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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
AHF	Alpha Handling Facility
amu	atomic mass unit
ANP	aircraft nuclear propulsion
Bq	becquerel
BSR	Bulk Shielding Reactor
CEF	Critical Experiments Facility
cfm	cubic feet per minute
Ci	curie
cm	centimeter
CRF	Curium Recovery Facility
d	day
DOE	U.S. Department of Energy
DOSAR	Dosimetry Applications Research
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
FCAF	Fuel Cycle Alpha Facility
FPDL	Fission Products Development Laboratory
ft	foot
g	an acceleration equal to the force of gravity at the Earth's surface
g	gram
gal	gallon
GCR	gas-cooled reactor
HEPA	high-efficiency particulate air
HFIR	High Flux Isotope Reactor
HP	health physics
HPRR	Health Physics Research Reactor
hr	hour
HRE	Homogeneous Reactor Experiment
in.	inch
IPL	Interim Plutonium Laboratory
kg	kilogram
kW	kilowatt
kW(t)	kilowatt (thermal)
L	liter
lb	pound
LITR	Low-Intensity Test Reactor
LLLW	low-level liquid waste
LLW	low-level waste
m	meter
MED	Manhattan Engineer District

MeV	megaelectron-volt
mg	milligram
mi	mile
min	minute
mL	milliliter
mph	miles per hour
mR	milliroentgen
mrad	millirad
mrem	millirem
mrep	millirep
MSRE	Molten Salt Reactor Experiment
MTR	Materials Test Reactor
MV	megavolt
MW	megawatt
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
OGR	Oak Ridge Graphite Reactor
ORELA	Oak Ridge Electron Linear Accelerator
ORNL	Oak Ridge National Laboratory
ORR	ORNL Research Reactor or Oak Ridge Research Reactor
PCA	Pool Critical Assembly
pCi	picocurie
POC	probability of causation
ppm	parts per million
PUREX	plutonium-uranium extraction
R	roentgen
R&D	research and development
RaLa	radioactive lanthanum
REDC	Radiochemical Engineering Development Center
REDOX	reduction-oxidation
s	second
SLLW	solid low-level waste
SNAP	Systems for Nuclear Auxiliary Power
SNS	Spallation Neutron Source
SRDB Ref ID	Site Research Database Reference Identification (number)
SWSA	Solid Waste Storage Area
TBP	tributylphosphate
THOREX	thorium extraction
TRU	transuranic
TSF	Tower Shielding Facility
TSR	Tower Shielding Reactor
TURF	Thorium Uranium Recycle Facility
U.S.C.	United States Code
UCC	Union Carbide Corporation
WAG	Waste Area Grouping

WEF	Waste Evaporator Facility
WOCC	Waste Operations Control Center
X-10	Oak Ridge National Laboratory
Y-12	Y-12 National Security Complex
µCi	microcurie
§	section or sections

2.1 INTRODUCTION

Technical basis documents and site profile documents are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH staff in the completion of the individual work required for each dose reconstruction.

In this document the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy [DOE] facility" as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA defines a DOE facility as "any building, structure, or premise, including the grounds upon which such building, structure, or premise is located … in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations … pertaining to the Naval Nuclear Propulsion Program)" [42 U.S.C. § 7384l(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations of any nature whatsoever is a DOE facility encompassed by EEOICPA.

For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled "Exposure in the Performance of Duty." That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer "shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer … was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the POC [probability of causation[1]] guidelines established under subsection (c) …" [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation guidelines (nor the dose reconstruction regulation) define "performance of duty" for DOE employees with a covered cancer or restrict the "duty" to nuclear weapons work.

As noted above, the statute includes a definition of a DOE facility that excludes "buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program" [42 U.S.C. § 7384l(12)]. While this definition contains an exclusion with respect to the Naval Nuclear Propulsion Program, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled "Exposure in the Performance of Duty"] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external dosimetry monitoring results are considered valid for use in dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction. NIOSH, however, does not consider the following exposures to be occupationally derived:

- Radiation from naturally occurring radon present in conventional structures
- Radiation from diagnostic X-rays received in the treatment of work-related injuries

[1] The U.S. Department of Labor is ultimately responsible under the EEOICPA for determining the probability of causation (POC).

2.1.1 Purpose

The purpose of this TBD is to describe the activities, facilities, and radiation sources at the Oak Ridge National Laboratory (ORNL) over its operating history to the extent these may pertain to EEOICPA claims. This information will be used as needed in the reconstruction of doses for monitored and unmonitored workers.

2.1.2 Scope

Since its operations began in 1943, the mission of ORNL has been to conduct research and development (R&D) and production missions in support of DOE and its predecessor agencies. (ORNL has also been known as X-10, Clinton Laboratories, and, briefly, Holifield National Laboratory.) Much of the earliest site work was devoted to the development and operation of the original plutonium production reactor and associated chemical separation facility to test the larger production reactors that were being built on the Hanford Site. The Graphite Reactor produced gram quantities of plutonium and later fission products [e.g., radioactive lanthanum (RaLa)]; other types of radioactive materials were separated in other site facilities. Waste control technologies during early site operations were in their infancy, and much of the current knowledge of transport of radionuclides in the environment was obtained during this time. The ability to detect, identify, and quantify radiation types and exposures was progressing along with new technologies being discovered in radioisotope production. Much of the information gained during the early years at ORNL was used for the design of future U.S. Atomic Energy Commission (AEC)/DOE facilities and detection systems. Waste radioactive material was released from early site operations as gaseous, liquid, and solid effluents with little or no pretreatment. Methods were later developed to capture many of the contaminants at their source and to reduce overall plant emissions. In some cases, this increased direct exposures to individuals in the immediate area and created locations in which incidents and spills occurred.

During the more than 60 years of operations at the site, facilities have been constructed, operated, decontaminated, and decommissioned based on need. Many buildings that remain standing in the main plant area were renumbered in the early 1950s to the current building numbering system. Attachment A lists buildings under the current numbering system along with applicable earlier numbers.

Major historic operations and processes at ORNL include:

- The operation of the Graphite Reactor for producing plutonium and other radioisotopes
- The development and refinement of chemical processes to separate plutonium, uranium, and thorium from irradiated fuel
- Chemical separation of RaLa from irradiated fuel slugs for use in implosion dynamics studies at Los Alamos National Laboratory
- Operation of facilities for the separation, packaging, and distribution of radioisotopes for government and commercial use

In addition, ORNL developed new reactor technologies. The Laboratory tested different reactor designs (pool, pressurized-water, boiling-water, liquid-metal, gas-cooled) that were either scrapped or developed further elsewhere. Reactors operated at ORNL include the Low-Intensity Test Reactor (LITR), Critical Experiments Facility [CEF at the Y-12 National Security Complex (Y-12)], Bulk Shielding Reactor (BSR)/Pool Critical Assembly (PCA), Oak Ridge Research Reactor (ORR), Tower Shielding Reactor (TSR), Health Physics Research Reactor (HPRR), Homogeneous Reactor

Experiment (HRE), Aircraft Nuclear Propulsion (ANP) Program, the High Flux Isotope Reactor (HFIR), and the Molten Salt Reactor Experiment (MSRE).

In 1947, several ORNL divisions moved to Y-12. These divisions conducted research in biological sciences, the production of stable isotopes in the calutron units, and engineering technology.

Attributions and annotations, indicated by bracketed callouts and used to identify the source, justification, or clarification of the associated information, are presented in Section 2.4.

2.2 MAJOR FACILITY DESCRIPTIONS

DOE and other agencies have used ORNL to test new ideas. Many of the earliest buildings changed through various mission objectives. For example, Building 3019 was the original pilot plant facility for separating plutonium from irradiated uranium slugs from the Graphite Reactor. The original bismuth-phosphate separation process was inefficient and created a lot of waste. Subsequent chemical separations processes in Building 3019 better refined the dissolved material, leaving less final product in the waste stream.

DOE owns most of the land and facilities at ORNL. [Since Revision 00 of this document, several buildings have been constructed in the eastern portion of the main campus area with private, State of Tennessee, and Federal funding. These include the Laboratory for Comparative and Functional Genomics, the Center for Nanophase Materials Sciences, the Advanced Microscopy Laboratory, and the joint institutes for computational sciences, biological sciences, and neutron sciences. The Spallation Neutron Source (SNS) is under construction on Chestnut Ridge, north of the main campus with an estimated completion date in 2006.] The management and operation of the site has been contracted to various organizations over the years (see Table 2-1).

Table 2-1. Contractors of Oak Ridge National Laboratory.

Period	Operated by	Name
1/1943–6/30/1945	E. I. DuPont de Nemours for University of Chicago	Clinton Laboratories
7/1945–12/1946	Monsanto Chemical Company	Clinton Laboratories
1/1/1947–2/28/1948	AEC	Clinton Laboratories
3/4/1948	Carbide & Carbon Chemicals Company, UCC	ORNL
1950	Carbide & Carbon Chemical Division, UCC	ORNL
1956	Union Carbide Nuclear Corporation, Division of UCC	ORNL
1964–1974	Union Carbide Nuclear Corporation, Nuclear Division	ORNL
1975	UCC, Nuclear Division	Holifield National Laboratory
1976–3/31/1984	UCC, Nuclear Division	ORNL
4/1/1984–3/31/1995	Martin Marietta Energy Systems, Inc.	ORNL
4/1/1995–12/31/1995	Lockheed Martin Energy Systems, Inc.	ORNL
1/1/1996–3/31/2000	Lockheed Martin Energy Research, Inc.	ORNL
4/1/2000–Present	UT-Battelle	ORNL

Since the late 1990s, two parcels of land immediately east of the main ORNL site in Bethel Valley have been deeded to organizations outside DOE (Battelle and the State of Tennessee). Many of the buildings have joint private funding sources and are occupied by non-DOE contractors. Although maintenance is the responsibility of the owner, the individuals in the facilities in the ORNL Site Radiation Protection Program plan receive thermoluminescent dosimetry and/or are included in the internal dosimetry program as necessary.

The original building identification numbers from the 1940s were different from those in use today. At the beginning, buildings received three-digit numbers (e.g., 105, 225, 706). In the early 1950s, the building numbering nomenclature changed to one with predominantly four digits. The current general ORNL site building numbering system is as follows:

- Numbers 0000 to 0999 are north of Bethel Valley Road.
- Numbers 1000 to 1499 are north of Central Avenue and west of First Street.
- Numbers 1500 to 1999 are south of Central Avenue and west of First Street.
- Numbers 2000 to 2499 are north of Central Avenue, east of First Street, and west of Third Street.
- Numbers 2500 to 2999 are south of Central Avenue, east of First Street, and west of Third Street.
- Numbers 3000 to 3499 are north of Central Avenue, east of Third Street, and west of Fifth Street.
- Numbers 3500 to 3999 are south of Central Avenue, east of Third Street, and west of Fifth Street.
- Numbers 4000 to 4499 are north of Central Avenue, east of Fifth Street, and west of the location of the East Vehicle Gate (demolished in 2004).
- Numbers 4500 to 4999 are south of Central Avenue, east of Fifth Street, and west of the location of the East Vehicle Gate.
- Numbers 5000 to 5499 are north of Central Avenue, east of the location of the East Vehicle Gate, and west of Main Entrance Drive.
- Numbers 5500 to 5999 are south of Central Avenue, east of the location of the East Vehicle Gate, and west of the Swan Pond.
- Numbers 6000 to 7499 facilities are farther east of the main plant site in Bethel Valley and north of Haw Ridge.
- Numbers 7500 to 7999 are south of Haw Ridge in Melton Valley.
- The ORNL facilities in the Y-12 National Security Complex begin with 9000 numbers. (The UT-Battelle team has begun reducing the number of facilities for which they are responsible on the Y-12 site.)

Attachment B contains maps of the main ORNL campus and subareas.

A March 1, 1953, document from the ORNL Facilities and Operations Directorate, *Oak Ridge National Laboratory Building List*, indicated a cross-linking from the old and new building numbering nomenclature at that time (ORNL 1953). The Directorate provided a current ORNL building list for all facilities at the site (Parr et al. 2002). Attachment A contains the combined list.

The remainder of this section provides information on specific facilities for which information was available. For convenience, the principal facilities and radionuclides of concern identified in the following sections are summarized in Attachment C. Section 2.3 provides information on ORNL processes and programs.

2.2.1 Building 0816 Cesium Soil Test Plots

The 5-acre fenced 0816 site is part of the 0800 Environmental Research Area, an approximately 50-acre, fescue-dominated field 330 ft north of the Clinch River at Clinch River Mile 20.5 (Tiner and Uziel 1994). The study area is about 1.3 mi south of the intersection of Bethel Valley Road and State Highway 95. A weapons fallout field study using ^{137}Cs fused at high temperatures to silica sand particles (100 µCi/g) began in August 1968 using eight 33-ft-by-33-ft soil treatment plots. Four plots were contaminated with about 2.2 Ci each and the other four were used as controls. The particles ranged in size from 88 µm to 177 µm in diameter and were spread over the plots to achieve an areal density of 72 g/m^2. A surface radiological investigation was conducted intermittently from July through September 1994 (Tiner and Uziel 1994). The highest exposure rate measurement documented in the report was 0.86 mR/hr. One soil sample indicated 9,000 ±400 pCi/g (dry wt.).

2.2.2 Building 2000 (formerly 101-D) Metallurgy Laboratory

Building 2000 is a Quonset-style structure. It was built in 1948 to house Metallurgy Operations. The 23,000-ft^2 building contained equipment and facilities to produce fuel elements containing highly enriched uranium. Facilities in the building included metal casting and fabrication equipment; laboratories for testing mechanical, chemical, and physical properties of uranium and fuel elements; and office space. The building had a once-through ventilation system to remove radioactive materials from the air using a cyclone separator system and absolute filters before release to the environment. This facility was used in the development of the aluminum-clad, aluminum-uranium fuel element used in the Materials Test Reactor (MTR) and LITR (LMERC 1997).

2.2.3 Building 2001 Information Center Complex

During the 1950s, this building was used as the “main health physics facility.” In the latter part of the 1950s, the Health Physics Division (including the Applied Health Physics, Dosimetry, and Radiation Physics groups) moved to Building 4500S (Auerbach 1992). The Ecology Group remained in Building 2001.

2.2.4 Building 2005 (formerly 706-B) Metallurgy Annex

Building 2005 was a frame structure built to serve Manhattan Project operations. It had approximately 4,000 ft^2 of floor space. The building was modified in 1950 to contain multiple test loops as well as early equipment for studying welding, braising, and nondestructive inspection. Liquid metals and molten salts were tested in the building for compatibility with reactor materials in thermally driven test loops.

2.2.5 Building 2024 Information Center Complex Annex

Building 2024 (10,300 ft^2) was added between Buildings 2000 and 2001 to provide additional office and laboratory space to support early radiological operations in Building 2000 (LMERC 1997).

2.2.6 Building 2026 Radioactive Materials Analytical Laboratory

Building 2026, constructed in 1964 (with additions in 1966 and 1985), provides 22,600 ft^2 of laboratory and office space dedicated to the application of general analytical chemistry of radioactive materials. The building has special containment and ventilation systems to handle radioactive materials with high gamma dose rates (hot cells) and high levels of alpha radiation-bearing material (glovebox system). It houses facilities designed to segregate low and high levels of radioactivity. In addition, it includes a radioactive liquid waste system that meets current regulatory requirements. It is equipped to handle the packaging and disposal of radioactive solid waste (UT-Battelle 2001).

A personnel contamination incident occurred in Building 2026 on October 6, 2003, when a waste drain overflowed due to a clogged line.

2.2.7 Building 3001 (formerly 105) Graphite Reactor Building (Clinton Pile)

Section 2.3.1 describes the Graphite Reactor. Radionuclides produced in the reactor included ^{35}S, ^{32}P, ^{31}Si, ^{42}K, $^{41-45}Ca$, ^{46}Sc, ^{51}Ti, ^{59}Fe, ^{55}Fe, ^{60}Co, ^{65}Ni, ^{64}Cu, ^{75}Se, ^{110}Ag, ^{114}In, ^{115}Cd, ^{124}Sb, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{182}Ta, ^{185}W, ^{185}Os, ^{191}Os, ^{193}Os, ^{204}Tl, ^{206}Tl, ^{210}Bi, ^{24}Na, ^{76}As, ^{82}Br, ^{86}Rb, ^{99}Mo, ^{198}Au, ^{131}I, $^{141-143}Ce$, ^{14}C, and ^{192}Ir. Activation of the cooling air system resulted in the chronic release of ^{41}Ar from the Building 3018 stack when the reactor was operating. In 1948, ^{41}Ar releases totaled 540 Ci/d at a reactor power of 4,000 kW(t) and an exit airflow rate of 51,000 cfm. Fuel slug ruptures in 1947 resulted in emissions of ^{131}I, ^{133}I, ^{129}I, ^{137}Cs, ^{90}Sr, ^{85}Kr, ^{133}Xe, ^{239}Pu, ^{103}Ru, ^{106}Ru, ^{144}Ce, ^{140}La, ^{140}Ba, ^{95}Zr, ^{89}Sr, ^{235}U, ^{238}U, and ^{95}Nb.

2.2.8 Building 3002 (formerly 114) Graphite Reactor Filter House

The Graphite Reactor Filter House is north of the Graphite Reactor outlet air duct and west of the Fan House (Building 3003) and Exhaust Stack (Building 3018). Its purpose was to provide high-efficiency particulate air (HEPA) filtration to prevent the release of radioactive particulates from the 3018 stack due to ruptured fuel slugs. The building, which was constructed in 1948, operated until 1963.

2.2.9 Building 3003 (formerly 115) Graphite Reactor Fan House and Surface Modification and Characterization Laboratory

The Graphite Reactor Fan House provided negative pressure and served as a passageway for filtered exhaust from the Graphite Reactor air filter building to the stack (Building 3018). It was in operation from 1948 to 1963. Information on operations at the Characterization Laboratory was not located.

2.2.10 Building 3004 (formerly 807) Water Demineralizer Facility

The Water Demineralizer Facility (Building 3004) no longer exists. It supported operations for the LITR, and water from this facility apparently was also used in the Bulk Shielding Reactor pool (Rupp and Cox 1955). It was a four-story, wooden-framed building with wooden siding and approximately 1,600 ft^2 of floor space (DOE 1996a). It provided demineralized water directly to Buildings 3001, 3002, 3010, and 3042, and by tanker truck to Building 7702 at the Tower Shielding Facility (TSF). The original Water Treatment System was replaced by a mixed resin bed system and associated process equipment. The treatment equipment was on the first floor; treated water was pumped to a 10,000-gal holding tank on the fourth floor. Though there were no radiological operations in the building, low levels of residual radioactivity reportedly existed as a result of historical activities unrelated to water demineralization (DOE 1996a).

2.2.11 Building 3005 (formerly 106) Low-Intensity Test Reactor

The LITR facility consists of three buildings: the Low-Intensity Test Reactor Building (3005), the Water Demineralizer Facility (3004), and the Low-Intensity Test Reactor Water-to-Air Heat Exchanger (3077). The LITR consists of five cylindrical steel and aluminum tank sections with all but the lowest section above ground. It measures 70 ft by 62 ft by 57 ft. The LITR facility is northeast of the Graphite Reactor (Building 3001). Section 2.3.6.1 describes the LITR facility further.

2.2.12 Building 3009 Bulk Shielding Facility Pumphouse

Building 3009 consists of a single-story, single-room concrete block structure with about 156 ft^2 of floor space. It is adjacent to the southwest side of the Bulk Shielding Reactor (Building 3010) below

grade level (DOE 1996a). The only exposed exterior surface of the building is the west wall adjacent to the stairwell. The building originally supported the cooling system of the reactor bay pool in Building 3010. Though there were no radiological operations in the building, low levels of residual radioactivity reportedly exist under paint because of historical activities unrelated to pumping operations.

2.2.13 Building 3010 Bulk Shielding Reactor Facility

The BSR is a two-story, steel-frame building with corrugated metal siding, a footprint of approximately 4,000 ft^2, and a total floor area of about 8,700 ft^2. It was constructed in 1951, and operations ended in 1987. The pool has internal dimensions of 40 ft by 20 ft. In addition to the pool, the building contains offices, instrument rooms, experiment rooms, and a small shop. Buildings 3004, 3009, 3088, 3098, 3101, 3117, and 3119 were directly associated with the operation of the BSR. Section 2.3.6.3 describes the BSR further.

2.2.14 Building 3012 Rolling Mill

Building 3012 was constructed in 1947 to fabricate MTR-type fuel plates. The building contained melting and casting, furnacing, and multipurpose rolling equipment. It provided fuel assemblies for several pool-type research reactors and conducted workability studies on tantalum, beryllium, and other metals (LMERC 1997). Before the rolling mill became available, preliminary work on MTR plates occurred in an annex to the Graphite Reactor (Building 3001).

2.2.15 Building 3018 Exhaust Stack (for Building 3003)

Building 3018 is a 200-ft stack of steel-reinforced concrete used from 1943 until 1963 to vent exhaust from the Graphite Reactor. Section 2.3.1 describes the Graphite Reactor further.

2.2.16 Building 3019-A (formerly 205) Radiochemical Processing Pilot Plant

Building 3019-A was the original building that contained reprocessing cells and equipment to chemically dissolve irradiated fuel slugs and separate plutonium from solution. Irradiated slugs were received in Cell 1 on the east end of the building through an underwater canal from Building 3001, the Graphite Reactor. In Cell 1, a large tank was used to dissolve the cladding and slugs; the following four cells were designed for the large stainless-steel tanks, centrifuges, and piping needed for the successive oxidation-reduction cycles (Brooksbank, Patton, and Krichinsky 1994). The last cell was a spare for storing contaminated equipment. Section 2.3.1 describes several of the more important operations that occurred in Building 3019. After World War II, isotope production campaigns for ^{131}I, ^{32}P, and ^{14}C were conducted in the building's hot cells (MMES 1994).

2.2.17 Building 3019-B High Radiation Level Analytical Facility

Building 3019-B is a concrete and masonry block building constructed in 1955 for separating, processing, and analyzing highly radioactive samples from ORNL programs, including those in Building 3019-A (LMES 1997a). It is physically attached to the west end of Building 3019-A. The samples handled in Building 3019-B included fission products, activation products, uranium, plutonium, and other transuranic (TRU) elements. From 1955 to 1958, the building primarily supported the Thorium Extraction (THOREX) Program. [A remote sample withdrawal system was developed for the process system to decrease radiation exposure to operators and analytical chemists (MMES 1994).] From 1958 to 1960, analytical capabilities in the building supported programs from several ORNL divisions. These included the development of the Plutonium-Uranium Extraction (PUREX) Process and the development of the MTR. From 1960 through 1964, the building supported the Fluoride Volatility and Kilorod Programs. The Fluoride Volatility Process involved

dissolving uranium in a fused fluoride bath by hydrofluorination and volatilizing it by fluorination. The Kilorod Program involved the preparation of about 1,000 Zircaloy-clad fuel rods containing 3% $^{233}UO_2$ and 97% ThO_2 to obtain information on radiation levels and personnel exposures (Brooksbank, Patton and Krichinsky 1994). Many operations in Building 3019-B were transferred to Building 2026 in 1964, and the building was used only sporadically until 1976. In 1985, it was identified as a surplus contaminated facility.

The building area is more than 3,000 ft^2; the building contains a hot cell bank with seven work cells equipped with manipulators and a central storage cell. To the east of the cell bank is the operating room (Room 15), location of cell viewing windows and manipulator controls. To the west of the cell bank is the cell charging area (Room 14), which was a staging area for large items moving in or out of cells. A loading dock on the west end of the building was used to load and unload carriers and other equipment. Personnel external exposure averaged 30 mrem/wk during processing of short-lived isotopes (MMES 1994).

2.2.18 Building 3020 Exhaust Stack (for Building 3019)

Building 3020 was initially used to exhaust Building 3019. The exhausts were later directed to the Building 3039 stack.

2.2.19 Building 3021 Fan House (Northeast of Building 3020)

This facility provided negative pressure to Building 3019 process activities and exhausted through the Building 3020 Exhaust Stack.

2.2.20 Building 3023 (formerly 206) North Tank Farm

The North Tank Farm occupies an area of approximately 100 ft by 200 ft at the northeast corner of the intersection of Central and Third Streets. It contained eight underground tanks (four gunite and four stainless steel) to accept wastes generated from chemical separations operations. Section 2.3 describes the North Tank Farm further. Table 2-2 lists radioisotopes that could occur in the tanks.

2.2.21 Building 3025-E Physical Examination Hot Cells

Building 3025-E, which was built in 1950, is 70% to 80% utilized. The literature indicates that this facility handled more radioactive material in the early years and smaller quantities as the years progressed. The hot cells were used to assess activated radioisotopes. A remote storage facility was added in 1958 and decommissioned in 1985. Cell 6 was enlarged and upgraded to a sealed cell in 1958. Sealed storage wells were installed in 1985. A major upgrade of the Low-Level Liquid Waste (LLLW) System was completed in 1998 (UT-Battelle 2001).

Table 2-2. North Tank Farm contents (Huang et al. 1984).

Tank	Years of operation	Radioisotopes of concern
W-1	1943–1960	Pu-238,239, Sr-90, Cs-137, Co-60, and H-3
W-1A	1951–1986	U-233, Am-241, Cm-244,-Pu-238,239, Sr-90, Cs-137, Co-60, and H-3
W-2	1943–1960s	U-233, U-235, Np-237, Pu-238,239, Sr-90, Cs-137, Co-60, and H-3
W-3	1943–1960s	U-233, U-235, Np-237, Am-241, Cm-244, Pu-238,239, Sr-90, Cs-137, Co-60, and H-3
W-4	1943–1960s	U-233, U-235, Np-237, Am-241, Cm-244, Pu-238,239, Sr-90, Cs-137, Co-60, and H-3
W-13	1943–1958	Pu-238, Sr-90, Cs-137, Co-60, and H-3
W-14	1943–1958	Pu-238,239, Sr-90, Cs-137, Co-60, and H-3
W-15	1943–1958	Pu-238,239, Sr-90, Cs-137, Co-60, and H-3

2.2.22 Buildings 3026-C and 3026-D (formerly 706-C and 706-D) By-Product Processing and Chemical Separation Laboratory

The chemical separations facilities in Buildings 3026-C and –D processed 1-Ci to 100-Ci amounts of RaLa. However, it processed quantities of radioactivity much larger than those for which they were designed. After RaLa operations ended in 1956, operational areas in each facility were used for other operations. Section 2.3.2 describes the major operations in Buildings 3026-C and -D. The following isotopes would have been in the Building 3026-C and -D complex: ^{129}I, ^{131}I, ^{79}Se, ^{106}Ru/Rh, ^{107}Pd, ^{147}Pm, ^{137}Cs, ^{140}Ba/La, ^{90}Sr, ^{85}Kr, ^{188}W, ^{191}Os, ^{133}Xe, actinides, uranium, ^{99}Tc, ^{60}Co, plutonium, and ^{3}H.

2.2.23 Building 3027 Special Nuclear Materials Storage Vault

The Special Nuclear Materials Storage Vault was built in 1980. It is used for storage of Security Category III radioactive materials. No material processing occurs in the building and two sealed barriers contain special nuclear materials at all times. The materials in the vault are inspected weekly. The building contains eight rooms and has an 18-in. concrete slab floor, reinforced 18-in. thick concrete walls, and a 10-in. reinforced concrete roof. It was designed to withstand a 0.15*g* earthquake and a 350-mph wind. The rooms are equipped with drains piped to a steel storage tank in a below-grade pit. The building is ventilated to the central off-gas system (UT-Battelle 2001).

2.2.24 Building 3028 (formerly 910) Alpha Powder Facility

Building 3028, which was constructed in 1950, originally housed the ^{131}I processing facility and separation facility for ^{147}Pm (LMES 1997b). It is on the northwest corner of Isotope Circle adjacent to the 3039 stack. The building is a four-story, steel-frame structure covered by aluminum siding; it has a four-story central section with one-story cell operation areas on the east and west sides. The first floor covers 4,000 ft^2 and has seven cells in which various processes took place. The three upper levels contain laboratories for isotope and target fabrication production. Section 2.3.3 further describes Building 3028.

2.2.25 Building 3029 (formerly 909) Source Development Laboratory

Building 3029, which was constructed in 1952 to support the Isotopes Program (LMES 1997c), is in the west-central area of Isotope Circle. It is a single-story, steel-frame structure covered by corrugated aluminum siding. It has a floor area of 3,000 ft^2 and four cells where various processes took place. Section 2.3.3 further describes Building 3029.

2.2.26 Building 3030 (formerly 908) Radioisotope Processing Building "C"

Building 3030 was constructed in 1950 for the production and development of radioisotopes for use in industry, medicine, and research (LMES 1997d). It is a single-story, steel-frame structure covered by corrugated aluminum siding. It has a floor area of 825 ft^2, a manipulator-type hot cell on the middle of the east wall, two laboratory hoods in the northeast corner and center of the north wall, and a glovebox. The hot cell has 2-ft-thick concrete walls with 4 in. of lead brick on the west and south sides. All high-level work was conducted there. Section 2.3.3 describes Building 3030 further.

2.2.27 Building 3031 (formerly 907) Radioisotope Processing Building "D"

Building 3031 was constructed in 1950 for the production and development of radioisotopes for use in industry, medicine, and research (LMES 1997e). It is a single-story, steel-frame structure with a floor area of 825 ft^2, a manipulator-type hot cell, and two laboratory-type hoods in the northeast and northwest corners. The hot cell has 2-ft-thick barites concrete and 5 in. of steel armor plate. All high-level work was conducted there. Section 2.3.3 describes Building 3031 further.

2.2.28 Building 3032 (formerly 906) Radioisotope Processing Building "E"

Building 3032 was constructed in 1950 to house the analytical facility for radiochemical support of Isotopes Production activities (LMES 1997f). It is a single-story, steel-frame structure covered by corrugated aluminum siding. It contains a laboratory with five hoods on the north side of the building and an office on the south side connected by an open passageway. No high-level work was conducted in this building, which operates at atmospheric pressure. Section 2.3.3 further describes Building 3032.

2.2.29 Building 3033 (formerly 905) Radioactive Gas Process Facility

Building 3033 was used to process ^{14}C, ^{85}Kr, and ^{3}H (LMES 1997g). Although the building construction date was not verified from site documentation, it apparently was constructed in 1950 because both adjoining buildings (3032 and 3034) were constructed in 1950. It is a steel-frame structure covered with corrugated aluminum siding with about 1,200 ft^2 of floor space. The outer surface of the building was sealed by a "cocooning" process to make it as airtight as possible. Personnel and equipment entrances are gasketed. Three internal structures that enclosed/contained the equipment used to separate gaseous isotopes were in the building. Section 2.3.3 describes Building 3033 further.

2.2.30 Building 3033-A Actinide Fabrication Facility Annex

Building 3033-A is a metal structure with 242 ft^2 of floor space constructed about 1960 by bridging the space between Buildings 3033 and 3034 and using their walls for support (LMES 1997g). The building was used primarily to house and contain facilities for the production, loading, welding, and decontamination of neutron dosimeter materials. It also housed operations to weigh milligram to gram quantities of actinide materials for research. In addition, a small area at the south end of the building was used to prepare ^{14}C as barium carbonate from beryllium nitride targets that had been irradiated at Hanford (ORNL 1986). Personnel access is through gasketed airlock entries. Section 2.3.3 describes Building 3033-A further.

2.2.31 Building 3034 Radioisotopes Services Building

Building 3034 houses the central electrical distribution station for the Isotopes Circle Area. It is a steel-frame structure covered with corrugated aluminum siding with about 825 ft^2 of floor space. It was used as a field shop for the Plant and Equipment Division, served as a storage area and drop point for supplies for the isotope area, and has offices for the Maintenance Coordinator and the Surveillance and Maintenance Supervisor for the area. No handling of radioactive materials occurred in this building.

2.2.32 Building 3038 (formerly 902) Isotope Research Materials Laboratory, Radioisotope Analytical and Packing Building

Building 3038, which has been in operation since 1949, was constructed to house all ORNL radioisotope shipping activities. It is a masonry structure divided into three sections by concrete brick interior walls. There is 7,250 ft^2 of floor space. Section 2.3.3 further describes Building 3038.

2.2.33 Building 3039 (formerly 911) Central Exhaust Stack (Radioisotope Area)

The 3039 Stack Ventilation System, which was built in 1950, was extensively modified and upgraded in 1984 to increase its efficiency and reliability. The 3039 stack is a 76.2-m (250-ft) high, unreinforced radial, brick masonry chimney. The Stack Ventilation System consists of seven collection systems, each with its own under- or above-ground ducting, fans, and controls. Five handle cell ventilation

waste streams from limited-access areas and hot cells. The other two systems handle the off-gas from process equipment and laboratory experiments (Parr et al. 2002). Section 2.3.4 further describes the Central Exhaust Stack.

2.2.34 Building 3042 Oak Ridge Research Reactor

Building 3042, which was built to house the ORR, covers approximately 11,000 ft^2. It is a semiairtight, steel-frame structure covered with insulated metal panels. The pool in which the reactor was placed had a minimum shield of 4 ft of barites concrete with a 10-ft thickness at the east end where the experimental beam ports were. Section 2.3.6.4 further describes the ORR.

2.2.35 Building 3047 Radioisotopes Development Laboratory

Constructed in 1962 and still in operation, Building 3047 is a three-story, steel-frame building with concrete block exterior and interior walls. It houses the Radioisotopes Development Laboratory and has four high-level beta-gamma cells, one alpha hot cell, seven laboratories for handling low-level radioactive materials, a decontamination room, offices, and service areas. It is used for R&D and to produce radioisotopes. Radioactive materials handled include ^{90}Sr (up to 100,000 Ci), with single sealed sources of ^{90}Sr up to 350,000 Ci. Other radionuclides include ^{137}Cs, $^{152,154}Eu$, ^{238}Pu, ^{111m}Sn, $^{166}Dy/^{166}Ho$, ^{186}Re, and $^{188}W/^{188}Re$ (MMES 1995).

The facility was used for research, development, and production of radioisotopes. Past processing cannot be described specifically because of frequent changes not only in processes but also in materials, operation procedures and parameters, and program requirements. Special safety summaries and approved procedures were required for each new experiment and operation. Before an operation could begin, all pertinent paperwork had to be reviewed and approved. If a potential hazard was identified, additional reviews and approval were needed.

2.2.36 Building 3088 Bulk Shielding Reactor Facility Storage Building

Building 3088 is a small (approximately 129 ft^2 of floor space), single-story, single-room, steel-framed building with metal siding north of the BSR (DOE 1996a). It was reportedly used for general storage of equipment and miscellaneous materials during BSR operations.

2.2.37 Building 3093 Storage Enclosure

Building 3093 is a permanent krypton storage enclosure adjacent to Building 3033. It is a roofless, reinforced-concrete enclosure containing four charcoal-filled storage tanks. Although the tanks are now empty, irretrievable amounts of krypton remain absorbed in their charcoal linings (DOE 1996b).

2.2.38 Building 3098 Bulk Shielding Reactor Facility Filter House

Building 3098 is a small (150 to 250 ft^2 of floor space) single-story, single-room concrete structure housing HEPA filters for the BSR and ORR ventilation systems (DOE 1996a). It was constructed into the side of a hill about 200 yards south of the BSR, apparently for shielding purposes. Air from the BSR reactor bay exhausted through filters before discharge to the atmosphere through the Central Exhaust Stack (Building 3039).

2.2.39 Building 3099 (Building 3032) Storage Pad

Building 3099 is a concrete storage pad adjacent to the west side of Building 3032. It has been used for temporary storage of items including containerized radioactive materials and wastes.

2.2.40 Building 3101 Bulk Shielding Reactor Facility Storage

Building 3101 is a small, single-story building west of the BSR with about 200 ft^2 of floor space (DOE 1996a). Half of this area was a storage room and the other half was a covered concrete pad storage area. It was used for storage of miscellaneous materials and equipment for BSR activities.

2.2.41 Building 3117 Bulk Shielding Reactor Facility Cooling Tower

Building 3117 is a small, single-story, wood-framed cooling tower east of the BSR (DOE 1996a). At present, it provides cooling water to BSR air conditioning units.

2.2.42 Building 3118 Radioisotope Processing Building "H"

Building 3118 was constructed in the early 1960s to enclose the space between Buildings 3030 and 3031 and provide direct access through rear doors to the hot cells in each facility. In addition, it provided general storage space, forklift charging and storage, temporary storage for hazardous and radiological waste, radiological shielding materials, and casks. The steel-frame structure is covered with corrugated aluminum siding.

2.2.43 Building 3119 Bulk Shielding Reactor Facility Heat Exchanger and Pumphouse

Building 3119 is a small, single-room, concrete-block structure with an approximately 667-ft^2 footprint east of the BSR (DOE 1996a). It was used to support the BSR bay pool cooling system.

2.2.44 Building 3504 Health Physics Waste Research Building

Construction of Building 3504 was completed in 1951. This building housed large-scale laboratory investigations into waste disposal. Specifically, studies were conducted of methods to remove fission products from water prior to releasing it to the environment. This facility was sometimes referred to as the Waste Disposal Laboratory.

2.2.45 Building 3505 Metal Recovery Facility

The Metal Recovery Facility was constructed in late 1951 and operated from 1952 until 1960 as a pilot and small-scale production facility for nuclear fuel reprocessing using the PUREX process (Mostella 1994). It was a two-story, steel-frame metal siding structure with numerous windows. It contained seven aboveground, high-density, reinforced concrete or concrete-block process cells (A through G), a canal, a dissolver room, and a dissolver pit. The building was used to recover uranium, plutonium, neptunium, and americium from waste solutions, scrap, and fuel elements. Its maximum capacity was 450 kg of irradiated uranium per day, reached during processing of natural uranium fuel elements (MMES 1994). The basic design philosophy was that the equipment would be remotely operated and directly maintained. Vulnerable pieces of equipment that would require frequent maintenance were "unit shielded" with lead to minimize personnel exposure. The exposure of maintenance personnel to radioactivity in 7 years of operation averaged 60 mrem/week (MMES 1994). Twenty-five processing campaigns were run through the facility, which was shut down and abandoned in 1960 due to lack of secondary containment (Mandry and Grisham 1994). The building apparently had no HEPA-filtered ventilation until the early 1980s (Mandry and Grisham 1994).

2.2.46 Building 3506 Waste Evaporator Facility

Building 3506, the old Waste Evaporator Facility (WEF), which was constructed in 1949, housed the first liquid waste evaporator at ORNL (ATG 1996). The WEF received LLLW from laboratories and isotope processing areas for concentration. After the LLLW was processed, the condensate was

transferred to the Process Waste System. The WEF was replaced by Building 2531 and later used as an experimental radioactive waste incinerator and an experimental facility for separating rare earth elements. In the 1980s, it was used as a changing room for personnel working in the North and South Tank Farm areas.

Building 3506 is approximately 32 ft by 23 ft and consists of three main areas: north cell, south cell, and main gallery. The north and south cells had concrete walls that were 2 ft and 3 ft thick, respectively, and extended to a below-grade depth of 6 ft. The concrete wall that separated the north and south cells was removed to produce a single cell area. The building originally included a second floor that provided access to the cells. The second floor and interior stairs leading into the cells were removed, but it is not clear when this occurred.

2.2.47 Building 3507 (formerly 206) South Tank Farm

The South Tank Farm occupies an area of about 130 ft by 200 ft at the southeast corner of the intersection of Central and Third Streets. It contains six underground gunite tanks, and includes an area to the east of approximately 80 ft by 230 ft containing a smaller underground gunite tank and six underground stainless-steel tanks. The tanks accepted wastes generated from chemical separations operations. Section 2.3.4 describes the South Tank Farm further. Table 2-3 lists radioisotopes that might have been present in the South Tank Farm tanks.

Table 2-3. South Tank Farm contents (Huang et al. 1984).

Tank	Years of operation	Radioisotopes of concern
W-5	1943–1978	U-233, U-235, H-3, Co-60, Sr-90, and Pu-238/239
W-6	1943–1978	U-233, U-235, H-3, Co-60, Sr-90, Pu-238/239, Cm-244, Eu-152/154, and Cf-252
W-7	1943–1978	U-233, U-235, H-3, Co-60, Sr-90, Th-232, Pu-238/239, Cm-244, Eu-152/154, and Cf-252
W-8	1943–1978	U-233, U-235, H-3, Co-60, Sr-90, Am-241, Pu-238/239, Cm-244, Eu-152/154, and Cf-252
W-9	1943–1978	U-233, U-235, H-3, Co-60, Sr-90, Am-241, Pu-238/239, Cm-244, Eu-152/154, and Cf-252
W-10	1943–1978	U-233, U-235, H-3, Co-60, Sr-90, Am-241, Pu-238/239, Cm-244, Eu-152/154, and Cf-252

2.2.48 Building 3508 Chemical Isolation Laboratory

Building 3508 housed chemical separations operations to purify materials initially processed (extracted) in recovery operations in Building 3505. For instance, solvent extraction processes in Building 3505 would be followed by ion exchange procedures in Building 3508 to clean up separation products. Separations research, such as experiments in removing plutonium from uranyl sulfate solutions in support of the Homogeneous Reactor Experiment Program, was conducted in 1957.

2.2.49 Building 3515 Fission Product Pilot Plant

The Fission Product Pilot Plant (formerly known as the ^{106}Ru tank arrangement) began operation in 1948. The facility initially consisted of several tanks and associated equipment on a concrete pad (Mandry and Snedaker 1994). A concrete block wall was the only shielding. A canvas tent was later placed over the equipment. In 1952, the block wall was replaced with a 1.5-ft-thick poured concrete wall, and a 1-ft-thick concrete ceiling was added. A control room originally on the east side of the structure was moved to the southern end in 1952. The south cell was added in 1952, as was more shielding.

Operations in Building 3515 included extracting radioisotopes from waste liquids from on- and offsite activities. The predominant elements included ruthenium, strontium, cesium, and cerium. Operations in the building ended in 1958. Section 2.3.1 further describes Building 3515.

2.2.50 Building 3517 Fission Products Pilot Plant

Building 3517 is a two-story, concrete-block structure with about 14,400 ft^2 of floor space. It was completed in 1958. The operating area consisted of nine process cells, ten manipulator and service cells, four tank farm cells, a ventilation filter pit, filtration housings, and several service/pipe tunnels. The tank farm cells and service tunnels are underground adjacent to the northwest corner of the facility. Two cell ventilation facilities (Buildings 3547 and 3548) and a storage building (Building 3542) are associated with Building 3517 (DOE 1996b). This facility is also known as the Fission Products Development Laboratory (FPDL).

The FPDL was originally designed and constructed to separate kilocurie quantities of ^{137}Cs, ^{90}Sr, ^{144}Ce, and ^{147}Pm from REDOX- and PUREX-type (liquid) waste streams. The facility was modified in 1963 to allow production of megacurie amounts of ^{137}Cs, ^{90}Sr, and ^{144}Ce primarily for use in the AEC Systems for Nuclear Auxiliary Power (SNAP) program. At the conclusion of the program (1975), the facility was placed in standby, and initial decontamination efforts undertaken (ORNL 1986). Large quantities of ^{244}Cm were stored in the building (DOE 1996b). A memo dated August 30, 1965, describes a contamination incident that occurred during unloading of a carrier containing strontium titanate ($^{90}SrTiO_3$) pellets (Burnett 1965). The incident occurred on July 7, 1965, so strontium titanate was handled in Building 3517 circa mid-1965.

2.2.51 Building 3518 Acid Neutralization Plant

In 1957, a new process waste treatment plant was built. The plant had the capacity of 500,000 gal/d. It included an 800,000-gal equalization and hold-up basin that could store wastewater before treatment. A lime-soda softening process was used to remove strontium through coprecipitation. The neutralization plant could remove 90% of the strontium and rare earths. After treatment, the wastewater was monitored, sampled, and discharged to White Oak Creek.

2.2.52 Building 3525 High Radiological Level Examination Laboratory

Building 3525, constructed in 1963, is a two-story brick building with a partial basement. The first floor houses the primary containment-shielded cell complex, consisting of three hot cells arranged in a U-shape. The hot cells are constructed of 3-ft-thick barites concrete walls and compatible oil-filled, lead glass, viewing windows, creating an essentially leak-tight barrier. The remainder of the laboratory outside the hot cell complex consists of the charging area, equipment maintenance air lock areas, operating area, truck unloading area, photographic rooms, main change room, and rooms housing mechanical equipment. A small laboratory that houses the core conduction cool-down test facility is on the east side of the truck unloading area. The core conduction cool-down test facility tests radioactive samples under controlled thermal conditions while monitoring the samples to determine the release of radioactive materials.

The processes performed in the facility consist of:

- Receipt and handling of irradiated materials (fuel or nonfuel, typically as experimental capsules) in shielded casks
- Transfer of material in and out of the hot cells
- Capsule disassembly
- Nondestructive and destructive testing of irradiated materials
- Packaging and shipment of irradiated materials (on or off the site)

- Waste packaging for disposal
- Maintenance of remote equipment
- Decontamination of the facility and equipment

Examination and testing activities include metrology; metallographic sample preparation by sectioning, grinding, and polishing; optical and electron microscopy; mass spectrometry of fission gases; gamma spectrometry; and other physical property evaluations appropriate to the experimental objectives of a program.

2.2.53 Building 3544 Process Waste Treatment Facility

The construction of Building 3544 was completed in 1957. This building housed a lime-soda softening process to precipitate strontium and cesium primarily (plus other unidentified isotopes) from liquid process wastes. It had a capacity of 500,000 gal/d (Auerbach 1992). The Process Waste Collection System consists of a series of underground pipes through which process wastewater flows from the source facility to a pumping station for transfer to the Process Waste Treatment Complex – either Building 3544 (for radiological treatment) or Building 3608 (for nonradiological treatment). Waste acceptance criteria administratively limit wastes that can be added to the process waste system to a total radionuclide concentration of the ingestion dose equivalent of 1×10^4 Bq/L ^{90}Sr. Chemicals are limited based on treatment system capabilities and effluent discharge permit limits. At strategic points throughout the collection system, manholes equipped with beta-gamma radiation monitors, pH monitors, and flow monitors are continuously monitored at the Waste Operations Control Center (WOCC) to enable personnel to detect unusual activity in the system (UT-Battelle 2001).

2.2.54 Building 3597 Hot Storage Garden

Building 3597, which is an annex to Building 3503, was used to store fuel assemblies and other irradiated materials. Personnel working in this facility received accidental radiation exposures on August 10, 2004, when inadequate prejob scoping did not identify existing radiological hazards.

2.2.55 Building 4500 Central Research and Administration Facility

The Building 4500 complex consists of two two-story brick buildings with basement and attic levels. Built in the early 1950s, each building consists of a main area with four wings containing primarily offices, laboratories, storage areas, maintenance shop areas, a mailroom, a canteen area, and utility equipment areas. Primary utilities include sanitary water and sewer; process water and sewer; steam and condensate return systems; compressed air; electrical utilities; and heating, ventilation, and air conditioning systems. A radioactive hot drain from 4500 South that is no longer in use connects the service chases serving the first- and second-floor laboratories.

Work with radioactive materials in the Building 4500 complex consisted of initial small-scale R&D efforts on chemical separations processes prior to scaling up these processes in other facilities (such as Building 4507). A discussion with the individual at ORNL responsible for sampling and documenting radiological air effluents indicated that currently (2004) only six labs (comprising a total of eight hoods) are required to report radiological releases in ORNL's annual stack report (Fleming 2006). However, in earlier years additional laboratory areas within the 4500 complex were used for work involving radioactive materials.

When evaluating potential exposures to employees, a caveat is appropriate for maintenance workers and those with similar duties. These individuals often worked on hot process drain lines, hood ventilation systems, and other systems and locations where they could have been exposed to

significantly different radionuclide mixes and activities than workers performing routine tasks. Dose reconstructors should consider such nonroutine exposures for workers responsible for maintenance and similar activities, using coworker data as appropriate. In addition, although monitoring or other records for maintenance workers might indicate their assignment to a single or central work area, in reality they worked in many ORNL facilities.

2.2.56 Building 4501 High Level Radiochemistry Laboratory

Building 4501 is a steel, concrete block, and brick building. Interior partitions are primarily poured concrete and concrete block faced with transite, gypsum block, or steel paneling. The building, which was constructed in 1952, has four floors. With the exception of the first floor, hallways and stairwells provide interior access connections from Building 4501 to Building 4505. The basement contains laboratories, shop areas, cell ventilation ducts, and storage areas. Four hot cells surrounded by support laboratories and operating areas are centrally located on the first floor. The outer part of this floor contains chemical and radiochemical laboratories and office space. On the second floor, immediately above the hot cells and surrounding laboratories, is the high bay area, which contains chemical and radiochemical laboratories and office space. The third floor is the attic area and provides space for building utilities, ventilation fans, and controlled storage. The roof contains several exhaust stacks for ventilation systems. A process to convert ^{233}U adsorbed on sodium-fluoride traps as part of MSRE design and development was conducted in the building.

2.2.57 Building 4507 High Level Chemical Development Facility

The High Level Chemical Development Facility, which was constructed in 1957, housed chemical separations research on highly irradiated nuclear fuels. Small sections of irradiated fuel or prototype fuel elements would be dissolved for laboratory-scale process development research (ORNL 1962). The building consists of hot cell banks and associated charging and operating areas. Following its work with irradiated nuclear fuels, Building 4507 became the Curium Recovery Facility (CRF; MMES 1994), which tested TRU processes at high activity levels. Curium-242 was recovered from $^{241}AmO_2$-Al targets irradiated in the MTR and ORR. CRF operations resulted in the successful isolation of about 35 g of ^{243}Am and ^{244}Cm and 25 g of ^{242}Cm.

2.2.58 Building 4508 Metals and Ceramics Laboratory

Building 4508 is immediately west of Building 4500 South. In the 1960s, the Interim Plutonium Laboratory (IPL) was assembled on the first floor within the Ceramics Laboratory. Placement of the IPL in Building 4508 was made possible by the secondary containment design. The IPL had high-quality gloveboxes and a purge system that provided them with working atmospheres having very low oxygen and water contents. The inert atmosphere was required for work with plutonium and uranium nitrides. The gloveboxes were equipped for synthesizing, pressing, and sintering pellets of these nitrides (LMERC 1997).

In addition, Building 4508 housed the Fuel Cycle Alpha Facility (FCAF), which fabricated plutonium oxide and plutonium-uranium oxide fuel pellets, and was used for coating sol gel-derived microspheres with pyrolytic carbon. In addition, special target materials for the HFIR were developed and fabricated. This facility was initially in the basement of Building 3019 before relocation to Building 4508. Two unique fuel-rod-loading techniques – vibratory compaction and slug injection – were studied in the FCAF (LMERC 1997).

2.2.59 Building 5505 Transuranium Research Laboratory

Construction of Building 5505, the Transuranium Research Laboratory, was completed in 1967. The building is a one-story structure with an equipment room on the roof. The building is reinforced

concrete with exterior walls of concrete block faced with brick. The equipment room is of steel-frame construction with exterior walls of uninsulated aluminum panels. The laboratories are back to back in the central portion of the building, separated by a central corridor providing controlled access to each laboratory for transfer of radioactive materials. Offices occupy the north, west, and south perimeters of the building and are across a corridor from the laboratories. At present, the facility generates no radioactive liquid waste, but provisions are in place for a radioactive bottling station if needed. The facility maintains negative pressure through the interaction of the laboratory and office air supply system, laboratory exhaust system, and glovebox exhaust system. Research involves the chemistry, physics, and material science of actinides and their compounds to provide fundamental and technological information as well as a platform for the development of analytical instrumentation.

2.2.60 Building 6000 Holifield Radioactive Ion Beam Facility

Building 6000, immediately east of the main plant site, contains the Holifield Radioactive Ion Beam Facility. The high-voltage generator is inside a 100-ft-high, 33-ft-diameter pressure vessel, with low- and high-energy acceleration tubes in the same column structure. Production of radioactive ions occurs using the Isotope-Separator-On-Line technique with subsequent injection into a 25-MV tandem electrostatic accelerator that accelerates ions to energies of 0.1 to 10 MeV per nucleon for light nuclei and up to 5 MeV per nucleon for nuclei heavier than 100 amu. Site preparation for the tandem accelerator began in August 1975. The first successful transmission of beam through the entire system occurred in May 1980.

2.2.61 Building 6010 Oak Ridge Electron Linear Accelerator

The Oak Ridge Electron Linear Accelerator (ORELA) facility consists of a 180-MeV electron accelerator, neutron-producing targets, buried and evacuated flight tubes up to 200 m long leading to underground detector locations, sophisticated detectors, and data acquisition and analysis systems. Neutrons are produced by *bremsstrahlung* from a tantalum radiator. Moderated or unmoderated neutrons are available, and further tailoring of the spectral shape is accomplished with movable filters.

An intense pulsed source of neutrons is produced at the accelerator when bursts of electrons from the accelerator stop inside a tantalum target. As the electrons slow down in the target, they generate an intense flux of gamma □rays. The gamma □rays produce neutrons via (gamma,*xn*) reactions on the tantalum. The neutrons are moderated in the cooling water surrounding the target and travel to the experimental stations through evacuated flight tubes. The resulting neutron spectrum is *white* in the sense that the covered energy range is relatively broad (from subthermal to approximately 50 MeV) and the flux is roughly proportional to $E^{-0.7}$ where E is neutron energy. The integrated flux is about 0.8×10^{14} neutron/s at a power of 50 kW.

2.2.62 Building 7025 Tritium Target Facility

Building 7025 is a prefabricated metal-sided building acquired from the Tennessee Valley Authority as surplus property. Erected in 1968, it has a total floor area of 590 ft^2 (LMES 1997h). It is about 1.4 mi northeast of the central ORNL campus to the east of the General Stores and buildings. It had a 26-ft-long, stainless-steel glovebox for titanium tritide target fabrication. The glovebox exhaust was unfiltered because no particulate radioactive material was present. The exhaust stream was monitored. In the late 1970s, a high-vacuum evaporator system moved from Building 3550 to Building 7025 for the preparation of thin-film uranium and thorium oxide targets. The evaporator operated in a HEPA-filtered hood. According to LMES (1997h), only benchtop quantities of uranium and thorium were handled. The building had a forced exhaust system that ran continuously in combination with a forced air intake system to exhaust tritium gas that would have escaped from the glovebox line. The tritium and ThO_2/UO_2 operations ended in October 1989 and January 1990, respectively.

2.2.63 Building 7500 Homogeneous Reactor Experiment Reactor Building

Section 2.3.6.7 describes the HRE Building.

2.2.64 Building 7503 Molten Salt Reactor Experiment

Section 2.3.6.10 describes the MSRE facility.

2.2.65 Building 7602 Integrated Process Demonstration Facility

Building 7602 is a 15,841-ft^2, concrete block and steel frame structure built in 1963 as a fueling building for the Experimental Gas-Cooled Reactor (LMES 1997i). This project was terminated during construction in 1965 and the reactor (Building 7600) was never fueled. No nuclear fuel was handled. The building, which has three floors and three pits (F-14, solvent extraction, and dissolver), was idle until 1974, when the Liquid Metal Fast Breeder Reactor Fuel Cycle Program moved into its offices. It is not clear if radioactive materials were processed during this program. From 1981 to 1983, additions and modifications supported a collaborative fuel reprocessing program with the Japanese. From 1984 through 1994, the building was used to test chemical separations processes, principally using PUREX. Tests used dummy fuel made from depleted and natural uranium. No spent nuclear fuel was processed in the building.

2.2.66 Building 7700 Tower Shielding Facility

Section 2.3.6.5 describes the Tower Shielding Facility.

2.2.67 Building 7735 Dosimetry Applications Research Calibration Laboratory

The Dosimetry Applications Research (DOSAR) Calibration Laboratory (CalLab) is a 2,800-ft^2, concrete-block building consisting primarily of a control room, a 6.1- by 7.0- by 4.3-m gamma irradiation room, a beta/X-ray room that is the same size as the gamma room, and a low-scatter 9.1- by 9.1- by 5.8-m neutron room. Sources include a $^{90}Sr/^{90}Y$ irradiator; a Büchler irradiator and source set that includes ^{147}Pm, ^{204}Tl, and two $^{90}Sr/^{90}Y$ sources; a 10-Ci ^{137}Cs beam irradiator and 1.2-Ci ^{137}Cs panoramic irradiator; a bare $^{238}PuBe$ source; and two ^{252}Cf sources that can be used bare and with various moderators, including polyethylene and heavy water (^3H_2O). A Pantak model HF320 X-ray generator is available for reproducing National Institute of Science and Technology beam codes. Table 2-4 lists the sealed sources in the facility. The assay date for the radionuclide sources is November 4, 2005.

Table 2-4. Sealed sources available at DOSAR Calibration Laboratory (Building 7735) (Bogard 2007).

Radiation	Source	Dose rate	Source distance (cm)
Beta	Sr-90/Y	5,563 mrad/hr	35
Beta	Pm-147	8.1 mrad/hr (surface)	20
Beta	Tl-204	5.9 mrad/hr	35
Beta	Sr-90/Y	961 mrad/hr	35
Beta	Sr-90/Y	24,081 mrad/hr	35
Gamma	Cs-137	991 mR/hr	51
Gamma	Cs-137	2,323 mR/hr	100
Neutron	Cf-252 (bare)	79 mrem/hr	50
Neutron	Cf-252 (bare)	19.8 mrem/hr	100
Neutron	Cf-252 (poly-moderated)	9.3 mrem/hr	50
Neutron	Cf-252 (poly-moderated)	2.3 mrem/hr	100
Neutron	Cf-252 (D2O-moderated)	53.1 mrem/hr	50
Neutron	Cf-252 (D2O-moderated)	13.3 mrem/hr	100

Radiation	Source	Dose rate	Source distance (cm)
Neutron	Pu-238:Be	21.1 mrem/hr	100
X-ray	Various beam qualities	2 to 300 R/hr	318

2.2.68 Buildings 7806, 7807, 7808, 7809, and 7810 Waste Pits and Trenches

About 1955, the ORNL ecology group constructed three unlined pits in Conasauga shale above White Oak Lake. The purpose of these pits was to test the sorptive properties of the shale for fission products. The three pits were designated Buildings 7806, 7807, and 7808. They received large volumes of "intermediate-level" radioactive wastes generated by fuel reprocessing studies in Building 3019. Thousands of curies of ^{90}Sr, ^{137}Cs, ^{60}Co, and ^{106}Ru were poured directly into the pits. With the exception of ^{106}Ru, this activity was retained in the soil immediately adjacent to the pits. High personnel exposures (external) rendered the pits too hazardous for continued use; they were filled and capped about 1960 (Auerbach 1992). These pits still exist. In place of the pits, covered trenches were built to distribute radioactive materials in liquid waste into the surrounding soils. These trenches were designated Buildings 7809 and 7810.

2.2.69 Building 7852 Old Hydrofracture Facility

The Old Hydrofracture site was built in 1963 and used from 1964 to 1979 for permanent disposal of LLLW in shale formations at depths of more than 780 ft. Facilities required to support the waste disposal operations included a building containing a mixing cell, pump cell, and injection well cell; five underground tanks for storage of the liquid waste prior to mixing it with grout; and an impoundment (Old Hydrofracture Pond) and waste pit (T-4 Waste Pit) for emergency storage of liquid waste due to system failures. Each cell had 1-ft-thick concrete walls and roofs of diamond-plated steel. The liquid waste tanks, interior to the building and the Pond, contained elevated levels of radioactive materials producing high exposure rates. Shielding was added to the roof in 1974 to reduce the dose rate over the mixer cell from 1 to 2 R/hr to about 100 to 200 mR/hr (AIMS and CDM 1996).

2.2.70 Building 7900 High Flux Isotopes Reactor

Section 2.3.6.9 describes the HFIR facility.

2.2.71 Building 7920 Transuranic Processing Facility

Building 7920 is part of the Radiochemical Engineering Development Center (REDC). The mission of the REDC is to separate and purify TRU isotopes (primarily ^{252}Cf) from ^{244}Cm target material irradiated in the HFIR. The REDC consists of Building 7920 and Building 7930, both of which contain hot cells and gloveboxes for working with irradiated targets and separated products. The separation and purification processes occur in Building 7920. Products are prepared to customer specifications and packaged in Building 7930. Elements handled in the REDC include californium, berkelium, einsteinium, and fermium.

Building 7920 receives isotopes from the HFIR and processes them in preparation for fabrication into sealed sources. It contains radioanalytical laboratories and heavily shielded hot cells. The primary radiological hazard in Building 7920 is neutron exposure from ^{252}Cf and other transcalifornium isotopes [1]. Operating areas in Building 7920 include the following:

- The Control Room.
- Room 105, the Counting Room.
- Room 111, the Shielded Cave Area, which contains hot cells and gloveboxes.

- Room 208, the Analytical Laboratory, is used to prepare samples for analysis. It contains gloveboxes, bench tops, fume hoods, etc.

- Room 211, the Alpha Lab, which contains glovebox banks.

- The Transuranium Decontamination Facility, which is a movable hot cell on top of the Building 7920 hot cell bank used to move materials from hot cells into other containers.

- The Waste Transfer Area, where waste passes through a square tunnel going through the wall of process cubicle Number 10.

- The Limited Access Area, where waste generated in the process cubicles is placed in casks. Waste is placed in the casks as necessary by removing their covers using an overhead crane.

2.2.72 Building 7930 Thorium Uranium Recycle Facility (TURF)

Building 7930 is in the HFIR (7900) area southeast of the main plant area (MMES 1994). (Limited information on this facility was located.) Constructed in the late 1960s, the facility was the focal point of the High Temperature Gas Reactor fuel cycle development and demonstration work, with collaborative efforts in solvent extraction work conducted by THOREX in Building 3019-B (MMES 1994). In 1968, it was equipped to prepare ^{233}U fuel for the MSRE. Due to the amount of ^{232}U in the feed (250 ppm), exposure rates from a 1-lb can of oxide measured 250 rem/hr at contact. This exposure rate made it necessary to handle the material remotely in cell G.

TURF operations ended in 1980, leaving approximately 50,000 gal of TRU waste in the five underground storage tanks. This waste was transferred to the Melton Valley Storage Tanks for processing and disposal. Building 7930, which is still part of REDC, contains gloveboxes used in the finishing and packaging of isotopic sources produced in Building 7920.

2.2.73 Building 9204-3 Actinide Area (Electromagnetic Isotope Separation at Y-12)

These operations were housed in a small area (less than 5,000 ft^2) on the second floor of the east end of Building 9204-3 at the Y-12 National Security Complex. They consisted of the calutron operations area (2,700 ft^2), where actinide isotopes were separated, and the components wash and service area (1,800 ft^2), where actinide isotopes were removed from calutron receivers and the receivers were prepared for use. About 1962, this area was modified to separate actinide isotopes for research. This was new construction with the exception of the calutron. The actinide area operated continuously until the mid-1970s, when it was placed in standby. It operated again in the late 1970s to isolate ^{242}Pu and was placed in standby again in 1980 (MMES 1995).

2.2.74 Solid Waste Storage Areas

Section 2.3.4 discusses Solid Waste Storage Areas (SWSAs) 1 to 6 in detail. The following paragraphs detail the known information about the presence of radioactive material:

1. Analyses from several SWSA 1 ground-water wells showed low concentrations of ^{90}Sr, but no indication of ^{137}Cs or transuranic elements.

2. Analyses of soil core samples from the SWSA 2 area indicated no contamination. Analyses included uranium, plutonium, and ^{137}Cs. Ground-water samples showed no contamination. Water sample analyses included tritium, gross alpha, and gross beta.

3. Ground-water samples from the SWSA 3 area indicated small amounts of trivalent rare earths, ^{90}Sr, ^{89}Sr, and ^{3}H contamination.

4. Ground- and surface-water samples from the SWSA 4 area indicated radioactive contamination in both. One well sample indicated alpha contamination while another 8 of the 16 well samples indicated beta/gamma contamination. Identified radioactive contaminants include ^{90}Sr, ^{106}Ru, ^{137}Cs, ^{60}Co, ^{210}Po, ^{239}Pu, ^{3}H, ^{125}Sb, and trivalent rare earths.

5. Water samples from the SWSA 5 area indicated radioactive contamination of ^{244}Cm, ^{238}Pu, ^{90}Sr, ^{3}H, ^{125}Sb, ^{106}Ru, ^{137}Cs, ^{60}Co, and trivalent rare earths.

6. Estimates of total radioactivity in SWSA 6 included 252,000 Ci through 1984, of which 211,000 Ci has been buried since 1977. Waste consists of 155,000 Ci europium, 2,970 Ci ^{90}Sr, 5,110 Ci ^{137}Cs, 32,200 Ci ^{60}Co, and 7,110 Ci ^{3}H. Water seepage has occurred in most of the 49 trenches. To decrease water seepage, a near-surface seal of a mixture of bentonite shale was applied to three sections of SWSA 6, and the area was covered with grass. Water seepage has been observed under the seal since it was applied; the migration of water has been both lateral and vertical.

2.3 ORNL SITE OPERATIONS AND PROCESSES

Section 2.2 describes operating facilities and the radioactive materials that were or are present at those facilities. This section describes specific processes associated with many of those facilities (e.g., a fan house, filter house, stack, and other ancillary facilities were associated with Graphite Reactor operation). Section 2.3.1 discusses early operation of the Graphite Reactor, the Hot Pilot Plant (Building 3019), and associated facilities. Section 2.3.2 describes RaLa activities. Section 2.3.3 describes isotope production areas. Section 2.3.4 discusses waste areas and processes. Section 2.3.5 describes biological and life sciences research in ORNL facilities at Y-12. Section 2.3.6 describes the remaining reactor development and operation activities at ORNL.

2.3.1 Early Operation of Graphite Reactor and Associated Facilities

After Glenn Seaborg had proven that the bombardment of ^{238}U with a cyclotron could produce plutonium, and Enrico Fermi had designed a graphite-moderated reactor that had achieved a self-sustaining, critical reaction, it was recognized that the production of plutonium in quantities great enough for weapons production could be attained only by construction of large reactors. The Federal Government decided to build an air-cooled, graphite-moderated reactor using natural uranium (enrichments), with sufficient concrete shielding to minimize radiation exposures to site personnel. The U.S. Army Corps of Engineers constructed the reactor at the Clinton Laboratories, which became the Oak Ridge National Laboratory in 1948. In 1942, the Manhattan Engineer District (MED) of the Corps became responsible for the management of uranium and plutonium plant construction and nuclear weapons production.

The Graphite Reactor, Building 3001 (originally 105), operated from November 4, 1943, to November 1963. The reactor was designed and built as a pilot plant to test the control and operating procedures of proposed larger production reactors and to provide needed quantities of plutonium for the MED for testing. The reactor was designed to operate at a thermal power rating of 1,000 kW; however, with subsequent modifications it reached at least 4,400 kW (Rupp and Cox 1955). There were 7 ft of concrete shielding between the reactor and the front wall of the shield from which operators would work [5 ft of barites concrete with 1 ft of structural concrete on each side as retaining walls (Rupp and Witkowski 1955)]. Natural uranium fuel slugs (4 in. long by approximately 1.1 in. in diameter) were inserted in the reactor through holes in the front face into horizontal channels in the graphite matrix. (The Aluminum Company of America provided the aluminum-clad fuel slugs for use in the reactor.)

Following irradiation, an operator standing at the front face used a long-handled rod to push the slugs out the back of the reactor. The irradiated slugs dropped into a water-filled transfer canal. The ORNL plutonium production mission was accomplished by the end of 1944 (MMES 1994).

In 1958, the maximum radiation levels in the transfer canal area ranged from 30 to 40 mR/hr due to highly contaminated concrete. A 1958 memorandum stated that most of the exposure to reactor operations personnel occurred during work adjacent to the transfer canal (Author unknown 1958). In 1959, the water level was increased and steel plating was placed over the contaminated concrete. Exposure rates to workers who worked "several hours at a time" were "reduced to about one-tenth of its former value" (Cox 1959a). Ruptured fuel slugs, allowed to oxidize in the transfer canal, were the major source of contamination and dose in the reactor building. Irradiated fuel slugs were moved underwater to the separations building (Building 3019, originally 205) after a cooling period to allow decay of short-lived radioisotopes. Rupp and Cox (1955) reported that elevated levels of ^{60}Co and ^{137}Cs were present in the canal waters in 1954.

Airborne wastes were removed from Building 3001 and exhausted to the atmosphere from a 200-ft stack (Building 3018) immediately north of the Graphite Reactor Building. Initial design of the exhaust system did not include a filtering mechanism. By 1948, it was recognized that radioactive particulates were being emitted from the stack. Particulate filtration was added to reduce emissions. Researchers later discovered that particulate contamination became elevated in the airborne effluent stream when fuel slugs pushed out the back of the reactor would fall and strike the mattress plates prior to being submerged underwater. The impact would sometimes breach or further breach the aluminum cladding of the slugs, resulting in a release of particulate matter to the air. The large building ventilation fans would entrain these particles and exhaust them out the stack. Therefore, concentrations of gaseous wastes such as noble gases (^{41}Ar and several xenon/krypton isotopes) and radioiodines were not filtered or quantified.

Construction activities for Building 3019 (originally 205) began in March 1943. Primary construction included six hot cells: one for dissolution of uranium from irradiated fuel slugs, four that housed equipment for successive chemical treatment of uranium (precipitation, oxidation, and reduction), and one that stored contaminated equipment from the other cells. The cell area was in a frame structure that contained the operating gallery and office areas. This facility, known as the Pilot Plant, was where new chemical separations processes were tested [e.g., bismuth phosphate, reduction-oxidation (REDOX), Hexone-25, tributylphosphate (TBP)-25, PUREX, fluoride volatility chemical process, and THOREX].

The first "hot run" to separate plutonium began on December 19, 1943. The first batch of irradiated fuel slugs were transferred from Building 3001 to the Building 3019 dissolver on December 20, 1943. On January 3, 1944, the first plutonium (1.54 mg) was shipped from ORNL to the Metallurgical Laboratory at the University of Chicago (MMES 1994). By the end of January 1944, approximately one-third ton of irradiated fuel from the reactor was going through the Pilot Plant each day. By May 1944, 30.737 g of purified plutonium had been shipped. [Purification of plutonium extracted in the Pilot Plant occurred in Building 3550 (originally 706-A).] Plutonium separation activities were placed on standby in January 1945 (Quist 2000). The final regular shipment in January 1945 brought the total to 289.438 g. Additional plutonium was reclaimed and purified during the process of shutting down and cleaning out the equipment, bringing the total amount of plutonium shipped to 326.390 g (MMES 1994).

Because of the variety of processes that took place in Building 3019, different radioisotopes were and are still present in the facility. At first, airborne emissions exhausted through the 200-ft stack from Building 3020 (the fan house was adjacent in Building 3021). In about May 1962, a deep-bed glass fiber filter was added, and effluents were sent to the large Central Exhaust Facility stack at Building 3039 (Klima 1962). Arnold, Gresky, and Nichols (1961) described the types of materials likely to be

exhausted through the filter. *Historical and Programmatic Overview of Building 3019* (Brooksbank, Patton, and Krichinsky 1994) describes all processes that occurred in Building 3019. This facility conducted much of the R&D operations for chemical separations at the site. Several of the processes are described below.

- From 1943 until 1945, the Bismuth-Phosphate Process recovered plutonium from fuel slugs from the Graphite Reactor. The process took place in six hot cells. The fuel slugs were transported from the Graphite Reactor through an underground water-filled canal. The process included dissolution of the slugs in acid in the initial cell. The remaining cells housed equipment used in precipitating plutonium from the dissolved fuel slugs and oxidation and reduction of the uranium. This batch process is based on the fact that plutonium will coprecipitate with bismuth phosphate in the +4 valence state but not in the +6 valence state. Aluminum cladding was dissolved away from the fuel elements with boiling sodium hydroxide solution. The bare uranium was dissolved in concentrated aqueous nitric acid, and plutonium was separated and concentrated by cycles of precipitation and dissolution using bismuth phosphate. The Bismuth-Phosphate Process could extract only plutonium; uranium remained as a waste product. Radionuclides of concern include ^{234}U, ^{235}U, ^{238}Pu, ^{239}Pu, and mixed fission products [2].

- The REDOX Process took place from 1945 until 1951. The REDOX facility was a pilot plant for the Argonne National Laboratory REDOX Processing Plant. REDOX was a method of extracting uranium and plutonium from reactor fuel using solvents. Radionuclides of concern include ^{234}U, ^{235}U, ^{238}Pu, ^{239}Pu, and mixed fission products [3].

- PUREX processing took place from 1949 to 1960. The PUREX Process involved the use of TBP for solvent extraction. TBP was used in organic and hydrocarbon diluents to isolate plutonium, uranium, zirconium, niobium, and ruthenium from fission product wastes. Radionuclides of concern include ^{234}U, ^{235}U, ^{238}Pu, ^{239}Pu and mixed fission products [4].

- The Fluoride Volatility Chemical Process used the volatility of uranium hexafluoride to separate ^{235}U from molten salt fuels and other fuels that were soluble in molten salt. Radionuclides of concern include ^{234}U, ^{235}U, ^{85}Kr, ^{133}Xe, ^{127}Te, ^{129}Te, ^{131}I, ^{103}Ru, ^{106}Ru, ^{238}Pu, and ^{239}Pu [5].

- The THOREX process was used to separate ^{233}U, ^{232}Th, ^{233}Th, and ^{233}Pa from irradiated thorium metal and other fission products. In 1956 and 1957, thorium metal was decayed at shorter periods than normal to test the equipment and processes under high radiation conditions. In 1959, an explosion in the THOREX pilot plant released 0.6 g of plutonium from a hot cell, spreading it onto the street and the Graphite Reactor. Radionuclides of concern include ^{238}Pu, ^{239}Pu, ^{233}U, ^{232}Th, ^{233}Th, ^{85}Kr, ^{95}Zr, ^{95}Nb, ^{103}Ru, ^{106}Ru, ^{131}I, ^{132}I (^{132}Te), ^{133}Xe, ^{140}Ba/^{140}La, ^{141}Ce, ^{144}Ce, and ^{233}Pa [6].

- Building 3019 originally housed the FCAF in a basement area before its relocation to Building 4508. The FCAF, which fabricated PuO and (Pu,U)O fuel pellets, was used for coating sol gel-derived microspheres with pyrolytic carbon. Special target materials for the HFIR were developed and fabricated in this facility. Two additional and unique fuel-rod-loading techniques – vibratory compaction and slug injection – were studied in the FCAF.

Wastes generated from Building 3019 operations flowed to underground storage tanks in the North and South Tank Farm areas, facilities 3023 and 3507. At times, volatile gases were released from the headspace of the tanks when liquids were being added. Section 2.3.4 contains more information on waste operations.

A chemical explosion occurred in Building 3019 at approximately 11:00 p.m. on November 20, 1959, in the intercycle evaporator in Cell 6. The explosion contaminated the interior of the cell area, blew open the door to the outside, and contaminated the area immediately outside with significant levels of plutonium. The explosion also contaminated the Graphite Reactor and other buildings. King and McCarley (1960) indicated that environmental contamination was immediately fixed at buildings and grass with paint, asphalt on roads, and either paint or tar on roofs. With the exception of Building 3019, the Graphite Reactor Building, and Hillside Road between Third Street and Building 3042, all areas were back in service by Monday morning, November 23 (King and McCarley 1960). A report issued August 25, 1961, indicated that decontamination efforts took place over an extended period and that approximately 141 g of plutonium were flushed from the cell area (Parrott 1961). Parrott indicated that, although many entries were made to the cell area for decontamination efforts, none of the workers was overexposed to beta/gamma radiation and there was "no detectable increase in the body burden of plutonium of any individual involved" in the decontamination efforts.

Other buildings in the Main Plant Area where radioisotopic separations occurred using slugs irradiated in the Graphite Reactor included 3026C, 3026D, 3505, 3515, and 3517. (Section 2.3.2 discusses activities in Buildings 3026C and -D.) The Building 3505 Metal Recovery Facility received irradiated fuel slugs from 1952 to 1960 and reprocessed the slugs to produce 320,662 kg of uranium, 184 kg of plutonium, 1,344 kg of neptunium, and 55 kg of americium (Alexander et al. 1982). Radiological fission products would have been present during reprocessing of the irradiated fuel. A radiological survey in 1981 indicated that the facility had widespread residual fission products, ^{137}Cs and ^{90}Sr, and uranic and TRU radioisotopes were present (Alexander et al. 1982). The building was demolished and removed from the site in about 2000.

Buildings 3515 (Fission Product Pilot Plant) and 3517 (Fission Product Development Laboratory) were used in the further separation of fission products from waste solutions from Building 3505. Building 3515, which operated from 1948 to 1958, was originally known as the ^{106}Ru tank arrangement. It was used to extract radioisotopes of ruthenium, strontium, cesium, cerium, and other fission products (BN 1994). In 1948, the facility consisted of a concrete pad with tanks surrounded by stacks of concrete blocks three rows deep. The pad was once covered by a tent. In 1950 or 1951, an 18-in.-thick, walled concrete hot cell with a 2-ft-thick concrete roof was built. Numerous spills occurred in the building, and the internal structure, particularly the concrete floor, was frequently soaked with contaminated waste (Mandry and Snedaker 1994). The building was posted as a high radiation area. Operations in Building 3515 moved to Building 3517 in 1958.

The hot cells in Building 3517 processed kilocurie amounts of fission products from REDOX and PUREX waste streams. A total of 1×10^6 Ci of fission products were processed until building operations ended in 1975. The radioisotopes separated during the late 1950s and early 1960s included ^{144}Ce, ^{137}Cs, ^{90}Sr, ^{147}Pm, ^{106}Ru, and ^{99}Tc; some uranic and TRU isotopes would have been present in the waste, as would other fission products [7].

2.3.2 Radioactive Lanthanum Activities

In mid-1942, radiological research was directed at small-scale studies of different radioisotopes in the Metallurgical Laboratory at the University of Chicago. While most of the research focused on the production of fissionable material for use in weapons manufacturing, some was on other radioisotopes (i.e., activation and fission products) to determine their potential value to the war effort. While the Graphite Reactor was still being conceptualized, special attention was given to barium, strontium, and lanthanum separation chemistry. Although initially purified ^{140}Ba had little gamma activity, ^{140}La, which grew into the purified ^{140}Ba, was of great interest due to its 1.6-MeV gamma ray and high specific activity. The program for the separation and production of radioactive lanthanum was called the RaLa Project. In the fall of 1943, much of the Metallurgical Laboratory moved to ORNL to continue the research on fission products. This research began in Building 3550 (706-A); on October 21, 1943,

there was a request to construct a larger production facility. Building 3026-C (706-C) was constructed with larger containers and equipment in 1944, and the new facility was placed in operation; its initial production run began on September 10, 1944.

The 3026-C facility was designed to handle 1- to 10-Ci amounts of radioactivity but, due to time constraints and unusual circumstances, at startup it was producing greater-than-100-Ci amounts. The facility processed irradiated slugs from the Graphite Reactor. In addition, nine production runs of RaLa were completed for shipment to Los Alamos, for a total of 3,852 Ci. (Multiple batches of irradiated slugs were dissolved to make up a completed run.) The last run in Building 3026-C was on May 28, 1945. During the initial lower activity production runs, spills, plugged lines, low chemical yields (requiring dissolution of additional batches of slugs), and failed equipment affected the completion of runs (Thompson 1949).

After the second successful RaLa run in Building 3026-C, discussions indicated the need to increase production rates further. Although the use of existing facilities in the Pilot Plant (Building 3019) was discussed and evaluated, it was determined that a new facility annexed to the current facility would be needed. Building 3026-D (706-D), which was designed to process much larger (up to 1,000 Ci) amounts of radioactivity, was attached to the east end of the 3026-C facility. As with the construction of Building 3026-C, time constraints caused design and development work to coincide with facility construction. The first production run of materials occurred on May 26, 1945, as the ninth and final run of RaLa was completed in Building 3026-C. Building 3026-D processed much higher activities than those designed for the facility.

Around 1948, the AEC decided to use irradiated slugs from Hanford production reactors as feed for RaLa. The higher power levels of the Hanford reactors (in relation to those of the Graphite Reactor) meant production of much larger quantities of RaLa in a shorter time, even with shipping the slugs across the country. A total of 68 RaLa runs had been completed at ORNL when operations ended in October 1956 (ChemRisk 1999). The RaLa program was transferred to the Idaho Chemical Processing Plant.

Due to the relatively short half-life of the parent ^{140}Ba, the freshly irradiated fuel slugs used in the RaLa process contained relatively large quantities of short-lived fission products, most notably noble gases and radioiodines.

Much of the iodine volatilized during the slug dissolving process was effectively removed from the dissolver off-gas stream by the reflux condenser and chemical scrubber in line before the gaseous waste went to the stack. Dissolver off-gas from RaLa production was vented to the 3020 stack from 1944 to 1950 and to the 3039 stack from 1950 to 1956. From 1944 to 1950, other airborne wastes were withdrawn from the building's two process cells to a 30-ft stack adjacent to the building until this stream was routed to the 3039 stack. In the later part of 1948, operations in Building 3026-D were a major contributor of airborne particles on the site. Air filter houses were installed to reduce particulate material in the effluent stream before release from the building. Liquid wastes from RaLa operations went to the local tank farms.

Other than operational problems (failed equipment, breached control systems, plugged feed lines) that occurred during RaLa operations, the worst incident occurred at about 5:00 p.m. on April 29, 1954. It was described as "the most serious accidental release of activity ever experienced in the history of the process" (Rupp and Witkowski 1955). Building 706-D logbooks indicate that 161 Hanford slugs had been loaded in the dissolver and three batches had been processed successfully during Run 56. After the third batch dissolution, liquid did not cover the slugs in the dissolver tank for approximately 28 hr and the slugs became thermally hot due to radioactive decay. When the fourth batch addition of acid was poured in the dissolver to initiate additional dissolution, a violent reaction forced dissolver solution up the slug-loading chute and solution addition lines. Air monitors

immediately sounded an alarm indicating elevated airborne radioactive material. The investigation that followed indicated that individuals donned gas masks and evacuated the building quickly. The release lasted from 10 min to 2 hr before the scrubbers could recover and begin filtering radioiodine from the building. A letter from the Laboratory Shift Superintendent to the ORNL Director indicated, "all people involved in the incident and later in the high level decontamination work are being given the standard HP [Health Physics] check including urine checks, etc." (Stanley 1954). Radiation levels reached 100 R/hr on the third floor, but were reduced to 100 mR/hr by 7:00 a.m. the next day; air sample results did not exceed the tolerance level of 3.0×10^{-08} µCi/mL. A "preliminary check of film badge results" indicated that the highest measured exposure was approximately 1250 mR (hard) and 4700 mrep (soft) (Stanley 1954).

ChemRisk (1999) contains detailed information on RaLa operations, source terms, emissions, and offsite radiation doses. This document provided historical process information as well as modeled concentrations of iodine to conduct offsite dose assessments.

2.3.3 Isotope Production Areas

Following the small-scale production of plutonium from the Graphite Reactor and large-quantity production of RaLa in Buildings 3026-C and -D, site facilities were built to produce other radioisotopes. Table 2-5 lists facilities involved in the ORNL isotope production program and radioisotopes that would have been present. Building 3026-C was the initial facility for commercial isotope production at ORNL (Kuhaida and Parker 1997). Most of the other isotope production facilities were built in the early 1950s. Some facilities have not produced any material since the 1960s, and some are used for storage. The following paragraphs contain information on several isotope production buildings.

Building 3028 was constructed in 1950 to house the ^{131}I processing facility and the separation facility for ^{147}Pm (LMES 1997b). The ^{131}I facility was converted to manipulator cells and expanded in the early 1960s to the Short-Lived Fission Product Facility, which operated until 1985. The ^{133}Xe facility was added at that time and operated until 1980 to produce ^{133}Xe, ^{131}I, and ^{99}Mo. Curium source fabrication began in 1964 to support Space Nuclear Systems. The process took place on the first floor in water-shielded cells. The cells were partially decontaminated in the mid-1980s and the facility was named the Alpha Powder Facility to support the full-cost-recovery isotopes program. In the late 1970s, the target facility moved to Building 3038; the upper floors were occupied by Nuclear Medicine Research until 1988.

Table 2-5. Radioisotopes of concern in isotope production facilities.

Building name	Building number	Isotopes formerly stored, used, or produced
Krypton-85 Enrichment Facility	3026-C	I-129, I-131, Se-79, Pd-107, Pm-147, Cs-137, Sr-90, actinides, Kr-85, U, Tc-99, Co-60, Pu, H-3
Alpha Powder Facility	3028	I-131, Xe-133, Cm-242/244, Pm-147, Mo-99, Pu-238
Source Development Laboratory	3029	Ir-192, Co-60, Cs-137, Sr-90, I-131, I-$CH_3$131, C-14, Tc-99
Radioisotope Production Laboratory–C	3030	Co-56/57, Au-198, Fe-55, Np-234, Se-75, Sr-90 nitrate, Sn-111, U-237, P-33, Ir-192, Ni-63, Pd-103
Radioisotope Production Laboratory–D	3031	Y-90, Gd-153
Radioisotope Production Laboratory–E	3032	Am-241, U-235, Pu-233, Eu-152,154, Gd-153, Co-56, Co-57, Au-198, Fe-55, Np-234, Se-75, Sr-90, Cs-137, Sn-111, U-237, P-33, Ir-192, Cm-244, Xe-131, I-131, Mo-99, Pm-147
Radioactive Gas Processing Facility	3033	H-3, Kr-85, C-14

Building name	Building number	Isotopes formerly stored, used, or produced
Radioactive Production Laboratory Annex	3033-A	C-14, Am-241, Np-237, Pu-238, highly enriched actinide isotopes
Radioisotopes Area Services	3034	Not established – former field shop for Plant and Equipment Division support
Alpha Handling Facility	3038-AHF	Cf-252, Cm-244, Am-241, Pu-238, U-234, Np-237, Pa-231, others
Isotope Materials Laboratory	3038-E	Transuranic elements, Y-90, U-235, Pm-147, Sr-90, Cm-244, Am-241
Radioisotope Packaging and Shipping Facility	3038-M	I-129, Cs-137, Co-60, Sr-90, Tc-99, Mn-89, Ru-106, Cl-36
Isotope Technology Building (MMES 1995)	3047	C-14, Eu-152,154, Co-60, Gd-153, Am-241, Cm-242/243
Storage Cubicle (Kuhaida and Parker 1997, p. 5-16)	3093	Kr-85
Storage Pad	3099	N/A
Radioisotope Production Laboratory–H	3118	Not established
Fission Products Development Laboratory (MMES 1995)	3517	Sr-90, Cs-137, Ce-144, Pm-147, Ru-106, Tc-99, Co-60, Ir-192, U-235, Eu-152,154, Am-241
Tritium Target Preparation Facility (MMES 1995)	7025	H-3, ThO_2, UO_2, Sr-90, Cs-137, Cm-244

Building 3029 was constructed in 1952 to support the Isotopes Program (LMES 1997c). A small manipulator cell (now called Cell 4) and a system of remotely operated barricades supported source fabrication of ^{192}Ir. In addition, small ^{60}Co sources were fabricated. In 1955 and 1956, an additional cell (Cell 1) was built to handle large amounts of ^{60}Co for source fabrication. The amount of ^{60}Co sources fabricated in the facility diminished in the late 1950s. Between 1960 and 1962, Cell 3 was built for ^{137}Cs source fabrication. Cell 2, which is between Cells 1 and 3, handled waste and served as a pass-through between the two cells. Major operations in Building 3029 included ^{60}Co, ^{137}Cs, and ^{90}Sr source fabrication and ^{192}Ir processing. A ^{60}Co storage and irradiation facility, called the ^{60}Co Garden, is below the floor of the east wing (DOE 1996b). The exact dates of operation of this facility are unknown, but the program ended in the late 1980s.

Building 3030 was constructed in 1950 to produce and develop radioisotopes for industry, medicine, and research (LMES 1997d). The building contained a hot cell for processing irradiated cyclotron and reactor targets to produce, purify, and separate radioisotopes such as ^{56}Co, ^{57}Co, ^{198}Au, ^{55}Fe, ^{234}Np, ^{75}Se, ^{90}Sr, ^{111}Sn, ^{237}U, ^{33}P, and ^{192}Ir. These isotopes were processed primarily from irradiated targets from the HFIR, ORR, and 86-in. Cyclotron. There is ^{63}Ni and ^{103}Pd contamination in the facility. The exact dates of operation are not known. The program the facility supported began in the late 1940s and ended in the late 1980s.

Building 3031 was constructed in 1950 as part of the Isotopes Program and used for storage, purification, processing, and dispensing radioisotopes (LMES 1997e) that were processed primarily from irradiated targets from the HFIR, ORR, and 86-in. Cyclotron. The hot cell was used for the final separation of gadolinium (^{153}Gd).

Building 3032 housed the analytical facility for radiochemical support of Isotopes Production activities (LMES 1997f). It has a laboratory with five hoods on the north side and an office on the south side connected by an open passageway. It was used for storage, purification, processing, and dispensing radioisotopes that were processed primarily from irradiated targets from the HFIR, ORR, and 86-in. Cyclotron. The exact dates of operation of this facility are unknown. The program it supported began in the late 1940s and ended in the late 1980s.

Building 3033 was used for processing ^{14}C, ^{85}Kr, and ^{3}H. Processing of ^{14}C ended in 1975 (LMES 1997g). Radioactive gas processing of tritium and krypton took place in this facility. Bulk tritium shipments from the Savannah River Site were received, purified, loaded in shipping canisters, and shipped around the world. Krypton from Idaho was received and purified (^{85}Kr) for sale to private industries or used as feed to the thermal diffusion columns in Building 3026-C. The exact dates of operation of this facility are unknown. The program it supported began in the late 1940s. Processing of ^{3}H ended in 1990. The last ^{85}Kr was produced in September 1989.

Building 3033-A (LMES 1997g) housed facilities for the fabrication of ceramic oxide wires and the loading of these wires, oxide powder, or metal into small metal capsules for use as in-core reactor neutron dosimeters. It also housed facilities for the fabrication of monoenergetic gamma sources, weighing and packaging of milligram to gram quantities of actinide materials, preparation of nanogram to milligram actinide samples for alpha counting, decontamination of nuclear material shipping containers, and storage of radioactive materials. In the early 1980s, the ^{14}C room was decontaminated and decommissioned, which included removal of the underground dissolver tank, and converted for storage. All production operations in the building ended in January 1990 because of funding problems. All stored special nuclear materials were transferred to other ORNL or DOE sites or disposed of as waste.

Building 3034 (LMES 1997j) houses the electrical distribution system for the isotopes area and serves as a storage area and drop point for supplies. It also contains office space. No radioactive operations took place in the building; however, 1995 radiological surveys indicated several limited locations of elevated fixed beta/gamma contamination. An exhaust duct on the west wall of the second floor also indicated elevated beta/gamma measurements.

Building 3038 was used from 1949 until 1990 for packaging, inspection, and shipping activities for radioisotopes. It contained five hot cells shielded by water-filled steel tanks. The operating face of each cell consisted of 3 ft of shielding, a viewing window, and manipulator ports. Each cell was 10 ft deep. From 1968 until 1990, the western portion, referred to as the Alpha Handling Facility (AHF), was used for the fabrication of targets. The center portion (referred to as 3038-M) contained radioactive isotope shipping operations. The east end (3038-E) contained analytical chemistry laboratories that supported isotope shipping activities (DOE 1996b). This area was converted to an isotope production and development facility, and was used in the late 1970s and early 1980s to support research activities involving plutonium alloys and compounds. In the mid-1980s, gloveboxes in this area were used for research on ^{147}Pm doped crystals. The northwest corner (3038-W) contained a storage area and an isotope technology low-level laboratory.

Building 3118 was constructed to cover and enclose entries made in the hot cells in Buildings 3030 and 3031. It was used as a temporary storage shed for drums and containers of hazardous and radiological waste, radioactive shielding materials, and casks.

Section 2.2.69 discusses the REDC, which produces TRU isotopes from target materials irradiated in the HFIR.

2.3.4 Waste Areas and Processes

Due to the varied history and growth of operations at ORNL, several waste disposition areas have been used. Early sites in or near the Main Plant Area accepted solid and liquid production wastes. In later years, disposal areas moved south of the Main Plant Area across Haw Ridge to Melton Valley. The following paragraphs describe the areas and amounts of radioactive materials present, if available.

The ORNL site was originally to operate for a short period to develop processes for use at other Manhattan Project facilities. Because of this short-term focus, maintenance of much of the wastes was expected to be in consolidation areas. The North and South Tank Farms were established for temporary storage of liquid wastes. Processing included treatment and precipitation of solids and drainage of the supernatant. The waste was sent to the waste holding basin and then to White Oak Creek. The holding areas treated the liquids and precipitated much of the radioactivity out of solution prior to offsite release. However, sediments in White Oak Creek and Lake contain radioactive materials that settled from the process liquids.

The North Tank Farm (Facility 3023), which was built in 1943, included four large concrete (gunite) underground tanks (W-1, W-2, W-3, and W-4) to store liquid chemical and radioactive wastes. In 1950, four stainless-steel underground tanks (W-1A, W13, W-14, and W-15) were built in the same general area. An extensive underground piping system transported liquid waste from Buildings 3019 and 3026 to the tanks.

The South Tank Farm (Facility 3507) is a series of six 170,000-gal underground gunite storage tanks placed in service in 1943. It was part of the LLLW system for collection, neutralization, storage, and transfer of aqueous radiological and chemical wastes generated at ORNL.

The Waste Holding Basin (Facility 3513) was built in 1944 by scooping a depression in the native clay and constructing earthen berms to contain the liquids. The unlined disposal area measured 220 ft by 220 ft and was 6.5 ft deep. Supernatant wastes from the South Tank Farm were piped to the northern end of the basin. Water from the process waste treatment plant that had been treated with fly ash and lime was discharged to the holding basin before discharge to White Oak Creek. The basin was removed from service in 1976, but it still contains water and contaminated sediments (Kuhaida and Parker 1997, p. 2-110).

The contaminants in these three waste storage areas consisted of soluble and insoluble radioisotopes that flowed from the chemical separations areas. The liquid wastes were often treated with caustic material to increase the pH and prompt radioactive material to settle out. Once treated, liquid waste could be transferred to make room for additional waste. The treated waste liquid was initially pumped into White Oak Creek. Liquid wastes were later transported by truck to Melton Valley, where they were poured into pits and trenches in which the liquid evaporated and chemically combined with the soil. The Old Hydrofracture Facility (Building 7852, see Section 2.2.47) disposed of LLLWs deep in geological faults that are separate from sources of drinking water.

There are additional underground storage tanks in the main plant area (thorium tanks, area 4500 tanks, and several tanks near the South Tank Farm).

Solid wastes were originally placed in disposal areas on or near the main plant site (SWSAs 1, 2, and 3). Solid wastes were later transported to Melton Valley where other landfills operated. The following paragraphs describe SWSAs 1 to 6:

- SWSA 1 is a 1.5-acre site on the north side and at the foot of Haw Ridge and immediately southeast of White Oak Creek in Bethel Valley. Solid waste was buried in this area in trenches south of Incinerator Drive beginning in April 1944. More waste was added in 1944, but the site was abandoned later that year due to water accumulating in the trenches. The area contains only a small amount of solid radioactive waste because fissionable material was maintained in the main plant site. At the time of waste generation, site operations did not include isotope separation and concentration of waste. Analyses from ground-water wells show low concentrations of ^{90}Sr, but no indication of ^{137}Cs or transuranic elements (Kuhaida and Parker 1997, p. 2-102).

- SWSA 2 is approximately 3.6 acres north of the location where the East Vehicle Gate existed, on the lower half of the hill adjacent to and west of the main parking lot. The site is not fenced or marked to identify its location. It was used from 1944 until 1946 for disposal of waste. Beta/gamma-contaminated solid waste was put in black drums and buried in trenches. Liquid waste contaminated with plutonium was put in stainless-steel drums and either buried in trenches or stored above ground in a ravine. Following closure of SWSA 2, the drums were removed and reburied in SWSA 3. Following drum removal between 1946 and 1949, the SWSA 2 hillside was bulldozed, backfilled, contoured, and seeded. Analyses of core samples indicated no contamination from uranium, plutonium, and ^{137}Cs. Ground-water samples showed no detectable contamination; analyses included tritium, gross alpha, and gross beta (Kuhaida and Parker 1997, p. 2-198).

- SWSA 3 is about 7 acres about 0.5 mi west of SWSA 1 and 0.6 mi west of the west ORNL entrance. It opened in 1946 and received contaminated trash, laboratory equipment, and other materials. The drums from SWSA 2 were placed in this area. Alpha-contaminated waste was put in drums and placed in concrete-lined trenches on the northeast end of the burial ground. Later, as the burial ground extended to the west, the drums were placed directly in unlined trenches and covered with concrete. Beta/gamma-contaminated wastes were buried in separate unlined trenches and backfilled with soil. Some large equipment contaminated with low levels of radioactivity was stored above ground until removal in 1979. Some items were moved to an area between SWSA 4 and the Chemical Waste Pits, while others were moved to SWSA 5 or 6 and buried. SWSA 3 closed in 1951. Ground-water samples indicate small amounts of trivalent rare earths, ^{90}Sr, ^{89}Sr, and ^{3}H contamination (Kuhaida and Parker 1997, p. 2-239).

- SWSA 4, which covers approximately 23 acres, received waste from 1951 until 1959. It is in Melton Valley on the south side of and at the foot of Haw Ridge, immediately west of White Oak Creek. Records about waste disposed of in SWSA 4 before 1957 are incomplete due to a fire. ORNL generated about 50% of the waste buried in SWSA 4 during 1957 and 1958; the remainder came from more than 50 other agencies; Argonne National Laboratory, Knolls Atomic Laboratory, Mound Laboratory, and the General Electric Company (Evendale, Ohio) were principal generators. Surface- and ground-water samples indicate the presence of radioactive contamination. One well sample indicated alpha contamination while another 8 of 16 well samples indicated beta/gamma contamination. Radioactive contaminants include ^{90}Sr, ^{106}Ru, ^{137}Cs, ^{60}Co, ^{210}Po, ^{239}Pu, ^{3}H, ^{125}Sb, and trivalent rare earths (Kuhaida and Parker 1997, p. 2-247).

- SWSA 5 is in Melton Valley north of Melton Branch and east of the confluence of White Oak Creek and Melton Branch. The 33-acre area opened in 1958 after space in SWSA 4 became limited. Low-level waste is stored in trenches in the larger southern section of the area, and TRU waste is stored in trenches in the northwest corner. Disposal of waste in SWSA 5 ended in 1975. Water seepage has filled the trenches, which were excavated with the long portions extending down the slope parallel to the hydraulic gradient of the water table. In 1975, underground dams were installed across two parallel trenches to reduce water seepage in the south end of the area. A plastic membrane was installed to cap the southern area where the dams were installed and grass was planted to inhibit erosion. A bentonite-shale mixture was added to seal the northern part of the area in more than 14 trenches in the TRU waste area. Water sample analyses indicate the presence of ^{244}Cm, ^{238}Pu, ^{90}Sr, ^{3}H, ^{125}Sb, ^{106}Ru, ^{137}Cs, ^{60}Co, and trivalent rare earths (Kuhaida and Parker 1997, p. 2-275).

- SWSA 6 opened in 1969 and is still operational, receiving low-activity solid waste and ^{235}U for storage. The 68-acre area is in Melton Valley north of White Oak Lake, south of Lagoon Road

and Haw Ridge, and immediately east of Highway 95. Beta/gamma and TRU waste is buried in trenches and auger holes at the site (Kuhaida and Parker 1997, p. 2-285).

The Central Exhaust Facility (Building 3039) is the major exhaust stack in the main plant area. The 3039 Stack Ventilation System off-gas and cell-ventilation facilities include cell ventilation, off-gas scrubber, and waste systems. Because of the diversity of activities in the buildings the system serves, any gaseous waste stream can contain TRU or fission product radioisotopes. Building operators, as the waste generators, are responsible for keeping radionuclides in the gaseous waste streams that discharge to the Stack Ventilation System to levels that limit risk to the health and safety of the public and employees. This occurs through a combination of administrative controls, input controls, application of health physics procedures, and treatment (usually by HEPA filters) of the gaseous waste stream before discharge to the Stack Ventilation System.

2.3.5 ORNL Facilities at the Y-12 National Security Complex

Due to a moratorium on construction activities immediately after World War II, insufficient space at ORNL caused the Biological Sciences Division to move to space at the Y-12 National Security Complex, which included Buildings 9207, 9208, 9210, 9211, 9220, 9224, 9743, 9767-3, 9767-5, 9982 and several cooling towers. The Biological Sciences Division conducted animal research, typically using low-strength radiological sources for carcinogenic research, determination of the relative biological effectiveness of differing radiation types and source strengths, and dosimetry in space flight. Many of the studies were conducted in Building 9210, known as the Mouse House.

Discussions with the current Radiological Control Officer for the Life Sciences Division (which had been Biological Sciences Division) indicated that the type of radiological studies conducted in the building complex used sealed radioactive sources for direct exposures (Fleming 2003). They used sealed sources that consisted of welded metal capsules. The greatest potential hazard was direct exposure to an unshielded capsule. This is unlikely to have presented a contamination hazard except in the event of a broken capsule weld. There is no information indicating that this type of accident ever occurred in these facilities. The source rooms had lead-lined walls and doors at all locations where there was a potential for personnel or public exposure. Procedures and safety interlocking devices minimized the potential for personnel to be exposed.

Radiation sources are no longer present in the Y-12 Biological Sciences facilities. Table 2-6 lists the sources used by the Biological Sciences Division at Y-12 over the last few decades.

Table 2-6. Radiation sources in Biological Sciences Division at Y-12 (Fleming 2003; McRee 1961).

Building	Room	Radioactive source	Quantity (Ci)	Dose rate (at 1 m, unshielded) (rad/hr)	Type of radiation	Main irradiation use
9207	403A	Cs-137 Cs-137	1,300 65	430 21.5	Gamma	Mice, rats Mice, rats
9207	4040	Cs-137	0.83	0.3	Gamma	Mice, rats
9210	341	Cs-137	2.5	0.8	Gamma	Mice
9779-2		Cs-137	80	26.5	Gamma	Mice
9207	127	Co-60	3.75	5	Gamma	Insects, mammalian tissue
9983-17	Trailer	Cf-252	3.91	0.8	Neutrons and gamma	Mice, rats, mammalian tissue

Two other ORNL programs moved to the Y-12 site. The Stable Isotopes Program emerged at the end of World War II when site personnel stopped using calutrons to separate uranium isotopes for atomic weapons. Researchers at first used four calutrons salvaged from electromagnetic equipment. Copper isotopes were the first to be collected, followed by isotopes of iron, platinum, lithium, and mercury. These were separated and shipped to universities, governments, and national laboratories.

In 1958, the building containing two beta calutron tracks (Building 9204-3, Tracks 5 and 6) became available and was assigned to the Stable Isotope Program. One track of calutrons was modified with heavy iron yokes so individual sections could be operated to separate isotopes of different elements. In 1963, the ORNL Electromagnetic Isotope Separations Program was providing more than 250 high-purity highly enriched isotopes for use in research and technical applications. During 1963, more than 17,000 g of separated material were collected from 28 of the calutrons allocated for the Stable Isotope Program. In late 1985, the Stable Isotope Program made over 229 isotopes available by direct sale or on a loan basis. At one time, this program was the largest DOE involvement with commercial markets. Stable isotopes were used in preparing specialty isotopes used in medical research, as tracers, and in a number of physics applications. Every year, the program produced and sold millions of dollars worth of these materials. Calutrons were last used for stable isotope production at Y-12 in 1990 (Wilcox 2001).

In 1951, the ORNL Engineering Technology Division was split into two divisions – the ANP and Reactor Experimental Engineering Divisions. Later that year, both divisions moved to Y-12 (ANP to Building 9201-3 and the Reactor Experimental Engineering Division to Building 9204-1). There is little indication that these divisions used substantial amounts of radioactive materials.

The ORNL CEF, also at Y-12, is discussed in Section 2.3.6.2.

2.3.6 Other Reactor Development and Operations

In addition to the Graphite Reactor operations described in Section 2.3.1, facilities were built at ORNL to test reactor designs, train personnel, or test criticality configurations. This section discusses the following facilities:

- Low-Intensity Test Reactor
- Critical Experiments Facility
- Bulk Shield Reactor/Pool Critical Assembly
- Oak Ridge Research Reactor
- Tower Shielding Facility
- Health Physics Research Reactor
- Homogeneous Reactor Experiment
- Aircraft Nuclear Propulsion Experiment
- High Flux Isotope Reactor
- Molten Salt Reactor Experiment

In addition to routine elevated external exposures adjacent to these facilities, each facility was known to have incidents that provided increased external and internal exposures. The following sections provide information on the operation of these facilities.

2.3.6.1 Low-Intensity Test Reactor

The LITR (Building 3005) was originally built as a mockup of the MTR being built in Idaho. It was a pool-type reactor with beryllium reflectors on each side and water used as a reflector on the top and bottom. Reactor specifications indicate that there could be as many as 25 fuel elements in a slab arrangement, but at times 25 fuel elements were not in place (Cox 1958, 1959b, 1960a). (This reactor was sometimes described as a box-type reactor.) Minimum shielding around the reactor was 10 ft 7 in. of unmortared concrete block with maximum measured exposure rates outside the shields of 6 mR/hr. Maximum radiation leakage around the beam plugs reached 1 R/hr (Rupp and Cox 1955). During operational testing, it was noted that the core region of the original reactor was close enough to the final design of the reactor being built in Idaho that it could be brought up to criticality and operated. The LITR was used for testing and checkout of instruments and controls of the MTR.

It was also used as a training facility for MTR operators. LITR controls were collocated in the Graphite Reactor Building. ORNL and AEC later decided to modify and operate the reactor for experimental and training purposes. It operated at a power level of 3 MW.

The LITR operated from 1951 until October 1968. Experiments could be approved by one individual, and no written procedures were followed during the experiments (Stapleton 1993). A series of documents (Cox 1958, 1959b, 1960a) described several minor incidents that caused elevated external exposure rates as well as contamination in the pool waters and airborne contamination in the facility. The cotton cord filters used in the bypass filters had an operational life of approximately 6 weeks, and changes were required before disintegration. After 8 yr of satisfactory use, sintered stainless-steel filters replaced the cotton filters. The stainless steel filters failed after about 1 yr, possibly from the dissolution of nickel. In addition, high-exposure conditions were encountered when experimental beam ports were vacuumed to minimize the spread of contamination when removing experiments. Radioactive particles were removed during vacuuming that caused exposure rates to exceed 10 R/hr at 4 in. Some contamination was dropped on blotter paper and on the floor, with exposure rates of 10 and 4 R/hr, respectively. The demineralizers used to filter radioisotopes out of solution would become sources of direct radiation exposure. Concentrations of ^{239}Np were detected in the pool waters in 1954 (Rupp and Cox 1955).

2.3.6.2 Critical Experiments Facility

The CEF (Building 9213) is at a remote site in the southwest portion of the Y-12 Main Plant Site in a pocket formed by the surrounding hills (Stapleton 1993). The building was constructed in 1946 for storing highly enriched uranium processed at Y-12 prior to shipment off the site (Auerbach 1992). It began critical and near-critical experiments in August 1950 in support of upcoming reactor designs (e.g., ANP, liquid fuels, TSR-II, and HFIR). The facility, which has three assembly areas and a control room, was designed with safety features (water-filled windows and an intercom system) to minimize occupational exposures to personnel. It operated until March 1987 and shut down permanently in 1992. Four incidents occurred:

- A polonium-beryllium neutron source containing nearly 7 Ci of polonium and 0.4 g of beryllium was accidentally opened in a CEF assembly area. This caused widespread dispersal of polonium throughout one of the assembly areas and resulted in internal and external contamination of an employee (ORNL 1967, pp. 56-57).

- On May 26, 1954, in an experiment with a uranium solution in a vertical cylinder, a poison cylinder placed in the center of the larger cylinder to absorb neutrons accidentally became tilted from its proper vertical position, resulting in 2.1% excess reactivity. Approximately 1×10^{17} fissions occurred. Automatic safety systems functioned and the reaction terminated. The incident occurred in an area shielded by 5 ft or more of concrete. Personnel exposures indicated on film badges ranged from 0.08 to 0.9 rem, with an average of about 0.3 rem (ORNL 1967, p. 57).

- On February 2, 1956, in an experiment with a uranium solution in a vertical cylinder, there was an unintentional overaddition of solution. The safety system actuated and waves caused in the solution by a falling cadmium sheet formed a prompt-critical configuration. About 1.6×10^{17} fissions occurred. The incident occurred in the shielded facility designed for such tests under remote operation. A considerable volume of solution was ejected from the cylinder. Personnel exposure indicated on film badges ranged from 0.14 to 0.575 rem (ORNL 1967, pp. 57-58).

- On November 10, 1961, a criticality incident occurred during assembly of enriched uranium metal that was paraffin-reflected. Two pieces of metal were brought together too quickly,

which caused an excursion that yielded 1×10^{15} to 1×10^{16} fissions. There was no exposure to personnel in the building, and no dispersal of radioactive material beyond the assembly area where the incident occurred (ORNL 1967, p. 59).

2.3.6.3 Bulk Shielding Reactor/Pool Critical Assembly

The BSR (Building 3010) was a pool-type reactor originally designed to operate at a power level of 10 kW for conducting radiation shielding experiments (Stapleton 1993) for the ANP Project. After the ANP Project, the facility was used by the Space Program to determine the effects of radiation on space capsules for the Mercury Project. In 1960, the Low-Temperature Irradiation Facility was installed to test the effects of radiation on metals and other materials at low temperatures. It also was used by a number of organizations for isotope production, materials irradiation, radiation shielding experiments, and training for reactor operators and students (DOE 1996a). It served as a model for university, industry, and government pool reactors. It began operating in 1951 for shielding experiments; in 1963, it was made available to the site as a general research reactor due to the shutdown of the Graphite Reactor. The BSR shut down in March 1987. It permanently shut down on September 10, 1991. Modifications to the reactor allowed it to run at a thermal power level of 2 MW when it was designated a general research reactor. The aluminum-clad, uranium-aluminum alloy fuel appears to have been highly enriched, similar to that used in the MTR.

The PCA is in the northwest corner of the same pool as the BSR (Stapleton 1993). It was designed as a low-power reactor (up to 10 kW) to supplement experiments that took place at other site reactors. The reactor controls were similar to those for the BSR. The PCA was used to train nuclear engineering students from around the country. It shut down in 1987 and has not operated since.

2.3.6.4 Oak Ridge Research Reactor

Construction of the ORR (Building 3042) was completed near the end of 1957 and criticality was attained in March 1958 (Stapleton 1993). The reactor was a light-water-moderated and -cooled, beryllium- and water-reflected research reactor using highly enriched uranium-aluminum alloy plate fuel. It was at one end of the pool. Though it initially operated at 20 MW, power levels up to 30 MW were reached in mid-1960. The reactor was designed to produce high neutron fluxes for basic research in the fields of physics and chemistry and to test materials and potential fuels for power-producing reactors. When operational, the ORR produced greater quantities of radioisotopes for research, medical, and industrial use than any reactor in the world. It contained the most advanced safety devices, including filters and scrubbers to minimize airborne releases. Reports indicate several releases from 1959 to 1961 (Cox 1959c, 1960b; Casto et al. 1961).

Building 3042 housed several facilities used for experiments over the years. These experiments included the following:

- The Gas Cooled Reactor (GCR) A9-B9 experiment to measure fission-product gases from ceramic fuels (1960 to 1969)
- A molten salt test loop for the analysis of homogenous fuels (1959 to 1967)
- The maritime ship reactor test loop for testing structural materials and fuel pins for nuclear merchant ship applications (1959 to 1962)
- A pneumatic tube irradiation facility used to transfer irradiated samples from the ORR to a laboratory in Building 3001 (1968 to 1973)
- The GCR test loop to test new fuels for gas-cooled reactors (1960 to 1967)

- GCR Loop I for irradiation of unclad graphite fuel to study fission product releases (1962 to 1963)

2.3.6.5 Tower Shielding Facility

The TSF (7700 area) was built in 1954 to support the ANP Project. Four 315-ft towers erected on a 200- by 100-ft rectangle were used to raise an operating reactor out of a shielded position and suspend it from the towers (Holland 1970). The design of the towers enabled testing of different shielding configurations. The TSF is on a knoll approximately 2.4 mi south-southeast of the ORNL main plant area. It enabled radiological measurements free of radiation scattering from the ground or enclosed structures. Four different reactor designs have been employed at the TSF. The original, TSR-I, was a box-shaped, 500-kW, MTR-type reactor. For a period during 1958, the Aircraft Shield Test Reactor was used for shielding research for an operating aircraft. It operated at a power level of 1 MW. It was replaced in 1960 with a spherically symmetric reactor (TSR-II) that operated at power levels up to 100 kW. The fourth reactor, the TSF-SNAP (Systems for Nuclear Auxiliary Power) reactor, was used at the facility at a power level of 10 kW. The TSF-SNAP reactor was removed from the site in 1973. Since 1975, the TSR-II has been inside a ground-based concrete shield (Big Beam Shield) (Stapleton 1993).

Safety control procedures are in place to ensure that personnel do not receive elevated exposures. A fence surrounds the reactor at a distance of 600 ft. Warning horns sound 3 min before the reactor is brought out of the shielded location. In addition, safety interlocks automatically shut the reactor down if a door or gate is open while the reactor is in the open (Stapleton 1993). There have been no known incidents at TSF. It is likely that external exposures to neutron and gamma radiations would have been present.

2.3.6.6 Health Physics Research Reactor

The HPRR (also known as the Fast Burst Reactor) was a small, unshielded, unmoderated, fast reactor designed at ORNL and built under the Laboratory's supervision. Following initial tests at the CEF in 1961, the HPRR was loaned to Operation Bare Reactor Experiment Nevada at the Nevada Test Site, where it was used to simulate nuclear weapon effects. The reactor was returned to ORNL in 1963 and was operated at the DOSAR facility (Building 7709). When not in use, the reactor was stored in a steel and concrete vault below floor level. Ancillary buildings were behind a hill and approximately 900 ft from the reactor building. There were no occurrences in which the safety of personnel was compromised or in which a failure seriously affected the equipment (Stapleton 1993).

2.3.6.7 Homogeneous Reactor Experiment (Kuhaida and Parker 1997, p. 2-392)

Building 7500 was constructed to conduct testing of homogeneous (fluidized fuel) reactors. The building initially contained the first experiment (HRE-1). A second reactor (HRE-2) took its place in 1953. The HRE-1 was an aqueous homogeneous fuel reactor. Its purpose was to prove the theory that a homogeneous reactor could generate electricity. The initial test run was completed in October 1952 and the designed power level of 1 MW was achieved on February 24, 1953. Many experiments were performed with the HRE-1 before its shutdown and dismantling in 1954.

The HRE-2 was built between 1953 and 1956. HRE-2, sometimes referred to as the Homogeneous Reactor Test, was a homogeneous reactor that could produce electricity and act as a breeder reactor, irradiating ^{232}Th source material to create ^{233}U for use as reactor fuel. The reactor consisted of the core and the thorium blanket. It reached criticality in 1957 and operated at normal full power of 5 MW. After 16,295 MW-hr of operation, the reactor shut down in 1961 due to a hole in the core tank, which allowed mixing of the fuel and blanket regions.

2.3.6.8 Aircraft Nuclear Propulsion Experiment

The ANP Experiment took place from October 30 until November 12, 1949, in an area of Melton Valley approximately 0.75 mi from the main ORNL site. The reactor operated for 221 hr at a maximum power output of 2.5 MW. The fuel was a mixture of fluorides of sodium and zirconium that flowed in a closed loop from a pump to the reactor to a heat exchanger and back to the pump. The active core area was a cylinder approximately 3 ft in diameter and 3 ft high. Beryllium oxide blocks moderated and reflected the neutron flux. Liquid sodium was pumped through the bottom of the reactor shell for cooling. Radioactive releases were minimal with practically all gaseous fission products and probably other volatile fission products removed from the circulating fuel (Cottrell et al. 1955). Off-gas treatment was provided by nitrogen-cooled charcoal tanks used to hold up the gaseous wastes. Waste gas was released via the effluent stack when the wind speed was greater than 5 mph and the concentration was less than 0.8 µCi/mL.

2.3.6.9 High Flux Isotope Reactor

The HFIR is a beryllium-reflected, light-water-cooled and -moderated, flux trap reactor that uses highly enriched ^{235}U as fuel (Stapleton 1993). It began low-power testing in August 1965, and was completed in January 1966. The design power output of 100 MW was attained in September 1966. One of the principal purposes of the HFIR is the production of radioisotopes for research, medical, and industrial applications. Radioisotopes produced in the HFIR include transuranic elements (most notably ^{252}Cf), ^{192}Ir, and ^{60}Co. The HFIR is also used in materials research.

In late 1986, the HFIR was shut down due to concerns over embrittlement of the reactor vessel. Following modifications, the HFIR restarted on April 18, 1989, and operated at low power levels (8.5 MW). The restart period revealed procedural inadequacies and the HFIR shut down again until January 1990. Full-power operation was reached on May 18, 1990 (Stapleton 1993).

The REDC, which operates in conjunction with the HFIR, includes the Transuranic Facility (Building 7920) and the TURF (Building 7930). These facilities are described in Sections 2.2.69 and 2.2.70, respectively.

2.3.6.10 Molten Salt Reactor Experiment (Kuhaida and Parker 1997, p. 2-387)

The MSRE (Building 7503 complex) was an 8-MW reactor operated from 1965 through 1969 to investigate the possibility of using molten salt reactor technology for commercial power applications. The reactor used a fluoride salt mixture of lithium, beryllium, and zirconium fluorides with uranium tetrafluoride as the fuel components. It was initially fueled with ^{235}U, which was replaced with ^{233}U in 1968. In 1969, the reactor contained less than 1 kg of plutonium trifluoride. A plan written in 1998 indicated the presence of 28,200 Ci of fission and activation products, 21.7 g of ^{233}U, 915 g of ^{235}U, and 709 g of ^{239}Pu in drain tanks and the fuel flush tank (Burman, Tiner, and Gosslee 1998). More than 99% of the activity in salt is from $^{90}Sr/Y$ and ^{137}Cs. Radionuclides of concern for the MSRE include ^{232}Th, ^{233}U, ^{90}Sr, ^{90}Y, ^{137}Cs, ^{137m}Ba, ^{151}Sm, ^{147}Pm, ^{155}Eu, ^{154}Eu, ^{99}Tc, ^{125}Sb, and ^{93}Zr.

2.3.6.11 Spallation Neutron Source (Parr et al. 2002)

The SNS site is on 80 acres of Chestnut Ridge about 2 mi northeast of the main ORNL site. The SNS, an accelerator-based neutron source, will provide neutron beams with up to 10 times more intensity than any other source in the world. Construction began in 1999 and is scheduled for completion in 2006.

2.4 ATTRIBUTIONS AND ANNOTATIONS

Where appropriate in this document, bracketed callouts have been inserted to indicate information, conclusions, and recommendations provided to assist in the process of worker dose reconstruction. These callouts are listed here in the Attributions and Annotations section, with information to identify the source and justification for each associated item. Conventional References, which are provided in the next section of this document, link data, quotations, and other information to documents available for review on the Project's Site Research Database.

Kenny Fleming served as the initial Subject Expert for this document. Mr. Fleming was previously employed at ORNL and his work involved management, direction or implementation of radiation protection and/or health physics program policies, procedures or practices related to atomic weapons activities at the site. This revision and earlier revisions have been overseen by a Document Owner who is fully responsible for the content, including all findings and conclusions. In all cases where such information or prior studies or writings are included or relied upon by Mr. Fleming, those materials are fully attributed to the source.

[1] Burns, Robert E. Shonka Research Associates. Senior Health Physicist. April 2007.
The hot cells and gloveboxes at the REDC shield the low-energy photons from the activated TRU materials more effectively than neutrons. See the latest revision of Section 6 of this Site Profile on external dosimetry for details on neutron-to-photon dose ratios for REDC workers (ORAUT 2004).

[2] Burns, Robert E. Shonka Research Associates. Senior Health Physicist. April 2007.
This list of radionuclides of concern reflects key components of low-burnup irradiated fuel slugs from both an external and internal dose perspective.

[3] Burns, Robert E. Shonka Research Associates. Senior Health Physicist. April 2007.
This list of radionuclides of concern reflects key components of irradiated fuel from both external and internal dose perspectives.

[4] Burns, Robert E. Shonka Research Associates. Senior Health Physicist. April 2007.
This list of radionuclides of concern reflects key components of irradiated fuel from both external and internal dose perspectives.

[5] Burns, Robert E. Shonka Research Associates. Senior Health Physicist. April 2007.
This list of radionuclides of concern highlights uranium as the key radionuclide in the process, and other radionuclides that are volatile or semivolatile in the molten salt process.

[6] Burns, Robert E. Shonka Research Associates. Senior Health Physicist. April 2007.
This list of radionuclides of concern reflects key components of irradiated fuel from both external and internal dose perspectives.

[7] Burns, Robert E. Shonka Research Associates. Senior Health Physicist. April 2007.
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GLOSSARY

barites concrete
Concrete containing barium sulfate ($BaSO_4$).

calutron (California University Cyclotron)
An accelerator used for the electromagnetic separation of isotopes based on their mass.

supernatant
A highly radioactive liquid overlying material deposited by settling, precipitation, etc.; also called supernate.

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Facility ID	Description	Old numbering
807	Cs-137 Erosion/Runoff Study Area	
813	Field Laboratory #1 Trailer	
814	Trailer	
816	Cesium Plots Study Area	
817	Ozone Generator Building	
818	Atmospheric Instrument Trailer	
819	Farm Implement Storage	
820	Carbon Dioxide Tank	
821	Ambient Air Station No. 39	
822	Environmental Sciences Division/National Oceanic and Atmospheric Administration (ESD/NOAA) Trailer	
823	Free Air Carbon Experiment (FACE) Complex	
0823A	FACE Ring #1 Shed	
0823B	FACE Ring #2 Shed	
0823C	FACE Ring #3 Shed	
0823D	FACE Ring #4 Shed	
0823E	FACE CO2 Tank/Evaporators	
830	White Oak Creek embayment structure	
853	White Oak Creek Below Dam	
855	Operations Building	
857	Goat Building	
858	Sycamore Plantation Trailer	
870	Raccoon Creek Monitoring Station	
900	Firearms Range	745-A,-B
0900A	Firing Range Storage	
0900B	Firing Range Canopy	
901	161 kilovolt (kV) Substation	501-H
902	Main Reservoir	803
903	Bethel Valley Church	
907	Walker Branch Watershed Laboratory	
910	Booster Pump Station	
926	1,500,000 gal Steel Water Reservoir	
0926A	Valve House	
0926B	Emergency Generator	
927	Storage Building	
929	Ish Creek Weir	
932	Walker Branch Watershed (WBW) Soil Block 1	
933	WBW Soil Block 2	
934	WBW Subsurface Weir Instrument Trailer	
935	WBW Subsurface Weir	
936	Environmental Sciences Division (ESD) Twin Towers Walker Branch	
937	Atmospheric Turbulence and Diffusion Division (ATDD)/NOAA Rain Gauge 2 Building	
940	Instrument Building 1	
941	Instrument Building 2	
0945A	Rain Gauge 1 Site	
0945B	Rain Gauge 2 Site	

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Facility ID	Description	Old numbering
0945C	Rain Gauge 3 Site	
0945D	Rain Gauge 4 Site	
0945E	Through-Fall Experiment Site	
0945F	Through-Fall Storage Building	
946	Katie's Kitchen Well	
950	Walker Branch, East Instrument House	
951	Walker Branch, West Instrument House	
952	Walker Branch East Weir	
953	Walker Branch West Weir	
954	Refuse Transfer Station	
955	Walker Branch Storage Building	
956	Spring Water Pumphouse	
957	Sample Storage Building	
958	Water Well No. 1	
960	Water Well No. 2	
961	ORNL Visitor Overlook	
963	White Oak Creek Headwaters Monitoring Station	
965	Parking Passenger Shelter	
966	West Entry Control Facility, Post 50	
967	Power Conductor Accelerated Test Facility	
1000	Engineering Office Building	703-C
1001	Solid Waste Storage Area (SWSA) #3 Burial Grounds	
1005	Laboratory For Functional And Comparative Genomics	
1055	Water Well No. 9	
1057	100-Meter Meteorological Tower	
1058	Substation No. 7-2	
1059	Health Effects Information Office Building	
1060	Environmental & Life Sciences Laboratory Facility	
1060COM	1060 Commerce Park Drive (COM)	
1061	Health Protection Services Office Building	
1062	West Office Building	
1096	Passenger Shelter, West Parking Lot	
111UNV	111 Union Valley (UNV) Road	
115UNV	Receiving, Acceptance, Testing & Storage Facility	
1503	Environmental Systems Laboratory	
1504	Aquatic Ecology Laboratory	
1505	Environmental Sciences Laboratory	
1506	Plant Sciences Laboratory	
1507	Life Sciences Data Analysis Office Building	
1508	Aquatic Storage Building	
1509	Environmental Engineering Office Building	
1510	Aquatic Storage Building 1	
1511	Aquatic Storage Building 2	
1512	Aquatic Storage Building 3	
1513	Aquatic Storage Building 4	
1514	Aquatic Storage Building 5	
1515	Aquatic Storage Building 6	

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Facility ID	Description	Old numbering
1542	Gas Storage Facility	
1552	Water Monitoring Equipment Shed	
1553	Service Pit for 1504	
1554	Contractor Disposal Area	
1556	East Cooling Tower	
1557	West Cooling Tower	
1558	Northwest Tributary Monitoring Station	
1559	Boat Shed	
1560	East Greenhouse	
1561	West Greenhouse	
1562	Scrap Metal Area	
1563	Substation No. 234-4	
1566	First Creek Monitoring Station	
2000	Solid State Annex	101-D
2001	Information Center Complex	104-B
2003	Process Water Control Station	
2007	Calibration Lab	
2008	ORNL Whole-Body Counter	719-B
2009	Cafeteria Warehouse	802
2010	ORNL Cafeteria	
2011	Electric and Air Conditioning (AC) Service Centers	
2013	West Maintenance Service Center	719-A
2016	Security Patrol Headquarters Annex	614-6
2016A	Pump Station No. 1, Core Hole-8	
2016B	Pump Station No. 2, Core Hole-8	
2016C	Ground-Water Collection and Transfer, Core Hole-8	
2017	East Research Service Shop	
2018	Electric and AC Service Center	717-C or 305
2019	Laser Laboratory	
2024	Quality Assurance and Inspection Office Building	
2026	Radioactive Materials Analytical Laboratory	
2026A	Tank Southeast of Building 2026	
2032	Manhole (MH) 240 Monitoring Station	
2033	Measurements and Controls Building	
2034	MH 95 Monitoring Station	
2061	Stack	
2069	Change House	708
2087	Storage Building	
2088	Emergency Generator Building for 2000	
2092	Storage Building	
2093	Environmental Storage Building	
2097	Cooling Tower For 2001	
2098	Substation No. 6-3	
2099	Building 2026 monitoring control station	
2101	Liquid and Gaseous Waste Operations Department (LGWOD) Health and Hygiene Support Building	
2102	Personnel Contamination Monitor Trailer	

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Facility ID	Description	Old numbering
2500	Fire Station And Protective Services Headquarters	720
2506	Plant and Equipment (P&E) Maintenance Shop and Support Building	717-B
2508	Instrumentation Trailer at W-Tanks	
2510	Air Compressor Building	
2517	Personnel Development Offices	735-A
2518	Facilities And Operations Office Building	
2519	Steam Plant	801-D
2519A	Standby Emergency Generator for 2519	
2519C	Emergency Generator, 2519	
2521	Sewage Treatment Plant	
2521A	Sewage Treatment Aeration Basin	
2521B	Emergency Generator Building	
2521C	Sludge Drying Bed	
2521D	Aerator Shed	
2521E	Calgon Tank Shed	
2521F	Sewage Digester Building	
2522	Fuel Oil Tank	
2523	Decontamination Laundry	
2523A	Decontamination Laundry Annex	
2525	P&E Machine Shop Facility	
2528	Waste Handling and Packaging Plant Development Facility	
2528A	Storage Tank	
2531	Liquid Low-Level Waste (LLLW) Evaporator Building	
2532	High-Level Waste Storage Cooling Pump House	
2533	Cell Ventilation Filter Pit for 2531 and 2537	
2534	Off-Gas Filter Pit for 2531 and 2537	
2535	Cooling Tower #1 for Building 2531	
2536	Coal Sample Preparation Building	
2537	Evaporator Service Tank and Control Room for 2531	
2539	Cooling Tower Substation for 2531	
2540	Steam Plant Substation	
2543	East Aeration Pond	
2544	West Aeration Pond	
2545	Sewage Treatment Facility	
2546	Monitoring Building for 2545	
2547	General Machine Shop	
2548	Sludge Drying Facility	
2549	Steam Plant Storage Building	
2555	250,000 gal Fuel Oil Storage Facility	717-I
2568	Cell Ventilation and Off-Gas Filter for 2531	
2572	Emergency Generator for 2500	502 #9
2600	Bethel Valley Storage Tank	713-S
2609	Sentry Post 3, West Portal	
2621	Waste Operations Support Shop	
2624	SWSA 1 Burial Grounds	
2628	Fire Protection Maintenance and Storage Building	
2630	Cask Component Drop Test Facility	

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Facility ID	Description	Old numbering
2632	5000-kV Substation	
2636	West Precipitator	
2637	East Precipitator	
2638	Steam Plant Scale House	
2643	Chlorinator Building	
2644	Coal Yard Runoff Treatment Plant	
2645	Emergency Generator, Coal Handling	
2646	Substation No. 33-6	
2648	Fire Training Tower	
2649	Transported Waste Receiving	
2650	Evaporator Chemical Shed	
2651	Emergency Generator, 2600 Area	
2652A	Trailer, Radiological Surveillance	
2652B	Trailer, Radiological Surveillance	
2652C	Trailer, Radiological Surveillance	
2653	Coal Yard Building	
2656	Sewage Treated Plant-Water Monitor Station	
2657	MH 243 Monitoring Station	
2658	F-4005 Monitoring Station	
2660	Waste Operations Support Facility	
2661	ORNL Training Building	
2663	Ozone Generator Equipment Building	
2664	Sodium Metabisulfite Building	
3000	13.8-kV Substation	
3001	Oak Ridge Graphite Reactor (OGR)	105
3002	OGR Filter House and Canal	114
3002A	Drain Tank South of 3002	
3003	Surface Modification And Characterization Facility	115
3003A	Drain Tank South of 3003	
3005	Low Intensity Testing Reactor (LITR)	106
3008	Security Patrol Storage	103
3009	Pump House for Building 3010	
3010	Bulk Shielding Reactor (BSR)	
3010A	BSR Support Facility, North Annex	
3012	Rolling Mill	101-B
3017	Quality Services Division Building	
3018	OGR Exhaust Stack for 3003	
3019A	Radiochemical Development Facility	205
3019B	High-Level Radiation Analytical Laboratory	
3020	Off-Gas Stack for 3019	
3023	North Tank Farm	206
3025E	Irradiated Material Examination and Testing (IMET) Hot Cell Facility	
3025M	Solid State Office and Laboratory Building	107
3026C	Krypton-85 Enrichment Facility	706-C
3026D	Metal Segmenting Hot Cell Facility	706-D
3027	Special Nuclear Materials Vault	
3028	Alpha Powder Facility	910

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Facility ID	Description	Old numbering
3029	Source Development Laboratory	909
3030	Radioisotope Production Laboratory-C	908
3031	Radioisotope Production Laboratory-D	907
3032	Radioisotope Production Laboratory-E	906
3033	Radioactive Gas Process Facility	905
3033A	Actinide Fabrication Facility Annex	
3034	Radioisotope Area Services	904
3036	Radioisotope Material Shipping and Packaging	903
3037	Chemical Technology Offices	901
3038	Radioisotopes Laboratory	902
3039	Central Radioactive Gas Disposal Facility	911
3042	Oak Ridge Research Reactor, ORR	
3044	West Complex Field Shop	
3047A	Radioisotope Development Laboratory	
3047B	Radioisotopes Development Laboratory	
3074	Interim Manipulator Repair Facility	
3078	Septic Tank for 3000 Pump Station	
3080	Superconductivity Laboratory	
3082	Data Concentrator 2, Waste Operations Control Center (WOCC) Data Acquisition System DAS	
3083	Neutron Spectrometer Station 1	
3084	Neutron Spectrometer Station 2	
3085	Pump House for ORR	
3086	Cooling Tower No. 1 – ORR	
3087	Heat Exchanger – ORR	
3089	Cooling Tower No. 2 – ORR	
3091	Filters for 3019	
3092	Off-Gas Scrubber Facility	
3093	Krypton Storage Cubicle	
3095	Reactor Area Equipment Building	
3098	Filter Facility – BSR	
3099	Storage Pad between 3031 and 3032	
3100	Source and Special Material Vault	
3102	Heat Exchanger No. 2 – ORR	
3103	Cooling Tower No. 3 – ORR	
3104	West Complex Maintenance Shop	
3105	LGWOD Health Physics (HP) Office Building	
3106	Cell Vent Filter for 4501, 4505, and 4507	
3107	25-meter Target House	
3108	Filter House for Building 3019	
3109	Process Off-Gas Filters for ORR	
3110	Filter House, Isotope Area	
3111	Security Post 8a	
3112	Storage Building	
3114	Efficiency Research Laboratory	
3115	Solid State Offices	
3116	Nitrogen Cylinder Storage Building	

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Facility ID	Description	Old numbering
3117	BSR Cooling Tower	
3117A	Sulfuric Acid tank	
3118	Radioisotope Production Laboratory-H	
3119	BSR Heat Exchanger and Pump House	
3121	Cell Off-Gas Filter House for 3019b	
3123	Diesel Generator	
3125	3039 Stack Area Emergency Generator	
3126	Normal Off-Gas (Charcoal) Filter Pit for ORR	
3127	Plutonium Storage Vault	
3129	Personnel Monitoring Station	
3130	Waste Operation Control Center	
3131	Emergency Generator	
3132	Emergency Generator for 3127, 3129, and 3027	
3133	Bethel Valley (BV) Valve Box 1A	
3135	Sentry Post 80, Building 3019	
3136	Equipment Test Facility – 3019	
3137	Surface Science Laboratory	
3138	Roof Thermal Research Center	
3139	Cell Ventilation (CV) Filters – ORR	
3140	CV Filters for 3026	
3144	Roof Research Center	
3145	LGWOD Storage Building	
3146	Emergency Generator for 3020 Stack	
3147	Efficiency and Renewable Research Office Building	
3150	Ceramics and Thin Film Laboratory	
3153	Envelope Systems Research Center	
3154	MH 112 Monitoring Building	
3155	MHs 114 and 234 Monitoring	
3156	Energy Division Office Building	
3158	North CV Duct Monitoring Building	
3159	South CV Duct Monitoring Building	
3160	3019 Motor Control Center #1 and #2	
3161	Quality Services Division (QSD) Storage Building	
3162	QSD Storage	
3163	West Weatherport	
3164	West Weatherport	
3500	Instrumentation and Controls (I&C) Division Offices	
3501	Sewage Pumping Station	
3502	East Research Service Center	706-HD
3502B	Data Concentrator 4, WOCC DAS 3502	
3503	High Radiation Level Chemical Engineering Laboratory	706-HB
3503A	3503 Storage Pad	
3504	Waste Research Building/Geosciences Laboratory	
3505	Metal Recovery Facility	
3507	South Tank Farm	206
3508	I&C Metrology and Calibration	

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Facility ID	Description	Old numbering
3513	Settling Basin	206
3515	Fission Products Laboratory No. 1	
3517	Fission Products Development Laboratory	
3518	Acid Neutralization Plant	
3518A	LGWOD Spare Parts Trailer	
3523	Expensed Bench Stock Building	
3524	Equalization Basin	
3525	Irradiated Fuels Examination Laboratory	
3532	Paint Storage Shed	
3536	Nitrogen Cylinder Tank Storage	
3538	Cooling Tower for 3525	
3539	190 Pond No. 1, North	
3540	190 Pond No. 2, South	
3541	Engineering Development Laboratory	
3542	Storage Building for 3506 and 3517	
3543	Maces Storage Building	
3544	Process Waste Treatment Plant	
3544A	ORNL Waste Water Treatment Trailer	
3544B	Filter Press Building	
3546	Computing and Computational Sciences Directorate (CCSD) Office Building	
3547	Cell Vent Roughing Filter for 3517	
3548	Cell Vent Filters for 3517	
3550	Research Materials Preparation Facility	706-A
3550T	Intercomparison Study Dilutions Laboratory	
3584	Solvent Operations Contaminant	713-UA
3587	Mail Services Building	
3592	Coal Conversion Facility	
3594	Waste Management Storage	
3597	Hot Storage Garden	
3598	Emergency Generator for 3500 Area	
3602	Cylinder Tank Storage for 3525	
3605	Treatment, Storage, and Disposal (TSD) Storage Building	
3606	South Office Annex	
3607	Cask Storage Building	
3608	Process Waste Treatment Plant	
3609	Substation No. 25-1-C	
3610	Storage Building	
3610A	Flammable Storage	
3613	Diversion Box Monitor Station	
3614	MH 190 Monitoring Station	
3615	MH 235 Monitoring Station	
3616	MH 149 Monitoring Station	
3617	MH 229 Monitoring Station	
3618	Pumping Station, WC-10, 11, 12, 13, 14	
3619	White Oak Creek Gauging Station	
3620	Hot Off-Gas Collection Pot	

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Facility ID	Description	Old Numbering
3621	Spill Response Vehicle Storage Facility	
3624	Flammable Storage for 3517	
4000	13.8/2.4 kV Substation	
4001	Pumping Station	
4003	SWSA 2 Burial Grounds	
4007	Security and Counterintelligence Office Building	
4500N	Central Research and Administration Building – North	
4500S	Central Research and Administration Building – South	
4501	Radiochemistry Laboratory	4501
4503	Standby Emergency Generator for 4500N	
4505	Experimental Engineering	4501
4507	High Level Chemical Dev Laboratory	
4508	Metals and Ceramics Laboratory	
4509	Central Chilled Water Plant	
4510	Cooling Tower for 4509	
4511	Cooling Tower for 4509	
4512	Laboratory Emergency Response Center	
4513	High Temperature Materials Laboratory (HTML) Electrical Substation	
4514	Generator – HTML	
4515	HTML	
4516	HTML Cooling Tower	
4521	Cooling Tower for Building 4509	
4556	Filter Pit for Building 4507	
4557	Sentry Post, No. 7B	
4559	Passenger Shelter	
4560	4512 Lift Station	
4561	Flammable Storage, 4509	
5000	Main Portal Building	4502
5002	Science and Technology Partnerships Office Building	
5100	Joint Institute of Computer Science	
5500	High Voltage Accelerator Laboratory	4503
5500A	South Office Annex	
5505	Transuranium Research Laboratory	
5507	Controlled Experiment Atmosphere	
5507A	Research, Development, Testing, and Evaluation Facility	
5510	Analytical Mass Spectrometry Laboratory	
5510A	QSD Metrology and Intercomparisons Studies Laboratories	
5554	Electrical Substation for 5505	
5600	Computational Sciences Building	
5700	Research Office Building	
5800	Engineering Technology Facility	
6000	Holifield Radioactive Ion Beam Facility	
6000B	Atomic Physics Research Laboratory	
6001	Cooling Tower for 6000	
6005	Gas Compressor House for 6000	
6007	Dormitory for Joint Institute for Heavy Ion Research (JIHIR)	
6008	JIHIR Office/Laboratory Facility	

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Facility ID	Description	Old Numbering
6010	Oak Ridge Electron Linear Accelerator	
6011	Computational Physics and Engineering Building	
6012	Computer Sciences Research	
6013	Chemical Feed System Enclosure	
6014	Compressor Building, 6001 Fire Protection System	
6016	Outfall 314 Dechlorination System	
6025	Computational Physics and Engineering	
6551	West Reservoir on Haw Ridge	
6552	East Reservoir on Haw Ridge	
6553	Standby Generator and Valve Pit	
6555	30M Meteorological Tower-B	
6556-ST1	Storage Trailers	
6556-ST2	Forest Management Storage Trailer	
6556-ST3	Storage Trailers	
6556-ST4	Storage Trailers	
6556-ST5	Storage Trailers	
6556-ST6	Storage Trailers	
6556-ST7	Storage Trailers	
6556-ST8	Storage Trailers	
6556-ST9	Storage Trailers	
6556A	Environmental Restoration (ER) Field Operations Trailer	
6556B	ER Field Operations Trailer	
6556C	ER Field Operations Trailer	
6556D	ER Field Operations Trailer	
6556E	ER Field Operations Trailer	
6556G	ER Field Operations Trailer	
6556J	ER Trailer, Single Wide	
6556K	ER Trailer, Single Wide	
6556L	ER Field Operations Trailer	
6556M	ER Field Operations Trailer	
6556Q	Forest Management Trailer	
6556R	ER Field Operations Trailer	
6556S	ER Field Operations Trailer	
6556T	ER Field Operations Trailer	
6556U	Environmental Management Office Trailer	
6556V	Environmental Management Office Trailer	
6556X	Environmental Management Office Trailer	
7000	Septic Tank for 7000 Area	
7001	General Stores	
7002	Garage and Ironworking Shop	
7003	Welding and Brazing Shop	
7005	Lead Shop	
7006	Storage Building	
7007	Paint Shop	
7009	Carpenter Shop	
7010	Dry Lumber Storage	
7012	Central Fabrication Shop	

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Facility ID	Description	Old numbering
7013	Chemical Reuse Building	
7015	Metal Storage and Cutting Facility	
7018	Bulk Receiving and Stores Building	
7019	Research Reactors Division Warehouse Facility – Category C Storage	
701SCA	701 Scarboro Road (SCA)	
7020	Interim Grounds Equipment Storage Building	
7020AR	Heating, Ventilation, and Air-Conditioning (HVAC) Decontamination Facility	
7020B	Temporary Waste Storage Facility	
7020C	Temporary Waste Storage Facility	
7020D	Office Trailer – SWSA 6	
7020E	Temporary Waste Storage Facility	
7020F	HP Office Trailer	
7021	Fabrication Equipment Storage	
7022	Gas Cylinder Storage Shed	
7025	Tritium Target Preparation Facility	
7026	Metals and Ceramics Storage	
7030	Heavy Equipment Storage Shelter	
7031	Fabrication Storage Shed	
7033	Line Crew Facility	
7035	Vacuum Asbestos Equipment Cleaning Facility	
7035A	Paint Mix Building	
7035B	Paint Storage	
7035C	Equipment Storage	
7035D	Can Drying Facility	
7035E	Utility Mechanics Storage	
7035F	Shed Storage Facility	
7037	Cold Storage Facility	
7038	P&E Temporary Waste Storage Pad	
7039	Material Staging Facility	
7040	Gas Cylinder Storage	
7041	Storage Building	
7042	Core Storage Building	
7043	Personnel Shelter – West of 7000	
7044	Substation 27-8, West of 7003	
7046	Environment, Safety, Health and Quality Office Trailer	
7053	Personnel Shelter – North	
7055	Grounds Equipment Storage Facility	
7057	Sandblast Cleaning Facility	
7058	Regulator Repair Facility	
7060	Steel Yard	
7061	Environmental Surveillance and Protection Storage	
7062	Crane Inspection Crew Offices	
7063	Emergency Generator for 7003	
7065	Rigger Equipment Storage	
7066	Grounds Maintenance Storage	
7067	Training Facility	
7069	Gasoline Service Facility	

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Facility ID	Description	Old numbering
7069E	Underground Storage Tank	
7069F	Underground Storage Tank	
7070	Storage Shed	
7071	Liquid Nitrogen Storage Tank	
7072	Sentry Post 20B, 7000 Area	
7073	Air Monitoring Station	
7074	Sentry Post 20C, Pedestrian Gate 7012	
7075	Waste Storage Building	
7077	Craft Support Office Bldg.	
7077A	Reservation Services Offices	
7078A	Bechtel-Jacobs Company (BJC) Office Trailer	
7078B	BJC Office Trailer	
7078C	BJC Office Trailer	
7078D	BJC Office Trailer	
7078E	BJC Office Support Trailer	
7078F	BJC Office Trailer	
7078G	Sprinkler Control Building	
7078H	Sprinkler Control Building	
7079	Bottle Storage Building	
7080	Cardboard Compressor	
7081	Portable Generator Storage Shed	
7082	Salt Storage Building	
7083	Model Airplane Shop	
7085	90-Day Waste Storage	
7086	Flammable Gas Storage	
7089	Flammable Storage	
7090	Electrical Storage West	
7091	Electrical Storage East	
7092	Hustler Mower Storage	
7093	Physics Division Storage 1	
7094	Physics Division Storage 2	
7095	Physics Division Storage 3	
7096	Environmental Protection Storage	
7097	Crane and Elevator Crew Office Trailer	
7098	Transportation Services Office Trailer	
7099	Pressure Reducing Valve Station	
7500	Homogeneous Reactor Experiment (HRE) Facility	
7501	Septic Tank	
7502	Radioactive Waste Evaporator	
7503	Molten Salt Reactor Experiment (MSRE)	
7505	LGWOP Maintenance Support Office	
7506	LGWOP Maintenance Support Shop	
7507	Hazardous waste storage facility	
7507W	Mixed hazardous waste storage pad	
7509	MSRE Office Building	
7511	Filter Pit for 7503	
7512	Stack for 7503	

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Facility ID	Description	Old numbering
7513	Cooling Tower for 7503	
7514	Filter House for 7503	
7516	Field Service Shop – 7500 Area	
7548	Hazardous Waste Storage Shed	
7549	Storage	
7553	Pump House – Tower Shielding Facility (TSF) Water Supply	20035
7554	Cooling Tower for 7500	
7554A	Morrison-Knudson (MK)-Ferguson Trailer	
7555	Diesel Generator House – 7503	
7556	HRE Settling Pond	
7557	Charcoal Absorber Pit for 7500	
7558	Waste Evaporator Loading Pit	
7559	Adsorber Valve Pit	
7560	Waste Tank for 7500	
7561	HRE Decontamination Pad/Shed	
7562	Waste Condensate Tank for 7500	
7563	Circulator Pump Pit for 7500	
7567	Central Pumping Station, Tanks T1, T2	
7568	Sentry Post 19, High Flux Isotope Reactor (HFIR) Area	
7569	LLLW Collection Tank, WC-20	
7571	30-Meter Meteorological Tower	
7572	Contact Handled, Transuranic (CH-TRU) Waste Storage Facility	
7574	Waste Storage Facility	
7575	SWSA 7	
7576	Bulk Contaminated Soil Facility	
7577	Transuranic (TRU) Storage Facility	
7578	Class 34 Waste Retrievable Storage	
7580	Solid Low Level Waste Staging Facilities	
7582	LGWOD Spare Parts Storage Facility	
7583A	Waste Operations Spare Parts Storage	
7583B	Waste Operations Spare Parts Storage	
7583C	Waste Operations Spare Parts Storage	
7584	BJC Office Trailer	
7600	Containment Building	
7601	Robotics and Process Systems (R&PS) Division Office Building	
7602	Integrated Process Demonstration Facility	
7603	Remote Operations and Maintenance	
7603A	Fuel Oil Storage Tanks	
7604	Utility Building	
7605	Storage Building	
7606A	Robotics Research and Development (R&D) Laboratory	
7606B	Research Service-Maintenance Building	
7607	Experimental Gas-Cooled Reactor (EGCR) River Pump Station	
7608	Plasma Torch Cutting Demonstration Facility	
7609	Stack Monitoring House	
7610	Storage House – R&PS	
7611	Sentry Post 30, R&PS Complex	

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Facility ID	Description	Old numbering
7613	Waste Retention Basin	
7614	Exhaust Stack	
7615	Radiochemical Engineering Development Center (REDC) Storage	
7616	Septic Tank	
7618	Diesel Generator for 7600	
7619	Cooling Tower	
7621	Headquarters Building	
7623	Bathhouse	
7624	Robotics Storage Building	
7630	Low-Risk Inactive Storage Facility	
7631	Low-Risk Inactive Storage Facility	
7632	Low-Risk Inactive Storage Facility	
7633	Low-Risk Inactive Storage Facility	
7651	Clean, Used Oil Storage Pad	
7652	Hazardous Waste Storage Facility	
7653	Chemical Waste Storage Facility	
7654	Hazardous Waste Storage Facility	
7658	Contractors Landfill	
7658A	BJC Office Trailer	
7658B	BJC Office Trailer	
7658C	BJC Office Trailer	
7658D	BJC Office Trailer	
7659	Leaking Gas Cylinder Area	
7661	Electrical Utility Building	
7662	Emergency Generator	
7666	Environmental Emergency Response	
7666A	Trailer	
7666B	Sprinkler Control Building	
7667	Chemical Detonation Area	
7668	Mixed Waste Storage Facility	
7670	Storage Tent	
7671	Storage	
7672	Passenger Shelter	
7700	TSF	20035
7701	TSF – Pool and Pad Area	20035
7702	TSF – Control House	20035
7703	TSF – Hoist House	20035
7704	TSF – Control House No. 2	20035
7705	TSF – Pump House	
7706	TSF – Cooler	
7707	TSF – Battery House	
7708	TSF – Reactor Shield Storage	
7709	Health Physics Research Reactor (HPRR)	
7710	HPRR-DOSimetry Applications Research (DOSAR) Facility	
7711	Process Waste Basin for 7709	
7712	DOSAR Low Energy Accelerator	
7716	Filter Pump House Maintenance Pool	

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Facility ID	Description	Old numbering
7720	Civil Defense Bunker	
7735	Radiation Calibration Laboratory	
7740	Radio Transmitter Facility	
7740A	Melton Hill Radio Facility	
7740B	Emergency Generator Building	
7740C	Melton Hill Radio Facility	
7750	Floor Drain Collection Tank	20035
7751	Sentry Post 22, TSF Exclusion Area	20036
7755	DOSAR (HPRR) Reservoir	
7756	Meter House	
7758	HFIR Parts Storage	
7759	Cesium Forest Research Area	
7800	SWSA 4 Burial Grounds	
7802	SWSA 5 Burial Grounds	
7802A	Seep "C" Collection and Treatment Unit	
7802B	Seep “D” Collection and Treatment System	
7802C	Deep Monitoring Well #1 Building	
7802D	Deep Monitoring Well # 2 Building	
7802E	Sludge Removal Test Tank	
7802F	Radiation Monitoring Equipment Storage Building	
7802N	SWSA 5 North Trench Disposal Area	
7803	Laboratory Trailer	
7805	Waste Pit No. 1	
7806	Waste Pit No. 2	
7807	Waste Pit No. 3	
7808	Waste Pit No. 4	
7809	Waste Trench No. 5	
7810	Chemical Waste Trench No. 6	
7810A	Interim Non-regulated Waste Storage	
7811	Geosciences Storage Building	
7811A	Pilot Pits Experiments Area	
7813	White Oak Creek Dam	
7818	Waste Trench No. 7	
7821	Emergency Waste Basin	
7822	SWSA 6 Burial Grounds	
7822A	High Range Disposal Wells	
7822J	Low Level Waste (LLW) Storage Pad	
7823	LLW Staging/Storage Facility	
7823A	Underground Storage Facility Well	
7823B	Temporary Waste Storage Facility	
7823C	Temporary Waste Storage Facility	
7823D	Temporary Waste Storage Facility	
7823E	Temporary Waste Storage Facility, Tent	
7823F	Storage Shed (SWSA 5)	
7824	Waste Examination And Assay Facility	
7824A	Waste Examination Assay Facility (WEAF) Support Facility Trailer	
7826	TRU Drum Storage Facility	

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Facility ID	Description	Old numbering
7827	Shielded Dry Well Facility	
7829	Shielded Dry Well Facility	
7830	Melton Valley Storage Facility	
7830A	Hazardous Waste Storage Tank	
7831	Field Office and Compactor Facility	
7831A	SLLW Storage Building	
7831C	SLLW storage shed	
7831D	SWSA 5 storage pad	
7833	Alpha Greenhouse Facility	
7834	TRU Drum Storage Facility	
7835	Sludge Waste Pond	
7841	Contaminated Equipment Storage Yard	
7841A	Waste Storage Area Office Trailer	
7842	Temporary LLW Storage Facility	
7842A	Liquid Low-Level Waste Solidification Project (LWSP) II Solidified Waste Storage	
7842B	Temporary LLW Storage Facility	
7842C	Temporary LLW Storage Facility, Tent	
7844	ER Storage Bunker	
7846	White Oak Lake	
7847	Vehicle/Personnel Monitoring Station	
7848	EPICORE II Storage Building	
7849	White Oak Creek Weir and Gauging Station	
7852	Old Hydrofracture Facility	
7853	LGWOD Storage Building	
7854	Drilling Equipment Storage	
7855	Concrete Cask Storage Facility	
7855A	SWSA 5 Equipment Tent	
7856	Melton Valley Storage Tank (MVST) Capacity Increase Project	
7857	Monitoring Station	
7858	White Oak Lake Storage Building	
7859	Sample Equipment Storage Building	
7859A	Sample Storage Buildings	
7860	New Hydrofracture Facility	
7863	General Storage for 7860	
7864	Gauging Station – East Seep	
7865	Gauging Station – West Seep	
7866	Sampling Station – 7500 Branch	
7867	Weir - Melton Branch	
7868	Sampling Station – White Oak Creek	
7869	Stream Flow Monitoring Station 5	
7870	RUBB Structure	
7871	Stream Flow Monitoring Station 3	
7872	Stream Flow Monitoring Station 4	
7874	Storage Building Southwest SWSA 4	
7875	Monitoring Storage Building	
7876	Health Physics Office Trailer	

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Facility ID	Description	Old numbering
7877	LLW Solidification Facility	
7878	CH-TRU Waste Storage Facility	
7878A	Temporary Waste Storage Tent	
7878B	Equipment Storage Tent	
7879	TRU /LLLW Staging Storage Facility	
7880	Waste Processing Facility	
7880A	TRUPACT Building	
7880B	Waste Processing Facility Personnel Building	
7880C	Waste Characterization Laboratory	
7880D	Waste Processing Facility Control Room	
7880E	Steam Boiler	
7880F	Air Compressor	
7880G	Switchgear/Transformer, Waste Processing Facility	
7880H	Diesel Generator, Waste Processing Facility	
7880I	NonDestructive Assay (NDA) Trailer, Waste Processing Facility	
7880J	NonDestructive Examination (NDE) Trailer, Waste Processing Facility	
7880K	Access Control Point, Waste Processing Facility	
7880L	DOE Office Trailer, Waste Processing Facility	
7880M	DOE Office Trailer, Waste Packaging Facility	
7880N	Construction Management, Waste Packaging Facility	
7880P	Break Facility, Waste Packaging Facility	
7880Q	Restroom Facility, Waste Packaging Facility	
7880R	Foster Wheeler Environmental Corporation (FWENC) Operations Trailer	
7882	Emergency Generator for 7877	
7883	CH-TRU Waste Storage Bunker	
7886	Interim Waste Storage Pad 1	
7887	Solid Liquid Separator	
7888	Cask Loading Facility	
7891	SWSA Office Trailer	
7892	Storage Building, 7856 Operations	
7893	Passenger Shelter	
7894	Waste Area Grouping (WAG) 6 Monitoring Station 3	
7900	HIFR	
7901	Electrical Building for 7900	
7902	Cooling Tower for 7900	
7903	7900 Cooling Tower Equipment Building	
7904	Sewage Treatment Plant – 7900	
7905	Retention Pond 1 for 7900	
7906	Retention Pond 2 for 7900	
7907	TRU Pond A	
7908	TRU Pond B	
7910	Research Reactors Office Building	
7911	Stack for 7900	
7911B	Monitoring Equipment Building for 7911	
7911C	Instrument Shed for 7911	
7912	Fan Shed And Electrical Equipment for 7900	
7913	Filter Pit for 7911 Stack	

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Facility ID	Description	Old numbering
7914	Equipment and Parts Storage Building	
7914A	HFIR Carpentry Shop	
7915	Operations Storage Building	
7916	HFIR Cooling Tower Water Treatment	
7917	Research Reactors Office Building	
7918	REDC Office and Training Building	
7920	REDC	
7921	Emergency Generator for 7920	
7922	Breeching and Fan Area and Electrical Equipment for 7920	
7922A	Data Concentrator 6 for WOCC DAS	
7923	REDC cooling tower	
7924	Materials Storage Tent	
7924A	Storage Building	
7924B	Storage Building	
7925A	Storage Building	
7925B	Storage Building	
7927	Storage Tent	
7930	Thorium-Uranium Recycle Facility (TURF)/REDC	
7930A	Filter Pit for 7930	
7931	Emergency Generator for 7930	
7932	Waste Sample Building for 7930	
7933	Office Trailer	
7934	CH-TRU Waste Storage Facility	
7935	Equipment Cleaning Facility	
7936	REDC Storage Building	
7939	Standby Emergency Generator for 7930	
7947	Melton Branch Headwater Flume	
7948	Melton Branch Monitoring Station	
7949	Melton Branch Tributary Weir	
7952	Melton Valley Waste Pump Station	
7953	Pump House – HPRR Waterline	
7953A	Research Reactors Office Trailer	
7953B	Research Reactors Storage Trailer	
7953C	Construction Trailer at HFIR	
7955	Sentry Post 19B, HFIR Entry	
7957	Office Trailer for 7920	
7958	Sentry Post 23, HPRR	
7960	HIFR Storage Building	
7961	Melton Valley Collection Tanks	
7962	Neutron Users Office and Laboratory	
7964A	Research Reactors Office Trailer	
7964B	Research Reactors Office Trailer	
7964C	Research Reactors Office Trailer	
7964D	Research Reactors Office Trailer	
7964E	Research Reactors Office Trailer	
7964F	Research Reactors Office Trailer	
7964G	HIFR Operations/Change House	

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Facility ID	Description	Old numbering
7964H	Solid State Office Trailer	
7964I	Solid State Office Trailer	
7965A	Chemical Technology Office Trailer	
7965B	Chemical Technology Office Trailer	
7965C	Chemical Technology Office Trailer	
7966	LLW Collection Tank, 7920, 7930	
7966A	Filter House, 7966	
7967A	Melton Branch Subsurface Weir	
7967B	Subsurface Weir Instrument Building	
7967C	Underground Weir	
7968	Trailer	
7969	Hazardous Material Enclosure	
7970	Neutron Science Support Bldg.	
7971	Hot Off-Gas (H.O.G.) Filter Facility	
7975	Water Monitoring Storage Building	
7977	Cold Source Equipment Building	
7977A	Cold Source Liquid Nitrogen Tank	
7980A	HFIR Storage 1	
7980B	HFIR Storage 2	
7980C	HFIR Storage 3	
7980D	HIFR Storage 4	
7980E	HIFR Storage 5	
7981A	P&E/HFIR Storage 1	
7981B	P&E/HFIR Storage 2	
7981C	P&E/HFIR Storage	
7982	TRU Staging Area Storage	
7983	TRU Facility Storage Building	
7984	Passenger Shelter	
7985	P&E/HFIR Storage 4	
7986	P&E/HIFR Storage 5	
8520	Ring Injection Dump Building	
9201-2	Fusion Energy Administration and Laboratory Building	
9204-1	Engineering Technology	
9204-3	Isotope Separations	
9207	Biology Building	Y-12
9210	Mammalian Genetics	Y-12
9211	Co-Carcinogenesis	
9220	Molecular Biology Facility	
9224	Molecular Biology Facility	
9401-1	Engineering Technology Laboratory Facility	
9409-15	Cooling Tower	
9422	Large Coil Test Facility (LCTF) Compressor	
9610-2	Flammable Building Storage Building	
9732-2	86-Inch Cyclotron Counting Room	
9743-2	Pigeon Quarters	Y-12
9767-6	Utilities – Control Center	
9767-7	Fan House for 9207	

ATTACHMENT A
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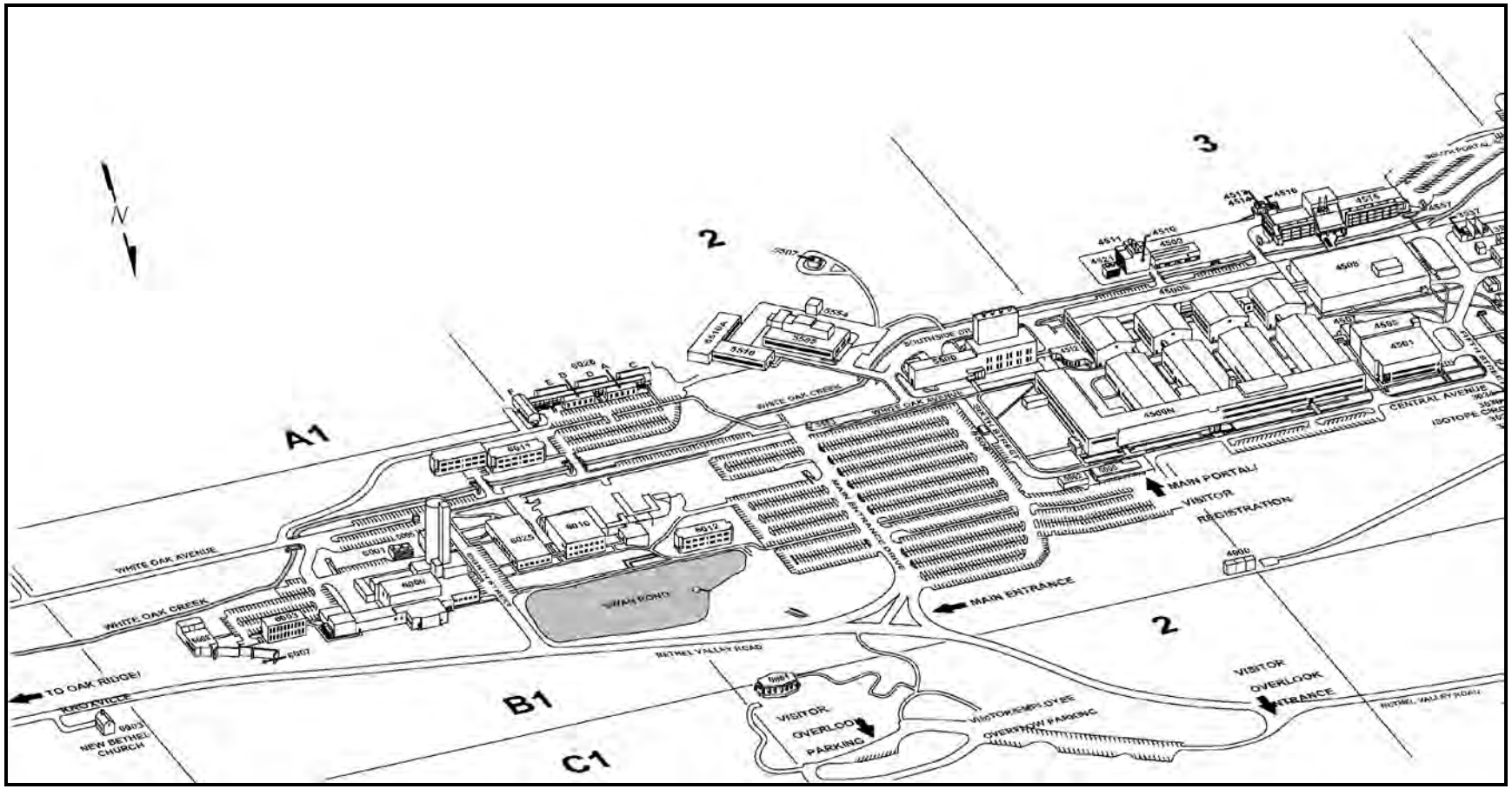
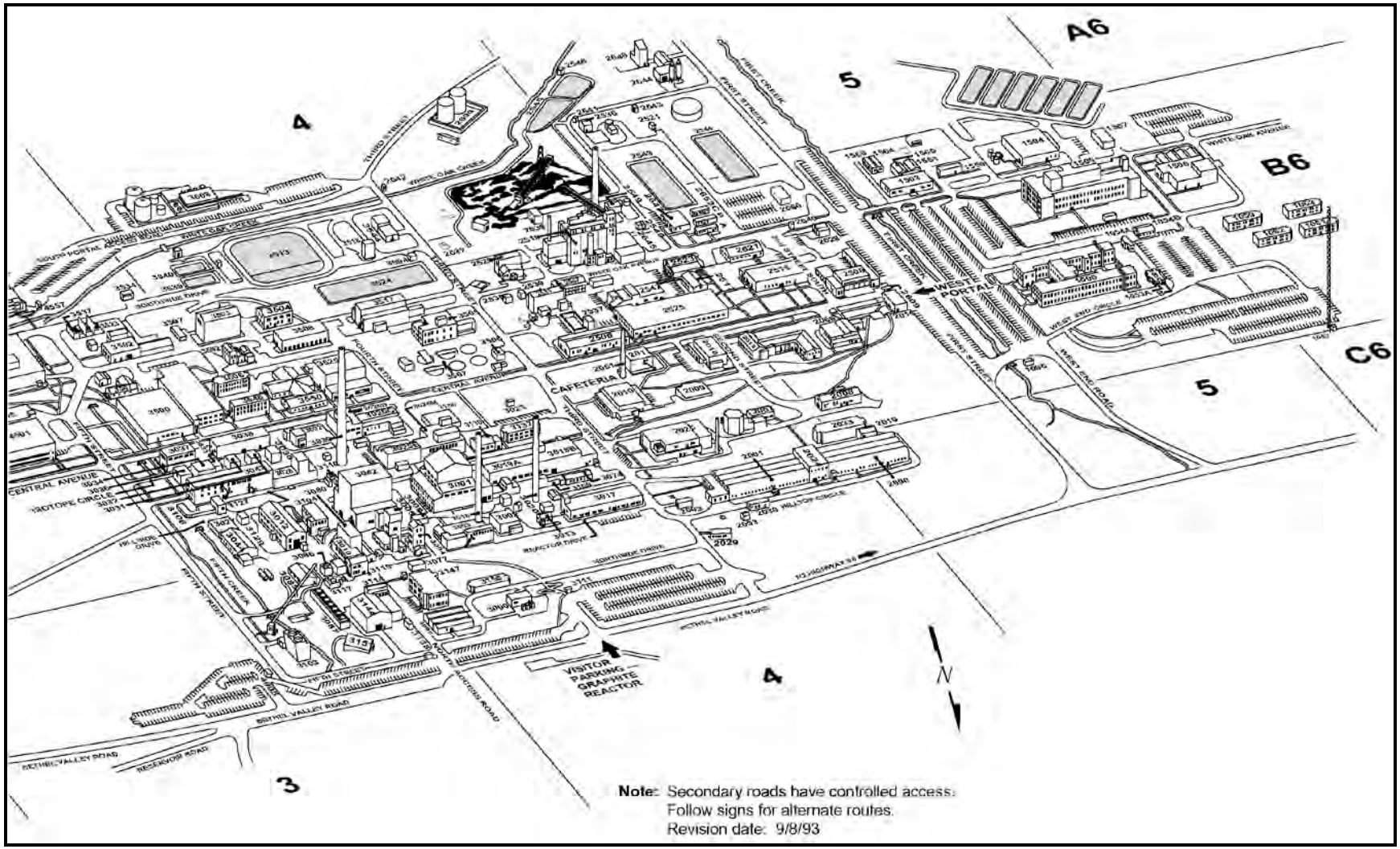
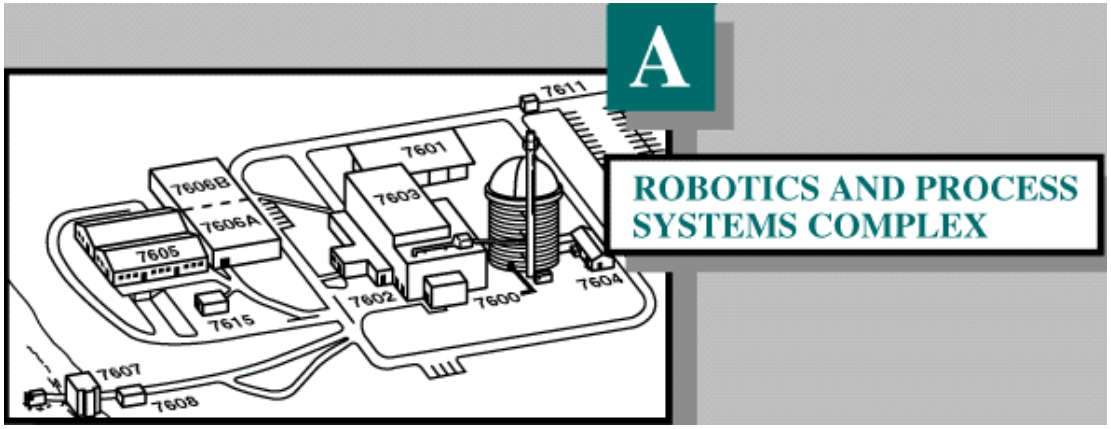
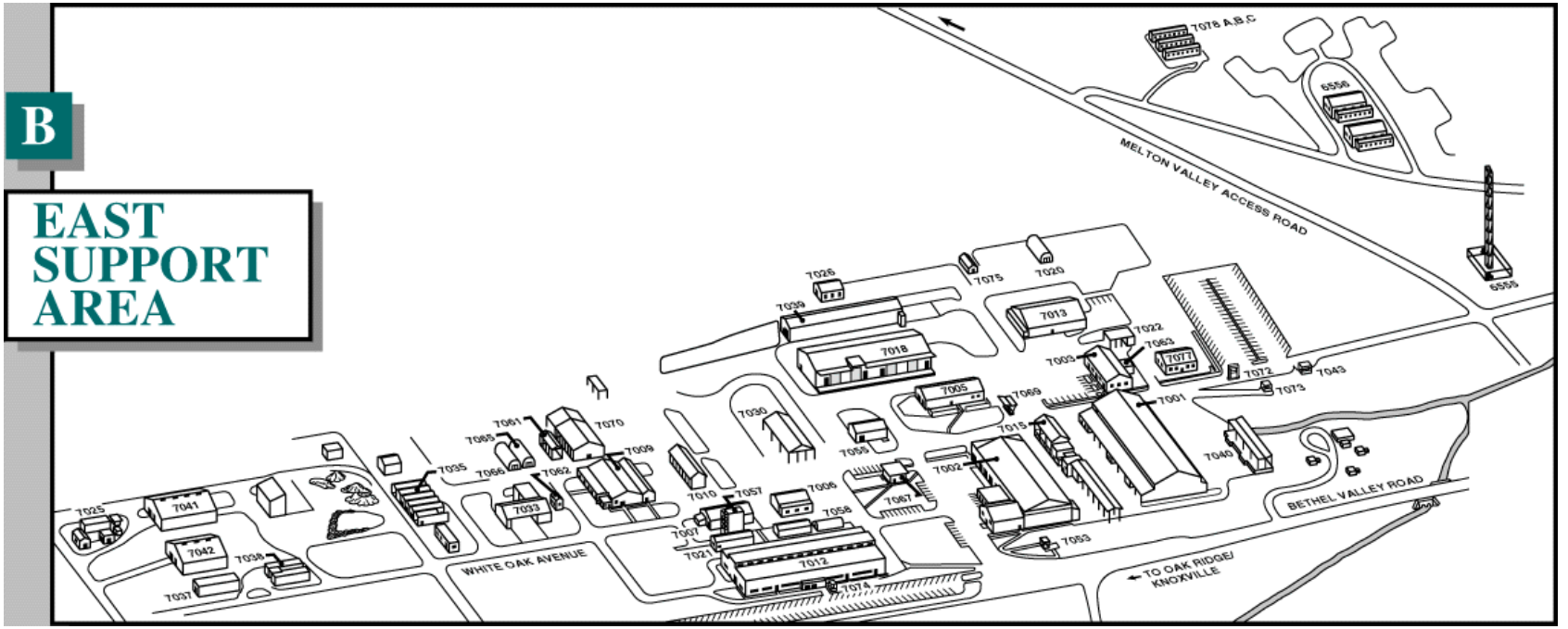
Facility ID	Description	Old numbering
9770-2	Radiation Source	Y-12
9983-FX	ESD Trailer	
9999-01	Motor Generator	
9999-03	Electrical Switchgear and Rectifier	
9999-04	Electrical Equipment	
9999-3	Power Supply	
9999-4	Electrical Equipment	
NTRC	National Transportation Research Center	
X185249	Trailer – SWSA 6	
X186600	Trailer – 7002 Area	

ATTACHMENT B
FACILITY MAPS




A6
B6
C6
5
4
3
CAFETERIA
WEST PORTAL
CENTRAL AVENUE
ISOTOPE CIRCLE
VISITOR PARKING — GRAPHITE REACTOR
BETHEL VALLEY ROAD
RESERVOIR ROAD
N
Note: Secondary roads have controlled access.
Follow signs for alternate routes.
Revision date: 9/8/93


A
ROBOTICS AND PROCESS SYSTEMS COMPLEX
7611
7601
7606B
7606A
7603
7605
7615
7602
7600
7604
7607
7608


B
EAST SUPPORT AREA
MELTON VALLEY ACCESS ROAD
WHITE OAK AVENUE
BETHEL VALLEY ROAD
TO OAK RIDGE/ KNOXVILLE
7076 A,B,C
6556
6555
7026
7039
7075
7020
7013
7018
7022
7063
7003
7077
7072
7043
7073
7005
7069
7001
7030
7058
7015
7040
7002
7061
7070
7065
7009
7066
7062
7035
7025
7041
7042
7038
7037
7033
7010
7057
7006
7056
7067
7007
7021
7012
7014
7053

ATTACHMENT B
FACILITY MAPS
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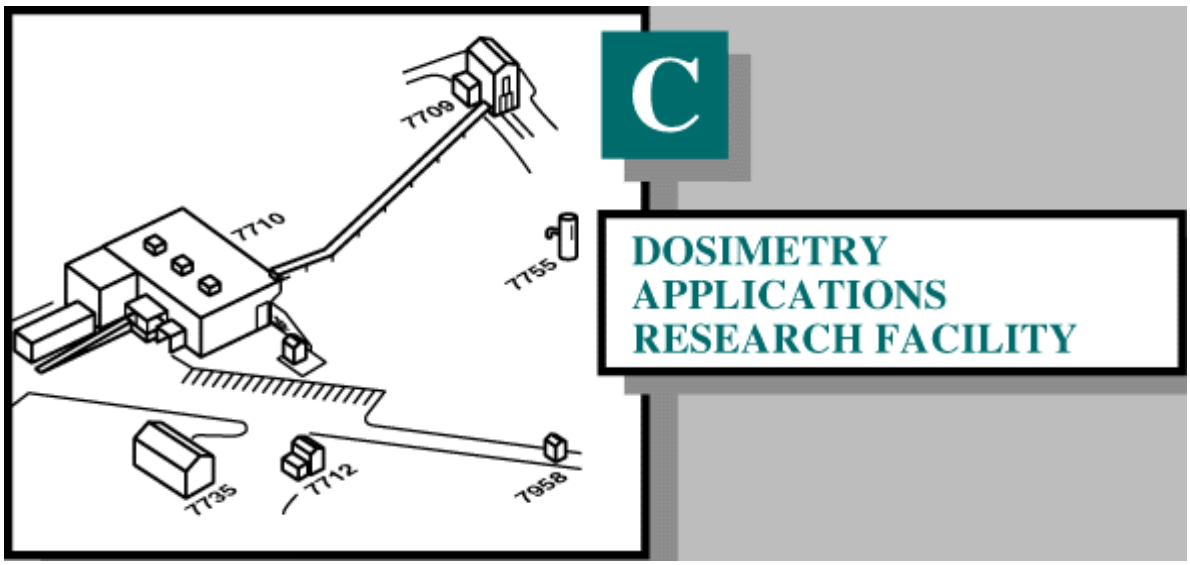

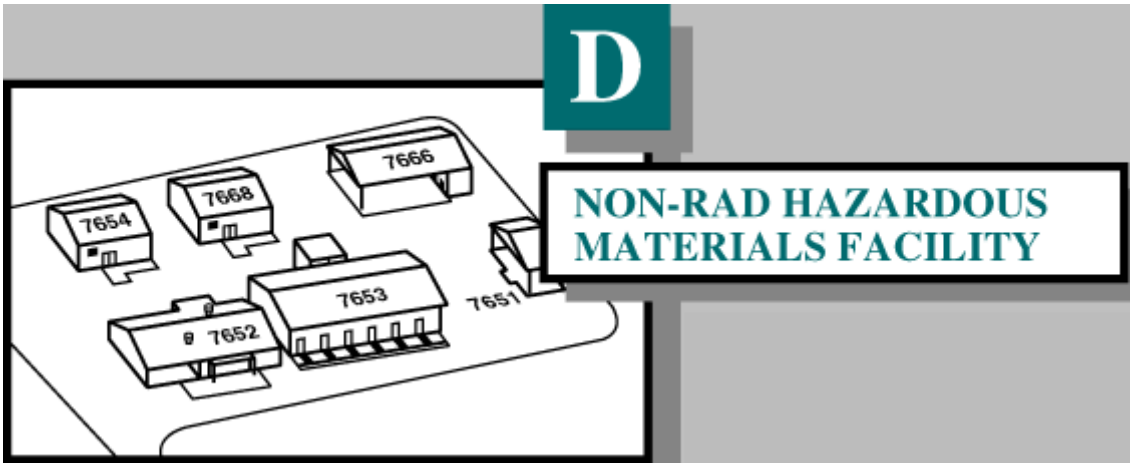

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FACILITY MAPS
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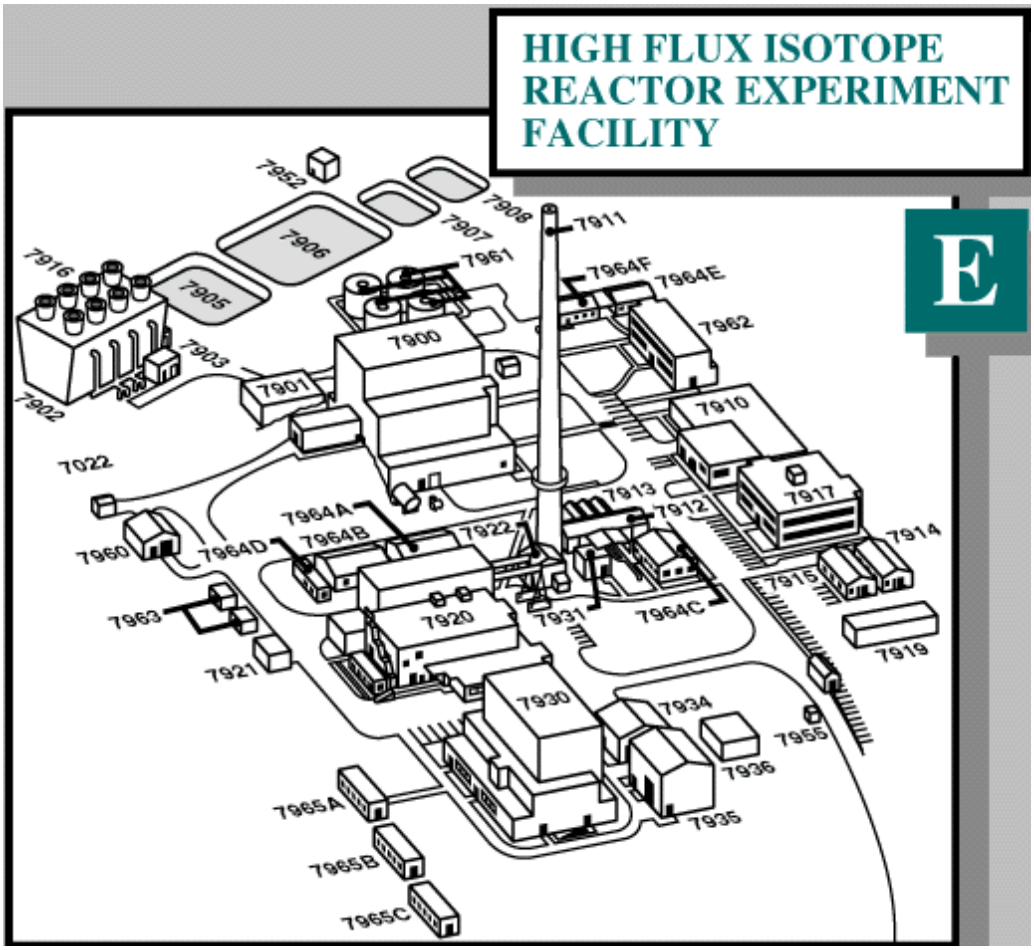

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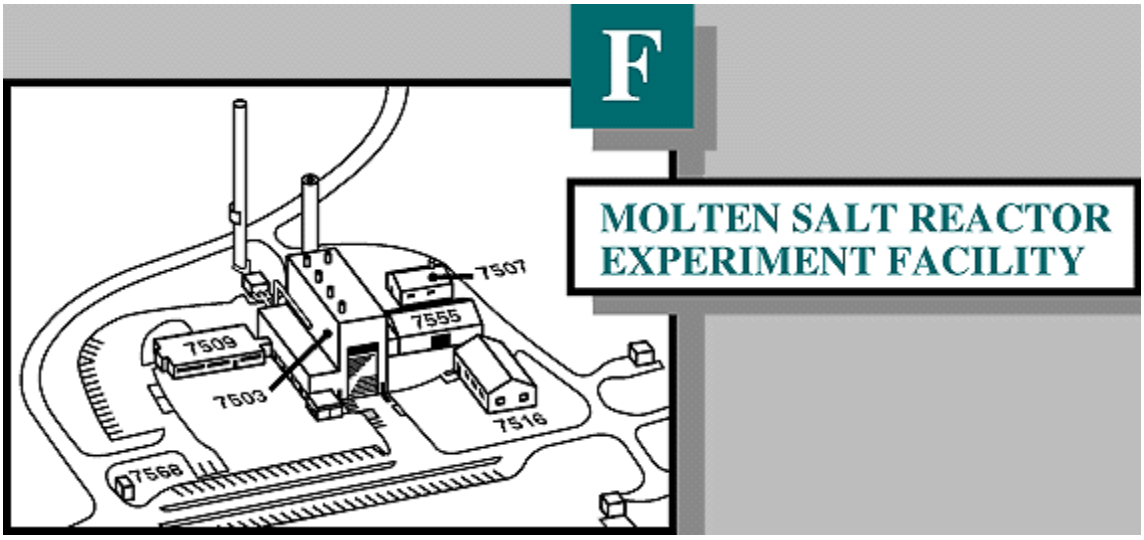

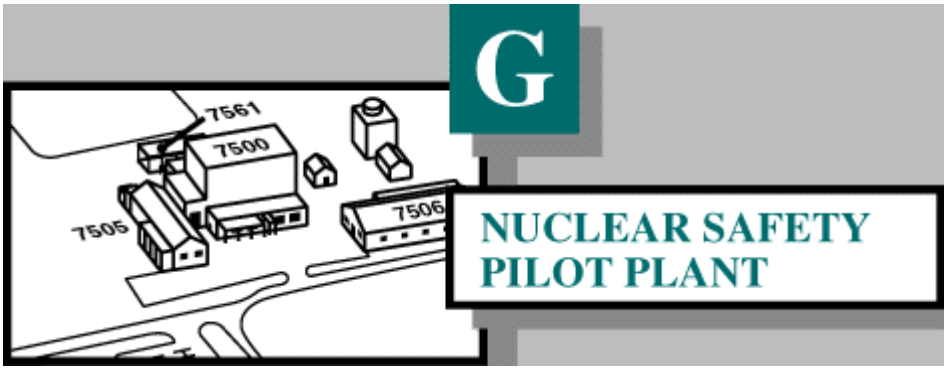

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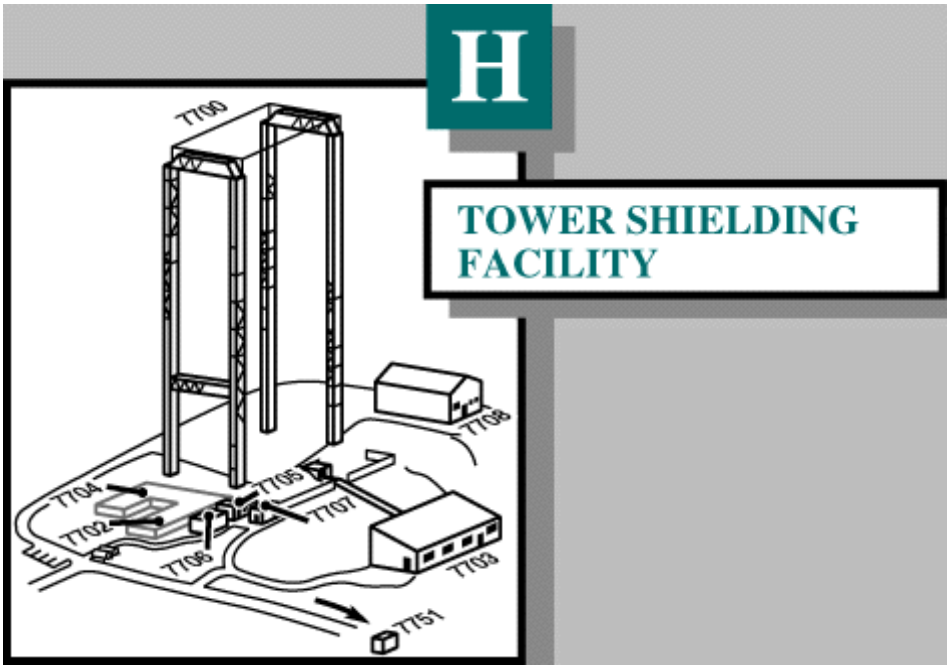

ATTACHMENT C
MAJOR FACILITIES AND RADIONUCLIDES OF CONCERN

Current building number	Former building number	Facility name or description	Dates of operation	Principal radionuclides of concern
3001	105	Graphite Reactor	Nov. 1943–Nov. 1963	Mixed fission/activation products, natural uranium
3005	106	Low-Intensity Test Reactor	1949–Oct. 1968	Volatile fission products, Na-24, N
3010		Bulk Shielding Reactor/Pool Critical Assembly	1951–1987	Volatile fission products, Na-24, N-16
3019	205	Pilot Plant	Dec., 1943–present (partly inactive and pending D&D)	Mixed fission/activation products, natural uranium, Th-232, U-233, TRU (liquid forms)
3023	206	North Tank Farm	1943–1986	Mixed fission/activation products, natural uranium, Th-232, U-233, TRU (liquid forms)
3026-C	706-C	Radiochemistry Laboratory (original RaLa building); Kr-85 enrichment facility	1944–ca. 1997 (pending D&D)	Mixed fission products, I-131, Kr-85 (liquid and gaseous forms)
3026-D	706-D	Radiochemistry Laboratory (RaLa building from May 1945 until 1958); Segmentation Facility	1945–?? (pending D&D)	Mixed fission products, I-131, Ru-106, noble gases (liquid and gaseous forms); uranics/TRU (segmentation facility)
3028	910	Radioisotope Processing Building A/ Alpha Powder Facility	1950–1985	Mo-99, I-131, Xe-133, Pm-147, Cm-242/244
3029	909	Source Development Laboratory	1952–late 1980s	Fission/activation products
3030	908	Radioisotope Processing Building C	ca. 1950–late 1980s	Fission/activation products
3031	907	Radioisotope Processing Building D	ca. 1950–late 1980s	Fission/activation products
3032	906	Radioisotope Processing Building E	ca. 1950–late 1980s	Fission/activation products
3033	905	Radioisotope Processing Building F, Radioactive Gas Processing Facility	ca. 1950–1990	H-3, C-14, Kr-85 (gaseous forms)
3038	902	Isotope Research Materials Laboratory/Alpha Handling Facility	1949–1990	Fission/activation products, uranics, TRU
3042		Oak Ridge Research Reactor	March, 1958–ca. 1987	Volatile mixed fission products; Na-24, N-16
3047		Radioisotopes Development Laboratory	1962–present	Fission products, Pu-238
3505		Metals Recovery Facility	1952–1960	Mixed fission products, uranics, TRU (liquid form)
3507	206	South Tank Farm	1943 –- 1978	Mixed fission/activation products, natural uranium, Th-232, U-233, TRU (liquid form)
3508		Alpha Isolation Laboratory	1952–ca. 1976	TRU, U-233 (gram quantities); mixed fission products
3515		Fission Product Pilot Plant	1948–1958	Mixed fission products, uranics, TRU (liquid form)
3517		Fission Product Development Laboratory	1958–1975	Mixed fission products, uranics, TRU (liquid form)
3525		High Radiation Level Examination Laboratory	1963–present	Fission/activation products
4501		High Level Radiochemistry Laboratory	1951–present	U-233 (OREX process)
4507		High-Level Chemical Development Facility	1957–?? (pending D&D)	Mixed fission products (liquid forms)
4508		Interim Plutonium Laboratory/Fuel Cycle Alpha Facility	1962–present	Uranics, TRU (nitride and oxide forms)
7025		Tritium Target Preparation Facility	1967–?? (pending D&D)	H-3, ThO_2, UO_2, Sr-90, Cs-137, Cm-244
7500		Homogeneous Reactor Experiment, Homogeneous Reactor Test	1952–April, 1961	Mixed fission/activation products, uranyl sulfate
7503		Molten Salt Reactor Experiment	1965–1969	Mixed fission products, Th-232, U-233
7920/ 7930		Radiochemical Engineering Development Center	1966–present	Cf-252, TRU, Dy/Ho-166, Re-186, Sn-117m, W/Re-188