SEC Petition Evaluation Report
Petition SEC-00196

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

Petitioner Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition A Receipt Date	DOE/AWE Facility Name
SEC-00196	83.14	November 3, 2011	Brookhaven National Laboratory

NIOSH-Proposed Class Definition
All employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked in any area at Brookhaven National Laboratory in Upton, New York, from January 1, 1980 through December 31, 1993, 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.

Related Petition Summary Information			
SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
SEC-00113	83.13	Brookhaven National Laboratory	Class added to the SEC: January 1, 1947 through December 31, 1979

Related Evaluation Report Information	
Report Title	DOE/AWE Facility Name
SEC Petition Evaluation Report for Petition SEC-00113	Brookhaven National Laboratory

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Evaluation Report Summary: SEC-00196, Brookhaven National Laboratory

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 in any area at Brookhaven National Laboratory in Upton, New York, from January 1, 1980 through December 31, 1993, 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.

Feasibility of Dose Reconstruction Findings

NIOSH lacks sufficient information, which includes *in vivo* and *in-vitro* monitoring data, to allow it to estimate with sufficient accuracy the potential internal exposures to various radionuclides to which the proposed class may have been subjected. NIOSH finds that it is likely feasible to reconstruct occupational medical dose for Brookhaven National Laboratory workers with sufficient accuracy.

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

- Principal sources of internal and external radiation for members of the proposed class included exposures to plutonium, uranium, tritium, fission and activation products, transuranic radionuclides, nuclear reactors, linear accelerators, radiography equipment, and a wide variety of other radioactive materials.

- NIOSH previously determined in its evaluation of petition SEC-00113 that it did not have access to sufficient urinalysis, air sampling data, *in vivo*, or *in vitro* analyses records to estimate internal exposures for the period evaluated (NIOSH, 2009). In 2010, DHHS designated the following class for inclusion in the SEC:

  All employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked at Brookhaven National Laboratory in Upton, New York, from January 1, 1947 to December 31, 1979, 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 (DHHS, 2010).

- NIOSH has determined that, due to undocumented worker movements across the site and limited claimant-specific information pertaining to work locations, it is unable to eliminate any specific worker from potential exposure scenarios based on assigned work location. NIOSH has found that a determination cannot always be made as to whether or not an employee worked in technical areas with a history of radioactive material use, or whether an employee should have been monitored for radiological exposures.

- Through the course of on-going dose reconstruction and research associated with the SEC-00113 class period, NIOSH has determined that, due to on-going difficulty of consistently obtaining all requested personnel monitoring records for individual BNL claims, NIOSH is unable to estimate with sufficient accuracy internal exposures for workers at Brookhaven National Laboratory during the time period from January 1, 1980 through December 31, 1993.

- NIOSH found that external exposure, including occupational medical doses, could be reconstructed for all employees between January 1, 1980 and December 31, 1993, consistent with the determination in the evaluation of SEC-00113 (NIOSH, 2009).

- 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 in any area at Brookhaven National Laboratory during the period from January 1, 1980 through December 31, 1993, 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 various radionuclides and from direct exposure to radioactive materials or radiation-producing equipment. 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 SEC.

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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 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]

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

[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.

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 in any area at Brookhaven National Laboratory in Upton, New York, from January 1, 1980 through December 31, 1993, 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. During this period, employees at this facility were involved in a wide variety of scientific programs, including research and development in:

- the fundamental structure and properties of matter.
- the interactions of radiation, particles and atoms with other atoms and molecules.
- the physical, chemical, and biological effects of radiation and of other energy-related environmental pollutants.
- the production of special radionuclides and their medical applications.
- energy- and nuclear-related technology.
- the assessment of energy sources, transmission, and uses, including their environmental and health effects.

The evaluation responds to Petition SEC-00196 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. 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).

[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.

4.0 Radiological Operations Relevant to the Proposed Class

The following subsections summarize the radiological operations at the Brookhaven National Laboratory from January 1, 1980 through December 31, 1993 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

Brookhaven National Laboratory is located in Upton, New York on a 5,265 acre site. Most of its main facilities comprise an area of approximately 900 acres near the center of the site (see Figure 4-1). Outlying facilities cover about 550 acres and include the hazardous waste management facility (HWMF), agricultural research fields, landfill areas, and a sewage treatment plant. For the period evaluated by NIOSH, the Brookhaven National Laboratory workforce consisted of approximately 3480 workers at the end of 1993.

BNL's early research focused on advanced physics, but expanded into its current suite of research in the fields of medicine, biology, chemistry, physics, materials science, nuclear engineering, and environmental research. BNL was organized into departments that provided research nuclear reactors, particle accelerators, and engineering facilities in support of the Biology, Chemistry, Physics, Medical, Applied Science, Accelerator, and Applied Mathematics Departments (ORAUT-TKBS-0048). BNL activities have been well-documented over the years and detailed descriptions are generally available in the public domain. Due to the large amount of information available for the time period under evaluation, only brief summaries of the available information are provided within this report. The following descriptive subsections are drawn from the *Summary Site Profile Document for the Brookhaven National Laboratory,* ORAUT-TKBS-0048.

Source: NIOSH, 2009

Figure 4-1: Aerial View of Brookhaven National Laboratory.

Research Reactors

BNL's reactor operations began in 1950 with the Brookhaven Graphite Research Reactor (BGRR), a research reactor used for peaceful scientific exploration in the fields of medicine, biology, chemistry, physics, and nuclear engineering. The BGRR operated until 1968. In 1965, its capacity was surpassed by the High Flux Beam Reactor (HFBR). The higher thermal neutron fluence of the HFBR permitted shorter irradiation times and expanded support for researchers of all disciplines, from solid state physics to art history. The HFBR ceased operations in December 1996.

Medical Research Center

Medical research at BNL began in 1950 with the opening of one of the first hospitals devoted to nuclear medicine. It was followed by the Medical Research Center (MRC) in 1958 and the Brookhaven Medical Research Reactor (BMRR) in 1959. The first nuclear reactor built exclusively for medical and biological research, the BMRR came on line on March 15, 1959 and operated until October 2000.

The Radiation Therapy Facility (RTF)

The Radiation Therapy Facility (RTF) is operated jointly by the BNL Medical Department and the State University of New York at Stony Brook. The RTF is a high-energy dual X-ray mode linear accelerator (LINAC) used for the radiation therapy of cancer patients. This accelerator was designed to deliver therapeutic beams of X-rays and electrons for conventional and advanced radiotherapy techniques. This facility began providing therapy in 1991 and is currently operational.

Particle Accelerators

High-energy particle physics research began in 1952 with the Cosmotron, the first particle physics accelerator to achieve billion-electron-volt energies. The Cosmotron operated from 1953 to 1966. In 1960, the Alternating Gradient Synchrotron (AGS), a large accelerator, was built to surpass the Cosmotron's capabilities. The AGS is capable of accelerating protons to energies up to 30 GeV and heavy ion beams to 15 GeV/amu. The AGS achieved full energy in 1960 and is still in use.

Between 1967 and 1970, the Tandem Van de Graaff, 60-inch Cyclotron, and Vertical Accelerator were used for medium-energy physics investigations and for special isotope production. The heavy ions from the Tandem Van de Graaff can also be injected into the AGS for physics experiments. The Tandem Van de Graaff began operating in 1970 and continues to the present.

The Heavy Ion Transfer tunnel connects the coupled Tandem Van de Graaff and the AGS. The interconnection of these two facilities permits intermediate mass ions to be injected into the AGS where they can be accelerated to an energy of 15 GeV/amu. These ions then are extracted and sent to the AGS experimental area for physics research. The AGS Booster is a circular accelerator with a circumference of 200 meters that receives either a proton beam from LINAC or heavy ions from the Tandem Van de Graaff. The Booster accelerates proton particles and heavy ions before injecting them into the AGS ring. The Booster receives protons and heavy ions from the LINAC and Tandem Van de Graaff facilities to increase their intensity for delivery to the AGS.

The Brookhaven LINAC Isotope Producer (BLIP) became operational in 1973. Protons from the LINAC are sent via an underground beam tunnel to the BLIP facility where they strike various target metals. These metals, which become activated by the proton beam, are then processed at the Target Processing Laboratory for use in radiopharmaceutical development and production.

The targets are cooled by a continuously-recirculating water system. The BLIP facility underwent significant upgrades in 1996 in support of the Brookhaven Isotope Research Center (BIRC) program. The 200 MeV Proton Linear Accelerator serves as a proton injector for the AGS and also supplies a continuous beam of protons for radionuclide production by spallation reactions in the BLIP.

In 1982, the National Synchrotron Light Source (NSLS) began operation. The NSLS guides charged particles in an orbit. As the electrons spin inside a hollow donut-shaped tube called an electron storage ring, they give off light called synchrotron light. This light, which can be detected by specialized instruments, is used to study the properties of matter. The NSLS uses a linear accelerator and booster synchrotron as an injection system for two electron storage rings that operate at energies of 750 MeV vacuum ultraviolet (VUV), and 2.5 GeV (X-ray). The synchrotron radiation produced by their stored electrons is used for VUV spectroscopy and for X-ray diffraction studies.

Brookhaven's newest accelerator facility is the Relativistic Heavy Ion Collider (RHIC), completed in 1999 (the large ring at the top of Figure 4-1).

Department of Applied Science/Nuclear Energy

The Target Processing Laboratory (also called the Hot Laboratory in 1993) officially opened on January 15, 1951 and is still in use today. The original purpose of the central facility was to provide appropriately-shielded areas for research with large amounts of radioactive material. The "hot" area of the Hot Laboratory included five hot cells, three chemical-processing hot cells, and three high-level hot cells for handling and processing radioactivity in gaseous, liquid, or solid form.

The High Intensity Radiation Development Laboratory (HIRDL), which contained (in the early 1970s) a million-curie range of Co-60 and Cs-137 sources, was used for source development and experimental process irradiations. A Co-60 pool in the HIRDL facility operated at lower activity levels into the 1990s. Currently, very little mission-specific work is occurring within the HIRDL.

Waste Management

Waste management has been intrinsic to BNL from the beginning of operations. In late 1949, the Health Physics & Safety Summary Monthly reports began to include a section titled "Waste Disposal" or "Waste Disposal and Reclamation," and later, "Waste Management." The group was composed of Safety and Environmental Protection (S&EP) personnel assisted by personnel from the Maintenance Department. The S&EP personnel remained quite constant over time, as seen in organizational charts captured from the site (BNL, 1960-1966).

4.2 Radiation Exposure Potential from Operations

Given the broad scope of BNL activities involving ionizing radiation, workers were potentially exposed to external photon, beta, and/or neutron radiation from a variety of sources. Potential sources included radioactive materials, nuclear reactors, particle accelerators, and X-ray-generating equipment.

4.2.1 Photon

Many BNL radiological operations involved gamma and X-ray photon radiation fields. Potential photon exposure sources to workers would have been associated with the following:

- Gamma-emitting fission and/or activation products resulting from reactor and accelerator operations
- Production and use of high-intensity gamma sources, typically Co-60 and Cs-137
- Radioisotopes used in medical research and treatment
- X-ray-generating machines
- Calibration sources of americium, thorium, radium, cobalt, cesium, and other miscellaneous radionuclides

The very high-intensity sources were handled in a shielded configuration or shielded facility. Highly-contaminated or activated equipment was handled using standard health physics controls of time, distance, and shielding.

4.2.2 Beta

BNL research and operations did not focus on activities with beta-particle-emitting source terms. However, beta radiation over a broad range of energies could have been encountered from activation and fission products from reactor and accelerator operations as well as other radionuclides, such as those used as calibration sources and for medical treatment and research.

Whether a beta source is considered an internal hazard or both an internal and external hazard depends on the maximum energy of the beta emission for a given radionuclide, the shielding employed, and the use of protective clothing. Higher-energy beta-emitters present both an external hazard (to the skin) and an internal hazard. In many cases, beta-emitting radionuclides also emit characteristic photons.

4.2.3 Neutron

There were many sources of potential neutron radiation exposure associated with BNL operations. The source of the neutron emissions from these activities and potential worker exposure would have been associated with the following:

- Accelerators
- Operating reactors, especially those designed to create neutron beams
- Neutron-generating sources, either via the α,n reaction (PuBe, RaBe, PoBe) or via spontaneous fission sources (Cf-252)

The broad scope of BNL neutron-generating activities resulted in a correspondingly extensive neutron energy spectrum. The spectrum ranged from the thermal energy region of 0.025 eV through the fission spectrum of 0.1 to 6.0 MeV (predominant energy of 0.7 to 1.0 MeV), and included high energy, accelerator-produced neutrons greater than 14 MeV. Additional information is available in ORAUT-TKBS-0048.

4.2.4 Radioactive Source Materials

Many of the radioactive source materials handled at BNL were alpha-particle emitters. Although alpha particles do not present an external exposure hazard, the prevention of internal alpha exposures was recognized from the onset of site operations as the most significant radiological internal hazard protection challenge (BNL, 1947, pdf p. 2).

There were also a variety of beta- and beta-gamma-emitting radionuclides that were potential internal dose hazards at BNL. Table 4-1 provides a summary of radionuclides that are recognized as potential contributors to internal dose to BNL workers. This list is not all-inclusive, but it does include all of the most significant sources of internal radiation dose. Radionuclides that emit both alpha and beta(-gamma) are simply listed as alpha-emitters because the alpha emission will be the predominant component of the internal dose. Likewise, beta-gamma emitters are simply listed as beta emitters.

Table 4-1: Potential Contributors to BNL Internal Dose and Their Primary Modes of Decay	
Radionuclide	**Primary Mode of Decay**
H-3	Beta
Mixed Fission Products (MFP)	Beta
Mixed Activation Products (MAP)	Beta
Th-232	Alpha
Uranium	Alpha
Plutonium	Alpha
Am-241	Alpha
Po-210	Alpha

4.2.4.1 Uranium

Depleted and natural uranium compounds were commonly used in ton quantities at BNL. Uranium in various enrichments, including highly-enriched, was used in critical assemblies and reactors.

Approximately 110 tons of natural uranium fuel slugs were fabricated into aluminum-clad fuel rods by the BNL metallurgy group. During the operation of the BGRR (1950-1958), there were 28 reported ruptures of BGRR fuel and one rupture of a uranium oxide (U_3O_8) sample that was being irradiated for the radioiodine-production program (ORAUT-TKBS-0048, pdf p. 20). Leaking or spent fuel elements were moved to a pool-type underwater storage area (“canal”) where they were chopped up for shipping for off-site disposal. Corrosion and oxidation of the natural fuel slugs occurred in the fuel transfer and storage canal. Over 2414 fuel elements generated during a 12-year period were shipped from the canal. The contaminated water, filter media, and back-flush from the ion exchange columns were pumped to the storage tanks at the Waste Concentration Facility, Building 811. In 1959, the natural uranium was replaced with a smaller enriched uranium core. The BGRR was partially decommissioned in 1972. The exhaust ducts from the reactor and to the stack have been sealed from the fans. The fans remain in their cells. The intake duct, exhaust duct, and fans are grossly contaminated from the fuel failures (ORAUT-TKBS-0048, pdf p. 21). The HFBR and MRR were operated with enriched uranium fuel. Both facilities have now been closed and the spent fuel sent off site. Un-irradiated fuel for the three reactor facilities was stored in secure vaults (DOE, 1996, pdf p. 39).

In about 1950, BNL started investigating the feasibility of processing spent fuel elements by dissolving them in fluorine-based interhalide compounds. After a laboratory study, a distillation plant was constructed in 1951; an engineering test facility was designed in 1953. On May 15, 1957, a series of explosions of liquid bromine trifluoride, uranium hexafluoride, and uranium metal occurred in Building 801. One worker was seriously burned and several others were treated and released. Approximately 50 pounds of natural, un-irradiated uranium were released to the atmosphere (Volatility, 1957).

Uranium was also used in critical assemblies for nuclear reactor research. Research and development on Liquid Metal Fuel Reactor (LMFR) technology took place in Building 820 from 1957-75. A simulated reactor with a core of uranium dissolved in bismuth was studied (ORAUT-TKBS-0048, pdf p. 36). Radiation and Chemical Technology Buildings 526-527 contained unknown quantities of uranium of various enrichments. This area originally housed a criticality facility for reactor physics (ERDA, 1977, pdf p. 48; Liverman, 1977). U-233 was used in the Th-U-233 Fuel Rod Development Program in 1962. ORNL was to fabricate and send 1000 rods to BNL for study in its critical experiments facility. A total of approximately 30 kg of U-233 was in the uranium-thorium mixture (Special Nuclear, 1963). The U-233 generally contains U-232 as an unavoidable contaminant. In 1974, U-233 targets were irradiated at the cyclotron using alpha particles, but only in milligram amounts (Progress Report, September 1974).

Uranium was fabricated into targets for irradiation in reactors and accelerators. The uranium was machined in the Hot Machine Shop (Building 530, replaced by Building 462). Uranium targets were reprocessed. For example, from March 1952 to June 1960 there was a program at the Hot Laboratory to produce I-131 by acid-dissolution of irradiated uranium samples. U-234 foils (100 μg) were irradiated with deuterons to produce Pu-234 in 1975 (Hull, 1977).

Depleted uranium (DU) was used in target areas of the AGS (ORAUT-TKBS-0048, pdf p. 25). A muon shield consisting of over 15 tons of DU was set up for a 1966 AGS experiment (HP Summary, May 1966). DU was cleaned for an experiment at CERN (Conseil Européen pour la Recherche Nucléaire, or European Council for Nuclear Research) in 1985-86.

Building 1008 was the Uranium Calorimeter Factory in 1988. One calorimeter module housed fifty 102-inch by 25-inch uranium plates. There were enough plates to construct 20 modules (Lazo, 1988b). NIOSH has obtained no further information about what went on in this factory.

In 1995, an inventory showed that DU was present in eleven buildings in quantities from a few grams to nearly 27,000 kilograms. Natural uranium was located in four buildings in quantities from 10s of grams to nearly 85 kilograms (Miltenberger, 1995).

4.2.4.2 Fission and Activation Products

Fission and activation products have been present at BNL from the earliest days to the present. Some fission and activation products were the intended outputs of the BNL reactors and accelerators. For example, targets were irradiated to produce materials for basic research, medical research, or source manufacture. Other fission and activation products were produced as unintended byproducts of these operations; for example, activation of facilities and equipment, cooling air activation, or activation of contaminants in targets. BNL also imported fission and activation products from other AEC/DOE facilities and commercial sources.

By 1948, 25 different isotopes were already in use, well before the start of operations at the BGRR (Cowan, 1948). From March 1952 to June 1960, there was a program at the Hot Laboratory to produce I-131 by acid-dissolution of irradiated uranium samples. During the late 1950s and early 1960s, a number of radioisotopes were in development and/or production at what was then known as LEAF (Low Energy Accelerator Facility), which included the cyclotrons and the Van de Graaff accelerator (Flood, 1982). The primary purpose of these isotopes was medical research. In the 1970s, the BLIP was set up to use the excess capacity of the 200 MeV Linac to produce radionuclides for the development of new radiopharmaceuticals, mostly for diagnostic purposes. The Chemistry Linac Irradiation Facility (CLIF) operated in a similar way, but it was used for irradiations of a few hours or less (ERDA, 1977). The Hot Laboratory and other locations were used to process targets (ORAUT-TKBS-0048, pdf p. 40). In 1971-1972, the High Intensity Radiation Development Laboratory (HIRDL), which contained million-curie range Co-60 and Cs-137 sources, was used for source development and experimental process irradiations (ORAUT-TKBS-0048).

The above are just some examples of the many uses of fission and activation products used or produced at BNL. They ranged from small quantities of short-lived isotopes to significant quantities of long-lived material. Many of these activities only involved a few researchers in close contact with the materials. In addition, the isotopes produced for diagnostic medical use had short half-lives to reduce the dose to the patients. After discontinuation of the research, only the longer-lived material remained as residual contamination. Much of the equipment used was decontaminated or disposed of as waste. The primary exception was at the BGRR. In 2000, there were an estimated 1,400 Ci of Fe-55, 0.7 Ci of Co-60, 13 Ci of Sr-90, and 15.5 Ci of Cs-137 remaining in the BGRR complex due to operations with failed fuel (Musolino, 2000).

4.2.4.3 Tritium

Tritium was encountered in several forms: tritiated water (HTO), tritiated gas (HT), organically-bound tritium (OBT), and metal tritide (MT). H-3 appears to have been widely used in medical and biological research. Medical research involving OBTs started in the 1950s. Tritiated thymidine was injected into patients and animals in the mid-1960s (Flood, 1967). In 1967, bean plants were grown in 2 Ci/liter of HTO at Medical/Biology (HP Summary, April 1967). In 1969, after gross H-3 contamination of one of the organic chemistry labs, a reference states that urine samples and CAMs indicated that the form was H-3-labeled benzoic acid (HP Summary, April 1969). There was a long-running experiment with mice in the 1970s and disposal of large quantities of contaminated mouse litter was reported monthly (Progress Reports, 1974).

In 1972, H-3-contaminated vacuum pump oils were a problem, especially at the 3.5 MeV Physics/Chemistry Van de Graaff (Flood, 1972). When tritium ions were accelerated, approximately 200 Ci/month of HT was used (ERDA, 1977). The Hot Laboratory fabricated H-3 into accelerator targets. The tritium targets were used at the 18-inch cyclotron, the 50 MeV AGS LINAC, the 3.5 MeV Van de Graaff, the Tandem Van de Graaff, and the 200 MeV LINAC. Accelerator targets were in the form of SMTs, such as zirconium tritide. At Building 919 in 1973, the 80-inch bubble chamber facility had a 250 mCi gas chromatograph source as well as other sources up to 100 mCi (Bubble Chamber, 1973). Cooling water at the AGS became tritiated, especially at the target stations. The levels ranged from 1,000 pCi/L to 400,000 pCi/L. These were closed systems that were drained prior to 2009 (Lessard, 2009).

The amount of H-3 on site increased dramatically with the HFBR start-up in 1965. The HFBR was a 30-60 MW thermal heavy-water-moderated nuclear research reactor. Heavy water flowing in the core was exposed to a dense neutron field that activated the deuterium atoms in the water to produce tritium. The typical concentration was about 2 mCi of H-3 per cm^3 of heavy water. The form was HTO, and this was the most important source of H-3 exposure at BNL from 1965 to 1999. The second most important source was probably the 3.5 MeV Van de Graaff where H-3 tritium beams and targets were frequently used. High-beam currents of protons or deuterons would cause the H-3 to diffuse out of the zirconium targets and into the beam pipe and the surrounding area. Substantial build-up of contamination was noted in 1970 (HP Summary, February 1970). During the change-out of a leaking H-3 source bottle in 1971, levels reached 2000 MPC in the area of leak. However, the highest exposure to the workers involved was only 24 mrem (HP Summary, October 1971).

4.2.4.4 Thorium

Thorium was present at BNL starting in the 1950s, and was used primarily in nuclear engineering research. All references to thorium at BNL are to natural thorium (Th-232-series). Control and accountability procedures were set up indicating that thorium was to be handled as a source material like uranium (BNL, 1948; Fox, 1950). In 1959, a study was made of ThO_2 hazards as a result of the increased use of this material in the Nuclear Engineering Laboratory (HP Summary, May 1959). The MPC of $4x10^{-12}$ $\mu Ci/cm^2$ was taken from a proposed revision of NBS Handbook 52, making it “very hazardous”; appropriate arrangements were being made for containment and monitoring. Various chemical compounds and physical forms (including dispersible powders) were present (BNL, October 1957; BNL, December 1957; HP Summary, February 1959; Progress Report, March 1952; Progress Report, April 1952; Progress Report, May 1952; Progress Report, October 1952; Progress Report, November 1953; Progress Report, December 1953; Progress Report, June 1954; Progress Report, August 1954; Rice, 1966).

There is evidence that thorium operations were monitored by health physics staff. For example, in 1969, among the operations monitored was the change-out of filters in line with a Th-228 molecular beam apparatus in Chemistry (HP Summary, October 1969). In 1971, thorium foils were used in studies for a fission track personnel dosimeter (HP Summary, September 1971). In the mid-1970s, a “thorium cow” was in use at Bldg. 510. This is a device that concentrates the daughter products from thoron (notably Pb-212) by precipitation on a charged electrode. This device was used to produce calibration sources and at the Tandem Van de Graaff (Progress Report, January 1974; Progress Report, November 1975; Progress Report, December 1975). In 1986, five workers in the Department of Applied Science working with “thorium series (magma)” were identified for whole body counts (Lukas, 1986), indicating that a small thorium program still existed (magma apparently referred to geothermal-research-related samples containing trace amounts of thorium). An inventory of dispersible radioactive material in 1997 indicated that only microcurie amounts were still on site (Flores, 1998).

4.2.4.5 Plutonium

Plutonium was among the first safety concerns at BNL, probably because its hazards were well known by the time BNL was established. Its early uses are not well described, but seemed to involve studying its various properties. Due to the activation of uranium, plutonium was present in the fuel of the operating reactors; however, BNL fuel was sent to other sites for reprocessing (Van Horn, 1962-1963). Nevertheless, plutonium was present in the residual contamination of some facilities, particularly the BGRR, which had a history of operations with failed natural uranium fuel elements. There was also Pu in the fission product mixture processed by the waste handlers (HP Summary, March 1949). Plutonium was also contained in neutron sources at Medical, Chemistry, and the calibration facility (ORAUT-TKBS-0048, pdf p. 94).

The following list briefly summarizes known occurrences involving Pu at BNL:

- In January 1963, a leaking glass carboy containing gold in a solution contaminated with plutonium was received at BNL (AEC, 1963, pdf p. 68).

- In December 1963, plans were being prepared for the conversion of a gamma facility in the Hot Lab to a plutonium metallurgy laboratory to perform physical and chemical tests on cold and irradiated plutonium carbide fuels (Progress Report, December 1963).

- In 1966, a lathe contaminated with U-235 and Pu-239 (originally from Mallinckrodt) appears to have been used in the shops at BNL, (HP Summary, January 1966).

- In 1966, plutonium was also used in nuclear engineering research in the critical assembly area; plans were designed to prevent surface or airborne contamination or damage to the encapsulated source material (HP Summary, March 1966).

- In March 1967, four grams of Pu-239 in the forms of oxide and carbide were introduced into one of the glove boxes at the Hot Lab. The experiment consisted of vaporization of oxide in a closed system. The operation was reviewed and covered by health physics (Progress Report, February 1967).

- In 1970, three Pu vaporization experiments were conducted in the alpha-gamma facility (HP Summary, February 1970).

- In June 1971, 61 PuO_2-UO_2 pellets containing 439 grams of Pu were encapsulated by the Hot Lab health physics personnel in a new glove box facility set up for this purpose (HP Summary, June 1971).

- By September 1971, plutonium work at the Hot Lab appears to have ended since some of the equipment was being converted to use in the chemical processing of BLIP targets at the Hot Lab (HP Summary, September 1971).

- In 1996, there were still gram quantities of plutonium stored in an SNM vault (DOE, 1996, pdf p. 40).

- In 2000, a total of 1.22 Ci plutonium isotopes were estimated to remain in the BGRR complex (Musolino, 2000).

4.2.4.6 Americium

Americium is generally present at BNL as a byproduct of plutonium production/irradiation. There is also evidence that operations involving purified Am-241 took place on site during the time period under evaluation. In 1959, an Am-241-contaminated dry box from the criticality facility was partially cleaned prior to storage (HP Summary, May 1959). Americium sources were also used for calibrations (HP Summary, October 1964; HP Summary, April 1965; HP Summary, June 1965) and X-ray fluorescence studies (Progress Report, Oct-Nov 1983). In 1966, americium "in sizable amounts" was to be used in the critical assembly area; plans were designed to prevent surface or airborne contamination or damage to the encapsulated source material (HP Summary, March 1966). There is no subsequent mention of this material, which is likely an indication that no problems were experienced. Site interviews indicate that since 1989 Am-241 has only been present in μCi amounts for research projects (Personal Communication, 2008). An inventory of dispersible radioactive material in 1997 indicated that only microcurie amounts were still on site (Flores, 1998). However, it may still be present in residual contamination with plutonium isotopes. In 2000, a total of 0.072 Ci of Am-241 was estimated to remain in the BGRR complex (Musolino, 2000).

4.2.4.7 Polonium

Polonium was among the first radionuclides received at BNL. Apparently, polonium sources were initially used due to security issues associated with using plutonium sources (HP Summary, October 1949). The two most common uses appear to have been as an alpha source for basic research and as a Po-Be neutron source for calibrations and other purposes. The hazards of polonium were recognized early on; in 1947, safety precautions were published by groups using polonium sources (Salant, 1947).

A Po-Be source was requested as early as 1947 (Hayner, 1947). There was a 1949 request for a replacement polonium source to be used in a spectrometer (Lancaster, 1949). Initially, the sources were constructed using a thin nickel plating that could allow the polonium to diffuse through it, and some of these sources leaked (Cowan, 1947; Progress Report, April 1965). Two individuals acquired 20% of the maximum permissible body burden (MPBB) from an incident in August 1960 (Haworth, 1960; HP Summary, January 1961). In 1963, the Chemo Nuclear group worked with 10-Ci polonium sources. The operations manual for this work was reviewed by health physics and emergency instructions were brought up-to-date prior to use. Instrumentation for monitoring these experiments was checked and found to be in working order (Progress Report, September 1963). A Po-210 contamination incident also occurred on December 21, 1964 (Progress Report, January 1965). A physics experiment that involved 297 mCi of Po-210 was planned in 1966 (HP Summary, March 1966). The material was to be dissolved in hydrofluoric acid, placed in a sealed container in the alpha dry box at the Hot Lab, and then transferred to the Physics lab in a sealed bag. Documentation has not been located that indicates whether the experiment took place. An inventory of dispersible radioactive material in 1997 indicated that only microcurie amounts were still on site (Flores, 1998).

4.3 Time Period Associated with Radiological Operations

Per the DOE Office of Health, Safety and Security, the time period associated with DOE operations at the Brookhaven National Laboratory is from 1947 to present. There is already an existing class in the SEC for BNL from January 1, 1947 through December 31, 1979, a period that is not included in this evaluation. Beginning in 1980, internal dosimetry was no longer filed in individual worker files. The records repositories were group-specific and this decentralization of records has inhibited the efficient collection of complete sets of internal dosimetry records for the purpose of this evaluation.

Although an internal monitoring program appears to have been active throughout the period under evaluation, the program was not formally documented (Implementation Plan, 1991). Through its research and reviews, NIOSH has identified an internal monitoring procedure drafted by BNL in August 1993 (Reciniello, 1993). Although documentation available to NIOSH suggests there was an operational internal monitoring program during the period under evaluation, personnel data management practices (i.e., lack of centralized databases) preclude the summarization and presentation of total internal monitoring data availability. This is an issue at least up to the period when the internal monitoring procedure was implemented in 1993.

An assessment performed by the DOE Chicago Operations Office in December 1993 found the BNL HP program “in compliance with applicable DOE standards and acceptable professional practices.” This assessment detailed the level of compliance for the external dosimetry program, the internal dosimetry program, the radiation and contamination survey program, and the personnel radiological records program (HP Assessment, 1993).

4.4 Site Locations Associated with Radiological Operations

Among the major scientific facilities operated at the Laboratory to carry out the various scientific programs during the time period under evaluation were:

- The High Flux Beam Reactor (HFBR) that was fueled with enriched uranium, moderated and cooled by heavy water, and operated at a routine power level of 40 MW.

- The Medical Research Reactor (MRR), an integral part of the Medical Research Center (MRC) that was fueled with enriched uranium, moderated and cooled by natural water, and operated intermittently at power levels up to 3 MW.

- The Alternating Gradient Synchrotron (AGS), a proton accelerator that operated at energies up to 33 GeV.

- The 200 MeV Proton Linac, that served as an injector for the AGS. It also supplied a continuous beam of protons for radionuclide production by spallation reactions in the Brookhaven Linac Isotopes Production Facility (BLIP) and in the Chemistry Linac Irradiation Facility (CLIF).

- The Tandem Van de Graaff, Vertical Accelerator, and Chemistry Van de Graaff, that were used in medium-energy physics investigations as well as for special radionuclide production.

- The National Synchrotron Light Source project, that used a linear accelerator and booster synchrotron as an injection system for two electron storage rings operating at energies of 700 MeV vacuum ultraviolet (VUV) and 2.5 GeV (X-ray). It was used for spectroscopy in the VUV ring and for diffraction studies in the X-ray ring.

Although the above listed areas are specifically identified for the use of AEC-related radiological materials, documentation available to NIOSH does not indicate any definite boundaries between radiological and non-radiological areas for the period being evaluated. NIOSH is therefore unable to define individual worker exposure scenarios based on specific work locations within the Brookhaven National Laboratory site during the period under evaluation. Based on this information, NIOSH has considered all work areas in its review of BNL for this evaluation.

4.5 Job Descriptions Affected by Radiological Operations

The Personnel Monitoring Policy was to provide a radiation dosimeter to all workers who had the potential to receive external exposure (HP Procedures, 1948; Personnel Monitoring, 1948; Personnel Monitoring, unknown date; Pocket Chambers, 1952; Safety Manual, 1948; Use of Dosimetry, 1995). This policy was implemented by designating facilities that used radioactive materials or created radiation sources as “radiation areas” and requiring that all who entered must have a radiation dosimeter. The available records clearly indicate that this policy was being implemented throughout the operating history. However, this resulted in a segment of workers who were not externally monitored and for whom no radiation exposure records are available. This is consistent with industry practice, as there would have been workers whose duties did not require them to be near a radiation source and would not have been expected to have received radiation exposure in the location of their normal work assignment.

It should be noted that AEC/ERDA/DOE requirements specified that only those individuals expected to exceed 10% of the annual dose limit (or later, exceed 100 mrem/y) were required to be monitored. Some examples of the types of workers who may not have been monitored include: those in administrative positions whose normal work location was not in one of the facilities with designated radiation areas; construction trade workers whose projects were located in non-radiation areas; and engineers or scientific personnel whose duties did not require that they enter a radiation area. Personnel dosimeter monitoring data will not be available for such types of workers.

Through the course of ongoing dose reconstruction and research, NIOSH has determined that, due to undocumented worker movements across the site and limited claimant-specific information pertaining to work locations, it is unable to eliminate any specific worker from potential exposure scenarios based on assigned work location. NIOSH has found that a determination cannot always be made as to whether or not an employee worked in technical areas with a history of radioactive material use, or whether an employee should have been monitored for radiological exposures.

NIOSH has determined that the site-specific and claimant-specific data available for Brookhaven National Laboratory for the time period under evaluation are insufficient to allow NIOSH to determine that any specific work group was not potentially exposed to radioactive material releases or possible subsequent contamination.

NIOSH has insufficient information associating job titles and/or job assignments with specific radiological operations or conditions. Without such information, NIOSH is unable to define potential radiation exposure conditions based on worker job descriptions. Based on this information, NIOSH has considered all job titles/duties in its review of BNL for this evaluation.

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

As a standard practice, NIOSH completed an extensive database and Internet search for information regarding Brookhaven National Laboratory. 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 1 contains a summary of Brookhaven National Laboratory 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.

Detailed information regarding NIOSH's data capture efforts for the Brookhaven National Laboratory can be found in the related NIOSH evaluation report for SEC-00113 (NIOSH, 2009).

5.2 Worker Interviews

To obtain additional information in support of its 2009 evaluation of Petition SEC-00113, NIOSH interviewed nine former Brookhaven National Laboratory employees. Details regarding these interviews can be found in the *SEC Petition Evaluation Report for Petition SEC-00113, Brookhaven National Laboratory* (NIOSH, 2009). Additional interviews for the specific purpose of supporting this evaluation were not deemed necessary, and therefore, were not performed.

5.3 Internal Personnel Monitoring Data

The majority of the available internal monitoring data applicable to the evaluation time frame still exists in hard copy form, resides in multiple locations, and is primarily sorted into individual employee files. Consequently, a definitive assessment of total monitoring data available would only be possible through the perusal and tallying of each file's contents. Constraints on the retrievability of the data from the site, especially for internal monitoring data prior to 1980, precluded NIOSH's accomplishment of this task. However, NIOSH has extracted and electronically entered monitoring data found within the approximately 2300 documents that were captured from the site and other sources as of May 2009. Furthermore, NIOSH conducted two additional data capture exercises focused specifically on retrieving monitoring data from individual worker files; data available within those captured files has been summarized in this evaluation.

The results of the NIOSH data capture efforts provide the basis for the observed data availability summaries presented in the following subsections. It is important to remember that the data presented do not represent the actual total available monitoring data, but rather, a subset that was available within the retrieved documents. Therefore, the captured results expectably indicate temporal and data quantity gaps. Nevertheless, when coupled with numerous captured documents describing BNL health and safety practices, the retrieved data provide additional support for the existence of a comprehensive and conscientious worker monitoring program appropriately based on exposure potential. However, personnel monitoring data retrievability issues, which are compounded by the site's record-keeping practices over the years, present the most significant issues affecting this report's evaluation. It is apparent that there was a turning point in the BNL radiological program and record-keeping requirements at the beginning of 1980 (following a 1979 site assessment). Based on this information, the assessment of NIOSH's ability to bound dose for the class under evaluation is primarily focused on the ability of the site (or other applicable entity) to identify, retrieve, and provide (to NIOSH) the applicable BNL personnel internal and external monitoring data.

For much of the site's operational history, department/division health physics representatives designated personnel for participation in the internal dosimetry program (WBCs and/or urinalysis) using professional judgment. This judgment could also have included monitoring frequency (BNL, 1995; Holeman, 1999). Table 5-1 summarizes *in vivo* and *in vitro* monitoring practices and data storage media throughout the operational history of the laboratory. In general, *in vivo* and *in vitro* dosimetry was performed for initial employment checks, annual physicals, for employees engaged in higher-exposure-potential work, and incidents. Details regarding the various analyses used and the associated minimum detectable activities are presented in the BNL TBD for Occupational Internal Dose (ORAUT-TKBS-0048).

Table 5-1: Internal Dosimetry Timelines and Data Source Descriptions		
Type	**Dates**	**Description**
In vivo	1960 - 1991	Outputs are available from the whole-body counting system that was in place at the time (several whole-body counting systems were in place during this time period). This hard copy output is kept in personnel dose history files, some log books, and some medical records.
	1992-present	*In vivo* bioassay performed routinely for Reactor Division personnel, Waste Management personnel, BLIP, Facility Support personnel, and Environmental Restoration personnel. These data are all available as hard copy reports from the PM Whole Body Counter.
	1999-present	*In vivo* bioassay data are also available electronically on the workstation of the Whole Body Counting System. The data have been exported and provided to NIOSH ("ABACOS2K" files). The data indicate that 2815 counts were performed on 963 individuals.
In vitro	1947- 1984	Results were manually kept in hard copy in different formats. This hard copy is kept in personnel dose history files.
	1984- 2003	*In vitro* bioassay performed for RD personnel. 1984-1995 tritium dose data were sent to Landauer and recorded in the Landauer System. Data are available on microfiche and have been entered into a spreadsheet by NIOSH. Many tritium monthly summaries from 1992-1999 are available in hard copy reports. The tritium data are primarily in terms of dose. Urinalysis data consisting of over 11,000 tritium results and a few gamma scans from the on-site Analytical Services Laboratory ("ASL" Access database) have been captured for the period 1995-2003.
	1999- present	After 1999, hard copy records of all *in vitro* bioassay results are maintained in the whole body counter office. After 2000, electronic versions are also available and have been captured by NIOSH.
Other	1998-present	Doses from intakes are recorded in HPRS. Doses could be the result of either *in vivo* or *in vitro* bioassay or assigned from air samples.

Source: NIOSH, 2009

Attachment 1 of the evaluation report for SEC-00113 (NIOSH, 2009) presents a summary of whole body counts and urinalysis monitoring data pulled from documents that NIOSH captured during the initial general-evaluation data capture events (as of May 1, 2009), plus results obtained from two later data-pedigree-focused efforts. Results in Attachment 1 have been presented in terms of the number of employees monitored per year. Extraction and entry of individual analytical results was performed only for data found in documents captured prior to May 1, 2009 (over 2,300 documents at that time). These individual analytical results are presented and discussed in the following two subsections.

Although an internal monitoring program appears to have been active throughout the period under evaluation, the program was not formally documented (Implementation Plan, 1991). Through its research and reviews, NIOSH has identified an internal monitoring procedure drafted by BNL in August 1993 (Reciniello, 1993). Although documentation available to NIOSH suggests that there was an operational internal monitoring program during the period under evaluation, personnel data management practices (i.e., lack of centralized databases) preclude the summarization and presentation of total internal monitoring data availability. This is an issue at least up to the period when the internal monitoring procedure was implemented in 1993.

An assessment performed by the DOE Chicago Operations Office in December 1993 found the BNL HP program "in compliance with applicable DOE standards and acceptable professional practices." This assessment detailed the level of compliance for the external dosimetry program, the internal dosimetry program, the radiation and contamination survey program, and the personnel radiological records program (HP Assessment, 1993).

5.3.1 Urinalysis Monitoring Data

As mentioned above, Attachment 1 of the evaluation report for SEC-00113 contains a compilation of the available *in vitro* bioassay results from the SRDB documents collected and posted by NIOSH as of May 1, 2009. The raw data compilation contains just under 9100 individual urinalysis sample results from 1049 individuals. Though many documents were used as data sources, a large portion of the internal data captured have come from two sets of urinalysis records from 1952-1975 (Urinalysis Records, 1952-1975a; Urinalysis Records, 1952-1975b). These documents contain handwritten bioassay records for individual employees who were terminated. The records appear to include all bioassay results for each employee listed within the documents, not just their termination results. Of the results collected, 87% were surveys, 7% were incidents, 5% were unknown, and 1% were re-checks.

In general, results include the employee's name and at least one identifier such as "BNL Life Number," division/department, and/or a location indicator. Major work groups identified included:

- Accelerator
- Biology, Chemistry, and Physics
- Critical Assembly, Department of Applied Science, and Nuclear Engineering
- Health Physics, Safety & Environmental Protection, and Waste Management
- Hot Lab and Medical
- Plant Maintenance and Shops
- Pile and Reactor

The "BNL Bioassay Record" (Form 1720) was used from 1951 to 1967 and includes MFP, Sr-90, H-3, and alpha column headers. The other form used from 1952 to 1976 is titled "Urinalysis Record" and includes gross (gamma), Sr-90, and Po-210 column headers. There is also a "Gross Activity" form (BN-945), a "BNL H-3 Exposure Evaluation" form, and memos that detail incident follow-ups. Other radionuclides that were monitored for specific incidents included:

- Ag-110
- Am-241
- Au-198
- Ce-141/143 (urine and fecal)
- Co-60
- Hf-181
- Na-24
- P-32
- Ra-226
- Ru-106
- U-233
- Zn-65

5.3.2 Whole Body Counting Data

During this evaluation process, NIOSH captured and entered over 1900 individual WBC results from 686 individuals. The data range from 1960 (the start of whole-body counting at BNL) to 2000, after which the data are kept in the HPRS. The majority of the captured data are from the 1980s; currently, data gaps exist for the years 1963, 1965-69, 1971, and 1991.

The data came primarily from several sets of whole-body results (WBC Summaries, 1987; Whole-Body Results, 1973-1981; Whole-Body Results, 1975-1981; Whole-Body Results, 1979-1986; Whole-Body Results, 1988-1994; Whole-Body/Thyroid Results, 1983-1984). Much of the data was compiled from memos written from WBC program managers to S&EP representatives when they forwarded the WBC results for employees working in their respective areas.

Typical radionuclides measured included: Cs-137, Co-58/60, Zn-65, Fe-59, Mn-54, and Be-7. There are also results for Cs-134, Ce-141/144, Ba/La-140, and the radioiodines. Results for lung and thyroid dose were also captured.

In general, results include the employee's name and at least one identifier such as "BNL Life Number," division/department, and/or a location indicator. There is some uncertainty regarding the WBC identifiers and work locations, but the data were cross-matched with the *in vitro* data or organizational charts when possible. Major work groups identified included:

- Accelerator
- Biology, Chemistry, and Physics
- Critical Assembly, Department of Applied Science, and Nuclear Engineering
- Health Physics, Safety & Environmental Protection, and Waste Management
- Hot Lab and Medical
- Plant Maintenance and Shops
- Pile and Reactor

5.4 External Personnel Monitoring Data

From the beginning of operations that may have involved radioactive material (in 1947), exposure to external radiation appears to have been consistently monitored throughout all years of operation at BNL. Table 5-2 summarizes the period of use, type of dosimeter, MDL, and exchange period.

Table 5-2: Minimum Detectable Levels for Photon, Beta, and Neutron Dose

Period of Use	Dosimeter	MDL (mrem)[a]	Exchange Frequency
Start-up through 1954	Multi-element film + NTA	40	Weekly Monthly
1955 through 1995	Multi-element film +NTA	30	Monthly
1996 to present	Harshaw 8814 and 8806 TLD + CR-39	10	Monthly
Start-up through 1995	NTA film[b]	~50	Weekly Monthly
1996 to present	CR-39[b]	~20	Monthly

Source: ORAUT-TKBS-0048

[a] Estimated MDLs for each dosimeter in the workplace even though many doses were reported at less than the MDL.

[b] Processing done by R. S. Landauer.

Table 5-3 provides a more specific listing of the types of monitoring performed at various times throughout BNL's history, the methods/materials used, how the data were recorded, and in what manner the data are available for retrieval for creating a worker's exposure history. The table shows that BNL periodically changed the monitoring methods to adopt better technologies for performing personnel monitoring.

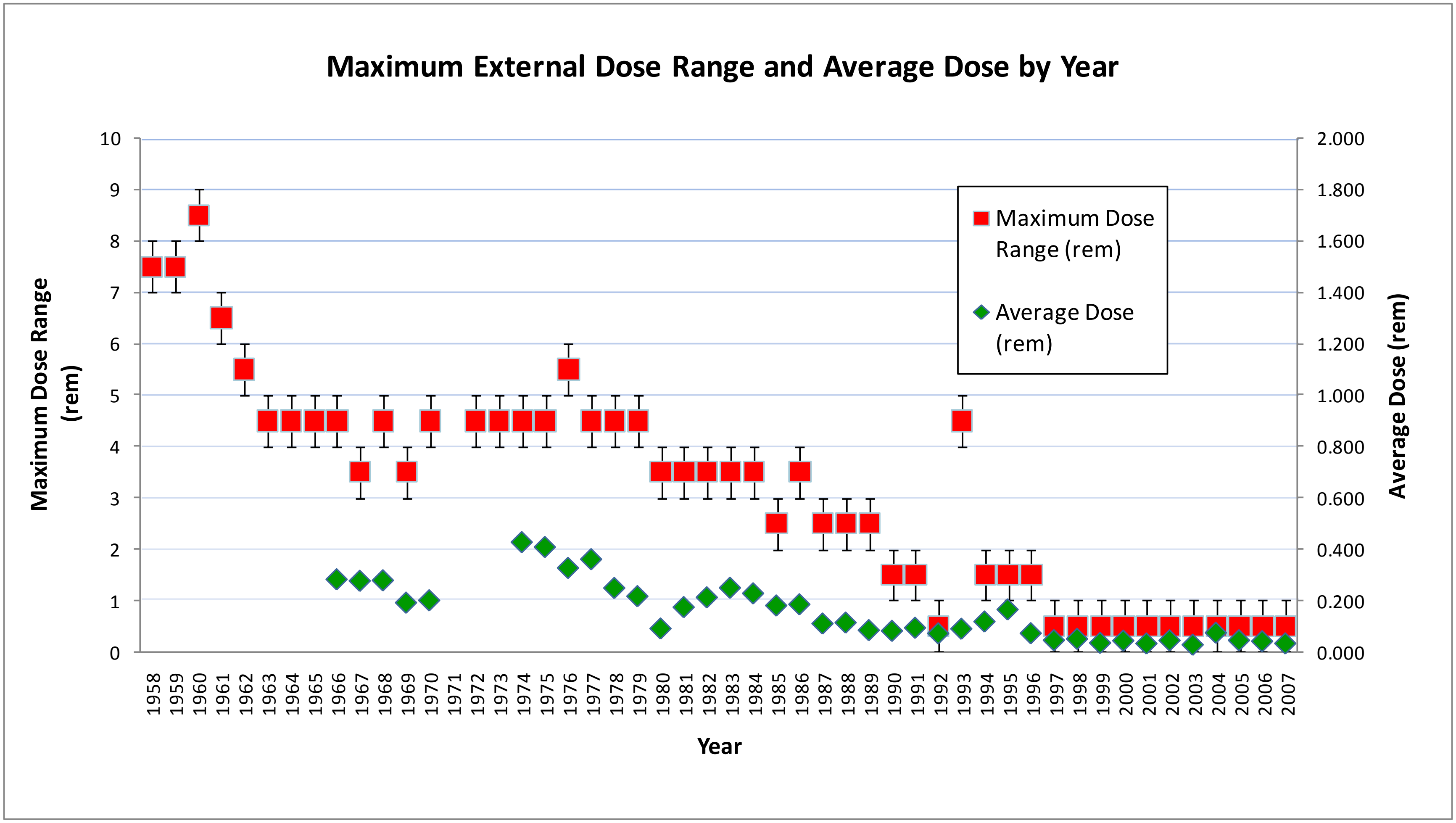
Table 5-3: External Dosimetry Timelines and Data Source Descriptions

Type	Dates	Description
Whole Body Badges	1947- 1965	BNL film badges: BNL read its own data and recorded data on personnel cards.
	1965- 1984	BNL film Badges: BNL read its own data and recorded data in a computer. These data are now available only in hard copy.
	1985- 1995	Landauer read Landauer film badges and stored data on their system. These data are now available on microfiche and paper monthly reports. Summary data for lifetime Dose of Record for personnel have been entered in HPRS.
	1996 –present	BNL implements TLDs, reads its own badges, and stores data in HPRS.
Ring Dosimetry	1947- 1965	BNL ring badges: BNL read its own data and recorded it on personnel cards.
	1965- 1984	BNL ring badges: BNL read its own data and recorded it in a computer. These data are available only in hard copy.
	1985- 1995	Landauer read Landauer rings and stored data on their own system. These data are now available on microfiche.
	1996 –present	Landauer read Landauer rings and transmitted the data to BNL. These data are stored in HPRS.
Environmental Monitoring	1947 – mid 1998	4 TLD-200 (calcium fluoride) 1cm x 1cm chips placed in a brass sphere which was then placed in a small plastic bottle with string attached.
	Mid 1998 – present	Harshaw 8807 with TLD 2211 cards.
Area Monitoring	1947- 1965	BNL film badges: BNL read its own data and recorded it on personnel cards.
	1965- 1984	BNL film badges: BNL read its own data and recorded it in a computer. These data are now available only in hard copy. Landauer read Landauer badges and stored data on their own system; these data are now available on microfiche. Summary data for personnel have been entered in HPRS.
	1996 –present	BNL implements TLDs, reads its own badges, and stores the data in HPRS.
Neutron Dosimetry	Pre-1984	BNL whole-body film badges used NTA films for neutron measurement.
	1985 - 1995	Landauer whole-body badges used combinations of NTA films, CR39, and Lexan for neutron monitoring.
	1996 - present	BNL Harshaw 8806 TLD badges used a TLD-600 element in all badges with the addition of Landauer-supplied CR39 and Lexan (discontinued after June 1997) when high-energy neutron monitoring at the Alternating Gradient Synchrotron (AGS) was desired.

Although the generally decentralized nature of BNL's radiation monitoring program has resulted in difficulty obtaining complete historical internal monitoring data sets, external monitoring summary data are available for the entire evaluation time period with the exception of the summary report for 1971. External results for individual employees are available for 1971, but the annual summary report was not discovered during the NIOSH data capture efforts.

Radiation exposure data were submitted annually to the AEC/ERDA/DOE in accordance with reporting requirements. Attachment 2 of the evaluation report for SEC-00113 (NIOSH, 2009) displays these data (except for 1971) and demonstrates that a significant number of workers were monitored every year. These data (from 1974 to 2007) were collected from the annual reports available on the DOE REMS website, and from similar annual reports found among BNL records (prior to 1974) (AEC, 1970; AEC, 1972; AEC, 1973; WBC Summary, 1960; WBC Summary, 1961; WBC Summary, 1964; Whole-Body Results, 1965-1969).

Figure 5-1 shows the dose distribution in the monitored population, indicating the maximum exposure range measured each year as well as the average exposure received by individuals with measureable exposure. Data provided to AEC/ERDA/DOE are reported in terms of individuals receiving a dose within a given range with 1 rem increments. The Maximum Dose Range presented in Figure 5-1 represents the maximum range for which at least one individual had a reported dose. Average dose data were not available in the summary reports for the years 1958-65 and 1971-73. Figure 5-1 shows that the maximum exposure range went from around 7-9 rem in the late 1950s down to around 4-5 rem from 1963 through the 1970s, and then slowly ramped down through the 1980s (2-4 rem) and 1990s (0-2 rem). Since 1990, the maximum exposure range has been 0-1 rem. For those years for which average dose data are available, the values were around 1-2 rem until 1980, after which the averages were generally below 1 rem.



Source: Data extracted from the following references: AEC, 1970; AEC, 1972; AEC, 1973; WBC Summary, 1960; WBC Summary, 1961; WBC Summary, 1964; Whole-Body Results, 1965-1969.

Figure 5-1: Maximum External Dose Range and Average Dose by Year

The Personnel Monitoring Policy was to provide a radiation dosimeter to all workers who had the potential to receive external exposure (HP Procedures, 1948; Personnel Monitoring, 1948; Personnel Monitoring, unknown date; Pocket Chambers, 1952; Safety Manual, 1948; Use of Dosimetry, 1995). This policy was implemented by designating facilities using radioactive materials or creating radiation sources as "radiation areas" and requiring all who entered to have a radiation dosimeter. The available records clearly indicate that this policy was being implemented throughout the operating history. However, this resulted in a segment of workers who were not externally monitored and for whom no radiation exposure records are available. This is consistent with industry practice, as there would have been workers whose duties did not require them to be near a radiation source and would not have been expected to have received radiation exposure in the location of their normal work assignment.

It should be noted that AEC/ERDA/DOE requirements specified that only those individuals expected to exceed 10% of the annual dose limit (or later, exceed 100 mrem/y) were required to be monitored. Some examples of the types of workers who may not have been monitored include: those in administrative positions whose normal work location was not in one of the facilities with designated radiation areas; construction trade workers whose projects were located in non-radiation areas; and engineers or scientific personnel whose duties did not require that they enter a radiation area. Personnel dosimeter monitoring data will not be available for such types of workers.

NIOSH has identified that personnel dosimeter monitoring data for reconstructing external doses are available for the entire time that BNL has been operational. These data include extensive external monitoring results, including neutron exposure data.

5.5 Workplace Monitoring Data

As a part of BNL's radiation protection program, it is evident that extensive monitoring of airborne radioactive dust has been regularly performed. In addition, air monitoring for tritium was performed and charcoal cartridges were used to sample for iodines. Information supporting these conclusions can be found in many captured documents. For example:

- *Air Samples* provides results for air samples taken during an operation that welded percussion pins onto uranium plates (Lazo, 1988a).

- *Respirator Use by RCG Personnel* discusses air samples taken to verify that respiratory protection was not required (Reciniello, 1992).

Burns & Roe was contracted by BNL to conduct an appraisal of airborne monitoring in 1991. The appraisal identified where airborne monitoring was satisfactory, where some improvements were desirable, and where airborne monitoring was not required because only small amounts of radioactivity were being used in the operations (BNL, 1990-1991a; BNL, 1990-1991b).

Although evidence of an extensive air monitoring program has been found, very few monitoring results from this program have been located. As indicated in the references above, results for a few isolated situations have been located, but data that reflect the daily air sampling results that would be needed to reconstruct potential worker exposure have not been located. The evidence suggests that, in general, airborne issues at the reactors, labs, and accelerators were very infrequent, thus resulting in a casual approach to record-keeping. The inability to locate comprehensive results limits the viability of using air monitoring results in the dose reconstruction process. Considering the limited air monitoring data available for the site at this time, further assessment of potential internal dose using air sample data will not be included in this evaluation report.

5.6 Radiological Source Term Data

Sources of radiation doses to members of the evaluated class included, but were not limited to, plutonium, uranium, tritium, fission and activation products, transuranic radionuclides, nuclear reactors, linear accelerators, and radiography equipment. The source term and activity data available to NIOSH are inadequate to supplement the dose reconstruction process for the performance of sufficiently-accurate dose reconstructions for the BNL class under evaluation in the absence of personnel or workplace monitoring data.

Additional information regarding the BNL source term data available to NIOSH can be found in the related evaluation report for BNL petition SEC-00113 (NIOSH, 2009), and the BNL Technical Basis Document (ORAUT-TKBS-0048).

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.

Despite the existence of organized occupational monitoring departments at BNL, some aspects of the personnel monitoring programs have been decentralized for much of the site's history. This decentralization is particularly applicable to internal exposure monitoring record maintenance. Monitoring requirements were determined primarily within specific departments or divisions (e.g., Reactor Division) based on work area and specific activity. These requirements were accomplished via assignment of health physicists to specific BNL work areas. The health physicists determined worker monitoring requirements under their purview based on their judgment of exposure potential. After analysis, personal monitoring results were returned to the area health physicists for comparison to standards in existence at the time, for assessment of safety adequacy, and for guidance for future monitoring. Internal monitoring results were frequently stored only in files located at the various site work areas. Records have also been stored in individual workers' files, medical files, or vendor files that, in turn, may exist in several different locations on site or in off-site archives.

These personnel data management practices (i.e., lack of centralized databases) preclude the summarization and presentation of total internal monitoring data availability because of the inability of the site to efficiently or effectively retrieve and produce the data. In addition to complicating the data availability assessment, BNL's data management practices have significantly affected the ultimate retrievability of internal monitoring data for the period prior to 1993 (based on the NIOSH efforts documented in this report). Retrievability issues were also a prevalent subject discussed in the previous site evaluation report for petition SEC-00113 (NIOSH, 2009). Data collected by NIOSH during an independent data capture was not included in record sets provided by BNL in response to requests for the monitoring records of specified former workers. In addition, an internal assessment aimed at evaluating BNL's compliance with the guidance given in the DOE RadCon Manual recognized the difficulties created by the decentralized records and pointed to them as a factor in designating BNL as being in only partial compliance with the radiological records directives given in the DOE RadCon Manual (Review, 1992).

Although an internal monitoring program was active throughout the period under evaluation, the program was not formally documented (Implementation Plan, 1991). As discussed earlier in this report, NIOSH has identified an internal monitoring procedure drafted by BNL in August 1993. Per the DOE RadCon Manual, this procedure required internal monitoring for any employee who had the potential to receive an annual internal exposure of 100 mrem or greater. The BNL internal monitoring procedure further specified which types of workers could be expected to receive such an exposure based on the nature of their job duties (Reciniello, 1993).

It is noteworthy that external radiation monitoring and the associated records have historically been more centralized. This may be due in part to the relatively low internal exposure potential for most work performed at BNL. From the beginning, an entity known as the "Personal Monitoring Group" collected and compiled all site external monitoring data for inclusion into external exposure summary reports, as required by the AEC/DOE.

Consolidation of BNL monitoring records is an ongoing effort at BNL. Data storage technology, of course, has greatly improved since the first data were collected in 1947. Of note is the fact that, as early as 1990, a DOE Tiger Team Assessment of the BNL Radiation Protection Program remarked that "the external and internal dosimetry programs are adequate to assess workers' radiation exposures… Internal radiation exposures are adequately assessed by use of whole body counters, thyroid counters, and urine analyses" (Tiger Team, 1990). An assessment performed by the DOE Chicago Operations Office in December 1993 found the BNL HP program "in compliance with applicable DOE standards and acceptable professional practices." This assessment detailed the level of compliance for the external dosimetry program, the internal dosimetry program, the radiation and contamination survey program, and the personnel radiological records program (HP Assessment, 1993).

Some later assessments have been critical of some aspects of the BNL Radiological Protection Program (Assessment, 1999). However, the majority of these criticisms point to isolated incidences of noncompliance rather than evidence of a systemic problem with the program. Findings directed at documentation issues within the program admit that procedures exist and had been implemented for individual aspects of the internal dosimetry program, but the evaluators listed as a concern the absence of a single, overarching procedure to link the independent segments together. The only finding in regards to recordkeeping listed as a result of this assessment was the inability of a clerk to locate prior revisions of the internal dosimetry procedures (Assessment, 1999). Other findings, such as shortfalls in procedures for reporting doses to individuals or the lack of cohesiveness between BNL procedures and technical basis documents do not have an effect on NIOSH's ability to reconstruct doses for individuals.

The launch of the Health Physics Record System (HPRS) can be considered the most significant technology change to the program thus far. The HPRS was launched in 1996 with a phased implementation between March 1995 and January 1996. Prior to that time, data were kept on hard copy or in vendor files.

Although documentation suggests that an internal monitoring program was active and documented during the period under evaluation, personnel data management practices (i.e., lack of centralized databases) preclude the summarization and presentation of total internal monitoring data availability. Based on data retrievability issues for personal internal monitoring data, NIOSH has concluded that it does not have access to sufficient personnel monitoring, workplace monitoring, or source term data to estimate potential internal exposures to various radionuclides during the period of DOE operations evaluated in this report (i.e., 1980 through 1993 - 1993 marking the procedural implementation of a revised internal monitoring program). Consequently, NIOSH finds that it is not feasible to estimate, with sufficient accuracy, internal exposures to various radionuclides 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 January 1, 1980 through December 31, 1993, 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). Partial dose reconstructions for individuals employed in any area at Brookhaven National Laboratory during the period from January 1, 1980 through December 31, 1993, 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 various radionuclides could not be reconstructed for a dose reconstruction referred to NIOSH by the Department of Labor (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.

However, NIOSH has determined that, based on the available information, there is nothing that currently disputes its ability to reconstruct external exposures, including occupational medical doses, for all employees between January 1, 1980 and December 31, 1993, which is consistent with the determination in the evaluation of SEC-00113 (NIOSH, 2009).

6.3 Class Parameters Associated with Infeasibility

Some aspects of the personnel monitoring programs have been decentralized for much of the site's history. This decentralization is particularly applicable to internal exposure monitoring record maintenance. Monitoring requirements were determined primarily within specific departments or divisions (e.g., Reactor Division) based on work area and specific activity.

These personnel data management practices (i.e., lack of centralized databases) preclude the summarization and presentation of total internal monitoring data availability. In addition to complicating the data availability assessment, BNL's data management practices have apparently adversely affected the ultimate retrievability of internal monitoring data collected prior to 1993. Retrievability issues became evident as a result of a previous site evaluation. Data collected by NIOSH during an independent data capture was not included in record sets provided by BNL in response to requests for the monitoring records of specified former workers.

An assessment performed by the DOE Chicago Operations Office in December 1993 found the BNL HP program "in compliance with applicable DOE standards and acceptable professional practices." This assessment detailed the level of compliance for the external dosimetry program, the internal dosimetry program, the radiation and contamination survey program, and the personnel radiological records program (HP Assessment, 1993). NIOSH therefore recommends that the class include the time period from January 1, 1980 through December 31, 1993.

Although the High Flux Beam Reactor, Medical Research Reactor, Alternating Gradient Synchrotron, Brookhaven Linac Isotopes Production Facility, Chemistry Linac Irradiation Facility, Van de Graaf facilities, and National Synchrotron Light Source are specifically identified for the use of AEC-related radiological materials, documentation available to NIOSH does not indicate any definite boundaries between radiological and non-radiological areas for the period being evaluated. NIOSH recommends that the proposed worker class definition include ALL buildings and locations during the specified time period.

Although the BNL Personnel Monitoring Policy was to provide a radiation dosimeter to all workers who had the potential to receive external exposure, NIOSH has determined that the site-specific and claimant-specific data available for BNL for the time period under evaluation are insufficient to allow NIOSH to determine that any specific work group was not potentially exposed to radioactive material releases or possible subsequent contamination. NIOSH has insufficient information associating job titles and/or job assignments with specific radiological operations or conditions. Without such information, NIOSH is unable to define potential radiation exposure conditions based on worker job descriptions. NIOSH therefore recommends that the proposed worker class definition include all workers at BNL during the specified time period.

7.0 Summary of Feasibility Findings for Petition SEC-00196

This report evaluates the feasibility for completing dose reconstructions for employees at Brookhaven National Laboratory from January 1, 1980 through December 31, 1993. NIOSH determined that members of this class may have received radiation exposures from both internal and external sources of radiation. NIOSH lacks sufficient information, which includes *in vivo* and *in vitro* monitoring data that would allow it to estimate the potential internal exposures to which the proposed class may have been exposed.

NIOSH has documented herein that it cannot complete the dose reconstruction 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.

NIOSH has determined that sufficient information exists and is readily retrievable to allow for the reconstruction of external exposures, including occupational medical doses, for all employees between January 1, 1980 and December 31, 1993, consistent with the determination in the evaluation of SEC-00113 (NIOSH, 2009).

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 in any area at Brookhaven National Laboratory during the period from January 1, 1980 through December 31, 1993, 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-00196

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 radionuclides 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-00196

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 in any area at Brookhaven National Laboratory in Upton, New York, from January 1, 1980 through December 31, 1993, 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.

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 Brookhaven National Laboratory for whom dose reconstruction may not be feasible.

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Review, 1992, *Review of Radiation Control Manual*, Brookhaven National Laboratory; August 14, 1992; SRDB Ref ID: 48474

Rice, 1966, *Summaries of Fuels and Materials Development Programs*, draft copy; edited by William L. R. Rice; March 1966; SRDB Ref ID: 21847

Safety Manual, 1948, *Summary of Responsibilities in Regard to Radiation Safety*, memorandum from F. P. Cowan to the Radiation Safety Committee Members; Brookhaven National Laboratory; March 1, 1948; SRDB Ref ID: 50634

Salant, 1947, *Precautions in Handling Radioactive Sources*, correspondence to the Nuclear Interaction Group (P-32); E. Salant; November 18, 1947; SRDB Ref ID: 50602

Special Nuclear, 1963, *Special Nuclear Material Draft*, Brookhaven National Laboratory; April 4, 1963; SRDB 45051, pdf p. 3

Tiger Team, 1990, Appendices, *Tiger Team Assessment of the Brookhaven National Laboratory*; U.S. Department of Energy, Environment, Safety and Health; DOE/EH—0140-Vol.2; June 1990; SRDB Ref ID: 48283

Urinalysis Records, 1952-1975a, *BNL Urinalysis/Bioassay Records from September 5, 1952 through February 12, 1975*; SRDB Ref ID: 48221

Urinalysis Records, 1952-1975b, *BNL Urinalysis/Bioassay Records from May 28, 1952 through September 22, 1975*; SRDB Ref ID: 48224

Use of Dosimetry, 1995, Use of Dosimetry, N. Contos; Brookhaven National Laboratory; FS-SOP-4020; September 1, 1995; SRDB Ref ID: 50587

Van Horn, 1962-1963, *Various Correspondence Regarding BNL Permits*; B. L. Van Horn; June 11, 1962 through May 9, 1963; SRDB Ref ID: 6517, pdf pp. 103-119

Volatility, 1957, *Explosion at Brookhaven National Laboratory*, office memorandum to K. E. Fields from M. Eisenbud; U.S. Atomic Energy Commission, New York Operations Office; June 7, 1957; SRDB Ref ID: 6319, pdf pp. 8-33

WBC Summary, 1960, *Summary of Whole Body Radiation Exposures to External Penetrating Radiation Accumulated During the Year 1960*, U.S. Atomic Energy Commission, New York Operations Office; 1960; SRDB Ref ID: 13786, pdf p. 44

WBC Summary, 1961, *Summary of Whole Body Radiation Exposures to External Penetrating Radiation Accumulated During the Year 1961*, U.S. Atomic Energy Commission, New York Operations Office; 1961; SRDB Ref ID: 13789, pdf p. 47

WBC Summary, 1964, *Summary of Whole Body Radiation Exposures to External Penetrating Radiation Accumulated During the Year 1964*, U.S. Atomic Energy Commission, New York Operations Office; 1964; SRDB Ref ID: 14442, pdf p. 12

WBC Summaries, 1987, Various summaries of whole body count results for 1987, Brookhaven National Laboratory; various dates in 1987; SRDB Ref ID: 50416

Whole-Body Results, 1965-1969, *1965-1969 Exposure of AEC and AEC Contractor Personnel to Whole-Body Penetrating Radiation*, various sites; Atomic Energy Commission (AEC); October 1965 through December 31, 1969; SRDB Ref ID: 13800

Whole-Body Results, 1973-1981, *BNL Whole-Body Counting Results from January 4, 1973 to December 12, 1981*; SRDB Ref ID: 48265

Whole-Body Results, 1975-1981, *BNL Whole-Body Counting Results from May 29, 1975 through November 20, 1981*; SRDB Ref ID: 48247

Whole-Body Results, 1979-1986, *BNL Whole-Body Counting Results from January 11, 1979 through October 23, 1986*; SRDB Ref ID: 48248

Whole-Body Results, 1988-1994, *BNL Whole-Body Counting Results from December 8, 1988 to July 22, 1994*; SRDB Ref ID: 50704

Whole-Body/Thyroid Results, 1983-1984, *BNL Whole-Body and Thyroid Counting Results from November 22, 1983 to October 26, 1984*; SRDB Ref ID: 48253

Attachment 1: Data Capture Synopsis

Table A1-1: Data Capture Synopsis for Brookhaven National Laboratory			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Primary Site/Company Name: Brookhaven National Laboratory DOE 1947-present Other Company Names: Associated Universities, Incorporated Brookhaven Science Associates Physical Site of the Site: 5320 Acres, 330 Buildings Site Population as of 10/2011: 2815 Employees 1500 Students 4354 Facility Users	Brookhaven histories and highlights, bioassay and whole body count reports, bioassay TBD for the Brookhaven Graphite Research Reactor (BGRR) decommissioning, High Flux Beam Reactor (HFBR) dose assessment reports, neutron dose distributions, Alternating Gradient Synchrotron (AGS) neutron dosimetry and surveys, internal dosimetry TBDs, medical x-ray QC report, incident reports, HFBR stack samples, the Radiation Control Manual, Health Physics summaries, HFBR whole body counts and bioassay results, dosimetry procedures, thyroid counting results, Tristan reports and dosimetry reports, individual employees' dosimetry results from their personnel monitoring and medical files, radiological and environmental surveys, facility progress and status reports, Marshall Islands reports, whole body counter logbooks, HFBR visitor registers, annual reports through 1970, accelerator radiation monitoring systems, decommissioning surveys and plans, a dosimetry database, and urinalysis results.	10/23/2011	2,910
State Contacted: NA	Note: Contacting the state was not considered necessary since Brookhaven is an active DOE site and cooperated with relevant data collection.	09/11/2009	0
Curtiss-Wright	A report from a radiological waste meeting hosted by Brookhaven.	03/10/2009	1
Department of Labor/Paragon	Material transfer reports and reports on uranium oxide reduction.	12/30/2008	21
DOE Argonne National Laboratory - East	A listing of Chicago Operations Office facilities, an ERDA neutron dosimetry conference, and 1961 weekly radiation safety summaries of Building 350.	03/26/2008	3
DOE General Atomics	Material transfer reports.	11/02/2005	1
DOE Germantown	Reports on beryllium hazards and proposed standards, a DOL document acquisition request, Brookhaven EEOICPA search procedures, Brookhaven EEOICPA records chart spreadsheet, and Manhattan District history excerpts.	03/07/2011	7
DOE Hanford	A 1967 Hanford report mentioning the potential sale of Co60 to Brookhaven, the December 1951 SF accountability report, and a 1952 scrap recovery report.	07/28/2011	3

Table A1-1: Data Capture Synopsis for Brookhaven National Laboratory			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
DOE Idaho National Laboratory (INL)/SC&A	Inventory and manufacturing statements and Chemical Processing Plant production monthly reports.	06/24/2010	46
DOE Lawrence Berkeley National Laboratory (LBNL)/SC&A	Safety problems and shielding of accelerators and treatment of radionuclide uptakes and intakes.	06/18/2009	3
DOE Lawrence Livermore National Laboratory (LLNL)	An accelerator characterization report and a 1984 estimate of Brookhaven's person-rem tritium dose.	06/10/2009	2
DOE Legacy Management - Grand Junction Office	Material transfer requests and reports, characterization of the BGRR canal, environmental reports, building survey and demolition reports, and operational reports.	08/25/2011	78
DOE Legacy Management - Morgantown	Operational progress reports, a 1983 pollution standards report, a site summary of safety and health needs, and a 1993 occurrence report.	01/27/2011	6
DOE Legacy Management - MoundView (Fernald Holdings, includes Fernald Legal Database)	Waste management reports, air emissions reports, AEC reports to Congress, AEC bioassay and analytical chemistry conference, a report on the uptake and effects of thorium dioxide, and The 1953 Health and Safety Division annual report.	05/13/2010	16
DOE Los Alamos National Laboratory (LANL)	Reports on mixed waste streams, AEC facilities information, photodosimetry, environmental impact statement - storage and disposition of weapons grade material.	12/06/2007	4
DOE Oak Ridge National Laboratory (ORNL)	A report on the machining of uranium for the Brookhaven Graphite Research Reactor and a summary on the Kilrod Project.	04/12/2007	2
DOE Oak Ridge Operations Records Holding Task Group	A 1955 site inspection,1947 film badge results, and transcripts of 1964 interviews.	12/14/2010	18
DOE Office of Scientific and Technical Information (OSTI)	A 2002 site environmental report, a reactor progress report, Tiger Team action plan, pile operating manual, survey of irradiation facilities, human radiation experiments, and observations on chronic lymphocytic leukemia.	08/06/2009	13
DOE Pacific Northwest National Laboratories (PNNL)	Results of the 1965 film badge reliability study.	12/29/2004	1
DOE Savannah River Site	Savannah River Site dosimetry visitor cards from the 1950's.	08/26/2008	7
[Name redacted]	A 1947 AEC recommendation for using vacations to recuperate from radiation exposure.	11/24/2009	1
[Name redacted]	A 1983 PNL dosimetry performance comparison.	08/13/2003	1
Federal Records Center (FRC) - Denver	A 1995 DOE occupational exposure report and the Photodosimetry Evaluation Book, Volume IV.	06/15/2010	2

Table A1-1: Data Capture Synopsis for Brookhaven National Laboratory			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Federal Records Center (FRC) - Kansas City	Film badge reports, individual employees' dosimetry information from their medical files, 1984-1985 High Flux Beam Reactor internal dose estimates, and exposure investigations.	07/01/2009	91
Federal Records Center (FRC) - San Bruno	Associated Universities organizations and objectives, summaries of fuels and materials development programs, air sampling at reactor sites, and potential hazards of specific accelerators.	02/01/2006	4
Hagley Museum and Library	Report of a 1951 health physics conference, reactor fuel reports, and Brookhaven's work with Hanford and Savannah River Site.	09/29/2010	7
Interlibrary Loan	The Atoms for Peace Program, Brookhaven papers describing radiopharmaceuticals and defining low radiation doses, environmental levels of radioactivity at AEC installations, radiation dosimetry at Brookhaven reactors, and a history of the Brookhaven Graphite Reactor.	10/24/2011	20
Internet	The 2003 DOE Occupational Radiation Exposure Report, accelerator physics, radiation dosimetry at Brookhaven reactors, and designation of a Brookhaven Special Exposure Cohort class.	3/9/2010	6
Internet - Comprehensive Epidemiologic Data Resource	No relevant documents identified.	11/20/2011	0
Internet - Defense Technical Information Center (DTIC)	The Brookhaven tritium leak, Alternating Gradient Synchrotron reports, application of the hot particle methodology to beta particle caused skin ulcers, and the 1949 safety manual.	10/3/2011	8
Internet - DOE	A 1994 DOE handbook on airborne radioactivity releases from nonreactor facilities.	12/4/2008	1
Internet - DOE Hanford Declassified Document Retrieval System (DDRS)	Monthly reports on Hanford/Brookhaven metallurgical projects, discussions of neutron monitoring and dosimetry, and nuclear reactor safety. These documents were added by site association review or previous data capture.	10/13/2011	8
Internet - DOE Legacy Management Considered Sites	No relevant documents identified.	10/13/2011	0
Internet - DOE National Nuclear Security Administration Library	No relevant documents identified.	10/13/2011	0
Internet - DOE OpenNet	New York Operations Office (NYOO) status reports, AEC reports to Congress, human experimentation fact sheet, a summary history of the nuclear weapons program. These documents were added by site association review or previous data capture.	10/14/2011	18
Internet - DOE OSTI	Report on the fabrication of U-233 fuel rods.	03/18/2009	1

Table A1-1: Data Capture Synopsis for Brookhaven National Laboratory			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Internet - DOE OSTI Energy Citations	Brookhaven Highlights 1978-1994, appendices to the Tiger Team Assessment, metal hydride reports, institutional plans, reactor operations reports, and a 1972 Health Physics and Safety report.	10/16/2011	29
Internet - DOE OSTI Information Bridge	Stannard's Radioactivity and Health, U-232 content of sapphire material, waste reports, human radiation experiments, radioisotope customers, environmental reports and plans, treatment planning at the Medical Research Reactor, High Flux Beam Reactor reports, Alternating Gradient Synchrtron shielding reports, and reactor operations reports.	10/23/2011	95
Internet - Google	Histories of the reactors, environmental reports, reports to Congress, DOE occupational exposure reports, waste disposal reports, work force restructuring, environmental cleanup reports site history and description, soil cleanup reports, reactor decommissioning reports, and monthly progress reports.	10/23/2011	221
Internet - Health Physics Journal	Articles on using a whole body counter to measure body burdens of a fallout-exposed population, an improved TLD system, radiation detection and alarm system for an accelerator complex, and the design and dosimetry of a strontium-yttrium beta irradiator. Searches to continue.	OPEN	4
Internet - Journal of Occupational and Environmental Hygiene	A 1961 article on design features and procedures for the new BNL laundry and decontamination facility, to be ordered.	OPEN	0
Internet - National Academies Press (NAP)	No relevant documents identified.	10/13/2011	0
Internet - NRC ADAMS	U.S. spent fuel and waste inventories reports, environmental reports, and an NRC assessment of the High Flux Beam Reactor.	8/26/2011	23
Internet- ORNL Library	Fuel element report, isotope production reports, operations division reports, and waste disposal reports.	11/8/2011	11
Internet - USACE/FUSRAP	No relevant documents identified.	10/13/2011	0
Internet - US Transuranium and Uranium Registries	No relevant documents identified.	10/13/2011	0
Missouri Department of Natural Resources	Report and appendix on environmental vulnerabilities of plutonium storage.	10/1/2008	2
Mound Museum	References to Brookhaven in Mound employee newsletter.	5/18/2010	2
National Archives and Records Administration (NARA) - Atlanta	DOE indoor radon study results, contamination of a Brookhaven zetraton neutron generator, polonium requests and requirements, U-233 reports, 1989 shipments, directory of AEC consultants, a report of a visit to Harshaw Chemical Company, hospitalization of a Harshaw employee at Brookhaven for a kidney study.	05/23/2008	13

Table A1-1: Data Capture Synopsis for Brookhaven National Laboratory			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
National Archives and Records Administration (NARA) - College Park	Waste reports, weekly and monthly status reports, NIOSH/ORAU Team researcher notes, uranium rod fabrication and shipping, industrial health advisory board report, and thorium research planning report.	07/16/2010	21
National Institute for Occupational Safety and Health (NIOSH)	Worker outreach meeting minutes.	12/01/2009	26
National Institute for Occupational Safety and Health (NIOSH)/SC&A	Highly enriched uranium working group reports.	02/16/2006	4
New South Associates	History of Savannah River Site with references to Brookhaven.	08/18/2009	1
Nuclear Regulatory Commission Public Document Room	Research activities progress reports and chemical changes in high level waste after 1000 years.	09/01/2011	2
Oak Ridge Library for Dose Reconstruction	A metal recovery report, waste reports, a 1957 isotopes division report, and history of ORNL.	5/12/2011	8
Oak Ridge Reading Room	A 1949 SF material accountability report.	04/08/2011	1
Ohio Department of Health	Chicago Operations Office environmental restoration and waste management site-specific plans.	11/3/2008	1
ORAU Team	Summary site profile, process knowledge expert interviews, and reviews of potential environmental release points.	07/28/2011	270
R.S. Landauer	Radiation dosimetry reports.	4/20/2010	214
S. Cohen & Associates (SC&A)	Process knowledge expert interviews, AEC neutron dosimetry workshop, Building 801 reports, neutron foil dosimetry of the BLIP facility, accelerator produced radionuclides, and the Safety and Environmental Protection Division file index.	08/14/2009	34
Science Applications International Corp (SAIC)	Radiation exposure summaries.	09/02/2004	9
Southern Illinois University, Edwardsville, IL	Disposal of Brookhaven wastes in the St. Louis area, AEC construction cost differentials, nuclear fuels development report, and the AEC cryptographic telephone network.	10/21/2008	4
University of Colorado Norlin Library	AEC and ERDA workshops on personnel neutron dosimetry and costs and benefits of a formal safety program.	04/10/2006	3
University of Rochester Miner Library	Using threshold detectors for neutron measurement at the Cosmotron.	08/21/2009	1
University of Tennessee Hodges Library	1948 and 1949 Health Physics summaries and a dosimetry report from ORNL to Brookhaven.	10/11/2011	3
Unknown	Site and NYOO status reports, environmental reports, and beryllium reports.	04/25/2005	91

Table A1-1: Data Capture Synopsis for Brookhaven National Laboratory			
Data Capture Information	**General Description of Documents Captured**	**Date Completed**	**Uploaded to SRDB**
Viacom Records	A newsletter noting that Westinghouse equipment powered the Brookhaven Cosmotron.	12/06/2004	1
TOTAL			**4,404**

Table A1-2: Databases Searched for Brookhaven National Laboratory			
Database/Source	**Keywords / Phrases**	**Hits**	**Selected**
NOTE: Database search terms employed for each of the databases listed below are available in the Excel file called "Brookhaven National Laboratory Rev 01, (83.14) 11-22-11"			
DOE CEDR http://cedr.lbl.gov/ COMPLETED 11/20/2011	See Note above	1	0
DOE Hanford DDRS http://www2.hanford.gov/declass/ COMPLETED 10/13/2011	See Note above	17	0
DOE Legacy Management Considered Sites http://csd.lm.doe.gov/ COMPLETED 10/13/2011	See Note above	161	0
DOE NNSA - Nevada Site Office www.nv.doe.gov/main/search.htm COMPLETED 10/13/2011	See Note above	0	0
DOE OpenNet http://www.osti.gov/opennet/advancedsearch.jsp COMPLETED 10/14/2011	See Note above	3,518	0
DOE OSTI Energy Citations http://www.osti.gov/energycitations/ COMPLETED 10/16/2011	See Note above	84,878	29
DOE OSTI Information Bridge http://www.osti.gov/bridge/advancedsearch.jsp COMPLETED 10/23/2011	See Note above	44,800	95

Table A1-2: Databases Searched for Brookhaven National Laboratory			
Database/Source	**Keywords / Phrases**	**Hits**	**Selected**
Google http://www.google.com COMPLETED 10/23/2011	See Note above	192,734,834	221
Journal of Occupational and Environmental Health http://www.ijoeh.com/index.php/ijoeh COMPLETED 11/20/2011	See Note above	1	0
National Academies Press http://www.nap.edu/ COMPLETED 10/13/2011	See Note above	24,719	0
NRC ADAMS Reading Room http://www.nrc.gov/reading-rm/adams/web-based.html COMPLETED 04/14/2011	See Note above	4,238	16
USACE/FUSRAP http://www.lrb.usace.army.mil/fusrap/ COMPLETED 10/13/2011	See Note above	0	0
U.S. Transuranium & Uranium Registries http://www.ustur.wsu.edu/ COMPLETED 10/13/2011	See Note above	7	0

Table A1-3: OSTI Documents Requested for Brookhaven National Laboratory			
Document Number	**Document Title**	**Requested Date**	**Received Date**
BNL-7581; CONF-337-3 OSTI ID: 4129174	Monitoring the Cooling Air Effluent from the Brookhaven Graphite Research Reactor at the Point of Release and in the Environment dated November 1963	10/18/2011	
BNL-736; BNL-T-265 OSTI ID: 4749855	Uranium-Bismuth In-Pile Corrosion Test Loop Radiation Loop No. 1 dated May 1961	10/18/2011	
BNL-12169 OSTI ID: 4555340	Evaluation of Fission Product and Activation Isotopes in a Reactor Stack Effluent and in the Nearby Environment dated October 31, 1968	10/18/2011	
BNL-3146 OSTI ID: 4348577	Summary Hazards Report on Enriched Fuel Element Loading for the BNL Research Reactor dated May 24, 1956	10/18/2011	
DOE/US-0017 OSTI ID: 6456599	Department of Energy's High Flux Beam Reactor (HFBR), September 15-19, 1980: An independent on-site safety review dated February 1981	10/18/2011	

Table A1-3: OSTI Documents Requested for Brookhaven National Laboratory			
Document Number	**Document Title**	**Requested Date**	**Received Date**
TID-14771 OSTI ID: 4818160	Preliminary Hazards Summary Report on the Brookhaven High Flux Beam Research Reactor dated May 1961	10/18/2011	
BNL-149 OSTI ID: 4390989	Quarterly Progress Report for October 1-December 31, 1951 Unclassified Section dated March 1952	10/12/2011	
BNL-189 OSTI ID: 4400080	Quarterly Progress Report for April 1-June 30, 1952 Unclassified Section dated October 1952	10/12/2011	
BNL-93 OSTI ID: 4424416	Quarterly Progress Report for October 1-December 31, 1950 dated March 1951	10/12/2011	
WHC-SP-0632 OSTI ID: 720991	Radioisotope production technology development; Annual report for fiscal year 1990	10/12/2011	
BNL-50780 OSTI ID: 5044188 Ref ID: 83793	Tritium storage development. Progress report No. 14, October-December 1977. [As a tritide in a metal hydride]	07/21/2010	07/29/2010
BNL-38317 OSTI ID: 5470215 Ref ID: 83795	Heat-actuated metal hydride hydrogen compressor testing	07/21/2010	07/29/2010
BNL-26047; CONF-790301-10 OSTI ID: 6051964 Ref ID: 83797	Metal hydride technology	07/21/2010	07/29/2010
BNL-25215; CONF-781142-2 OSTI ID: 6440486 Ref ID: 83799	Metal hydride research and development program at Brookhaven National Laboratory	07/21/2010	07/29/2010
BNL-22062; CONF-761134-2 OSTI ID: 7307323 Ref ID: 83800	Metal hydride materials program at BNL: current status and future plans	07/21/2010	07/29/2010
NA OSTI ID: 441060 Ref ID: 71851	Design and Dosimetry of a Strontium-90--yttrium-90 Beta Irradiation Facility from Health Phys., v. 26, no. 1, pp. 99-101	07/21/2009	08/25/2009
CONF-8705273- OSTI ID: 5168103 Ref ID: 71828	What is a Low Dose of Radiation from Int J Radiat Biol Relat Stud Phys, Chem, Med Vol. 53(1):1-12, 01/02/1988	07/21/2009	08/18/2009
NA OSTI ID: 4096108 Ref ID: 71827	Radiopharmaceuticals from Phys. Rep., v. 21, no. 6, pp. 315-367	07/21/2009	08/18/2009
BNL-22664 OSTI ID: 6621747 Ref ID: 71825	Chronic Lymphocytic Leukemia: Concepts and Observations from Blood Cells Vol 3:637-649	07/21/2009	08/06/2009

Table A1-3: OSTI Documents Requested for Brookhaven National Laboratory			
Document Number	**Document Title**	**Requested Date**	**Received Date**
BNL-10490 OSTI ID: 4421770 Ref ID: 71849	Improved Thermoluminescence Dosimetry System from Health Phys., 13: 567-73(June 1967).	07/21/2009	08/06/2009
BNL-17025 OSTI ID: 4569426 Ref ID: 71850	Radiation and Alarm System (Amos II) for Habitable Areas of an Accelerator Complex from Health Phys. 24: No. 4, 442-443(Apr 1973)	07/21/2009	08/06/2009
NA OSTI ID: NA Ref ID: 56600	A Whole Body Counter with an Invariant Response to Radionuclide Distribution and Body Size by S. H. Cohn, et al., Phys. Med. Biol. 14:4, pp. 645-658 (1969)	12/22/2008	12/29/2008 - Dr. Falco Provided
HKF-116(Rev) OSTI ID: NA Ref ID: 54015	Quarterly Report for October 1 to December 31, 1951	10/19/2007	11/04/2008
HKF-1492D-41(Del) OSTI ID: NA Ref ID: 54017	Plutonium Production Reactor Progress Memorandum dated 9/25/1951	10/19/2007	11/04/2008
M-4414 OSTI ID: NA Red ID: 54018	Brookhaven National Laboratory Pile Operating Manual Book No. 2 dated 4/1/1949	10/19/2007	11/04/2008
HKF-1492D-39 OSTI ID: NA Ref ID: 53179	Criticality Hazards in Processing 1% Enriched Uranium dated 9/24/1951	10/19/2007	11/03/2008
BNL-52256 OSTI ID: 6628605 Ref ID: 48682	Action Plan for the Tiger Team Assessment Report dated 8/30/1990	08/07/2008	09/18/2008
DOE/EH-0140 Vol. 2 OSTI ID: 6774838 Ref ID: 48283	Tiger Team Assessment of the Brookhaven National Laboratory Volume 2 dated 06/01/1990	08/07/2008	08/28/2008

Table A1-4: Interlibrary Loan Documents Requested for Brookhaven National Laboratory			
Document Number	**Document Title**	**Requested Date**	**Received Date**
OSTI ID: 4709767 Ref ID: 102604	12 Years Experience Operating the Brookhaven Graphite Reactor from Nucleonics Volume 21 pages 2, 60 dated February 1963	10/18/2011	10/24/2011
OSTI ID: 20005835 Ref ID: 102603	Radiation Dosimetry at the BNL Reactor Facilities from Transactions of the American Nuclear Society, Journal Volume 81, Conference: American Nuclear Society 1999 Winter Meeting, 11/14/1999-11/18/1999	10/18/2011	10/24/2011

Table A1-5: DTIC Documents Requested for Brookhaven National Laboratory			
Document Number	**Document Title**	**Requested Date**	**Received Date**
BNL/NPB-88-33	200-MeV Neutral Beam Test Facility Description and Radiation Safety	11/14/2011	