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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
BNWL	Battelle Northwest Laboratories
BPNL	Battelle Pacific Northwest Laboratory
°C	degrees Celsius
Ci	curie
cm	centimeter
cpm	counts per minute
dpm	disintegrations per minute
DOE	U.S. Department of Energy
EDL	Engineering Development Laboratory
FERTF	Fuel Element Rupture Test Facility
FFTF	Fast Flux Test Facility
FRPP	Fuel Recycle Pilot Plant
ft	foot
g	gram
gal	gallon
HEDL	Hanford Engineering Development Laboratory
HEPA	High Efficiency Particulate Air
hr	hour
HTLTR	High Temperature Lattice Test Reactor
HTR	Hanford Test Reactor
kCi	kilocurie
keV	kilovolt-electron, 1,000 electron volts
kg	kilogram
kVp	kilovolt-peak, applied voltage in kilovolts-
kW	kilowatt
L	liter
m	meter
mCi	millicurie
MeV	megavolt-electron, 1 million electron volts
mg	milligram
mi	mile
mR	milliroentgen
MW	megawatt
n	neutron

PCTR	Physical Constants Test Reactor
PFPP	Plutonium Fuels Pilot Plant
PNNL	Pacific Northwest National Laboratory
PRCF	Plutonium Recycle Critical Facility
PRTR	Plutonium Recycle Test Reactor
PUREX	plutonium-–uranium extraction
R	roentgen
R&D	research and development
s	second
SERF	Special Environmental Radio-metallurgical Facility
SMF	Shielded Materials Facility
TLD	thermoluminescent dosimeter
TRIGA	Training Research Isotopes, General Atomics Reactor
TTR	Thermal Test Reactor
U.S.C.	United States Code
W	watt
WSEP	Waste Solidification Engineering Project
µCi	microcurie

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 [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 POC.

On April 27, 1964, Battelle Memorial Institute submitted a proposal to the U.S. Atomic Energy Commission (AEC) to operate the Hanford Laboratories on the Hanford Site. On January 4, 1965, Battelle took over the Hanford Laboratories operations, which became known as the Pacific Northwest Laboratory. In 1995, the U.S. Department of Energy (DOE) changed the name to Pacific Northwest National Laboratory (PNNL), which this document applies for convenience to the Laboratory history from January 4, 1965, to the present.

The primary mission was originally research and development related to nuclear energy and other peaceful uses of nuclear materials. One of the significant projects was PNNL's design of the Fast Flux Test Facility (FFTF) in the 400 Area. The purpose of FFTF was to test fuels and materials for the Liquid Metal Fast Breeder Reactor, the cornerstone of the AEC's commercial nuclear power program. PNNL was involved in the early design of the FFTF, but was never involved in the reactor’s operation. In addition, PNNL managed the Arid Lands Ecology Reserve for the AEC. This large stretch of land adjacent to the Hanford Site was a relatively undisturbed area of dry grasslands with rolling hills. PNNL was charged with protecting the natural ecosystem from intrusion, conducting research, and educating the public about the land.

In 1969 PNNL was chosen by the National Aeronautics and Space Administration to analyze lunar material collected during the Apollo program. PNNL measured the concentration of primordial and both solar and galactic cosmic-ray-produced radionuclides in 75% of the lunar materials.

In the early 1970s the AEC announced that the management of the FFTF would be transferred to the Westinghouse Hanford Company and that all of the remaining reactors at Hanford, with the exception of N Reactor, would be shut down. As the nuclear program underwent changes, PNNL expanded its research programs in energy, environment, health, and national security. During this time, PNNL developed vitrification, a process to turn hazardous waste and glass-forming materials into glass. Vitrification locks dangerous materials into a stable glass form that will last for thousands of years.

In general, PNNL does not handle large volumes of hazardous materials, and most experiments that would use such materials occur at other DOE sites. Individual laboratories do have some radioactive and chemical hazards, but these materials are present in limited areas. There are currently no production-scale facilities at PNNL.

The Hanford Site was originally divided into several distinct numbered areas: 100 Area, 200 Area, 300 Area, etc. This TBD concentrates on the major facilities in the 300 Area that were the responsibility of PNNL (either as landlord or owner). The 300 Area contains facilities involved in the majority of PNNL activities dealing with radioactive materials.

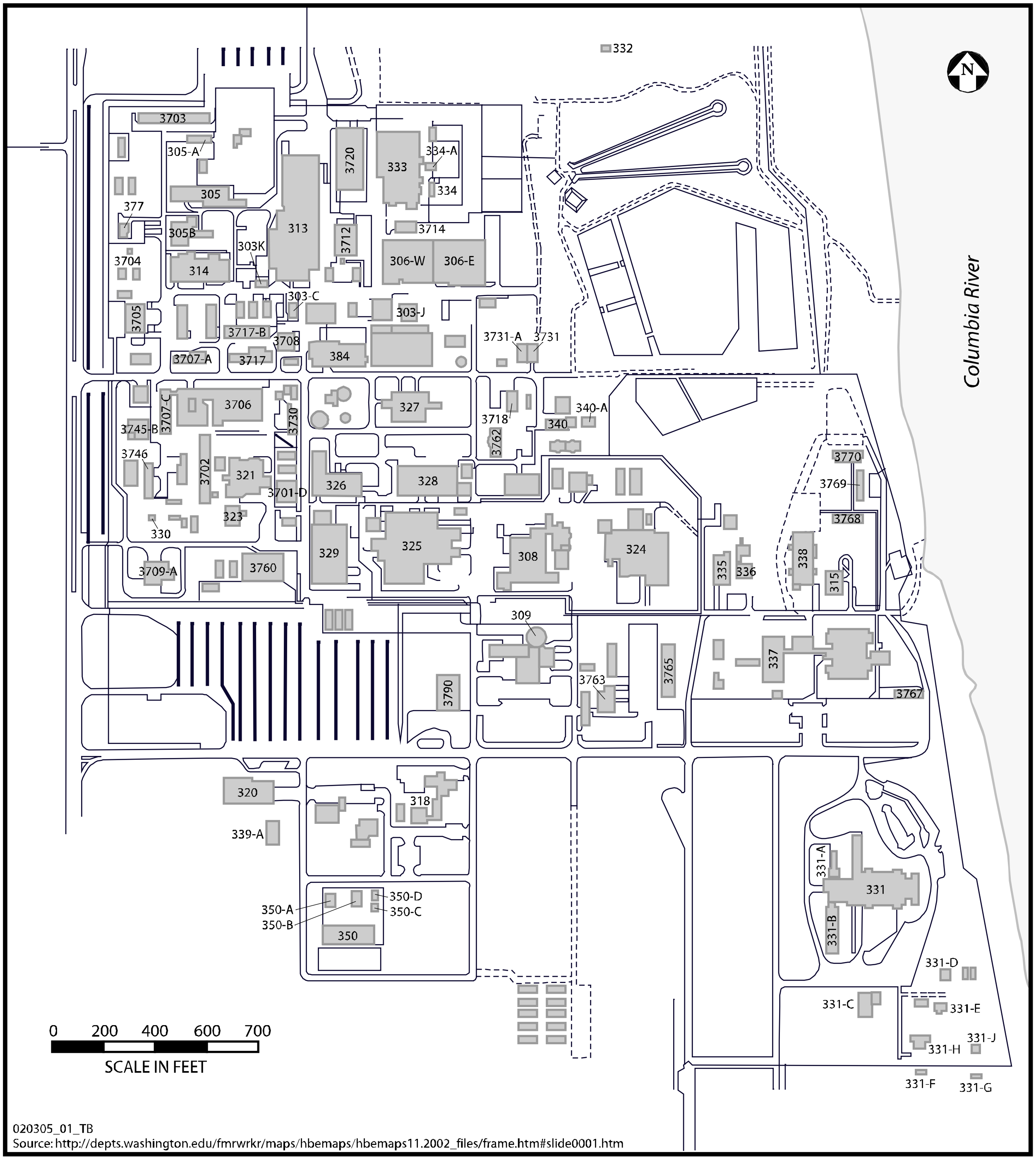

Figure 2-1. Hanford Site 300 Area.

The Hanford Site 300 Area consists of a 0.52-mi^2 industrial complex along the Columbia River about 1 mi north of Richland, Washington (Figure 2-1), as well as approximately 1 mi^2 of additional areas surrounding the complex that were used for solid and liquid waste disposal. Several 300 Area facilities are part of the PNNL. There are currently 100 active PNNL buildings; DOE owns 40 and leases another 6, while Battelle owns 44 and leases 10. Although Table 2-1 lists 165 buildings, many of them do not contain radioactive material; they are included for completeness.

Table 2-1. Buildings PNNL has owned or for which PNNL has served as landlord.

Building number	Building name	Location	Referenced in[a]			Year Acquired[a]	Possible presence of radioactive materials
			1964 (1)	1984(2)	2000(3)		
141-N	Animal Sewage Effluent Pump House	100	Yes			1965 (1)	
185-D	Thermal Hydraulics Lab	100 D-DR	Yes	Yes		1965 (1)	
189-D	Mechanical Development Laboratory	100 D-DR	Yes	Yes		1965 (1)	
190-D	Storage	100 D-DR		Yes			
190-DA	Storage	100 D-DR		Yes			
108-F	Biology Lab and Office Space	100-F	Yes			1965 (1)	
108-FC	Electrical and Glass Shop	100-F	Yes			1965 (1)	
141-B	Feed Storage Barn	100-F	Yes			1965 (1)	
141-C	Chronic Feeding Barn	100-F	Yes			1965 (1)	
141-F	Animal Barn and Exposure Laboratory	100-F	Yes			1965 (1)	
141-G	Pig Gestation Barn	100-F	Yes			1965 (1)	
141-H	Isolation Barn	100-F	Yes			1965 (1)	
141-M	Office, Lunchroom & Change House	100-F	Yes			1965 (1)	
141-P	Pig Farrowing Barn	100-F	Yes			1965 (1)	
141-S	Animal Shelter	100-F	Yes			1965 (1)	
142-F	Biology Storage	100-F	Yes			1965 (1)	
143-F	Well Water House	100-F	Yes			1965 (1)	
144-F	Particle Exposure House	100-F	Yes			1965 (1)	Yes
144-R	Kennels	100-F	Yes			1965 (1)	
145-F	Animal Monitoring	100-F	Yes			1965 (1)	
146-FR	Aquatic Biology Lab	100-F	Yes			1965 (1)	
149-F	Biology Storage and Boat House	100-F	Yes			1965 (1)	
1705-F	Pharmacology Lab and Greenhouse	100-F	Yes			1965 (1)	
146-TC	Biology Change House and Storage	100-K	Yes			1965 (1)	
209-E	Critical Mass Laboratory	200-E	Yes	Yes		1965 (1)	Yes
2101-M	Spare Parts Warehouse, Miscellaneous offices	200-E	Yes				
242-B	Waste Evaporator, Radioactive Particle Research Laboratory	200-E	Yes	Yes		1965 (1)	Yes
242-BL	Cask Loading Building	200-E	Yes			1965 (1)	
2709-E	Fire Protection Headquarters	200-E	Yes				
2714-EA	Critical Mass Storage Building	200-E		Yes		1965 (1)	
2718-E	Critical Mass Storage Building	200-E		Yes		1965 (1)	Yes
271-CRL	Waste Treatment Pilot Plant	200-E	Yes			1965 (1)	
222-U	Geophysics and Geochemistry	200-W	Yes			1965 (1)	Yes
2707-U	222-U Annex (Soil Sampling Building)	200-W	Yes			1965 (1)	
2715-Z	Oil Storage Building	200-W	Yes			1965 (1)	
2719-W	Administration Building	200-W	Yes			1965 (1)	
292-T	Fission Products Release Laboratory	200-W	Yes			1965 (1)	
305	Hanford Test Reactor, Physical Constants Test Reactor, Thermal Test Reactor, Engineering Development Laboratory Annex,	300	Yes	Yes	Yes	1965 (1)	Yes
308	Training Research Isotopes, General Atomics Reactor, Fuels Development Laboratory, Plutonium Fabrication Pilot Plant	300	Yes	Yes		1965 (1)	Yes
309	Plutonium Recycle Test Reactor, Plutonium Recycle Critical Reactor, Equipment Storage	300	Yes	Yes		1965 (1)	Yes
312	Pump House	300	Yes			1965 (1)	
314	Press Building Metallurgical Engineering, Engineering Development Laboratory	300	Yes	Yes		1965 (1)	Yes
315	Filter Plant	300	Yes			1965 (1)	
318	High Temperature Lattice Test Reactor, Radiological Calibrations Building	300	Yes	Yes	Yes	1967 (3)	Yes
320	Low Level Radiochemistry Building, Analysis and Nuclear Research Laboratory	300	Yes	Yes	Yes	1965 (1)	Yes

Building number	Building name	Location	Referenced in[a]			Year Acquired[a]	Possible presence of radioactive materials
			1964 (1)	1984(2)	2000(3)		
321	Separation Building, Cold Semi works	300	Yes			1965 (1)	
323	Mechanical Properties Laboratory	300			Yes	1987 (3)	
324	Fuels Recycle Pilot Plant, Chemical Materials Engineering Laboratory	300	Yes	Yes		1965 (1)	Yes
325	Radiochemistry Building, Radiochemistry Process Laboratory, Applied Chemistry Laboratory	300	Yes	Yes	Yes	1965 (1), 1987(3)	Yes
326	Pile Technology Building, Physics and Metallurgy, Material Science Laboratory	300			Yes	1987	Yes
327	Radio-metallurgy, Post-Irradiation Testing Laboratory	300	Yes			1965 (1)	Yes
328	Engineering Management & Technical Shops Annex	300	Yes			1965 (1)	
329	Biophysics Laboratory, Physical Science Laboratory, Chemical Science Laboratory	300	Yes	Yes	Yes	1965 (1)	Yes
330	Stress Rupture Test Facility	300	Yes			1965 (1)	
332	Hazardous Waste Interim Holding Facility	300		Yes			
336	High Bay Testing Facility	300			Yes	1986(3)	
337	Technical Management Center	300			Yes	1987(3)	
338	Prototype Engineering Laboratory	300			Yes	1971(3)	
350	Plant Operations and Maintenance Facility	300		Yes	Yes	1980 (built) (3)	
377	Steam Generator Examination Facility	300		Yes			Yes
3201	Laboratory Offices and Administration	300	Yes			1965 (1)	
3702	Office Building	300	Yes			1965 (1)	
3705	Personnel Meters and Records, Photography Building	300	Yes	Yes		1965 (1)	
3706	Technical Laboratory, General Services Building	300	Yes			1965 (1)	
3708	Radiation Measurements Building, Radioanalytical Laboratory	300		Yes			Yes
3714	Solvent Storage, Organic Chemistry Laboratory	300	Yes	Yes		1965 (1)	
3718	Laboratories Equipment Pool	300	Yes			1965 (1)	Yes
3720	Central Services Laboratory, Environmental Sciences Laboratory, Materials Science Laboratory	300		Yes	Yes	1971(3)	Yes
3730	Graphite Shop, Gamma Irradiation Facility	300	Yes		Yes	1965 (1), 1987(3)	Yes
3731	Graphite Storage Laboratory Equipment Central Pool	300	Yes	Yes		1965 (1)	
3745	Standards Building, Radiological Dev. & Calibration	300	Yes	Yes		1965 (1)	Yes
3746	Radiological Physics Building	300	Yes	Yes		1965 (1)	
3760	Management and Technical Information, Technical Library	300	Yes	Yes	Yes	1965 (1), 1968 (3)	
3762	Laboratory Safety	300		Yes			
303 A-J	Fresh Metal Storage Building	300		Yes			Yes
305B	Hazardous Waste Storage Building	300		Yes	Yes	1977(3)	
306 (306-E, 306-W)	Metal Fabrication Development, Met Semi-Works	300	Yes			1965 (1)	Yes
306-J	Material Storage Building	300		Yes			
314-B	Stress Rupture Test Facility	300		Yes			
318-A	Detector Building	300		Yes			Yes
3201-A	Service Building	300	Yes			1965 (1)	
324-A	Stack Gas Sampling Building	300	Yes			1965 (1)	Yes
328-A	Engineering Management & Technical Shops Annex	300	Yes			1965 (1)	

Building number	Building name	Location	Referenced in[a] 1964 (1)	1984(2)	2000(3)	Year Acquired[a]	Possible presence of radioactive materials
331, 331A-J and HB1-H-12	Life Sciences Laboratory and associated buildings	300		Yes	Yes	1970 (built)(3)	Yes
340, 340-A, 340-B	Retention and Neutralization	300	Yes			1965 (1)	Yes
350-A	Paint Shop	300		Yes			
350-B	Warehouse	300		Yes			
350-C	Storage Building	300		Yes			
3614-A	River Monitoring Station	300	Yes	Yes		1965 (1)	
3701-A	West Gate House	300	Yes			1965 (1)	
3701-L	Badge House	300	Yes			1965 (1)	
3701-Z	Construction Badge House	300	Yes			1965 (1)	
3706-A	Ventilation Equipment	300	Yes			1965 (1)	
3707-B	Change House, Janitor Supply	300	Yes			1965 (1)	
3707-C	General Services Building Annex	300	Yes			1965 (1)	
3717-B	Instrument Shop	300	Yes			1965 (1)	Yes
3718-A	Laboratories Equipment Pool	300	Yes	Yes		1965 (1)	
3718-B	Laboratory Equipment Central Pool	300	Yes	Yes		1965 (1)	
3718-C	PRTR Storage	300	Yes			1965 (1)	
3718-D	Laboratory Storage	300	Yes			1965 (1)	
3718-G	Storage Building	300		Yes			
3731-A	Graphite Machine Shop	300		Yes			
3745-A	Van deGraaff Electron Accelerator	300	Yes	Yes		1965 (1)	Yes
3745-B	Van deGraaff Positive Ion Accelerator	300	Yes	Yes		1965 (1)	Yes
3746-A	Radiological Physics Laboratory	300		Yes			
3746-D	Technical Service Annex	300		Yes			
646	Radioecology Field Laboratory	600	Yes	Yes		1965 (1)	
#2	Mechanical Equipment Development Storage	600	Yes			1965 (1)	
#3	Chemical Development Storage	600	Yes			1965 (1)	
213 J	Storage Vault	600		Yes		1983(3)	Yes
622-A	Office and Tower Control Room	600	Yes	Yes		1965 (1)	
622-B	Pilot Balloon Release	600	Yes	Yes		1965 (1)	
622-C	Storage Building	600	Yes	Yes		1965 (1)	
622-D	Blimp Storage, Storage Building	600	Yes	Yes		1965 (1)	
622-E	Instrument Repair and Storage Hut	600	Yes			1965 (1)	
622-F	Atmospheric Physics Lab	600	Yes	Yes		1965 (1)	
622-G	Battery Charge Shed, Atmospheric Physics Annex	600	Yes	Yes		1965 (1)	
622-H	Field Office (Atmospheric Physics)	600	Yes			1965 (1)	
622-R	Atmospheric Physics, Hanford Meteorology Station	600		Yes	Yes	1966 (built) (3)	
6652-C	Space Science Laboratory	600		Yes			
6652-D	Pumphouse	600		Yes			
6652-E	Lysimeter Preparation Building	600		Yes			
6652-G	ALE Field Storage	600		Yes			
6652-H	ALE Laboratory I	600		Yes			
6652-I	ALE Headquarters	600		Yes			
6652-J	ALE Sample Storage, ALE Laboratory II	600		Yes			
6652-K	Pumphouse	600		Yes			
6652-M	Fallout Laboratory	600		Yes			Yes
6652-O	Storage Building	600		Yes			
6652-PH	Fire Protection Pumphouse	600		Yes			
TC-4	Skid Shack	600	Yes			1965 (1)	
703	Administration Building	700	Yes	Yes		1965 (1)	
700 Area	Federal Building	700		Yes			
717-B	Environmental Sampling Station	700	Yes			1965 (1)	
747-A	Whole Body Counter	700	Yes	Yes	Yes	1965 (1)	Yes
Annex	Richland Research Complex	RRC		Yes	Yes	1973 (3)	
Auditorium	Battelle Auditorium	RRC		Yes	Yes	1967 (3)	

Building number	Building name	Location	Referenced in[a]			Year Acquired[a]	Possible presence of radioactive materials
			1964 (1)	1984(2)	2000(3)		
BRSW	Battelle Receiving and Shipping Warehouse	RRC			Yes	1970 (built) (3)	
CEL	Chemical Engineering Laboratory	RRC		Yes			
EDL	Engineering Development Laboratory	RRC		Yes	Yes	1973 (3)	
EMSL	Environmental Molecular Sciences Laboratory	RRC			Yes	1997 (3)	
EPRI 1 & 2	Large Animal Exposure Facility	RRC		Yes			
ESB	Engineering Support Building	RRC		Yes			
LSL II, LSL A, LSL B	Life Science Laboratory II, Chemical Storage and Transfer Facility, and Portable Chemical Storage Facility	RRC		Yes	Yes	1975 (built) (3)	Yes
Math Building	Math Building	RRC		Yes	Yes	1975 (3)	
MDL	Mechanical Development Laboratory	RRC		Yes			
MRC	Materials Research Center	RRC		Yes			
OSB	Operations and Services Building	RRC		Yes			
PGF	Plant Growth Facility	RRC		Yes			
PSL	Physical Science Laboratory	RRC		Yes	Yes	1967	
ROB	Research Operations Building	RRC		Yes	Yes	1969 (3)	
RTL 510	Chemical and Flammable Storage	RRC		Yes			
RTL 520	Research Technology Laboratory	RRC		Yes	Yes	1966 (3) (built)	
RTL 530	Radioactive Storage	RRC		Yes			Yes
RTL 540	Storage Shelter	RRC		Yes			
RTL 550	Technical Services	RRC		Yes			
RTL 560	Utility Building	RRC		Yes			
RTL 570	Autoclave Center	RRC		Yes			
RTL 580	Crafts Shop	RRC		Yes			
RTL 590	Warehouse	RRC		Yes			
2400 Stevens	Office Building			Yes	Yes	1979 (3)	
WBF 1	Boat Storage			Yes			
WBF 2	Storage			Yes			

a. Sources: (1) AEC (1964a,b), (2) PNL (1984), (3) PNNL (2000).

Information on the buildings under PNNL control comes from three sets of documents:

- The original property transfer letter and addendum from December 1964 (AEC 1964a and b)
- *Facilities Catalog, 1984* (PNL 1984)
- *PNNL Major Buildings Directory, October 2000* (PNNL 2000), which appears to be heavily redacted.

Table 2-1 summarizes the information available from these sources on buildings that were considered part of PNNL as of the dates of these three documents. Because some information has been redacted, the absence of a positive indication that a building was part of PNNL as of 2000 does not necessarily mean that it was not. Table 2-1 also shows the year the building was turned over to PNNL if known. The "Possible Presence of Radioactive Materials" column provides an indication of the presence of radioactive materials or activities in that building based on the more detailed discussions of radioactive materials and processes in Section 2.2. Many buildings in Table 2-1 do not provide an indication of the presence or absence of radioactive material because there is no specific information available. However, as can be seen from the building name it is most likely that no radioactive material was present. The presence of radioactive materials in the major buildings has been identified. Minor buildings such as Environmental Monitoring Stations and Office Trailers have not been included in Table 2-1 because either they were very small buildings (Environmental Monitoring Stations were typically 40 to 46 ft^2) or they were used only for office space.

2.2 PURPOSE

The purpose of this TBD is to describe the activities, facilities, and radiation sources at PNNL over its operating history. The TBD provides the historical technical information on plant operations and facilities that is needed to reconstruct doses for both monitored and unmonitored workers.

2.3 SCOPE

This document provides a historical overview of: the activities and processes that have occurred in the buildings and facilities at PNNL; the treatment and storage of radioactive wastes; the on-site radionuclides and their solubility and radiation sources; and the accidents that have affected large groups of workers or large areas of the site.

Attributions and annotations, indicated by bracketed callouts and used to identify the source, justification, or clarification of the associated information, are presented in Section 2.7.

2.4 SITE PROCESSES AND ACTIVITIES

The following sections discuss the facilities for which PNNL had responsibility for either maintenance or operation. These include reactors; fuel fabrication; research, development, and testing; and waste handling facilities. Each section is ordered by building number followed alphabetically by facilities without a number.

2.4.1 Reactors

PNNL operated seven testing, research, and demonstration reactors in the 300 Area. These included the 305 Hanford Test Reactor (HTR), Physical Constants Test Reactor (PCTR), Thermal Test Reactor (TTR), Plutonium Recycle Test Reactor (PRTR), Plutonium Recycle Critical Facility (PRCF), High Temperature Lattice Test Reactor (HTLTR), and the Training Research Isotopes, General Atomics (TRIGA) reactor. Table 2-2 lists radionuclides for all research and test reactors that dose reconstructors should consider as potential sources of internal or external exposure.

Table 2-2. Radionuclides of concern for all research and test reactors (Marceau 2002).

^{3}H	^{141}Ce	^{238}U
^{35}S	^{144}Ce	^{238}Pu
^{60}Co	^{144}Pr	^{239}Pu
^{95}Zr/Nb	^{210}Po	^{237}Np
^{103}Ru	^{226}Ra	^{240}Pu
^{106}Rh	^{233}U	^{244}Cm
^{106}Ru	^{234}U	^{252}Cf
^{140}Ba/La	^{235}U	

108-A, Training Research Isotopes, General Atomics
A 250-kW TRIGA reactor was installed in the late 1970s in Room 160 in the A-wing to perform neutron radiography quality assurance testing of fuel elements and fuel jackets. The TRIGA reactor sat in a double containment water tank and operated only at a 250-kW power level (Gerber 1992).

305 Hanford Test Reactor
The 305 HTR (also called the Test Pile) in the 305 Building was the first reactor to operate at Hanford starting in 1943. It was operated until 1972 at a very low critical level (usually less than 50 W) to test fuel elements, fuel configuration, graphite samples, and other materials for the production reactors. It was used as a quality assurance tool to house testing of samples of each lot of graphite, uranium, aluminum jacketing material, and other materials used in the large production reactors. The reactor consisted of a graphite pile and was air cooled. It was removed from the 305 Building in 1976 or 1977 (Gerber 1992, 1993a).

305-B Physical Constants Test Reactor
The PCTR operated from 1954 until 1970. This 800-W test reactor was in a shielded room in the 305-B Building. The mission of the PCTR was to measure reactor changes as a result of use of different reactor fuels. Some plutonium contamination that occurred in the reactor room as a result of an accident in 1961 could have been the source of minor internal exposure during cleanup. External exposure was negligible because the reactor was in a shielded underground room and workers operated it remotely (Gerber 1992).

305-B Thermal Test Reactor
The TTR operated from 1954 until 1978. This 1-kW reactor was in a shielded underground room in the 305-B Building and workers operated it remotely. The mission of the TTR was to measure thermal impact on fission cross sections. The reactor functioned as an early and small version of the HTLTR. External exposure was minimized because workers operated the reactor remotely (Gerber 1992).

309 Plutonium Recycle Test Reactor
The PRTR in the 309 Building operated from 1960 until 1969. The PRTR was a 40-MW heavy-water-cooled and --moderated reactor. It was chosen for a large fuels diversification program known as the Plutonium Fuels Utilization Program. Tests were to be performed with various mixed-oxide fuels using various methods of manufacture. For example, tests were performed on a variety of powdered and pelletized fuels using plutonium oxide blended with uranium oxide and other metallic oxides. The fuel was a nominal 96% depleted uranium oxide and 4% plutonium-oxide powder that was vibration compacted within the fuel pin. External exposure was minimized due to remote operation and the shielding. Maintenance operations resulted in external exposure from activation and fission products. A high extremity exposure occurred when a worker picked up an irradiated steel pin. Tritium oxide was the principal internal exposure contaminant during normal operation. This whole-body exposure was added into the external whole body dose summary (see the internal and external dosimetry portions of this site profile.)

On September 29, 1965, a major operating accident occurred. During a test to examine the effects of temperature increases on fuel growth, distortion, and other factors a portion of the fuel core was brought to a molten state and released 705 g of fuel, contaminating the heavy-water moderator. Cleanup took 6 months. Measurement of surface contamination on October 4, 1965, gave results ranging from 1,000 µCi/ft^2 in A-cell down to 0.75 µCi/ft^2 throughout the reactor hall. Airborne contamination initially produced a radiation field of 20 R/hr in the reactor hall but the airborne concentrations declined from 2×10^{-5} µCi/cm^3 on September 30 to less than from 1×10^{-10} µCi/cm^3 on October 10 (primarily ^{131}I, ^{133}Xe). The PRTR did not have charcoal filters to trap the ^{131}I (Gerber 1992).

In addition, operation of the PRTR before 1965 resulted in increased primary system radioactivity levels that continued into 1965. This consisted of the following:

- Primary system contamination (mainly ^{60}Co), piping radiation levels from 200 to 300 mR/hr;
- Tritium accumulation reached 1.3 Ci/L in the reflector, 1.0 Ci/L in the moderator, and 0.36 Ci/L in the primary coolant.
- Tritium exposure was a major consideration.

The reactor was shut down in 1969 after an accident resulted in high local contamination in the reactor. A sample of the contamination showed the major contaminant was ^{95}Zr/Nb. Other contaminants included ^{60}Co, ^{103}Ru, ^{106}Ru, ^{106}Rh, ^{140}Ba/La, ^{141}Ce, ^{144}Ce, and ^{144}Pr (Gerber 1992).

309 Plutonium Recycle Critical Facility
The PRCF in the 309 Building operated from 1969 until 1976 (Gerber 1992). PRCF's major mission was to house experimental lattice testing for the design of various light-water-cooled reactors. PRCF examined burnable poisons for reactors, flux distributions, and many other variables in reactor operations. In 1988 and 1989, PRCF hardware and equipment were removed (Gerber 1992).

318 High Temperature Lattice Test Reactor
The HTLTR was a 2-MW test reactor in the 318 Building that operated from 1968 until 1971 (Gerber 1992). The reactor consisted of a graphite cube in a large shielded room and operated at temperatures up to 1,000^{0} C. The mission was to advance reactor physics technology. It was shut down in 1971 after 3 years of operation spanning 4 actual years, during which time it operated with six different cores (three ^{233}U, one ^{235}U, one ^{238}U, and one ^{239}Pu). Because the reactor was heavily shielded and was operated remotely, external exposure was at background levels. There were no contamination incidents, so internal exposure was negligible. The building and the shielded room were modified in the early 1980s and used as the new Hanford Radiological Calibration and Development Laboratory.

The building now houses an X-ray unit, photon facility, and several radiation source wells containing 1 kCi ^{60}Co, 100 Ci ^{137}Cs, and a 10^{9} n/s ^{252}Cf source.

2.4.2 Fuel Fabrication Facilities

The Hanford Fuel Fabrication facilities were operated in the 300 Area from 1944 until 1988. These include three fuel fabrication facilities involving PNNL: 314 Uranium Metal Extrusion, 303 Fresh Metal Storage Facility, and 306 Reactor Fuel Manufacturing Pilot Plant. Each is described below.

314 Uranium Metal Extrusion Facility

The 314 Building was known as the Press Building, the Metallurgical Engineering Laboratory, and later as the Uranium Metal Extrusion Facility. Operation of the 314 Press Building began in July 1944 with a mission to process raw uranium billets into extruded rods suitable for fabrication into fuel elements. By 1971 all fuel element preparation activities for the single-pass reactors ceased. Removal of two doors in 1979 resulted in local contamination readings up to 60,000 cpm (Gerber 1992).

303 Fresh Metal Storage Facilities
Ten buildings (303-A, B, C, D, E, F, G, J, K, and M) were built from 1944 to 1983 to store fresh uranium, chemicals, uranium scraps, and plutonium. Uranium was shipped to Hanford in the form of metal billets. These were moved to the 303 Fresh Metal Storage buildings where they were inspected, entered into accountability records, and held for processing. Many spontaneous fires

occurred in the uranium scrap barrels and in concreted uranium scrap billets. These autoignition events, along with oxide conversion activities, produced much particulate contamination that settled in soils (Gerber 1992).

In 1970 the 303-C Building was used by PNNL to store plutonium and americium. On March 13, 1979, pressurization of one of the sealed metal storage cans resulted in the spread of plutonium dioxide (PuO_2) contamination (1.2 to 1.3 mCi released to the atmosphere) and the subsequent shutdown of the building until cleanup (Gerber 1992). It currently is being used for other purposes.

306, 306-J, 306-W Reactor Fuel Manufacturing Pilot Plant
The 306 Building began operation in May 1957 as a pilot plant for reactor fuel production. Throughout its history, its missions have centered on various alloy and fabrication testing and development work. The building had a complete fuel element canning line with the exception of autoclaving. This process was developed in the 306-E Building in the early 1960s in support of the N Reactor fuel needs. The 306 Building was built in two phases. The original was completed in 1956 as the Fuel Element Pilot Plant or the Fuel Fabrication Pilot Plant. In 1960 that facility was expanded to contain the extrusion fabrication process for N Reactor fuel elements. In 1972 use of the 306 Building was divided between PNNL and the Hanford Engineering Development Laboratory (HEDL). At that time, the newer portion building was designated as 306-E and allocated to HEDL, and the older portion designated as 306-W and allocated to PNNL(Gerber 1992).

Airborne dust and particulate contamination in and near this facility included uranium and thorium. Poor ventilation was a continual problem throughout the first 15 years of operation. In addition, multiple fires and leaks occurred over the years in and around the 306 Building in barrels and waste “load luggers" containing uranium, thorium, and heavy metals. Tools and fabrication work areas in the building often displayed contamination levels of 20,000 to 80,000 cpm during the 1950s and 1960s. The highest radiation levels generally were found in the specialty shop for uranium machining in the west end, also called the Regulated Shop or the Hot Shop. One furnace pot read 40 R/hr when surveyed in 1971. As recently as 1987, contaminated equipment entered the building from off the Hanford Site and spread spotty contamination up to 100,000 dpm (Gerber, 1992).

In 1977 a radiological safety survey found significant accumulated uranium contamination in a tailings pile just west of the 306 Building. As recently as November 1990, a PNNL survey performed after a windstorm found hot particles in the soil surrounding the 306-W Building. The report stated the cause of this residual contamination as "prior year’s practices in handling and storage of machine shop chip wastes” (Gerber 1992).

2.4.3 Research, Development, and Testing Facilities

Research, development, and testing facilities were built at Hanford beginning in 1944 to support the development and testing of new processes, materials, and equipment. In some instances the facilities were used for several different purposes throughout their operating lives. Many of the buildings were turned over to PNNL at the beginning of 1965.

305-B Experimental Test Reactor, Engineering Development Laboratory Annex, Hazardous Waste Storage Building
The 305-B Building was built in 1954 as a pile physics laboratory to develop improvements in reactor lattice (i.e., configuration) designs to produce more plutonium in the production reactors. The original portion of 305-B Building was the basement area, which contained two small test reactors, the PCTR, and the TTR. All of the reactor equipment was decommissioned and removed after tests were discontinued in both facilities in 1978. The building now provides space for the Mechanical

Metallurgical Laboratory and is currently used to store and prepare shipments of dangerous waste and radioactive mixed waste (Gerber 1992).

308 Plutonium Fuels Pilot Plant

The Plutonium Fuels Pilot Plant (PFPP) was constructed in the 308 Building in 1960 to perform research and development on fuel elements used in the PRTR. In the mid-1960s the PRTR fuel work was terminated. In the late 1960s neptunium–aluminum alloy fuel target elements were produced for use in the N Reactor for a ^{238}Pu production run. A high bay area was added to the building in 1971. A ^{147}Pm contamination incident occurred in the 308 Building in 1971. From 1977 to 1991 the facility was used for the production of FFTF fuel elements. The 308-A Annex was added to the PFPP in 1979 to accommodate additional plutonium fuels work. A 250-kW TRIGA reactor was installed in the annex in the late 1970s to perform neutron radiography, a feature of the quality assurance testing program. During its operation, the building experienced many incidents involving the loss of control of radioactive materials, primarily plutonium. Most of these were usually contained within one laboratory and the adjacent corridors. Glovebox fires, explosions, and ruptures were the most frequent causes of contamination. The most serious contamination event in the building's history took place in August 1965 when a spark ignited acetone vapors in a glovebox in Room 113. The resultant explosion and fire spread nearly 10 g of plutonium throughout Rooms 113 and 101 and the adjacent hallways. Improperly sealed irradiated sample containers were another common cause. These incidents occasionally resulted in internal exposures. The 308 facilities were deactivated in 1990 (Gerber 1992).

309 Plutonium Recycle Test Reactor, PRTR Equipment Storage

The PRTR was located in Building 309 and began operations in 1960. It was designed to be the operating test reactor in the Hanford Works Plutonium Fuels Utilization Program, the purpose of which was to research and develop nuclear fuel technology for using plutonium as a fuel in nuclear reactors. In 1962 the PRCF was added to support PRTR operations as the location where reactivity values of fuel assemblies before and after irradiation was checked. In 1969 the reactor was placed in layaway condition. In 1986 and 1987, a new space technology development program known as SP-100 was assigned to 309 Building, which led to an extensive cleaning out of the original PRTR features (Gerber 1992).

314 Press Building Metallurgical Engineering, Engineering Development Laboratory

The 314 Building provides high-bay, heavy capacity space for mockups and test equipment. Fuel elements were initially fabricated and jacketed in this building. By 1971 all fuel element preparation activities for the single-pass reactors ceased (Gerber 1992).

318 Radiological Calibration and Development Laboratory

The 318 Building was built in 1967 to house the HTLTR, which operated from 1968 to 1972 and provided reactor physics data. In the early 1980s, the reactor was removed and the heavily shielded 10-m cube reactor cell was converted to a free-in-air calibration facility that contains a large ^{252}Cf neutron source (1×10^9 n/s) and a large ^{137}Cs photon source (about 100 Ci) used for dosimeter calibration. A shielded facility was built in the basement to house a high-level ^{60}Co source (about 1 kCi) to create accident dose rate levels and three 300-kVp X-ray machines. The calibration laboratory commenced operation in 1983. Three major additions were constructed in 1985, 1987, and 1989. The first contained four source wells that held two ^{137}Cs, one ^{60}Co, and one ^{252}Cf sources used for instrument calibration. The second addition housed instrument testing and repair laboratories, and the last addition provided office facilities for the staff. As a result of the shielding, isolation, remote operations, and operating procedures, external exposures were minimized. Internal exposures were negligible.

The facility is still in operation. The wells contain radioactive sources strong enough to project a field or shine area straight above the wells and beyond the roof. This creates concern for personnel who work on the roof area over the wells (PNNL 2000).

318-A Detector Building
The 318-A Building contains a low-level radiochemistry building in which very sensitive radiochemical analyses, sample preparation, and method development can be performed. It was originally part of the HTLTR but is now used as storage area. Half of the building is used as a laboratory for thermoluminescent dosimeter (TLD) work (Gerber 1992).

320 Low-Level Radiochemistry Building
The 320 Low-Level Radiochemistry Building was built in 1966 to house analytical chemistry services and plant support. The current missions include radiochemical environmental analyses, sample preparation, methods development, and classified programs using analytical procedures. Throughout its history, the 320 Building has processed only very small amounts and very low levels of wastes. It was not connected to the Radioactive Liquid Waste System because radioactive wastes (liquid as well as solid) were of such small volume that they were removed in containers and casks. On occasion through the years, small spills of radioactive material have occurred in the facility. In all known cases the contamination was contained within the building, and there have been no known instances involving airborne radioactive releases (Gerber 1992).

321 Separation Facility (Gerber 1992)
The 321 Building was constructed during World War II as a pilot-scale plant to test chemical process improvements using unirradiated or low-activity substances. Beginning in the late 1950s, chemists embarked on the development of several pioneering methods of extracting high-heat isotopes from high-level nuclear waste. Among the most prominent isotope extracts were ^{90}Sr, ^{137}Cs, ^{144}Ce, ^{147}Pm and ^{237}Np. In addition, several different attempts were made to produce ^{233}U from thorium. Known as the THOREX (thorium extraction) program, these processes involved the chemical separation of various forms of thorium target fuel elements after irradiation.

In 1988 an exterior contamination survey of the 321 Building found several areas of fixed contamination including flaking exterior paint chips reading 150,000 dpm beta/gamma and 25,000 dpm alpha attributed to, “plutonium–uranium extraction (PUREX) research and development (R&D) radiological chemical separation operations." Loose smearable contamination was found in a routine survey of the building’s interior in 1991, which was attributed to residual remains of past operations. At present, all entries to the structure are controlled by the Health Physics Department.

The 321 Building was deactivated in 1988 and was emptied and sealed as of 1992.

323 Mechanical Properties Laboratory (Metals Creep Laboratory)
The 323 Building (originally the 321-A Building) served as a support building for waste vitrification techniques in the 321 Building. In 1968 the mission changed to metallurgical research initiatives. The building was transferred to PNNL in 1987. There are no known significant radiological concerns in this building (Gerber 1992).

324 Chemical and Materials Engineering Laboratory
The 324 Building was constructed during 1964 to 1966 as a Fuel Recycle Pilot Plant (FRPP). It was designed partially to support PRTR operations by housing chemical reprocessing and metallurgical examination on the PRTR fuel elements. It was also designed to house the Waste Solidification Engineering Project (WSEP), one of the first high-level waste vitrification demonstration programs in the world. The radiochemical portion contains four hot cells. The southeast section of the 324

Building contains the Radiometallurgy and Materials Testing Laboratories, including three large hot cells known as the Shielded Materials Facility (SMF). The 324 Building also contains many other laboratory facilities including two Engineering Development Laboratories (EDLs) designed for hot work (EDL-146 and -147). EDL-146 is a multipurpose laboratory that performed experiments with radioactive sodium in the 1970s and 1980s. EDL-147 is known as the Regulated Shop because it performed decontamination and repair of manipulators having high radiation levels.

A large basement area in the 324 Building contains four laboratories, three facilities connected with shipping and packaging, various tanks, and the Fissile Materials Storage Vault. The 324 Building basement contains three additional chemistry laboratories. The largest, 3G, contains a shielded glovebox that handles various fission products, sodium, and up to 15 g of irradiated plutonium-oxide fuel. Laboratory 3G previously held an inert atmosphere glovebox used to study ^{137}Cs in molten sodium. Laboratory 3F contains two vented hoods and functioned as a low-level metallography laboratory involved in tritium work. Many radioactive substances were handled throughout the many laboratories and areas in Building 324 including plutonium, normal and depleted uranium and thorium, ^{90}Sr, ^{137}Cs, ^{144}Ce, and ^{252}Cf. In 1991 to 1992 cesium-chloride capsules were manufactured for Nordion for medical use. These capsules contained activity ranging from 500 to 3,000 Ci each (Gerber 1992).

A number of significant contamination events have occurred (Gerber 1992):

- In November 1968 a load-out stall floor became contaminated with liquid ^{144}Ce. Contamination on the floor read up to 100 R/hr and the steam manifold valve read 500 R/hr.

- In January 1969 contamination spread to the floor, piping, and tools outside of the B-Cell. Radiation readings were up to 159 R/hr.

- In October 1971, an event involving ^{144}Ce spread contamination through a large portion of the building. There was also airborne ^{144}Ce contamination.

- The rupture of storage casks containing ^{137}Cs and ^{252}Ca [^{252}Cf] led to localized contamination spreads in 1972 and 1973. [There is no such thing as ^{252}Ca, and the half-lives of the calcium radioisotopes are generally very short. This appears to be a typographical error in the source document and is treated here as ^{252}Cf.] In the case of the ^{137}Cs, a leaking lead pig discharged visible particles and produced radiation readings up to 500 R/hr in the basement.

- In 1986 ^{137}Cs contamination was spread in the truck lock when a highly contaminated filter from B-Cell was dropped during a removal procedure.

- In October 1990, cesium-chloride contamination was spread in the SMF gallery.

325 Radiochemistry Laboratory

The 325 Building was constructed in 1953 to safely house and manipulate multi curie-level radioactive chemical development work. During 1959 and 1960, a large addition known as the High-Level Radiochemistry wing was constructed. The 325 Building was transferred to PNNL in 1965. In 1970, the operations were split between PNNL (who had the large hot cells in the newer addition) and Westinghouse Hanford. The entire building was then transferred to PNNL in 1987.

In its years of prime use in the 1960s, the building contained over 50 laboratories and 11 hot cells. Standard laboratories were bays of 10 by 12 ft. The building also contained over 20 laboratory hoods and many gloveboxes. The primary mission of the 325 Building was as an analytical radiochemistry laboratory that provided verification and research support of complex environmental and industrial issues requiring chemical or radiochemical analysis. A number of techniques were developed that separated or fractionized specific isotopes from high-level waste by ion exchange, carrier precipitation, and solvent extraction. Other radiochemical work conducted in the hot cells has included characterization of double-shell tank slurry, tests of fuel iodine control and fuel uranium dissolution methods for the N Reactor, and experiments in the recovery of strontium using antimonic acid. The building houses processing equipment for preparation of radioactive waste. It also provides specially shielded ventilated laboratory space for studies with chemical and mechanical processes that have radiation levels of up to 1 million R/hr. Several legacy wastes such as unused gloveboxes and tank wastes remain in some of the laboratories and hot cells (Gerber 1992).

The entire ventilation system was engineered in a reverse flow. All air pressure was below atmospheric. The air first passed through the offices then corridors, then through the cold and low-level laboratories, then through the hot cells. High-Efficiency Particulate Air (HEPA) filters were installed in the early 1960s, and a second bank was emplaced in 1970. Major stack decontamination efforts and repairs were undertaken in late 1967 and in 1970, and the main stack was replaced in 1978. Air in the cell and laboratory sections was completely changed and recirculated every two minutes. In 1959 and 1960 three large hot cells were added. All of these cells were surrounded by 4-ft-thick high-density concrete walls with stainless-steel liners. Each of the 11 hot cells was equipped with remote manipulators, periscopes, and leaded glass windows (Gerber 1992).

The High-Level Radiochemistry addition was completed in time to house the “isotope campaigns”. High-level waste was the prime source to supply these isotopes. The feed material was generally PUREX IWW (first cycle waste) or waste from the commercial nuclear power plant at Shippingport, Pennsylvania. The isotopes in highest demand included ^{90}Sr, ^{137}Cs, ^{244}Cm, ^{241}Am, and ^{147}Pm. During the first years of operation, 14 million Ci of ^{147}Pm, 1 kg of ^{90}Sr, 3 kg of ^{241}Am, and 65 g of ^{244}Cm were purified in A-Cell. B-Cell developed a flow sheet for the large-scale recovery mission of ^{90}Sr/^{137}Cs for use in Hanford Works B Plant from 1968 to 1978. Strontium fluoride and cesium chloride encapsulation chemistry for the B plant was also studied in B-Cell. C-Cell was used for compatibility studies for strontium fluoride capsule development and experiments in the recovery of ^{238}Pu (Gerber 1992).

Studies that were part of the large DOE Nuclear Waste Vitrification Project took place in A-, B-, and C-Cells from 1977 to 1980. Experiments in high-level waste behavior during thermal concentration and high water reactor fuel dissolution tests for waste partitioning took place in B-Cell. During the same period, demonstrations of the molten salt electrodeposition of uranium oxide (UO_2) and plutonium oxide (PuO_2) occurred in C-Cell. The large mission was placed in standby by DOE in 1980, and much of the contaminated material was left in A-, B-, and C-Cells (Gerber 1992).

Over the years, there have been numerous liquid and airborne contamination events inside the 325 Building. UO_2 crushing operations in the basement ceramic fuels laboratory in March 1966 spread uranium dusts and fines. A leak of solution containing ^{239}Pu from B-Cell in August 1972 produced readings from 40 to 100 rads/hour in the 325 Building basement. In October, 1977 alpha contamination consisting of ^{238}Pu, ^{239}Pu and ^{241}Am to the level of 120,000 dpm was spread in the outside of a glovebox and other surfaces in Laboratory 400. In August 1981, a vacuum pump was wired in the reverse direction, which resulted in a spread of contamination to two main floor rooms and in basement Room 50. Contamination readings in the incident reached 1 million dpm. A contaminated water leak from B-Cell in April 1988 produced dose rates of 15 to 200 mR/hr in the affected area (Gerber 1992).

326 Pile Physics Technology and Metallurgy Facility
The 326 Building opened in 1953. It was transferred to PNNL in 1987 and was called the Material Sciences Laboratory. The primary mission of the 326 Building is analysis of metallurgical samples of post-irradiated materials. The facility sinks, drains, and trenches have contamination from previous years. Soil samples near the former Radioactive Liquid Waste System diverter show contamination. Hoods and ductwork date back many years and are also potential sources of contamination. In some areas, high radiation fields exist due to inadequate shielding. During the 1970 and 1980s, several laboratories were converted to chemical work involving unirradiated or low-level radioactive materials, though the central mission continued to support research of reactor components and fuel elements (Gerber 1992).

A High Energy Electron Microscope was installed in the basement in 1971 to perform materials studies. During microscope operations, there was a major spread of plutonium and irradiated steel (i.e., iron) contamination. This and other contamination incidents resulted in some internal exposure. In 1983 the 326 Building became the Chemical Science Building (Gerber 1992).

Contamination found in and around the 326 Building include $^{235/238}$U, $^{231/234}$Th, $^{223/226}$Ra, ^{231}Pr, $^{134/137}$Cs, ^{144}Ce/^{144}Pr, ^{155}Eu, ^{241}Am, ^{228}Ac (Gerber 1992).

327 Post Irradiation Testing Laboratory (Radiometallurgy Building)
The 327 Building opened in 1953. The main laboratory area was an east-west ”canyon" that held eight small hot cells, two water basins for holding irradiated fuel rods, two lead brick cells, a burst test facility, and a decontamination chamber. In 1970, the decontamination chamber was torn out and replaced with the Special Environmental Radio-metallurgical Facility (SERF), a large hot cell with a controlled atmosphere of inert nitrogen. In 1978, the 327 Building also received extensive office modifications. The building passed from General Electric to PNNL in 1965, then to Westinghouse Hanford in 1970 and back to PNNL in 1987 (Gerber 1992).

As part of the Hanford waste vitrification projects of the 1960s and 1970s, performance evaluations of both components and glassified products were conducted in the 327 Building. Both destructive and nondestructive examination for the PRTR and FFTF were conducted at PNNL; the General Electric Test Reactor (a fast flux test reactor) in Vallecitos, California, that used enriched UO_2 fuel); and from the Experimental Breeder Reactor II and Materials Test Reactor at Idaho National Engineering Laboratory (Gerber 1992).

The nature of the work performed in the 327 Building involved extremely high-activity wastes. Irradiated materials, including ruptured or failed fuel rods containing plutonium and fresh fission products, were examined while they were "green” (i.e., when they had experienced little decay or stabilization time).

Intense waste and contamination problems developed in the 327 Building. Some of the most severe instances of contamination spreads within the 327 Building occurred as the result of the transfer of radioactive materials and wastes in and out of the hot cells and radioactive materials storage basins. Such transfers produced numerous floor and other surface contamination events throughout the 1950s to 1970s, some of which were termed "gross" in Health Instruments Division monitoring reports. Contamination spreads that resulted from sample transfer problems in and around the building occurred in 1963, 1965, 1972, 1973 (two events), 1974 (two events), 1979, and 1990. In the 1965 incident, a criticality alarm sounded in the building when it was subjected to a radiation flash exposure as an N Reactor fuel element was being pulled out of a cask. In 1990, ^{137}Cs waste from transfer operations out of D-Cell spread contamination in the 327 Canyon. The most serious explosion took place in February 1986 in the SERF cell, which spread plutonium and fission products around the canyon. Cleanup took 7 months (Gerber 1992).

328 Engineering Management and Technical Shops Annex
The 328 Building was constructed in 1952 to house the craft, equipment, and fabrication services to the 300 Area laboratories. Over the years the 328 Building functions changed very little. There are virtually no known instances of radioactive contamination. On a few occasions, contaminated pieces of equipment found their way into the facility (Gerber 1992).

329 Biophysics Laboratory (Chemical Science Building)
The 329 Biophysics Laboratory was built in 1952 and 1953 to support the environmental and bioassay programs. In 1974 Section D of the building, a pit known as the Neutron Multiplier Facility, was added but it did not receive nuclear material until 1977 when a 100-mg ^{252}Cf neutron source fueled by 93% enriched ^{235}U for sample irradiation was emplaced. In 1975 Room 14-C was designated as an Isolated Facility for work with plutonium and enriched uranium. The building was transferred to PNNL in 1965. In 1970 it was split between Westinghouse and PNNL, and the Westinghouse portion was transferred back to PNNL in 1987 (Gerber 1992).

The primary original mission of the 329 Building was to house preparation and counting of radioactivity levels in samples of air, vegetation, soil, wildlife, river and well water, and various types of bioassay samples. Other building missions over the years have included counting and spectrometry studies of activation products found in film buildup on the inside of reactor process tubes and of fission products found in Hanford underground waste storage tanks (Gerber 1992).

Radioactive contamination was introduced to the 329 Building early in its history. Samples in casks leaked unexpected amounts of radioactivity into the building. Events of this type occurred in 1967 (^{170}Tm), twice in 1974 (^{31}Si and mixed contaminated from irradiated sea salts), in 1987 (^{60}Co and $^{134/137}$Cs), and in 1989 (mixed alpha-emitting contaminants) (Gerber 1992).

331, 331A-J, and HB1 Life Sciences Laboratory and Associated Buildings
The 331 Life Sciences Building was constructed in 1970. The functions of the 331 Building and its many ancillary facilities have always involved biological and botanical research. The facility was used to perform radiation effects studies on plants, animals, and fish. Studies involved many radionuclides including ^{90}Sr, ^{131}I, ^{147}Pm, ^{148m}Pm ^{238}U, and ^{239}Pu. The 331 complex conducted plutonium inhalation studies on dogs and plutonium injection studies on rats. Experiments with the effects of radiation exposure on hair and skin were conducted on swine. Artificial heart research with swine involved the use of ^{238}Pu. A hot cell that originally contained a 15-kCi ^{60}Co source was used for special irradiation studies. External and internal exposures were minimal. In 1977 there were several instances of ^{238}Pu contamination in Building 331. In 1981 the small ^{60}Co irradiation source in the 331 Building was shut down due to numerous safety violations (Gerber 1992).

331-H Plant Exposure Facility
331-H building provides space to accommodate the exposure equipment required for performing advanced stages of research on plants. Plants are exposed to various aerosols and actinide elements in the test chamber (Gerber 1992).

338 Prototype Engineering Laboratory
In 1971 the 338 Building was moved from the 100-F Area to provide space to receive, mock up, test, and store components and certified materials for use in the High Temperature Sodium Facility. By 1981 FFTF development work had diminished greatly. The building was converted that year to house the Secured Automated Fabrication Cold Test Facility, a nonradioactive demonstration project of

oxide fuel processing operations for operations in the 427 Building. In 1988 the facility was converted to a chemical and hazardous materials storage area (Gerber 1992). There are no radioactive materials used in the building.

377 Steam Generator Examination Facility
The 377 Building was designed and constructed to provide a facility to conduct nondestructive testing, inspection, and examination of a retired nuclear steam generator. Other programs include chemical cleaning and decontamination experiments and vibration (PNL 1984).

3705 Personnel Meters and Records Building
The 3705 Building was constructed in 1963 to provide laboratory space for processing film badges and meters worn by personnel. It was managed by PNNL from 1965 through mid-1987, when it was transferred to Westinghouse Hanford. During the years when the facility functioned to process personnel dosimeters, a few minor contamination events involving radiation sources, particularly ^{241}Am, occurred in the northwest corner. On other occasions, X-ray machines sometimes released uncontrolled beams (Gerber 1992).

3706 Radiochemistry Laboratory
The 3706 Building was the original radiochemistry laboratory for the Hanford Engineering Works. By 1964 the 3706 Building was called the General Services Building. Although it still contained some analytical laboratories, most of its space was devoted to mail services, duplicating, photographic, and drafting services, a first aid station, and the 300 Area patrol headquarters. During the 1970s and 1980s, all laboratory work was eventually phased out (Gerber 1992).

3708 Radioanalytical Laboratory
The 3708 Building was built in 1948 to process personnel dosimetry badges and meters. In the early 1960s it was an electrical and optical shop used for storage, maintenance, and development of electrical and optical instruments. In 1968 neptunium oxide fuel targets were manufactured in a reduction process. In the early 1970s the north end of the 3708 Building was used for the experimental canning of americium oxide and curium oxide fuel blends. During that period, tools in the building occasionally displayed 40,000 cpm radiation. An atmospheric release of plutonium occurred from a waste drum in about 1984 or 1985. During the 1970s and 1980s about a third of the building was being used for transuranic element studies in gloveboxes (PNL 1984).

3720 Materials Sciences Laboratory
The 3720 Building was built in 1959 and was used for analytical chemistry work in support of Hanford Works reactors in the 1960s and 1970s. In 1971, the 3720 Building was turned over to PNNL and used by many departments including craft services, fuels and metallurgy, and atmospheric sciences. In 1980 a one-story addition was added and equipped for low-level radioactive laboratory work (Gerber 1992).

3730 Gamma Irradiation Facility
The 3730 Building was originally constructed in 1949 as a shop. In 1956 the work performed in the 3741 Building was transferred to this building. A 350 kCi ^{60}Co source was placed in a small, water-filled belowground pit in the late 1960s. Gamma irradiation was used for testing materials, analyzing waste tank solutions, performing studies of corrosion and stress-corrosion cracking, and evaluation of probes under irradiated conditions. A leak occurred in the source beginning in the early 1970s. When repairs were being made in 1974-76, the radiation level in the pit was measured at 7.2 million rads/hour. The facility also houses hot cells, which are used to break up and receive samples for analysis performed at the adjacent 326 Building. The hot cells contain legacy samples that remain

from the defunct breeder program. Building operations were transferred to PNNL in 1987 (Gerber 1992) (PNNL 2000).

3745 Radiological Calibrations and Standards Laboratory
The Radiological Calibrations and Standards Laboratory was opened in the 3745 Building in October 1944. The two-story wooden frame building contained a low scatter room in which dosimeters were calibrated using a ^{226}Ra source and a 220 kVp X-ray machine. Other sources used included large ^{60}Co and ^{137}Cs photon sources and ^{252}Cf, ^{226}Ra-Be, ^{210}Po-B, ^{210}Po-Be, ^{238}Pu-Be, ^{239}Pu-F, and ^{124}Sb-Be neutron sources. Instrument calibrations were performed in a different room that contained two vertical concrete-shielded wells in which the photon sources were housed and used. Instrument calibration sources included ^{60}Co, ^{137}Cs, and ^{226}Ra sources [1].

The building contained a reinforced concrete vault, a large calibration room, and two laboratories. The calibration room contained an industrial 200 keV X-ray unit. The work involved a wide range of radiation detection instruments using X-ray, alpha, gamma and neutron sources. Although radiation sources were stored in the vault, occasional minor contamination events occurred in various building areas as the result of leaking radium, polonium/beryllium-polonium/boron, ^{60}Co, and other materials from the 1940s through the 1960s.

In 1988 the 3745 Building was scheduled for demolition, but the demolition was canceled in 1989.

3745-A Van deGraaff Electron Accelerator
The 3745-A Building provides a shielded laboratory space for research using a 200-MeV Van deGraaff accelerator and a 600 kVp flash X-ray machine (PNL 1984).

3745-B Van deGraaff Positive Ion Accelerator
The 3745-B Building provides shielded laboratory space for research with positive ion bombardment using a 2-MeV Van deGraaff accelerator (PNL 1984).

Annex Richland Research Complex
The Annex is an animal and cell culture exposure facility. Studies are conducted on the magnitude of toxicity, the type of health endpoints produced, and dose-response relationships from exposure of laboratory animals to chemicals, pharmaceuticals, ionizing radiation, nonionizing radiation, and other agents (PNNL 2000).

LSL II – Life Science Laboratory II
LSL II provides laboratory and office space for biological and ecological research. Special facilities are provided for research in toxicology, aerosol physics applied to inhalation toxicology, medical sciences, aquatic ecology, and related biological ecological investigations. LSL buildings originally were designed and operated as a Health Sciences Building focusing on animal research capabilities with the ability to perform radiological work (PNNL 2000).

RTL 530 Radioactive Storage
RTL 530 is a small building that provides space for the temporary storage of experimental radioactive materials. The floor is concrete and contains a pit for storage of highly radioactive materials. The pit has a lead cover (PNL 1984).

2.4.4 Waste Handling Facilities

340, 340-A, and 340-B Liquid Waste Handling Buildings
The expansion of plutonium production facilities and laboratories during the early 1950s brought an urgent need for a more modern and efficient means to sample and dispose of radioactive effluents from the 300 Area. This led to the construction of the 340 Retention and Neutralization Building and the 307 Basins. If radioactivity was not detected above release limits, these wastes were disposed of to the 307 Trenches. If levels proved to be above release limits, the effluents were pumped into the 340 Building tanks and trucked to the 200 Area disposal facilities (Gerber 1992).

In 1953 the 340 Building contained a sampling room and two 15,000-gal stainless-steel tanks located below the building enclosed in a 94,000-gal concrete pit. In 1975 the 340 Building vault was decontaminated.

Major specific contamination events and losses to the environment included a large disposal of low-level radioactive light water coolant from an accident in the PRTR in September 1965. Water was disposed to the soil near the present site of the 3763 Building. In 1967 the capacity of the 340 facilities was overwhelmed by a ^{147}Pm contamination incident in the 325 Building. About 250 mCi of ^{147}Pm was released to the 300 Area process ponds. In the mid-1980s, liquid wastes from the N Reactor fuel manufacturing processes in the 333 Building migrated out of equipment at the Tank Truck Unloading Station at the 340 facility. On other occasions in recent years, barrels storing hazardous wastes on a temporary basis have leaked onto 340 facility concrete storage pads and into soils (Gerber 1992).

The radionuclides of concern include ^{60}Co, ^{90}Sr, ^{90}Y, ^{137}Cs, ^{147}Pm, ^{238}Pu, ^{239}Pu, and ^{144}Ce. Access to the tank area was administratively controlled. The external exposures to the operators were related to the high-energy betas and photons. Internal exposures that occurred were unplanned and would be related to leaks or accidents. The facility is still in use (Gerber 1992).

2.5 MAJOR INCIDENTS

The following are the major incidents that occurred in facilities operated by PNNL (after January 4, 1965); Section 2.2 discusses many instances of contamination of individual facilities. The major incident descriptions are based on information in *Hanford Process Review* (DOE 1991) and *Past Practices Technical Characterization Study-300 Area-Hanford Site* (Gerber 1992).

Incident Number PRTR-2, September 29, 1965
Test 17 using UO_2 – 4 wt% PuO_2 fuel was being conducted in the Fuel Element Rupture Test Facility (FERTF) on a partially molten, intentionally defected fuel rod. Enlargement of the defect caused the pressure tube to rupture, which released 705 g of fuel and burst the FERTF process tube. The release grossly contaminated the heavy water moderator with fission products. Measurement of contamination, which was first allowed on October 4, gave results ranging from 1,000 $\mu Ci/ft^2$ in A-Cell down to 0.75 $\mu Ci/ft^2$ throughout the reactor hall. Airborne contamination initially produced a radiation field of 20 R/hr within the reactor hall but the airborne concentrations declined from 2×10^{-5} $\mu Ci/cm^3$ on September 30 to less than 1×10^{-10} $\mu Ci/cm^3$. Contamination spreads and dose rates were 25 R/hr at C-Cell, 43 R/hr at the A-Cell lower access, 2 R/hr in the labyrinth between A- and C-Cells, and 0.15 R/hr in the reactor hall at the heavy-water clean-up area.

No injuries or overexposure to radiation occurred as a result of this accident. The contractor was Battelle Northwest Laboratories (BNWL).

Incident Number L-6, August 23, 1965
An explosion occurred in Glovebox #10 in Room 113 of Building 308. The explosion blew out a side of the glovebox and two of the gloves. A subsequent fire burned one of the gloves and some rags in the box. The explosion and fire spread nearly 10 g of plutonium throughout Rooms 113 and 101 and adjacent hallways. There were no injuries.

Three of the 11 employees surveyed were grossly contaminated with plutonium. On August 24, the most highly contaminated person had about 5 times the maximum permissible body burden of plutonium.

Incident Number L-8, March 13, 1979
About 1.2 to 1.3 mCi of PuO_2 were released while unpacking a shipment for storage in Room 303-C. A sudden release of air from the package occurred together with a yellow-brown exhalation. Measurements and calculations indicated that no employee or member of the public received exposure or internal deposition exceeding standards (BNWI 1979) (DOE Undated).

2.6 SPECIAL PROGRAMS OR PROCESSES

On January 4, 1965, BPNL took over the Hanford Laboratory and assumed responsibility for the research and development on the Hanford Reservation. As the R&D contractor, no special programs or processes, as relates to production, were applicable to the PNNL.

2.7 MAGNITUDE OF SITE ACTIVITY

Of all the buildings associated with PNNL, Building 318, the calibration facility, houses the highest activity radionuclides. The highest activity radionuclides are ^{137}Cs (about 100 Ci), ^{60}Co (1 kCi), ^{252}Cf (1×10^9 n/s), and ^{241}Am (unknown activity). These radionuclides are maintained in a shielded state and are unshielded only to provide radiation fields for the purposes of calibration. Table 2-1 contains additional information on radionuclides and the magnitude of the activity.

2.8 RADIOLOGICAL ACCESS CONTROLS

Radiation protection programs were developed in 1944 at Hanford. These programs have evolved over the years and have been in place at PNNL since BPNL took over the operation at Hanford in 1965. Routine practices appear to have required assignment of dosimeters to all workers who entered a controlled radiation area. Dosimeters were exchanged on a routine schedule. When BPNL took over there were routine bioassay programs and each individual wore film or TLD badges when entering radiological areas.

2.9 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.

[1] Scalsky, Edward D. Dade Moeller & Associates. Senior Health Physicist. April 2007. The information is a summation by Jack M. Selby, Site Expert for the Hanford Site Description TBD and based on material in Ballinger and Hall (1991), Hanford Site (no date), Marceau et al.,

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