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☐ New ☐ Total Rewrite ☒ Revision ☐ Page Change

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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
10/15/2003	00	New document to establish Occupational Environmental Dose Section 4. First approved issue. Initiated by Edward D. Scalsky.
12/20/2006	01	Approved revision as a result of the biennial document review. Revises Section 4.3.3 to respond to SC&A comments. Table 4-3 was revised to include more absorption types, in accordance with ICRP 68, and type S Sr was removed. Tables A-13 through A-21 were removed and replaced by revised Tables A-11-13 that provides only one air concentration per radionuclide per year. Incorporates internal and NIOSH formal review comments. Constitutes a total rewrite of document. This revision results in an increase in assigned dose and a PER is required. Training required: As determined by the Task Manager. Initiated by Edward D. Scalsky.
06/05/2007	02	Approved revision initiated to include Attributions and Annotations. No further changes occurred as a result of formal internal review. This revision results in no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by Edward D. Scalsky.

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ACRONYMS AND ABBREVIATIONS

BMIPND	Battelle Memorial Institute – Pacific Northwest Division
Bq	becquerel
Ci	curie
cm	centimeter
d	day
DOE	U.S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ft	foot
GM	geometric mean
GSD	geometric standard deviation
in.	inch
km	kilometer
m	meter
MeV	megaelectron-volt, 1 million electron-volts
mg	milligram
mo	month
mrad	millirad
mrep	millirep
nCi	nanocurie
nGy	nanogray
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
pCi	picocurie
POC	probability of causation
PUREX	plutonium–uranium extraction
REDOX	reduction oxidation
s	second
Sv	sievert
TBD	technical basis document
TBq	terabecquerel
U.S.C.	United States Code
yr	year
µCi	microcurie
µm	micrometer
§	section or sections

4.1 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

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

- Radiation from diagnostic X-rays received in the treatment of work-related injuries

4.1.1 Purpose

This TBD provides the rationale, historical background, and data for the reconstruction of occupational environmental doses for unmonitored personnel at the Hanford Site. The occupational environmental dose is the dose received by individuals while outside of operational facilities on the site such as process buildings, chemical separations plants, reactors, or other structures. Internal dose from the inhalation of radioactive materials may be determined from radionuclide air concentrations. External dose from radioactive materials outside the body may be determined from immersion in a cloud of inert gases, from deposition of particles on the skin, or from adjacent operational facilities.

4.1.2 Scope

This TBD provides information on the routine releases from the various Hanford facilities and the doses received by personnel as a result of these releases.

The four chemical separations plants, T Plant, B Plant, REDOX Plant, and PUREX Plant, along with the plutonium-handling Z Plant, are shown in Figure 4-1 and are the most important release points at Hanford. Section 4.3.2 shows that ^{41}Ar from the reactors was also an important source of worker exposure. For individuals working outside process buildings and facilities at Hanford, pathways of concern are [1]:

- The inhalation of radionuclides in the air.
- Direct external radiation from plumes.
- Physical contact with particulate radionuclides incident on the skin.

Construction workers, contractors, security guards, environmental monitoring personnel, and personnel involved with outdoor work duties would be the personnel likely to receive occupational environmental doses [2].

Gerber (1992) shows the location of the Hanford Camp, the Columbia Camp, and other locations where individuals worked and lived. For example, up to 40,000 individuals, mainly construction workers, resided at Hanford Camp until it closed in February 1945. Gerber (1993) provides details on the buildings and facilities. Figure 4-1 shows many of these locations, which were selected as locations where annual intakes of radionuclides in the air were determined.

Attributions and annotations, indicated by bracketed callouts and used to identify the source, justification, or clarification of the associated information, are presented in Section 4.4.

4.2 DOSES FROM ONSITE ATMOSPHERIC RADIONUCLIDE CONCENTRATIONS

In 1943 the Hanford Site was selected as the location to produce plutonium for the U.S. atomic weapons program (Groves 1962). Nine reactors, four chemical separations plants, and a plutonium-handling plant became operational at the site in the following years (Ballinger and Hall 1991; Gydesen 1992; Till et al. 2002). Table 4-1 lists the dates of operation of these facilities.

The plutonium produced in the reactor fuel elements was extracted from the irradiated fuel in the chemical separations plants (T, B, REDOX, and PUREX) and converted to metallic plutonium in the Z plant. Throughout operations of the reactors, chemical separations plants, and Z Plant, a portion of

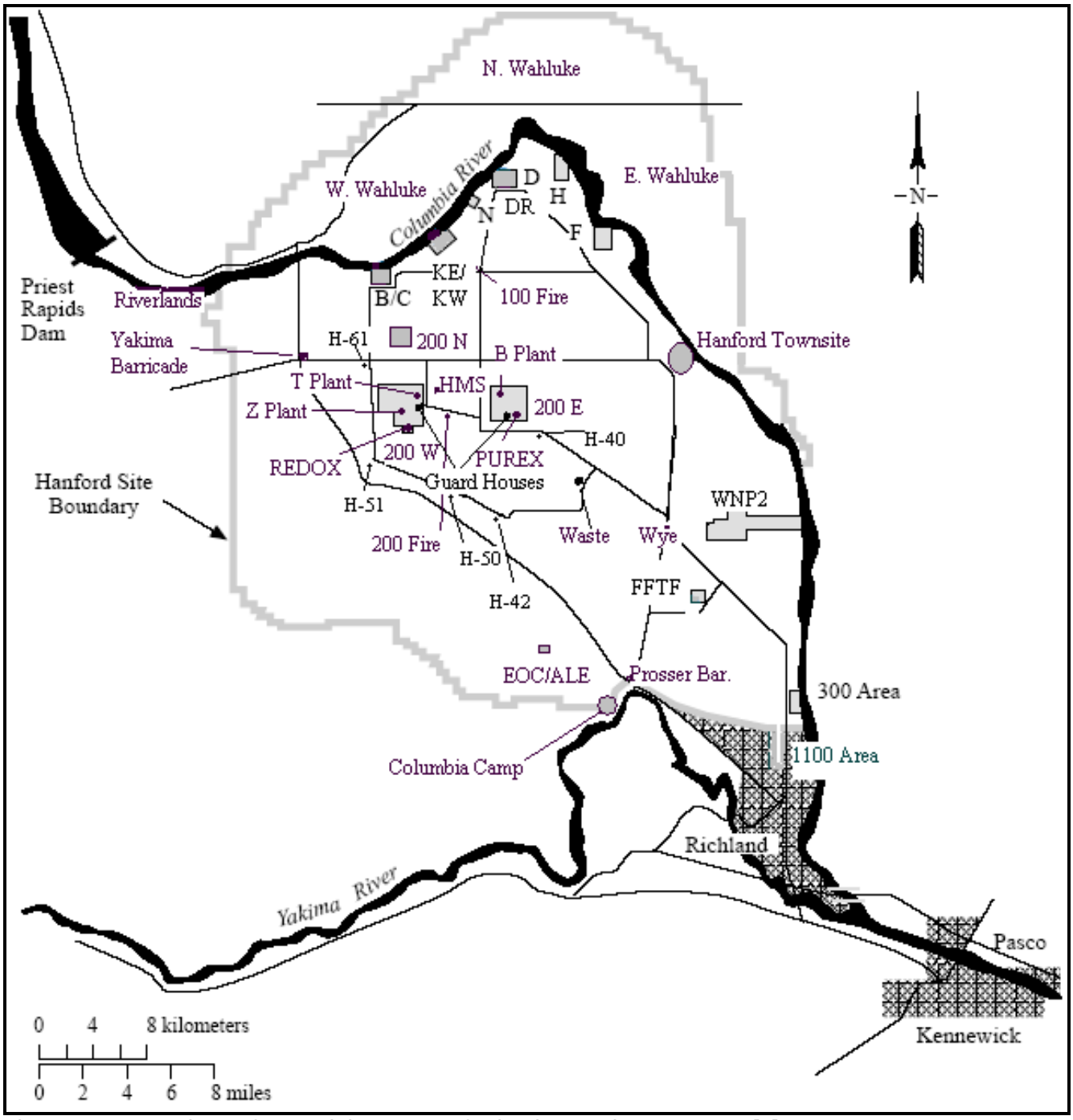

Figure 4-1. Locations of potential exposure for intakes and exposures. [3]

the radionuclides being processed was released into the atmosphere and transported primarily downwind to the northeast (Farris et al. 1994).

4.2.1 Onsite Releases to Air

Figure 4-2 shows the fuel element cooling time, which is the elapsed time between discharge of the fuel elements from the reactors and the start of fuel processing in the chemical plants. Between 1944 and 1945 the fuel element cooling time was approximately 40 d. By 1947 the cooling time was

Table 4-1. Facility operation dates.

Facility	Dates of operation
Reactors	
100-B	1944–1968
100-D	1944–1967
100-F	1945–1965
100H	1949–1965
100-DR	1950–1964
100-C	1952–1969
100-KE	1955–1971
100-KW	1955–1970
100-N	1963–1987
Chemical separations plants	
T	1944–1956
B	1945–1952
REDOX	1952–1966
PUREX	1956–1990
Pu-handling plant	
Z	1949–1976

extended to approximately 90 d. The shorter cooling time resulted in the releases of larger quantities of volatile, short-lived radionuclides in comparison to later years. For example, in 1945 up to 90,000 Ci of ^{131}I were released each month compared to 10,000 Ci/mo after 1946. Because there was no filtration to limit release of the volatile radionuclides in the earliest years, the releases to the atmosphere in 1945 were the largest at any time at Hanford (Till et al. 2002).

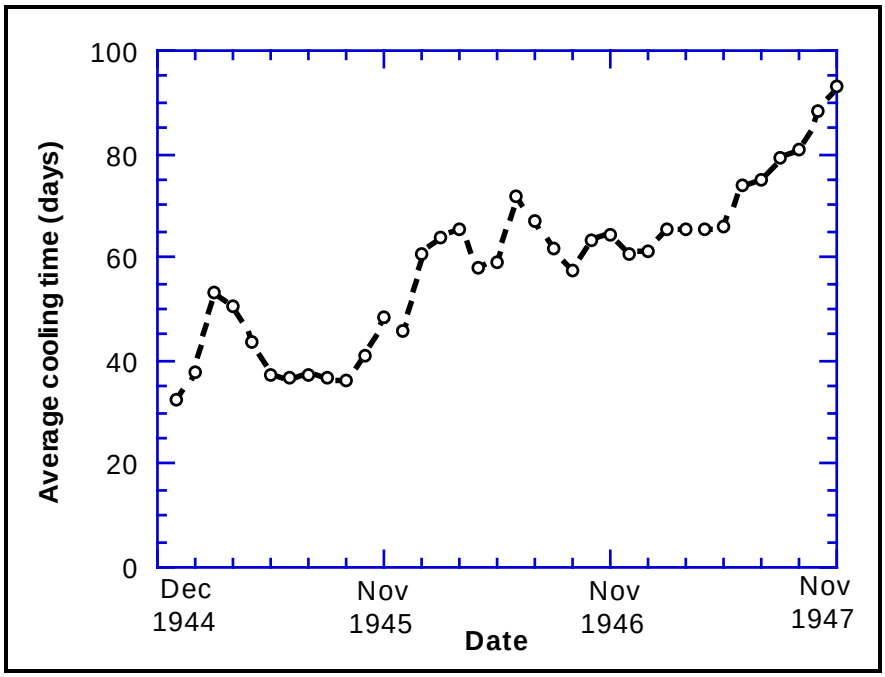

Figure 4-2. Average fuel cooling times before processing.

Heeb (1994) lists the releases of ^{41}Ar, ^{14}C, and ^{3}H from the reactors based on historical measurements. Screening studies eliminated from dose consideration ^{3}H and ^{14}C releases to the atmosphere from the reactors based on the product of the amount released and the dose conversion factors shown in Table 4-2. The estimated dose contribution of ^{41}Ar was 10,000 times greater than

that of ^{3}H and 3,000 times greater than that of ^{14}C. However, due to the large ^{3}H release from the 108-B facility, the dose from ^{3}H was assessed. Section 4.2.1.5 contains more information on releases of tritium for 108-B, and Section 4.3.2 contains additional information on ^{41}Ar.

Table 4-2. Estimated release rates from Hanford reactors with air pathway screening factors for ^{41}Ar, ^{3}H, and ^{14}C.

Radionuclide	Estimated release from all reactors (Bq/d)[a]	Screening factor for inhalation and direct radiation exposure (Sv per Bq/m^3)[b]
Ar-41	5.5E+13	1.5E-06
H-3	5.2E+10	1.4E-07
C-14	3.7E+09	4.5E-06

a. Release estimates from Heeb (1994).
b. Screening factors from Appendix B of NCRP (1996).

Similar screening of the radionuclides released demonstrated that the dose from the radionuclides listed in Table 4-3 should be considered (Till et al. 2002). The table lists the assumed absorption types for each radionuclide. Radionuclides listed in pairs are parents with associated short-lived progeny. These are assumed to be in equilibrium in the environment. Source terms are release rates of radioactive materials at specific locations. Tables A-1 to A-9 in ATTACHMENT A list the source terms for the reactors, chemical separations plants, and the plutonium-handling plant.

Table 4-3. Assumed absorption types[a] for each radionuclide [4].

Radionuclide	Absorption type
Ar-41	Not applicable
H-3	Water Gas (HT or T_2) submersion
I-131	Class SR-1, type F or vapor
Ce-144/Pr-144	M for all compounds except oxides, hydroxides, and fluorides S for oxides
Cs-137	F for all compounds
Pu-239	M for unspecified compounds or S for insoluble oxides
Ru-103/Rh-103	F for unspecified compounds or S for oxides and hydroxides
Ru-106/Rh-106	F for unspecified compounds or S for oxides and hydroxides
Sr-90/Y-90	F for all compounds
Zr-95/Nb-95	F for all compounds except M for oxides, hydroxides, halides, and nitrates S for carbides

a. F = fast; M = moderate; S = slow.

4.2.1.1 Routine Releases from T and B Plants

Stack releases to the environment under normal operating conditions at the chemical separations plants were proportional to the rates at which the material entered as irradiated fuel from the reactors. The most likely source of these releases was iron-oxide particulates from corroding ductwork in the ventilation systems of the T and B Plants. Analysis of the particles indicated that the radionuclides were deposited on the blowers and other iron surfaces and were released into the ventilation air stream as the iron parts corroded. Figure 4-3 shows the estimated distributions of physical, aerodynamic, and radiological properties of the released particles. Other physical characteristics of

the particles and their distributions are reported in Michelson (1947), Parker (1948a), Gross (1948), and Thorburn (1948) (see Table 4-4).

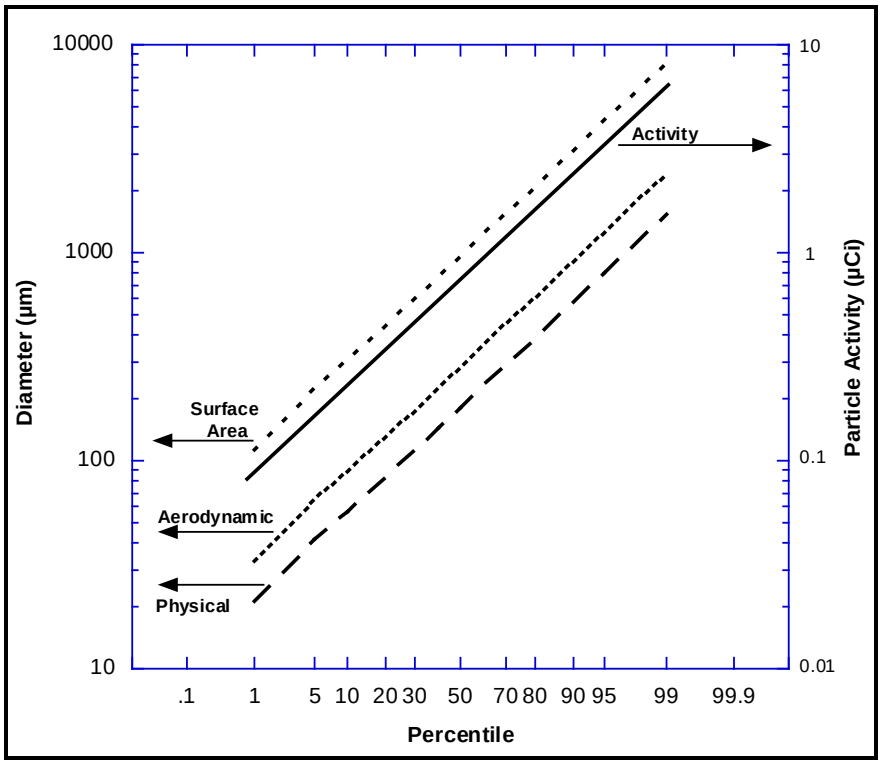

Figure 4-3. Estimated distributions of physical and aerodynamic diameters for large, "active particles" with estimated distributions for particle surface area and activity (Till et al. 2002).

For routine releases from T and B Plants, the estimated monthly release is the product of the following factors [5]:

- The monthly processing rates for each radionuclide compiled by Heeb (1994), which are the rates at which the radionuclide enters the separation plants as irradiated fuel from the reactors. The processing rates were estimated by Till et al. (2002) for ^{137}Cs and by Heeb (1994) for ^{90}Sr, ^{103}Ru, ^{106}Ru, ^{131}I, ^{144}Ce, and ^{239}Pu.
- The release fraction, which is the ratio of the rate that the radionuclide was released to the processing rate of that radionuclide.
- The effluent treatment modifier, which accounted for increased release rates in the early years of operation of T and B Plant when there were no scrubbers or filters on the effluents.
- Uncertainty factors related to processing rates and the amount of radioactive decay that occurred between fuel irradiation and fuel processing.

Figures 4-4 and 4-5 illustrate the releases of ^{144}Ce and ^{131}I from T Plant. Effluents from B Plant were similar to those from T Plant but were higher due to difficulties encountered with the effluent filtration and scrubber system [6].

Table 4-4. Physical, chemical, and radiological properties of radioactive particles released from 1945 to 1956.

Interval		Source report	Location of sample	Physical characteristics	Chemical characteristics	Radiological characteristics
Beginning	Ending					
	May 7, 1945	Healy 1945	Stack samples taken from the T Plant.			0.6–0.8 MeV beta presumably from iodine; also 1.5–2.0 MeV betas.
1945	1947	Healy 1948	Vegetation, processing plant effluent air, and ambient air.			Total beta 7 nCi/filter.
	April 1947	Stainken 1948	Outside near T Plant fence.	Presence of singular large particles not indicated.		Mostly Ce and decay product Pr.
	April 1947	Roberts 1958	Outside in 200 Areas.			Effective half-life of about 300 d. Principal contaminants were (in order): Ce, Y, Sr, Ru, Cs.
	Fall 1947	Michelson 1947	Outside ground near T, B Plants.	Can be mechanically separated from dirt.		Total beta activity ranging from 0.5 µCi to 1 µCi. Most of the beta activity was Ce; most alpha was Pu (range 0.07–1.7 nCi).
	Fall 1947	Parker 1948b	Outside ground near T, B Plants.	Color reddish brown; carrier particles >100 µm, range 20 to 1500 µm linear dimensions; small particles, mists, and droplets emitted since operations began.	Contain iron oxides; can be separated with magnets.	Alpha activity mostly Pu, 1/20 as much U. Beta activity correlated with surface area of particle; mostly Ce (and daughter Pr-144), Y, Sr, Ru, and Cs.
	April 1947	Parker 1947	Outside ground near T, B Plants.	Mass of 0.1 to 1 mg; brown color (different from soil).		0.1 µCi to 1 µCi. T Plant particles 60–90% Ce and up to 15%Y. B Plant 30–55% Ce, 7–20% Sr, and 30–45% Y.
April 1947	April 1948	Parker 1948	Outside ground near T, B Plants.	Physical sizes of 153 large particles ranged from 40 µm to >1 mm. Median 300 µm. No reliable data on very small particles.	Essentially all particles contain enough iron to be separated magnetically.	0.0001 to 3 µCi. 30–50% Ce; 10–50% Y; 10–20% Sr.
	~March 1948	Gross 1948	Processing plant effluent.	Some are <1 µm.		
	Spring 1948	Adley 1948	Processing plant effluent.	Mists mean size <5 µm; magnetic specks, density of iron.		
	Spring 1948	Thorburn 1948	Ground and roofs surrounding processing plants.	Usually less than 500 µm; range 20–1,500 µm.	High in iron; low carbon and calcium.	2.5 pCi to 3.2 µCi beta/particle. Max. beta energy 3.0 MeV.
	Spring 1948	Thorburn 1948	Processing plant effluent.			Beta mostly Ce; alpha mostly Pu.
	~April 1948	Gregg 1948	Outside ground.	10–1,000 µm.	Associated with rust.	Max 3 µCi beta/particle.
April 1948	April 1948	Singlevich 1949	Particles collected by air samplers.			1–10 pCi fission products/particle.
April 1948	April 1948	Singlevich 1949	Stacks of 314 Building, the Melt Plant, in 300 Area.			Mostly uranium.
	1950	Delong 1950	Ventilation air of the B Plant before sand filter.			100% of alpha was Pu; most of beta was Ce, rare earths, Ru, Zr, Y, and Sr.
	April 3, 1952	Parker 1954	On survey meter inside car with window open.			Particle read 40 rad/hr.

Interval		Source report	Location of sample	Physical characteristics	Chemical characteristics	Radiological characteristics
Beginning	Ending					
	April 29, 1952	Parker 1954	Eastern and northern sections of the REDOX area.			From 100 counts/minute at 1 in. to 800 mrad/hr at surface; gross beta activity ranged up to 0.1 µCi/sample.
April 1952	June 1952	Paas 1952	Particles emitted from REDOX Plant (second, third, and fourth episodic releases on April 3, April 29, and June 24).	Ranged from microscopic translucent hydroscopic crystals adhering to the soil sand, to visible chalky particles varying in shape and size—a few with diameter ~0.5 in. Larger visible particles easily fractured, apparently a conglomerate of microscopic crystals.	Chemically, the composition of the inactive material was mainly ammonium nitrate with a small amount of occluded dust particles.	90 to 98% of the total beta activity was Ru; I-131 in particulate contamination ranged from 1–5%. Beta particle activity varied in direct relationship with size.
	June 24, 1952	Ebright 1954	Outside: flakes from fourth episodic release from REDOX.	1/64–1/32-in. thick and up to several inches in diameter. Large flaky radioactive particles found near the eastern REDOX exclusion area rapidly disappeared, though activity spots were detectable with survey instruments. Flakes fragile and hydroscopic.	Carrier crystal was predominately ammonium nitrate.	Mostly ruthenium.
	March 12, 1953	Paas 1953a	Ambient air near REDOX.			36% of beta activity was Ru, 43% rare earths and Y.
	Spring 1953	Adley et al. 1953	Base (inside) of the REDOX stack.	Median particle size about 0.2 µm with GSD of 1.6 during one sample and 2.5 during another.		Activity median particle size was 0.6 µm.
August 7, 1953	August 14, 1953	Donelson 1953, Ebright 1954	Outside ground southeasterly direction from the REDOX stack.	Up to 5 in. (13 cm); average 0.5 in. (1.3 cm); up to 0.5 to 0.75 in. thick.	Carrier crystals were ammonium nitrate.	Max 15 rep/hr; average 300–500 mrep/hr surface. 70% Ru, 25% rare earths and Y, and trace amounts of Sr, Ba, and Zr.
	December 1953	Adley et al. 1954	Air entering sand filter of REDOX.	Two cascade impactor sample results geometric mean of 0.3 µm (GSD 2.8) and 0.5 µm (GSD 3.2); ave. 5.3E08 particles/cm^3.		
	December 1953	Adley et al. 1954	Air at 10-ft level inside REDOX stack.	Four cascade impactor sample results ranged from geometric median size 0.3 µm (GSD 2.0) to 0.4 µm (GSD 3.8); ave. 2.4E08 particles/cm^3.		
August 9, 1954	May 18, 1954	Paas 1954	Air entering REDOX Plant sand filter.			92% of total beta activity was Ru in March; in May, 24% was Ru, 28% rare earths, 14% Zr, and 25% Nb.
		Parker 1954	General review: input side of process sand filter.			Less Ru (80%) and more of the rare earths (10–15%) and Sr (1–2%), compared to particles emitted to the environment.

Interval		Source report	Location of sample	Physical characteristics	Chemical characteristics	Radiological characteristics
1952	1954	Parker 1954	General review: REDOX releases to environment.	Primary particles about 2 µm; large secondary particles typically 100 µm.	Carrier base is an aggregate of ammonium nitrate, sometimes sand. Inhalable particles were between 40–80% soluble after 36 hr in simulated lung fluid. Large particles were 3– 70% soluble after 48 hr in simulated gastric juice.	Primary particles up to 5 nCi/particle, dose rate of 0.5 mrad/hr; secondary particles dose rates up to 20 rad/hr and 200 µCi/particle. Ru and Rh activity 98% of the total, with Sr-89 and Sr-90 <0.3%; rare earths plus Y <1.0%; and Zr-95 <0.5%.
	June 1954	Ebright 1954	Outside ground in 200 Areas.	No well-defined relationship between particle size and dose rate. Particles of several thousand square µm were observed. Easily fractured.	Ammonium nitrate present.	90% of beta activity was Ru; activity ratio 103:106 was 0.6 to 1.4; one particle with dose rate of 1.2 rad/hr contained 6.3 µCi; another reading 120 mrad/hr had 0.49 µCi; average dose rate/µCi was about 200 mrad/hr.
	November 7, 1954	Regional Radiation Measurement Unit 1955	Five particles emitted from REDOX stack.	Four of the particles were agglomerates of smaller white crystals with yellow discoloration on some surfaces. One particle was bright yellow without the crystalline appearance.	Ammonium nitrate and iron were found in four particles. The bright yellow particle was mostly calcium and iron.	95% of the beta activity was from Ru/Rh isotopes with the ratio of activity of ^{103}Ru to ^{106}Ru being less than 0.05. Also Sr, rare earths, Zr, Pu.
October 1954	December 1954	Pilcher et al. 1954	Ground surfaces around REDOX.	Maximum dimensions ranging from a few µm to ~1,000 µm.		Nearly all beta was Ru/Rh; Ru-103:Ru-106 ratio less than 1.
	December 1954	Healy 1955	Ground surfaces around REDOX.	Relative to a unit length, the average width was 0.75 +/□ 0.14 and the depth was 0.39 +/□ 0.18. The density is believed to be about 1.5.		
May 29, 1956	June 4, 1956	Anderson and Soldat 1956	Outside of U Plant in 200-West Area.	Large paint flakes up to 8 in. long, peeled off duct work between sand filter and U Plant stack.	Associated with painted stack liner.	Alpha and beta.

Note: The blanks in the interval columns in the table indicate the release happened on the date given in the column under ending. The blanks in the characteristic column indicate the specific characteristics are not applicable for the stated release.

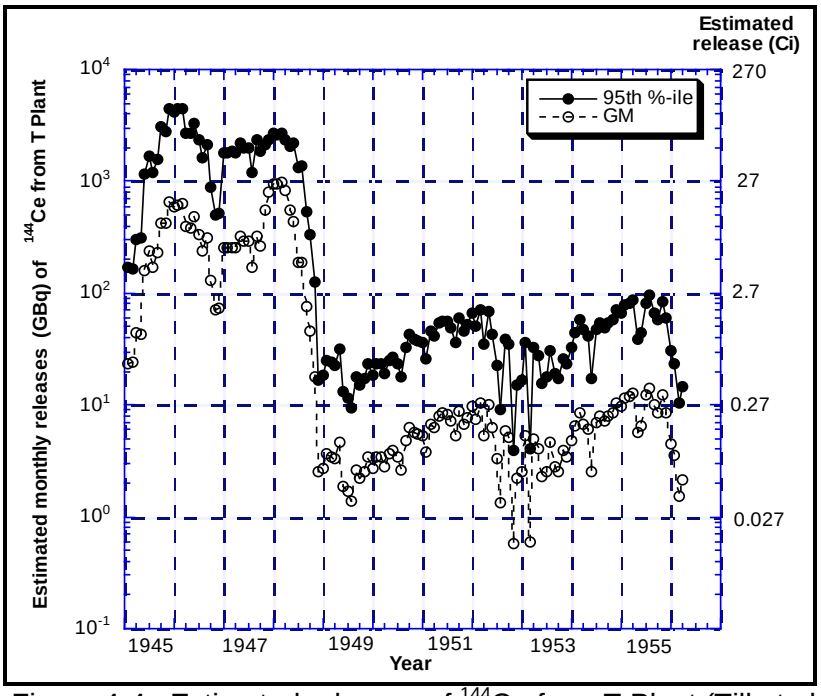

Figure 4-4. Estimated releases of ^{144}Ce from T Plant (Till et al. 2002).

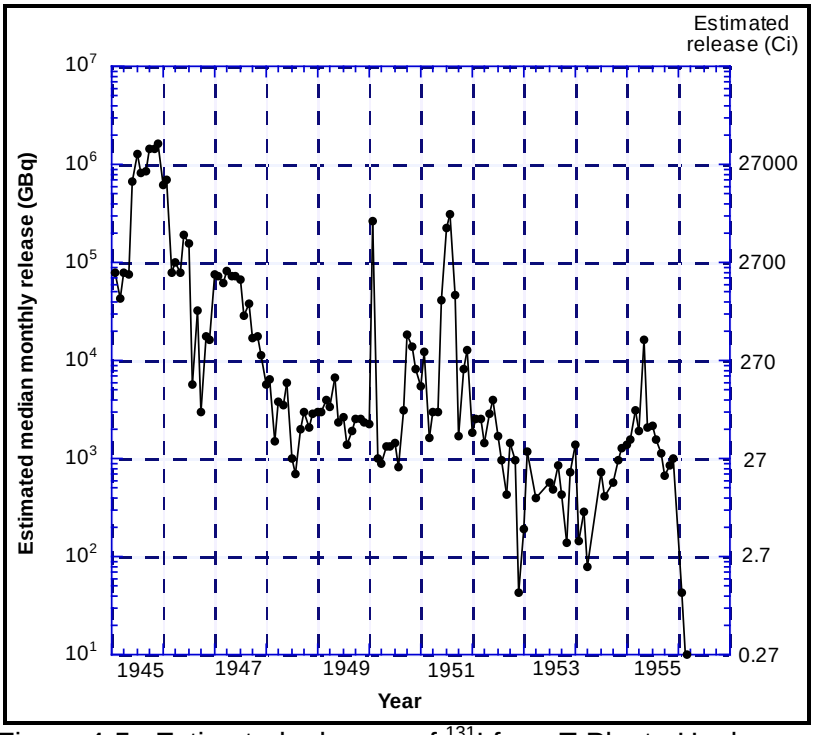

Figure 4-5. Estimated releases of ^{131}I from T Plant. Heeb (1994) and Napier (2002) provided estimates (Till et al. 2002).

4.2.1.2 Routine Releases of Plutonium from Z Plant

Z plant was not one of the chemical separations plants but was located in the 200-W area of Hanford. Z plant produced and fabricated metallic plutonium from plutonium nitrate that came from the chemical separations plants. Plutonium-239 was released as small particles of usually less than 1 µm. Figure 4-6 shows the estimated annual releases of ^{239}Pu from Z Plant as median estimates and the 95th percentiles of the distribution (Till et al. 2002).

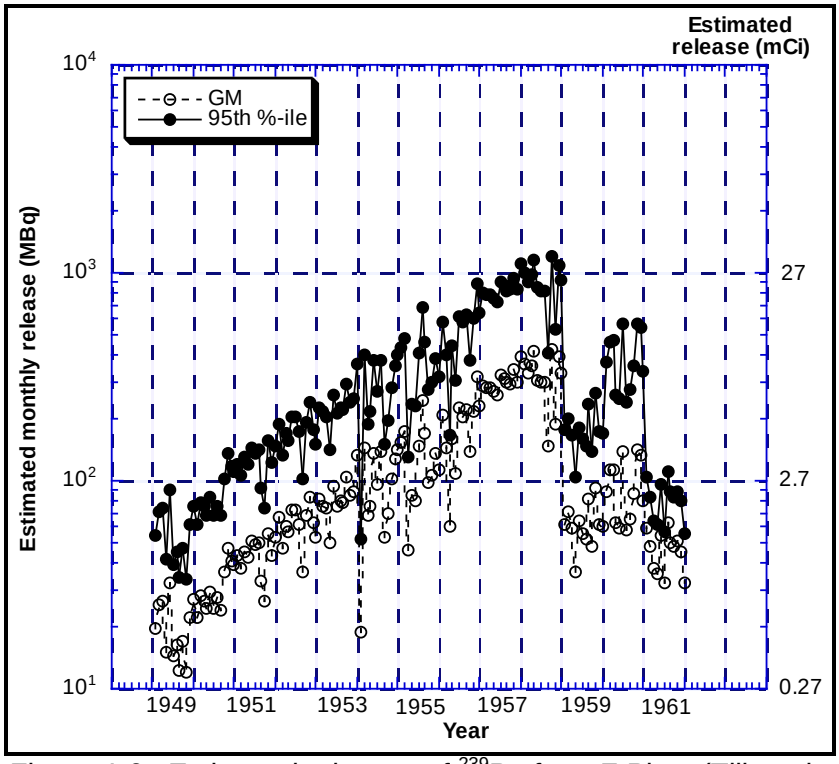

Figure 4-6. Estimated releases of ^{239}Pu from Z Plant (Till et al. 2002).

4.2.1.3 Routine Releases of Iodine from the Chemical Separations Plants

Iodine-131 was released from the four chemical separations plants (T, B, REDOX, and PUREX) from 1946 until 1962. Screening calculations indicated that ^{131}I was the most important radionuclide conveying dose to persons on the site (Till et al. 2002). Heeb (1994), Warren (1961), Junkins et al. (1960), and Foster and Nelson (1961) reported estimates of the ^{131}I releases. The estimates were complicated by different reported fuel element cooling times for the same fuel elements, unusual releases not included in the release estimates such as a boil-over and a fire in a dissolver, the presence of organic halides that were not included in the estimates, and unaccounted for plateout of elemental iodine in the sampling systems. Figure 4-5 shows the estimates of ^{131}I releases for T Plant.

The estimates were compiled by Till et al. (2002) based on the amount of iodine in the fuel elements sent to the dissolvers of the chemical separations plants (Heeb 1994) and the stack monitoring data and environmental measurements (Napier 2002). The absorption type for all compounds of iodine is F, and it is assumed to be a class SR-1 vapor for internal dose calculations.

4.2.1.4 Nonroutine Releases from the REDOX Plant

Ammonium nitrate flakes formed on the inside of the exhaust stack of the REDOX Plant and were released from 1952 through 1954. The largest release occurred in 1954. The flakes formed from the mixture of ammonia and nitrous oxides in the ventilation air. Volatile ruthenium oxide (RuO_4) formed in an oxidation step in the plant, and it combined with the ammonium nitrate to form the flakes containing ^{103}Ru and ^{106}Ru. Some of the flakes were up to 10 cm in diameter, contained up to 200 µCi (7.4×10^6 Bq) of ruthenium, and produced surface contact dose rates up to 20 rad/hr (1 Ci = 3.7×10^{10} Bq). Adley et al. (1953) and Greenfield (1954) reported the physical characteristics of the particles. Contact dose rates for 65.5% of the particles were in the range of 5 to 50 mrad/hr. The maximum deposition density occurred within about 400 m of the stacks and was 2 to 5 particles/100 m^2 (Parker 1954, 1956). These releases exposed military and other personnel on the site (Johnson 1954).

Table 4-4 is a summary of the physical, chemical, and radiological properties of radioactive particles released from Hanford from 1945 to 1956 and includes releases from T, B, and REDOX Plants. Figure 4-7 shows the monthly ^{106}Ru releases from the REDOX plant (Till et al. 2002).

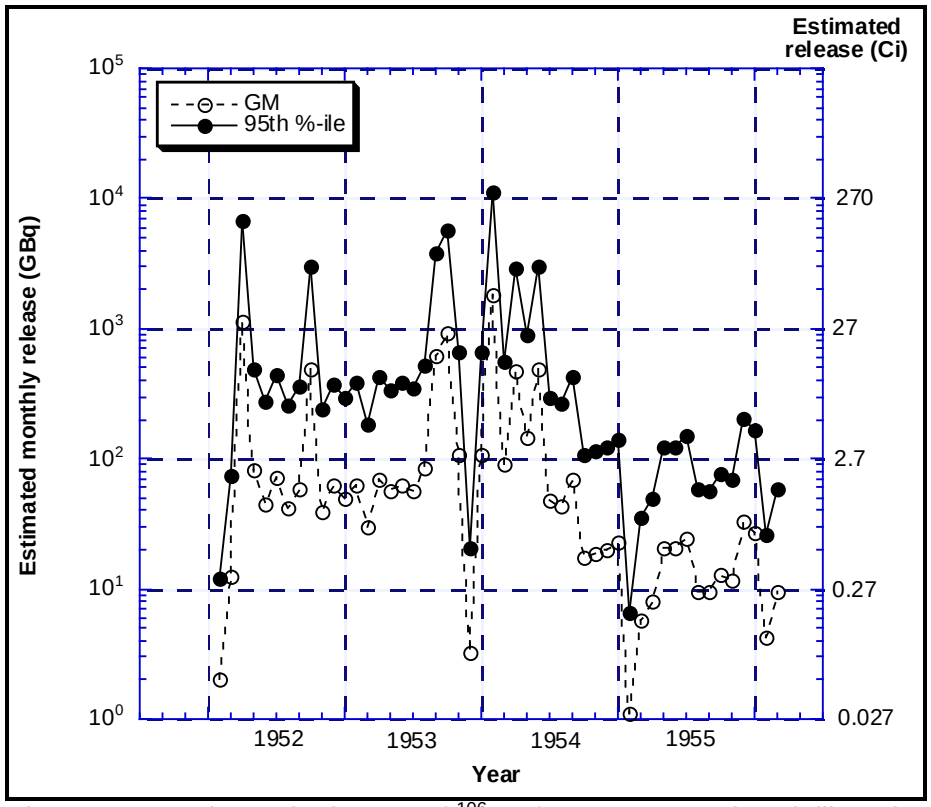

Figure 4-7. Estimated releases of ^{106}Ru from REDOX Plant (Till et al. 2002).

4.2.1.5 Releases of Tritium from 108-B

Between 1949 and 1954, the Hanford Site produced tritium for the early weapons development period; the tritium was extracted in the 108-B facility from targets irradiated in the Hanford reactors. The product tritium was collected in flasks and sent to Los Alamos in gaseous diatomic form (T_2). The facility initially had a roof vent about 75 ft off the ground, and eventually all building and hood air was

exhausted to a 300-ft stack (Heeb and Gydesen 1994). Heeb and Gydeson (1994) estimated the releases from both routine operations and process upsets and Gydesen described the uncertainty in the releases using a uniform distribution ranging from 0.222 to 1.778 times the central estimate. For the purposes of propagating the uncertainty in this dose reconstruction, the uncertainty has been approximated as a standard deviation of 40% of the central estimate. Table 4-5 lists the total annual releases and standard deviations.

Table 4-5. Annual amount of tritium released from 108-B.

Year	Tritium released (Ci)	Standard deviation (Ci)
1949	683	273
1950	6,134	2,455
1951	27,060	10,824
1952	39,737	15,895
1953	3,911	1,564
1954	122,728	49,091

The releases were primarily elemental tritium. Elemental tritium slowly oxidizes to tritiated water (HTO and T_2O) in the atmosphere. If dose reconstruction inhalation estimates are made with dose conversion factors for tritiated water, the level of conservatism will range from factors between 1 and 1,000 [7].

4.2.2 Environmental Air Monitoring

Beginning in 1946 beta activity was monitored on air filters to measure ^{131}I concentrations in air (Singlevich 1948), and alpha monitoring began in 1951 (Anderson and Soldat 1956). The reported values are of limited use because the atmospheric releases from weapons testing in the 1950s contributed to activity on the environmental filters that was not associated with operations at the Hanford Site. However the measured activities are useful as a check on the atmospheric dispersion calculations used to calculate occupational environmental doses [8].

4.2.3 Intake of Airborne Radionuclides

The RATCHET computer program and an Excel® spreadsheet were used to calculate favorable to claimant but realistic intakes from airborne radionuclides. [Hcalc (Till et al. 2002) was not used because Hcalc calculates worst-case or maximum hypothetical dose rather than a realistic dose.] Examples of the conservative overbiasing in the Hcalc program include:

- The program neglects plume rise at the point of release of radionuclides to the atmosphere. Without plume rise the program overestimates air concentrations and deposition on vegetation and soil near the point of release.

- The program neglects plume depletion caused by wet and dry deposition. Without plume depletion this program overestimates air concentrations and deposition on vegetation and soil.

- The program overestimates the radionuclides concentrations in the shallow surface soil and the external gamma dose because the program neglects leaching.

- The program assumes a 12-yr buildup of radionuclides in the root zone of soil rather than the NCRP (1996) default value of 30 yr. The smaller buildup maximizes root uptake for the food

ingestion pathway. The work scope for the Hanford site profile specifically excludes the food pathway.

The computer file *srclist.dat* from Till et al. (2002) provided the initial source terms in the spreadsheet. That file was based on the extensive research performed by Heeb (1994). Till et al. (2002) provides monthly release estimates for the period from Hanford Site startup in 1944 through 1961. These files were extended to Hanford facility shutdown dates using the data from Heeb (1994) and augmented with the revisions to the ^{131}I releases by Napier (2002). Minor releases in the 1980s were added as reported in the Hanford Site annual reports for those years. The ^{41}Ar source terms for the reactors from Till et al. (2002) were extended through the date when each reactor was shut down using the approach used in that report. The ^{239}Pu releases from the Z Plant were also extended using the 2-mo lag time approximation of Till et all (2002). Because of differences in estimating atmospheric transport described below, emissions were tabulated as particulate, iodine, and noble gases. The following radionuclides were evaluated:

- ^{41}Ar
- ^{144}Ce-^{144}Pr
- ^{137}Cs-^{137}Ba
- ^{3}H
- ^{131}I-^{131m}Xe
- ^{239}Pu
- ^{103}Ru-^{103m}Rh
- ^{106}Ru-^{106}Rh
- ^{90}Sr-^{90}Y
- ^{95}Zr-^{95}Nb

Annual emissions were evaluated for the following sources:

- T Plant particles
- B Plant particles
- REDOX Plant particles
- PUREX Plant particles
- Z Plant particles
- T Plant iodine
- B Plant iodine
- REDOX Plant iodine
- PUREX Plant iodine
- B & C Reactor noble gas
- KE & KW Reactors noble gas
- N Reactor noble gas
- D & DR Reactors noble gas
- H Reactor noble gas
- F Reactor noble gas
- 108-B elemental tritium

Uncertainties in the source term were described using an “uncertainty factor” in Heeb (1994). These factors represent the ratio of the 95th percentile to the 50th percentile; if the distribution is assumed to be lognormal the “uncertainty factor” may be converted into a geometric standard deviation (GSD) using the equation (Till et al. 2002)

$$\mathrm{GSD} = \left(\frac{95\text{th percentile}}{50\text{th percentile}} \right)^{\left(\frac{1}{1.645} \right)}$$

The geometric standard deviation may be related to the more-conventional standard deviation through additional manipulation. Tables A-1 to A-9 in ATTACHMENT A list the source terms along with the uncertainties expressed as a standard deviation. Some uncertainties in the 1980s were approximated as the standard deviation equal to 10% of the measured values. Table A-10 lists atmospheric dispersion factors with uncertainties as standard deviations. The RATCHET computer program (Ramsdell, Simenon, and Burk 1994) was used to calculate annual average atmospheric dispersion coefficients. The RATCHET code was run for unit releases of 1-µm particles, noble gases, and iodine speciated as a combination of elemental iodine, particle-bound iodine, and organic iodine as described in Farris et al. (1994). Hourly observations of wind speed, direction, stability, and precipitation from the extensive Hanford network of meteorological monitoring stations were used as input to the code. Results were calculated for monthly intervals from 1993 through 2002. A dense calculation output grid of 41 by 53 nodes on 1-km centers was used for all release points. Output was integrated to give total integrated exposure in units of Bq-s/m^3 per Bq released. These normalized values were then averaged over the 10-yr observation period to provide monthly averages and standard deviations, which were then further rolled up into annual averages and standard deviations, which are listed in Table A-10 in ATTACHMENT A [9]. The dose reconstructor can calculate intakes for different source terms than those in Tables A-1 through A-9 by multiplying the atmospheric dispersion coefficient in Table A-10 by the source term in becquerels.

Thirty-eight potential receptor locations were selected to represent exposure locations on the Hanford Site (see Figure 4-1). Table 4-6 lists these locations along with the east-west and north-south node identifiers from the computational grid [10].

Table 4-6. Selected receptor locations with identifying computational nodes [11].

Receptor location	E-W Node	N-S Node	Receptor location	E-W Node	N-S Node
T Plant	12	30	200 Firestation	15	29
B Plant	20	29	100 Firestation	17	38
REDOX Plant	11	28	HMS Tower (622)	14	30
PUREX Plant	20	29	Columbia Camp	26	10
Z Plant	11	29	North Richland	38	6
B & C Reactors	9	37	300 Area	38	9
KW & KE Reactors	13	39	1100 Area	37	3
N Reactor	16	43	EOC/ALE Hq	19	10
D & DR Reactors	18	45	Hanford Townsite	31	32
H Reactor	22	46	Waste Disposal Site	26	21
F Reactor	25	41	WNP2 Region	34	21
200 N	12	34	FFTF Region	31	14
Midway (Riverland)	3	38	Army H-61	8	32
West Waluke	11	46	Army H-51	8	26
North Waluke	21	49	Army H-42	18	22
East Waluke	27	46	Army H-40	20	28
Yakima Barricade	4	32	Army H-50	8	28
Prosser Barricade	28	11	200E Guard House	19	28
Wye Barricade	29	21	200W Guard House	12	30

The atmospheric dispersion factors for each location were multiplied by the emission rates from each source by radionuclide for each year from 1944 through 2001, even though the emissions from the reactors or the chemical separations plants after 1988 were minimal. The resultant annual air concentrations were then multiplied by 2,400 m^3/yr, which is the recommended breathing rate by reference man doing light work of 1.2 m^3/hr times a use factor of 2,000 hr/yr (ORAUT 2003). A standard deviation of 0.4 m^3/hr was assigned to this breathing rate. The final intake results in Table A-12 provide the annual intakes in becquerels per year for the maximum median receptor location by year and by radionuclide. Table 4-7 lists the maximum intake values by radionuclide.

Table 4-7. Maximum intakes by radionuclide.

Radionuclide	Maximum intake (Bq)
Ce-144	6.64E+01
Cs-137	2.35E+00
H-3	1.15E+05
I-131	1.04E+05
Pu-239	1.47E-02
Ru-103	5.84E+02
Ru-106	1.93E+02
Sr-90	2.67E+00
Zr-95	7.92E+01

In a similar fashion, the annual exposures for air submersion in ^{41}Ar were adjusted for 2,000 hr/yr occupancy. Those exposure values in becquerel-seconds per cubic meter were multiplied by the dose factor 6.15×10^{-14} Sv/Bq-s/m^3 (Eckerman et al. 1999) to give the submersion doses in sieverts in Table A-11 (1 Sv = 100 rem). Similarly the annual exposures from ^{41}Ar were multiplied by the dose factor 1.01×10^{-13} Sv/Bq-s/m^3 (Eckerman et al. 1999) to give the skin beta-gamma dose in sieverts in Table A-11. The maximum ^{41}Ar submersion dose was 3.47×10^{-5} Sv, and the maximum ^{41}Ar beta skin dose was 5.7×10^{-5} Sv.

4.3 EXTERNAL DOSE

4.3.1 Ambient Radiation

The chemical separations plants began operations in April 1945. Quarterly environmental monitoring reports published from 1945 to 1955 and annual environmental reports published since 1956 present gamma exposure levels at various locations throughout the Hanford Site. Up through 1953 radiation exposure measurements were reported in milliroentgen, millirep, and subsequently in millirad. Hanf and Thiede (1994) stated that the difference in deposited energy in tissue between units is so small that the units can be considered nearly identical. The data in Singlevich (1948) summarized the measured natural background radiation levels between 1946 and 1948 as 0.3 to 0.5 mrad/d. For this document, the natural gamma background radiation level attributed to cosmic radiation and naturally occurring radioactive materials in the environment was assumed to be 0.4 mrad/d or 146 mrad/yr. The background was not subtracted from the ambient readings [12].

Figure 4-8 illustrates that external gamma radiation attributed to site operations in the chemical separations area (200-East) averaged 0.4 mrad/d above background levels and that the maximum exposures occurred in 1945 and 1946. The external gamma exposure levels measured near the reactors were near natural background levels (Singlevich 1948). Levels were measured by detachable C chambers; at 200-East (separations area), levels averaged roughly twice those at 100-B (a reactor area). The average level at 100-B was 0.35 mrep/24 hr, which is within the stated background range of the instrument (0.3–0.5 mrep/24 hr), and the average level at 200-East was 0.75 mrep/24 hr (Singlevich 1948) (Till et al. 2002).

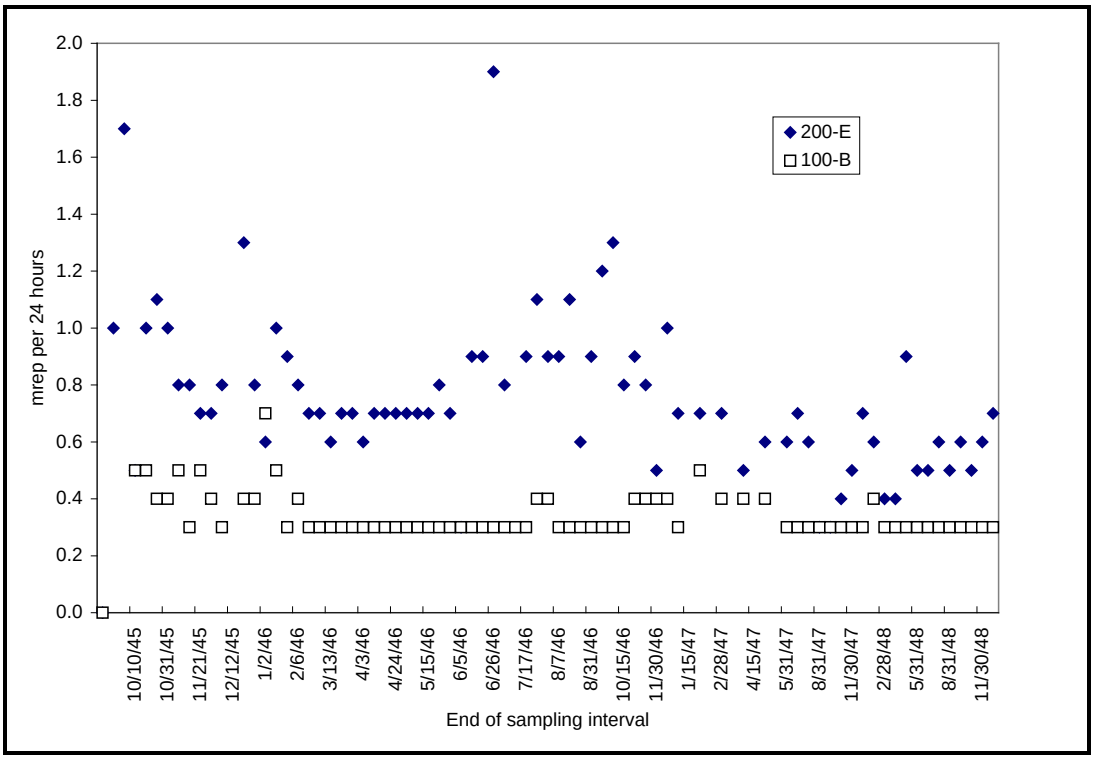

Figure 4-8. Radiation levels at two locations, 1945 to 1948.

Figure 4-9 illustrates the exposure rates measured near the REDOX Plant and the closest residence locations to REDOX, which were military sites H-50, H-51, and H-61 (Irish 1955). Measured exposure rates at the REDOX perimeter are the highest of all environmental stations monitored between 1945 and 1955. Monitoring at the perimeter was discontinued in December 1954, but monitoring continued in the REDOX area (Till et al. 2002).

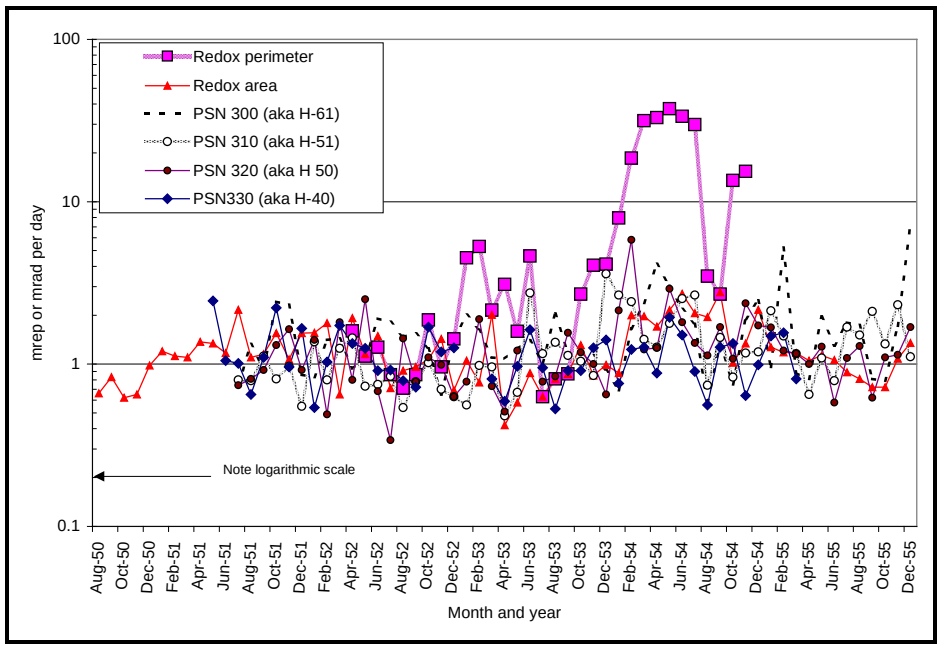

Figure 4-9. Exposure rates measured near the REDOX Plant and at four military installations.

Figure 4-10 illustrates the relationship between ^{131}I and ^{106}Ru releases per year as well as the net radiation exposures levels measured between the REDOX Plant perimeter and the 200 areas. The net gamma exposure rates are mainly due to the ^{131}I and ^{106}Ru releases. The principal gamma ray from ^{131}I is 0.364 MeV emitted 82% of the time. The principal gamma rays from ^{106}Ru are from its progeny ^{106}Rh and are 0.512 MeV emitted 21% of the time and 0.622 MeV emitted 11% of the time. A measured background exposure rate of 0.4 mrep/d was subtracted from the onsite exposure rate measurements to obtain net exposure rates (Till et al. 2002).

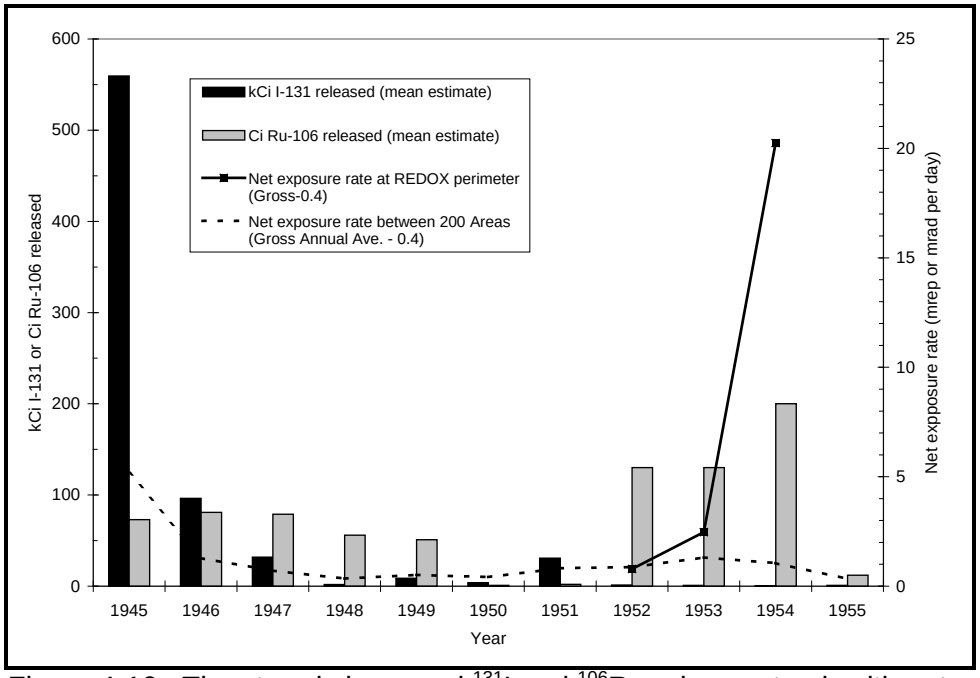

Figure 4-10. Time trends in annual ^{131}I and ^{106}Ru releases to air with net exposure rates between the 200 Areas (Building 622) and at the REDOX plant perimeter.

Table 4-8 lists the external gamma measurements at Hanford from 1944 through 2001 including fallout and background. The values are average values in millirem per year for exposures of 2,000 hr/yr. Blank values in the table indicate that measurements were not available for those years.

4.3.2 Releases of Noble Gases

4.3.2.1 Xenon

The relative dose contribution of ^{133}Xe to ^{131}I can be estimated by comparing the products of the release rates and the dose conversion factors. At its peak in 1945 the ^{133}Xe release rate was 42,000 Ci/mo. The increase in fuel element cooling time that began in 1946 resulted in more than a 10-fold reduction in ^{133}Xe releases to the atmosphere that continued in subsequent years. The ^{131}I release rate at the peak ^{133}Xe release rate was 89,000 Ci/mo. The dose conversion factors for ^{133}Xe and ^{131}I are 4.3×10^{-8} and 2.4×10^{-4} Sv/Bq/m^3, respectively. Comparing the products of the release rate and the dose conversion factor for each radionuclide, the ^{131}I contribution to the dose was more than 10,000 times larger than that from ^{133}Xe (Till et al. 2002). Therefore, ^{131}I is listed as a major contributor to the occupational environmental dose and ^{133}Xe is not.

Table 4-8. External gamma radiation (mrem/yr) [13].

	300 Area	400 Area/ FFTF	Hanford Townsite	Columbia Camp	Prosser Barricade	ALE	Wahluke	WNP2 Region	Wye Barricade	Yakima Barricade	Army Loop
1945	170		149								
1946	69		41								
1947	121		88								
1948	76		115								
1949	60		158								
1950	49		32								
1951	49		32								
1952	96		15								
1953	35		23								
1954	24		31								
1955	84		76								
1956	160		126								
1957	269										
1958											
1959											
1960[a,c]	80	30	30	30	30	30	30	30	30	30	30
1961[a,c]	80	30	30	30	30	30	30	30	30	30	30
1962[a,c]	80	39	39	39	39	39	39	39	39	39	39
1963[a,d]	46	39	39	39	39	39	39	39	39	39	39
1964[a,d]	46	34	34	34	34	34	34	34	34	34	34
1965[a,d]	46	27	27	27	27	27	27	27	27	27	27
1966	39	30	44	30	30	30	30	30	30	30	30
1967	40		49								
1968	39		35								
1969	80										
1970	31		13								
1971	17	16	13			15	16		13	16	
1972	21	19	17			18	20		16	22	
1973	18	16	16		17	17	17		16	17	
1974	17	16	15		17	17	17		16	18	
1975	17	16	15		16	17	17		16	17	
1976	16	16	15		16	17	16		16	17	
1977	16	16	15		16	16	17		15	17	
1978	15	16	15		16	16	16		16	17	
1979	16	16	16		17	18	18		17	18	
1980	19	16	16		17	17	17		16	18	
1981	29	16	16		18	18	17		17	18	
1982	121	16	17		17	18	18		17	18	
1983	98	17	16	16	16	18	18		17	18	17
1984	21	17	16	15	16	17	18		17	18	16
1985	19	14	13	14	15	16	16	16	15	16	15
1986	21	16	12	16	17	17	16	15	14	17	16
1987	21	18	17	18	19	20	19	18	18	21	19
1988	19	19	18	20	20	21	20	19	18	21	20
1989	20	20	19	19	20	21	20	23	18	23	21
1990	19	19	19	18	17	20	20	20	19	20	19
1991	22	21						21	21		
1992	22	22						22	21		
1993	21	23						20	22		
1994	24	24						24	24		
1995	19	19						20	19		
1996	18	19						20			
1997	18	19						19			
1998	19	19			20		21	19	19	21	19
1999	19	19	20		20	22	21	21	20	22	20
2000	19	19	17		20	20	20	20	19	22	19
2001	19	19	18		21	22	21	20	20	22	20

	100 Area Fire Station	100 B	100 D	100 F	100 K	100 N	100 H	1100 Area	200 East	200 West	200 N
1945		127	135	123					194	185	
1946		47	33	38					122	50	
1947		42	60	85					115	57	
1948		24	52	76					67	30	
1949		31	17	38			25		16	20	
1950		55	44	40			37		37	45	
1951		55	44	40			37		37	45	
1952		35	31	19			33		13	37	
1953		48	33	34			38		49	63	
1954		88	119	71			133		71	217	
1955		38	95	253	87		35		178	265	
1956		347	216	258			37		242	230	
1957[b]									146		
1958[b]									319		
1959[b]									173		
1960[c]		111	99	127	87		55		98	143	
1961[c]		111	99	127	87		55		98	143	
1962[c]		111	99	127	87		55		98	143	
1963[d]	30	53	45	52	118	76	46	30	64	45	30
1964[d]	30	53	45	52	118	76	46	30	64	45	30
1965[d]	30	53	45	52	118	76	46		64	45	30
1966	30	53	48	44	108	56	39	30	66	56	30
1967		60	47	75	125	69	53		69	41	
1968		63	47	49	157	95	46		42	41	
1969		62	55	69	125	83			103	57	
1970		29	29	24	74				39	31	
1971			17	16	17	31			30	17	
1972			17	19	24	34			30	21	
1973	16		18	18	17	37			37	21	
1974	16		17	18	17	22			33	22	
1975	18		17	17	17	22			31	21	
1976	16		17	15	15	19			27	18	
1977	15		16	15	14	20			27	19	
1978	16		17		15	21		15	22	20	
1979	16		18		16	21		14	22	21	
1980	16		17		15	20		14	22	18	
1981	17		17		15	20		14	21	18	
1982	16		17		17	21		14	21	17	
1983	17		17		15	21		15	17		18
1984	16		18		17	21			15		17
1985	13		15		13	18		14	14		16
1986	15		16		13	20		14	16		16
1987	18		19		17	20		17	19		19
1988	18		20		17	21		18	19		20
1989	19		19		18	21		20	20	20	20
1990	19		19		18	21		17	17	20	19
1991			27		19	23		19	20	21	21
1992			21		20	24		20	22	22	23
1993			23		19	23		19	22	23	23
1994			25		22	28		22	24	25	26
1995			20		16			17	19	19	20
1996			20		16			17	19	19	20
1997			20		16			16	19	18	20
1998			20		17			17	19	19	21
1999			20	20	16			17	20	20	22
2000			19	19	17			17	19	19	21
2001			20	20	18			19	20	19	21

a. Based on the annual average dose rate for entire Hanford Site as reported in annual reports, except for 100, 200, and 300 Areas.
b. Based on monthly reports where dose rate ranges (max and min) were reported for “Separations Area” and “Residential Area” only. Maximum dose rate reported here.
c. Based on an average of 1952-1956 gamma levels at the 100, 200, and 300 Areas.
d. Based on an average of 1966-1970 gamma levels at the 100, 200, and 300 Areas.

4.3.2.2 Argon Releases from the Production Reactors

Argon-41 was released from the Hanford reactors as a neutron activation product of stable argon in air and not from the chemical separations facilities. Effluent concentrations were measured for only brief periods over the years, and the reactors did not operate continuously. Despite those problems Till et al. (2002) created percentiles from the distributions of monthly releases of ^{41}Ar, which Table 4-9 lists. Table 4-10 lists the ^{41}Ar concentrations in the reactor stacks along with stack flow rates.

Table 4-9. Distributions of monthly release estimates for ^{41}Ar from reactors and Areas (Till et al., 2002).

	Percentiles of distributions of release estimates (Ci/mo) for individual reactors and areas with two reactors				
Reactor	**5th**	**25th**	**50th**	**75th**	**95th**
B, D, or F	320	1,200	2,200	3,300	4,100
C	4,000	5,600	7,000	8,700	11,000
B and C[a]	5,600	7,600	9,300	11,000	14,000
DR	5,900	6,600	7,600	8,500	9,400
D and DR[b]	7,100	8,600	9,800	11,000	13,000
H	5,700	7,000	8,600	10,000	12,000
KE	4,200	5,900	7,400	9,100	12,000
KW	4,100	5,600	7,000	8,700	11,000
KE and KW[c]	10,000	13,000	15,000	17,000	20,000

a. Both reactors operated in the same area after November 1952.
b. Both reactors operated in the same area after October 1950.
c. Both reactors operated in the same area after April 1955.

Table 4-10. Concentrations of ^{41}Ar measured in effluent flow rates for production reactor stacks (Till et al. 2002).

		Measured concentration (μCi/m^3) of ^{41}Ar[a]		Stack effluent flow rate (m^3/s)[c]
Reactor	**N[b]**	**Average**	**Maximum**	
B	0	20	39	47
D	4	23	39	47
F	0	17	27	47
DR	11	80	110	40
C	3	<4	<4	64
H	8	48	66	76
KE	[d]	[d]	[d]	67
KW	[d]	[d]	[d]	64

a. Argo-41 concentration data from Paas (1953a).
b. Number of samples collected (Paas 1953a,b).
c. Based on flow rates given in Heeb (1994).
d. The reactor was not operating at the time of the measurements.

4.3.3 Skin Deposition of Airborne Particulate Emissions

Emissions of particles of greater than respirable size occurred from 1947 through 1948 from T and B Plants and from 1952 through 1955 from the REDOX Plant. The releases from T and B Plants were relatively continuous, having been caused by deposition of radioactive mists on the insides of metal ductwork, which resulted in corrosion and the release of small iron particles coated with radioactive material. The releases from REDOX were more episodic, although one of the mechanisms was similar (i.e., accumulation and release of radionuclides on ductwork) [14].

Total releases from aged fission products carried on particles from T and B Plants totaled from 20 to 100 Ci/mo each. The average particle contained about 1.1 µCi (Till et al. 2002), so between about 40 to 180 million particles were emitted per month from about September 1947 through April 1948, when sand filters were installed to stop the release (Cleavenger and Gydesen 1989). The greatest activity measured on a T or B Plant particle was 3.2 µCi; therefore, assuming a 5 µCi particle would be favorable to claimants.

Notable from REDOX were the large ammonium-sulfate flakes containing ^{103}Ru and ^{106}Ru that were emitted from REDOX in March 1952 (Ebright 1954). The median estimate for the total release activity was 145 Ci (5.37 TBq). An estimated 290 million particles were released. Somewhat smaller releases occurred from REDOX in April, June, and September 1952, August and September 1953, and January, April, May, and June 1954. REDOX ruthenium particles generally contained less than 300 µCi (1.11×10^7 Bq) ^{106}Ru and 170 µCi (6.29E6 Bq) ^{103}Ru. The estimated skin dose rate was 1,300 to 2,400 rads/hr.

Based on binomial and Poisson distribution theory, the probability that an individual would encounter one or more released particles on their skin is almost one (Till et al. 2002). Till et al. (2002) calculated the number of radioactive particles from the REDOX Plant that would fall on a person at different locations during the 1950s. The values ranged from 100 particles for a person in Richland to 830 particles at military location H-50. Because the numbers are maximum values for 24-hr occupancy 7 days a week, the numbers should be multiplied by the use factor of 0.1 to provide a realistic favorable to claimant number of particles. The use factor was developed as follows: If one assumes that an individual worked 8 hr/d 5 d/week, the use factor would be 40 work hours divided by 168 hr/week or 0.24. If the worker was indoors, exposures could be reduced by factors of up to 10. Therefore, a use factor of 0.1 is favorable to claimants. Using the 0.1 use factor, the greatest number of particle encounters at any of the military camps is 83 particles from March 1952 through June 1954 at military location H-50.

Table 4-11 lists the probability that an individual would be exposed to one or more particles from T and B Plants in the period from 1947 to 1948 for various locations assuming a use factor of 0.1. Similarly, Table 4-12 lists the probability that an individual would be exposed to one or more particles from REDOX in the period from 1952 to 1954 for various locations [15]. It can be seen that for an individual in most locations who was present throughout the periods of interest, the likelihood of encountering at least one particle is essentially 100%.

Table 4-13 presents the dose coefficients for different radionuclides attached to or contained in the particles released to the air. Assuming 5 µCi (1.85×10^5 Bq) particles released as iron particles in the 1940s from T and B Plants, such a particle would have a localized skin dose rate of 11 to 32 rads/hr. For the REDOX ruthenium particles containing 300 µCi (1.11×10^7 Bq) ^{106}Ru and 170 µCi ($6.29E \times 10^6$ Bq) ^{103}Ru released in the 1950s, the estimated skin dose rate is 1,300 to 2,400 rads/hr.

Jones, Mansfield, and Bell (1998) obtained retention half-lives of particles deposited on skin that were between 1 and 3 hr. This translates to a mean residence time ($T_{1/2} \div \ln 2$) of 1.4 to 4.3 hr (Whicker and Schultz 1982).

Similar calculations have been done to evaluate the likelihood of inhalation of airborne large radioactive particles or of the ingestion of a large radioactive particle that deposits on the skin. For both of these potential pathways, the maximum combined likelihood from all releases is less than 0.01 for all Hanford locations, and is generally less than 0.001 for individual months. Therefore, these pathways have not been included in the dose reconstruction.

Table 4-11. Probability of interaction of an individual with at least one T- or B-Plant particle by receptor location and by month for a 10% use factor [16].

Receptor	***9/47***	***10/47***	***11/47***	***12/47***	***1/48***	***2/48***	***3/48***	***4/48***	***Total***
T Plant	0.78	0.95	0.98	0.98	0.98	0.95	0.79	0.53	1.00
B Plant	0.90	0.99	1.00	1.00	1.00	0.99	0.90	0.67	1.00
REDOX	0.55	0.78	0.85	0.85	0.86	0.79	0.55	0.32	1.00
PUREX	0.79	0.95	0.97	0.97	0.97	0.95	0.78	0.51	1.00
Z Plant	0.62	0.84	0.90	0.90	0.91	0.85	0.62	0.37	1.00
B/C Reactor	0.30	0.49	0.57	0.57	0.57	0.50	0.30	0.15	0.99
KW/KE Reactors	0.36	0.58	0.66	0.66	0.66	0.59	0.36	0.19	1.00
N Reactor	0.38	0.60	0.68	0.68	0.69	0.61	0.38	0.20	1.00
D/DR Reactor	0.32	0.53	0.60	0.60	0.61	0.53	0.32	0.17	0.99
H Reactor	0.29	0.49	0.56	0.56	0.57	0.50	0.29	0.15	0.99
F Reactor	0.34	0.55	0.63	0.63	0.63	0.56	0.34	0.18	1.00
200 N	0.39	0.62	0.70	0.70	0.70	0.63	0.39	0.21	1.00
Midway	0.17	0.30	0.36	0.36	0.36	0.31	0.17	0.09	0.92
West Wahluke	0.28	0.47	0.54	0.54	0.55	0.48	0.28	0.14	0.99
North Wahluke	0.21	0.36	0.42	0.42	0.43	0.37	0.21	0.10	0.96
East Wahluke	0.23	0.39	0.46	0.46	0.47	0.40	0.23	0.12	0.97
Yakima Barricade	0.17	0.30	0.35	0.35	0.36	0.30	0.17	0.08	0.92
Prosser Barricade	0.28	0.47	0.54	0.54	0.55	0.48	0.28	0.14	0.99
Wye Barricade	0.42	0.65	0.72	0.73	0.73	0.66	0.42	0.23	1.00
200 Fire	0.72	0.91	0.95	0.95	0.95	0.92	0.72	0.46	1.00
100 Fire	0.37	0.59	0.67	0.67	0.67	0.60	0.37	0.20	1.00
HMS	0.63	0.85	0.91	0.91	0.91	0.86	0.63	0.38	1.00
Columbia Camp	0.23	0.40	0.47	0.47	0.47	0.41	0.23	0.12	0.97
North Richland	0.23	0.39	0.46	0.46	0.46	0.40	0.23	0.11	0.97
300 Area	0.22	0.38	0.44	0.44	0.45	0.38	0.22	0.11	0.96
1100 Area	0.24	0.41	0.48	0.48	0.48	0.42	0.24	0.12	0.98
EOC/ALE	0.10	0.19	0.23	0.23	0.23	0.19	0.10	0.05	0.77
Hanford Townsite	0.30	0.50	0.57	0.57	0.58	0.50	0.30	0.16	0.99
Waste Disposal Area	0.48	0.72	0.79	0.79	0.79	0.72	0.48	0.27	1.00
WNP2	0.31	0.51	0.59	0.59	0.59	0.52	0.31	0.16	0.99
FFTF	0.30	0.50	0.58	0.58	0.58	0.51	0.30	0.16	0.99
H-61	0.30	0.51	0.58	0.58	0.59	0.51	0.31	0.16	0.99
H-51	0.24	0.41	0.48	0.48	0.49	0.42	0.24	0.12	0.98
H-42	0.34	0.55	0.63	0.63	0.64	0.56	0.34	0.18	1.00
H-40	0.82	0.96	0.98	0.98	0.98	0.97	0.82	0.56	1.00
H-50	0.25	0.43	0.50	0.50	0.50	0.43	0.25	0.13	0.98
200E Guardhouse	0.77	0.94	0.97	0.97	0.97	0.95	0.77	0.50	1.00
200W Guardhouse	0.78	0.95	0.98	0.98	0.98	0.95	0.79	0.53	1.00

Table 4-12. Probability of interaction of an individual with at least one REDOX particle by receptor location and by month for a 10% use factor [17].

Receptor	*Mar-52*	*Apr-52*	*Jun-52*	*Sep-52*	*Aug-53*	*Sep-53*	*Jan-54*	*Apr-54*	*May-54*	*Jun-54*	*Total*
T Plant	0.95	0.20	0.00	0.01	0.01	0.87	0.99	0.00	0.01	0.00	1.00
B Plant	0.84	0.12	0.00	0.01	0.01	0.70	0.93	0.00	0.00	0.00	1.00
REDOX	1.00	0.88	0.02	0.10	0.12	1.00	1.00	0.03	0.07	0.01	1.00
PUREX	0.84	0.13	0.00	0.01	0.01	0.70	0.94	0.00	0.00	0.00	1.00
Z Plant	1.00	0.38	0.00	0.02	0.03	0.99	1.00	0.01	0.02	0.00	1.00
B/C Reactor	0.65	0.07	0.00	0.00	0.00	0.50	0.79	0.00	0.00	0.00	0.97
KW/KE Reactors	0.74	0.09	0.00	0.00	0.01	0.58	0.86	0.00	0.00	0.00	0.99
N Reactor	0.77	0.10	0.00	0.01	0.01	0.62	0.89	0.00	0.00	0.00	0.99
D/DR Reactor	0.70	0.08	0.00	0.00	0.01	0.55	0.84	0.00	0.00	0.00	0.98
H Reactor	0.66	0.08	0.00	0.00	0.00	0.51	0.80	0.00	0.00	0.00	0.97
F Reactor	0.74	0.09	0.00	0.00	0.01	0.58	0.86	0.00	0.00	0.00	0.99
200 N	0.77	0.10	0.00	0.00	0.01	0.62	0.89	0.00	0.00	0.00	0.99
Midway	0.48	0.05	0.00	0.00	0.00	0.35	0.62	0.00	0.00	0.00	0.88
West Wahluke	0.62	0.07	0.00	0.00	0.00	0.47	0.77	0.00	0.00	0.00	0.96
North Wahluke	0.52	0.05	0.00	0.00	0.00	0.38	0.66	0.00	0.00	0.00	0.91
East Wahluke	0.56	0.06	0.00	0.00	0.00	0.41	0.70	0.00	0.00	0.00	0.93
Yakima Barricade	0.60	0.06	0.00	0.00	0.00	0.45	0.74	0.00	0.00	0.00	0.95
Prosser Barricade	0.84	0.13	0.00	0.01	0.01	0.70	0.94	0.00	0.00	0.00	1.00
Wye Barricade	0.83	0.12	0.00	0.01	0.01	0.68	0.93	0.00	0.00	0.00	1.00
200 Fire	0.95	0.19	0.00	0.01	0.01	0.85	0.99	0.00	0.01	0.00	1.00
100 Fire	0.77	0.10	0.00	0.00	0.01	0.61	0.88	0.00	0.00	0.00	0.99
HMS	0.93	0.18	0.00	0.01	0.01	0.83	0.98	0.00	0.01	0.00	1.00
Columbia Camp	0.81	0.11	0.00	0.01	0.01	0.66	0.92	0.00	0.00	0.00	1.00
North Richland	0.60	0.06	0.00	0.00	0.00	0.46	0.75	0.00	0.00	0.00	0.95
300 Area	0.57	0.06	0.00	0.00	0.00	0.43	0.72	0.00	0.00	0.00	0.94
1100 Area	0.67	0.08	0.00	0.00	0.00	0.51	0.80	0.00	0.00	0.00	0.97
EOC/ALE	0.46	0.04	0.00	0.00	0.00	0.33	0.60	0.00	0.00	0.00	0.86
Hanford Townsite	0.69	0.08	0.00	0.00	0.01	0.53	0.82	0.00	0.00	0.00	0.98
Waste Disposal Area	0.94	0.18	0.00	0.01	0.01	0.84	0.98	0.00	0.01	0.00	1.00
WNP2	0.67	0.08	0.00	0.00	0.00	0.52	0.81	0.00	0.00	0.00	0.97
FFTF	0.78	0.10	0.00	0.01	0.01	0.63	0.89	0.00	0.00	0.00	0.99
H-61	0.79	0.11	0.00	0.01	0.01	0.65	0.90	0.00	0.00	0.00	0.99
H-51	0.87	0.14	0.00	0.01	0.01	0.74	0.95	0.00	0.01	0.00	1.00
H-42	0.96	0.21	0.00	0.01	0.01	0.89	0.99	0.00	0.01	0.00	1.00
H-40	0.88	0.14	0.00	0.01	0.01	0.75	0.96	0.00	0.01	0.00	1.00
H-50	0.90	0.15	0.00	0.01	0.01	0.78	0.97	0.00	0.01	0.00	1.00
200E Guardhouse	0.89	0.15	0.00	0.01	0.01	0.77	0.96	0.00	0.01	0.00	1.00
200W Guardhouse	0.95	0.20	0.00	0.01	0.01	0.87	0.99	0.00	0.01	0.00	1.00

Table 4-13. Dose coefficients for radionuclides contained in Hanford active particles (Till et al. 2002).

Primary radionuclide and (decay product)	**Fraction of beta activity for T and B Plant particles**	**Dose coefficient (nGy h^{-1} per Bq cm^{-2})[a]**	
		Skin depth of 0.07 mm	**Skin depth of 0.4 mm**
Ru-103	0.13	568	28
Ce-141	0.14	1,538	169
Zr-95 (Nb-95)	0.06	1,288	86
Sr-89	0.14	1,667	887
Y-91	0.23	1,669	897
Ru-106 (Rh-106)	0.03	1,845	1,165
Ce-144 (Pr-144)	0.26	2,630	634
Sr-90 (Y-90)	0.05	3,133	1,384
Cs-137	0.05	1,432	384

a. Dose coefficients for distances along the axis of a circular source with area of 1 cm^2 or a point source averaged over that area from Cross et al. (1992). Tabled values include contributions of radioactive decay products.

4.4 ATTRIBUTIONS AND ANNOTATIONS

Where appropriate in the preceding text, bracketed callouts have been inserted to indicate information, conclusions, and recommendations to assist in the process of worker dose reconstruction. These callouts are listed in this section with information that identifies the source and justification for each item. Conventional references are provided in the next section that link data, quotations, and other information to documents available for review on the Oak Ridge Associated Universities (ORAU) Team servers.

Bruce Napier serves as a Site Expert for this document. As such, he is responsible for advising on site-specific issues and incidents as necessary and ensures the completeness and accuracy of the document. Because of his prior work experience at the site, he possesses, or is aware of information that is relevant for reconstructing radiation doses experienced by claimants who worked at the site. In all cases where such information or prior studies or writings are included or relied upon by the document owner, those materials are fully attributed. Mr. Napier's Disclosure Statement is available at www.oraucoc.org.

[1] Napier, Bruce. Battelle Memorial Institute – Pacific Northwest Division (BMIPND). Principal Health Physicist. August 2006.
Each of the different routes, or pathways, by which people can be exposed to radiation, result in exposures to different parts of the body. Health physicists must analyze the potential for and effects of exposure via each of the three basic pathways – inhalation, ingestion, and direct exposure – when calculating exposures or estimating the effects of exposures. For workers, the opportunity for ingestion of airborne material or local surface deposits in the occupational setting is small (no crops are grown on the Hanford Site), so the focus is on inhalation and external exposure, from immersion in contaminated air and from direct deposition of particles on the skin.

[2] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The listed workers were not considered to be radiation workers and thus did not have their own personal dosimeters.

[3] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The specific locations for calculation were selected by B. A. Napier on the basis of geographical coverage, known release points, known occupied areas, and anticipated public interest.

[4] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The chemical forms that are associated with the listed inhalation classes are those recommended in ICRP Publication 68, Annex F, for the calculation of inhalation dose coefficients (ICRP 1995) . The selection of the appropriate chemical form for a particular exposure is left to the dose reconstructor.

[5] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The estimates of release of all gaseous and particulate radionuclides from the Hanford stacks followed the multiplicative steps initially elaborated by Heeb (1994).

[6] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
As reported in Till et al. (2002), the qualitative reports tabulated in Cleavenger and Gydesen (1989) indicate that more difficulties with the new effluent treatment systems were experienced at B Plant.

[7] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The tritium was produced by neutron bombardment of lithium targets in the absence of oxygen. The resulting tritium would have been atomic and would have combined into HT or TT gas, not water. HT gas slowly oxidizes into water in the environment. The ratio of inhalation dose rate conversion factors for HTO to HT is 1,000. As the released material was transported downwind the initial doses would be almost entirely HT; at longer distances, the HTO component would increase.

[8] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
A discussion of the applicability of environmental monitoring to Hanford releases, and the use of the measurements as a validation of the modeling technique employed, is presented in Napier (2002). This reference also provides an extensive listing of the available historical documentation of environmental monitoring at Hanford.

[9] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
These activities were performed at Pacific Northwest National Laboratory by B. A. Napier and J. V. Ramsdell, Jr., in August 2003 to provide the necessary information to estimate doses via the atmospheric dispersion pathway.

[10] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The specific locations for calculation were selected by B. A. Napier on the basis of geographical coverage, known release points, known occupied areas, and anticipated public interest.

[11] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The specific locations for calculation were selected by B. A. Napier on the basis of geographical coverage, known release points, known occupied areas, and anticipated public interest.

[12] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The background was not subtracted from the environmental measurements in compliance with the general guidance of ORAUT-PROC-0031, *DOE Technical Basis Document Development, Review, and Approval Process* (ORAUT 2006), Section 6.3.13.

[13] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The external dose rate table was prepared by E. J. Antonio, B. A. Napier, and L. E. Bisping from the extensive collection of Hanford records. The dose rates for 1945 to 1949 are based on daily measurements using Integron devices. The dose rates for 1970 to 2001 are based on the Hanford environmental monitoring thermoluminescent dosimeter database. The dose rates for the intermediate period are based on individual measurements that were extracted from hundreds of Hanford Site monthly, quarterly, annual, and special reports from the DOE Reading Room at the Washington State University Tri-Cities library.

[14] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
The Hanford reprocessing plants dissolved the uranium with nitric acid, separated the uranium and plutonium, and further processed the plutonium (all in the 200 Area facilities). Particularly in the chemical processes in the 200 Area facilities, radioactive gases, mists, and fumes were generated. In the early years, these were vented directly to the 200-ft exhaust stacks via metal ducting. In T- and B-Plants in the 1940s, these chemically reactive mists corroded the ductwork, which resulted in the emission of rust particles contaminated with a fraction of the radionuclides. These particles deposited near the emission points (i.e., near the foot of the

stacks) and were detected as a result of recurrent personnel contamination in the vicinity (Parker 1948b, p. 4). Even at that time, the particle emission was recognized as symptomatic of the larger overall releases (e.g., Parker 1948b, p. 2). The particulate problem that began at REDOX in the early 1950s was of similar origin. When the dichromate head-end process was replaced with the permanganate process in 1953, the enhanced volatilization of ruthenium resulted in increased environmental release up the stack. Together with chemical reactions in the exhaust ducting and stack, this also created the conditions for evolution of a ruthenium-contaminated ammonium nitrate film that lined the ducts and stack. Under certain conditions, this film would break loose and blow as relatively large particles (up to several centimeters diameter) up the stack.

[15] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
Tables 4-11 and 4-12 were prepared by B. A. Napier using the methods of Till et al. (2002) and additional Hanford-specific data.

[16] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
Table 4-11 was prepared by B. A. Napier using the methods of Till et al. (2002) and additional Hanford-specific data.

[17] Napier, Bruce. BMIPND. Principal Health Physicist. August 2006.
Table 4-12 was prepared by B. A. Napier using the methods of Till et al. (2002) and additional Hanford-specific data.

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LIST OF TABLES

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Table A-1. Source term data for ^{131}I releases (Ci/yr).

Date	T plant	T_SD	B plant	B_SD	REDOX	R_SD	PUREX	P_SD
1944	2.10E+03	3.97E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	2.60E+05	1.71E+05	2.94E+05	1.98E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	2.25E+04	1.59E+04	7.40E+04	4.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	1.32E+04	8.78E+03	1.88E+04	1.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	8.76E+02	5.33E+02	9.66E+02	6.20E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	8.07E+03	1.36E+04	6.53E+02	3.85E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	4.25E+03	3.36E+03	3.18E+03	2.85E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	2.22E+04	2.03E+04	1.56E+04	1.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	2.88E+03	2.44E+03	1.32E+03	1.52E+03	2.85E+03	2.13E+03	0.00E+00	0.00E+00
1953	7.88E+02	5.65E+02	0.00E+00	0.00E+00	1.62E+03	1.08E+03	0.00E+00	0.00E+00
1954	6.42E+02	4.85E+02	0.00E+00	0.00E+00	4.94E+02	3.41E+02	0.00E+00	0.00E+00
1955	2.40E+02	1.68E+02	0.00E+00	0.00E+00	6.94E+02	6.41E+02	0.00E+00	0.00E+00
1956	1.75E-02	3.21E-02	0.00E+00	0.00E+00	1.24E+02	9.78E+01	3.96E+01	3.53E+01
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E+02	2.25E+02	1.02E+02	7.50E+01
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.68E+02	5.00E+02	4.67E+02	3.01E+02
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E+00	2.28E+00	3.11E+02	1.85E+02
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E+00	4.39E+00	3.11E+02	2.56E+02
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E+01	1.34E+01	1.16E+02	6.99E+01
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.34E+01	6.80E+01	1.09E+02	1.25E+02
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.64E+01	3.48E+01	1.55E+02	1.94E+02
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E+01	2.07E+01	8.83E+01	5.93E+01
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.30E+01	4.71E+01	4.19E+01	3.54E+01
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.67E+00	3.69E+00	5.92E+01	5.06E+01
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.09E+01	3.19E+01
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.87E+00	6.64E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E+00	2.46E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.89E-01	5.26E-01
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E-01	1.65E-01
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.01E-01	1.11E-10
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	2.00E-02
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	2.00E-02
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.00E-05
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-04	4.00E-05
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-02	1.70E-03
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-03	1.40E-04
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Table A-2. Source term data for ^{41}Ar releases (Ci/yr).

Year	B	B_SD	C	C_SD	KE	KE_SD	KW	KW_SD
1944	6.69E+03	3.76E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	2.68E+04	7.53E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	6.69E+03	3.76E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	1.34E+04	5.32E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	2.68E+04	7.53E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	2.68E+04	7.53E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	2.68E+04	7.53E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	2.68E+04	7.53E+03	1.40E+04	9.67E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1953	2.68E+04	7.53E+03	8.42E+04	2.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1954	2.68E+04	7.53E+03	8.42E+04	2.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1955	2.68E+04	7.53E+03	8.42E+04	2.37E+04	6.62E+04	2.15E+04	6.98E+04	2.15E+04
1956	2.23E+04	6.87E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1957	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1958	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1959	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1960	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1961	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1962	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1963	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1964	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1965	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1966	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1967	2.68E+04	7.53E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1968	4.46E+03	3.07E+03	8.42E+04	2.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1969	0.00E+00	0.00E+00	2.81E+04	1.37E+04	8.83E+04	2.48E+04	8.38E+04	2.36E+04
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.83E+04	2.48E+04	6.98E+03	6.80E+03
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.36E+03	7.17E+03	0.00E+00	0.00E+00
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Year	N	N_SD	D	D_SD	DR	DR_SD	H	H_SD	F	F_SD
1944	0.00E+00	0.00E+00	2.24E+03	2.18E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	0.00E+00	0.00E+00	2.69E+04	7.56E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+04	7.20E+03
1946	0.00E+00	0.00E+00	2.69E+04	7.56E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.68E+04	7.53E+03
1947	0.00E+00	0.00E+00	2.69E+04	7.56E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.68E+04	7.53E+03
1948	0.00E+00	0.00E+00	2.69E+04	7.56E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.68E+04	7.53E+03
1949	0.00E+00	0.00E+00	2.69E+04	7.56E+03	0.00E+00	0.00E+00	2.57E+04	1.45E+04	2.68E+04	7.53E+03
1950	0.00E+00	0.00E+00	2.69E+04	7.56E+03	6.72E+03	3.78E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1951	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1952	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1953	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1954	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1955	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1956	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1957	0.00E+00	0.00E+00	2.46E+04	7.24E+03	2.69E+04	7.56E+03	9.44E+04	2.77E+04	2.68E+04	7.53E+03
1958	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1959	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1960	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1961	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1962	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1963	0.00E+00	0.00E+00	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1964	1.30E+05	1.30E+04	2.69E+04	7.56E+03	2.69E+04	7.56E+03	1.03E+05	2.90E+04	2.68E+04	7.53E+03
1965	1.30E+05	1.30E+04	2.69E+04	7.56E+03	0.00E+00	0.00E+00	3.43E+04	1.67E+04	1.34E+04	5.32E+03
1966	1.30E+05	1.30E+04	2.69E+04	7.56E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1967	1.30E+05	1.30E+04	1.34E+04	5.35E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1968	1.30E+05	1.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1969	1.30E+05	1.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1970	1.30E+05	1.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1971	1.30E+05	1.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1972	1.00E+05	1.00E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1973	1.00E+05	1.00E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	5.00E+04	5.00E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	3.09E+04	3.09E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	3.54E+04	3.54E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	1.31E+05	1.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	1.10E+05	1.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	8.60E+04	8.60E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	2.30E+04	2.30E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	6.50E+04	6.50E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	1.14E+05	1.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	1.21E+05	1.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1984	7.70E+04	7.70E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1985	6.90E+04	6.90E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1986	1.20E+05	1.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1987	4.50E+03	4.50E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Table A-3. Source term data for $^{144}Ce/^{144}Pr$ particulate releases (Ci/yr).

Date	T	T_SD	B	B_SD	REDOX	R_SD	PUREX	P_SD
1944	6.60E-01	5.72E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	1.00E+02	3.11E+01	9.28E+01	2.99E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	9.85E+01	2.81E+01	1.75E+02	4.44E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	8.85E+01	2.24E+01	1.01E+02	2.56E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	2.95E+01	1.26E+01	3.46E+01	1.49E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	9.19E-01	2.41E-01	8.22E-01	2.21E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	1.41E+00	3.64E-01	1.54E+00	4.02E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	2.50E+00	6.33E-01	2.31E+00	6.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	1.59E+00	4.67E-01	6.40E-01	2.97E-01	4.38E+00	1.21E+00	0.00E+00	0.00E+00
1953	1.19E+00	3.20E-01	0.00E+00	0.00E+00	1.75E+01	9.70E+00	0.00E+00	0.00E+00
1954	2.61E+00	6.78E-01	0.00E+00	0.00E+00	8.92E+00	2.39E+00	0.00E+00	0.00E+00
1955	3.03E+00	8.06E-01	0.00E+00	0.00E+00	9.23E+00	2.52E+00	0.00E+00	0.00E+00
1956	1.00E-01	6.20E-02	0.00E+00	0.00E+00	8.66E+00	2.43E+00	1.21E+01	3.57E+00
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.93E+00	2.58E+00	2.40E+01	6.06E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.66E+00	2.18E+00	2.94E+01	7.83E+00
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.35E+00	1.39E+00	3.59E+01	9.31E+00
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.59E+00	1.30E+00	4.14E+01	1.11E+01
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.23E+00	2.17E+00	4.05E+01	1.06E+01
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.36E+01	6.84E+00	1.27E+02	3.42E+01
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E+01	8.10E+00	1.13E+02	3.36E+01
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.52E+01	1.01E+01	1.26E+02	3.66E+01
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.75E+01	1.09E+01	1.17E+02	3.28E+01
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.97E+01	1.90E+01	7.82E+01	2.67E+01
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+02	2.87E+01
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E+02	2.79E+01
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.28E+01	1.94E+01
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E+01	8.25E+00
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.03E+01	1.12E+01
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.55E+00	2.53E+00
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-01	1.00E-02
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-01	1.00E-02
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-04	1.00E-05
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Table A-4. Source term data for $^{137}Cs/^{137m}Ba$ particulate releases (Ci/yr).

Date	T	T_SD	B	B_SD	REDOX	R_SD	PUREX	P_SD
1944	1.90E-02	1.65E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	3.38E+00	1.07E+00	3.12E+00	1.01E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	3.74E+00	1.09E+00	6.14E+00	1.56E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	3.26E+00	8.23E-01	3.68E+00	9.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	1.16E+00	4.94E-01	1.36E+00	5.83E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	3.86E-02	1.01E-02	3.11E-02	8.62E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	5.94E-02	1.54E-02	6.49E-02	1.68E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	9.19E-02	2.33E-02	8.65E-02	2.25E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	5.92E-02	1.71E-02	2.37E-02	1.10E-02	1.71E-01	4.71E-02	0.00E+00	0.00E+00
1953	4.41E-02	1.21E-02	0.00E+00	0.00E+00	2.87E-01	7.80E-02	0.00E+00	0.00E+00
1954	8.60E-02	2.22E-02	0.00E+00	0.00E+00	3.41E-01	9.17E-02	0.00E+00	0.00E+00
1955	1.05E-01	2.80E-02	0.00E+00	0.00E+00	3.93E-01	1.14E-01	0.00E+00	0.00E+00
1956	4.20E-03	2.62E-03	0.00E+00	0.00E+00	3.23E-01	9.22E-02	4.62E-01	1.38E-01
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.54E-01	9.13E-02	8.57E-01	2.16E-01
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-01	7.59E-02	9.88E-01	2.64E-01
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-01	6.16E-02	1.23E+00	3.18E-01
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-01	5.51E-02	1.44E+00	3.85E-01
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.47E-01	9.11E-02	1.40E+00	3.71E-01
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.67E-02	2.47E-02	5.34E-01	1.44E-01
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-01	3.06E-02	4.89E-01	1.40E-01
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-01	4.68E-02	5.02E-01	1.45E-01
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-01	4.02E-02	5.24E-01	1.49E-01
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-01	4.30E-02	3.66E-01	1.22E-01
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.29E-01	1.17E-01
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E-01	9.96E-02
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-01	7.37E-02
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-02	3.05E-02
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-01	9.73E-02
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.32E-02	3.67E-02
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-02	2.90E-03
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	4.00E-03
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02	1.00E-03
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.70E-03	8.70E-04
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-05	4.00E-06
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.00E-04	8.00E-05
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-03	1.30E-04
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-04	6.90E-05
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-03	4.10E-04
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-02	2.30E-03
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-02	1.80E-03
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.60E-04	6.60E-05
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-04	6.50E-05
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-04	6.00E-05
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.60E-04	9.60E-05
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-04	2.20E-05
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.50E-05	8.50E-06
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-04	1.80E-05
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-04	1.50E-05

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Table A-5. Source term data for ^{239}Pu particulate releases (Ci/yr).

Date	T	T_SD	B	B_SD	REDOX	R_SD	PUREX	P_SD	Z	Z_SD
1944	6.50E-04	1.26E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	1.09E-01	7.66E-01	1.01E-01	7.29E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	1.18E-01	7.56E-01	1.98E-01	1.12E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	1.05E-01	5.91E-01	1.20E-01	6.79E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	3.76E-02	3.57E-01	4.38E-02	4.19E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	1.22E-03	7.15E-03	1.12E-03	6.73E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-03	8.53E-03
1950	1.83E-03	1.06E-02	2.01E-03	1.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-03	1.30E-02
1951	2.78E-03	1.57E-02	2.59E-03	1.50E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.23E-03	1.83E-02
1952	1.76E-03	1.14E-02	7.09E-04	7.29E-03	5.03E-03	3.10E-02	0.00E+00	0.00E+00	4.53E-03	2.58E-02
1953	1.28E-03	7.78E-03	0.00E+00	0.00E+00	8.55E-03	5.20E-02	0.00E+00	0.00E+00	6.17E-03	3.53E-02
1954	2.75E-03	1.60E-02	0.00E+00	0.00E+00	9.90E-03	5.94E-02	0.00E+00	0.00E+00	7.10E-03	4.28E-02
1955	3.38E-03	2.00E-02	0.00E+00	0.00E+00	1.17E-02	7.44E-02	0.00E+00	0.00E+00	9.45E-03	5.68E-02
1956	1.35E-04	1.89E-03	0.00E+00	0.00E+00	9.76E-03	6.10E-02	1.35E-02	8.87E-02	1.34E-02	7.93E-02
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-02	6.06E-02	2.56E-02	1.44E-01	2.20E-02	1.24E-01
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.85E-03	4.98E-02	2.95E-02	1.76E-01	2.34E-02	1.35E-01
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.78E-03	3.40E-02	3.53E-02	2.04E-01	2.56E-02	1.46E-01
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.80E-03	3.09E-02	4.19E-02	2.50E-01	2.85E-02	1.67E-01
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.92E-03	4.65E-02	4.14E-02	2.42E-01	3.26E-02	1.86E-01
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.65E-02	1.83E-01	5.28E-04	3.16E-03	1.52E-02	1.38E-01
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-02	6.83E-02	4.63E-04	3.08E-03	7.05E-03	4.49E-02
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-02	8.91E-02	1.02E-03	1.15E-02	7.68E-03	4.98E-02
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.01E-02	2.96E-01	5.33E-04	3.30E-03	1.77E-02	1.76E-01
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E-02	1.47E-01	3.29E-04	2.47E-03	1.50E-02	1.23E-01
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.09E-04	3.09E-03	7.57E-04	9.31E-03
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.08E-04	3.00E-03	3.25E-04	1.93E-03
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.95E-04	2.37E-03	2.47E-04	1.49E-03
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.24E-05	9.90E-04	1.08E-04	9.27E-04
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.52E-04	2.05E-03	1.61E-04	1.30E-03
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-05	5.07E-04	2.03E-05	3.23E-04
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.20E-04	6.20E-05	0.00E+00	0.00E+00
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.40E-03	7.40E-04	0.00E+00	0.00E+00
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02	1.00E-03	0.00E+00	0.00E+00
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-03	3.00E-04	0.00E+00	0.00E+00
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-04	4.00E-05	0.00E+00	0.00E+00
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.00E-05	0.00E+00	0.00E+00
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.20E-04	8.20E-05
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-04	3.00E-05
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.40E-04	4.40E-05
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-04	4.70E-05
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.60E-04	5.60E-05
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-04	4.20E-05
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-04	1.20E-05
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-04	2.40E-05
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-04	1.20E-05
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.00E-05
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-04	2.10E-05
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-04	5.10E-05
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-04	1.50E-05

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Table A-6. Source term data for $^{103}Ru/^{103m}Rh$ particulate releases (Ci/yr).

Date	T	T_SD	B	B_SD	REDOX	R_SD	PUREX	P_SD
1944	9.70E-01	1.14E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	8.69E+01	3.51E+01	8.65E+01	3.70E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	5.56E+01	2.19E+01	1.17E+02	4.01E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	4.69E+01	1.64E+01	5.45E+01	1.93E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	1.02E+01	5.88E+00	1.18E+01	6.90E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	3.07E-01	1.11E-01	2.63E-01	9.65E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	5.27E-01	1.92E-01	5.61E-01	2.05E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	1.67E+00	5.75E-01	1.50E+00	5.32E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	1.02E+00	4.36E-01	4.37E-01	2.82E-01	4.02E+01	2.68E+01	0.00E+00	0.00E+00
1953	7.19E-01	2.57E-01	0.00E+00	0.00E+00	4.72E+02	5.15E+02	0.00E+00	0.00E+00
1954	1.82E+00	6.53E-01	0.00E+00	0.00E+00	1.14E+03	1.29E+03	0.00E+00	0.00E+00
1955	1.74E+00	6.61E-01	0.00E+00	0.00E+00	2.68E+01	1.02E+01	0.00E+00	0.00E+00
1956	1.70E-02	1.43E-02	0.00E+00	0.00E+00	2.25E+01	8.36E+00	4.25E+00	1.72E+00
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.18E+01	1.15E+01	1.07E+01	3.74E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.15E+01	1.28E+01	1.31E+01	5.37E+00
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.28E+00	2.21E+00	1.95E+01	6.85E+00
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.40E+00	2.72E+00	2.12E+01	8.01E+00
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E+01	4.97E+00	1.85E+01	6.52E+00
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+00	5.33E-01	8.05E+00	3.09E+00
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.49E-01	3.69E-01	6.79E+00	2.74E+00
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-01	2.93E-01	8.57E+00	3.49E+00
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E+00	5.96E-01	6.41E+00	2.44E+00
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E+00	7.01E-01	4.08E+00	2.19E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.82E+00	1.62E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.97E+00	8.26E-01
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.31E-01	2.99E-01
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.95E-01	1.75E-01
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-01	1.05E-01
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.85E-03	4.61E-03
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-04	5.00E-05
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E-01	5.20E-02
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-02	2.00E-03
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.00E-05
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-04	5.00E-05
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Table A-7. Source term data for $^{106}Ru/^{106}Rh$ particulate releases (Ci/yr).

Date	T	T_SD	B	B_SD	REDOX	R_SD	PUREX	P_SD
1944	6.30E-02	7.37E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	1.11E+01	4.73E+00	1.03E+01	4.53E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	1.20E+01	4.79E+00	1.94E+01	6.65E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	9.99E+00	3.41E+00	1.14E+01	3.91E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	3.38E+00	1.95E+00	3.96E+00	2.30E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	1.16E-01	4.11E-02	1.06E-01	3.85E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	1.98E-01	6.95E-02	2.15E-01	7.56E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	3.57E-01	1.23E-01	3.34E-01	1.18E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	2.43E-01	9.59E-02	9.79E-02	6.10E-02	1.52E+01	9.12E+00	0.00E+00	0.00E+00
1953	1.72E-01	6.40E-02	0.00E+00	0.00E+00	1.71E+02	1.76E+02	0.00E+00	0.00E+00
1954	3.06E-01	1.07E-01	0.00E+00	0.00E+00	3.53E+02	3.53E+02	0.00E+00	0.00E+00
1955	3.42E-01	1.23E-01	0.00E+00	0.00E+00	1.02E+01	4.06E+00	0.00E+00	0.00E+00
1956	1.23E-02	1.03E-02	0.00E+00	0.00E+00	8.70E+00	3.55E+00	1.84E+00	7.72E-01
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E+01	3.59E+00	3.48E+00	1.19E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.79E+00	3.00E+00	4.15E+00	1.50E+00
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.44E+00	1.94E+00	5.51E+00	1.94E+00
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.56E+00	1.78E+00	6.30E+00	2.29E+00
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.83E+00	2.79E+00	6.25E+00	2.21E+00
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.48E-01	2.91E-01	4.65E+00	1.68E+00
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.02E-01	3.60E-01	4.20E+00	1.71E+00
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E+00	4.37E-01	4.65E+00	1.84E+00
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E+00	4.78E-01	4.18E+00	1.59E+00
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E+00	1.18E+00	2.65E+00	1.23E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E+00	1.58E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.78E+00	1.75E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.61E+00	1.29E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.87E-01	5.72E-01
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E+00	5.71E-01
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-01	1.14E-01
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	2.00E-02
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-01	6.00E-02
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-01	4.00E-02
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-02	2.00E-03
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-01	1.80E-02
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-02	2.20E-03
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E-03	2.80E-04
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-03	2.90E-04
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-06	4.00E-07
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05	1.80E-06
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Table A-8. Source term data for $^{90}Sr/^{90}Y$ particulate releases (Ci/yr).

Date	T	T_SD	B	B_SD	REDOX	R_SD	PUREX	P_SD
1944	2.20E-02	1.91E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	3.84E+00	1.21E+00	3.55E+00	1.15E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	4.26E+00	1.24E+00	6.97E+00	1.77E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	3.70E+00	9.35E-01	4.19E+00	1.06E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	1.32E+00	5.64E-01	1.55E+00	6.66E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	4.36E-02	1.15E-02	3.54E-02	9.82E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	6.77E-02	1.75E-02	7.37E-02	1.91E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	1.06E-01	2.68E-02	9.79E-02	2.54E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	6.78E-02	1.97E-02	2.71E-02	1.25E-02	1.96E-01	5.42E-02	0.00E+00	0.00E+00
1953	5.01E-02	1.38E-02	0.00E+00	0.00E+00	3.26E-01	8.85E-02	0.00E+00	0.00E+00
1954	9.79E-02	2.53E-02	0.00E+00	0.00E+00	3.90E-01	1.05E-01	0.00E+00	0.00E+00
1955	1.21E-01	3.20E-02	0.00E+00	0.00E+00	4.48E-01	1.30E-01	0.00E+00	0.00E+00
1956	4.80E-03	3.00E-03	0.00E+00	0.00E+00	3.65E-01	1.04E-01	5.25E-01	1.57E-01
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.04E-01	1.04E-01	9.75E-01	2.46E-01
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.08E-01	8.65E-02	1.13E+00	3.01E-01
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-01	6.95E-02	1.39E+00	3.61E-01
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-01	6.27E-02	1.64E+00	4.40E-01
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.96E-01	1.04E-01	1.59E+00	4.18E-01
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-01	1.24E-01	2.16E+00	5.78E-01
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.50E-01	1.63E-01	1.92E+00	5.73E-01
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.32E-01	2.09E-01	2.11E+00	6.17E-01
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.99E-01	2.03E-01	2.02E+00	5.69E-01
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E+00	4.08E-01	1.41E+00	4.73E-01
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.12E+00	5.70E-01
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E+00	5.79E-01
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E+00	4.64E-01
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	1.99E-01
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+00	4.06E-01
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-01	7.73E-02
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-03	3.00E-04
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-02	2.30E-03
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.50E-03	8.50E-04
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-04	2.10E-05
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.00E-05
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-04	1.00E-05
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.60E-03	4.60E-04
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.30E-03	5.30E-04
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-03	2.40E-04
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.40E-04	4.40E-05
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.70E-04	3.70E-05
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.00E-05
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-04	2.50E-05
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.50E-04	4.50E-05
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.90E-04	5.90E-05
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.70E-04	3.70E-05
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-04	4.20E-05
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-04	3.30E-05
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-04	2.90E-05

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Table A-9. Source term data for $^{95}Zr/^{95}Nb$ particulate releases (Ci/yr).

Date	T	T_SD	B	B_SD	REDOX	R_SD	PUREX	P_SD
1944	2.35E+00	8.08E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1945	1.91E+02	2.23E+02	1.83E+02	2.30E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	1.35E+02	1.52E+02	2.82E+02	2.83E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	1.44E+02	1.45E+02	1.68E+02	1.68E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	6.24E+01	8.57E+01	1.12E+02	1.22E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	9.07E-01	9.69E-01	1.34E+01	2.39E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	1.91E-01	6.58E-01	1.30E-01	4.48E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	2.00E+00	2.02E+00	1.79E+00	1.84E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	1.02E+00	1.24E+00	4.31E-01	8.05E-01	2.46E+00	2.66E+00	0.00E+00	0.00E+00
1953	7.17E-01	7.51E-01	0.00E+00	0.00E+00	3.81E+00	4.12E+00	0.00E+00	0.00E+00
1954	2.39E+00	2.62E+00	0.00E+00	0.00E+00	3.20E+00	3.41E+00	0.00E+00	0.00E+00
1955	2.46E+00	2.73E+00	0.00E+00	0.00E+00	4.44E+00	5.02E+00	0.00E+00	0.00E+00
1956	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.75E+00	3.95E+00	4.29E+00	4.85E+00
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.44E+00	3.68E+00	8.22E+00	8.42E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E+00	3.40E+00	1.14E+01	1.20E+01
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.11E-01	7.93E-01	1.06E+01	1.09E+01
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.69E-01	9.05E-01	1.15E+01	1.25E+01
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E+00	1.36E+00	1.03E+01	1.06E+01
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E+00	1.32E+00	7.47E+00	8.22E+00
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.24E-01	1.08E+00	6.72E+00	7.68E+00
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E+00	1.19E+00	7.34E+00	8.67E+00
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E+00	1.74E+00	6.40E+00	7.13E+00
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E+00	1.67E+00	2.20E+00	4.10E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E+00	4.43E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E+00	2.68E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+00	1.21E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E-01	6.58E-01
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E-01	7.51E-01
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.32E-02	1.18E-01
1973	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1974	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1975	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1976	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1977	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1978	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1979	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1980	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1983	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1984	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1985	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1986	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1987	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1988	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1990	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1991	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1992	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1994	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1995	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1996	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1997	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1999	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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In this table, numerical identifiers are used as row and column headings. The row headings are the 38 receptor locations described in Table 4-6. The column headings represent the combination of source location and emission type as:

Table A-10. Atmospheric dispersion factors [Bq-(s/m^3) per Bq released].

1	T Plant particles
2	B Plant particles
3	REDOX Plant particles
4	PUREX Plant particles
5	Z Plant particles
6	T Plant iodine
7	B Plant iodine
8	REDOX Plant iodine
9	PUREX Plant iodine
10	B & C Reactors noble gas
11	KE & KW Reactors noble gas
12	N Reactor noble gas
13	D & DR Reactors noble gas
14	H Reactor noble gas
15	F Reactor noble gas

Node Averages

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.17E-07	1.80E-08	3.03E-08	1.44E-08	5.74E-08	1.18E-07	1.84E-08	3.07E-08	1.47E-08	1.53E-08	1.07E-08	7.17E-09	5.86E-09	4.65E-09	4.92E-09
2	2.46E-08	1.35E-07	1.80E-08	5.86E-08	2.03E-08	2.49E-08	1.35E-07	1.84E-08	5.91E-08	1.77E-08	1.17E-08	8.38E-09	6.99E-09	5.87E-09	6.52E-09
3	5.40E-08	1.36E-08	2.92E-07	1.17E-08	2.27E-07	5.46E-08	1.39E-08	2.93E-07	1.20E-08	1.26E-08	8.66E-09	5.78E-09	4.76E-09	3.81E-09	4.05E-09
4	2.35E-08	8.34E-08	1.82E-08	1.20E-07	1.99E-08	2.39E-08	8.39E-08	1.86E-08	1.20E-07	1.72E-08	1.13E-08	7.99E-09	6.90E-09	6.05E-09	6.92E-09
5	6.81E-08	1.46E-08	6.51E-08	1.20E-08	1.94E-07	6.86E-08	1.49E-08	6.55E-08	1.23E-08	1.40E-08	9.21E-09	6.28E-09	5.09E-09	4.11E-09	4.32E-09
6	1.42E-08	1.29E-08	1.04E-08	1.13E-08	1.13E-08	1.45E-08	1.33E-08	1.08E-08	1.17E-08	3.80E-07	1.84E-08	1.10E-08	8.84E-09	6.89E-09	7.04E-09
7	1.62E-08	1.77E-08	1.32E-08	1.75E-08	1.43E-08	1.66E-08	1.82E-08	1.36E-08	1.79E-08	3.13E-08	3.59E-07	2.64E-08	1.79E-08	1.24E-08	1.24E-08
8	1.67E-08	1.95E-08	1.46E-08	1.98E-08	1.51E-08	1.73E-08	2.01E-08	1.52E-08	2.03E-08	2.15E-08	2.64E-08	1.86E-07	4.92E-08	2.22E-08	2.21E-08
9	1.36E-08	1.56E-08	1.20E-08	1.56E-08	1.24E-08	1.41E-08	1.61E-08	1.25E-08	1.61E-08	1.74E-08	2.11E-08	4.43E-08	1.22E-07	3.08E-08	2.67E-08
10	1.21E-08	1.40E-08	1.07E-08	1.38E-08	1.11E-08	1.26E-08	1.44E-08	1.12E-08	1.42E-08	1.63E-08	2.12E-08	3.35E-08	4.88E-08	1.08E-07	3.46E-08
11	1.48E-08	1.67E-08	1.32E-08	1.63E-08	1.37E-08	1.53E-08	1.72E-08	1.37E-08	1.67E-08	1.97E-08	2.87E-08	4.02E-08	3.57E-08	2.63E-08	2.44E-07
12	2.13E-08	1.74E-08	1.44E-08	1.43E-08	1.66E-08	2.17E-08	1.77E-08	1.48E-08	1.46E-08	3.55E-08	1.79E-08	1.11E-08	8.63E-09	6.52E-09	6.96E-09
13	7.65E-09	6.78E-09	6.46E-09	6.24E-09	7.06E-09	7.89E-09	7.01E-09	6.68E-09	6.45E-09	1.76E-08	9.68E-09	6.50E-09	5.19E-09	3.98E-09	4.19E-09
14	1.13E-08	1.33E-08	9.64E-09	1.32E-08	1.02E-08	1.18E-08	1.37E-08	1.01E-08	1.36E-08	1.58E-08	1.97E-08	3.06E-08	2.84E-08	1.95E-08	1.71E-08
15	8.06E-09	9.34E-09	7.24E-09	9.20E-09	7.46E-09	8.40E-09	9.70E-09	7.58E-09	9.53E-09	1.15E-08	1.43E-08	2.08E-08	2.50E-08	3.54E-08	2.04E-08
16	9.18E-09	1.04E-08	8.05E-09	1.02E-08	8.43E-09	9.53E-09	1.07E-08	8.40E-09	1.05E-08	1.35E-08	1.93E-08	2.77E-08	3.37E-08	4.98E-08	2.50E-08
17	8.62E-09	5.76E-09	8.99E-09	5.22E-09	1.00E-08	8.84E-09	5.94E-09	9.21E-09	5.40E-09	9.76E-09	5.48E-09	3.99E-09	3.28E-09	2.60E-09	2.81E-09
18	1.44E-08	1.12E-08	1.82E-08	1.12E-08	1.62E-08	1.48E-08	1.15E-08	1.86E-08	1.15E-08	7.44E-09	5.60E-09	4.23E-09	3.88E-09	3.84E-09	4.72E-09
19	1.83E-08	2.22E-08	1.73E-08	2.32E-08	1.67E-08	1.88E-08	2.25E-08	1.77E-08	2.36E-08	1.32E-08	1.00E-08	7.18E-09	6.52E-09	6.39E-09	7.66E-09
20	6.87E-08	3.41E-08	2.89E-08	2.23E-08	3.33E-08	6.92E-08	3.46E-08	2.92E-08	2.27E-08	1.43E-08	1.01E-08	7.13E-09	5.95E-09	4.85E-09	5.27E-09
21	1.68E-08	1.81E-08	1.43E-08	1.89E-08	1.52E-08	1.73E-08	1.86E-08	1.48E-08	1.94E-08	2.67E-08	7.34E-08	2.82E-08	2.09E-08	1.42E-08	1.46E-08
22	5.53E-08	2.60E-08	2.66E-08	1.88E-08	3.16E-08	5.57E-08	2.65E-08	2.70E-08	1.92E-08	1.54E-08	1.09E-08	7.59E-09	6.22E-09	5.04E-09	5.39E-09
23	1.18E-08	8.79E-09	1.64E-08	8.79E-09	1.43E-08	1.21E-08	9.07E-09	1.68E-08	9.05E-09	6.01E-09	4.53E-09	3.49E-09	3.18E-09	3.13E-09	3.84E-09
24	8.96E-09	1.04E-08	9.14E-09	1.07E-08	8.78E-09	9.27E-09	1.08E-08	9.46E-09	1.11E-08	8.02E-09	7.46E-09	5.79E-09	5.44E-09	5.52E-09	7.13E-09
25	8.35E-09	1.01E-08	8.37E-09	1.06E-08	8.08E-09	8.64E-09	1.04E-08	8.67E-09	1.09E-08	8.23E-09	8.08E-09	6.47E-09	6.16E-09	6.33E-09	8.05E-09
26	1.01E-08	1.07E-08	1.08E-08	1.11E-08	1.01E-08	1.04E-08	1.10E-08	1.11E-08	1.14E-08	7.66E-09	6.43E-09	4.76E-09	4.35E-09	4.33E-09	5.65E-09
27	4.83E-09	3.71E-09	6.09E-09	3.63E-09	5.70E-09	5.02E-09	3.85E-09	6.30E-09	3.77E-09	3.10E-09	2.45E-09	2.00E-09	1.82E-09	1.72E-09	1.97E-09
28	1.22E-08	1.45E-08	1.15E-08	1.49E-08	1.16E-08	1.26E-08	1.49E-08	1.19E-08	1.53E-08	1.46E-08	2.18E-08	1.91E-08	1.56E-08	1.33E-08	2.06E-08
29	2.59E-08	2.42E-08	2.72E-08	2.44E-08	2.59E-08	2.64E-08	2.47E-08	2.78E-08	2.48E-08	1.25E-08	8.59E-09	6.29E-09	5.69E-09	5.48E-09	6.87E-09
30	1.16E-08	1.59E-08	1.10E-08	1.64E-08	1.08E-08	1.19E-08	1.62E-08	1.14E-08	1.68E-08	1.43E-08	1.44E-08	1.09E-08	1.02E-08	1.02E-08	1.26E-08
31	1.38E-08	1.38E-08	1.48E-08	1.39E-08	1.41E-08	1.42E-08	1.42E-08	1.52E-08	1.42E-08	9.64E-09	7.76E-09	5.86E-09	5.45E-09	5.40E-09	6.56E-09
32	2.01E-08	9.57E-09	1.56E-08	8.49E-09	2.26E-08	2.05E-08	9.84E-09	1.59E-08	8.73E-09	1.62E-08	8.56E-09	5.86E-09	4.88E-09	3.84E-09	4.11E-09
33	1.45E-08	7.60E-09	2.04E-08	6.84E-09	2.23E-08	1.48E-08	7.84E-09	2.07E-08	7.06E-09	9.03E-09	5.66E-09	3.99E-09	3.28E-09	2.64E-09	2.80E-09
34	1.97E-08	1.33E-08	3.29E-08	1.30E-08	2.52E-08	2.01E-08	1.37E-08	3.34E-08	1.33E-08	8.70E-09	6.23E-09	4.72E-09	4.09E-09	3.63E-09	4.22E-09
35	3.03E-08	9.06E-08	2.10E-08	1.91E-07	2.24E-08	3.07E-08	9.10E-08	2.13E-08	1.92E-07	1.50E-08	9.94E-09	7.33E-09	6.30E-09	5.64E-09	6.52E-09
36	1.49E-08	8.18E-09	2.29E-08	7.39E-09	2.64E-08	1.52E-08	8.42E-09	2.33E-08	7.61E-09	1.06E-08	6.48E-09	4.54E-09	3.74E-09	2.97E-09	3.15E-09
37	3.12E-08	7.41E-08	2.18E-08	1.25E-07	2.39E-08	3.15E-08	7.46E-08	2.22E-08	1.25E-07	1.44E-08	9.58E-09	7.07E-09	6.10E-09	5.30E-09	6.02E-09
38	1.17E-07	1.80E-08	3.03E-08	1.44E-08	5.74E-08	1.18E-07	1.84E-08	3.07E-08	1.47E-08	1.53E-08	1.07E-08	7.17E-09	5.86E-09	4.65E-09	4.92E-09

Node Standard Deviations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	4.56E-08	2.40E-09	4.81E-09	1.78E-09	8.48E-09	4.58E-08	2.50E-09	4.86E-09	1.83E-09	2.38E-09	1.40E-09	7.50E-10	6.57E-10	5.90E-10	5.83E-10
2	2.53E-09	3.04E-08	1.40E-09	6.99E-09	1.59E-09	2.60E-09	3.03E-08	1.38E-09	7.04E-09	3.88E-09	1.71E-09	8.27E-10	7.12E-10	5.67E-10	6.93E-10
3	1.03E-08	2.01E-09	3.79E-08	1.43E-09	2.40E-08	1.04E-08	2.03E-09	3.78E-08	1.45E-09	1.81E-09	1.21E-09	5.54E-10	4.96E-10	4.11E-10	4.17E-10
4	2.61E-09	1.73E-08	1.57E-09	2.76E-08	2.52E-09	2.62E-09	1.75E-08	1.58E-09	2.77E-08	3.85E-09	1.96E-09	8.56E-10	6.50E-10	5.98E-10	7.07E-10
5	1.67E-08	2.12E-09	9.23E-09	1.56E-09	3.77E-08	1.68E-08	2.14E-09	9.25E-09	1.59E-09	1.97E-09	1.12E-09	6.48E-10	5.15E-10	4.59E-10	4.81E-10
6	1.31E-09	1.43E-09	9.47E-10	1.08E-09	1.07E-09	1.31E-09	1.46E-09	9.49E-10	1.08E-09	4.64E-08	2.21E-09	1.01E-09	9.46E-10	7.16E-10	8.42E-10
7	1.23E-09	1.37E-09	1.37E-09	1.91E-09	1.43E-09	1.28E-09	1.40E-09	1.39E-09	1.96E-09	3.31E-09	1.35E-07	3.38E-09	1.93E-09	1.77E-09	1.48E-09
8	2.27E-09	2.19E-09	1.88E-09	2.09E-09	2.04E-09	2.31E-09	2.24E-09	1.93E-09	2.17E-09	2.51E-09	2.15E-09	9.19E-08	5.89E-09	3.01E-09	2.72E-09
9	1.79E-09	1.74E-09	1.51E-09	1.53E-09	1.63E-09	1.82E-09	1.79E-09	1.54E-09	1.60E-09	2.10E-09	2.07E-09	5.64E-09	4.56E-08	4.10E-09	2.75E-09
10	1.39E-09	1.46E-09	1.21E-09	1.39E-09	1.28E-09	1.41E-09	1.48E-09	1.21E-09	1.40E-09	1.72E-09	2.59E-09	2.99E-09	3.84E-09	3.64E-08	2.27E-09
11	1.88E-09	2.34E-09	1.64E-09	2.09E-09	1.73E-09	1.92E-09	2.35E-09	1.64E-09	2.13E-09	2.88E-09	5.04E-09	4.18E-09	4.10E-09	2.48E-09	5.83E-08
12	2.13E-09	9.54E-10	1.32E-09	1.31E-09	2.31E-09	2.15E-09	9.68E-10	1.34E-09	1.32E-09	8.05E-09	1.98E-09	1.20E-09	9.00E-10	7.73E-10	7.34E-10
13	7.38E-10	6.61E-10	6.07E-10	5.91E-10	5.47E-10	7.73E-10	6.88E-10	6.33E-10	6.13E-10	1.71E-09	1.03E-09	6.01E-10	4.91E-10	4.01E-10	4.44E-10
14	1.21E-09	1.50E-09	9.81E-10	1.48E-09	1.08E-09	1.22E-09	1.55E-09	1.02E-09	1.53E-09	1.66E-09	2.16E-09	3.41E-09	3.62E-09	2.60E-09	2.25E-09
15	8.95E-10	9.56E-10	8.20E-10	8.91E-10	8.75E-10	9.04E-10	9.71E-10	8.33E-10	9.03E-10	1.41E-09	1.77E-09	2.67E-09	2.55E-09	4.18E-09	1.41E-09
16	1.18E-09	1.32E-09	9.77E-10	1.22E-09	1.03E-09	1.19E-09	1.34E-09	9.86E-10	1.24E-09	2.19E-09	3.24E-09	1.95E-09	2.70E-09	2.52E-09	1.90E-09
17	6.55E-10	4.19E-10	8.49E-10	4.48E-10	8.52E-10	6.85E-10	4.35E-10	8.61E-10	4.60E-10	1.17E-09	5.76E-10	3.99E-10	3.65E-10	2.58E-10	3.00E-10
18	1.71E-09	1.30E-09	1.85E-09	1.22E-09	1.71E-09	1.77E-09	1.34E-09	1.91E-09	1.26E-09	1.29E-09	8.61E-10	5.56E-10	5.28E-10	4.99E-10	4.80E-10
19	9.43E-10	2.35E-09	1.19E-09	2.70E-09	1.20E-09	9.53E-10	2.37E-09	1.26E-09	2.75E-09	2.19E-09	1.97E-09	8.45E-10	7.50E-10	6.49E-10	7.60E-10
20	7.57E-09	5.60E-09	3.17E-09	2.30E-09	3.64E-09	7.63E-09	5.67E-09	3.22E-09	2.37E-09	1.96E-09	1.38E-09	6.71E-10	6.05E-10	5.87E-10	5.74E-10
21	2.44E-09	3.20E-09	1.89E-09	2.83E-09	1.95E-09	2.50E-09	3.23E-09	1.94E-09	2.87E-09	3.51E-09	1.27E-08	2.82E-09	1.91E-09	1.72E-09	1.65E-09
22	1.37E-08	3.53E-09	2.90E-09	2.26E-09	4.54E-09	1.37E-08	3.62E-09	2.88E-09	2.31E-09	2.30E-09	1.30E-09	7.43E-10	6.98E-10	5.86E-10	6.39E-10
23	9.69E-10	8.85E-10	1.50E-09	8.68E-10	1.08E-09	9.85E-10	9.39E-10	1.56E-09	9.09E-10	9.14E-10	5.88E-10	4.47E-10	4.21E-10	4.13E-10	4.38E-10
24	8.76E-10	1.08E-09	9.15E-10	1.05E-09	7.95E-10	9.12E-10	1.15E-09	9.36E-10	1.10E-09	9.87E-10	1.33E-09	7.23E-10	5.78E-10	5.67E-10	7.50E-10
25	6.87E-10	9.11E-10	6.56E-10	8.74E-10	5.50E-10	7.12E-10	9.48E-10	6.74E-10	9.07E-10	9.14E-10	1.41E-09	7.94E-10	6.15E-10	6.13E-10	9.00E-10
26	1.06E-09	1.35E-09	1.11E-09	1.33E-09	1.03E-09	1.10E-09	1.41E-09	1.17E-09	1.40E-09	1.22E-09	1.23E-09	5.87E-10	4.75E-10	4.72E-10	5.87E-10
27	3.42E-10	2.50E-10	5.62E-10	2.47E-10	4.83E-10	3.63E-10	2.66E-10	5.83E-10	2.74E-10	2.93E-10	2.46E-10	2.15E-10	2.01E-10	1.94E-10	1.78E-10
28	1.22E-09	1.35E-09	1.03E-09	1.36E-09	1.18E-09	1.24E-09	1.38E-09	1.06E-09	1.35E-09	1.87E-09	3.06E-09	1.34E-09	1.06E-09	8.62E-10	2.33E-09
29	2.60E-09	3.94E-09	2.25E-09	4.08E-09	1.92E-09	2.67E-09	4.02E-09	2.28E-09	4.14E-09	2.61E-09	1.60E-09	7.93E-10	6.77E-10	5.40E-10	6.33E-10
30	8.33E-10	1.38E-09	7.45E-10	1.25E-09	8.16E-10	8.53E-10	1.37E-09	7.55E-10	1.25E-09	7.26E-10	1.80E-09	1.05E-09	8.55E-10	7.09E-10	7.90E-10
31	1.38E-09	1.62E-09	1.00E-09	1.67E-09	8.93E-10	1.44E-09	1.66E-09	1.05E-09	1.71E-09	1.63E-09	1.26E-09	6.38E-10	6.36E-10	5.60E-10	5.70E-10
32	1.86E-09	5.11E-10	2.09E-09	4.04E-10	2.96E-09	1.88E-09	5.45E-10	2.11E-09	4.09E-10	1.71E-09	9.12E-10	6.30E-10	5.49E-10	3.87E-10	4.75E-10
33	2.10E-09	1.03E-09	2.74E-09	8.49E-10	2.95E-09	2.18E-09	1.06E-09	2.81E-09	8.78E-10	8.41E-10	7.49E-10	4.33E-10	3.38E-10	3.00E-10	3.09E-10
34	1.96E-09	1.03E-09	3.56E-09	1.14E-09	2.45E-09	2.06E-09	1.11E-09	3.70E-09	1.22E-09	1.11E-09	7.46E-10	4.72E-10	3.60E-10	3.25E-10	3.46E-10
35	4.55E-09	7.64E-09	1.32E-09	1.85E-08	2.09E-09	4.55E-09	7.56E-09	1.34E-09	1.85E-08	2.91E-09	1.53E-09	6.83E-10	5.49E-10	5.62E-10	6.28E-10
36	2.19E-09	8.72E-10	2.47E-09	8.44E-10	4.32E-09	2.25E-09	9.11E-10	2.57E-09	8.79E-10	1.21E-09	8.34E-10	5.18E-10	4.17E-10	3.46E-10	3.63E-10
37	3.76E-09	9.30E-09	2.01E-09	1.75E-08	2.88E-09	3.77E-09	9.39E-09	2.02E-09	1.77E-08	3.11E-09	1.28E-09	6.13E-10	6.04E-10	5.23E-10	5.70E-10
38	4.56E-08	2.40E-09	4.81E-09	1.78E-09	8.48E-09	4.58E-08	2.50E-09	4.86E-09	1.83E-09	2.38E-09	1.40E-09	7.50E-10	6.57E-10	5.90E-10	5.83E-10

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Table A-11. Ar-41 submersion gamma dose (Sv) and skin dose (Sv).

Ar-41	Gamma dose	GSD	Skin dose	GSD
1944	1.15E-06	1.71	1.90E-06	1.71
1945	5.28E-06	1.34	8.67E-06	1.34
1946	3.77E-06	1.37	6.19E-06	1.37
1947	3.70E-06	1.38	6.08E-06	1.38
1948	3.84E-06	1.36	6.31E-06	1.36
1949	5.38E-06	1.33	8.84E-06	1.33
1950	6.92E-06	1.41	1.14E-05	1.41
1951	7.45E-06	1.38	1.22E-05	1.38
1952	8.40E-06	1.34	1.38E-05	1.34
1953	2.20E-05	1.28	3.61E-05	1.28
1954	2.20E-05	1.28	3.61E-05	1.28
1955	2.65E-05	1.47	4.35E-05	1.47
1956	3.27E-05	1.46	5.37E-05	1.46
1957	3.27E-05	1.46	5.37E-05	1.46
1958	3.28E-05	1.46	5.38E-05	1.46
1959	3.28E-05	1.46	5.38E-05	1.46
1960	3.28E-05	1.46	5.38E-05	1.46
1961	3.28E-05	1.46	5.38E-05	1.46
1962	3.28E-05	1.46	5.38E-05	1.46
1963	3.28E-05	1.46	5.38E-05	1.46
1964	3.47E-05	1.44	5.69E-05	1.44
1965	3.38E-05	1.45	5.56E-05	1.45
1966	3.35E-05	1.45	5.51E-05	1.45
1967	3.34E-05	1.45	5.48E-05	1.45
1968	3.29E-05	1.46	5.40E-05	1.46
1969	3.18E-05	1.48	5.23E-05	1.48
1970	1.80E-05	1.51	2.95E-05	1.51
1971	1.13E-05	1.61	1.86E-05	1.61
1972	8.62E-06	1.61	1.42E-05	1.61
1973	8.62E-06	1.61	1.42E-05	1.61
1974	4.31E-06	1.61	7.08E-06	1.61
1975	2.66E-06	1.61	4.37E-06	1.61
1976	3.05E-06	1.61	5.01E-06	1.61
1977	1.13E-05	1.61	1.85E-05	1.61
1978	9.48E-06	1.61	1.56E-05	1.61
1979	7.41E-06	1.61	1.22E-05	1.61
1980	1.98E-06	1.61	3.26E-06	1.61
1981	5.60E-06	1.61	9.20E-06	1.61
1982	9.83E-06	1.61	1.61E-05	1.61
1983	1.04E-05	1.61	1.71E-05	1.61
1984	6.64E-06	1.61	1.09E-05	1.61
1985	5.95E-06	1.61	9.77E-06	1.61
1986	1.03E-05	1.61	1.70E-05	1.61
1987	3.88E-07	1.61	6.37E-07	1.61
1989 through 2001 all values are 0.00 Reactors Shut Down				

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Table A-12. Intakes of particulate radionuclides (Bq/yr).

	Ce/Pr-144		Cs/Ba-137		Pu-239		Ru/Rh-103	
Date	**Intake**	**GSD**	**Intake**	**GSD**	**Intake**	**GSD**	**Intake**	**GSD**
1944	1.45E-01	2.46	4.18E-03	2.46	9.75E-06	12.00	1.83E-01	2.87
1945	3.79E+01	1.59	1.28E+00	1.59	6.84E-03	7.04	3.40E+01	1.68
1946	6.64E+01	1.56	2.35E+00	1.56	1.47E-02	6.43	4.28E+01	1.64
1947	4.05E+01	1.55	1.48E+00	1.55	9.71E-03	6.30	2.13E+01	1.62
1948	1.32E+01	1.69	5.20E-01	1.69	2.11E-03	8.18	4.30E+00	1.85
1949	3.42E-01	1.55	1.32E-02	1.55	2.21E-04	6.16	1.08E-01	1.62
1950	6.20E-01	1.55	2.61E-02	1.55	3.50E-04	6.10	2.22E-01	1.63
1951	9.56E-01	1.54	3.57E-02	1.55	5.16E-04	6.02	6.12E-01	1.61
1952	3.53E+00	1.54	1.37E-01	1.54	1.62E-03	5.69	2.60E+01	2.01
1953	1.20E+01	1.86	2.21E-01	1.54	2.37E-03	5.82	2.47E+02	2.59
1954	7.05E+00	1.54	2.68E-01	1.54	2.81E-03	5.79	5.84E+02	2.65
1955	7.34E+00	1.54	3.08E-01	1.55	3.37E-03	5.87	1.96E+01	1.66
1956	6.85E+00	1.54	2.56E-01	1.55	3.73E-03	5.71	1.65E+01	1.65
1957	1.24E+01	1.51	4.42E-01	1.51	5.40E-03	5.56	2.35E+01	1.64
1958	1.49E+01	1.53	5.00E-01	1.53	4.81E-03	5.78	2.30E+01	1.68
1959	1.80E+01	1.52	6.18E-01	1.52	4.67E-03	5.85	9.65E+00	1.61
1960	2.06E+01	1.53	7.18E-01	1.53	4.65E-03	6.06	1.04E+01	1.63
1961	2.04E+01	1.53	7.07E-01	1.53	6.06E-03	5.84	9.55E+00	1.59
1962	6.36E+01	1.53	2.67E-01	1.53	2.90E-03	7.70	3.88E+00	1.65
1963	5.66E+01	1.56	2.45E-01	1.55	2.47E-03	6.19	3.24E+00	1.67
1964	6.35E+01	1.55	2.54E-01	1.55	3.12E-03	6.19	4.07E+00	1.67
1965	5.94E+01	1.54	2.64E-01	1.54	4.53E-03	7.67	3.13E+00	1.64
1966	4.05E+01	1.58	1.84E-01	1.59	3.71E-03	6.91	1.91E+00	1.81
1967	5.25E+01	1.54	2.10E-01	1.54	5.45E-05	6.58	1.79E+00	1.70
1968	5.05E+01	1.54	1.81E-01	1.54	4.95E-05	6.60	9.22E-01	1.69
1969	3.57E+01	1.53	1.32E-01	1.54	3.78E-05	6.66	3.44E-01	1.68
1970	7.87E+00	1.76	2.85E-02	1.77	8.20E-06	8.05	7.37E-02	2.32
1971	1.44E+01	1.64	1.32E-01	1.62	1.80E-05	7.74	4.15E-02	2.37
1972	1.47E+00	2.06	2.22E-02	2.03	1.17E-06	10.50	1.78E-03	2.39
All years from 1973 through 1982 have values of 0.00								
1983			1.47E-02	1.42	3.13E-04	1.42		
1984	5.05E-02	1.42	2.02E-02	1.42	3.74E-03	1.42	2.53E-04	1.42
1985	5.05E-02	1.42	5.05E-03	1.42	5.05E-03	1.42	2.63E-01	1.42
1986			4.40E-03	1.42	1.52E-03	1.42	1.01E-02	1.42
1987			2.02E-05	1.42	2.02E-04	1.42	1.01E-04	1.42
1988	5.05E-05	1.42	4.04E-04	1.42	1.01E-04	1.42	2.53E-04	1.42
1989			6.57E-04	1.42	4.92E-04	1.43		
1990			3.49E-04	1.42	1.80E-04	1.43		
1991			2.07E-03	1.42	2.64E-04	1.43		
1992			1.16E-02	1.42	2.82E-04	1.43		
1993			9.09E-03	1.42	3.36E-04	1.43		
1994			3.33E-04	1.42	2.52E-04	1.43		
1995			3.28E-04	1.42	7.20E-05	1.43		
1996			3.03E-04	1.42	1.44E-04	1.43		
1997			4.85E-04	1.42	7.20E-05	1.43		
1998			1.11E-04	1.42	1.20E-04	1.43		
1999			4.29E-05	1.42	1.26E-04	1.43		
2000			9.09E-05	1.42	3.06E-04	1.43		
2001			7.58E-05	1.42	9.00E-05	1.43		

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	Ru/Rh-106		Sr/Y-90		Zr/Nb-95		I-131	
Date	Intake	GSD	Intake	GSD	Intake	GSD	Intake	GSD
1944	1.19E-02	2.87	4.84E-03	2.46	1.91E-01	5.33	2.88E+02	3.78
1945	4.09E+00	1.69	1.45E+00	1.59	5.24E+01	2.60	1.04E+05	1.94
1946	7.28E+00	1.63	2.67E+00	1.56	7.92E+01	2.41	2.42E+04	1.90
1947	4.48E+00	1.61	1.68E+00	1.55	5.16E+01	2.33	6.30E+03	2.02
1948	1.44E+00	1.85	5.93E-01	1.69	3.08E+01	2.50	3.48E+02	1.90
1949	4.30E-02	1.62	1.50E-02	1.55	2.36E+00	3.50	1.24E+03	3.50
1950	8.50E-02	1.62	2.97E-02	1.55	1.95E-02	4.62	1.14E+03	2.23
1951	1.35E-01	1.61	4.05E-02	1.54	5.74E-01	2.32	5.66E+03	2.11
1952	1.01E+01	1.92	1.57E-01	1.54	1.46E+00	2.47	2.27E+03	1.96
1953	9.22E+01	2.51	2.51E-01	1.54	2.11E+00	2.53	1.17E+03	1.94
1954	1.93E+02	2.47	3.06E-01	1.54	2.05E+00	2.39	4.14E+02	1.89
1955	7.38E+00	1.68	3.51E-01	1.55	2.64E+00	2.51	4.33E+02	2.29
1956	6.29E+00	1.69	2.89E-01	1.55	2.14E+00	2.48	7.69E+01	2.16
1957	7.64E+00	1.62	5.03E-01	1.51	3.12E+00	2.43	1.70E+02	2.19
1958	5.76E+00	1.66	5.72E-01	1.53	4.16E+00	2.49	4.31E+02	2.09
1959	4.14E+00	1.62	6.99E-01	1.52	3.79E+00	2.49	1.37E+02	1.91
1960	3.49E+00	1.65	8.17E-01	1.53	4.00E+00	2.56	1.23E+02	2.21
1961	5.91E+00	1.62	8.04E-01	1.52	3.72E+00	2.48	5.14E+01	1.91
1962	2.26E+00	1.62	1.08E+00	1.53	2.61E+00	2.57	4.03E+01	2.56
1963	2.03E+00	1.67	9.66E-01	1.56	2.29E+00	2.63	5.15E+01	2.75
1964	2.26E+00	1.65	1.07E+00	1.55	2.47E+00	2.68	3.84E+01	1.99
1965	2.06E+00	1.64	1.03E+00	1.54	2.26E+00	2.58	3.22E+01	2.28
1966	1.51E+00	1.84	7.95E-01	1.65	5.82E-01	3.44	2.32E+01	2.25
1967	2.08E+00	1.63	1.04E+00	1.54	1.08E+00	2.84	1.65E+01	2.16
1968	2.28E+00	1.63	1.07E+00	1.53	7.45E-01	2.70	3.07E+00	2.24
1969	1.73E+00	1.62	8.54E-01	1.54	3.49E-01	2.66	7.54E-01	2.61
1970	3.79E-01	1.97	1.91E-01	1.76	5.46E-02	4.13	2.80E-01	2.13
1971	5.18E-01	1.79	5.19E-01	1.64	6.04E-02	4.17	1.26E-01	1.89
1972	4.25E-02	2.42	4.46E-02	2.07	7.54E-03	4.48	2.56E-01	1.40
All years from 1973 through 1982 have values of 0.00								
1983			1.52E-03	1.42				
1984	1.01E-01	1.42	1.16E-02	1.42				
1985	3.03E-01	1.42	4.29E-03	1.42			1.02E-01	1.42
1986	2.02E-01	1.42	1.06E-04	1.42			1.02E-01	1.42
1987	1.01E-02	1.42	1.01E-04	1.42			1.02E-04	1.42
1988	9.09E-02	1.42	5.05E-05	1.42			2.03E-04	1.42
1989	1.11E-02	1.42	2.32E-03	1.42			8.63E-03	1.42
1990	1.41E-03	1.42	2.68E-03	1.42			7.11E-04	1.42
1991	1.47E-03	1.42	1.21E-03	1.42				
1992			2.22E-04	1.42				
1993	2.02E-06	1.42	1.87E-04	1.42				
1994			1.01E-04	1.42				
1995	9.09E-06	1.42	1.26E-04	1.42				
1996			2.27E-04	1.42				
1997			2.98E-04	1.42				
1998			1.87E-04	1.42				
1999			2.12E-04	1.42				
2000			1.67E-04	1.42				
2001			1.47E-04	1.42				

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Table A-13. Intakes from ^{3}H from 108-B (Bq/yr).

	Tritium	
	GM Intake	**GSD**
1949	6.39E+02	1.68
1950	5.74E+03	1.68
1951	2.53E+04	1.68
1952	3.72E+04	1.68
1953	3.66E+03	1.68
1954	1.15E+05	1.68