to estimate potential internal exposures to the listed exposure scenarios. The exposure scenarios evaluated include the following areas and time periods:

Polonium:

- Area 100 from January 1, 1945 through December 31, 1971
- Area 200 from January 1, 1965 through December 31, 1966
- Area 300 from January 1, 1963 through December 31, 1969

Thorium:

- Area 100 from January 1, 1965 through December 31, 1968
- Area 200 from January 1, 1965 through December 31, 1970
- Area 300 from October 1, 1945 through December 31, 1970

Neptunium:

- Area 200 from May 1, 1948 through June 30, 1972
- Area 300 from January 1, 1966 through December 31, 1970

Additionally, as designated by HHS, NIOSH lacks sufficient bioassay or in-situ monitoring data from the onset of Hanford radiological operations in October 1943 through August 1946 to allow for direct reconstruction of an individual's internal dose (HHS, 2007). Combining the time periods associated with the polonium, thorium, and neptunium operations listed above with the 2007 HHS designated SEC class for the 300 Area for the period October 1943 through August 1946, yields a summative time period for identified internal dose reconstruction infeasibilities of October 1, 1943 through June 30, 1972.

As presented in Section 4, NIOSH has determined that the Hanford site-specific and claimant-specific data available for the listed exposure scenarios and time periods are insufficient to allow NIOSH to: (1) characterize worker movements across the site or between the 100, 200, and 300 Areas; or (2) limit a worker's potential exposure scenarios based on job titles and/or job assignments. The operational Areas associated with this evaluation include the 100 Area, the 200 Area, and the 300 Area of the Hanford site. Due to undocumented worker movements across site and limited claimant-specific information, NIOSH is unable to eliminate any specific worker or class of workers from any of the listed potential exposure scenarios based on worker job descriptions. NIOSH is not able to define the proposed class of workers based on Area-specific parameters. NIOSH therefore proposes that all Hanford workers be included in the proposed class for the time period from October 1, 1943 through June 30, 1972.

NIOSH does not have access to sufficient personnel monitoring, workplace monitoring, or source term data to estimate potential internal exposures to polonium, thorium, or neptunium during the period of from January 1, 1945 through June 30, 1972. Consequently, NIOSH finds that it is not feasible to estimate, with sufficient accuracy, internal exposures to polonium, thorium, or neptunium and resulting doses for the class of employees covered by this evaluation.

Although NIOSH found that it is not possible to completely reconstruct internal radiation doses for the period from October 1, 1943 through June 30, 1972, NIOSH intends to use any internal monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Dose reconstructions for individuals employed at Hanford during the period from October 1, 1943 through December 31, 1972, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

6.2 Feasibility of Estimating External Exposures

This evaluation responds to a petition based on NIOSH determining that internal radiation exposures to purified polonium, thorium, and neptunium could not be reconstructed for a dose reconstruction referred to NIOSH by the DOL. As noted above, HHS will consider this determination to be sufficient without further consideration to determine that it is not feasible to estimate the levels of radiation doses of individual members of the class with sufficient accuracy. Consequently, it is not necessary for NIOSH to fully evaluate the feasibility of reconstructing external radiation exposures for the class of workers covered by this report.

Adequate reconstruction of medical dose is likely to be feasible by using claimant-favorable assumptions in the technical information bulletin titled, *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (ORAUT-OTIB-0006) and Hanford site profile documents.

Although NIOSH found that it is not possible to completely reconstruct radiation doses for all workers for the period from October 1, 1943 through June 30, 1972, NIOSH intends to use 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 Hanford during the period from October 1, 1943 through June 30, 1972, but who do not qualify for inclusion in the SEC may be performed using these data as appropriate.

6.3 Class Parameters Associated with Infeasibility

Combining the time periods associated with the operations listed above with the HHS designated SEC class for the 300 Area for the period October 1943 through August 1946 yields a summative time period for identified dose reconstruction infeasibilities of October 1, 1943 through June 30, 1972. Therefore, NIOSH recommends that the class include the period from October 1, 1943 through June 30, 1972.

The operational areas associated with this evaluation include the 100 Area, the 200 Area, and the 300 Area of the Hanford site. Due to undocumented worker movements across the site and limited claimant-specific information during the period under evaluation, NIOSH is unable to eliminate any specific worker from any of the potential exposure scenarios based on worker job descriptions. NIOSH recommends that the class definition include all Areas and all covered workers during the specified time period.

7.0 Summary of Feasibility Findings for Petition SEC-00152

There are currently two classes of Hanford workers associated with the previous NIOSH evaluations of SEC petition SEC-00057, for which the Secretary of Health and Human Services (HHS) has designated inclusion in the Special Exposure Cohort. This report evaluates the feasibility for completing dose reconstructions for employees at Hanford from October 1, 1943 through June 30, 1972. NIOSH determined that during this period members of this class may have received radiation exposures as previously determined for the existing SEC classes (HHS, 2007; HHS, 2008) as well as radiation exposures from intakes of polonium, thorium, and neptunium. NIOSH lacks sufficient information, which includes biological monitoring data, sufficient air monitoring information, or sufficient process and radiological source information that would allow it to estimate the potential internal exposures to which the proposed class may have been exposed. NIOSH determined that it is likely feasible to reconstruct with sufficient accuracy the occupational medical dose received by Hanford workers.

NIOSH has documented herein that it cannot complete the dose reconstructions related to this petition. The basis of this finding demonstrates that NIOSH does not have access to sufficient information to estimate either the maximum radiation dose incurred by any member of the class or to estimate such radiation doses 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 Hanford during the period from October 1, 1943 through June 30, 1972, 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-00152

The health endangerment determination for the class of employees covered by this evaluation report is governed by EEOICPA and 42 C.F.R. § 83.14(b) and § 83.13(c)(3). Pursuant to these requirements, if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, NIOSH must determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. The regulations require NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for a number of work days aggregating at least 250 work days within the parameters established for the class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

NIOSH has determined that members of the class were not exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. However, the evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic radiation exposures through intakes of polonium, thorium, and neptunium and from direct exposure to radioactive materials. Consequently, NIOSH is specifying that health was endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

9.0 NIOSH-Proposed Class for Petition SEC-00152

The evaluation defines a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. This class includes all employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked at the Hanford site in Richland, Washington, from October 1, 1943 through June 30, 1972, 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 included in the Special Exposure Cohort.

10.0 Evaluation of Second Similar Class

In accordance with § 83.14(a), NIOSH may establish a second class of co-workers at the facility, similar to the class defined in Section 9.0, for whom NIOSH believes that dose reconstruction may not be feasible, and for whom additional research and analyses is required. If a second class is identified, it would require additional research and analyses. Such a class would be addressed in a separate SEC evaluation rather than delay consideration of the current claim. At this time, NIOSH has not identified a second similar class of employees at the Hanford site for whom dose reconstruction may not be feasible.

11.0 References

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Attachment 1: Data Capture Synopsis

Table A1-1: Summary of Holdings in the SRDB for Hanford			
Data Capture Information	Data Capture Description	Completed	Number Uploaded into SRDB
<p><u>Primary Site/Company Name:</u> Hanford DOE; 1942-present</p> <p><u>Other Site Names:</u> Hanford Engineer Works (HEW)</p>	<p>Air samples, ALARA program, americium and neptunium recovery processes, annual and repetitive neutron survey assignment and exposure reports, bioassay reports and procedures, neutron badge log sheets, chest X-ray requirements, concentration neptunium-237 relative to plutonium-239, radiation overexposure and contaminated injury events, departmental progress and activity reports, dose data from Hanford DuPont personnel meter exposure records applicable to the Mancuso Study, DTPA treatment data, environmental data, exposure evaluations, technical basis manuals, fission products separation from urine salts, highly enriched fuel program, hot particle data, incident investigations, internal dose evaluation procedures, neptunium data, neutron and gamma field surveys, neutron database, neutron dosimeter data, production of U-233 from thorium and production of polonium, radioactive shipment records, radiological surveys and log sheets, reactor power levels, safety analysis reports, special work permits, stack gas particulates report, thorium experience, uranium bioassay program, and a whole body counting manual.</p>	07/02/2009	3,606
State Contacted: NA	<p><u>Note:</u> Contacting the state was not considered necessary since Hanford is an active DOE site and cooperated with relevant data collection.</p>	09/03/2009	0
CDC Interlibrary Loan	Radiation safety in the Manhattan Project.	04/01/2008	1
Claimant	Environmental monitoring data, study of uranium losses, in vivo cross comparison studies, how plutonium specimen disintegrates under pressure, behavior and characteristics of radioactive debris from Chinese nuclear weapons tests, and information on reducing the concentration of radioisotopes in effluent water.	06/01/2009	9
Curtiss-Wright	Plutonium Fuel Development Laboratory special procedure, packaging archive waste containers for shipment, and shipping records and orders.	04/26/2009	10
Dade Moeller & Associates	Investigation of personal monitoring film, accidental irradiated fuel discharge from N Reactor, radiation exposures of Hanford workers dying from cancer and other causes, Hanford historical production history of all reactors, separations at the Purex Plant, and organizational charts.	08/11/2008	42
Department of Energy (DOE) Germantown	Calculations and poisonous effects of various materials, communications between AEC and Westinghouse, procedures and policies, discussion with Westinghouse personnel regarding oxide fuel materials, feasibility of Hanford to provide U-233, fission distribution in uranium oxide pellets,	06/18/2008	62

Table A1-1: Summary of Holdings in the SRDB for Hanford			
Data Capture Information	Data Capture Description	Completed	Number Uploaded into SRDB
	forecast for discharge of thorium, Hanford codes, irradiation of thorium, Manhattan District history books, monthly material accountability, NYOO uranium operations flow chart, organizational charts, radiation exposures, thorium as pile flattening material, trip reports, U-233 production, waste recovery centrifuge test, and radiation surveys.		
Department of Labor/Paragon	Vitrification of Niagara Falls Storage Site residues, progress reports, shipment of thorium oxide slugs, tabulation of Sylvania's outstanding orders, and disposition of 763 reject Hanford slugs.	12/30/2008	21
DOE Argonne National Laboratory - East	Evaluations of intake and deposition based on bioassay data, meetings on proposed high temperature oxide pile, and plutonium scrap processing.	04/04/2008	7
DOE General Atomics	Nuclear material shipping and receiving reports, health physics reports, and Medical Department reports.	01/09/2006	2
DOE General Electric Vallecitos	TLD and film badge technical information.	05/18/2007	2
DOE Hanford Declassified Document Retrieval System (DDRS)	Alpha hand monitoring, americium recovery, radiological surveys, attenuation of a neutron and gamma ray beam, calibrated neutron sources and area monitoring chambers, power levels versus Po-210 production, dosimetry and spectrometry of fast neutrons by radio-activation, dosimetry in the Hanford gamma irradiation facilities, double moderator neutron dosimeter, iodine release, sensitivities of reactor neutron flux monitors at B Reactor, measurements produced neptunium, integrated thermal neutron exposure, determination of the radon content of water, neptunium recovery, neutron dosimetry and irradiation of solids, neutron flux monitor detector, power and exposure levels of Hanford reactors, notes on dosimetry problems, production statistics of N Reactor operations, radiation exposure data, radiological incidents, safety analysis report, slow and fast neutrons, scintillation count-rate and dose-rate meter, monthly and weekly reports, thorium U-233 separation, and tritium exposures.	04/30/2009	1,368
DOE Hanford Downwinders Database	100 areas technical activities report, environs report, and a daily summary for the 200 west area.	04/02/2007	4
DOE Lawrence Berkeley National Laboratory	Status report on Materials Testing Accelerator.	02/07/2007	1
DOE Legacy Management Considered Sites	Decontamination and decommissioning of the Westinghouse Nuclear Fuel Facility at Cheswick, PA and progress reports.	10/25/2007	4
DOE Legacy Management - Grand Junction	Mixed waste oil by Hanford, C and D materials produced at Hanford, contract documents, concentrations of plutonium in soil, production reports, elimination of feed production at Linde and Electro Metallurgical, enriched uranium account report, extrusion of uranium for Hanford, history of	07/11/2008	67

Table A1-1: Summary of Holdings in the SRDB for Hanford			
Data Capture Information	Data Capture Description	Completed	Number Uploaded into SRDB
	refinery operations and site material accountability, Manhattan District history, metal requirements for X-10, monthly progress reports, waste characterization data and management of radioactive tank waste, rolled uranium and fabrication yields, scrap material from Chapman Valve, shipment of rods, spent nuclear fuel project 324 and 327 Buildings material classifications, and Tonawanda progress reports.		
DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database)	Personnel at risk in plutonium-238 operations, re-irradiation of radium, effluent information system/onsite discharge information system, evaluation of high assay Pu-238 oxide for use in fabrication of plasma-fired microspheres, external radiation levels, development and use of actinium, Hanford wastes, production machining of uranium, incineration of radioactive solid wastes, Battelle occupational exposure history, production reports, radiological incidents, shipping documents, standard operating procedures, thorium accountability documents, U-233 as a contaminant in thorium nitrate solution, and a symposium on occupational health experience and practices in the uranium industry.	11/26/2008	87
DOE Los Alamos National Laboratory (LANL)	Isotopic content and specific activity of pile-produced plutonium, radioactive waste disposal and related issues, monitoring of certain personnel for internal plutonium contamination, and quantities and characteristics of the contact handled low-level mixed waste streams for the DOE complex.	12/13/2007	6
DOE Nevada Test Site	Photographs of workers in protective clothing.	04/26/2005	2
DOE Oak Ridge Operations Vault	Film badge and exposure correspondence.	06/21/2004	2
DOE Office of Scientific and Technical Information (OSTI)	Ionium, uranium-232, and thorium-228 properties, applications, and availability, survey of irradiation facilities, meeting on collection and measurement of radioactive air contaminants, preliminary hazards report for a reactor experiment at CANEL, and proposed Purex Separations Plant study.	09/17/2008	6
DOE OpenNet	Absorption and translocation by plants of radioactive elements from "jangle" soil, human radiation experiments information, air pathway report, Columbia River pathway dosimetry report, fission product iodine during early Hanford operations, hematological effects on heavily irradiated Japanese fishermen, history of the Inhalation Toxicology Research Institute, Manhattan District history book, monthly activities, products, operations and progress reports, Newell Stannard interview with Robert Thomas, Bikini fall of 1978, plutonium release estimates, radiation dose estimates from Hanford radioactive material releases to the air and the	02/29/2008	75

Table A1-1: Summary of Holdings in the SRDB for Hanford			
Data Capture Information	Data Capture Description	Completed	Number Uploaded into SRDB
	Columbia River, radiological incidents, and a thyroid disease study.		
DOE OSTI Energy Citations	Pinellas Plant feasibility study, radioactive waste shipments to Hanford, characterization of Uo-2 and Pu-O2 powders, process description for the retrieval of earth-covered transuranic waste containers, decontamination and decommissioning information, wrap module 1 sampling and analysis plan, and monthly activity reports.	04/08/2009	12
DOE OSTI Information Bridge	Risk of transporting plutonium oxide and liquid plutonium nitrate, wastes in and around early reactors, contaminated sites and facilities within the DOE complex, environmental management report, external dosimetry technical basis, americium recovery and purification, fuel element technical manual, fuels preparation and operations monthly reports, hazard analysis for 300 area N Reactor fuel fabrication and storage facility, human radiation experiments, monthly processing and research reports, plutonium safety evaluation report, hazards evaluation for enriched uranium-thoria, processing E-metal in the 200 areas, production tests, protective measures for personnel manual, radiation control standards and procedures, radiation survey report, reprocessing uranium - molybdenum alloy fuels, survey of worldwide light water reactor experience with mixed uranium-plutonium oxide fuel, 300 area history, low-level waste vitrification melter, exponential pile measurements in graphite-uranium lattices, iodine-131 releases, and ionium for radioisotope preparation status report.	11/19/2008	139
DOE Paducah Gaseous Diffusion Plant	Radioactivity analysis reports, air samples, trace element analysis, ash results, power results, and sample data unspecified.	06/15/2005	2
DOE Rocky Flats Environmental Technology Site (RFETS)	External dosimetry technology TBD (2003).	10/03/2003	1
DOE Savannah River Site	Irradiation of thorium slugs, use of pocket dosimeters, progress reports, thorium irradiation program, exposure to gamma radiation, thorium slug failures, production summary 100 and 200 areas, dosimetry visitors cards, polonium production, health physics procedures, exposure data for Hanford test badges, Hanford film badges exposed in the plutonium facility at the Savannah River Site, Savannah River Site lab notebook, and a health physics methods logbook.	01/29/2009	27
DOE West Valley Demonstration Project	Shipping of Pu product to Hanford.	11/28/2006	2
[Name redacted] Personal Files	Procurement history and a monthly operations report.	11/04/2008	2
EML Library	Hanford uranium bioassay program.	02/15/2005	1
Google	Aero radioactivity survey and aerial geology of the Hanford area, B	07/25/2009	40

Table A1-1: Summary of Holdings in the SRDB for Hanford			
Data Capture Information	Data Capture Description	Completed	Number Uploaded into SRDB
	Reactor museum association history of 100-B/C reactor operations, separation of the uranium isotopes by gaseous diffusion, General Atomics hot cell facility decontamination, monthly reports, health-physics, instrumentation, and radiation protection, history of the department of nuclear science and engineering, Manhattan Project history, nuclear weapons data-book, process of a chain reaction in uranium producing plutonium, Project Trinity, FUSRAP reports, annual site environmental report with radiological doses and releases, and U.S. nuclear weapons research, development, testing, and production.		
Missouri Department of Natural Resources	Individual interviews, history of the St. Louis Uranium Processing Plant, and a feasibility study for the St. Louis site.	10/03/2008	3
NARA - Atlanta	Annual reports, review of the existing reactor confinement program at Hanford, assay of uranium by-product materials, contamination of express cars (Hanford shipment), Dragon Project irradiations, human chromosome aberrations, investigative report on X-ray overexposure, list of commission and contractor personnel by professional category, Madison Square area monthly accountability reports, employee monitoring, monthly progress reports, report on health and safety aspects of recycle material, DOE indoor radon study, summary of work done at Berkeley, fission of uranium-235 or plutonium-239, and product specifications.	05/23/2008	31
National Technical Information Service (NTIS)	Feasibility studies of the correlation of lifetime health and mortality.	08/21/2006	2
New York State Department of Environmental Conservation	Nickel plating of uranium slugs.	09/25/2008	1
NRC Agencywide Document Access and Management (ADAMS)	NRC's decommissioning procedures and criteria, environmental statement on the use of recycled plutonium in mixed oxide fuel in light water cooled reactors, and a survey of waste solidification process technologies.	01/22/2008	3
Oak Ridge National Laboratory (ORNL)	Safe handling of unprocessed metal, DuPont employee roster, and Mancuso Study data.	04/16/2007	26
Office of Compensation Analysis and Support (OCAS)	Analysis of ignition testing on K-west basin fuel, storage of highly enriched uranium, DOE Ohio sites recycled uranium project report, effects of rolling on the crystallography and metallography of uranium, excretion of Pu-239 in a patient with a plutonium contaminated injury, generation and flow of recycled uranium, highly enriched uranium working group report, list of classified documents, production and recovery of U-233 from thorium, reactor production tests, standardization of gold and indium foils and the absolute neutron flux determination, technical activities, research and development reports, testing prediction capabilities of an I-131	08/04/2008	48

Table A1-1: Summary of Holdings in the SRDB for Hanford			
Data Capture Information	Data Capture Description	Completed	Number Uploaded into SRDB
	terrestrial transport model, and USTUR active registrants living and deceased.		
ORAU Team	Basis for thoron concentration and doses for thoria processing, bounding estimate of neutron dose based on measured photon dose around single pass reactors at Hanford, correspondence on the Mallinckrodt badge program, documented communication, dosimetry data, human radiation exposures related to nuclear weapons industries, annual reports, ORAU Team generated spreadsheets, radiation dose estimates and hazard evaluation for inhaled airborne radionuclides, Savannah River Site thorium processing timeline, study of atmospheric contamination in the Melt Plant, technical basis documents, and workplace measurements of neutron and photon doses.	08/21/2009	71
Pacific Northwest National Laboratories (PNNL)	Hanford environmental surveillance, ORAU Team project spreadsheets, tracking of exposure to airborne radioactive material, radiation protection procedures, whole body counter activities, measurement and evaluation of internal exposure, in vivo bioassay methods and sensitivities, comparative metabolism of intravenously injected promethium in swine and humans, preparation of project proposal for new rolling mill, uranium rolling studies, and fixed time estimation of counting rates with background corrections.	09/06/2006	22
San Bruno Federal Records Center (FRC)	Hanford's request for data on the UCRL radiation exposure incident of April 1954.	01/10/2006	1
SAIC	Radiation exposures by AEC Operating Office and summaries of whole body radiation exposures.	09/02/2004	3
Southern Illinois University, Edwardsville, IL	Mallinckrodt uranium information, disposal of radioactive wastes in the metropolitan St. Louis area, metal billets for Hanford, inspection of uranium casting facilities, and remelting of Hanford uranium scrap at Mallinckrodt.	11/01/2008	10
University of Colorado Norlin Library	Background measurements of alpha particle emitters at Rocky Flats.	08/20/2003	1
University of Rochester Miner Library	Quarterly review report.	10/14/2008	1
Unknown	Nuclear track emulsions and analysis of urine for very low level plutonium, bioassay procedures, calculation of neutron flux and exposure in Hanford reactors, film badge comparison, decontamination and decommissioning, detection limits, bioassay data, environmental reports, estimation of plutonium lung burden by urine analysis, experience with a routine fecal sampling program, external dosimetry manual, fast neutron dose, fission	01/22/2009	590

Table A1-1: Summary of Holdings in the SRDB for Hanford

Data Capture Information	Data Capture Description	Completed	Number Uploaded into SRDB
	product analysis of urine, gamma dose measurement with film badges, external dosimetry program, monthly reports, site history, medical X-ray exposure study, estimating neutron exposure, neutron exposure at the 105-DR Reactor, personnel film badge neutron dosimeter, plutonium, neptunium, and americium waste tank inventories, radiation protection aspects of work with promethium-147, radioactive contamination reports and investigations, radionuclide releases, thyroid disease study, nuclear track dosimeters exposed to plutonium sources, shipping documents, site maps, stack release data, summary of recorded external radiation doses, Tiger Team assessment, and whole body counter activities.		
Washington University Libraries - St. Louis	Fast neutron monitoring of personnel.	04/27/2007	1
Total			6,424

Table A1-2: Internet Searches for Hanford

Database/Source	Keywords	Hits	Number Uploaded into SRDB
<p>Note: The normal prescribed publicly accessible internet database searches were not performed for Hanford. This action was not taken due to Hanford being an active DOE site and the cooperation of the site in collecting relevant data. Limited internet searches were conducted to attempt to locate data not available via the site's resources.</p>			

Table A1-3: OSTI Documents Ordered for Hanford

Document Number	Document Title	Date Requested	Date Received
HW-81964 OSTI ID: 4020618 SRDB: 59951	Beta-Gamma Dose Rates From U232 in U233 dated 1964	01/05/2009	02/24/2009