APPENDIX K
HUMAN HEALTH RISK ANALYSIS

This appendix presents the methodologies and assumptions used for estimating potential impacts on, and risks to, individuals and the general public from exposure to releases of radioactive and hazardous chemical materials during normal operations and as a result of hypothetical accidents. It also presents the methodology that was used to assess industrial safety. This information is intended to support the public and occupational health and safety assessments described in Chapter 4 of this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. Section K.1 presents background information on the nature and hazards of radiation and chemicals. Section K.2 presents the methodology used in the assessment of normal radiological impacts, followed by the results of the radiological impact analyses. Section K.3 presents the assumptions and methodologies used in the assessment of facility accidents, followed by presentation of the impacts of accidental radioactive material and hazardous chemical releases. Section K.4 discusses the method used for assessment of industrial safety.

K.1 BACKGROUND

K.1.1 Radiation

Radiation exposure and its consequences are topics of interest to the general public. For this reason, this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* provides the reader with information regarding the consequences of exposure to radiation, provides the reader with information about the nature of radiation, and explains the basic concepts used to evaluate radiation health effects.

K.1.1.1 What Is Radiation?

Radiation is energy and/or mass transferred in the form of particles or waves. Globally, human beings are exposed constantly to radiation from cosmic sources (outer space); terrestrial sources, such as the Earth's rocks and soils; and radionuclides naturally present in the body. This radiation contributes to the natural background radiation that always surrounds us. Manmade sources of radiation also exist, including medical and dental x-rays, household smoke detectors, and materials released from nuclear and coal-fired power plants.

All matter in the universe is composed of atoms. Radiation comes from the activity of tiny particles within an atom. An atom consists of a positively charged nucleus (central part of an atom) with a number of negatively charged electron particles in various orbits around the nucleus. There are two types of particles in the nucleus: neutrons, which are electrically neutral, and protons, which are positively charged. Atoms with different numbers of protons are known as "elements." There are more than 100 natural and manmade elements. An element has equal numbers of electrons and protons. When atoms of an element differ in their number of neutrons, they are called "isotopes" of that element. All elements have three or more isotopes, some or all of which could be unstable (i.e., change over time).

Unstable isotopes undergo spontaneous change, known as "radioactive disintegration" or "radioactive decay." The process of continuously undergoing spontaneous disintegration is called "radioactivity." The "radioactivity" of a material decreases with time. The time it takes a material to lose half of its original radioactivity is its half-life. An isotope's half-life is a measure of its decay rate. For example, an isotope with a half-life of 8 days will lose one-half of its radioactivity in that amount of time. In 8 more days, one-half of the remaining radioactivity will be lost, and so on. Each radioactive element has a characteristic half-life. The half-lives of various radioactive elements may vary from millionths of a second to millions of years.

As unstable isotopes change into more-stable forms, they emit energy and/or particles (mass). A particle may be either an alpha particle (a helium nucleus), a beta particle (an electron), or a neutron, with various levels of kinetic energy. Sometimes these particles are emitted in conjunction with gamma rays. The particles and gamma rays are referred to as "ionizing radiation." Ionizing radiation means that the particles and gamma rays can ionize, or electrically charge, an atom by stripping off one or more of its electrons. Even though gamma rays do not carry an electric charge, they can ionize atoms by ejecting electrons as they pass through an element. Thus, they cause ionization indirectly. Ionizing radiation can change the chemical composition of many things, including living tissue (organs), which can affect the way they function.

When a radioactive isotope of an element emits a particle, it changes to an entirely different element or isotope, one that may or may not be radioactive. Eventually, a stable element is formed. This transformation, which may take several steps, is known as a "decay chain." For example, radium, a member of the radioactive decay chain of uranium, has a half-life of 1,622 years. It emits an alpha particle and becomes radon, a radioactive gas with a half-life of only 3.8 days. Radon decays first to polonium, then through a series of further decay steps to bismuth, and ultimately to a stable isotope of lead. The characteristics of various forms of ionizing radiation are briefly described below.

Alpha (α) particles—Alpha particles are the heaviest type of ionizing radiation. They can travel only a few centimeters in air. Alpha particles lose their energy almost as soon as they collide with anything. They can be stopped easily by a sheet of paper or by the skin's surface.

Beta (β) particles—Beta particles are much (7,300 times) lighter than alpha particles. They can travel a longer distance than alpha particles in the air. A high-energy beta particle can travel a few meters in the air. Beta particles can pass through a sheet of paper, but may be stopped by a thin sheet of aluminum foil or glass.

Gamma (γ) rays—Gamma rays (and x-rays), unlike alpha or beta particles, are waves of pure energy. Gamma rays travel at the speed of light. Gamma radiation is very penetrating and requires a large mass, such as a thick wall of concrete, lead, or steel, to stop it.

Neutrons (n)—Neutrons are particles that contribute to radiation exposure both directly and indirectly. The most prolific source of neutrons is a nuclear reactor. Indirect radiation exposure occurs when gamma rays and alpha particles are emitted following neutron capture in matter. A neutron has about one-quarter the weight of an alpha particle. It will travel in the air until it is absorbed by another element.

K.1.1.1.1 Measurement Units for Radiation

During the early days of radiological experimentation, there was no precise measurement unit for radiation. Therefore, a variety of units were used to determine the amount, type, and intensity of radiation. Just as heat can be measured in terms of its intensity or effects using units of calories or degrees, amounts of radiation or its effects can be measured in units of curies, radiation absorbed dose (rad), or dose equivalent (roentgen equivalent man, or rem). The following paragraphs describe the basis for these units.

Curie—The curie, named after the scientists Marie and Pierre Curie, describes the "intensity" or activity of a sample of radioactive material. The rate of decay of 1 gram of radium was the basis of this unit of measure. Because the measured decay rate kept changing slightly as measurement techniques became more accurate, the curie was subsequently defined as exactly 37 billion disintegrations (decays) per second.

Rad—The rad is used to measure the physical absorption of radiation. The total energy absorbed per unit quantity of tissue is referred to as "absorbed dose" (or simply dose). As sunlight heats pavement by giving up an amount of energy to it, radiation similarly gives up energy to objects in its path. One rad is equal to the amount of radiation that leads to the deposition of 0.01 joule of energy per kilogram of absorbing material.

Rem—A rem is used to measure dose equivalent. The dose equivalent in rem equals the absorbed dose in rads in tissue multiplied by the appropriate quality factor (the biological effectiveness of a given type of radiation) and possibly other modifying factors. The rem is used in measuring the effects of radiation on the body similar to the way degrees Celsius or Fahrenheit (°C or °F) are used in measuring the effects of sunlight heating pavement. Thus, 1 rem from one type of radiation is presumed to have the same biological effects as 1 rem from any other kind of radiation. This allows comparison of the biological effects of radionuclides that emit different types of radiation. One thousandth of a rem is called a "millirem."

Person-rem—A person-rem used to measure collective radiation dose, i.e., the sum of the individual doses received by a population or group from exposure to a specified source of radiation.

Equivalent Radiation Units in the International System of Units

Traditional Unit	International System Unit
1 curie	3.7×10^{10} becquerel (Bq)
1 rad	0.01 gray (Gy)
1 rem	0.01 sieverts (Sv)

The units of measure for radiation in the International System of Units are becquerels (used to measure source intensity [activity]), grays (used to measure absorbed dose), and sieverts (used to measure dose equivalent).

An individual may be exposed to ionizing radiation externally (from a radioactive source outside the body) or internally (from ingesting or inhaling radioactive material). The external dose is different from the internal dose because an external dose is delivered only during the actual time of exposure to the external radiation source, while an internal dose continues to be delivered as long as the radioactive source is in the body. The dose from internal exposure is typically calculated over 50 years following the initial exposure. Both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time.

Doses projected from normal operations and from accidents are reported in terms of total effective dose equivalent, the sum of the effective dose equivalent due to penetrating radiation from sources external to the body and the committed effective dose equivalent from internal deposition of radionuclides. The committed effective dose equivalent is an estimate of the radiation dose to a person resulting from inhalation or ingestion of radioactive material that takes into account the radiation sensitivities of different organs and the time (up to 50 years) a particular substance stays in the body (further discussed in Section K.1.1.1.3).

K.1.1.1.2 Sources of Radiation

The average American receives a total dose of approximately 365 millirem per year from all sources of radiation, both natural and manmade; approximately 300 millirem per year of this total are from natural sources (NCRP 1987). The sources of radiation can be divided into six different categories: (1) cosmic radiation, (2) terrestrial radiation, (3) internal radiation, (4) consumer products, (5) medical diagnosis and therapy, and (6) other sources. These categories are discussed in the following paragraphs.

Cosmic radiation—Cosmic radiation is ionizing radiation resulting from energetic charged particles from space continuously hitting the Earth's atmosphere. These particles, and the secondary particles and photons they create, constitute cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with the altitude above sea level. The average dose to a person in the United States from this source is approximately 30 millirem per year.

External terrestrial radiation—External terrestrial radiation is the radiation emitted from the radioactive materials in the Earth's rocks and soils. The average individual dose from external terrestrial radiation is approximately 30 millirem per year.

Internal radiation—Internal radiation results from inhalation or ingestion of natural radioactive material. Natural radionuclides in the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, potassium, rubidium, and carbon. The major contributors to the annual dose equivalent for internal radioactivity are the short-lived decay products of radon, which contribute approximately 200 millirem per year. The average individual dose from other internal radionuclides is approximately 40 millirem per year.

Consumer products—Consumer products also contain sources of ionizing radiation. In some products, such as smoke detectors and airport x-ray machines, the radiation source is essential to the product's operation. In other products, such as televisions and tobacco, the radiation occurs as the products function. The average dose from consumer products is approximately 10 millirem per year.

Medical diagnosis and therapy—Radiation is an important diagnostic medical tool and cancer treatment. Diagnostic x-rays result in an average dose of 39 millirem per year. Nuclear medical procedures result in an average dose of 14 millirem per year.[1]

Other sources—There are a few additional sources of radiation that contribute minor doses to individuals in the United States. The dose from nuclear fuel cycle facilities (e.g., uranium mines, mills, and fuel processing plants) and nuclear power plants has been estimated to be less than 1 millirem per year. Radioactive fallout from atmospheric atomic bomb tests, emissions from certain mineral extraction facilities, and transportation of radioactive materials contribute less than 1 millirem per year to the average dose to an individual. Air travel contributes approximately 1 millirem per year to the average dose.

K.1.1.1.3 Exposure Pathways

As stated earlier, an individual may be exposed to ionizing radiation both externally and internally. The different routes that could lead to radiation exposure are called "exposure pathways." Each type of exposure and its associated exposure pathways are discussed separately in the following paragraphs.

External exposure—External exposure results from exposure to radiation outside the body via any of several different pathways, including exposure to a cloud of radiation passing over the receptor (an exposed individual), standing on ground that is contaminated with radioactivity, and swimming or boating in contaminated water. If the receptor departs from the source of radiation exposure, the dose rate will decrease. It was assumed that external exposure occurs uniformly during the year. The appropriate dose measure for external pathways is called the "effective dose equivalent."

Internal exposure—Internal exposure results from a radiation source entering the human body through either inhalation of contaminated air or ingestion of contaminated food or water. In contrast to external exposure, once a radiation source enters the body, it remains there for a period of time that varies depending on its biological half-life (the time required for a radioactive material taken in by a living organism to be reduced to half the initial quantity by a combination of biological elimination

[1] Exposures from nuclear diagnostic and medical procedures vary over a wide range depending on the procedure. The reported values are average annual doses in the U.S. population (NCRP 1987).

processes and radioactive decay). The absorbed dose to each organ of the body is calculated for a period of 50 years following the intake. The calculated absorbed dose is called the "committed dose equivalent." Various organs have different susceptibilities to harm from radiation. The quantity that takes these different susceptibilities into account is called the "committed effective dose equivalent"; it provides a broad indicator of the risk to the health of an individual from radiation. The committed effective dose equivalent is a weighted sum of the committed dose equivalent in each major organ or tissue. The concept of committed effective dose equivalent applies only to internal pathways.

K.1.1.1.4 Radiation Protection Guides

Various organizations have issued radiation protection guides. The responsibilities of the main radiation safety organizations, particularly those that affect policies in the United States, are summarized below.

International Commission on Radiological Protection (ICRP)—The ICRP is responsible for providing guidance in matters of radiation safety. The operating policy of this organization is to prepare recommendations that address basic principles of radiation protection, leaving to the various national protection committees the responsibility to prepare detailed technical regulations, recommendations, or codes of practice best suited to the needs of their countries.

National Council on Radiation Protection and Measurements—In the United States, this council is the national organization responsible for adapting and providing detailed technical guidelines to implement ICRP recommendations. The council consists of technical experts who are specialists in radiation protection and scientists who are experts in disciplines that form the basis for radiation protection.

National Research Council/National Academy of Sciences—The National Research Council, which functions under the auspices of the National Academy of Sciences, integrates the broad science and technology community with the Academy's mission to further knowledge and advise the Federal Government. The National Research Council's Committee on the Biological Effects of Ionizing Radiation (BEIR Committee) prepares reports to advise the Federal Government on the health consequences of radiation exposure.

U.S. Environmental Protection Agency (EPA)—EPA has published a series of documents, *Radiation Protection Guidance to Federal Agencies*. This guidance is used as a regulatory benchmark by a number of Federal agencies, including the U.S. Department of Energy (DOE), in the realm of limiting public and occupational workforce exposures to the greatest extent possible.

U.S. Nuclear Regulatory Commission (NRC)—NRC regulates source materials, special nuclear materials, and byproduct materials used by commercial entities, such as nuclear power plants, either directly or through state agreements. NRC has promulgated "Standards for Protection Against Radiation" in Title 10 of the *Code of Federal Regulations* (CFR), Part 20 (10 CFR 20), which apply to commercial uses of the materials listed above.

U.S. Department of Energy (DOE)—DOE establishes requirements for radiological protection at DOE sites in regulations and orders. Requirements for worker protection are included in 10 CFR 835. Radiological protection of the public and environment are addressed in DOE Order 5400.5.

K.1.1.2 Limits of Radiation Exposure

Limits of exposure to members of the public and radiation workers are derived from ICRP recommendations. EPA uses National Council on Radiation Protection and Measurements and ICRP recommendations to set specific annual exposure limits (usually less than those specified by the ICRP) in its radiation protection guidance to federal agencies documents. Each regulatory organization then establishes its own set of radiation standards. The various exposure limits set by DOE and EPA for radiation workers and members of the public are given in Table K–1.

Table K–1. Exposure Limits for Members of the Public and Radiation Workers

Guidance Criteria (Organization)	Public Exposure Limits at the Site Boundary	Worker Exposure Limits
10 CFR 835 (DOE)	–	5,000 millirem per year[a]
10 CFR 835.1002 (DOE)	–	1,000 millirem per year[b]
DOE Order 5400.5 (DOE)[c]	10 millirem per year (all air pathways) 4 millirem per year (drinking-water pathways) 100 millirem per year (all pathways)	–
40 CFR 61.90–61.97 (EPA)	10 millirem per year (all air pathways)	–
40 CFR 141 (EPA)	4 millirem per year (drinking-water pathways)	–

[a] Although this measurement is a limit (or level) that is enforced by DOE, worker doses must be managed in accordance with as low as is reasonably achievable principles. Refer to footnote b.

[b] This measurement is a control level. It was established by DOE to assist in achieving its goal to maintain radiological doses as low as is reasonably achievable. DOE recommends that facilities adopt a more-limiting 500 millirem per year Administrative Control Level (DOE Standard 1098-99). Reasonable attempts have to be made by the site to maintain individual worker doses below these levels.

[c] Derived from or consistent with 40 CFR 61.90–61.97; 40 CFR 141; and 10 CFR 20.

Key: CFR=*Code of Federal Regulations*; DOE=U.S. Department of Energy; EPA=U.S. Environmental Protection Agency.

K.1.1.3 Health Effects due to Exposure to Radiation

To provide the background for discussions of impacts, this section explains the basic concepts used in the evaluation of radiation effects. Radiation can cause a variety of damaging health effects in people. The most significant effects are induced cancer fatalities, called "latent cancer fatalities" (LCFs) because the onset of cancer may take many years to develop after the radiation dose is received. In this *TC & WM EIS*, LCFs are used to measure the estimated risk due to radiation exposure.

The National Research Council's BEIR Committee has prepared a series of reports to advise the Federal Government on the health consequences of radiation exposure. Based on its 1990 report, *Health Effects of Exposure to Low Levels of Ionizing Radiation, BEIR V* (National Research Council 1990), the former Committee on Interagency Radiation Research and Policy Coordination recommended cancer risk factors of 0.0005 per rem for the public and 0.0004 per rem for working-age populations (CIRRPC 1992). In 2002, the Interagency Steering Committee on Radiation Standards (ISCORS) recommended that Federal agencies use conversion factors of 0.0006 fatal cancers per rem for mortality and 0.0008 cancers per rem for morbidity when making qualitative or semiquantitative estimates of risk from radiation exposure to members of the general public. No separate values were recommended for workers. The DOE Office of Environmental and Policy Guidance subsequently recommended that DOE personnel and contractors use the risk factors recommended by ISCORS, stating that, for most purposes, the value for the general population (0.0006 fatal cancers per rem) could be used for both workers and members of the public in National Environmental Policy Act (NEPA) analyses (DOE 2003).

Recent publications by both the BEIR Committee and the ICRP support the continued use of the ISCORS-recommended risk values. *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2* (National Research Council 2006) reported fatal cancer risk factors of 0.00048 per rem for males and 0.00066 per rem for females in a population with an age distribution similar to that of the entire U.S. population (average value of 0.00057 per rem for a population with equal numbers of males and females). ICRP Publication 103 (Valentin 2007) recommends nominal cancer risk coefficients of 0.00041 and 0.00055 per rem for adults and the general population, respectively, and estimates the risk from heritable effects to be about 3 to 4 percent of the nominal fatal cancer risk (see Table K–2).

Table K–2. Nominal Health Risk Estimators Associated with Exposure to Ionizing Radiation[a]

Exposed Population	Cancer[b]	Genetic Effects	Total
Worker (Adult)[c]	0.00041	0.00001	0.00042
Whole	0.00055	0.00002	0.00057

[a] Risk per rem (individual dose) or person-rem (population dose). For individual doses equal to or greater than 20 rem, the health risk estimators are multiplied by 2.

[b] Risk of all cancers, adjusted for lethality and quality-of-life impacts.

[c] Ages 18–64 years.

Source: Valentin 2007, Table A.4.4.

Accordingly, a risk factor of 0.0006 LCFs per rem was used in this *TC & WM EIS* to estimate risk due to radiation doses from normal operations and accidents. For high individual doses (greater than or equal to 20 rem), the health risk factor was multiplied by 2. In addition, nuclide-specific risk coefficients were developed using techniques accounting for gender, age, and exposure pathway (Eckerman et al. 1999). These coefficients, documented in the Health Effects Assessment Summary Tables database, were adopted for use in evaluation of impacts occurring in the long-term period following stabilization or closure of the high-level radioactive waste (HLW) tanks.

Using the risk factors discussed above, a calculated dose can be used to provide an estimate of the risk of an LCF. For example, if each member of a population of 100,000 people were exposed to a one-time dose of 100 millirem (0.1 rem), the collective dose would be 10,000 person-rem (100,000 persons times 0.1 rem). Using the risk factor of 0.0006 LCFs per person-rem, this collective dose is expected to cause 6 additional LCFs in this population (10,000 person-rem times 0.0006 LCFs per person-rem).

Sometimes, calculations of the number of LCFs do not yield whole numbers, and may yield a number less than 1. For example, if each individual of a population of 100,000 people were to receive an annual dose of 1 millirem (0.001 rem), the collective dose would be 100 person-rem, and the corresponding risk of an LCF would be 0.06 (100,000 persons times 0.001 rem times 0.0006 LCFs per person-rem). A fractional result should be interpreted as a statistical estimate. That is, 0.06 is the average number of LCFs expected if many groups of 100,000 people were to experience the same radiation exposure situation. For most groups, no LCFs would occur; in a few groups, 1 LCF would occur; in a very small number of groups, 2 or more LCFs would occur. The average number of LCFs over all of the groups would be 0.06 (just like the average of 0, 0, 0, and 1 is 1 divided by 4, or 0.25). In the preceding example, the most likely outcome for any single group would be 0 LCFs. In this *TC & WM EIS*, LCFs calculated for a population are presented as both the rounded whole number, representing the most likely outcome for that population, and the calculated statistical estimate of risk, presented in parentheses.

The numerical estimates of LCFs presented in this environmental impact statement (EIS) were obtained using a linear extrapolation from the nominal risk estimated for lifetime total cancer mortality that results from a dose of 0.1 gray (10 rad). Other methods of extrapolation to the low-dose region could yield higher or lower numerical estimates of LCFs. Studies of human populations exposed to low doses are inadequate to demonstrate the actual level of risk. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiologic observation. However, comprehensive review of available biological and biophysical data supports a “linear-no-threshold” risk model—in which the risk of cancer proceeds in a linear fashion at lower doses without a threshold—and that the smallest dose has the potential to cause a small increase in risk to humans (National Research Council 2006).

K.1.2 Chemicals

The reprocessing of nuclear fuels, the manufacture of nuclear materials, and the processing of fuel cycle waste entail the use of chemicals. Some of the more-hazardous chemicals could pose risks to human health, even to the point of being fatal, if they are accidentally released to the environment or if they come into contact with workers in an occupational setting. The risks from exposure are of two general types: toxic, noncarcinogenic (non-cancer-causing) effects and cancer-inducing effects. In addition, the presence of some chemicals may pose a physical hazard to humans, such as chemical burns to the skin or internal organs, explosions or thermal hazards, displacement of oxygen, or runaway chemical reactions that cause high-energy release events.

K.1.2.1 What is a Toxic or Hazardous Chemical?

Nearly every chemical that exists can be detrimental to human health under specific exposure conditions. A large number, both carcinogenic (cancer-causing) and noncarcinogenic, are specifically addressed in Occupational Safety and Health Administration (OSHA) regulations. The exposure limit or guideline for any given substance depends on the basic toxic or hazardous properties of the material, its physical properties (solid, liquid, gas, or vapor), the circumstances of exposure (inhalation, consumption of water or food, or contact with soil or contaminated surfaces), and whether the exposure occurs at a low rate during normal operations or at a high rate as a result of an accident. Occupational exposure limitations and other controls for specific toxic or hazardous chemicals are provided in various sections of the "Occupational Safety and Health Standards" (29 CFR 1910). Acute exposure concentration guidelines for more than 3,000 chemicals have been developed by DOE and others for use in hazards analyses and emergency planning and response (DOE 2008).

K.1.2.2 Usage of Chemicals

Chemical usage can be categorized by either process chemicals or chemicals that support and maintain waste management operations. Process chemicals are those required in the direct processing of wastes. The specific chemicals used depend upon the specific processes chosen. The waste being processed, with its various chemical constituents, also falls into the category of process chemicals. Nonprocess chemicals that support and maintain waste management operations are typically cleaning fluids and lubricants.

K.1.2.3 Exposure Pathways

To cause toxic effects on human biological systems, chemicals must make contact with or be introduced into the body. There are three general means of entry into the body: inhalation, ingestion, and dermal (skin) contact. The effects through a particular pathway will depend essentially on the properties of the toxic chemical, its concentration in one or more environmental media (air, water, and soil), and human behavior. Exposure may be dominated by contact with chemicals in a single medium or may reflect concurrent contacts with multiple media.

K.1.2.4 Chemical Exposure Limits and Criteria

Exposure to chemicals in occupational settings is limited to levels within applicable OSHA Permissible Exposure Limits (29 CFR 1910) or the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (ACGIH 2002). Exposures are typically maintained below the levels specified in these references by either engineered controls or the use of protective equipment.

The flammable and explosive hazards associated with chemicals are typically controlled through standards promulgated by OSHA (29 CFR 1910.106). These standards address the storage, labeling, and information required to be provided to the worker.

For accidental airborne releases of hazardous chemicals into the environment, DOE has specified criteria to be used as indicators of human health impacts resulting from acute exposures (DOE Guide 151.1–2). For each specific hazardous chemical of concern, criteria are drawn from one of the following systems (listed in order of preference): the Acute Exposure Guideline Levels (AEGLs) promulgated by EPA; the Emergency Response Planning Guidelines (ERPGs), published by the American Industrial Hygiene

Association; and the Temporary Emergency Exposure Limits (TEELs), developed by DOE. The system of AEGLs includes values for five exposure periods, ranging from 10 minutes to 8 hours. However, the ERPG and TEEL systems provide values only for exposures of 1 hour. To allow the systems to be used together, DOE has specified that the 1-hour (60-minute) AEGL values are to be used. For the chemicals addressed by each system, three exposure levels (i.e., thresholds), expressed in terms of airborne concentrations, have been developed. Although the specific definitions vary slightly between the systems, the levels of human health impact associated with exposure for 1 hour to each airborne concentration level can be paraphrased as follows: exposures of up to 1 hour at or below level 1 may result in mild, transient, adverse health effects; exposures of up to one hour above level 1 and up to level 2 should not result in irreversible or other serious health effects or symptoms that could impair a person's ability to take protective actions; exposures of up to 1 hour above level 2 and up to level 3 should not result in an experience or development of life-threatening health effects; and exposures of up to 1 hour above level 3 could result in life-threatening health effects or death. DOE has specified that level 2 is the threshold above which unacceptable human health effects may be experienced. At concentrations above level 2, action should be taken to avoid, reduce, or mitigate human exposure. Level 3 has been identified as the threshold above which severe human health effects are expected.

K.1.2.5 Health Effects of Hazardous Chemical Exposure

Various chemicals invoke different types of damage to human biological systems. The harm may even vary according to the sensitivity of each individual person exposed. Hazardous chemical releases from routine operations generally are expected to result in concentrations below levels that would cause acute toxic health effects. Acute toxic health effects generally result from short-term exposure to relatively high concentrations of the toxic contaminant, such as those resulting from accidental releases. Long-term exposure to lower concentrations can produce adverse chronic health effects, both carcinogenic and noncarcinogenic. Excess incidences of cancer are the endpoint of carcinogenic effects. However, a spectrum of chemical-specific noncancer health effects (e.g., headaches, skin irritation, neurotoxicity, immunotoxicity, reproductive and genetic toxicity, liver/kidney toxicity, and developmental toxicity) could be observed due to exposure to noncarcinogenic compounds.

K.1.2.6 Hazardous Chemical Impact Assessment

Illness, injury, and death resulting from industrial accidents in occupational settings (i.e., routine operations) are assessed in the "Industrial Safety" sections of Chapter 4 (see Sections 4.1.15, 4.2.15, 4.3.15, and 4.4.13) and summarized in Chapter 2 (see Sections 2.8.1.15, 2.8.15, and 2.8.3.15. These industrial safety impacts are included in the general industry incidence rates. The remainder of this discussion pertains to the assessment of impacts on populations other than direct facility workers. The results of these assessments for each alternative may be found in Chapter 4, Sections 4.1.11, 4.2.11, and 4.3.11, "Public and Occupational Health and Safety—Facility Accidents." Additional information is also provided in Appendix G, "Air Quality Analysis," and Appendix P, "Ecological Resources and Risk Analysis."

The exposure assessment for accidents estimated how chemicals could travel to a receptor, how these chemicals could come into contact with a receptor's body, and whether the chemicals present in the environmental medium were likely to be of sufficient concentration to cause significant adverse effects. The exposure assessment assumes inhalation to be the only pathway and air the only medium. This simplification was based principally on the volatility of the chemicals released. Normal human behavior also was considered (i.e., an individual was assumed to perform activities under normal conditions). To maximize the impact of the exposure, the analysis also assumed that the released chemicals would remain in the air with no or negligible partitioning to other media (i.e., water and ground). Thus, no dermal contact or ingestion is considered in this assessment.

To determine long-term impacts (see Appendix Q), noncancer health effects were estimated by comparing the annual concentrations of contaminants to the reference concentrations published in the *Integrated Risk Information System* (EPA 2008). The potential toxic effects on an individual from exposure to a toxic chemical were evaluated by dividing the estimated inhalation concentration of that chemical by its reference concentration value to obtain a noncancer Hazard Quotient (EPA 1989). For exposure to multiple compounds, Hazard Quotients were calculated for each toxic chemical and then summed to generate a Hazard Index as shown in the following equation

$$HI = \sum_i \frac{CA_i}{RfC_i}$$

where:

HI = Hazard Index
CA_i = concentration of the chemical i in the air, micrograms per cubic meter
RfC_i = reference concentration for chemical i, micrograms per cubic meter

The Hazard Index is the estimate of the total noncancer toxicity impact. According to the EPA risk assessment guidelines, if the Hazard Index value is less than or equal to 1, the exposure is unlikely to produce adverse toxic effects. However, if it exceeds 1, adverse toxic effects may result from exposure to the considered chemicals.

The risks from exposure to carcinogenic chemicals were evaluated using chemical-specific unit risk factors, which are estimates of the maximum lifetime probability of an individual developing cancer from exposure to the chemical and the chemical concentration in the air. The unit risk factors for carcinogenic chemicals were taken from EPA's *Integrated Risk Information System* database. Therefore, for carcinogenic chemicals, the risk was estimated by the following equation (EPA 1989):

$$\text{Risk} = 1 - e^{(-CA \times URF)}$$

where :

e = ~2.718
CA = contaminant concentration in the air, micrograms per cubic meter
URF = unit risk factor for inhalation specific to the contaminant obtained from the Integrated Risk Information System, cancers per micrograms per cubic meter

As the value in the parentheses is generally small (less than 0.01), the equation is simplified to:

$$\text{Risk} = CA \times URF$$

CA = contaminant concentration in the air, micrograms per cubic meter
URF = unit risk factor for inhalation specific to the contaminant obtained from the Integrated Risk Information System, cancers per micrograms per cubic meter

K.2 NORMAL OPERATIONS

This section describes the methodology used to evaluate the impacts of radiological emissions from tank closure, Fast Flux Test Facility (FFTF) decommissioning, and waste management activities on the public and workers. Dose assessments were performed for members of the general public near Hanford Site (and Idaho National Laboratory [INL] for selected FFTF decommissioning options) to estimate the incremental doses and related risks that would be associated with the alternatives addressed in this *TC & WM EIS*. Incremental doses for members of the public were calculated using the Hanford

Environmental Radiation Dosimetry Software System (Generation II) (GENII) computer code (Napier et al. 1988) for the following receptors:

- *Population*—The general public living within 80 kilometers (50 miles) of the facilities.
- *Maximally exposed individual (MEI)*—The MEI is a hypothetical individual member of the public located at the position near the site boundary that would yield the highest impacts during normal operations.
- *Onsite MEI*—The onsite MEI is a member of the public who works at Hanford but is not associated with DOE facilities or operations. The Columbia Generating Station and the Laser Interferometer Gravitational-Wave Observatory were the two worksites considered. This receptor would only be exposed during a normal work shift.

Impacts were also evaluated for two classes of workers: (1) radiation workers, involved workers who might be exposed to radiation while performing activities associated with the alternatives; and (2) noninvolved workers, onsite workers who may be incidentally exposed as a result of the actions taken to implement a project, but who are not directly involved in the project. Radiological impacts were determined for both radiation workers and noninvolved workers.

K.2.1 Tank Closure Alternatives

K.2.1.1 Impacts on the Public During Normal Operations

This section describes the methodology used to evaluate the impacts of radiological emissions from waste treatment and tank closure activities on the population near Hanford. Later sections of this appendix address any differences in the methodology as it was applied to radiological impacts analysis for FFTF decommissioning and waste management.

K.2.1.1.1 Approach

Under normal operations, radiological releases would occur during activities associated with tank farm operations, including waste retrieval, pretreatment, and treatment and tank farm closure. Small amounts of radioactivity from normal operations may be released in liquid effluents. The liquid effluents would be routed to the Treated Effluent Disposal Facility or the Liquid Effluent Retention Facility/Effluent Treatment Facility, which are existing, state-permitted facilities. Effluents are sampled prior to release and treated, as necessary, using best available technologies to ensure they meet state discharge limits. Based on a previous environmental assessment (DOE 1992), discharges from these facilities were determined to be of no significant impact and therefore are not expected to make a distinguishable difference in the calculated doses to members of the public.

For purposes of evaluating the impacts of radiological air emissions, the activities and facilities associated with each Tank Closure alternative are treated as originating from one of three locations: the Waste Treatment Plant (WTP), the 200-East Area, or the 200-West Area. Releases modeled as originating from the WTP included those from the vitrification and pretreatment facilities. All other activities and facilities in the 200-East Area were modeled as if they were located at the 200-East Area Supplemental Treatment Technology Site (STTS-East) in the southeast corner of the 200-East Area (see Figure K–1). This location has been identified for supplemental technologies (e.g., bulk vitrification, cast stone, or steam reforming) if they are deployed in the 200-East Area. This location was selected because the emissions of the supplemental technologies would be substantially higher for most radionuclides than those associated with other project-related, 200-East Area activities, such as normal tank farm operations or waste retrieval. Similarly, emissions from the 200-West Area were modeled as if they arose from the 200-West Area STTS (STTS-West) in the southeast corner of the 200-West Area (see Figure K–1), the site for deployment of supplemental technologies in the 200-West Area. Although tank farms are located at a number of positions within the 200-East and 200-West Areas (all tank farms are within 2.6 kilometers [1.6 miles] of STTS-East and -West), the simplifying assumption that radiological emissions other than those from the WTP would come from these STTSs added a level of conservatism to the analysis because the STTSs would be located closer to the principal receptors in the predominant downwind direction, the population centers of Richland, Pasco, and Kennewick, and closer to the MEI, located eastward.

The activities associated with each of these emission source locations are summarized as follows:

WTP:

- HLW vitrification
- Low-activity waste (LAW) vitrification
- Cesium and strontium de-encapsulation and processing
- Waste pretreatment
- Sulfate removal

STTS-East:

- Tank farm operations
- Tank waste retrieval
- Tank farm facilities deactivation
- Bulk vitrification
- Cast stone
- Steam reforming
- Remote-handled transuranic (TRU) waste treatment
- Contact-handled TRU waste treatment
- Tank removal
- Soil removal

STTS-West:

- Tank farm operations
- Tank waste retrieval
- Tank farm facilities deactivation
- Bulk vitrification
- Cast stone
- Steam reforming
- Contact-handled TRU waste treatment
- Tank removal
- Soil removal

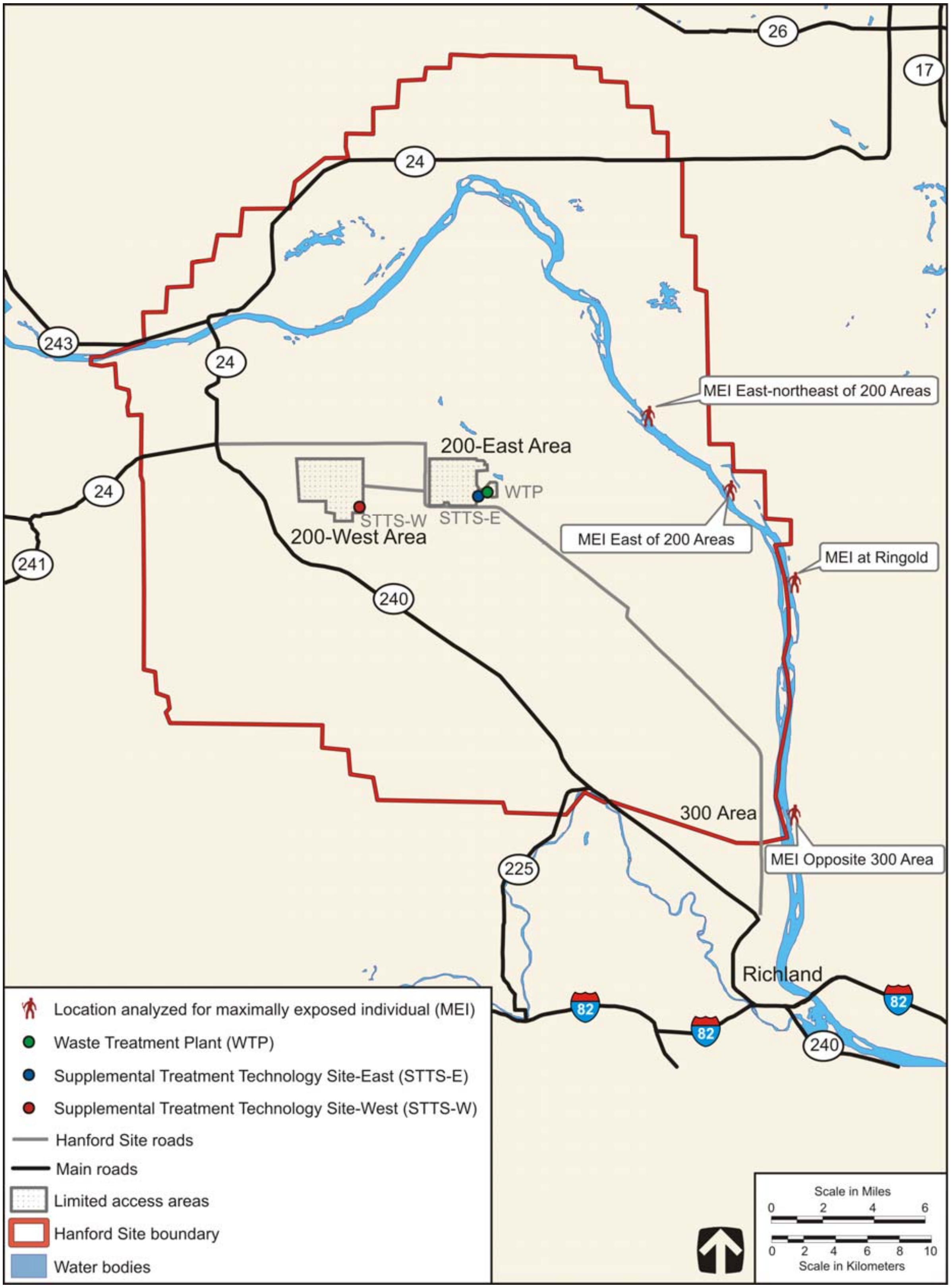

Figure K–1. Locations Assumed to Be Sources of Radiological Air Emissions and Possible Locations of the Maximally Exposed Individual

K.2.1.1.1.1 Exposure Scenarios

The analysis of radioactive releases from normal operations evaluated the impacts on three public receptors: the general population living within 80 kilometers (50 miles) of the release locations, a hypothetical MEI, and an onsite MEI. The general population, the MEI, and the onsite MEI would receive external as well as internal doses from radioactive releases.

The population living within 80 kilometers (50 miles) of the release locations would be exposed to atmospheric releases of radioactive materials that are carried by the wind. Therefore, the meteorological conditions at Hanford and the population distribution around the site would affect the dose received by the population. Details of the population distribution and the meteorological conditions are presented in Section K.2.1.1.3, "Input Parameters." Members of the general population would receive an external exposure to radiation from the radioactive plume as it passes and from materials that are deposited on the ground. They would also receive an internal dose from the inhalation and ingestion of radionuclides. Members of the population would receive an internal dose through inhalation of contaminated air as the plume passes and inhalation of resuspended materials that are deposited on the ground. They were also assumed to receive an internal dose by consuming produce grown in a family garden and animal products from regional livestock contaminated by deposition and uptake of radioactive materials. The assumed respiration rate and the amount of contaminated food consumed are discussed in Section K.2.1.1.3.

For the purpose of analyzing the impacts of radiological releases to the air from normal operations, the MEI was assumed to be an individual who lives near the Hanford boundary in the location that results in the maximum impact. The GENII computer code (Napier et al. 1988), which was used to project the impacts of radiological releases from normal operations, was also used to evaluate possible locations of the MEI. Using the joint frequency distribution of meteorological data for the Hanford 200 Areas, the assumed emission source locations (the WTP, STTS-East, and STTS-West), and the release inventories, MEI analyses were performed for multiple locations on the bank of the Columbia River opposite Hanford (see Figure K–1). These analyses showed that the MEI would be located at one of the following locations: (1) a point about 11 kilometers (6.8 miles) east-northeast of the WTP, (2) a point about 13.1 kilometers (8.1 miles) east of the WTP, or (3) a point along the Ringold section of the Columbia River about 18.2 kilometers (11.3 miles) east-southeast of the WTP. A point across the river from the Hanford 300 Area, about 22 kilometers (13.7 miles) southeast of the WTP, was also considered but never yielded the maximum result. As the relative emissions from the three source locations change, the location of the MEI would also change. Generally, the more the emissions are dominated by elevated releases from the WTP (modeled as coming from the 61-meter-[200-foot-] high stack), the more likely the MEI would be to the east or east-southeast. Although it is expected that the supplemental treatment technologies would have elevated releases (e.g., from stack emissions), no detailed design information for the associated facilities was available to use in the analysis. Therefore, it was assumed that the emissions from the supplemental treatment facilities at STTS-East and -West would be at ground level. Emissions modeled as arising from ground-level sources would not disperse as much as those from elevated release points. As reduced dispersal would mean more-concentrated plumes, this assumption resulted in a conservative analysis that overestimated the dose impact.

The MEI would be exposed in the same manner as the general population, that is, by external exposure to the plume and deposited radioactive materials and by internal exposure from inhalation of radioactive materials and ingestion of contaminated food. The MEI was assumed to consume a larger quantity of produce grown in a family garden.

The onsite MEI, a member of the public whose workday is spent at the Columbia Generating Station or Laser Interferometer Gravitational-Wave Observatory at Hanford, would receive an external dose from the plume and material deposited on the ground and an internal dose from inhalation of the plume and resuspended radioactive materials deposited on the ground.

K.2.1.1.2 Modeling

The radiological impacts of releases during normal operations of the facilities used to retrieve and treat tank waste and to deactivate and close tank farm facilities were calculated using Version 1.485 of the GENII computer code (Napier et al. 1988). Site-specific input data were used, including location, meteorology, population, and source terms. This section briefly describes GENII and outlines the approach used for estimating impacts of normal operations.

K.2.1.1.2.1 Description of the GENII Code

The GENII computer code, developed by Pacific Northwest National Laboratory, is an integrated system of models (referred to as “modules”) that analyzes environmental contamination resulting from acute or chronic releases to, or initial contamination in, air, water, or soil. The GENII computer code calculates radiation doses to individuals and populations. Its assumptions, technical approach, method, and quality assurance are well documented. The code has gone through an extensive quality assurance and quality control process, which included comparing results from model computations with those from manual calculations and performing internal and external peer reviews (Napier et al. 1988).

The GENII code consists of several modules for various applications, as described in the code manual (Napier et al. 1988). For this *TC & WM EIS*, only the ENVIN, ENV, and DOSE modules were used. The output of one module is stored in a file that can be used by the next module in the system. The functions of the three modules used in this EIS are discussed below.

ENVIN

The ENVIN module of the GENII code controls the reading of input files and organizes input for optimal use in the environmental transport and exposure module, ENV. The ENVIN module interprets the basic input, reads the basic GENII data libraries and other optional input files, and organizes the input into sequential segments based on radionuclide decay chains.

A standardized file that contains scenario, control, and inventory parameters is used as input to ENVIN. Radionuclide inventories can be entered as functions of releases to air or water, concentrations in basic environmental media (air, soil, or water), or concentrations in foods. If certain atmospheric dispersion options have been selected, this module generates tables of atmospheric dispersion parameters that are used in later calculations. The ENVIN module prepares the data transfer files that are used as input by the ENV module; ENVIN generates the first portion of the calculation documentation, the run input parameters report.

ENV

The ENV module calculates the environmental transfer, uptake, and human exposure to radionuclides that result from the chosen scenario for the user-specified source term. The module reads the input files from ENVIN and then, for each radionuclide chain, sequentially performs the preliminary calculations to establish the conditions at the start of the exposure scenario. Environmental concentrations of radionuclides at the start are established by assuming decay of pre-existing sources, considering biotic transport of existing subsurface contamination, and defining soil contamination from continuing atmospheric or irrigation depositions. For each year of postulated exposure, the module then estimates the concentrations of each radionuclide in the chain in air, surface soil, deep soil, groundwater, and surface water. Human exposure and intake of each radionuclide are calculated for (1) pathways of external exposure from finite or infinite atmospheric plumes; (2) external exposure from contaminated soil, sediments, and water; (3) external exposure from special geometries (e.g., a shoreline exposure); (4) internal exposure from inhalation; and (5) internal exposure from consumption of terrestrial foods, aquatic foods, drinking water, and animal products, and inadvertent intake of soil. The intermediate information on annual media concentrations and intake rates is written to data transfer files. Although these may be accessed directly, they are usually used as input to the DOSE module of GENII.

DOSE

The DOSE module reads the intake and exposure rates defined by the ENV module and converts the data to radiation dose.

K.2.1.1.3 Input Parameters

Site-specific and scenario-dependent data are used as input to the GENII computer code. The following paragraphs describe the development of data that were used in the analyses of doses to the general public and the MEI near Hanford.

K.2.1.1.3.1 Meteorological Data

The GENII computer code uses a data set of the joint frequency distribution of windspeed, direction, and Pasquill atmospheric stability class as input to modeling the atmospheric transport of radioactive emissions. Tables K–3 and K–4 present the joint frequency distribution data for the Hanford 200 Areas for the 61-meter (200-foot) and 9-meter (30-foot) heights, respectively. These data represent the 10-year averages of data collected from 1997 through 2006 at the 200 Area Hanford Meteorological Station (Burk 2007). Wind rose representations of these data are included in Chapter 3, Section 3.2.4.1.

In the current *TC & WM EIS* analysis, the meteorological data from the 61-meter (200-foot) height were used in evaluating the impacts of releases from the WTP. This height is consistent with the current WTP design in which most emissions would be from a 61-meter (200-foot) height. The 9-meter (30-foot) height joint frequency data were used as input to model the transport of releases from STTS-East and -West.

Table K–3. Joint Frequency Distribution for the Hanford Site 200 Areas at a 61-Meter Height

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.78	A	0.11	0.12	0.14	0.12	0.12	0.1	0.08	0.07	0.07	0.04	0.05	0.04	0.04	0.06	0.07	0.08
	B	0.05	0.06	0.07	0.06	0.06	0.04	0.04	0.04	0.02	0.03	0.03	0.03	0.04	0.03	0.04	0.06
	C	0.05	0.06	0.06	0.04	0.04	0.05	0.05	0.03	0.03	0.03	0.01	0.02	0.02	0.02	0.03	0.05
	D	0.41	0.41	0.39	0.33	0.33	0.25	0.38	0.3	0.19	0.18	0.17	0.17	0.2	0.24	0.32	0.41
	E	0.21	0.18	0.17	0.18	0.2	0.2	0.33	0.23	0.18	0.15	0.16	0.15	0.18	0.22	0.23	0.25
	F	0.17	0.15	0.12	0.14	0.13	0.13	0.18	0.17	0.12	0.13	0.15	0.15	0.2	0.15	0.19	0.18
	G	0.05	0.06	0.05	0.06	0.06	0.05	0.08	0.08	0.08	0.07	0.06	0.06	0.09	0.11	0.1	0.08
2.5	A	0.58	0.64	0.5	0.47	0.62	0.4	0.5	0.46	0.27	0.24	0.24	0.16	0.18	0.24	0.48	0.77
	B	0.17	0.17	0.14	0.12	0.13	0.11	0.16	0.1	0.08	0.09	0.08	0.07	0.07	0.11	0.21	0.26
	C	0.14	0.12	0.1	0.09	0.08	0.09	0.12	0.08	0.06	0.05	0.06	0.04	0.04	0.07	0.14	0.19
	D	0.64	0.47	0.41	0.37	0.43	0.37	0.49	0.39	0.23	0.2	0.24	0.27	0.34	0.57	1.09	1
	E	0.32	0.27	0.19	0.2	0.26	0.26	0.37	0.33	0.19	0.17	0.27	0.34	0.57	0.81	0.91	0.55
	F	0.26	0.15	0.14	0.1	0.15	0.15	0.31	0.3	0.21	0.2	0.26	0.41	0.66	0.82	0.86	0.57
	G	0.07	0.05	0.05	0.05	0.05	0.06	0.07	0.12	0.08	0.1	0.17	0.22	0.33	0.33	0.29	0.16
4.5	A	0.29	0.3	0.2	0.1	0.14	0.09	0.08	0.07	0.09	0.18	0.28	0.3	0.14	0.26	0.74	0.44
	B	0.08	0.09	0.03	0.01	0.02	0.02	0.01	0.02	0.03	0.05	0.08	0.09	0.06	0.12	0.27	0.1
	C	0.07	0.04	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.03	0.05	0.06	0.04	0.09	0.21	0.08
	D	0.18	0.13	0.08	0.06	0.12	0.09	0.08	0.11	0.1	0.16	0.28	0.32	0.35	0.82	1.34	0.35
	E	0.14	0.1	0.11	0.09	0.15	0.13	0.09	0.2	0.1	0.16	0.31	0.53	1.06	1.85	1.5	0.35
	F	0.09	0.05	0.03	0.03	0.04	0.05	0.06	0.21	0.1	0.07	0.19	0.47	1.02	1.63	1.41	0.39
	G	0.02	0	0	0	0.01	0	0.01	0.05	0.03	0.03	0.07	0.17	0.38	0.47	0.47	0.15
7.0	A	0.08	0.14	0.08	0.02	0.02	0.01	0	0.01	0.03	0.09	0.27	0.34	0.1	0.23	0.52	0.1
	B	0.02	0.03	0.01	0	0	0	0	0.01	0.01	0.02	0.06	0.09	0.04	0.09	0.11	0.02
	C	0.01	0.01	0.01	0	0.01	0	0	0.01	0.01	0.01	0.05	0.06	0.02	0.06	0.09	0.01
	D	0.06	0.07	0.05	0.01	0.01	0	0.01	0.05	0.1	0.16	0.33	0.4	0.35	1	0.96	0.07
	E	0.04	0.06	0.03	0.01	0.02	0.01	0.02	0.1	0.11	0.16	0.41	0.77	0.98	2.58	1.56	0.11
	F	0.02	0.03	0.02	0.01	0.01	0	0.01	0.06	0.03	0.02	0.07	0.29	0.42	1.19	1.18	0.09
	G	0	0	0	0	0	0	0	0.03	0.01	0.01	0.01	0.05	0.08	0.17	0.63	0.05

Table K–3. Joint Frequency Distribution for the Hanford Site 200 Areas at a 61-Meter Height *(continued)*

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**
9.6	A	0.01	0.02	0.03	0	0	0	0	0	0	0.04	0.17	0.2	0.05	0.12	0.35	0.02
	B	0	0.01	0.01	0	0	0	0	0	0	0.01	0.05	0.05	0.01	0.03	0.07	0
	C	0	0.01	0.01	0	0	0	0	0	0	0.01	0.03	0.03	0	0.02	0.06	0
	D	0.01	0.03	0.02	0	0	0	0	0.02	0.06	0.15	0.33	0.26	0.14	0.65	0.65	0.01
	E	0.01	0.03	0.04	0.01	0	0	0	0.05	0.13	0.17	0.36	0.34	0.21	1	0.91	0.01
	F	0	0	0	0	0	0	0	0	0.01	0.01	0.03	0.05	0.04	0.12	0.16	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.08	0
12.5	A	0	0	0	0	0	0	0	0	0	0.01	0.11	0.09	0.02	0.04	0.18	0
	B	0	0	0	0	0	0	0	0	0	0	0.04	0.02	0.01	0.01	0.05	0
	C	0	0	0	0	0	0	0	0	0	0.01	0.02	0.02	0.01	0.01	0.04	0
	D	0	0	0.01	0	0	0	0	0.01	0.06	0.14	0.28	0.15	0.03	0.3	0.45	0
	E	0	0.01	0.01	0	0	0	0	0.02	0.05	0.12	0.18	0.11	0.03	0.3	0.26	0
	F	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.9	A	0	0	0	0	0	0	0	0	0	0.01	0.04	0.02	0.01	0	0.03	0
	B	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0.01	0
	C	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0.01	0
	D	0	0	0	0	0	0	0	0	0.01	0.08	0.11	0.03	0.01	0.02	0.04	0
	E	0	0	0	0	0	0	0	0	0	0.03	0.06	0.04	0.01	0.03	0.04	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.8	A	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0.02	0.02	0.02	0.01	0	0	0
	E	0	0	0	0	0	0	0	0	0	0.01	0.04	0.01	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: To convert meters to feet, multiply by 3.281.
Source: Burk 2007.

Table K–4. Joint Frequency Distribution for the Hanford Site 200 Areas at a 9-Meter Height

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.78	A	0.29	0.31	0.34	0.27	0.28	0.25	0.19	0.17	0.13	0.12	0.12	0.1	0.1	0.13	0.17	0.22
	B	0.12	0.11	0.12	0.09	0.08	0.09	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.1
	C	0.09	0.09	0.1	0.05	0.06	0.07	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.06
	D	0.68	0.56	0.57	0.44	0.4	0.39	0.42	0.39	0.3	0.24	0.26	0.3	0.35	0.41	0.55	0.67
	E	0.36	0.29	0.27	0.24	0.27	0.32	0.47	0.4	0.35	0.34	0.48	0.53	0.55	0.52	0.57	0.46
	F	0.24	0.16	0.17	0.17	0.17	0.19	0.27	0.25	0.33	0.34	0.39	0.38	0.41	0.39	0.38	0.3
	G	0.09	0.07	0.1	0.09	0.08	0.08	0.11	0.1	0.1	0.11	0.1	0.1	0.13	0.13	0.14	0.11
2.5	A	0.72	0.53	0.42	0.36	0.46	0.47	0.45	0.28	0.24	0.24	0.32	0.25	0.2	0.29	0.66	0.78
	B	0.18	0.14	0.11	0.11	0.1	0.13	0.13	0.07	0.08	0.08	0.09	0.08	0.08	0.13	0.27	0.28
	C	0.16	0.11	0.09	0.08	0.07	0.1	0.1	0.08	0.04	0.04	0.07	0.06	0.05	0.09	0.21	0.22
	D	0.62	0.36	0.29	0.27	0.37	0.4	0.49	0.34	0.23	0.23	0.31	0.39	0.52	0.96	1.56	1.08
	E	0.25	0.15	0.13	0.14	0.23	0.31	0.38	0.38	0.33	0.32	0.63	1.13	2.04	2.26	1.69	0.56
	F	0.12	0.06	0.06	0.06	0.09	0.14	0.3	0.45	0.42	0.5	0.89	1.78	2.15	2.12	1.55	0.44
	G	0.04	0.02	0.02	0.03	0.03	0.03	0.08	0.19	0.2	0.24	0.37	0.75	0.62	0.69	0.59	0.11
4.5	A	0.21	0.22	0.16	0.06	0.08	0.04	0.02	0.04	0.05	0.14	0.27	0.4	0.2	0.35	0.76	0.27
	B	0.05	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.09	0.13	0.08	0.13	0.23	0.06
	C	0.03	0.03	0.01	0	0.01	0	0.01	0.01	0.01	0.02	0.06	0.08	0.04	0.09	0.18	0.04
	D	0.12	0.12	0.07	0.03	0.05	0.03	0.03	0.08	0.11	0.21	0.36	0.53	0.58	1.18	1.36	0.18
	E	0.05	0.05	0.04	0.02	0.02	0.01	0.04	0.12	0.15	0.19	0.46	0.91	1.24	2.28	1.57	0.11
	F	0	0	0	0.01	0.01	0	0.01	0.07	0.04	0.03	0.12	0.39	0.31	0.53	0.52	0.03
	G	0	0	0	0	0	0	0	0.02	0.01	0.01	0.04	0.2	0.04	0.17	0.21	0.01
7.0	A	0.02	0.06	0.05	0.01	0	0	0	0	0.01	0.05	0.25	0.37	0.09	0.2	0.5	0.07
	B	0	0.01	0.01	0	0	0	0	0	0.01	0.02	0.06	0.09	0.03	0.04	0.12	0.01
	C	0	0	0.01	0	0	0	0	0	0.01	0.01	0.04	0.06	0.02	0.04	0.09	0
	D	0.01	0.03	0.04	0.01	0	0	0	0.02	0.1	0.2	0.43	0.39	0.2	0.7	0.92	0.02
	E	0.01	0.03	0.03	0.01	0	0	0	0.05	0.14	0.21	0.39	0.29	0.17	0.57	0.76	0.01
	F	0	0	0	0	0	0	0	0	0.01	0	0.01	0.01	0.01	0.01	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table K–4. Joint Frequency Distribution for the Hanford Site 200 Areas at a 9-Meter Height *(continued)*

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**
9.6	A	0	0	0	0	0	0	0	0	0	0.01	0.1	0.13	0.04	0.05	0.16	0
	B	0	0	0	0	0	0	0	0	0	0	0.04	0.03	0.01	0.01	0.04	0
	C	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.01	0.01	0.03	0
	D	0	0	0.01	0	0	0	0	0	0.04	0.11	0.22	0.13	0.03	0.1	0.23	0
	E	0	0	0.01	0	0	0	0	0.01	0.01	0.04	0.08	0.06	0.02	0.06	0.1	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	A	0	0	0	0	0	0	0	0	0	0.01	0.02	0.02	0	0	0.02	0
	B	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0.03	0.03	0.03	0.01	0.01	0	0
	E	0	0	0	0	0	0	0	0	0	0.01	0.02	0.01	0	0	0.01	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.9	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.8	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: To convert meters to feet, multiply by 3.281.

Source: Burk 2007.

K.2.1.1.3.2 Population Data

The analysis considered the impacts on the populations residing within an 80-kilometer (50-mile) radius of the sources of emissions on the 200 Area plateau, the WTP, STTS-East, and STTS-West: 447,354; 451,556; and 488,897 people, respectively. The population data used in the analysis were taken from the 2000 census. Data from this year were used to provide a common basis for comparing impacts among the alternatives. Projections of future population growth were not been made because the long duration of some alternatives would make such projections extremely speculative. Population distributions within 80 kilometers (50 miles) of the WTP, STTS-East, and STTS-West are shown in Figures K–2 through K–4 respectively. These figures illustrate the population distribution used in the calculations conducted with the GENII computer code. Concentric circles shown in each figure are centered on the locations discussed above and have the following radii: 1.6 kilometers (1 mile), 3.2 kilometers (2 miles), 4.8 kilometers (3 miles), 6.4 kilometers (4 miles), 8.0 kilometers (5 miles), 16 kilometers (10 miles), 32 kilometers (20 miles), 48 kilometers (30 miles), 64 kilometers (40 miles), and 80 kilometers (50 miles). The population in each sector was calculated using data from the 2000 census (Census 2007a, 2007b). All sectors located within 8.0 kilometers (5 miles) and many of the sectors located within 16 kilometers (10 miles) of the center points have zero populations because no one is allowed to reside on the Hanford Site.

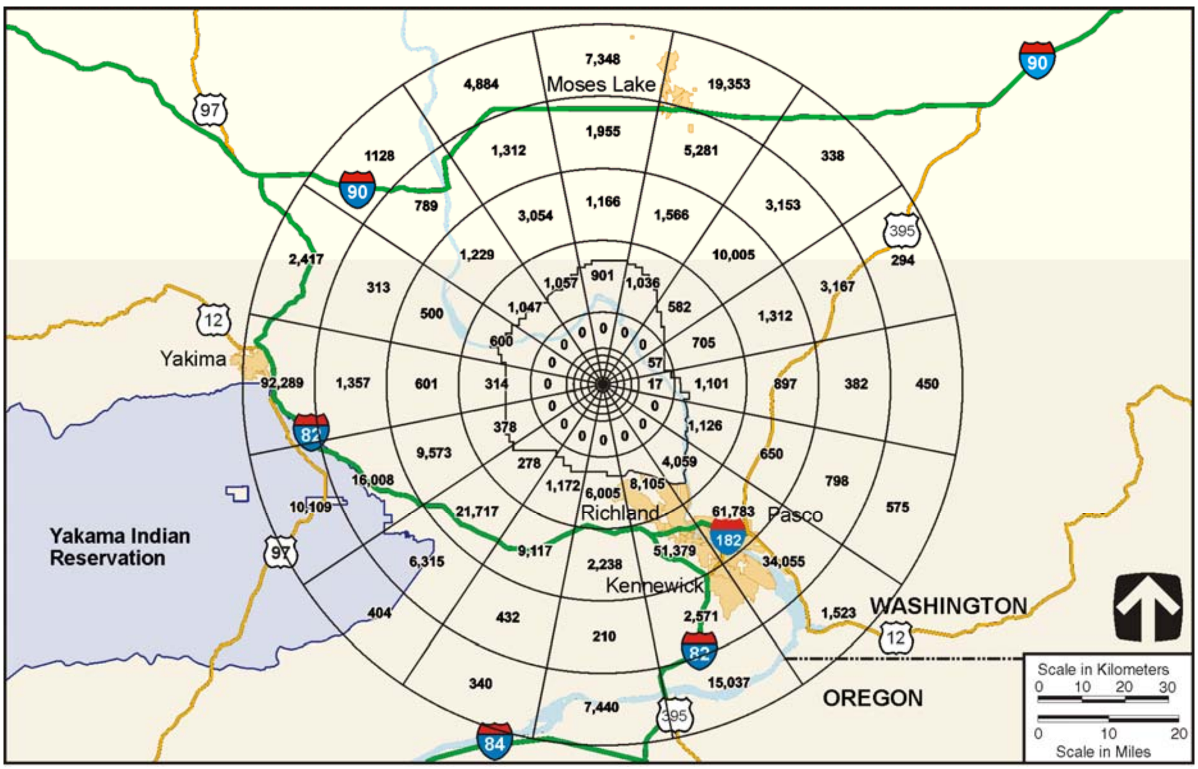

Figure K–2. Population Distribution Within 80 Kilometers (50 Miles) of the Waste Treatment Plant

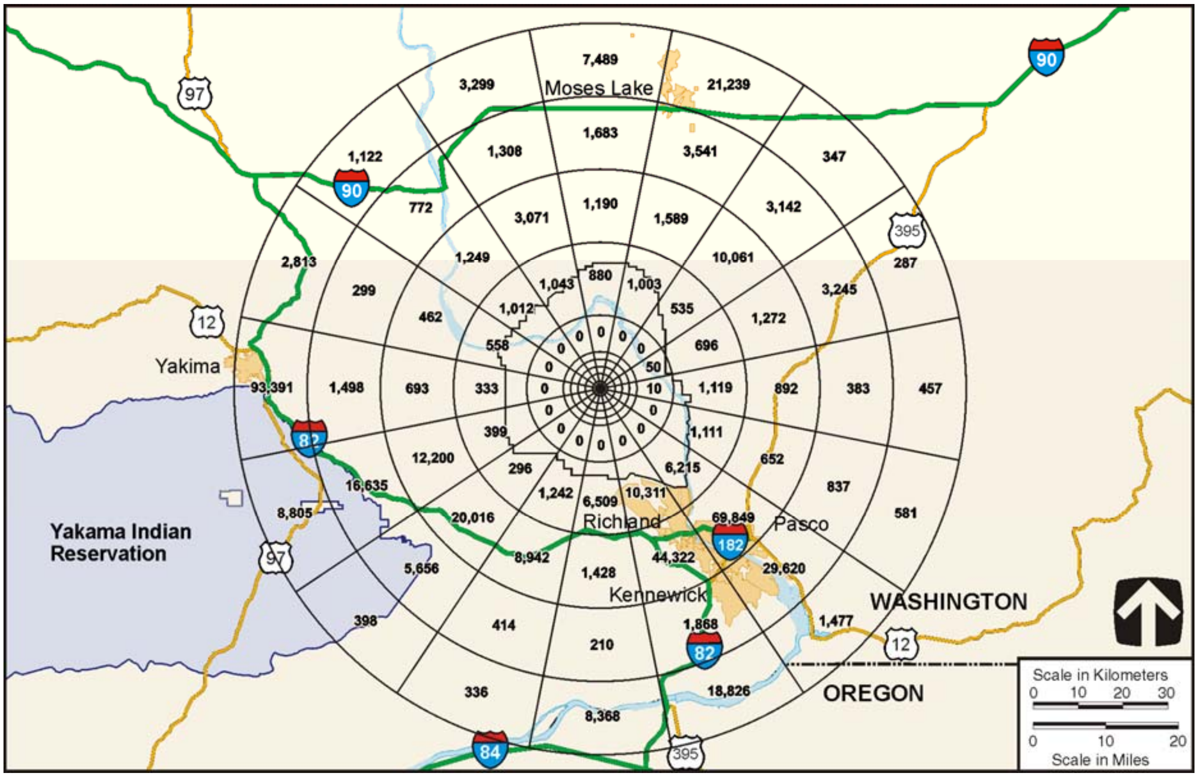

Figure K–3. Population Distribution Within 80 Kilometers (50 Miles) of the 200-East Area Supplemental Treatment Technology Site

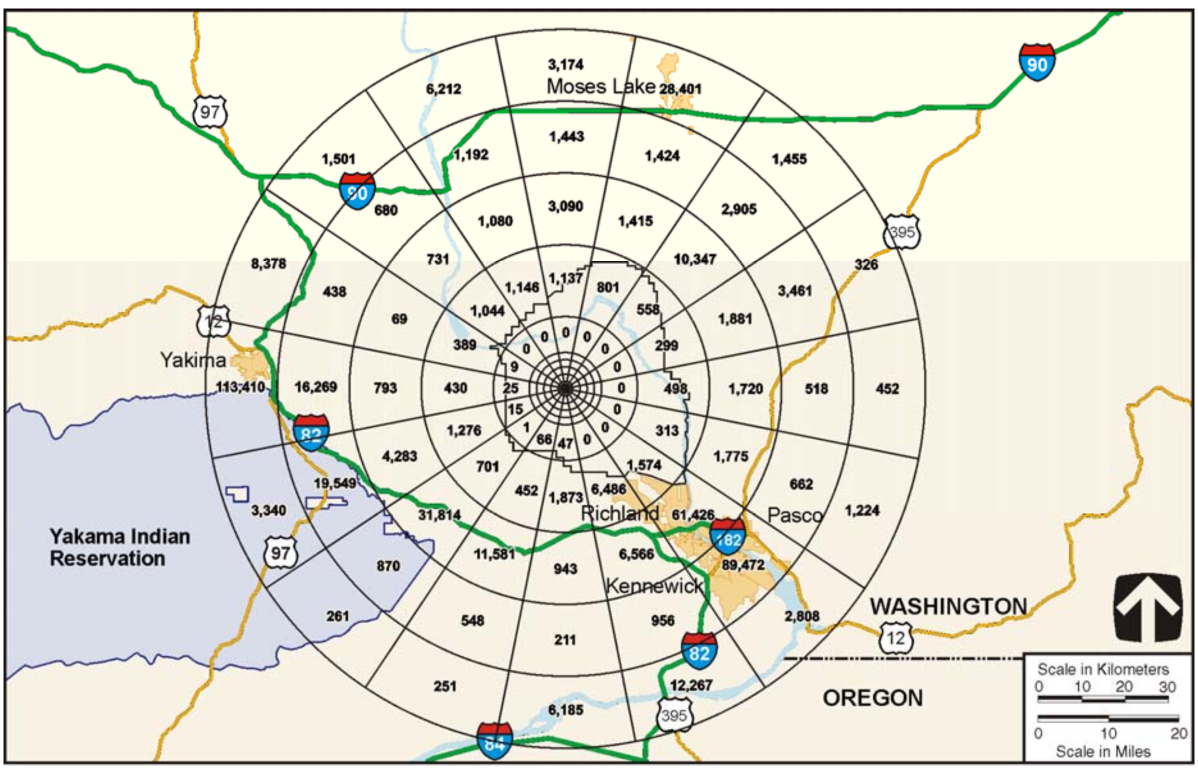

Figure K–4. Population Distribution Within 80 Kilometers (50 Miles) of the 200-West Area Supplemental Treatment Technology Site

K.2.1.1.3.3 Exposure Data

During normal operations of managing, retrieving, pretreating, and treating tank waste and deactivating and closing tanks and tank farm facilities, the general population would be exposed to atmospheric emissions. Exposure parameters for evaluating dose to the general population, the MEI, and the onsite MEI were primarily based on parameters from the *Hanford Site Risk Assessment Methodology (HSRAM)* (DOE 1995). As discussed below, the *HSRAM* parameters were modified, combined, or replaced where there was a reasonable basis for doing so. The parameters used for the general population, the MEI, and the onsite MEI are shown in Table K–5. Certain inputs to the GENII computer code required the number of hours per year that an exposure could occur. A full year was defined as 8,766 hours, or 365.25 days, to account for leap years.

Table K–5. Exposure Input Parameters for Members of the Public

Medium	Exposure Pathway	Rate	Reference
Population			
Air (plume)	External	8,766 hours per year	Napier et al. 1988
	Internal – inhalation	20 cubic meters per day	DOE 1995
Soil	External	2,192 hours per year	Napier et al. 1988
	Internal – ingestion	120 milligrams per day	EPA 2000a
Food[a]	Internal – ingestion of:		
	Leafy vegetable	21 kilograms per year	Beyeler et al. 1999
	Other vegetable	29.2 kilograms per year	DOE 1995
	Fruit	15.3 kilograms per year	DOE 1995
	Grain	14 kilograms per year	Beyeler et al. 1999
	Meat	27.8 kilograms per year	DOE 1995
	Dairy	110 kilograms per year	DOE 1995
	Poultry	28.5 kilograms per year	Beyeler et al. 1999
	Eggs	19 kilograms per year	Beyeler et al. 1999
Maximally Exposed Individual			
Air (plume)	External	8,766 hours per year	Napier et al. 1988
	Internal – inhalation	20 cubic meters per day	DOE 1995
Soil	External	4,380 hours per year	Napier et al. 1988
	Internal – ingestion	120 milligrams per day	EPA 2000a
Food[a]	Internal – ingestion of:		
	Leafy vegetable	65 kilograms per year	Beyeler et al. 1999, DOE and Ecology 1996
	Other vegetable	120 kilograms per year	DOE and Ecology 1996
	Fruit	120 kilograms per year	DOE and Ecology 1996
	Grain	90 kilograms per year	Beyeler et al. 1999
	Meat	27.8 kilograms per year	DOE and Ecology 1996
	Dairy	110 kilograms per year	DOE 1995
	Poultry	28.5 kilograms per year	Beyeler et al. 1999
	Eggs	19 kilograms per year	Beyeler et al. 1999
Onsite Maximally Exposed Individual			
Air (plume)	External	2,000 hours per year	DOE 1995
	Internal – inhalation	2,000 hours per year	DOE 1995
Soil	External	1,168 hours per year	DOE 1995
	Internal – ingestion	50 milligrams per day	DOE 1995

[a] Food consumption rates represent the portion of the diet consisting of contaminated food.

Note: To convert cubic meters to cubic feet, multiply by 35.315; milligrams to ounces, by 0.00003527; kilograms to pounds, by 2.2046.

Members of the public would be exposed via two pathways by the passing plume. They would receive an external dose 24 hours per day from direct exposure to the passing plume. They also would receive an internal dose from breathing 20 cubic meters (706 cubic feet) of contaminated air per day (DOE 1995). Respiration of resuspended radionuclides that have been deposited on the ground was also included in the dose from inhalation.

Radionuclides deposited on the ground represent another means of exposure because they may cause an external exposure to individuals near the contamination. In this analysis, it was assumed that an average member of the public would be exposed 25 percent of the time, 2,192 hours, during the entire year, and the MEI would be exposed 50 percent of the time, 4,380 hours per year. Soil could also be inadvertently ingested, resulting in an internal dose. The *HSRAM* assumes ingestion rates of 200 milligrams (0.71 ounces) per day for children and 100 milligrams (0.35 ounces) per day for adults. In this analysis, a single rate of 120 milligrams (0.42 ounces) per day was used (EPA 2000a). This is the weighted average of the values in the *HSRAM*—ingestion of 200 milligrams (0.71 ounces) per day over a 6-year period and ingestion of 100 milligrams (0.35 ounces) per day over a 24-year period.

Exposure of members of the public was also assumed to occur as a result of a portion of their diet coming from fruits and vegetables grown in a family garden. These fruits and vegetables could become contaminated by the deposition of radioactive materials. When consumed, the radioactive materials would result in an internal dose. Consistent with the *HSRAM*, members of the general public were assumed to consume 15.3 kilograms (33.7 pounds) of fruit and 29.2 kilograms (64.2 pounds) of non-leafy vegetables per year that have become contaminated by deposition of radioactive material (DOE 1995). Additionally, individuals were assumed to consume 21 kilograms (46.2 pounds) per year of leafy vegetables and 14 kilograms (30.8 pounds) per year of grains that have become contaminated (Beyeler et al. 1999). The MEI was assumed to consume a larger portion of his or her diet from fruits and vegetables grown in a family garden. Annual consumption was assumed to be 120 kilograms (264 pounds) of fruit, 120 kilograms (264 pounds) of non-leafy vegetables, 65 kilograms (143 pounds) of leafy vegetables, and 90 kilograms (198 pounds) of grains (Beyeler et al. 1999; DOE and Ecology 1996).

Analysis of the radiological impact on members of the public was based on an assumption that a portion of their diet would come from animal products from livestock raised in the area. Consuming forage that has been contaminated through the deposition of radioactive material would expose the animals. A person was assumed to consume 27.8 kilograms (61.2 pounds) of meat per year, consisting of 27.4 kilograms (60.3 pounds) of beef and 0.4 kilograms (0.9 pounds) of venison (DOE 1995). The consumption rate of contaminated dairy products was assumed to be 110 kilograms (242 pounds) per year (DOE 1995). The entire annual intake of 28.5 kilograms (62.7 pounds) of poultry and 19 kilograms (41.8 pounds) of eggs was assumed to come from local sources (Beyeler et al. 1999). The MEI consumption of meat, poultry, eggs, and dairy products was assumed to be the same as consumption by the members of the public.

Exposure parameter values for the onsite MEI dose analysis are shown in Table K–5. The onsite MEI was assumed to be exposed during the workday. Exposure to the passing plume and inhalation were assumed to occur for a normal 40-hour work week, or about 2,000 hours per year. Exposure to deposited materials on the ground was assumed to occur for only a portion of this time, about 1,168 hours per year. Ingestion of resuspended soil would result in consumption of 50 milligrams (0.0018 ounces) per day.

K.2.1.1.3.4 Source Terms

Doses and risks to the public from the atmospheric release of radionuclides during normal operations were estimated for the year of maximum impact and for the life of the project for each Tank Closure alternative. The atmospheric releases were evaluated as arising from three locations: the WTP, STTS-East, and STTS-West. Therefore, six sets of source terms were developed for each Tank Closure alternative.

Radionuclides that would dominate the dose to the public through the air pathway were selected for detailed analysis. These were the radionuclides that are known to be the main contributors to the air pathway dose or that are of specific interest. To ensure that no major radionuclides were eliminated from the detailed analysis, a screening analysis was performed. In the screening analysis, it was assumed that one millionth of the tank farms' Best-Basis Inventory would enter an air stream through a treatment system that would remove 99.95 percent of the particulates. Exceptions were hydrogen-3 (tritium), carbon-14, and iodine-129, all of which would likely be in a gaseous state, are easily volatilized, and are poorly captured in air treatment systems. In the screening analysis, the entire Best-Basis Inventory of these three radionuclides was assumed to be released. Inhalation dose conversion factors (Eckerman, Wolburst, and Richardson 1988) were multiplied by the released inventory to determine the radionuclides in the tank farm inventory of greatest potential impact. Table K–6 lists the radionuclides considered in the detailed dose analysis. These radionuclides account for 99.99 percent of the dose estimated from the screening analysis. A second screening analysis was done that assumed that the air treatment system removed 99 percent of the iodine-129. This assumption is consistent with the way iodine-129 releases from the WTP, Bulk Vitrification Facilities, and Cast Stone Facilities were modeled in the dose analysis. This second screening also showed that the radionuclides selected for detailed analysis were responsible for 99.99 percent of the estimated dose.

Table K–6. Radionuclides Included in Air Pathway Dose Analysis

Radionuclide	**Symbol**
Hydrogen-3 (tritium)	H-3
Carbon-14	C-14
Cobalt-60	Co-60
Strontium-90	Sr-90
Technetium-99	Tc-99
Iodine-129	I-129
Cesium-137	Cs-137
Uranium[a]	U
Plutonium-238	Pu-238
Plutonium-239 and -240	Pu-239, Pu-240
Plutonium-241	Pu-241
Americium-241	Am-241

[a] Uranium inventories include the isotopes uranium-233, uranium-234, uranium-235, and uranium-238.

Estimates of the release of radionuclides associated with the Tank Closure alternatives evaluated in this *TC & WM EIS* were derived from data packages that defined the various activities needed to execute the tank closure project. These data packages defined the resource and labor requirements, radiological and nonradiological air emissions, worker dose, waste generation, and scope and duration of activities, such as installing risers (access ports into the underground tanks), retrieving waste from tanks (determined by retrieval technology), processing waste, removing and filling tanks, and other closure activities. Various combinations of these activities form the Tank Closure alternatives.

The data package activities had to be scaled to correspond to the Tank Closure alternatives evaluated in this EIS. Scaling is proportionally adjusting the values in the data packages to account for differences in the assumptions or basis of each alternative. Scaling accounts for a number of differences, including the duration of an activity and the number of actions performed as part of an activity. For example, the amount of a radionuclide emitted from processing 99 percent of the tank waste would remain essentially the same for a given treatment technology under any of the alternatives, but the annual release might change depending on the number of years taken to process the waste under a specific alternative. Scaling was used to adjust the emissions to account for the number of years of operations for a particular alternative compared with the duration assumed in the data packages. Similarly, if a data package activity was developed based on the installation of 50 new risers but the alternative requires 75 new risers, the resource requirements, emissions, and other data associated with the activity would be increased by 50 percent to scale the data to match the alternative. The scaled data are included in the scaled data sets.

Estimated emissions for the treatment facilities (e.g., the Pretreatment Facility and WTP) presented in the scaled data sets (SAIC 2007a, 2008) were conservatively based on a reduction factor of 2,000 for particulate emissions. This factor represents the reduction associated with a single stage of high-efficiency particulate air (HEPA) filters. The air treatment equipment currently proposed for the WTP includes a number of other technologies that would further reduce emissions to the atmosphere, including, for example, scrubbers, high-efficiency mist eliminators, and a second stage of HEPA filters. The source terms from the treatment facilities were adjusted by a factor of 100 for particulates and iodine-129 to take credit equivalent to that provided by a second set of HEPA filters (for particulates) or caustic scrubbers and other treatments (for iodine). This adjustment still resulted in an overestimation of the radionuclides in the treatment facility air discharges because no credit was taken for other air treatment technologies that would be employed. No reduction factors were applied to tritium and carbon-14 emissions. They are treated as gaseous emissions that would not be abated by the air treatment technologies.

The source terms for the WTP and STTS-East and -West were based on the estimated annual emissions from the scaled data sets (SAIC 2007a, 2008). Then the radiological emissions, or a portion thereof, were assigned to one of the three locations. Emissions associated with pretreatment or vitrification of tank waste, de-encapsulation and vitrification of cesium and strontium, or deactivation of the associated facilities were attributed to the WTP. Radiological emissions from all other activities are divided between STTS-East and -West, based on the actions and facilities involved. For example, emissions from tank waste retrieval via a particular technology were divided between the two locations based on the proportion of tanks in the 200-East and 200-West Areas on which the technology would be used. Similarly, emissions from supplemental treatment technologies such as bulk vitrification, cast stone, or steam reforming were assigned to the appropriate area to reflect the assumptions employed in developing a specific alternative.

The timeframe over which each activity would occur was determined for all of the activities associated with an alternative. The total annual emissions for each of the three locations were determined by summing the emissions from each activity that would be ongoing during a year. In most cases, the year of maximum impact was immediately apparent because the emissions from the WTP and supplemental treatment technologies would contribute most to variability in the release of radionuclides and these activities would operate simultaneously; when necessary to distinguish which year would result in the maximum impact, emissions from different years were evaluated. Tables K–7 through K–19 present the emissions for the year of maximum impact (based on the population and MEI doses in Tables K–20 through K–45) and the year in which those emissions would occur under each Tank Closure alternative.

Total emissions over the operational life of the project were also calculated for the WTP, the 200-East Area, and the 200-West Area for each Tank Closure alternative. The total emissions were calculated by summing the releases for each location across all the years of release. The results are also presented in Tables K–7 through K–19. For the life-of-project emissions, the timespan presented in the tables reflects the portion of the project in which radiological emissions were projected to occur. Except for Tank Closure Alternatives 6A and 6B, which include clean closure of all of the tank farms, each alternative would have an administrative control period or a postclosure care period. Under Tank Closure Alternatives 1 and 2A, which do not include any closure, life-of-project emissions would include those that occur over the administrative control period. The postclosure care periods were not included in the timespan for the life-of-project emissions for the other Tank Closure alternatives because no radiological emissions are expected to occur.

Table K–7. Tank Closure Alternative 1 Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2107) (curies)			Annual Emissions in Year of Maximum Impact (2008) (curies)		
	Waste Treatment Plant[a]	200-East Area STTS	200-West Area STTS	Waste Treatment Plant[a]	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	0	6.1×10^{4}	5.9×10^{4}	0	6.1×10^{2}	5.9×10^{2}
Carbon-14	0	0	0	0	0	0
Cobalt-60	0	2.9	2.8	0	2.9×10^{-2}	2.8×10^{-2}
Strontium-90	0	3.3×10^{-1}	3.2×10^{-1}	0	6.4×10^{-3}	6.2×10^{-3}
Technetium-99	0	0	0	0	0	0
Iodine-129	0	7.3×10^{-1}	7.1×10^{-1}	0	1.4×10^{-2}	1.3×10^{-2}
Cesium-137	0	4.0	3.9	0	7.9×10^{-2}	7.5×10^{-2}
Uranium	0	1.9	1.8	0	1.9×10^{-2}	1.8×10^{-2}
Plutonium-238	0	0	0	0	0	0
Plutonium-239, -240	0	6.5×10^{-8}	6.1×10^{-8}	0	1.7×10^{-9}	1.2×10^{-9}
Plutonium-241	0	0	0	0	0	0
Americium-241	0	5.0×10^{-8}	4.6×10^{-8}	0	1.5×10^{-9}	9.6×10^{-10}

[a] There would be no emissions from the Waste Treatment Plant because it would not operate under this alternative.
Key: STTS=Supplemental Treatment Technology Site.

Table K–8. Tank Closure Alternative 2A Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2193) (curies)			Annual Emissions in Year of Maximum Impact (2093) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	1.2×10^{4}	6.1×10^{4}	5.9×10^{4}	0	0	0
Carbon-14	3.1×10^{3}	0	0	0	0	0
Cobalt-60	4.0×10^{-2}	2.9	2.8	0	0	0
Strontium-90	4.0×10^{2}	6.0×10^{-1}	5.8×10^{-1}	1.0×10^{2}	0	0
Technetium-99	1.5×10^{-1}	0	0	0	0	0
Iodine-129	4.8×10^{-1}	1.3	1.3	0	0	0
Cesium-137	5.8×10^{2}	7.3	7.1	2.4×10^{2}	0	0
Uranium	4.7×10^{-3}	1.9	1.8	0	0	0
Plutonium-238	2.4×10^{-2}	1.2×10^{-7}	3.2×10^{-7}	0	0	0
Plutonium-239, -240	4.1×10^{-1}	1.6×10^{-5}	4.1×10^{-5}	0	1.0×10^{-9}	0
Plutonium-241	6.2×10^{-1}	0	0	0	0	0
Americium-241	7.2×10^{-1}	1.6×10^{-6}	3.5×10^{-6}	0	0	0

Key: STTS=Supplemental Treatment Technology Site.

Table K–9. Tank Closure Alternative 2B Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2045) (curies)			Annual Emissions in Year of Maximum Impact (2040) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	1.2×10^{4}	0	0	4.6×10^{2}	0	0
Carbon-14	3.1×10^{3}	0	0	1.2×10^{2}	0	0
Cobalt-60	4.1×10^{-2}	0	0	1.6×10^{-3}	0	0
Strontium-90	4.2×10^{2}	1.2×10^{-1}	1.2×10^{-1}	1.2×10^{2}	3.2×10^{-3}	3.1×10^{-3}
Technetium-99	1.5×10^{-1}	0	0	5.7×10^{-3}	0	0
Iodine-129	4.8×10^{-1}	2.7×10^{-1}	2.6×10^{-1}	1.8×10^{-2}	7.0×10^{-3}	6.7×10^{-3}
Cesium-137	5.8×10^{2}	1.5	1.4	2.5×10^{2}	3.9×10^{-2}	3.8×10^{-2}
Uranium	4.7×10^{-3}	0	0	1.8×10^{-4}	0	0
Plutonium-238	2.4×10^{-2}	5.6×10^{-7}	7.6×10^{-7}	9.3×10^{-4}	1.5×10^{-7}	1.5×10^{-7}
Plutonium-239, -240	4.1×10^{-1}	7.2×10^{-5}	9.7×10^{-5}	1.6×10^{-2}	1.9×10^{-5}	1.9×10^{-5}
Plutonium-241	6.3×10^{-1}	0	0	2.4×10^{-2}	0	0
Americium-241	7.2×10^{-1}	5.9×10^{-6}	7.8×10^{-6}	2.8×10^{-2}	1.5×10^{-6}	1.5×10^{-6}

Key: STTS=Supplemental Treatment Technology Site.

Table K–10. Tank Closure Alternative 3A Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2042) (curies)			Annual Emissions in Year of Maximum Impact (2040) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	3.5×10^{3}	4.6×10^{3}	3.9×10^{3}	0	2.1×10^{1}	1.8×10^{1}
Carbon-14	9.6×10^{2}	1.2×10^{3}	9.9×10^{2}	0	5.3	4.5
Cobalt-60	3.3×10^{-2}	3.5×10^{-3}	3.4×10^{-3}	0	1.6×10^{-5}	1.5×10^{-5}
Strontium-90	4.0×10^{2}	1.8×10^{-1}	2.4	1.0×10^{2}	2.1×10^{-5}	1.1×10^{-2}
Technetium-99	4.4×10^{-2}	5.4×10^{-4}	4.8×10^{-2}	0	2.6×10^{-4}	2.1×10^{-4}
Iodine-129	1.4×10^{-1}	4.2×10^{-1}	3.8×10^{-1}	0	8.3×10^{-4}	7.0×10^{-4}
Cesium-137	5.6×10^{2}	2.5	2.3×10^{1}	2.4×10^{2}	5.2×10^{-3}	1.0×10^{-1}
Uranium	4.3×10^{-3}	1.1×10^{-4}	1.5×10^{-4}	0	4.9×10^{-7}	6.8×10^{-7}
Plutonium-238	2.1×10^{-2}	6.8×10^{-5}	3.0×10^{-4}	0	7.5×10^{-10}	1.3×10^{-6}
Plutonium-239, -240	3.7×10^{-1}	8.0×10^{-4}	5.4×10^{-3}	0	1.4×10^{-8}	2.4×10^{-5}
Plutonium-241	5.6×10^{-1}	1.2×10^{-3}	8.0×10^{-3}	0	2.0×10^{-8}	3.6×10^{-5}
Americium-241	6.0×10^{-1}	2.4×10^{-3}	7.0×10^{-3}	0	3.6×10^{-8}	3.2×10^{-5}

Key: STTS=Supplemental Treatment Technology Site.

Table K–11. Tank Closure Alternative 3B Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2042) (curies)			Annual Emissions in Year of Maximum Impact (2040) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	3.5×10^{3}	4.6×10^{-2}	3.9×10^{-2}	0	2.1×10^{-4}	1.8×10^{-4}
Carbon-14	9.6×10^{2}	1.2×10^{-2}	9.9×10^{-3}	0	5.3×10^{-5}	4.5×10^{-5}
Cobalt-60	3.3×10^{-2}	7.7×10^{-5}	6.7×10^{-5}	0	3.1×10^{-7}	3.0×10^{-7}
Strontium-90	4.0×10^{2}	1.9×10^{-1}	1.5×10^{-1}	1.0×10^{2}	4.1×10^{-7}	2.1×10^{-4}
Technetium-99	1.0×10^{-1}	4.6×10^{-5}	9.5×10^{-4}	0	5.1×10^{-8}	4.3×10^{-6}
Iodine-129	1.4×10^{-1}	2.4×10^{-1}	2.3×10^{-1}	0	8.3×10^{-9}	7.0×10^{-9}
Cesium-137	5.6×10^{2}	1.4	1.7	2.4×10^{2}	1.0×10^{-4}	2.0×10^{-3}
Uranium	4.3×10^{-3}	6.7×10^{-6}	3.4×10^{-6}	0	9.7×10^{-9}	1.4×10^{-8}
Plutonium-238	2.1×10^{-2}	6.9×10^{-5}	7.1×10^{-6}	0	1.5×10^{-11}	2.7×10^{-8}
Plutonium-239, -240	3.7×10^{-1}	8.2×10^{-4}	2.8×10^{-4}	0	1.3×10^{-9}	4.8×10^{-7}
Plutonium-241	5.6×10^{-1}	1.2×10^{-3}	1.7×10^{-4}	0	4.0×10^{-10}	7.2×10^{-7}
Americium-241	6.0×10^{-1}	2.4×10^{-3}	1.6×10^{-4}	0	7.3×10^{-10}	6.3×10^{-7}

Key: STTS=Supplemental Treatment Technology Site.

Table K–12. Tank Closure Alternative 3C Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2042) (curies)			Annual Emissions in Year of Maximum Impact (2040) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	3.5×10^{3}	4.6×10^{3}	3.9×10^{3}	0	2.1×10^{1}	1.8×10^{1}
Carbon-14	9.6×10^{2}	1.2×10^{3}	9.9×10^{2}	0	5.3	4.5
Cobalt-60	3.3×10^{-2}	3.5×10^{-3}	3.4×10^{-3}	0	1.6×10^{-5}	1.5×10^{-5}
Strontium-90	4.0×10^{2}	1.9×10^{-1}	2.4	1.0×10^{2}	2.1×10^{-5}	1.1×10^{-2}
Technetium-99	1.0×10^{-1}	5.7×10^{-2}	4.8×10^{-2}	0	2.6×10^{-4}	2.1×10^{-4}
Iodine-129	1.4×10^{-1}	4.2×10^{-1}	3.8×10^{-1}	0	8.3×10^{-4}	7.0×10^{-4}
Cesium-137	5.6×10^{2}	2.5	2.3×10^{1}	2.4×10^{2}	5.2×10^{-3}	1.0×10^{-1}
Uranium	4.3×10^{-3}	1.1×10^{-4}	1.5×10^{-4}	0	4.9×10^{-7}	6.8×10^{-7}
Plutonium-238	2.1×10^{-2}	6.9×10^{-5}	3.0×10^{-4}	0	7.5×10^{-10}	1.3×10^{-6}
Plutonium-239, -240	3.7×10^{-1}	8.0×10^{-4}	5.4×10^{-3}	0	1.4×10^{-8}	2.4×10^{-5}
Plutonium-241	5.6×10^{-1}	1.2×10^{-3}	8.0×10^{-3}	0	2.0×10^{-8}	3.6×10^{-5}
Americium-241	6.0×10^{-1}	2.4×10^{-3}	7.0×10^{-3}	0	3.6×10^{-8}	3.2×10^{-5}

Key: STTS=Supplemental Treatment Technology Site.

Table K–13. Tank Closure Alternative 4 Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2045) (curies)			Annual Emissions in Year of Maximum Impact (2043) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	3.6×10^{3}	4.8×10^{-2}	3.9×10^{3}	0	2.8×10^{-6}	2.8×10^{-6}
Carbon-14	9.7×10^{2}	1.2×10^{-2}	1.0×10^{3}	0	2.7×10^{-7}	2.7×10^{-7}
Cobalt-60	3.4×10^{-2}	2×10^{-4}	3.6×10^{-3}	0	2.2×10^{-7}	2.2×10^{-7}
Strontium-90	4.0×10^{2}	2.1	4.9	1.0×10^{2}	5.8×10^{-3}	5.8×10^{-3}
Technetium-99	4.4×10^{-2}	1.6×10^{-3}	4.8×10^{-2}	0	2.0×10^{-6}	2.0×10^{-6}
Iodine-129	1.4×10^{-1}	2.6×10^{-1}	4.1×10^{-1}	0	3.7×10^{-9}	3.7×10^{-9}
Cesium-137	5.6×10^{2}	2.5	2.5×10^{1}	2.4×10^{2}	4.7×10^{-3}	4.7×10^{-3}
Uranium	4.4×10^{-3}	5.6×10^{-5}	2.0×10^{-4}	0	2.5×10^{-7}	2.5×10^{-7}
Plutonium-238	2.1×10^{-2}	1.3×10^{-4}	3.6×10^{-4}	0	4.6×10^{-7}	4.6×10^{-7}
Plutonium-239, -240	3.7×10^{-1}	2.8×10^{-3}	8.0×10^{-3}	0	2.6×10^{-5}	2.6×10^{-5}
Plutonium-241	5.7×10^{-1}	2.1×10^{-3}	9.0×10^{-3}	0	4.4×10^{-6}	4.4×10^{-6}
Americium-241	6.1×10^{-1}	4.4×10^{-3}	9.8×10^{-3}	0	5.5×10^{-6}	5.5×10^{-6}

Key: STTS=Supplemental Treatment Technology Site.

Table K–14. Tank Closure Alternative 5 Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2036) (curies)			Annual Emissions in Year of Maximum Impact (2034) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	5.8×10^{3}	1.6×10^{-2}	3.5×10^{3}	3.6	1.0×10^{-4}	2.2×10^{1}
Carbon-14	1.5×10^{3}	4.1×10^{-3}	9.0×10^{2}	9.1	2.5×10^{-5}	5.6
Cobalt-60	4.1×10^{-2}	3.1×10^{-5}	3.1×10^{-3}	5.4×10^{-5}	1.5×10^{-7}	1.9×10^{-5}
Strontium-90	3.8×10^{2}	1.6×10^{-1}	2.2	1.0×10^{2}	2.0×10^{-7}	1.3×10^{-2}
Technetium-99	2.1×10^{-1}	4.3×10^{-4}	4.3×10^{-2}	8.8×10^{-4}	2.4×10^{-6}	2.7×10^{-4}
Iodine-129	2.3×10^{-1}	2.0×10^{-1}	3.3×10^{-1}	1.4×10^{-6}	4.0×10^{-9}	8.8×10^{-4}
Cesium-137	5.4×10^{2}	1.1	2.3×10^{1}	2.4×10^{2}	4.9×10^{-5}	1.4×10^{-1}
Uranium	4.3×10^{-3}	4.8×10^{-6}	1.4×10^{-4}	1.7×10^{-6}	4.6×10^{-9}	8.6×10^{-7}
Plutonium-238	1.9×10^{-2}	6.2×10^{-5}	2.7×10^{-4}	2.6×10^{-9}	7.1×10^{-12}	1.7×10^{-6}
Plutonium-239, -240	3.4×10^{-1}	6.8×10^{-4}	4.9×10^{-3}	4.5×10^{-8}	1.1×10^{-9}	3.0×10^{-5}
Plutonium-241	5.1×10^{-1}	1.1×10^{-3}	7.3×10^{-3}	6.8×10^{-8}	1.9×10^{-10}	4.5×10^{-5}
Americium-241	5.5×10^{-1}	2.2×10^{-3}	6.4×10^{-3}	1.3×10^{-7}	3.5×10^{-10}	3.9×10^{-5}

Key: STTS=Supplemental Treatment Technology Site.

Table K–15. Tank Closure Alternative 6A, Base Case, Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2168) (curies)			Annual Emissions in Year of Maximum Impact (2163) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	1.2×10^{4}	6.0×10^{1}	5.7×10^{-1}	0	7.7×10^{-2}	7.7×10^{-2}
Carbon-14	3.1×10^{3}	1.1×10^{1}	1.0×10^{-1}	0	1.4×10^{-2}	1.4×10^{-2}
Cobalt-60	4.1×10^{-2}	2.7×10^{-3}	7.6×10^{-5}	0	2.7×10^{-6}	2.7×10^{-6}
Strontium-90	4.3×10^{2}	2.2×10^{1}	6.9×10^{-1}	1.0×10^{2}	2.1×10^{-2}	2.1×10^{-2}
Technetium-99	1.5×10^{-1}	3.8×10^{-2}	3.7×10^{-4}	0	5.0×10^{-5}	5.0×10^{-5}
Iodine-129	4.8×10^{-1}	1.2	8.0×10^{-3}	0	1.9×10^{-4}	1.9×10^{-4}
Cesium-137	6.4×10^{2}	7.0×10^{1}	6.6×10^{-1}	2.4×10^{2}	8.3×10^{-2}	8.3×10^{-2}
Uranium	4.7×10^{-3}	2.2×10^{-3}	2.1×10^{-5}	0	2.8×10^{-6}	2.8×10^{-6}
Plutonium-238	2.4×10^{-2}	1.2×10^{-3}	1.2×10^{-5}	0	1.8×10^{-6}	1.5×10^{-6}
Plutonium-239, -240	4.1×10^{-1}	1.4×10^{-2}	6.5×10^{-4}	0	4.9×10^{-5}	1.2×10^{-5}
Plutonium-241	6.3×10^{-1}	8.2×10^{-3}	9.2×10^{-5}	0	1.0×10^{-5}	1.0×10^{-5}
Americium-241	7.3×10^{-1}	1.6×10^{-2}	8.8×10^{-4}	0	1.4×10^{-5}	1.1×10^{-5}

Key: STTS=Supplemental Treatment Technology Site.

Table K–16. Tank Closure Alternative 6A, Option Case, Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2168) (curies)			Annual Emissions in Year of Maximum Impact (2163) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	1.2×10^{4}	1.4×10^{3}	1.4×10^{3}	0	1.9	1.9
Carbon-14	3.1×10^{3}	1.4×10^{1}	1.4×10^{1}	0	1.9×10^{-2}	1.9×10^{-2}
Cobalt-60	4.1×10^{-2}	5.0×10^{-3}	5.0×10^{-3}	0	5.4×10^{-6}	5.4×10^{-6}
Strontium-90	4.3×10^{2}	2.6×10^{1}	2.6×10^{1}	1.0×10^{2}	2.3×10^{-2}	2.3×10^{-2}
Technetium-99	1.5×10^{-1}	5.6×10^{-2}	5.6×10^{-2}	0	7.3×10^{-5}	7.3×10^{-5}
Iodine-129	4.8×10^{-1}	1.3	1.3	0	2.7×10^{-4}	2.7×10^{-4}
Cesium-137	6.4×10^{2}	7.2×10^{1}	7.2×10^{1}	2.4×10^{2}	8.5×10^{-2}	8.5×10^{-2}
Uranium	4.7×10^{-3}	3.0×10^{-3}	3.0×10^{-3}	0	3.8×10^{-6}	3.8×10^{-6}
Plutonium-238	2.4×10^{-2}	2.3×10^{-3}	2.3×10^{-3}	0	3.3×10^{-6}	3.0×10^{-6}
Plutonium-239, -240	4.1×10^{-1}	9.1×10^{-2}	9.1×10^{-2}	0	1.5×10^{-4}	1.1×10^{-4}
Plutonium-241	6.3×10^{-1}	6.3×10^{-2}	6.3×10^{-2}	0	8.1×10^{-5}	8.1×10^{-5}
Americium-241	7.3×10^{-1}	3.4×10^{-2}	3.4×10^{-2}	0	3.1×10^{-5}	2.8×10^{-5}

Key: STTS=Supplemental Treatment Technology Site.

Table K–17. Tank Closure Alternative 6B, Base Case, Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2100) (curies)			Annual Emissions in Year of Maximum Impact (2040) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	1.2×10^{4}	5.9×10^{1}	5.9×10^{1}	4.6×10^{2}	7.7×10^{-1}	7.7×10^{-1}
Carbon-14	3.1×10^{3}	1.1×10^{1}	1.1×10^{1}	1.2×10^{2}	1.4×10^{-1}	1.4×10^{-1}
Cobalt-60	4.1×10^{-2}	2.7×10^{-3}	2.7×10^{-3}	1.6×10^{-3}	5.0×10^{-5}	3.9×10^{-5}
Strontium-90	4.1×10^{2}	2.2×10^{1}	2.2×10^{1}	1.1×10^{2}	4.3×10^{-1}	3.2×10^{-1}
Technetium-99	1.5×10^{-1}	3.8×10^{-2}	3.8×10^{-2}	5.7×10^{-3}	5.0×10^{-4}	5.0×10^{-4}
Iodine-129	4.8×10^{-1}	4.1×10^{-1}	4.0×10^{-1}	1.8×10^{-2}	8.9×10^{-3}	8.6×10^{-3}
Cesium-137	5.8×10^{2}	6.5×10^{1}	6.5×10^{1}	2.5×10^{2}	8.7×10^{-1}	8.7×10^{-1}
Uranium	4.7×10^{-3}	2.2×10^{-3}	2.2×10^{-3}	1.8×10^{-4}	2.8×10^{-5}	2.8×10^{-5}
Plutonium-238	2.4×10^{-2}	1.2×10^{-3}	1.2×10^{-3}	9.3×10^{-4}	1.5×10^{-5}	1.5×10^{-5}
Plutonium-239, -240	4.1×10^{-1}	1.4×10^{-2}	1.4×10^{-2}	1.6×10^{-2}	3.0×10^{-4}	2.1×10^{-4}
Plutonium-241	6.3×10^{-1}	8.1×10^{-3}	8.1×10^{-3}	2.4×10^{-2}	1.1×10^{-4}	1.1×10^{-4}
Americium-241	7.2×10^{-1}	1.6×10^{-2}	1.7×10^{-2}	2.8×10^{-2}	4.3×10^{-4}	2.8×10^{-4}

Key: STTS=Supplemental Treatment Technology Site.

Table K–18. Tank Closure Alternative 6B, Option Case, Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2100) (curies)			Annual Emissions in Year of Maximum Impact (2040) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	1.2×10^{4}	1.4×10^{3}	1.4×10^{3}	4.6×10^{2}	1.9×10^{1}	1.9×10^{1}
Carbon-14	3.1×10^{3}	1.4×10^{1}	1.4×10^{1}	1.2×10^{2}	1.9×10^{-1}	1.9×10^{-1}
Cobalt-60	4.1×10^{-2}	5.0×10^{-3}	5.0×10^{-3}	1.6×10^{-3}	8.6×10^{-5}	6.6×10^{-5}
Strontium-90	4.1×10^{2}	2.5×10^{1}	2.5×10^{1}	1.1×10^{2}	5.3×10^{-1}	3.4×10^{-1}
Technetium-99	1.5×10^{-1}	5.6×10^{-2}	5.6×10^{-2}	5.7×10^{-3}	7.3×10^{-4}	7.3×10^{-4}
Iodine-129	4.8×10^{-1}	4.7×10^{-1}	4.6×10^{-1}	1.8×10^{-2}	9.7×10^{-3}	9.4×10^{-3}
Cesium-137	5.8×10^{2}	6.7×10^{1}	6.7×10^{1}	2.5×10^{2}	9.0×10^{-1}	8.9×10^{-1}
Uranium	4.7×10^{-3}	3.0×10^{-3}	3.0×10^{-3}	1.8×10^{-4}	3.8×10^{-5}	3.8×10^{-5}
Plutonium-238	2.4×10^{-2}	2.3×10^{-3}	2.3×10^{-3}	9.3×10^{-4}	3.0×10^{-5}	3.0×10^{-5}
Plutonium-239, -240	4.1×10^{-1}	9.1×10^{-2}	9.1×10^{-2}	1.6×10^{-2}	1.3×10^{-3}	1.2×10^{-3}
Plutonium-241	6.3×10^{-1}	6.3×10^{-2}	6.3×10^{-2}	2.4×10^{-2}	8.2×10^{-4}	8.1×10^{-4}
Americium-241	7.2×10^{-1}	3.3×10^{-2}	3.3×10^{-2}	2.8×10^{-2}	7.3×10^{-4}	4.4×10^{-4}

Key: STTS=Supplemental Treatment Technology Site.

Table K–19. Tank Closure Alternative 6C Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project (2006–2045) (curies)			Annual Emissions in Year of Maximum Impact (2040) (curies)		
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Waste Treatment Plant	200-East Area STTS	200-West Area STTS
Hydrogen-3 (tritium)	1.2×10^{4}	0	0	4.6×10^{2}	0	0
Carbon-14	3.1×10^{3}	0	0	1.2×10^{2}	0	0
Cobalt-60	4.1×10^{-2}	0	0	1.6×10^{-3}	0	0
Strontium-90	4.1×10^{2}	1.2×10^{-1}	1.2×10^{-1}	1.1×10^{2}	3.2×10^{-3}	3.1×10^{-3}
Technetium-99	1.5×10^{-1}	0	0	5.7×10^{-3}	0	0
Iodine-129	4.8×10^{-1}	2.7×10^{-1}	2.6×10^{-1}	1.8×10^{-2}	7.0×10^{-3}	6.7×10^{-3}
Cesium-137	5.8×10^{2}	1.5	1.4	2.5×10^{2}	3.9×10^{-2}	3.8×10^{-2}
Uranium	4.7×10^{-3}	0	0	1.8×10^{-4}	0	0
Plutonium-238	2.4×10^{-2}	5.6×10^{-7}	7.6×10^{-7}	9.3×10^{-4}	1.5×10^{-7}	1.5×10^{-7}
Plutonium-239, -240	4.1×10^{-1}	7.2×10^{-5}	9.6×10^{-5}	1.6×10^{-2}	1.9×10^{-5}	1.9×10^{-5}
Plutonium-241	6.3×10^{-1}	0	0	2.4×10^{-2}	0	0
Americium-241	7.2×10^{-1}	5.9×10^{-6}	7.8×10^{-6}	2.8×10^{-2}	1.5×10^{-6}	1.5×10^{-6}

Key: STTS=Supplemental Treatment Technology Site.

K.2.1.1.4 Results

The results of the dose analyses are presented in this section. Tables K–20 through K–32 show the estimated doses to the population living within 80 kilometers (50 miles) of the 200 Areas over the life of the project and during the year of maximum impact under each Tank Closure alternative. Tables K–33 through K–45 show the estimated doses to the MEI over the life of the project and during the year of maximum impact under each Tank Closure alternative. The year of maximum impact was determined by considering the combined impacts on the population or the MEI from the three emission source locations: the WTP, STTS-East, and STTS-West. For purposes of comparison, the National Emission Standards for Hazardous Air Pollutants annual dose limit to an individual member of the public is 10 millirem (0.01 rem) per year for all emission sources from a DOE site (40 CFR 61.90–61.97).

For activities that occur over a number of years, an average emission was assumed for each year. This approach can result in the peak impact spanning a number of years rather than occurring in a single year. Under all Tank Closure alternatives except Alternative 1, the year in which cesium and strontium would be de-encapsulated and processed at the WTP would result in the largest annual impacts.

Note that some of the alternatives would take much longer than others to complete; this difference would affect the population dose. As a result of the duration of some of the alternatives, the exposed population could include multiple generations. The radioactive inventories were not adjusted to account for the differences in the duration of the alternatives (radioactive decay over time would reduce the radioactivity of each radionuclide); however, the analyses still support a general comparison of the impacts on the offsite population and MEI.

Table K–20. Tank Closure Alternative 1 Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant[b]	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant[b]	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	0	2.6×10^{1}	2.5×10^{1}	5.0×10^{1}	0	2.6×10^{-1}	2.5×10^{-1}	5.0×10^{-1}
Carbon-14	0	0	0	0	0	0	0	0
Cobalt-60	0	1.3	1.3	2.6	0	1.3×10^{-2}	1.3×10^{-2}	2.6×10^{-2}
Strontium-90	0	2.2×10^{-1}	2.1×10^{-1}	4.4×10^{-1}	0	4.3×10^{-3}	4.1×10^{-3}	8.5×10^{-3}
Technetium-99	0	0	0	0	0	0	0	0
Iodine-129	0	1.4×10^{1}	1.3×10^{1}	2.7×10^{1}	0	2.7×10^{-1}	2.6×10^{-1}	5.2×10^{-1}
Cesium-137	0	2.1	2.1	4.2	0	4.2×10^{-2}	4.0×10^{-2}	8.2×10^{-2}
Uranium	0	2.6×10^{2}	2.5×10^{2}	5.2×10^{2}	0	2.6	2.5	5.2
Plutonium-238	0	0	0	0	0	0	0	0
Plutonium-239, -240	0	3.4×10^{-5}	3.2×10^{-5}	6.6×10^{-5}	0	9.2×10^{-7}	6.4×10^{-7}	1.6×10^{-6}
Plutonium-241	0	6.4×10^{-7}	6.0×10^{-7}	1.2×10^{-6}	0	0	0	0
Americium-241	0	2.7×10^{-5}	2.5×10^{-5}	5.2×10^{-5}	0	7.9×10^{-7}	5.2×10^{-7}	1.3×10^{-6}
Total	0	3.1×10^{2}	2.9×10^{2}	6×10^{2}	0	3.2	3.1	6.3
Number of latent cancer fatalities[c]				0 (4×10^{-1})				0 (4×10^{-3})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] There would be no emissions from the Waste Treatment Plant because it would not operate under this alternative.

[c] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–21. Tank Closure Alternative 2A Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6	2.6×10^{1}	2.5×10^{1}	5.2×10^{1}	0	0	0	0
Carbon-14	7.2×10^{1}	0	0	7.2×10^{1}	0	0	0	0
Cobalt-60	5.7×10^{3}	1.3	1.3	2.6	0	0	0	0
Strontium-90	8.5×10^{1}	4.0×10^{-1}	3.9×10^{-1}	8.6×10^{1}	2.2×10^{1}	0	0	2.2×10^{1}
Technetium-99	1.8×10^{-3}	0	0	1.8×10^{-3}	0	0	0	0
Iodine-129	2.7	2.5×10^{1}	2.4×10^{1}	5.2×10^{1}	0	0	0	0
Cesium-137	9.3×10^{1}	3.9	3.7	1.0×10^{2}	3.8×10^{1}	0	0	3.8×10^{1}
Uranium	2.1×10^{-1}	2.6×10^{2}	2.5×10^{2}	5.2×10^{2}	0	0	0	0
Plutonium-238	3.7	5.9×10^{-5}	1.5×10^{-4}	3.7	0	0	0	0
Plutonium-239, -240	6.5×10^{1}	8.6×10^{-3}	2.2×10^{-2}	6.5×10^{1}	0	5.3×10^{-7}	0	5.3×10^{-7}
Plutonium-241	1.3	1.6×10^{-4}	4.0×10^{-4}	1.3	0	0	0	0
Americium-241	1.2×10^{2}	8.8×10^{-4}	1.9×10^{-3}	1.2×10^{2}	0	0	0	0
Total	4.5×10^{2}	3.2×10^{2}	3.1×10^{2}	1.1×10^{3}	6.0×10^{1}	5.3×10^{-7}	0	6.0×10^{1}
Number of latent cancer fatalities[b]				1 (0.6)				0 (4×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–22. Tank Closure Alternative 2B Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6	0	0	1.6	6.0×10^{-2}	0	0	6.0×10^{-2}
Carbon-14	7.2×10^{1}	0	0	7.2×10^{1}	2.7	0	0	2.7
Cobalt-60	5.7×10^{-3}	0	0	5.7×10^{-3}	2.2×10^{-4}	0	0	2.2×10^{-4}
Strontium-90	8.9×10^{1}	8.2×10^{-2}	7.9×10^{-2}	8.9×10^{1}	2.6×10^{1}	2.2×10^{-3}	2.1×10^{-3}	2.6×10^{1}
Technetium-99	1.8×10^{-3}	0	0	1.8×10^{-3}	6.8×10^{-5}	0	0	6.8×10^{-5}
Iodine-129	2.7	5.1	4.8	1.3×10^{1}	1.0×10^{-1}	1.3×10^{-1}	1.3×10^{-1}	3.7×10^{-1}
Cesium-137	9.3×10^{1}	7.9×10^{-1}	7.6×10^{-1}	9.5×10^{1}	4.0×10^{1}	2.1×10^{-2}	2.0×10^{-2}	4.0×10^{1}
Uranium	2.1×10^{-1}	0	0	2.1×10^{-1}	7.9×10^{-3}	0	0	7.9×10^{-3}
Plutonium-238	3.7	2.7×10^{-4}	3.6×10^{-4}	3.7	1.4×10^{-1}	7.0×10^{-5}	7.0×10^{-5}	1.4×10^{-1}
Plutonium-239, -240	6.5×10^{1}	3.8×10^{-2}	5.1×10^{-2}	6.5×10^{1}	2.6	9.9×10^{-3}	9.9×10^{-3}	2.7
Plutonium-241	1.3	7.1×10^{-4}	9.6×10^{-4}	1.3	7.4×10^{-2}	0	0	7.4×10^{-2}
Americium-241	1.2×10^{2}	3.2×10^{-3}	4.2×10^{-3}	1.2×10^{2}	4.4	7.9×10^{-4}	7.9×10^{-4}	4.4
Total	4.5×10^{2}	6.0	5.7	4.6×10^{2}	7.6×10^{1}	1.7×10^{-1}	1.6×10^{-1}	7.6×10^{1}
Number of latent cancer fatalities[b]				0 (3×10^{-1})				0 (5×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–23. Tank Closure Alternative 3A Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	4.6×10^{-1}	1.9	1.6	4.0	0	8.8×10^{-3}	7.4×10^{-3}	1.6×10^{-2}
Carbon-14	2.2×10^{1}	8.8×10^{1}	7.4×10^{1}	1.8×10^{2}	0	4.0×10^{-1}	3.3×10^{-1}	7.3×10^{-1}
Cobalt-60	4.7×10^{-3}	1.6×10^{-3}	1.5×10^{-3}	7.7×10^{-3}	0	7.0×10^{-6}	6.8×10^{-6}	1.4×10^{-5}
Strontium-90	8.4×10^{1}	1.2×10^{-1}	1.6	8.6×10^{1}	2.2×10^{1}	1.4×10^{-5}	7.1×10^{-3}	2.2×10^{1}
Technetium-99	5.3×10^{-4}	2.2×10^{-5}	1.9×10^{-3}	2.4×10^{-3}	0	1.0×10^{-5}	8.6×10^{-6}	1.9×10^{-5}
Iodine-129	8.0×10^{-1}	8.0	7.3	1.6×10^{1}	0	1.6×10^{-2}	1.3×10^{-2}	2.9×10^{-2}
Cesium-137	8.9×10^{1}	1.3	1.2×10^{1}	1.0×10^{2}	3.8×10^{1}	2.7×10^{-3}	5.3×10^{-2}	3.8×10^{1}
Uranium	1.9×10^{-1}	1.6×10^{-2}	2.1×10^{-2}	2.3×10^{-1}	0	6.8×10^{-5}	9.6×10^{-5}	1.6×10^{-4}
Plutonium-238	3.1	3.3×10^{-2}	1.4×10^{-1}	3.3	0	3.6×10^{-7}	6.4×10^{-4}	6.4×10^{-4}
Plutonium-239, -240	5.9×10^{1}	4.2×10^{-1}	2.9	6.3×10^{1}	0	7.4×10^{-6}	1.3×10^{-2}	1.3×10^{-2}
Plutonium-241	1.1	7.9×10^{-3}	5.4×10^{-2}	1.2	0	2.0×10^{-7}	3.6×10^{-4}	3.6×10^{-4}
Americium-241	1.0×10^{2}	1.3	3.8	1.1×10^{2}	0	2.0×10^{-5}	1.7×10^{-2}	1.7×10^{-2}
Total	3.6×10^{2}	1.0×10^{2}	1.0×10^{2}	5.7×10^{2}	6.0×10^{1}	4.2×10^{-1}	4.5×10^{-1}	6.1×10^{1}
Number of latent cancer fatalities[b]				0 (3×10^{-1})				0 (4×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–24. Tank Closure Alternative 3B Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	4.6×10^{-1}	2.0×10^{-5}	1.6×10^{-5}	4.6×10^{-1}	0	8.8×10^{-8}	7.4×10^{-8}	1.6×10^{-7}
Carbon-14	2.2×10^{1}	8.9×10^{-4}	7.4×10^{-4}	2.2×10^{1}	0	4.0×10^{-6}	3.3×10^{-6}	7.3×10^{-6}
Cobalt-60	4.7×10^{-3}	3.5×10^{-5}	3.0×10^{-5}	4.7×10^{-3}	0	1.4×10^{-7}	1.4×10^{-7}	2.8×10^{-7}
Strontium-90	8.4×10^{1}	1.2×10^{-1}	1.0×10^{-1}	8.5×10^{1}	2.2×10^{1}	2.8×10^{-7}	1.4×10^{-4}	2.2×10^{1}
Technetium-99	1.2×10^{-3}	1.8×10^{-6}	3.8×10^{-5}	1.2×10^{-3}	0	2.0×10^{-9}	1.7×10^{-7}	1.7×10^{-7}
Iodine-129	8.0×10^{-1}	4.5	4.3	9.7	0	1.6×10^{-7}	1.3×10^{-7}	2.9×10^{-7}
Cesium-137	8.9×10^{1}	7.4×10^{-1}	9.2×10^{-1}	9.1×10^{1}	3.8×10^{1}	5.5×10^{-5}	1.1×10^{-3}	3.8×10^{1}
Uranium	1.9×10^{-1}	9.3×10^{-4}	4.8×10^{-4}	1.9×10^{-1}	0	1.4×10^{-6}	1.9×10^{-6}	3.3×10^{-6}
Plutonium-238	3.1	3.3×10^{-2}	3.4×10^{-3}	3.2	0	7.2×10^{-9}	1.3×10^{-5}	1.3×10^{-5}
Plutonium-239, -240	5.9×10^{1}	4.4×10^{-1}	1.5×10^{-1}	6.0×10^{1}	0	6.7×10^{-7}	2.5×10^{-4}	2.5×10^{-4}
Plutonium-241	1.1	8.1×10^{-3}	2.8×10^{-3}	1.2	0	3.9×10^{-9}	7.2×10^{-6}	7.2×10^{-6}
Americium-241	1.0×10^{2}	1.3	8.4×10^{-2}	1.0×10^{2}	0	3.9×10^{-7}	3.4×10^{-4}	3.4×10^{-4}
Total	3.6×10^{2}	7.2	5.6	3.8×10^{2}	6.0×10^{1}	6.2×10^{-5}	1.8×10^{-3}	6.0×10^{1}
Number of latent cancer fatalities[b]				0 (2×10^{-1})				0 (4×10^{-2})

a The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

b The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–25. Tank Closure Alternative 3C Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	4.6×10^{-1}	1.9	1.6	4.0	0	8.8×10^{-3}	7.4×10^{-3}	1.6×10^{-2}
Carbon-14	2.2×10^{1}	8.8×10^{1}	7.4×10^{1}	1.8×10^{2}	0	4.0×10^{-1}	3.3×10^{-1}	7.3×10^{-1}
Cobalt-60	4.7×10^{-3}	1.6×10^{-3}	1.5×10^{-3}	7.7×10^{-3}	0	7.0×10^{-6}	6.8×10^{-6}	1.4×10^{-5}
Strontium-90	8.4×10^{1}	1.3×10^{-1}	1.6	8.6×10^{1}	2.2×10^{1}	1.4×10^{-5}	7.1×10^{-3}	2.2×10^{1}
Technetium-99	1.2×10^{-3}	2.3×10^{-3}	1.9×10^{-3}	5.4×10^{-3}	0	1.0×10^{-5}	8.6×10^{-6}	1.9×10^{-5}
Iodine-129	8.0×10^{-1}	8.0	7.3	1.6×10^{1}	0	1.6×10^{-2}	1.3×10^{-2}	2.9×10^{-2}
Cesium-137	8.9×10^{1}	1.3	1.2×10^{1}	1.0×10^{2}	3.8×10^{1}	2.7×10^{-3}	5.3×10^{-2}	3.8×10^{1}
Uranium	1.9×10^{-1}	1.6×10^{-2}	2.1×10^{-2}	2.3×10^{-1}	0	6.8×10^{-5}	9.6×10^{-5}	1.6×10^{-4}
Plutonium-238	3.1	3.3×10^{-2}	1.4×10^{-1}	3.3	0	3.6×10^{-7}	6.4×10^{-4}	6.4×10^{-4}
Plutonium-239, -240	5.9×10^{1}	4.2×10^{-1}	2.9	6.3×10^{1}	0	7.4×10^{-6}	1.3×10^{-2}	1.3×10^{-2}
Plutonium-241	1.1	7.9×10^{-3}	5.4×10^{-2}	1.2	0	2.0×10^{-7}	3.6×10^{-4}	3.6×10^{-4}
Americium-241	1.0×10^{2}	1.3	3.8	1.1×10^{2}	0	2.0×10^{-5}	1.7×10^{-2}	1.7×10^{-2}
Total	3.6×10^{2}	1×10^{2}	1×10^{2}	5.7×10^{2}	6.0×10^{1}	4.2×10^{-1}	4.5×10^{-1}	6.1×10^{1}
Number of latent cancer fatalities[b]				0 (3×10^{-1})				0 (4×10^{-2})

a The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

b The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–26. Tank Closure Alternative 4 Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	4.7×10^{-1}	2.0×10^{-5}	1.7	2.1	0	1.2×10^{-9}	1.2×10^{-9}	2.4×10^{-9}
Carbon-14	2.2×10^{1}	9.0×10^{-4}	7.5×10^{1}	9.7×10^{1}	0	2.0×10^{-8}	2.0×10^{-8}	4.0×10^{-8}
Cobalt-60	4.7×10^{-3}	9.0×10^{-5}	1.6×10^{-3}	6.4×10^{-3}	0	1.0×10^{-7}	1.0×10^{-7}	2.0×10^{-7}
Strontium-90	8.5×10^{1}	1.4	3.3	9.0×10^{1}	2.2×10^{1}	3.9×10^{-3}	3.9×10^{-3}	2.2×10^{1}
Technetium-99	5.3×10^{-4}	6.4×10^{-5}	1.9×10^{-3}	2.5×10^{-3}	0	8.1×10^{-8}	8.1×10^{-8}	1.6×10^{-7}
Iodine-129	8.1×10^{-1}	4.9	7.7	1.3×10^{1}	0	7.0×10^{-8}	7.0×10^{-8}	1.4×10^{-7}
Cesium-137	9.0×10^{1}	1.3	1.3×10^{1}	1.0×10^{2}	3.8×10^{1}	2.5×10^{-3}	2.5×10^{-3}	3.8×10^{1}
Uranium	1.9×10^{-1}	7.9×10^{-3}	2.8×10^{-2}	2.3×10^{-1}	0	3.5×10^{-5}	3.5×10^{-5}	6.9×10^{-5}
Plutonium-238	3.2	6.4×10^{-2}	1.7×10^{-1}	3.4	0	2.2×10^{-4}	2.2×10^{-4}	4.4×10^{-4}
Plutonium-239, -240	6.0×10^{1}	1.5	4.2	6.5×10^{1}	0	1.4×10^{-2}	1.4×10^{-2}	2.7×10^{-2}
Plutonium-241	1.2	2.8×10^{-2}	7.9×10^{-2}	1.3	0	4.4×10^{-5}	4.4×10^{-5}	8.8×10^{-5}
Americium-241	1.0×10^{2}	2.4	5.3	1.1×10^{2}	0	3.0×10^{-3}	3.0×10^{-3}	6.0×10^{-3}
Total	3.7×10^{2}	1.2×10^{1}	1.1×10^{2}	4.9×10^{2}	6.0×10^{1}	2.3×10^{-2}	2.3×10^{-2}	6.0×10^{1}
Number of latent cancer fatalities[b]				0 (3×10^{-1})				0 (4×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–27. Tank Closure Alternative 5 Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	7.6×10^{-1}	6.8×10^{-6}	1.5	2.2	4.7×10^{-4}	4.2×10^{-8}	9.2×10^{-3}	9.7×10^{-3}
Carbon-14	3.5×10^{1}	3.1×10^{-4}	6.8×10^{1}	1.0×10^{2}	2.1×10^{-1}	1.9×10^{-6}	4.2×10^{-1}	6.3×10^{-1}
Cobalt-60	5.8×10^{-3}	1.4×10^{-5}	1.4×10^{-3}	7.1×10^{-3}	7.5×10^{-6}	6.7×10^{-8}	8.5×10^{-6}	1.6×10^{-5}
Strontium-90	8.0×10^{1}	1.1×10^{-1}	1.5	8.2×10^{1}	2.2×10^{1}	1.3×10^{-7}	8.8×10^{-3}	2.2×10^{1}
Technetium-99	2.6×10^{-3}	1.7×19^{-5}	1.7×10^{-3}	4.3×10^{-3}	1.1×10^{-5}	9.8×10^{-8}	1.1×10^{-5}	2.1×10^{-5}
Iodine-129	1.3	3.7	6.3	1.1×10^{1}	8.2×10^{-6}	7.6×10^{-8}	1.7×10^{-2}	1.7×10^{-2}
Cesium-137	8.7×10^{1}	6.0×10^{-1}	1.2×10^{1}	1.0×10^{2}	3.8×10^{1}	2.6×10^{-5}	7.3×10^{-2}	3.8×10^{1}
Uranium	1.9×10^{-1}	6.8×10^{-4}	1.9×10^{-2}	2.1×10^{-1}	7.3×10^{-5}	6.5×10^{-7}	1.2×10^{-4}	1.9×10^{-4}
Plutonium-238	2.9	3.0×10^{-2}	1.3×10^{-1}	3.0	3.9×10^{-7}	3.4×10^{-9}	8.0×10^{-4}	8.0×10^{-4}
Plutonium-239, -240	5.4×10^{1}	3.6×10^{-1}	2.6	5.7×10^{1}	7.6×10^{-6}	6.0×10^{-7}	1.6×10^{-2}	1.6×10^{-2}
Plutonium-241	1.0	6.7×10^{-3}	4.9×10^{-2}	1.1	2.1×10^{-7}	1.9×10^{-9}	4.5×10^{-4}	4.5×10^{-4}
Americium-241	9.3×10^{1}	1.2	3.5	9.8×10^{1}	2.0×10^{-5}	1.9×10^{-7}	2.1×10^{-2}	2.1×10^{-2}
Total	3.6×10^{2}	6.0	9.5×10^{1}	4.6×10^{2}	6.0×10^{1}	3.0×10^{-5}	5.6×10^{-1}	6.1×10^{1}
Number of latent cancer fatalities[b]				0 (3×10^{-1})				0 (4×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–28. Tank Closure Alternative 6A, Base Case, Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6	2.5×10^{-2}	2.4×10^{-4}	1.6	0	3.2×10^{-5}	3.2×10^{-5}	6.5×10^{-5}
Carbon-14	7.2×10^{1}	7.9×10^{-1}	7.6×10^{-3}	7.3×10^{1}	0	1.0×10^{-3}	1.0×10^{-3}	2.1×10^{-3}
Cobalt-60	5.7×10^{-3}	1.2×10^{-3}	3.4×10^{-5}	6.9×10^{-3}	0	1.2×10^{-6}	1.2×10^{-6}	2.4×10^{-6}
Strontium-90	9.0×10^{1}	1.5×10^{1}	4.6×10^{-1}	1.1×10^{2}	2.2×10^{1}	1.4×10^{-2}	1.4×10^{-2}	2.2×10^{1}
Technetium-99	1.8×10^{-3}	1.5×10^{-3}	1.5×10^{-5}	3.3×10^{-3}	0	2.0×10^{-6}	2.0×10^{-6}	4.0×10^{-6}
Iodine-129	2.8	2.4×10^{1}	1.5×10^{-1}	2.6×10^{1}	0	3.6×10^{-3}	3.6×10^{-3}	7.3×10^{-3}
Cesium-137	1.0×10^{2}	3.7×10^{1}	3.5×10^{-1}	1.4×10^{2}	3.8×10^{1}	4.4×10^{-2}	4.4×10^{-2}	3.8×10^{1}
Uranium	2.1×10^{-1}	3.1×10^{-1}	2.9×10^{-3}	5.2×10^{-1}	0	4.0×10^{-4}	4.0×10^{-4}	7.9×10^{-4}
Plutonium-238	3.7	5.7×10^{-1}	6.0×10^{-3}	4.2	0	8.8×10^{-4}	7.4×10^{-4}	1.6×10^{-3}
Plutonium-239, -240	6.5×10^{1}	7.3	3.4×10^{-1}	7.3×10^{1}	0	2.6×10^{-2}	6.2×10^{-3}	3.2×10^{-2}
Plutonium-241	1.3	1.4×10^{-1}	6.4×10^{-3}	1.4	0	1.0×10^{-4}	1.0×10^{-4}	2.0×10^{-4}
Americium-241	1.2×10^{2}	8.9	4.7×10^{-1}	1.3×10^{2}	0	7.5×10^{-3}	5.9×10^{-3}	1.3×10^{-2}
Total	4.6×10^{2}	9.3×10^{1}	1.8	5.6×10^{2}	6.0×10^{1}	9.7×10^{-2}	7.6×10^{-2}	6.0×10^{1}
Number of latent cancer fatalities[b]				0 (3×10^{-1})				0 (4×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–29. Tank Closure Alternative 6A, Option Case, Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6	6.0×10^{-1}	6.0×10^{-1}	2.8	0	7.8×10^{-4}	7.8×10^{-4}	1.6×10^{-3}
Carbon-14	7.2×10^{1}	1.1	1.1	7.4×10^{1}	0	1.4×10^{-3}	1.4×10^{-3}	2.8×10^{-3}
Cobalt-60	5.7×10^{-3}	2.3×10^{-3}	2.3×10^{-3}	1.0×10^{-2}	0	2.4×10^{-6}	2.4×10^{-6}	4.9×10^{-6}
Strontium-90	9.0×10^{1}	1.8×10^{1}	1.8×10^{1}	1.3×10^{2}	2.2×10^{1}	1.5×10^{-2}	1.5×10^{-2}	2.2×10^{1}
Technetium-99	1.8×10^{-3}	2.2×10^{-3}	2.2×10^{-3}	6.3×10^{-3}	0	2.9×10^{-6}	2.9×10^{-6}	5.8×10^{-6}
Iodine-129	2.8	2.5×10^{1}	2.4×10^{1}	5.1×10^{1}	0	5.1×10^{-3}	5.1×10^{-3}	1.0×10^{-2}
Cesium-137	1.0×10^{2}	3.8×10^{1}	3.8×10^{1}	1.8×10^{2}	3.8×10^{1}	4.5×10^{-2}	4.5×10^{-2}	3.8×10^{1}
Uranium	2.1×10^{-1}	4.1×10^{-1}	4.1×10^{-1}	1.0	0	5.4×10^{-4}	5.4×10^{-4}	1.1×10^{-3}
Plutonium-238	3.7	1.1	1.1	5.9	0	1.6×10^{-3}	1.4×10^{-3}	3.0×10^{-3}
Plutonium-239 -240	6.5×10^{1}	4.8×10^{1}	4.8×10^{1}	1.6×10^{2}	0	7.7×10^{-2}	5.8×10^{-2}	1.3×10^{-1}
Plutonium-241	1.3	9.0×10^{-1}	9.0×10^{-1}	3.1	0	8.0×10^{-4}	8.0×10^{-4}	1.6×10^{-3}
Americium-241	1.2×10^{2}	1.8×10^{1}	1.8×10^{1}	1.6×10^{2}	0	1.7×10^{-2}	1.5×10^{-2}	3.2×10^{-2}
Total	4.6×10^{2}	1.5×10^{2}	1.5×10^{2}	7.6×10^{2}	6.0×10^{1}	1.6×10^{-1}	1.4×10^{-1}	6.0×10^{1}
Number of latent cancer fatalities[b]				0 (5×10^{-1})				0 (4×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–30. Tank Closure Alternative 6B, Base Case, Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6	2.5×10^{-2}	2.5×10^{-2}	1.6	6.0×10^{-2}	3.2×10^{-4}	3.2×10^{-4}	6.0×10^{-2}
Carbon-14	7.2×10^{1}	7.9×10^{-1}	7.9×10^{-1}	7.3×10^{1}	2.7	1.0×10^{-2}	1.0×10^{-2}	2.8
Cobalt-60	5.7×10^{-3}	1.2×10^{-3}	1.2×10^{-3}	8.1×10^{-3}	2.2×10^{-4}	2.2×10^{-5}	1.8×10^{-5}	2.6×10^{-4}
Strontium-90	8.5×10^{1}	1.5×10^{1}	1.5×10^{1}	1.1×10^{2}	2.4×10^{1}	2.9×10^{-1}	2.2×10^{-1}	2.4×10^{1}
Technetium-99	1.8×10^{-3}	1.5×10^{-3}	1.5×10^{-3}	4.8×10^{-3}	6.8×10^{-5}	2.0×10^{-5}	2.0×10^{-5}	1.1×10^{-4}
Iodine-129	2.7	7.9	7.6	1.8×10^{1}	1.0×10^{-1}	1.7×10^{-1}	1.6×10^{-1}	4.4×10^{-1}
Cesium-137	9.3×10^{1}	3.5×10^{1}	3.5×10^{1}	1.6×10^{2}	4.0×10^{1}	4.6×10^{-1}	4.6×10^{-1}	4.1×10^{1}
Uranium	2.1×10^{-1}	3.1×10^{-1}	3.1×10^{-1}	8.2×10^{-1}	7.9×10^{-3}	4.0×10^{-3}	4.0×10^{-3}	1.6×10^{-2}
Plutonium-238	3.7	5.7×10^{-1}	5.7×10^{-1}	4.8	1.4×10^{-1}	7.4×10^{-3}	7.4×10^{-3}	1.5×10^{-1}
Plutonium-239, -240	6.5×10^{1}	7.3	7.4	8.0×10^{1}	2.6	1.6×10^{-1}	1.1×10^{-1}	2.9
Plutonium-241	1.3	1.4×10^{-1}	1.4×10^{-1}	1.5	7.4×10^{-2}	1.1×10^{-3}	1.1×10^{-3}	7.6×10^{-2}
Americium-241	1.2×10^{2}	8.9	9.0	1.4×10^{2}	4.4	2.3×10^{-1}	1.5×10^{-1}	4.8
Total	4.5×10^{2}	7.5×10^{1}	7.5×10^{1}	6.0×10^{2}	7.4×10^{1}	1.3	1.1	7.6×10^{1}
Number of latent cancer fatalities[b]				0 (4×10^{-1})				0 (5×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–31. Tank Closure Alternative 6B, Option Case, Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6	6.0×10^{-1}	6.0×10^{-1}	2.8	6.0×10^{-2}	7.8×10^{-3}	7.8×10^{-3}	7.5×10^{-2}
Carbon-14	7.2×10^{1}	1.1	1.1	7.4×10^{1}	2.7	1.4×10^{-2}	1.4×10^{-2}	2.8
Cobalt-60	5.7×10^{-3}	2.2×10^{-3}	2.2×10^{-3}	1.0×10^{-2}	2.2×10^{-4}	3.9×10^{-5}	3.0×10^{-5}	2.9×10^{-4}
Strontium-90	8.5×10^{1}	1.7×10^{1}	1.7×10^{1}	1.2×10^{2}	2.4×10^{1}	3.6×10^{-1}	2.3×10^{-1}	2.4×10^{1}
Technetium-99	1.8×10^{-3}	2.2×10^{-3}	2.2×10^{-3}	6.3×10^{-3}	6.8×10^{-5}	2.9×10^{-5}	2.9×10^{-5}	1.3×10^{-4}
Iodine-129	2.7	9.0	8.8	2.0×10^{1}	1.0×10^{-1}	1.8×10^{-1}	1.8×10^{-1}	4.7×10^{-1}
Cesium-137	9.3×10^{1}	3.6×10^{1}	3.6×10^{1}	1.6×10^{2}	4.0×10^{1}	4.8×10^{-1}	4.7×10^{-1}	4.1×10^{1}
Uranium	2.1×10^{-1}	4.2×10^{-1}	4.2×10^{-1}	1.0	7.9×10^{-3}	5.4×10^{-3}	5.4×10^{-3}	1.9×10^{-2}
Plutonium-238	3.7	1.1	1.1	5.9	1.4×10^{-1}	1.5×10^{-2}	1.4×10^{-2}	1.7×10^{-1}
Plutonium-239, -240	6.5×10^{1}	4.8×10^{1}	4.8×10^{1}	1.6×10^{2}	2.5	7.1×10^{-1}	6.3×10^{-1}	3.8
Plutonium-241	1.3	9.0×10^{-1}	9.0×10^{-1}	3.1	7.4×10^{-2}	8.1×10^{-3}	8.1×10^{-3}	9.0×10^{-2}
Americium-241	1.2×10^{2}	1.8×10^{1}	1.8×10^{1}	1.6×10^{2}	4.7	4.0×10^{-1}	2.4×10^{-1}	5.3
Total	4.5×10^{2}	1.3×10^{2}	1.3×10^{2}	7.1×10^{2}	7.4×10^{1}	2.2	1.8	7.8×10^{1}
Number of latent cancer fatalities[b]				0 (4×10^{-1})				0 (5×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–32. Tank Closure Alternative 6C Impacts on the Population During Normal Operations

Radionuclides	Dose over Life of Project (person-rem)[a]				Dose in Year of Maximum Impact (person-rem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6	0	0	1.6	6.0×10^{-2}	0	0	6.0×10^{-2}
Carbon-14	7.2×10^{1}	0	0	7.2×10^{1}	2.7	0	0	2.7
Cobalt-60	5.7×10^{-3}	0	0	5.7×10^{-3}	2.2×10^{-4}	0	0	2.2×10^{-4}
Strontium-90	8.5×10^{1}	8.2×10^{-2}	7.9×10^{-2}	8.5×10^{1}	2.4×10^{1}	2.2×10^{-3}	2.1×10^{-3}	2.4×10^{1}
Technetium-99	1.8×10^{-3}	0	0	1.8×10^{-3}	6.8×10^{-5}	0	0	6.8×10^{-5}
Iodine-129	2.7	5.1	4.9	1.3×10^{1}	1.0×10^{-1}	1.3×10^{-1}	1.3×10^{-1}	3.7×10^{-1}
Cesium-137	9.3×10^{1}	7.9×10^{-1}	7.6×10^{-1}	9.5×10^{1}	4.0×10^{1}	2.1×10^{-2}	2.0×10^{-2}	4.0×10^{1}
Uranium	2.1×10^{-1}	0	0	2.1×10^{-1}	7.9×10^{-3}	0	0	7.9×10^{-3}
Plutonium-238	3.7	2.7×10^{-4}	3.6×10^{-4}	3.7	1.4×10^{-1}	7.0×10^{-5}	7.0×10^{-5}	1.4×10^{-1}
Plutonium-239, -240	6.5×10^{1}	3.8×10^{-2}	5.1×10^{-2}	6.5×10^{1}	2.6	9.9×10^{-3}	9.9×10^{-3}	2.7
Plutonium-241	1.3	7.1×10^{-4}	9.6×10^{-4}	1.3	7.4×10^{-2}	0	0	7.4×10^{-2}
Americium-241	1.2×10^{2}	3.2×10^{-3}	4.2×10^{-3}	1.2×10^{2}	4.4	7.9×10^{-4}	7.9×10^{-4}	4.4
Total	4.5×10^{2}	6.0	5.7	4.6×10^{2}	7.4×10^{1}	1.7×10^{-1}	1.6×10^{-1}	7.4×10^{1}
Number of latent cancer fatalities[b]				0 (3×10^{-1})				0 (4×10^{-2})

[a] The reported result is the collective dose for a population of approximately 463,000, the average of the populations of 447,354; 451,556; and 488,897 that live within 80 kilometers (50 miles) of the Waste Treatment Plant, 200-East Area STTS, and 200-West Area STTS, respectively. There is no regulatory standard for a population dose.

[b] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–33. Tank Closure Alternative 1 Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)[a]				Dose in Year of Maximum Impact (millirem per year)[b]			
	Waste Treatment Plant[c]	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant[c]	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	0	1.0	5.2×10^{-1}	1.6	0	1.0×10^{-2}	5.2×10^{-3}	1.6×10^{-2}
Carbon-14	0	0	0	0	0	0	0	0
Cobalt-60	0	4.4×10^{-2}	2.2×10^{-2}	6.6×10^{-2}	0	4.4×10^{-4}	2.2×10^{-4}	6.6×10^{-4}
Strontium-90	0	1.3×10^{-2}	6.4×10^{-3}	1.9×10^{-2}	0	2.4×10^{-4}	1.2×10^{-4}	3.7×10^{-4}
Technetium-99	0	0	0	0	0	0	0	0
Iodine-129	0	5.5×10^{-1}	2.8×10^{-1}	8.3×10^{-1}	0	1.1×10^{-2}	5.4×10^{-3}	1.6×10^{-2}
Cesium-137	0	7.3×10^{-2}	3.8×10^{-2}	1.1×10^{-1}	0	1.4×10^{-3}	7.3×10^{-4}	2.1×10^{-3}
Uranium	0	6	3.1	9.1	0	6.0×10^{-2}	3.1×10^{-2}	9.1×10^{-2}
Plutonium-238	0	0	0	0	0	0	0	0
Plutonium-239, -240	0	7.8×10^{-7}	3.9×10^{-7}	1.2×10^{-6}	0	2.1×10^{-8}	7.7×10^{-9}	2.9×10^{-8}
Plutonium-241	0	0	0	0	0	0	0	0
Americium-241	0	6.6×10^{-7}	3.0×10^{-7}	9.5×10^{-7}	0	1.9×10^{-8}	6.3×10^{-9}	2.5×10^{-8}
Total	0	7.7	3.9	1.2×10^{1}	0	8.3×10^{-2}	4.2×10^{-2}	1.3×10^{-1}
Lifetime risk of a latent cancer fatality				7×10^{-6}				8×10^{-8}

[a] Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The dose from 70 years of exposure at the average annual dose rate would be 8 millirem, with a corresponding lifetime risk of a latent cancer fatality of 5×10^{-6}.

[b] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

[c] There would be no emissions from the Waste Treatment Plant because it would not operate under this alternative.

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–34. Tank Closure Alternative 2A Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)[a]				Dose in Year of Maximum Impact (millirem per year)[b]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	2.8×10^{-2}	1.0	5.2×10^{-1}	1.6	0	0	0	0
Carbon-14	1.7	0	0	1.7	0	0	0	0
Cobalt-60	8.1×10^{-5}	4.4×10^{-2}	2.2×10^{-2}	6.6×10^{-2}	0	0	0	0
Strontium-90	2.1	2.3×10^{-2}	1.2×10^{-2}	2.1	6.4×10^{-1}	0	0	6.4×10^{-1}
Technetium-99	6.2×10^{-5}	0	0	6.2×10^{-5}	0	0	0	0
Iodine-129	4.8×10^{-2}	9.9×10^{-1}	5.1×10^{-1}	1.5	0	0	0	0
Cesium-137	1.5	1.3×10^{-1}	6.8×10^{-2}	1.7	7.2×10^{-1}	0	0	7.2×10^{-1}
Uranium	2.1×10^{-3}	6.0	3.1	9.1	0	0	0	0
Plutonium-238	3.7×10^{-2}	1.4×10^{-6}	1.8×10^{-6}	3.7×10^{-2}	0	0	0	0
Plutonium-239, -240	6.9×10^{-1}	1.9×10^{-4}	2.6×10^{-4}	6.9×10^{-1}	0	7.8×10^{-9}	0	7.8×10^{-9}
Plutonium-241	2.0×10^{-2}	0	0	2.0×10^{-2}	0	0	0	0
Americium-241	1.2	2.1×10^{-5}	2.3×10^{-5}	1.2	0	0	0	0
Total	7.3	8.3	4.2	2.0×10^{1}	1.4	7.8×10^{-9}	0	1.4
Lifetime risk of a latent cancer fatality				1×10^{-5}				8×10^{-7}

[a] Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The dose from 70 years of exposure at the average annual dose rate would be 7.4 millirem, with a corresponding lifetime risk of a latent cancer fatality of 4×10^{-6}.

[b] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–35. Tank Closure Alternative 2B Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)				Dose in Year of Maximum Impact (millirem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	3.3×10^{-2}	0	0	3.3×10^{-2}	1.2×10^{-3}	0	0	1.2×10^{-3}
Carbon-14	2.2	0	0	2.2	8.2×10^{-2}	0	0	8.2×10^{-2}
Cobalt-60	1.0×10^{-4}	0	0	1.0×10^{-4}	3.9×10^{-6}	0	0	3.9×10^{-6}
Strontium-90	2.6	3.0×10^{-3}	1.7×10^{-3}	2.6	7.6×10^{-1}	7.9×10^{-5}	4.6×10^{-5}	7.6×10^{-1}
Technetium-99	7.4×10^{-5}	0	0	7.4×10^{-5}	2.8×10^{-6}	0	0	2.8×10^{-6}
Iodine-129	5.8×10^{-2}	1.3×10^{-1}	7.4×10^{-2}	2.6×10^{-1}	2.2×10^{-3}	3.4×10^{-3}	1.9×10^{-3}	7.6×10^{-3}
Cesium-137	1.7	1.8×10^{-2}	1.0×10^{-2}	1.8	7.4×10^{-1}	4.7×10^{-4}	2.7×10^{-4}	7.5×10^{-1}
Uranium	2.5×10^{-3}	0	0	2.5×10^{-3}	9.5×10^{-5}	0	0	9.5×10^{-5}
Plutonium-238	4.4×10^{-2}	3.9×10^{-6}	3.1×10^{-6}	4.4×10^{-2}	1.7×10^{-3}	1.0×10^{-6}	6.0×10^{-7}	1.7×10^{-3}
Plutonium-239, -240	8.1×10^{-1}	5.6×10^{-4}	4.4×10^{-4}	8.1×10^{-1}	3.1×10^{-2}	1.5×10^{-4}	8.6×10^{-5}	3.1×10^{-2}
Plutonium-241	2.4×10^{-2}	0	0	2.4×10^{-2}	9.1×10^{-4}	0	0	9.1×10^{-4}
Americium-241	1.4	4.6×10^{-5}	3.7×10^{-5}	1.4	5.5×10^{-2}	1.2×10^{-5}	6.9×10^{-6}	5.5×10^{-2}
Total	8.9	1.5×10^{-1}	8.6×10^{-2}	9.2	1.7	4.1×10^{-3}	2.4×10^{-3}	1.7
Lifetime risk of a latent cancer fatality				5×10^{-6}				1×10^{-6}

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–36. Tank Closure Alternative 3A Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)				Dose in Year of Maximum Impact (millirem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	8.1×10^{-3}	7.9×10^{-2}	3.5×10^{-2}	1.2×10^{-1}	0	2.3×10^{-4}	1.2×10^{-4}	3.5×10^{-4}
Carbon-14	5.4×10^{-1}	4.9	2.2	7.7	0	1.4×10^{-2}	7.1×10^{-3}	2.1×10^{-2}
Cobalt-60	6.7×10^{-5}	5.2×10^{-5}	2.6×10^{-5}	1.5×10^{-4}	0	1.5×10^{-7}	8.8×10^{-8}	2.4×10^{-7}
Strontium-90	2.0	7.1×10^{-3}	4.9×10^{-2}	2.1	6.4×10^{-1}	5.1×10^{-7}	1.6×10^{-4}	6.4×10^{-1}
Technetium-99	1.8×10^{-5}	1.7×10^{-6}	7.6×10^{-5}	9.6×10^{-5}	0	5.1×10^{-7}	2.6×10^{-7}	7.7×10^{-7}
Iodine-129	1.4×10^{-2}	3.2×10^{-1}	1.5×10^{-1}	4.9×10^{-1}	0	4.1×10^{-4}	2.0×10^{-4}	6.1×10^{-4}
Cesium-137	1.4	4.5×10^{-2}	2.3×10^{-1}	1.7	7.2×10^{-1}	6.2×10^{-5}	7.1×10^{-4}	7.2×10^{-1}
Uranium	1.9×10^{-3}	3.6×10^{-4}	2.6×10^{-4}	2.5×10^{-3}	0	9.7×10^{-7}	8.2×10^{-7}	1.8×10^{-6}
Plutonium-238	3.1×10^{-2}	7.5×10^{-4}	1.7×10^{-3}	3.4×10^{-2}	0	5.2×10^{-9}	5.5×10^{-6}	5.5×10^{-6}
Plutonium-239, -240	6.3×10^{-1}	9.6×10^{-3}	3.5×10^{-2}	6.7×10^{-1}	0	1.1×10^{-7}	1.1×10^{-4}	1.1×10^{-4}
Plutonium-241	1.8×10^{-2}	2.7×10^{-4}	9.6×10^{-4}	1.9×10^{-2}	0	3.0×10^{-9}	3.1×10^{-6}	3.1×10^{-6}
Americium-241	1.0	3.2×10^{-2}	4.6×10^{-2}	1.1	0	2.9×10^{-7}	1.5×10^{-4}	1.5×10^{-4}
Total	5.7	5.4	2.7	1.4×10^{1}	1.4	1.5×10^{-2}	8.6×10^{-3}	1.4
Lifetime risk of a latent cancer fatality				8×10^{-6}				8×10^{-7}

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–37. Tank Closure Alternative 3B Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)				Dose in Year of Maximum Impact (millirem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	9.5×10^{-3}	5.1×10^{-7}	2.6×10^{-7}	9.5×10^{-3}	0	2.3×10^{-9}	1.2×10^{-9}	3.5×10^{-9}
Carbon-14	6.6×10^{-1}	3.2×10^{-5}	1.6×10^{-5}	6.6×10^{-1}	0	1.4×10^{-7}	7.1×10^{-8}	2.1×10^{-7}
Cobalt-60	8.3×10^{-5}	7.5×10^{-7}	3.9×10^{-7}	8.4×10^{-5}	0	3.0×10^{-9}	1.8×10^{-9}	4.8×10^{-9}
Strontium-90	2.5	4.5×10^{-3}	2.3×10^{-3}	2.5	6.4×10^{-1}	1.0×10^{-8}	3.1×10^{-6}	6.4×10^{-1}
Technetium-99	5.0×10^{-5}	9.1×10^{-8}	1.1×10^{-6}	5.1×10^{-5}	0	1.0×10^{-10}	5.1×10^{-9}	5.2×10^{-9}
Iodine-129	1.7×10^{-2}	1.2×10^{-1}	6.6×10^{-2}	2.0×10^{-1}	0	4.1×10^{-9}	2.0×10^{-9}	6.1×10^{-9}
Cesium-137	1.7	1.7×10^{-2}	1.2×10^{-2}	1.7	7.2×10^{-1}	1.2×10^{-6}	1.4×10^{-5}	7.2×10^{-1}
Uranium	2.3×10^{-3}	1.3×10^{-5}	4.1×10^{-6}	2.3×10^{-3}	0	1.9×10^{-8}	1.6×10^{-8}	3.6×10^{-8}
Plutonium-238	3.8×10^{-2}	4.8×10^{-4}	2.9×10^{-5}	3.8×10^{-2}	0	1.0×10^{-10}	1.1×10^{-7}	1.1×10^{-7}
Plutonium-239, -240	7.4×10^{-1}	6.4×10^{-3}	1.3×10^{-3}	7.5×10^{-1}	0	9.8×10^{-9}	2.2×10^{-6}	2.2×10^{-6}
Plutonium-241	2.1×10^{-2}	1.8×10^{-4}	1.5×10^{-5}	2.2×10^{-2}	0	5.9×10^{-11}	6.2×10^{-8}	6.2×10^{-8}
Americium-241	1.2	1.9×10^{-2}	7.3×10^{-4}	1.2	0	5.7×10^{-9}	3.0×10^{-6}	3.0×10^{-6}
Total	6.8	1.6×10^{-1}	8.3×10^{-2}	7.1	1.4	1.4×10^{-6}	2.3×10^{-5}	1.4
Lifetime risk of a latent cancer fatality				4×10^{-6}				8×10^{-7}

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–38. Tank Closure Alternative 3C Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)				Dose in Year of Maximum Impact (millirem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	8.1×10^{-3}	7.9×10^{-2}	3.5×10^{-2}	1.2×10^{-1}	0	2.3×10^{-4}	1.2×10^{-4}	3.5×10^{-4}
Carbon-14	5.4×10^{-1}	4.9	2.2	7.7	0	1.4×10^{-2}	7.1×10^{-3}	2.1×10^{-2}
Cobalt-60	6.7×10^{-5}	5.2×10^{-5}	2.6×10^{-5}	1.5×10^{-4}	0	1.5×10^{-7}	8.8×10^{-8}	2.4×10^{-7}
Strontium-90	2.0	7.2×10^{-3}	4.9×10^{-2}	2.1	6.4×10^{-1}	5.1×10^{-7}	1.6×10^{-4}	6.4×10^{-1}
Technetium-99	4.2×10^{-5}	1.8×10^{-4}	7.6×10^{-5}	2.9×10^{-4}	0	5.1×10^{-7}	2.6×10^{-7}	7.7×10^{-7}
Iodine-129	1.4×10^{-2}	3.2×10^{-1}	1.5×10^{-1}	4.9×10^{-1}	0	4.1×10^{-4}	2.0×10^{-4}	6.1×10^{-4}
Cesium-137	1.4	4.5×10^{-2}	2.3×10^{-1}	1.7	7.2×10^{-1}	6.2×10^{-5}	7.1×10^{-4}	7.2×10^{-1}
Uranium	1.9×10^{-3}	3.6×10^{-4}	2.6×10^{-4}	2.5×10^{-3}	0	9.7×10^{-7}	8.2×10^{-7}	1.8×10^{-6}
Plutonium-238	3.1×10^{-2}	7.6×10^{-4}	1.7×10^{-3}	3.4×10^{-2}	0	5.2×10^{-9}	5.5×10^{-6}	5.5×10^{-6}
Plutonium-239, -240	6.3×10^{-1}	9.6×10^{-3}	3.5×10^{-2}	6.7×10^{-1}	0	1.1×10^{-7}	1.1×10^{-4}	1.1×10^{-4}
Plutonium-241	1.8×10^{-2}	2.7×10^{-4}	9.6×10^{-4}	1.9×10^{-2}	0	3.0×10^{-9}	3.1×10^{-6}	3.1×10^{-6}
Americium-241	1.0	3.2×10^{-2}	4.6×10^{-2}	1.1	0	2.9×10^{-7}	1.5×10^{-4}	1.5×10^{-4}
Total	5.7	5.4	2.7	1.4×10^{1}	1.4	1.5×10^{-2}	8.6×10^{-3}	1.4
Lifetime risk of a latent cancer fatality				8×10^{-6}				8×10^{-7}

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–39. Tank Closure Alternative 4 Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)				Dose in Year of Maximum Impact (millirem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	9.0×10^{-3}	6.7×10^{-7}	3.2×10^{-2}	4.1×10^{-2}	0	3.1×10^{-11}	1.9×10^{-11}	4.9×10^{-11}
Carbon-14	6.0×10^{-1}	4.2×10^{-5}	2.0	2.6	0	7.2×10^{-10}	4.2×10^{-10}	1.1×10^{-9}
Cobalt-60	7.8×10^{-5}	2.6×10^{-6}	2.6×10^{-5}	1.1×10^{-4}	0	2.2×10^{-9}	1.3×10^{-9}	3.5×10^{-9}
Strontium-90	2.3	6.7×10^{-2}	8.9×10^{-2}	2.5	6.4×10^{-1}	1.4×10^{-4}	8.7×10^{-5}	6.4×10^{-1}
Technetium-99	2.0×10^{-5}	4.2×10^{-6}	7.3×10^{-5}	9.7×10^{-5}	0	4.1×10^{-9}	2.4×10^{-9}	6.5×10^{-9}
Iodine-129	1.6×10^{-2}	1.7×10^{-1}	1.5×10^{-1}	3.3×10^{-1}	0	1.8×10^{-9}	1.1×10^{-9}	2.9×10^{-9}
Cesium-137	1.6	3.7×10^{-2}	2.2×10^{-1}	1.8	7.2×10^{-1}	5.6×10^{-5}	3.3×10^{-5}	7.2×10^{-1}
Uranium	2.1×10^{-3}	1.6×10^{-4}	3.3×10^{-4}	2.6×10^{-3}	0	4.9×10^{-7}	3.0×10^{-7}	7.9×10^{-7}
Plutonium-238	3.4×10^{-2}	1.3×10^{-3}	2.0×10^{-3}	3.7×10^{-2}	0	3.2×10^{-6}	1.9×10^{-6}	5.1×10^{-6}
Plutonium-239, -240	6.7×10^{-1}	2.8×10^{-2}	4.7×10^{-2}	7.5×10^{-1}	0	2.0×10^{-4}	1.2×10^{-4}	3.2×10^{-4}
Plutonium-241	1.9×10^{-2}	4.2×10^{-4}	1.0×10^{-3}	2.1×10^{-2}	0	6.7×10^{-7}	3.8×10^{-7}	1.0×10^{-6}
Americium-241	1.2	4.8×10^{-2}	6.0×10^{-2}	1.3	0	4.4×10^{-5}	2.6×10^{-5}	7.0×10^{-5}
Total	6.4	3.5×10^{-1}	2.6	9.3	1.4	4.5×10^{-4}	2.7×10^{-4}	1.4
Lifetime risk of a latent cancer fatality				6×10^{-6}				8×10^{-7}

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–40. Tank Closure Alternative 5 Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)				Dose in Year of Maximum Impact (millirem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	1.6×10^{-2}	1.8×10^{-7}	2.3×10^{-2}	3.9×10^{-2}	9.7×10^{-6}	1.1×10^{-9}	1.4×10^{-4}	1.5×10^{-4}
Carbon-14	1.1	1.1×10^{-5}	1.4	2.5	6.3×10^{-3}	6.8×10^{-8}	8.9×10^{-3}	1.5×10^{-2}
Cobalt-60	1.0×10^{-4}	3.0×10^{-7}	1.8×10^{-5}	1.2×10^{-4}	1.3×10^{-7}	1.4×10^{-9}	1.1×10^{-7}	2.5×10^{-7}
Strontium-90	2.3	3.9×10^{-3}	3.3×10^{-2}	2.4	6.4×10^{-1}	4.8×10^{-9}	1.9×10^{-4}	6.4×10^{-1}
Technetium-99	1.1×10^{-4}	8.5×10^{-7}	5.2×10^{-5}	1.6×10^{-4}	4.4×10^{-7}	4.9×10^{-9}	3.2×10^{-7}	7.7×10^{-7}
Iodine-129	2.8×10^{-2}	9.6×10^{-2}	9.6×10^{-2}	2.2×10^{-1}	1.7×10^{-7}	2.0×10^{-9}	2.5×10^{-4}	2.5×10^{-4}
Cesium-137	1.6	1.4×10^{-2}	1.7×10^{-1}	1.8	7.2×10^{-1}	5.9×10^{-7}	9.8×10^{-4}	7.2×10^{-1}
Uranium	2.3×10^{-3}	9.7×10^{-6}	1.7×10^{-4}	2.4×10^{-3}	8.9×10^{-7}	9.3×10^{-9}	1.0×10^{-6}	1.9×10^{-6}
Plutonium-238	3.4×10^{-2}	4.3×10^{-4}	1.1×10^{-3}	3.6×10^{-2}	4.6×10^{-9}	5.0×10^{-11}	6.8×10^{-6}	6.9×10^{-6}
Plutonium-239, -240	6.7×10^{-1}	5.3×10^{-3}	2.3×10^{-2}	7.0×10^{-1}	8.9×10^{-8}	8.8×10^{-9}	1.4×10^{-4}	1.4×10^{-4}
Plutonium-241	2.0×10^{-2}	1.6×10^{-4}	6.3×10^{-4}	2.0×10^{-2}	2.6×10^{-9}	2.8×10^{-11}	3.9×10^{-6}	3.9×10^{-6}
Americium-241	1.1	1.7×10^{-2}	3.0×10^{-2}	1.1	2.5×10^{-7}	2.7×10^{-9}	1.9×10^{-4}	1.9×10^{-4}
Total	6.9	1.4×10^{-1}	1.8	8.9	1.4	6.9×10^{-7}	1.1×10^{-2}	1.4
Lifetime risk of a latent cancer fatality				5×10^{-6}				8×10^{-7}

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–41. Tank Closure Alternative 6A, Base Case, Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)[a]				Dose in Year of Maximum Impact (millirem per year)[b]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	3.3×10^{-2}	6.6×10^{-4}	3.8×10^{-6}	3.3×10^{-2}	0	8.5×10^{-7}	5.1×10^{-7}	1.4×10^{-6}
Carbon-14	2.2	2.8×10^{-2}	1.6×10^{-4}	2.2	0	3.7×10^{-5}	2.2×10^{-5}	5.9×10^{-5}
Cobalt-60	1.0×10^{-4}	2.6×10^{-5}	4.4×10^{-7}	1.3×10^{-4}	0	2.6×10^{-8}	1.6×10^{-8}	4.2×10^{-8}
Strontium-90	2.6	5.4×10^{-1}	1.0×10^{-2}	3.2	6.4×10^{-1}	5.1×10^{-4}	3.1×10^{-4}	6.4×10^{-1}
Technetium-99	7.4×10^{-5}	7.7×10^{-5}	4.4×10^{-7}	1.5×10^{-4}	0	9.9×10^{-8}	6.0×10^{-8}	1.6×10^{-7}
Iodine-129	5.8×10^{-2}	6.1×10^{-1}	2.3×10^{-3}	6.7×10^{-1}	0	9.4×10^{-5}	5.5×10^{-5}	1.5×10^{-4}
Cesium-137	1.9	8.4×10^{-1}	4.7×10^{-3}	2.8	7.2×10^{-1}	9.9×10^{-4}	5.9×10^{-4}	7.2×10^{-1}
Uranium	2.5×10^{-3}	4.4×10^{-3}	2.5×10^{-5}	6.9×10^{-3}	0	5.7×10^{-6}	3.4×10^{-6}	9.1×10^{-6}
Plutonium-238	4.4×10^{-2}	8.3×10^{-3}	5.1×10^{-5}	5.2×10^{-2}	0	1.3×10^{-5}	6.3×10^{-6}	1.9×10^{-5}
Plutonium-239, -240	8.2×10^{-1}	1.1×10^{-1}	3.0×10^{-3}	9.3×10^{-1}	0	3.8×10^{-4}	5.4×10^{-5}	4.4×10^{-4}
Plutonium-241	2.4×10^{-2}	1.2×10^{-3}	7.9×10^{-6}	2.5×10^{-2}	0	1.6×10^{-6}	8.9×10^{-7}	2.4×10^{-6}
Americium-241	1.5	1.3×10^{-1}	4.1×10^{-3}	1.6	0	1.1×10^{-4}	5.1×10^{-5}	1.6×10^{-4}
Total	9.2	2.3	2.5×10^{-2}	1.1×10^{1}	1.4	2.1×10^{-3}	1.1×10^{-3}	1.4
Lifetime risk of a latent cancer fatality				7×10^{-6}				8×10^{-7}

[a] Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The dose from 70 years of exposure at the average annual dose rate would be 4.9 millirem, with a corresponding lifetime risk of a latent cancer fatality of 3×10^{-6}.

[b] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–42. Tank Closure Alternative 6A, Option Case, Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)[a]				Dose in Year of Maximum Impact (millirem per year)[b]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	2.8×10^{-2}	2.4×10^{-2}	1.3×10^{-2}	6.5×10^{-2}	0	2.1×10^{-5}	1.2×10^{-5}	3.3×10^{-5}
Carbon-14	1.8	6.0×10^{-2}	3.2×10^{-2}	1.8	0	5.0×10^{-5}	3.0×10^{-5}	8.0×10^{-5}
Cobalt-60	8.1×10^{-5}	7.5×10^{-5}	4.0×10^{-5}	2.0×10^{-4}	0	5.2×10^{-8}	3.1×10^{-8}	8.4×10^{-8}
Strontium-90	2.2	9.9×10^{-1}	5.3×10^{-1}	3.7	6.4×10^{-1}	5.5×10^{-4}	3.4×10^{-4}	6.4×10^{-1}
Technetium-99	6.2×10^{-5}	1.7×10^{-4}	9.0×10^{-5}	3.3×10^{-4}	0	1.5×10^{-7}	8.7×10^{-8}	2.3×10^{-7}
Iodine-129	4.8×10^{-2}	9.7×10^{-1}	5.0×10^{-1}	1.5	0	1.3×10^{-4}	7.8×10^{-5}	2.1×10^{-4}
Cesium-137	1.6	1.3	6.9×10^{-1}	3.6	7.2×10^{-1}	1.0×10^{-3}	6.0×10^{-4}	7.2×10^{-1}
Uranium	2.1×10^{-3}	9.5×10^{-3}	5.0×10^{-3}	1.7×10^{-2}	0	7.7×10^{-6}	4.6×10^{-6}	1.2×10^{-5}
Plutonium-238	3.7×10^{-2}	2.6×10^{-2}	1.4×10^{-2}	7.6×10^{-2}	0	2.3×10^{-5}	1.2×10^{-5}	3.6×10^{-5}
Plutonium-239, -240	7.0×10^{-1}	1.1	5.8×10^{-1}	2.4	0	1.1×10^{-3}	5.0×10^{-4}	1.6×10^{-3}
Plutonium-241	2.0×10^{-2}	1.4×10^{-2}	7.5×10^{-3}	4.2×10^{-2}	0	1.2×10^{-5}	7.0×10^{-6}	1.9×10^{-5}
Americium-241	1.2	4.4×10^{-1}	2.2×10^{-1}	1.9	0	2.4×10^{-4}	1.3×10^{-4}	3.7×10^{-4}
Total	7.6	4.9	2.6	1.5×10^{1}	1.4	3.2×10^{-3}	1.7×10^{-3}	1.4
Lifetime risk of a latent cancer fatality				9×10^{-6}				8×10^{-7}

a Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The dose from 70 years of exposure at the average annual dose rate would be 6.5 millirem, with a corresponding lifetime risk of a latent cancer fatality of 4×10^{-6}.

b The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–43. Tank Closure Alternative 6B, Base Case, Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)[a]				Dose in Year of Maximum Impact (millirem per year)[b]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	3.0×10^{-2}	8.3×10^{-4}	4.9×10^{-4}	3.1×10^{-2}	1.2×10^{-3}	8.5×10^{-6}	5.1×10^{-6}	1.3×10^{-3}
Carbon-14	1.9	3.7×10^{-2}	2.1×10^{-2}	2.0	8.2×10^{-2}	3.7×10^{-4}	2.2×10^{-4}	8.3×10^{-2}
Cobalt-60	9.3×10^{-5}	3.4×10^{-5}	1.9×10^{-5}	1.5×10^{-4}	3.9×10^{-6}	4.8×10^{-7}	2.3×10^{-7}	4.6×10^{-6}
Strontium-90	2.3	6.9×10^{-1}	3.9×10^{-1}	3.4	7.0×10^{-1}	1.0×10^{-2}	4.8×10^{-3}	7.2×10^{-1}
Technetium-99	6.8×10^{-5}	1.0×10^{-4}	5.7×10^{-5}	2.3×10^{-4}	2.8×10^{-6}	1.0×10^{-6}	6.0×10^{-7}	4.4×10^{-6}
Iodine-129	5.3×10^{-2}	2.6×10^{-1}	1.5×10^{-1}	4.7×10^{-1}	2.2×10^{-3}	4.4×10^{-3}	2.5×10^{-3}	9.1×10^{-3}
Cesium-137	1.6	9.8×10^{-1}	5.9×10^{-1}	3.2	7.4×10^{-1}	1.0×10^{-2}	6.1×10^{-3}	7.6×10^{-1}
Uranium	2.3×10^{-3}	6.1×10^{-3}	3.5×10^{-3}	1.2×10^{-2}	9.5×10^{-5}	5.7×10^{-5}	3.4×10^{-5}	1.9×10^{-4}
Plutonium-238	3.9×10^{-2}	1.1×10^{-2}	6.4×10^{-3}	5.7×10^{-2}	1.7×10^{-3}	1.1×10^{-4}	6.3×10^{-5}	1.9×10^{-3}
Plutonium-239, -240	7.3×10^{-1}	1.4×10^{-1}	8.2×10^{-2}	9.5×10^{-1}	3.1×10^{-2}	2.3×10^{-3}	9.7×10^{-4}	3.4×10^{-2}
Plutonium-241	2.1×10^{-2}	1.6×10^{-3}	9.0×10^{-4}	2.4×10^{-2}	9.1×10^{-4}	1.6×10^{-5}	9.2×10^{-6}	9.3×10^{-4}
Americium-241	1.4	1.8×10^{-1}	1.0×10^{-1}	1.7	5.5×10^{-2}	3.4×10^{-3}	1.3×10^{-3}	6.0×10^{-2}
Total	8.1	2.3	1.3	1.2×10^{1}	1.6	3.2×10^{-2}	1.6×10^{-2}	1.7
Lifetime risk of a latent cancer fatality				7×10^{-6}				1×10^{-6}

a Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The dose from 70 years of exposure at the average annual dose rate would be 8.7 millirem, with a corresponding lifetime risk of a latent cancer fatality of 5×10^{-6}.

b The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–44. Tank Closure Alternative 6B, Option Case, Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)[a]				Dose in Year of Maximum Impact (millirem per year)[b]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	2.8×10^{-2}	2.4×10^{-2}	1.3×10^{-2}	6.5×10^{-2}	1.2×10^{-3}	2.1×10^{-4}	1.2×10^{-4}	1.6×10^{-3}
Carbon-14	1.7	6.0×10^{-2}	3.2×10^{-2}	1.8	8.2×10^{-2}	5.0×10^{-4}	3.0×10^{-4}	8.3×10^{-2}
Cobalt-60	8.1×10^{-5}	7.5×10^{-5}	3.9×10^{-5}	2.0×10^{-4}	3.9×10^{-6}	8.4×10^{-7}	3.8×10^{-7}	5.1×10^{-6}
Strontium-90	2.1	9.7×10^{-1}	5.1×10^{-1}	3.5	7.0×10^{-1}	1.3×10^{-2}	5.1×10^{-3}	7.2×10^{-1}
Technetium-99	6.2×10^{-5}	1.7×10^{-4}	9.0×10^{-5}	3.3×10^{-4}	2.8×10^{-6}	1.5×10^{-6}	8.7×10^{-7}	5.2×10^{-6}
Iodine-129	4.8×10^{-2}	3.5×10^{-1}	1.8×10^{-1}	5.9×10^{-1}	2.2×10^{-3}	4.7×10^{-3}	2.7×10^{-3}	9.7×10^{-3}
Cesium-137	1.5	1.2	6.5×10^{-1}	3.3	7.4×10^{-1}	1.1×10^{-2}	6.3×10^{-3}	7.6×10^{-1}
Uranium	2.1×10^{-3}	9.5×10^{-3}	5.0×10^{-3}	1.7×10^{-2}	9.5×10^{-5}	7.7×10^{-5}	4.6×10^{-5}	2.2×10^{-4}
Plutonium-238	3.7×10^{-2}	2.6×10^{-2}	1.4×10^{-2}	7.6×10^{-2}	1.7×10^{-3}	2.1×10^{-4}	1.2×10^{-4}	2.0×10^{-3}
Plutonium-239, -240	6.9×10^{-1}	1.1	5.8×10^{-1}	2.4	3.1×10^{-2}	1.0×10^{-2}	5.4×10^{-3}	4.7×10^{-2}
Plutonium-241	2.0×10^{-2}	1.4×10^{-2}	7.5×10^{-3}	4.2×10^{-2}	9.1×10^{-4}	1.2×10^{-4}	7.0×10^{-5}	1.1×10^{-3}
Americium-241	1.2	4.3×10^{-1}	2.1×10^{-1}	1.9	5.5×10^{-2}	5.8×10^{-3}	2.1×10^{-3}	6.3×10^{-2}
Total	7.3	4.2	2.2	1.4×10^{1}	1.6	4.6×10^{-2}	2.2×10^{-2}	1.7
Lifetime risk of a latent cancer fatality				8×10^{-6}				1×10^{-6}

[a] Impacts are provided for comparison to other alternatives. The life-of-project dose would not be received by one individual person due to the duration of this alternative. The dose from 70 years of exposure at the average annual dose rate would be 10 millirem, with a corresponding lifetime risk of a latent cancer fatality of 6×10^{-6}.

[b] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

Table K–45. Tank Closure Alternative 6C Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Dose over Life of Project (millirem)				Dose in Year of Maximum Impact (millirem per year)[a]			
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources
Hydrogen-3 (tritium)	3.3×10^{-2}	0	0	3.3×10^{-2}	1.2×10^{-3}	0	0	1.2×10^{-3}
Carbon-14	2.2	0	0	2.2	8.2×10^{-2}	0	0	8.2×10^{-2}
Cobalt-60	1.0×10^{-4}	0	0	1.0×10^{-4}	3.9×10^{-6}	0	0	3.9×10^{-6}
Strontium-90	2.5	3.0×10^{-3}	1.7×10^{-3}	2.5	7.0×10^{-1}	7.9×10^{-5}	4.6×10^{-5}	7.0×10^{-1}
Technetium-99	7.4×10^{-5}	0	0	7.4×10^{-5}	2.8×10^{-6}	0	0	2.8×10^{-6}
Iodine-129	5.8×10^{-2}	1.3×10^{-1}	7.4×10^{-2}	2.6×10^{-1}	2.2×10^{-3}	3.4×10^{-3}	2.0×10^{-3}	7.6×10^{-3}
Cesium-137	1.7	1.8×10^{-2}	1.0×10^{-2}	1.8	7.4×10^{-1}	4.7×10^{-4}	2.7×10^{-4}	7.5×10^{-1}
Uranium	2.5×10^{-3}	0	0	2.5×10^{-3}	9.5×10^{-5}	0	0	9.5×10^{-5}
Plutonium-238	4.4×10^{-2}	3.9×10^{-6}	3.1×10^{-6}	4.4×10^{-2}	1.7×10^{-3}	1.0×10^{-6}	6.0×10^{-7}	1.7×10^{-3}
Plutonium-239, -240	8.1×10^{-1}	5.6×10^{-4}	4.4×10^{-4}	8.1×10^{-1}	3.1×10^{-2}	1.5×10^{-4}	8.6×10^{-5}	3.1×10^{-2}
Plutonium-241	2.4×10^{-2}	0	0	2.4×10^{-2}	9.1×10^{-4}	0	0	9.1×10^{-4}
Americium-241	1.4	4.6×10^{-5}	3.7×10^{-5}	1.4	5.5×10^{-2}	1.2×10^{-5}	6.9×10^{-6}	5.5×10^{-2}
Total	8.8	1.5×10^{-1}	8.6×10^{-2}	9.1	1.6	4.1×10^{-3}	2.4×10^{-3}	1.6
Lifetime risk of a latent cancer fatality				5×10^{-6}				1×10^{-6}

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Note: Sums and products presented in the table may differ from those calculated from table entries due to rounding.

Key: STTS=Supplemental Treatment Technology Site.

An onsite MEI would receive a dose from emissions from the WTP, STTS-East, and STTS-West. Table K–46 presents the doses from each source location, the sum of those doses, and the associated risk of an LCF for the life of the project under each Tank Closure alternative. These data are provided for comparison among the alternatives, recognizing that some of the alternatives (Alternatives 1; 2A; 6A, Base and Option Cases; and 6B, Base and Option Cases) would span multiple generations. Table K–47 presents the doses and associated risks for the year or years of projected maximum impact. The location of the onsite MEI would be affected by the relative amounts of emissions from the three source areas, the WTP, STTS-East, and STTS-West.

Table K–46. Tank Closure Alternatives – Impacts on the Onsite Maximally Exposed Individual Over the Life of the Project During Normal Operations

Tank Closure Alternative	Dose (millirem)				Lifetime Risk of an LCF	Location
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources		
1[a]	0	1.1	6.5×10^{-1}	1.8	1×10^{-6}	CGS
2A[a]	0.76	1.1	6.5×10^{-1}	2.6	2×10^{-6}	CGS
2B	1.0	1.7×10^{-3}	2.2×10^{-4}	1.0	6×10^{-7}	LIGO
3A	0.90	2.2×10^{-2}	1.1×10^{-2}	9.3×10^{-1}	6×10^{-7}	LIGO
3B	0.90	2.4×10^{-3}	4.1×10^{-4}	9.0×10^{-1}	5×10^{-7}	LIGO
3C	0.90	2.2×10^{-2}	1.1×10^{-2}	9.3×10^{-1}	6×10^{-7}	LIGO
4	0.90	7.7×10^{-3}	1.5×10^{-2}	9.3×10^{-1}	6×10^{-7}	LIGO
5	0.83	2.0×10^{-3}	1.0×10^{-2}	8.4×10^{-1}	5×10^{-7}	LIGO
6A Base Case[a]	1.0	1.1×10^{-1}	9.5×10^{-4}	1.2	7×10^{-7}	LIGO
6A Option Case[a]	0.78	3.3×10^{-1}	2.0×10^{-1}	1.3	8×10^{-7}	CGS
6B Base Case[a]	1.0	1.1×10^{-1}	2.5×10^{-2}	1.2	7×10^{-7}	LIGO
6B Option Case[a]	0.76	3.3×10^{-1}	2.0×10^{-1}	1.3	8×10^{-7}	CGS
6C	1.0	1.7×10^{-3}	2.2×10^{-4}	1.0	6×10^{-7}	LIGO

[a] The life-of-project dose would not be received by one individual person due to the duration of these alternatives. The dose and lifetime risk of an LCF from 40 years of exposure at the average annual dose rate would be: Alternative 1 – 0.71 millirem, 4×10^{-7} LCF risk; Alternative 2A – 0.55 millirem, 3×10^{-7} LCF risk; Alternative 6A, Base Case – 0.28 millirem, 2×10^{-7} LCF risk; Alternative 6A, Option Case – 0.32 millirem, 2×10^{-7} LCF risk; Alternative 6B, Base Case – 0.49 millirem, 3×10^{-7} LCF risk; Alternative 6B, Option Case – 0.54 millirem, 3×10^{-7} LCF risk.

Key: CGS=Columbia Generating Station; LCF=latent cancer fatality; LIGO=Laser Interferometer Gravitational-Wave Observatory; STTS=Supplemental Treatment Technology Site.

Table K–47. Tank Closure Alternatives – Impacts on the Onsite Maximally Exposed Individual in the Year of Maximum Impact During Normal Operations

Tank Closure Alternative	Dose (millirem per year)[a]				Lifetime Risk of an LCF	Location
	Waste Treatment Plant	200-East Area STTS	200-West Area STTS	Combined Sources		
1	0	1.1×10^{-2}	6.5×10^{-3}	1.8×10^{-2}	1×10^{-8}	CGS
2A	5.8×10^{-2}	7.6×10^{-10}	0	5.8×10^{-2}	4×10^{-8}	LIGO
2B	9.7×10^{-2}	5.8×10^{-5}	1.4×10^{-5}	9.7×10^{-2}	6×10^{-8}	LIGO
3A	5.8×10^{-2}	8.6×10^{-5}	4.9×10^{-5}	5.8×10^{-2}	4×10^{-8}	LIGO
3B	5.8×10^{-2}	1.1×10^{-7}	7.5×10^{-7}	5.8×10^{-2}	4×10^{-8}	LIGO
3C	5.8×10^{-2}	8.6×10^{-5}	4.9×10^{-5}	5.8×10^{-2}	4×10^{-8}	LIGO
4	5.8×10^{-2}	3.3×10^{-5}	1.7×10^{-5}	5.8×10^{-2}	4×10^{-8}	LIGO
5	5.8×10^{-2}	5.0×10^{-5}	6.3×10^{-5}	5.8×10^{-2}	4×10^{-8}	LIGO
6A Base Case	5.8×10^{-2}	1.5×10^{-4}	2.3×10^{-5}	5.9×10^{-2}	4×10^{-8}	LIGO
6A Option Case	5.8×10^{-2}	2.3×10^{-4}	7.9×10^{-5}	5.9×10^{-2}	4×10^{-8}	LIGO
6B Base Case	9.4×10^{-2}	1.7×10^{-3}	3.8×10^{-4}	9.6×10^{-2}	6×10^{-8}	LIGO
6B Option Case	9.4×10^{-2}	2.7×10^{-3}	9.5×10^{-4}	9.8×10^{-2}	6×10^{-8}	LIGO
6C	9.4×10^{-2}	5.8×10^{-5}	1.4×10^{-5}	9.4×10^{-2}	6×10^{-8}	LIGO

Table K–47. Tank Closure Alternatives – Impacts on the Onsite Maximally Exposed Individual in the Year of Maximum Impact During Normal Operations *(continued)*

[a] The regulatory limit for exposure of an individual to radiological air emissions from U.S. Department of Energy facilities is 10 millirem per year (40 CFR 61.90–61.97).

Key: CGS=Columbia Generating Station; LCF=latent cancer fatality; LIGO=Laser Interferometer Gravitational-Wave Observatory; STTS=Supplemental Treatment Technology Site.

K.2.1.2 Impacts on Workers During Normal Operations

This section describes the methodologies used to evaluate the impacts of waste treatment and closure activities on Hanford workers. Two groups of workers were considered in the evaluation—project radiation workers who are engaged in the waste treatment and closure activities and nearby, noninvolved workers. Different methodologies were used to determine the radiological impacts on these two receptors.

K.2.1.2.1 Project Radiation Workers

Project radiation workers are exposed to radiation through the performance of activities related to the retrieval and processing of tank waste and the deactivation and closure of tank farm facilities. External exposure to radiation is the principal cause of doses to radiation workers.

Doses to radiation workers under each Tank Closure alternative were estimated using data provided in the scaled data sets developed to support this *TC & WM EIS* (SAIC 2007a, 2008). The data sets present conservative estimates of expected worker doses for a range of activities that make up the Tank Closure alternatives. Those estimates were based on a number of factors, including dose rates and doses associated with current tank farm operations, engineering studies of related activities, and conservative engineering estimates for accomplishing particular scopes of work. Scaled data sets representing the Tank Closure alternatives included in this *TC & WM EIS* include scaled estimates of the radiation worker labor hours required to accomplish the activities that make up an alternative and the associated radiation doses.

Total doses associated with each Tank Closure alternative were estimated by summing the dose estimates for each activity that is a component of the alternative, resulting in the project dose estimates shown in Table K–48. These results are presumed to overestimate the dose that would likely be received by the worker population. A number of factors contributed to the conservatism. Conservative dose estimates were included in the original data packages to ensure that they represented the upper range of expected doses associated with performing the activities. Linear scaling of the resources, labor hours, and doses to develop the alternatives added to the conservatism because there was no recognition of economies of scale or changes in annual resource needs commensurate with changes in the duration of activities. For example, the annual labor requirements for operating a facility to process a given amount of material were the same whether the processing period would be 30 years or 80 years. Consequently, the conservatism in the project doses may be greater for alternatives with long operating periods. Through the application of administrative and engineering controls to maintain exposure as low as is reasonably achievable, actual total radiation worker doses from executing an alternative would likely be lower than the estimates.

Data from the scaled data sets were used to develop an estimate of the average annual dose per work year for each Tank Closure alternative. Doses to radiation workers were calculated based on a full-time equivalent (FTE) worker, who was assumed to have a 2,080-hour work year for the purposes of this dose evaluation. The time and dose associated with the various activities that make up an alternative vary, resulting in comparatively low dose rates for some activities and high dose rates for others. In practice, DOE and its contractors would implement controls to limit the exposure of individual workers for all activities in accordance with regulations and guidance (10 CFR 835; DOE Standard 1098-99). Therefore, the average FTE doses calculated for each alternative are not necessarily representative of the actual doses that would be received by individual workers. Rather, they represent an overestimation of the average dose that a worker would receive.

The average dose per FTE under an alternative was calculated by dividing the total radiation worker dose by the number of FTEs. The number of FTEs was determined by dividing the total radiation worker labor hours by 2,080 hours per work year. An average dose for an FTE radiation worker assumed to be involved with the project for an entire working career was also calculated for each alternative. The career dose was estimated by multiplying the average annual FTE dose by 40 years. The average dose per FTE and the average career dose are shown in Table K–48.

Table K–48. Tank Closure Alternatives – Radiation Worker Impacts and Labor Estimates

Alternative	Life-of-Project Collective Worker Impact		Life-of-Project Full-Time Equivalent Radiation Worker Labor		Average Annual Impact per Full-Time Equivalent Radiation Worker		Average Project Impact per Full-Time Equivalent Radiation Worker[a]	
	Dose (person-rem)	LCFs[b]	Hours	Years	Dose (millirem/year)	LCFs[c]	Dose (millirem)	LCFs
1	2.8×10^{2}	0 (0.2)	4.07×10^{6}	2,000	1.4×10^{2}	9×10^{-5}	5.7×10^{3}	3×10^{-3}
2A	2.3×10^{4}	13	2.72×10^{8}	131,000	1.7×10^{2}	1×10^{-4}	6.9×10^{3}	4×10^{-3}
2B	1.1×10^{4}	7	1.44×10^{8}	69,100	1.6×10^{2}	1×10^{-4}	6.4×10^{3}	4×10^{-3}
3A	1.0×10^{4}	6	1.36×10^{8}	65,600	1.6×10^{2}	1×10^{-4}	6.3×10^{3}	4×10^{-3}
3B	1.0×10^{4}	6	1.32×10^{8}	63,400	1.6×10^{2}	9×10^{-5}	6.3×10^{3}	4×10^{-3}
3C	1.1×10^{4}	6	1.41×10^{8}	67,600	1.6×10^{2}	1×10^{-4}	6.4×10^{3}	4×10^{-3}
4	4.3×10^{4}	26	1.74×10^{8}	83,800	5.2×10^{2}	3×10^{-4}	2.1×10^{4}	1×10^{-2}
5	8.8×10^{3}	5	1.24×10^{8}	59,400	1.5×10^{2}	9×10^{-5}	5.9×10^{3}	4×10^{-3}
6A Base Case	1.2×10^{5}	72	6.02×10^{8}	289,000	4.2×10^{2}	2×10^{-4}	1.7×10^{4}	1×10^{-2}
6A Option Case	1.2×10^{5}	75	6.47×10^{8}	311,000	4.0×10^{2}	2×10^{-4}	1.6×10^{4}	1×10^{-2}
6B Base Case	8.2×10^{4}	49	1.96×10^{8}	94,100	8.7×10^{2}	5×10^{-4}	3.5×10^{4}	2×10^{-2}
6B Option Case	8.5×10^{4}	51	2.25×10^{8}	108,000	7.9×10^{2}	5×10^{-4}	3.2×10^{4}	2×10^{-2}
6C	1.1×10^{4}	7	1.44×10^{8}	69,100	1.6×10^{2}	1×10^{-4}	6.4×10^{3}	4×10^{-3}

[a] Full-time equivalent radiation worker project dose and individual risk of an LCF from 40 years of occupational exposure.
[b] Increased number of LCFs for the worker population as a result of the radiation dose received under the alternative. If zero, the number in parentheses is the value calculated by multiplying the dose by the risk factor of 0.0006 LCFs per person-rem.
[c] The increased individual risk of an LCF from one year of occupational exposure.
Key: LCF=latent cancer fatality.

K.2.1.2.2 Noninvolved Workers

Doses were also estimated for a noninvolved worker, i.e., a person working at the site who is incidentally exposed due to the radiological emissions associated with the Tank Closure alternatives. The GENII model described in Section K.2.1.1.2 was used to estimate doses to noninvolved workers. The exposure parameters for a noninvolved worker were different from those used for an offsite member of the public. Because the worker was assumed to spend only a work shift at the site, exposure to and inhalation of the radioactive plume was assumed to occur only for a portion of the day. It was also assumed that a portion of the worker's job is performed outdoors, resulting in exposure to deposited material. The outdoor activity was assumed to result in ingestion of contaminated soil suspended by wind or work activities. Unlike doses to members of the offsite population, there was no assumption that any portion of the exposure associated with work would result from consumption of radioactively contaminated fruits, vegetables, or animal products. Table K–49 shows the parameters used for the dose analysis of noninvolved workers.

Table K–49. Dose Assessment Parameters for Noninvolved Workers

Medium	Exposure Pathway	Rate	Reference
Air (plume)	Internal – inhalation	20 cubic meters per day	DOE 1995
	Internal – inhalation	2,000 hours per year	DOE 1995
	External	2,000 hours per year	Consistent with inhalation exposure
Soil	External	1,168 hours per year	DOE 1995
	Internal – ingestion	50 milligrams per day	DOE 1995

Note: To convert cubic meters to cubic feet, multiply by 35.315; milligrams to ounces, by 0.00003527.

As discussed in Section K.2.1.1.1, for purposes of assessing the impacts of radiological emissions, all emissions were assigned to one of three sources; the WTP, STTS-East, or STTS-West.

Doses to a noninvolved worker were evaluated for a location in the 200-East Area and a location in the 200-West Area. The locations selected are near the assumed emission sources in facilities that are expected to be staffed on a daily basis. In the 200-East Area, the noninvolved worker was assumed to be at the 242-A Evaporator, about 0.7 kilometers (760 yards) west of the WTP and 0.6 kilometers (660 yards) north-northwest of STTS-East.

In the 200-West Area, two locations were considered for the noninvolved worker. The Environmental Restoration Disposal Facility (ERDF) was selected for detailed analysis after determining that the impact on a noninvolved worker located there would be higher than that on one located at the 222-S Laboratory. The ERDF is about 1.1 kilometers (1,200 yards) east of the STTS-West, while the 222-S Laboratory is southwest of the STTS-West.

Doses to a noninvolved worker at the 242-A Evaporator under each Tank Closure alternative were determined for releases from the STTS-East and the WTP, based on releases of 1 curie of each radionuclide identified in Table K–6. The dose to a noninvolved worker at the ERDF under each Tank Closure alternative was determined for releases from the STTS-West, based on 1-curie releases. The doses to noninvolved workers were scaled based on the estimated releases from the WTP, STTS-East, and STTS-West under each Tank Closure alternative (see Tables K–7 through K–19) over the life of the project and during the years of maximum impact. The doses to noninvolved workers in the year(s) of maximum impact are presented in Table K–50. Although the emissions that would impact a noninvolved worker or an MEI would be the same, the year(s) of maximum impact for these receptors may be different. The emissions from the STTSs would comprise a mix of sources, such as routine tank farm operations, tank waste retrieval activities, supplemental waste treatment, and tank closure, each of which would occur in a different time period during the project. The year(s) of maximum impact for a noninvolved worker at the ERDF would occur when the STTS-West emissions were largest. Similarly, the year(s) of maximum impact for a noninvolved worker at the 242-A Evaporator would be when emissions from the WTP, STTS-East, or both were largest. At a distance of more than 9.6 kilometers (6 miles), the MEI would be exposed to a combination of emissions from the WTP and STTS-East and -West; consequently, the combined impacts of all three emission sources could affect the year of maximum impact. However, the peak impacts on the MEI and noninvolved worker at the 242-A Evaporator would be dominated by the emissions from processing cesium and strontium at the WTP under all Tank Closure alternatives except Alternatives 1 and 2A. The alternatives have been conceptualized such that all of the cesium and strontium from capsules would be processed in a single year at the WTP, resulting in increased cesium and strontium emissions that year. Alternative 1 does not include cesium and strontium processing, and peak impacts under Alternative 2A would occur from continuing tank emissions during the period of administrative control and emissions occurring during deactivation of the WTP.

Table K–50. Tank Closure Alternatives – Impacts on Noninvolved Workers in the Year(s) of Maximum Impact During Normal Operations

Tank Closure Alternative	Noninvolved Worker at 242-A Evaporator					Noninvolved Worker at ERDF		
	Dose from 200-East Area STTS (millirem per year)	Dose from WTP (millirem per year)	Total Dose (millirem per year)	Lifetime Risk of a Latent Cancer Fatality	Year(s) of Maximum Impact	Dose from 200-West Area STTS (millirem per year)	Lifetime Risk of a Latent Cancer Fatality	Year(s) of Maximum Impact
1	$2.5×10^{-1}$	0	$2.5×10^{-1}$	$2×10^{-7}$	2008	$7.1×10^{-1}$	$4×10^{-7}$	2008
2A	$2.5×10^{-1}$	$4.4×10^{-2}$	$3.0×10^{-1}$	$2×10^{-7}$	2094–2095	$7.1×10^{-1}$	$4×10^{-7}$	2094–2193
2B	$4.2×10^{-3}$	$2.9×10^{-1}$	$2.9×10^{-1}$	$2×10^{-7}$	2040	$4.2×10^{-3}$	$2×10^{-9}$	2040
3A	$1.5×10^{-3}$	$1.7×10^{-1}$	$1.8×10^{-1}$	$1×10^{-7}$	2040	$1.4×10^{-1}$	$9×10^{-8}$	2018–2019
3B	$9.9×10^{-7}$	$1.7×10^{-1}$	$1.7×10^{-1}$	$1×10^{-7}$	2040	$4.2×10^{-3}$	$3×10^{-9}$	2018–2019
3C	$1.5×10^{-3}$	$1.7×10^{-1}$	$1.8×10^{-1}$	$1×10^{-7}$	2040	$1.4×10^{-1}$	$9×10^{-8}$	2018–2019
4	$1.7×10^{-3}$	$1.7×10^{-1}$	$1.8×10^{-1}$	$1×10^{-7}$	2043	$2.0×10^{-1}$	$1×10^{-7}$	2034–2039
5	0	$1.7×10^{-1}$	$1.7×10^{-1}$	$1×10^{-7}$	2034	$1.8×10^{-1}$	$1×10^{-7}$	2018–2019
6A Base Case	$4.2×10^{-3}$	$1.7×10^{-1}$	$1.8×10^{-1}$	$1×10^{-7}$	2163	$7.5×10^{-2}$	$4×10^{-8}$	2054–2061
6A Option Case	$9.9×10^{-3}$	$1.7×10^{-1}$	$1.8×10^{-1}$	$1×10^{-7}$	2163	$2.0×10^{-1}$	$1×10^{-7}$	2138–2140
6B Base Case	$5.2×10^{-2}$	$2.8×10^{-1}$	$3.3×10^{-1}$	$2×10^{-7}$	2040	$1.1×10^{-1}$	$7×10^{-8}$	2040
6B Option Case	$1.2×10^{-1}$	$2.8×10^{-1}$	$4.0×10^{-1}$	$2×10^{-7}$	2040	$2.8×10^{-1}$	$2×10^{-7}$	2040
6C	$1.4×10^{-3}$	$2.8×10^{-1}$	$2.8×10^{-1}$	$2×10^{-7}$	2040	$4.2×10^{-3}$	$2×10^{-9}$	2040

Note: Total may not equal the sum of the contributions due to rounding.

Key: ERDF=Environmental Restoration Disposal Facility; STTS=Supplemental Treatment Technology Site; WTP=Waste Treatment Plant.

Table K–51. Tank Closure Alternatives – Impacts on Noninvolved Workers over the Life of the Project During Normal Operations

Tank Closure Alternative	Noninvolved Worker at 242-A Evaporator				Noninvolved Worker at ERDF		Years of Project Emissions
	Dose from 200-East Area STTS (millirem)	Dose from WTP (millirem)	Total Dose (millirem)	Lifetime Risk of a Latent Cancer Fatality	Dose from 200-West Area STTS (millirem)	Lifetime Risk of a Latent Cancer Fatality	
1[a]	$2.5×10^{1}$	0	$2.5×10^{1}$	$2×10^{-5}$	$7.1×10^{1}$	$4×10^{-5}$	2006–2107
2A[a]	$2.5×10^{1}$	3.0	$2.8×10^{1}$	$2×10^{-5}$	$7.1×10^{1}$	$4×10^{-5}$	2006–2193
2B	$2.2×10^{-2}$	3.0	3.0	$2×10^{-6}$	$6.5×10^{-2}$	$4×10^{-8}$	2006–2045
3A	$5.1×10^{-1}$	2.6	3.1	$2×10^{-6}$	3.2	$2×10^{-6}$	2006–2042
3B	$2.2×10^{-2}$	2.6	2.8	$2×10^{-6}$	$1.2×10^{-1}$	$7×10^{-8}$	2006–2042
3C	$5.1×10^{-1}$	2.6	3.1	$2×10^{-6}$	3.2	$2×10^{-6}$	2006–2042
4	$4.3×10^{-1}$	2.7	3.1	$2×10^{-6}$	4.2	$3×10^{-6}$	2006–2045
5	$1.6×10^{-1}$	2.4	2.6	$2×10^{-6}$	3.0	$2×10^{-6}$	2006–2036
6A Base Case[a]	2.6	3.1	5.6	$3×10^{-6}$	$2.8×10^{-1}$	$2×10^{-7}$	2006–2168
6A Option Case[a]	7.3	3.1	$1.0×10^{1}$	$6×10^{-6}$	$2.1×10^{1}$	$1×10^{-5}$	2006–2168
6B Base Case[a]	2.5	3.0	5.5	$3×10^{-6}$	7.3	$4×10^{-6}$	2006–2100
6B Option Case[a]	7.2	3.0	$1.0×10^{1}$	$6×10^{-6}$	$2.1×10^{1}$	$1×10^{-5}$	2006–2100
6C	$2.2×10^{-2}$	3.0	3.0	$2×10^{-6}$	$6.5×10^{-2}$	$4×10^{-8}$	2006–2045

[a] The life-of-project dose would not be received by one individual person due to the duration of these alternatives. The dose and lifetime risk of an LCF for the noninvolved worker with the larger impact from 40 years of exposure at the average annual dose rate would be: Alternative 1 – 28 millirem, $2×10^{-5}$ LCF risk; Alternative 2A – 15 millirem, $9×10^{-6}$ LCF risk; Alternative 6A, Base Case – 1.4 millirem, $8×10^{-7}$ LCF risk; Alternative 6A, Option Case – 5.2 millirem, $3×10^{-6}$ LCF risk; Alternative 6B, Base Case – 3.1 millirem, $2×10^{-6}$ LCF risk; Alternative 6B, Option Case – 8.8 millirem, $5×10^{-6}$ LCF risk.

Note: Total may not equal the sum of the contributions due to rounding.

Key: ERDF=Environmental Restoration Disposal Facility; LCF=latent cancer fatality; STTS=Supplemental Treatment Technology Site; WTP=Waste Treatment Plant.

Doses to noninvolved workers from emissions over the entire duration of each Tank Closure alternative are shown in Table K–51. Note that these project doses are presented for comparison purposes only. The duration of some of the alternatives (in particular, Alternatives 1; 2A; 6A, Base and Option Cases; and 6B, Base and Option Cases) would make it impossible for a single worker to receive the dose from the project's total emissions.

K.2.1.2.3 Chemical Risks to Workers

Workers involved in performing activities associated with the storage, retrieval, and processing of tank waste and the closure of the tank farm facilities could be exposed to chemical vapors. Chemical exposure is a concern because the tanks are continuously vented to the atmosphere, and workers would need to access parts of the tank farm system to monitor or retrieve the waste. The primary route of chemical exposure to workers during routine operations was assumed to be inhalation.

Exposures to tank farm vapors have been reported by workers since 1987. Between July 1987 and May 1993, 19 vapor exposure events involving 34 workers were reported (Osborne et al. 1995). These workers reported musty and foul odors, including the smell of ammonia, emanating from several single-shell tanks (SSTs) (Osborne and Huckaby 1994). They also reported effects such as headaches, burning sensations in the nose and throat, nausea, and impaired pulmonary functioning (Osborne et al. 1995).

In 1992, DOE and Westinghouse Hanford Company, which operated the tank farms at that time, determined that the tank farm vapor emissions had not been adequately characterized and represented a potential health risk to workers in the immediate vicinity of the tanks (Osborne and Huckaby 1994). To address this potential health risk, workers in certain areas of the tank farms (e.g., within the buffer zone of tank 214-C-103) were required to use supplied-air respirators (Osborne and Huckaby 1994). The Tank Vapor Issue Resolution Program was established in 1992 to characterize waste tank headspace vapors and understand their impact if they migrated into the workers' breathing zones (Osborne and Huckaby 1994).

In 1993, the Defense Nuclear Facilities Safety Board issued Recommendation 93-5, which indicated the need for better characterization of tank waste and headspace gases to understand the hazards present. As a result, an extensive tank waste characterization program was initiated that included process history and waste transfer records analysis, solid- and liquid-phase sampling and analysis, and vapor sampling and analysis (Cash 2004).

Between 1992 and 1997, headspace gas samples were collected from 109 SSTs (Stock and Huckaby 2000), primarily from SSTs that had passive ventilation. Some headspace vapor samples were also taken from double-shell tanks; however, all double-shell tanks have active ventilation, which greatly diminishes vapors (Cash 2004). Over 1,200 chemical species were identified as a result of this sampling effort (Stock and Huckaby 2000). By the end of 1996, the potential for hazardous vapor exposure had been analyzed, and acceptable controls were put in place. Based on the results of tank sample analysis and extensive reviews by outside oversight committees, including the Worker Health and Safety Subpanel of the DOE Tanks Advisory Panel, the vapor issue as known at that time was closed. Worker protection controls were implemented in the tank farms around those tanks known to contain larger amounts of noxious gases. The subpanel agreed that the implemented controls were adequate to protect the tank farm workers (Cash 2004).

Using sampling and monitoring data, a tank farm industrial hygiene program was implemented to prevent worker exposure to chemicals above occupational exposure limits. Among other actions designed to ensure worker protection, a tank farm health and safety plan was developed and implemented in 1993 and has been revised as necessary. The plan set action limits for organic chemical agents and ammonia that are below national occupational exposure limits. It further established case-by-case monitoring requirements based on the specific tank located near where the work is to be performed and the nature of the work activity (CH2M HILL 2003a).

From 1997 until 1999, waste-disturbing activities were minimal. Interim stabilization of the SSTs resumed in 1999 under an enforceable consent decree with the State of Washington (Consent Decree No. CT-99-5076-EPS). This waste-disturbing activity increased during late 2001 and early 2002, and several negative evaluation reports were made by tank farm workers with concerns about odors in and around specific tank farms (Cash 2004).

In early 2002, workers were asked to report all smells or odors, and procedures were developed that required a medical evaluation of any worker exhibiting symptoms due to vapor exposure (CH2M HILL 2004a). In 2002, 19 workers reported vapor smells and received medical evaluations. Between January 1, 2003, and September 30, 2003, 40 workers reported vapor smells and received medical evaluations (CH2M HILL 2003a). Efforts to understand and address this increase were made in 2002 and were made the subject of a project in September 2003 to accelerate progress on resolving vapor issues (CH2M HILL 2004b).

A September 2003 report by the Government Accountability Project (GAP) (GAP 2003) stated that there had been an increase in the number of workers reporting deleterious effects of exposure to the chemical vapors in tank farms. The report was generally critical of the quality and adequacy of the exposure monitoring program and alleged that workers were sick and injured as a result of being exposed to vapors from HLW tanks and other toxic and carcinogenic substances. The GAP report and subsequent GAP statements also alleged that there were instances of improper medical record-keeping, including falsification of records and collusion to undermine worker compensation claims. Further, the GAP alleged that there had been instances in which injuries and illnesses had not been properly reported.

In February 2004, the Secretary of Energy directed the DOE Office of Independent Oversight and Performance Assurance (OA) to evaluate the GAP report allegations and assess past practices and current operations to determine whether additional actions were needed to ensure a safe work environment at Hanford. OA conducted an investigation of selected aspects of worker safety and health systems at Hanford from February through April 2004. The OA team consisted of 23 experts from various disciplines, including occupational medicine, industrial hygiene, radiological protection, nuclear engineering, waste management, environmental protection, chemistry, maintenance, operations, and management systems.

The April 2004 OA report (DOE 2004a) identified 18 individual findings, including deficiencies or weaknesses related to the following:

- Hazards analysis, exposure control, and exposure assessment
- Engineering practices and operational controls that threaten tank integrity and control of vapor emissions
- Processes for defining and investigating vapor exposure issues and managing corrective actions
- Classification and reporting of injury and illness cases
- DOE oversight and coordination of contractor industrial hygiene and occupational medicine programs

In its report, the OA team observed that there were no known instances of tank farm worker vapor exposures that exceeded regulatory limits. However, the team concluded that longstanding deficiencies in the characterization of tank farm vapors and the industrial hygiene program were such that the site could not adequately assure that all exposures were below regulatory limits. Furthermore, to ensure that the vapor exposure issues would be fully addressed, OA reported that improvements were needed in various management systems, including engineering processes, industrial hygiene programs, integrated safety management implementation, communications, contractor feedback systems, and DOE Office of River Protection (ORP) line management oversight. The OA team identified an overarching weakness in that the strategy for protecting workers from vapors was not adequately defined and documented at a level that could be translated into a set of engineered controls, administrative controls, and personal protective equipment.

At the time of the assessment, the OA team determined that the contractor had adopted an "as low as is reasonably achievable" approach as the starting point for addressing this weakness, but had not yet characterized tank vapors (i.e., the chemicals of concern and conditions under which they are likely to be released) or established a technically sound industrial hygiene program that would provide for adequate sampling and monitoring of breathing zones and personnel air. The OA report also concluded that the Richland Operations Office had not established the necessary interfaces between prime contractors and the occupational medicine program to ensure the integration of occupational medicine program services as required by DOE directives and contractor requirements. Data on OSHA recordable accidents and in the Computerized Accident/Incident Reporting System (CAIRS) (see Section K.4) were found not to be as reliable as they should have been. Also, the CAIRS database was not being updated in a timely manner to reflect new information or the discovery of errors or omissions.

On the positive side, the OA report stated that the interim actions instituted by ORP and the contractor, which included respiratory protection for most work performed in tank farms, provided assurance that most of the immediate concerns were being addressed. Ongoing and planned actions regarding tank characterization, sampling, and personnel monitoring were seen as providing a good framework for developing longer-term solutions. The OA team found Hanford Environmental Health Foundation clinical practices and protocols to be consistent with standard occupational medical practices. The OA team found no substantiation of any of the health-related GAP allegations except for isolated instances of incomplete treatment information being provided to contractor record-keeping case managers. Although the need for some improvements was noted, OA concluded that the number and type of discrepancies identified in their investigation did not negate the overall usefulness of injury and illness metrics as a tool for monitoring safety performance and focusing attention on problem areas or trends. No indication of significant or pervasive underreporting of injuries and illnesses was noted, and most injury and illness events were found to be appropriately categorized. No egregious examples of misreporting were identified. This finding was consistent with a later Office of the Inspector General report of an independent review, which noted that the medical files were in good order (Friedman 2004).

Due to the increase in vapor exposure reports, mandatory respiratory protection for workers within the tank farm boundaries was implemented in March 2004 (Aromi 2004). In April 2004, a requirement for supplied-air respirators was implemented because of concerns about the amount of nitrous oxide in the tank vapors and the effectiveness of air-purifying respirators. Other actions taken to address vapor exposure issues included the following:

- Personal sampling devices were put into use to characterize tank farm worker breathing-zone vapor concentrations to better understand the exposure potential for various tasks. As of June 3, 2004, a total of 326 personal breathing-zone samples had been collected (124 for volatile organic compounds, 88 for ammonia, and 114 for nitrous oxide). Preliminary analysis of 79 of the nitrous oxide samples showed typical breathing-zone concentrations of less than 1 part per million (ppm) compared with the 50 ppm Threshold Limit Value established by ACGIH. Of the 29 ammonia samples for which analysis was complete, 17 showed less than detectable levels, while 12 showed levels ranging from 0.04 to 0.24 ppm, less than 1 percent of the 25 ppm Threshold Limit Value for ammonia.

- To better understand nitrous oxide emissions from tanks, samples were obtained from the breather filter openings for all 149 SSTs. Results of the sample analyses are provided in *Results of Nitrous Oxide Monitoring Equipment Tests and Badge Monitoring Non-personnel Area Tests Within Hanford Single Shell Tank Farms* and are summarized as follows (Schofield 2004):
  - Results from 62 samples taken from 10 selected tanks believed to have high nitrous oxide concentrations in the tank headspace showed that the 24-hour time-weighted average concentrations at a distance of 0.9 to 1.5 meters (3 to 5 feet) from the breather filters were all below 1.0 ppm. Results from an additional 25 samples showed no 24-hour time-weighted average concentrations above 1.0 ppm at a distance of 46 centimeters (18 inches) from the breather filters on 5 selected tanks with high nitrous oxide concentrations in the tank headspace.
  - Results for 12-hour and 24-hour samples taken directly from the tank breather filter outlets showed, out of 343 samples, only 30 with time-weighted average concentrations above 1 ppm and 6 above 10 ppm. The highest value was 38 ppm, and the remaining 307 samples were less than 1.0 ppm.
- Tank headspace gas and vapor samples were obtained, and the 16 SSTs in the C tank farm were the first to be sampled. Data from these samples were used to monitor changes in vapor chemistry over time and determine appropriate protective measures (CH2M HILL 2004c).
- Other actions taken included installation of active ventilation systems, stack extensions to raise vapors above the worker breathing zone, and enhanced worker training (CH2M HILL 2004c).

An April 2005 assessment of the tank farms industrial hygiene program by ORP concluded that the program complied with applicable DOE and OSHA regulations and standards and was effective in protecting tank farm workers from industrial hazards (Schepens 2005). The assessment also sampled 57 of the 101 corrective actions arising from the April 2004 OA report (DOE 2004a) and verified adequate implementation for all 57. The assessment noted that the contractor had a plan to implement engineering controls in the tank farms to elevate exhaust points, and, in some cases, provide exhaust fans to minimize worker exposure. A number of key actions, including some engineering controls, had already been implemented, and all workers entering areas where they might be exposed to tank vapors were being required to use respiratory protection. It was also noted that the use of respiratory protection introduced several new hazards. From January 1, 2004, to March 30, 2005, about 33 percent of workplace injuries (mainly muscle strains, slips, and trips and falls) could be directly related to the use of a self-contained breathing apparatus (SCBA), which caused reduced visibility. Respiratory tract irritation from breathing the very dry air supplied by SCBAs was also noted (Schepens 2005).

On July 27, 2007, about 320 liters (85 gallons) of tank waste were spilled during a transfer from tank 241-S-102; the resulting Type A Accident Investigation Report identified several worker chemical exposure issues associated with the spill (DOE 2007a). A number of workers identified odors, experienced symptoms, or expressed concerns about their potential exposure to chemicals from the spill. Two individuals approached the spill location about 10 minutes after the leak and may have been exposed to tank vapors. One person noticed a strong odor and later reported symptoms, while the other, only a few feet away, did not. Others who reported symptoms were outside the tank farm fence, at least 40 meters (130 feet) from the leak location. Workers were sheltered for an extended time in a very warm mobile office building without ventilation, which may have contributed to the stress, concern, and symptoms (headaches) reported by some. There was no industrial hygiene sampling or monitoring for a chemical vapor release for more than 13 hours following the spill. However, any chemical vapors would have dissipated quickly and would have been difficult to measure quantitatively under the best of circumstances. Dispersion modeling conducted in the days following the spill indicated that, even in the maximum reasonably foreseeable case scenario with conservative assumptions, only individuals inside the S tank farm fence would have been subjected to chemical concentrations at or above the applicable occupational exposure limit. The accident investigation report concluded that the contractor needed to better integrate industrial hygiene into its response to abnormal events that may involve chemical releases. It was also concluded that the Hanford fire department needed to improve the performance of its emergency medical technicians in the areas of documentation of patient encounters and communications with the site occupational medical services provider. The need for more-frequent review of patient records by physicians and enhanced documentation of patient encounters was also identified (DOE 2007a).

Estimates of worker exposure to chemicals and the resulting health effects are highly dependent on modeling assumptions. If a worker were assumed to be very close to the chemical emission point, the predicted consequences might vary from zero to extreme (severe, irreversible health effects), depending on the assumed duration of the release and exposure and the location of the worker with respect to the emission point and wind direction. Therefore, no attempt was made to estimate involved worker exposure to chemical releases associated with routine operations. Through compliance with applicable requirements and the scrutiny provided by internal and external review of chemical exposure issues, it is expected that involved worker exposure would be maintained below the thresholds identified by OSHA and ACGIH.

Because a noninvolved worker was assumed to be some distance away, it is possible to model exposures using average meteorological conditions at the site. Impacts on a noninvolved worker from carcinogenic and noncarcinogenic chemicals, ammonia, benzene, 1,3-butadiene, formaldehyde, mercury, toluene, and xylene were modeled. The modeling and risk assessment approach is described in Appendix G. The resulting toxic chemical concentrations and associated Hazard Quotients and risks are presented in Chapter 4, Section 4.1.4, for each Tank Closure alternative. The Hazard Index (the sum of the individual Hazard Quotients for all noncarcinogenic toxic chemicals) would be less than 1 under all alternatives, indicating that concentrations would be below a level requiring action to protect the noninvolved worker. The risk of cancer from exposure to the carcinogenic chemicals (benzene, 1,3-butadiene, and formaldehyde) would be on the order of 1 in 100,000 or less under all Tank Closure alternatives.

K.2.2 FFTF Decommissioning Alternatives

K.2.2.1 Impacts on the Public During Normal Operations

The methodology employed to evaluate impacts on the public and workers from decommissioning FFTF is similar to that discussed in Section K.2.1 for evaluating impacts of tank closure activities. Under FFTF Decommissioning Alternative 1: No Action, current impacts that are part of the Hanford baseline as presented in Chapter 3 would continue. The following sections address differences in scenarios and assumptions affecting human health impacts due to radiological emissions under FFTF Decommissioning Alternative 2: Entombment, and FFTF Decommissioning Alternative 3: Removal. Unless noted otherwise, assumptions described in Section K.2.1 also apply to the FFTF decommissioning radiological impacts analysis.

K.2.2.1.1 Approach

FFTF Decommissioning alternatives comprise three activities: (1) facility disposition (decommissioning of FFTF and auxiliary buildings), (2) disposition of remote-handled special components (RH-SCs), and (3) disposition of contaminated bulk sodium. Disposition of RH-SCs and bulk sodium would occur either at Hanford or the Materials and Fuels Complex (MFC) at INL; therefore, the three activities were evaluated separately.

Under normal operations, radiological releases could occur from any of the activities listed above. Deactivation activities were previously evaluated in the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006). Based on the environmental assessment, DOE found no significant impact on the offsite population. The impact on an MEI was estimated to be 0.00026 millirem per year, assuming all of the tritium contamination was released to the environment (DOE 2006:4-2). Impacts of deactivation activities would be the same under all FFTF Decommissioning alternatives and were not included in the alternatives' dose estimates.

Impacts were evaluated for the same public receptors as the Tank Closure alternatives (described in the introduction to Section K.2): the offsite population, an MEI, and an onsite MEI. Impacts on an MEI due to FFTF emissions were evaluated for the dominant downwind directions; the MEI was identified as being about 9.1 kilometers (5.6 miles) to the southeast, across the river from the 300 Area. Ground-level radiological emissions were assumed for facility disposition activities or disposition of bulk sodium in a new facility at Hanford. This conservative assumption resulted in overestimation of the impacts. Emissions associated with the potential treatment of RH-SCs at Hanford would emanate from the 200-West Area near the T Plant complex. The same source location assumed for the 200-West Area tank closure emissions was assumed for the RH-SC emissions, i.e., STTS-West. This assumption resulted in conservative estimates of the impacts to members of the public.

FFTF Decommissioning Alternatives 2 and 3 include options for processing RH-SCs, bulk sodium, or both at the INL MFC. The MEI would be about 5.2 kilometers (3.2 miles) south-southeast of the MFC. A release height of 24 meters (78 feet) was assumed, based on the building and stack heights presented in the facility conceptual design report (ANL-W 2004:27, 53).

K.2.2.1.2 Modeling

The GENII computer code was used to evaluate impacts on the offsite populations of Hanford and INL.

K.2.2.1.3 Input Parameters

Input parameters for the GENII computer code included items that are a function of the location of the action being taken. For FFTF Decommissioning alternatives, the input parameters that were different than those used in evaluating Tank Closure alternatives were the meteorological data, population data, and radiological source terms.

K.2.2.1.3.1 Meteorological Data

FFTF Decommissioning alternatives could include activities that occur at FFTF (the Hanford 400 Area), the INL MFC, or the Hanford 200-West Area. Meteorological data for evaluating offsite impacts of activities that would occur in the Hanford 200-West Area were the same as those used in evaluating emissions from STTS-West for the Tank Closure alternatives (see Table K–4). Meteorological data for activities that would occur at FFTF (facility disposition or disposition of bulk sodium) are presented in Table K–52. These data represent 10-year averages of data collected from 1997 through 2006 at the 9-meter (30-foot) height at the FFTF Meteorological Station (Burk 2007). Wind rose representations of these data are included in Chapter 3, Section 3.2.4. Meteorological data for activities occurring at the INL MFC are presented in Table K–53. These data are based on meteorological data collected at the MFC Meteorological Station from 2000 through 2004.

Table K–52. Joint Frequency Distribution for the Hanford Site 400 Area (Fast Flux Test Facility) at a 9-Meter Height

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.78	A	0.13	0.14	0.12	0.11	0.13	0.17	0.13	0.11	0.11	0.08	0.08	0.06	0.06	0.05	0.06	0.1
	B	0.04	0.05	0.07	0.04	0.05	0.05	0.07	0.05	0.05	0.04	0.03	0.02	0.03	0.03	0.02	0.04
	C	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.03	0.03	0.02	0.03
	D	0.27	0.29	0.24	0.22	0.25	0.26	0.3	0.26	0.26	0.25	0.23	0.21	0.21	0.25	0.33	0.27
	E	0.27	0.22	0.21	0.21	0.21	0.2	0.25	0.3	0.36	0.35	0.35	0.33	0.36	0.35	0.41	0.3
	F	0.29	0.21	0.18	0.13	0.15	0.14	0.21	0.24	0.3	0.3	0.3	0.26	0.29	0.27	0.32	0.27
	G	0.09	0.08	0.06	0.06	0.05	0.06	0.07	0.08	0.1	0.12	0.1	0.09	0.1	0.11	0.09	0.11
2.5	A	0.43	0.49	0.41	0.34	0.4	0.48	0.57	0.55	0.64	0.43	0.22	0.14	0.15	0.13	0.18	0.28
	B	0.18	0.16	0.12	0.07	0.09	0.1	0.19	0.17	0.19	0.13	0.08	0.04	0.04	0.05	0.07	0.14
	C	0.14	0.12	0.07	0.06	0.08	0.09	0.15	0.1	0.15	0.1	0.03	0.03	0.02	0.04	0.07	0.11
	D	0.68	0.67	0.45	0.31	0.28	0.33	0.7	0.82	0.89	0.63	0.4	0.22	0.25	0.38	0.78	0.87
	E	0.66	0.55	0.37	0.21	0.19	0.27	0.63	1.03	1.18	1.19	0.62	0.46	0.47	0.66	1.08	0.95
	F	0.57	0.54	0.31	0.15	0.1	0.16	0.47	0.88	1.08	0.94	0.52	0.28	0.21	0.31	0.75	0.72
	G	0.28	0.24	0.13	0.04	0.03	0.05	0.14	0.31	0.32	0.27	0.17	0.08	0.06	0.12	0.31	0.31
4.5	A	0.4	0.46	0.24	0.07	0.09	0.12	0.21	0.25	0.83	0.74	0.28	0.17	0.16	0.13	0.19	0.27
	B	0.14	0.11	0.03	0.02	0.02	0.02	0.06	0.09	0.22	0.27	0.09	0.07	0.04	0.05	0.08	0.12
	C	0.08	0.07	0.03	0.01	0.01	0.01	0.04	0.05	0.15	0.19	0.05	0.03	0.04	0.03	0.05	0.09
	D	0.4	0.27	0.1	0.06	0.05	0.08	0.3	0.56	0.87	1.02	0.39	0.24	0.18	0.4	0.97	0.83
	E	0.23	0.18	0.1	0.03	0.01	0.03	0.36	0.98	0.99	1.19	0.54	0.28	0.27	0.57	1.43	0.96
	F	0.17	0.14	0.07	0.01	0.01	0.01	0.27	1.13	0.87	0.77	0.24	0.05	0.04	0.07	0.61	0.68
	G	0.06	0.06	0.03	0	0	0	0.13	0.46	0.27	0.17	0.04	0.01	0	0.01	0.23	0.29
7.0	A	0.1	0.16	0.06	0.01	0	0.01	0.02	0.02	0.23	0.66	0.4	0.19	0.12	0.12	0.19	0.09
	B	0.02	0.02	0.01	0	0	0	0.01	0.01	0.04	0.16	0.11	0.05	0.02	0.02	0.06	0.05
	C	0.02	0.01	0.01	0	0	0	0.01	0.01	0.04	0.15	0.08	0.05	0.02	0.01	0.05	0.02
	D	0.07	0.07	0.03	0.01	0	0	0.03	0.07	0.28	0.84	0.49	0.23	0.16	0.29	0.75	0.21
	E	0.04	0.05	0.03	0	0	0	0.05	0.1	0.31	0.77	0.56	0.18	0.12	0.3	0.67	0.1
	F	0.01	0.01	0.01	0	0	0	0.01	0.07	0.13	0.26	0.08	0.01	0.01	0.01	0.05	0.02
	G	0	0	0	0	0	0	0.01	0.09	0.05	0.07	0.04	0.01	0	0	0.01	0.01

Table K–52. Joint Frequency Distribution for the Hanford Site 400 Area (Fast Flux Test Facility) at a 9-Meter Height *(continued)*

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
9.6	A	0	0.01	0.01	0.01	0	0	0	0	0.02	0.12	0.16	0.13	0.08	0.03	0.1	0.02
	B	0	0	0	0	0	0	0	0	0.01	0.02	0.06	0.03	0.02	0.01	0.02	0
	C	0	0	0	0	0	0	0	0	0	0.03	0.04	0.02	0.01	0	0.03	0
	D	0.01	0.02	0.02	0	0	0	0	0.01	0.04	0.23	0.27	0.12	0.06	0.08	0.23	0.02
	E	0.01	0.04	0.03	0	0	0	0.01	0.01	0.03	0.2	0.26	0.07	0.03	0.06	0.12	0.01
	F	0	0	0	0	0	0	0	0	0	0.02	0.02	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	0	0	0
12.5	A	0	0	0	0	0	0	0	0	0	0.01	0.05	0.05	0.03	0	0.02	0
	B	0	0	0	0	0	0	0	0	0	0.01	0.03	0.01	0	0	0.01	0
	C	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0.01	0
	D	0	0	0.01	0	0	0	0	0	0	0.06	0.14	0.05	0.02	0.01	0.04	0
	E	0	0	0.01	0	0	0	0	0	0	0.05	0.08	0.03	0.01	0.01	0.02	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.9	A	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0.02	0.04	0.01	0.01	0	0	0
	E	0	0	0	0	0	0	0	0	0	0.01	0.02	0.01	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.8	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: To convert meters to feet, multiply by 3.281.
Source: Burk 2007.

Table K–53. Joint Frequency Distribution for the Idaho National Laboratory Materials and Fuels Complex at a 10-Meter Height

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1.2	A	0.32	0.32	0.29	0.23	0.16	0.1	0.13	0.13	0.16	0.19	0.21	0.21	0.24	0.28	0.31	0.3
	B	0.04	0.05	0.07	0.05	0.02	0.01	0	0.01	0.02	0.01	0.01	0	0	0	0.01	0.06
	C	0.04	0.07	0.05	0.03	0.01	0	0.01	0.01	0.01	0.01	0.01	0	0.01	0	0.01	0.06
	D	0.06	0.07	0.09	0.1	0.06	0.02	0.01	0.09	0.11	0.04	0.01	0.01	0	0	0.01	0.05
	E	0.08	0.12	0.11	0.14	0.12	0.05	0.02	0.13	0.15	0.09	0.03	0.01	0	0	0.02	0.04
	F	0.52	0.62	0.73	0.81	0.75	0.66	0.58	0.69	0.67	0.57	0.45	0.37	0.2	0.27	0.35	0.4
1.9	A	0.49	0.55	0.36	0.21	0.13	0.07	0.1	0.12	0.13	0.19	0.3	0.29	0.3	0.3	0.3	0.42
	B	0.12	0.18	0.1	0.04	0.03	0	0.01	0.01	0.03	0.03	0.04	0.03	0.02	0.01	0.02	0.06
	C	0.07	0.17	0.19	0.07	0	0	0	0.01	0.02	0.03	0.03	0.03	0	0	0.01	0.05
	D	0.08	0.26	0.25	0.22	0.1	0.02	0.01	0.11	0.17	0.13	0.05	0.01	0	0	0	0.06
	E	0.11	0.18	0.21	0.23	0.11	0.03	0.02	0.12	0.26	0.19	0.1	0.05	0.01	0.01	0.09	0.08
	F	0.37	0.57	0.65	0.62	0.42	0.27	0.23	0.41	0.63	0.65	0.49	0.35	0.22	0.2	0.19	0.27
2.6	A	0.25	0.44	0.35	0.19	0.13	0.08	0.07	0.15	0.21	0.27	0.34	0.34	0.27	0.13	0.16	0.22
	B	0.12	0.21	0.14	0.04	0.03	0.01	0.01	0.01	0.04	0.06	0.08	0.09	0.05	0.03	0.02	0.04
	C	0.07	0.34	0.19	0.06	0.02	0.01	0.04	0.02	0.03	0.05	0.06	0.05	0.03	0.01	0.01	0.04
	D	0.15	0.68	0.75	0.58	0.16	0.05	0.04	0.31	0.5	0.53	0.27	0.13	0.03	0.01	0.03	0.08
	E	0.08	0.22	0.31	0.36	0.12	0.03	0.05	0.12	0.25	0.21	0.14	0.07	0.05	0.03	0.03	0.05
	F	0.11	0.23	0.3	0.28	0.13	0.08	0.07	0.18	0.26	0.28	0.25	0.18	0.09	0.1	0.08	0.1
3.5	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0.16	0.28	0.36	0.16	0.09	0.07	0.07	0.15	0.29	0.5	0.54	0.4	0.2	0.11	0.1	0.11
	C	0.07	0.32	0.23	0.07	0.02	0.02	0.02	0.09	0.08	0.12	0.14	0.12	0.03	0.03	0.02	0.03
	D	0.26	0.8	0.78	0.72	0.23	0.08	0.14	0.62	1.01	0.93	0.69	0.35	0.1	0.07	0.09	0.18
	E	0.07	0.2	0.22	0.33	0.17	0.06	0.08	0.36	0.34	0.29	0.14	0.08	0.04	0.05	0.03	0.07
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.7	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.17	0.3	0.37	0.14	0.07	0.05	0.04	0.17	0.43	1.01	0.98	0.49	0.15	0.11	0.1	0.12
	D	0.33	0.72	0.8	0.42	0.16	0.1	0.13	1.09	0.93	1.49	1.46	0.56	0.11	0.11	0.1	0.2
	E	0	0.07	0.12	0.21	0.18	0.05	0.07	0.69	0.16	0.4	0.1	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table K–53. Joint Frequency Distribution for the Idaho National Laboratory Materials and Fuels Complex at a 10-Meter Height *(continued)*

Average Windspeed (meters per second)	Pasquill Atmospheric Stability Class	Percentage of Time Wind Blows from the Indicated Direction															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
6.9	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.03	0.05	0.05	0.02	0	0.01	0.02	0.03	0.11	0.26	0.34	0.1	0.02	0.02	0.02	0.01
	D	0.45	0.71	0.77	0.21	0.06	0.05	0.04	0.62	1.35	3.49	4.44	1.5	0.14	0.16	0.13	0.23
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.7	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0.27	0.39	0.19	0.05	0.01	0	0.01	0.03	0.5	1.46	4.68	1.79	0.04	0.03	0.03	0.04
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: To convert meters to feet, multiply by 3.281.

K.2.2.1.3.2 Population Data

The potentially exposed offsite population used for analysis depends on where an activity would occur. The population potentially exposed to emissions from disposition of FFTF and the auxiliary buildings would be within an 80-kilometer (50-mile) radius centered on the 400 Area. The population data represent results of the 2000 census. Under the Hanford Reuse Option of processing the bulk sodium at Hanford, the same population would be used because the Sodium Reaction Facility would be located in the 400 Area. The distribution of the 80-kilometer (50-mile) population around the 400 Area is shown in Figure K–5.

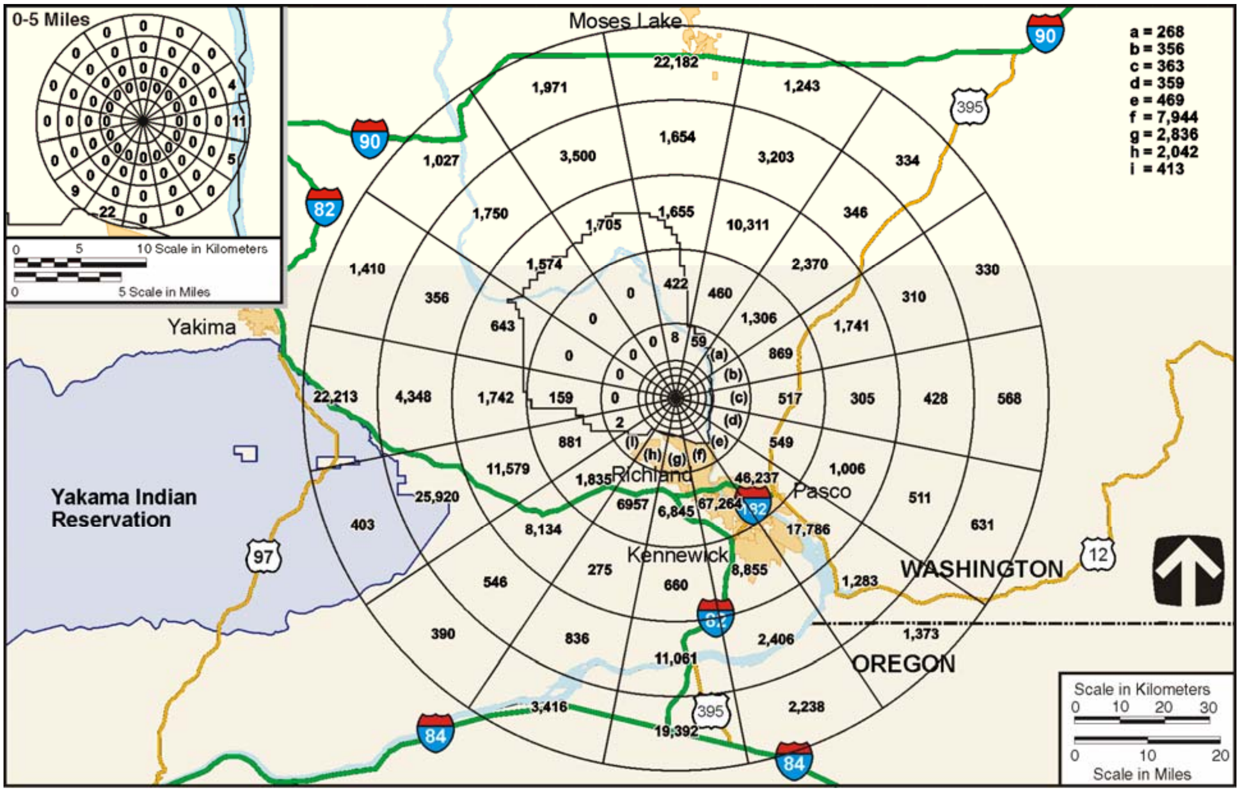

Figure K–5. Population Distribution Within 80 Kilometers (50 Miles) of the Fast Flux Test Facility

The Hanford Option for processing the RH-SCs would be to construct a facility adjacent to the T Plant in the 200-West Area. The same population distribution used for evaluating impacts of tank closure activities that would occur in the 200-West Area was used for evaluating impacts from processing RH-SCs (see Figure K–4). The center of the 80-kilometer (50-mile) region of influence, STTS-West in the southeast corner of 200-West Area, is closer than the T Plant to population centers in the dominant downwind directions, which contributed a degree of conservatism to the analysis.

FFTF Decommissioning Alternatives 2 and 3 include options for processing RH-SCs and bulk sodium in facilities at the INL MFC (the Idaho Option for disposition of RH-SCs and the Idaho Reuse Option for disposition of bulk sodium). The 80-kilometer (50-mile) population distribution used for analysis of impacts from these activities is shown in Figure K–6.

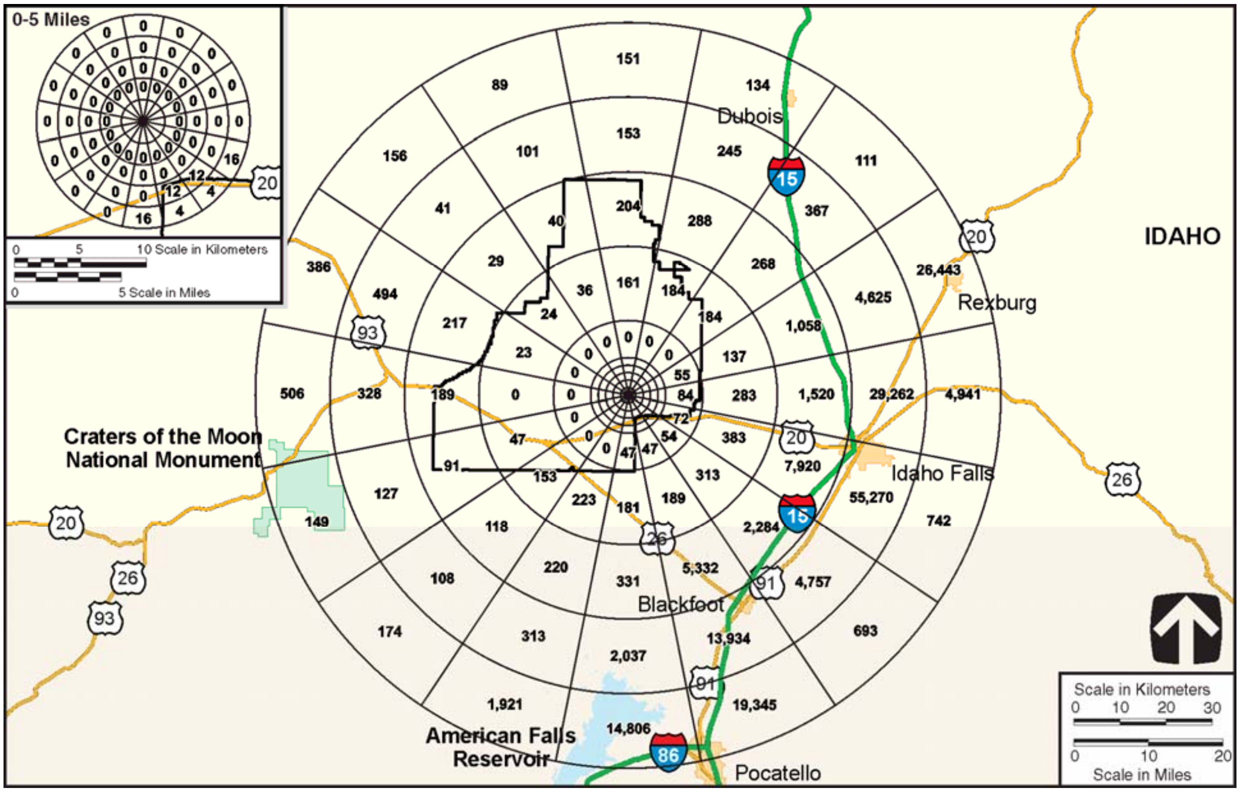

Figure K–6. Population Distribution Within 80 Kilometers (50 Miles) of the Idaho National Laboratory Materials and Fuels Complex

K.2.2.1.3.3 Source Terms

Radioactive emissions could be associated with each of the three activities that make up FFTF decommissioning. Emissions could result from activities to dispose of FFTF and the auxiliary buildings. FFTF Decommissioning Alternative 2 would require filling vessels and rooms that would remain in place prior to being covered by a barrier. Filling the voids could dislodge radioactive contaminants that would then be pushed out of the vessels and rooms as grout replaces the air in the voids. Under FFTF Decommissioning Alternative 3, the demolition practices employed, such as crimping or capping pipes and vessels, would control contamination such that negligible offsite emissions are expected.

Emissions from disposition of RH-SCs could occur at Hanford or INL, depending on which option is selected; the emissions would be the same regardless of location. Disposition of bulk sodium could occur at Hanford or INL. The total project emissions would be slightly higher under the Hanford Reuse Option because decommissioning the Sodium Reaction Facility is an additional activity. Deactivation of the Sodium Processing Facility (SPF) was assumed not to be required at INL because use of the facility would continue to support other activities. Table K–54 presents the source terms from radiological emissions assumed for each of the activities: facility disposition, disposition of RH-SCs, and disposition of bulk sodium.

Table K–54. FFTF Decommissioning Alternatives 2 and 3 – Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project		Annual Emissions in Year(s) of Maximum Impact	
	Curies	Year(s)	Curies	Year(s)
Facility Disposition[a]				
Cesium-137	1.5×10^{-6}	2017	1.5×10^{-6}	2017
Disposition of Remote-Handled Special Components – Hanford or Idaho Option				
Cesium-137	2.6×10^{-4}	2017–2018	1.7×10^{-4}	2017
Disposition of Bulk Sodium – Hanford Reuse Option				
Hydrogen-3 (tritium)	1.3×10^{1}	2017–2019	5.7	2017–2018
Cesium-137	7.3×10^{-4}		3.3×10^{-4}	
Uranium	2.1×10^{-7}		9.5×10^{-8}	
Disposition of Bulk Sodium – Idaho Reuse Option				
Tritium	1.1×10^{1}	2015–2016	5.7	2015–2016
Cesium-137	6.6×10^{-4}		3.3×10^{-4}	
Uranium	1.9×10^{-7}		9.5×10^{-8}	

a Emissions apply to Alternative 2 only.

Key: FFTF=Fast Flux Test Facility.

K.2.2.1.4 Results

The radiological impacts on the public due to the FFTF Decommissioning alternatives and options are presented in Table K–55 for the population, in Table K–56 for an MEI, and in Table K–57 for an onsite MEI at Hanford. Impacts under FFTF Decommissioning Alternative 1 are part of the Hanford baseline and are not addressed in this appendix. Impacts of FFTF Decommissioning Alternatives 2 and 3 would include the impacts of facility disposition, disposition of RH-SCs, and disposition of bulk sodium. Based on the calculated collective population dose, no LCFs are expected as a result of any of the alternatives or options; all calculated LCF values are much less than 1. The incremental risk of an LCF to an MEI would be extremely small in all cases; the largest risk over the life of the project would be about 2×10^{-10}, or less than 1 in a billion.

The incremental risk to an onsite MEI assumed to work at the Columbia Generating Station would be even smaller due to the shorter exposure time (a daily work shift) and typical wind direction.

Table K–55. FFTF Decommissioning Alternatives 2 and 3 – Impacts on the Population During Normal Operations

Radionuclides	Life of Project		Year(s) of Maximum Impact	
	Dose (person-rem)	LCFs[a]	Dose (person-rem per year)	LCFs[a]
Alternative 2, Facility Disposition				
Cesium-137	1.0×10^{-6}	0 (6×10^{-10})	1.0×10^{-6}	0 (6×10^{-10})
Alternative 3, Facility Disposition				
	–	–	–	–
Alternative 2 or 3, Disposition of Remote-Handled Special Components – Hanford Option				
Cesium-137	1.4×10^{-4}	0 (8×10^{-8})	9.0×10^{-5}	0 (5×10^{-8})
Alternative 2 or 3, Disposition of Remote-Handled Special Components – Idaho Option				
Cesium-137	1.1×10^{-5}	0 (7×10^{-9})	7.3×10^{-6}	0 (4×10^{-9})

Table K–55. FFTF Decommissioning Alternatives 2 and 3 – Impacts on the Population During Normal Operations *(continued)*

Radionuclides	Life of Project: Dose (person-rem)	Life of Project: LCFs[a]	Year(s) of Maximum Impact: Dose (person-rem per year)	Year(s) of Maximum Impact: LCFs[a]
Alternative 2 or 3, Disposition of Bulk Sodium – Hanford Reuse Option				
Hydrogen-3 (tritium)	6.7×10^{-3}		3.0×10^{-3}	
Cesium-137	4.9×10^{-4}		2.2×10^{-4}	
Uranium	3.8×10^{-5}		1.7×10^{-5}	
Total	7.2×10^{-3}	0 (4×10^{-6})	3.3×10^{-3}	0 (2×10^{-6})
Alternative 2 or 3, Disposition of Bulk Sodium – Idaho Reuse Option				
Tritium	3.9×10^{-4}		1.9×10^{-4}	
Cesium-137	2.8×10^{-5}		1.4×10^{-5}	
Uranium	2.1×10^{-6}		1.0×10^{-6}	
Total	4.2×10^{-4}	0 (3×10^{-7})	2.1×10^{-4}	0 (1×10^{-7})

[a] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Key: FFTF=Fast Flux Test Facility; LCF=latent cancer fatality.

Table K–56. FFTF Decommissioning Alternatives 2 and 3 – Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Life of Project: Dose (millirem)	Life of Project: Lifetime Risk of an LCF	Year(s) of Maximum Impact: Dose (millirem per year)	Year(s) of Maximum Impact: Lifetime Risk of an LCF	Wind Direction	Distance (kilometers)
Alternative 2, Facility Disposition						
Cesium-137	3.0×10^{-8}	2×10^{-14}	3.0×10^{-8}	2×10^{-14}	SE	8.2
Alternative 3, Facility Disposition						
	–	–	–	–	–	–
Alternative 2 or 3, Disposition of Remote-Handled Special Components – Hanford Option						
Cesium-137	2.5×10^{-6}	1×10^{-12}	1.6×10^{-6}	1×10^{-12}	ENE	22.2
Alternative 2 or 3, Disposition of Remote-Handled Special Components – Idaho Option						
Cesium-137	2.1×10^{-6}	1×10^{-12}	1.4×10^{-6}	8×10^{-13}	SSE	5.2
Alternative 2 or 3, Disposition of Bulk Sodium – Hanford Reuse Option						
Hydrogen-3 (tritium)	2.4×10^{-4}		1.1×10^{-4}		SE	8.2
Cesium-137	1.5×10^{-5}		6.6×10^{-6}			
Uranium	7.5×10^{-7}		3.4×10^{-7}			
Total	2.5×10^{-4}	2×10^{-10}	1.2×10^{-4}	7×10^{-11}		
Alternative 2 or 3, Disposition of Bulk Sodium – Idaho Reuse Option						
Tritium	8.5×10^{-5}		4.2×10^{-5}		SSE	5.2
Cesium-137	5.3×10^{-6}		2.7×10^{-6}			
Uranium	2.7×10^{-7}		1.3×10^{-7}			
Total	9.0×10^{-5}	5×10^{-11}	4.5×10^{-5}	3×10^{-11}		

Note: To convert kilometers to miles, multiply by 0.6214.

Key: FFTF=Fast Flux Test Facility; LCF=latent cancer fatality.

Table K–57. FFTF Decommissioning Alternatives 2 and 3 – Impacts on the Hanford Onsite Maximally Exposed Individual During Normal Operations

Radionuclides	Life of Project		Year(s) of Maximum Impact		Wind Direction	Distance (kilometers)
	Dose (millirem)	Lifetime Risk of an LCF	Dose (millirem per year)	Lifetime Risk of an LCF		
Alternative 2, Facility Disposition						
Cesium-137	1.9×10^{-9}	1×10^{-15}	1.9×10^{-9}	1×10^{-15}	NNE	4.5
Alternative 3, Facility Disposition						
	–	–	–	–	–	–
Alternative 2 or 3, Disposition of Remote-Handled Special Components – Hanford Option						
Cesium-137	5.1×10^{-8}	3×10^{-14}	3.4×10^{-8}	2×10^{-14}	ESE	22.7
Alternative 2 or 3, Disposition of Bulk Sodium – Hanford Reuse Option						
Hydrogen-3 (tritium)	2.3×10^{-5}		1.0×10^{-5}		NNE	4.5
Cesium-137	9.4×10^{-7}		4.3×10^{-7}			
Uranium	5.0×10^{-7}		2.3×10^{-7}			
Total	2.4×10^{-5}	1×10^{-11}	1.1×10^{-5}	7×10^{-12}		

Note: To convert kilometers to miles, multiply by 0.6214.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; LCF=latent cancer fatality.

K.2.2.2 Impacts on Workers During Normal Operations

K.2.2.2.1 Project Radiation Workers

Workers would receive radiation doses from deactivation activities that were previously evaluated in the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006). The collective dose to the worker population from deactivation activities would be 576 person-rem (DOE 2006:4-2). This dose would be incurred regardless of which FFTF Decommissioning alternative is selected.

Worker doses would result from maintaining administrative controls (under FFTF Decommissioning Alternative 1) or from facility disposition, disposition of RH-SCs, and disposition of bulk sodium (under FFTF Decommissioning Alternatives 2 and 3). Table K–58 presents the worker doses that would be received from these activities.

Table K–58. FFTF Decommissioning Alternatives – Radiation Worker Impacts and Labor Estimates

Alternative	Life of Project Collective Worker Impact		Life of Project Full-Time Equivalent Radiation Worker Labor		Average Annual Impact per Full-Time Equivalent Radiation Worker		Activity Duration
	Dose (person-rem)	LCFs[a]	Hours	Years	Dose (millirem per year)	Lifetime Risk of an LCF	Years
1	1	0 (6×10^{-4})	4.16×10^{4}	20	50	3×10^{-5}	2008–2107
2	**Facility Disposition**						
	0.37	0 (2×10^{-4})	7.68×10^{3}	4	100	6×10^{-5}	2017
3	**Facility Disposition**						
	6.3	0 (4×10^{-3})	1.31×10^{5}	63	100	6×10^{-5}	2013–2014
2 or 3	**Disposition of Remote-Handled Special Components – Hanford or Idaho Option**						
	1.2	0 (7×10^{-4})	1.25×10^{5}	60	20	1×10^{-5}	2017–2018
	Disposition of Bulk Sodium – Hanford Reuse Option						
	3.7	0 (2×10^{-3})	1.96×10^{5}	94	39	2×10^{-5}	2017–2019
	Disposition of Bulk Sodium – Idaho Reuse Option						
	3.6	0 (2×10^{-3})	1.91×10^{5}	92	39	2×10^{-5}	2014–2016

a Increased number of LCFs for the worker population as a result of the radiation dose received under the alternative. If zero, the number in parentheses is the value calculated by multiplying the dose by the risk factor of 0.0006 LCFs per person-rem.

Key: FFTF=Fast Flux Test Facility; LCF=latent cancer fatality.

Source: SAIC 2007b.

K.2.2.2.2 Noninvolved Workers

For the FFTF Decommissioning alternatives, the noninvolved worker that would be potentially affected by either facility disposition or disposition of bulk sodium was assumed to be located in the 300 Area, which is about 9.3 kilometers (5.8 miles) southeast of FFTF. For emissions from the T Plant in the 200-West Area that would result from disposition of RH-SCs at Hanford, the noninvolved worker was assumed to be located at a distance of 100 meters (110 yards) to the east-northeast. For emissions occurring at the INL MFC, the noninvolved worker was assumed to be located at the Experimental Breeder Reactor II (EBR-II) in the MFC, approximately 100 meters (110 yards) away. Table K–59 presents the doses and risks calculated for a noninvolved worker for facility disposition, disposition of bulk sodium, and disposition of RH-SCs. In all cases the doses would be small.

Table K–59. FFTF Decommissioning Alternatives – Impacts on the Noninvolved Worker During Normal Operations

Alternative	Noninvolved Worker Location	Life of Project		Year of Maximum Impact	
		Dose (millirem)	Lifetime Risk of an LCF	Dose (millirem)	Lifetime Risk of an LCF
Facility Disposition					
2	300 Area	6.6×10^{-10}	4×10^{-16}	6.6×10^{-10}	4×10^{-16}
3	300 Area	-	-	-	-
Disposition of Remote-Handled Special Components – Hanford Option					
2 or 3	100 meters east-northeast	2.8×10^{-4}	2×10^{-10}	1.9×10^{-4}	1×10^{-10}
Disposition of Remote-Handled Special Components – Idaho Option					
2 or 3	EBR-II	1.7×10^{-6}	1×10^{-12}	1.1×10^{-6}	7×10^{-13}
Disposition of Bulk Sodium – Hanford Reuse Option					
2 or 3	300 Area	8.0×10^{-6}	5×10^{-12}	3.7×10^{-6}	2×10^{-12}
Disposition of Bulk Sodium – Idaho Reuse Option					
2 or 3	EBR-II	1.1×10^{-4}	7×10^{-11}	5.5×10^{-5}	3×10^{-11}

Key: EBR-II=Experimental Breeder Reactor II; FFTF=Fast Flux Test Facility; LCF=latent cancer fatality.

K.2.3 Waste Management Alternatives

K.2.3.1 Impacts on the Public During Normal Operations

The methodology employed to evaluate the impacts of the Waste Management Alternatives on the public and workers was similar to that discussed in Section K.2.1 for evaluating the impacts of Tank Closure alternatives. Under Waste Management Alternative 1: No Action, currently approved operation of waste treatment facilities would continue; no impacts above those that are part of the current Hanford baseline would result. The scope of the expanded waste treatment activities is the same under Waste Management Alternatives 2 and 3; emissions from the expanded waste treatment activities could result in radiological impacts on the public and are addressed in this section. Differences between Waste Management Alternatives 2 and 3 are in the proposed locations and sizes of waste disposal facilities. As the facilities would receive packaged waste, they are not expected to contribute to offsite doses.

Unless noted otherwise, assumptions in Section K.2.1 also apply to the waste management radiological impacts analysis. The following sections address differences in scenarios and assumptions affecting human health impacts due to radiological emissions from waste management.

K.2.3.1.1 Approach

Waste Management alternatives include treatment, storage, and disposal activities. Existing emissions from the Waste Receiving and Processing Facility (WRAP) and from waste treatment at the T Plant complex would continue under Waste Management Alternative 1. Under Waste Management Alternatives 2 and 3, additional treatment capacity would be added at WRAP and the T Plant complex and additional waste volumes would be processed. These facilities would be located in the 200-West Area. For purposes of evaluating radiological impacts on the public, emissions from waste treatment activities were modeled as originating from a single location, the STTS-West in the southeast corner of 200-West Area, which was the same location used for modeling emissions from the 200-West Area under the Tank Closure and FFTF Decommissioning alternatives.

Waste storage capacity at the Central Waste Complex (CWC) would be expanded under Waste Management Alternatives 2 and 3. Under Waste Management Alternative 2, waste disposal would occur in the 200-East Area Integrated Disposal Facility (IDF-East) and the proposed River Protection Project Disposal Facility (RPPDF) to be located between the 200-East and 200-West Areas. Under Waste Management Alternative 3, in addition to IDF-East and RPPDF, a 200-West Area Integrated Disposal Facility (IDF-West) would be used for waste disposal. Stored waste and waste placed in the disposal facilities would be in packages or large roll-on, roll-off containers; therefore, no radiological emissions with the potential to cause offsite impacts are expected from waste storage and disposal.

K.2.3.1.2 Modeling

The GENII computer code was used to evaluate impacts on the offsite populations of Hanford.

K.2.3.1.3 Input Parameters

The waste treatment facilities would be in the 200-West Area, so many of the GENII input parameters would be the same as those used in modeling impacts from 200-West Area tank closure activities. Common input parameters include meteorological data (see Table K–4) and population distribution (see Figure K–4). The same pathway and exposure assumptions used in the tank closure analysis were used for evaluating waste management impacts (see Section K.2.1.1.3.3).

K.2.3.1.3.1 Source Terms

The emissions of the proposed waste treatment facilities were estimated based on emissions from current treatment facilities. Isotopic data reported in the *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2006* (Rokkan et al. 2007) for operation of WRAP and Buildings 2706-T/TA were used where available. If no specific alpha-emitting isotopes were reported, the reported gross alpha emissions were used and assumed to be plutonium-239. In the absence of specific beta-emitting isotopes, the reported gross beta emissions were used and assumed to be strontium-90. Emissions for the duration of the waste treatment activities and for the years of maximum impact are presented in Table K–60.

Table K–60. Waste Management Alternatives – Radiological Emissions During Normal Operations

Radionuclides	Emissions over Life of Project		Annual Emissions in Years of Maximum Impact	
	Curies	Years	Curies	Years
Waste Management Alternative 2 or 3				
Strontium-90	7.4×10^{-6}	2013–2051	2.0×10^{-7}	2019–2051
Plutonium-239	9.2×10^{-7}		2.4×10^{-8}	
Americium-241	3.2×10^{-7}		8.8×10^{-9}	

K.2.3.1.4 Results

The radiological impacts of Waste Management Alternative 1 on members of the public are accounted for in analyses of the impacts of ongoing Hanford waste management operations. The impacts of Waste Management Alternatives 2 and 3 would be the same because there are no differences in waste treatment activities between the alternatives. Estimated impacts on the offsite population are presented in Table K–61. Impacts on an MEI assumed to be on the far bank of the Columbia River to the east-northeast are presented in Table K–62. Impacts on an onsite MEI assumed to be at the Laser Interferometer Gravitational-Wave Observatory to the east-southeast of the 200-West Area are presented in Table K–63. Impacts at this location would exceed those at the Columbia Generating Station because it is in the same general direction, but closer to the emission source.

Table K–61. Waste Management Alternatives 2 and 3 – Impacts on the Population During Normal Operations

Radionuclides	Life of Project		Years of Maximum Impact	
	Dose (person-rem)	LCFs[a]	Dose (person-rem)	LCFs[a]
Waste Management Alternative 2 or 3				
Strontium-90	5.0×10^{-6}		1.3×10^{-7}	
Plutonium-239	4.9×10^{-4}		1.3×10^{-5}	
Americium-241	1.7×10^{-4}		4.7×10^{-6}	
Total	6.7×10^{-4}	0 (4×10^{-7})	1.8×10^{-5}	0 (1×10^{-8})

[a] The integer indicates the number of excess latent cancer fatalities that would be expected in the population based on the risk factor of 0.0006 latent cancer fatalities per person-rem; the value in parentheses is the value calculated from the dose and risk factor.

Key: LCF=latent cancer fatality.

Table K–62. Waste Management Alternatives 2 and 3 – Impacts on the Maximally Exposed Individual During Normal Operations

Radionuclides	Life of Project		Years of Maximum Impact		Wind Direction	Distance (kilometers)
	Dose (millirem)	Lifetime Risk of an LCF	Dose (millirem per year)	Lifetime Risk of an LCF		
Waste Management Alternative 2 or 3						
Strontium-90	1.5×10^{-7}		4.0×10^{-9}		ENE	18.2
Plutonium-239	5.9×10^{-6}		1.5×10^{-7}			
Americium-241	2.1×10^{-6}		5.7×10^{-8}			
Total	8.2×10^{-6}	5×10^{-12}	2.1×10^{-7}	1×10^{-13}		

Note: To convert kilometers to miles, multiply by 0.6214.

Key: LCF=latent cancer fatality.

Table K–63. Waste Management Alternatives 2 and 3 – Impacts on the Onsite Maximally Exposed Individual During Normal Operations

Radionuclides	Onsite Maximally Exposed Individual Doses and Risks					
	Life of Project		Years of Maximum Impact			
	Dose (millirem)	Lifetime Risk of an LCF	Dose (millirem per year)	Lifetime Risk of an LCF	Wind Direction	Distance (kilometers)
Waste Management Alternative 2 or 3						
Strontium-90	6.0×10^{-9}		1.6×10^{-10}		ESE	18.4
Plutonium-239	1.6×10^{-6}		4.1×10^{-8}			
Americium-241	5.8×10^{-7}		1.6×10^{-8}			
Total	2.2×10^{-6}	1×10^{-12}	5.7×10^{-8}	3×10^{-14}		

Note: To convert kilometers to miles, multiply by 0.6214.
Key: LCF=latent cancer fatality.

K.2.3.2 Impacts on Workers During Normal Operations

K.2.3.2.1 Project Radiation Workers

Impacts on workers would result from waste treatment and storage activities and from waste disposal operations. Under Waste Management Alternative 1, the impacts of currently operating treatment, storage, and disposal facilities would continue through 2035. Under Waste Management Alternatives 2 and 3, additional worker exposure would occur due to expanded treatment and storage operations beginning in 2013 and continuing through 2051. Waste Management Alternatives 2 and 3 include the same treatment and storage activities, so the worker dose would be the same under both alternatives. Radiation worker doses received from disposal operations would be comparable regardless of the Waste Management alternative, but the worker dose would be affected by the duration of disposal operations, which would depend on the disposal group selected. Disposal groups are based on which Tank Closure alternative is selected (see Chapter 2, Sections 2.5.4.2 and 2.5.4.3). Table K–64 shows the projected worker radiation doses for the Waste Management alternatives and the various disposal groups.

Table K–64. Waste Management Alternatives – Radiation Worker Impacts and Labor Estimates During Normal Operations

Alternative	Life-of-Project Collective Worker Impact		Life-of-Project Full-Time Equivalent Radiation Worker Labor		Average Annual Impact per Full-Time Equivalent Radiation Worker		Activity Duration
	Dose (person-rem)	LCFs[a]	Hours	Years	Dose (millirem per year)	Lifetime Risk of an LCF	Years
1	**Treatment, Storage, and Disposal Operations**						
	37	0 (2×10^{-2})	3.87×10^{5}	186	200	1×10^{-4}	2007–2035
2 or 3	**Treatment and Storage Operations**						
	3.0×10^{3}	2	3.13×10^{7}	15,054	200	1×10^{-4}	2013–2051
2	**Disposal Operations**						
	Disposal Group 1 (for Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C)						
	360	0 (2×10^{-1})	3.76×10^{6}	1,806	200	1×10^{-4}	2007–2050
	Disposal Group 2 (for Tank Closure Alternatives 2A and 6B)						
	3.6×10^{3}	2	3.69×10^{7}	17,720	200	1×10^{-4}	2007–2100
	Disposal Group 3 (for Tank Closure Alternative 6A)						
	6.4×10^{3}	4	6.67×10^{7}	32,061	200	1×10^{-4}	2007–2165

Table–64. Waste Management Alternatives – Radiation Worker Impacts and Labor Estimates During Normal Operations *(continued)*

Alternative	Life-of-Project Collective Worker Impact		Life-of-Project Full-Time Equivalent Radiation Worker Labor		Average Annual Impact per Full-Time Equivalent Radiation Worker		Activity Duration
	Dose (person-rem)	LCFs[a]	Hours	Years	Dose (millirem per year)	Lifetime Risk of an LCF	Years
3	**Disposal Operations**						
	Disposal Group 1 (for Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C)						
	360	0 (2×10^{-1})	3.75×10^{6}	1,803	200	1×10^{-4}	2007–2050
	Disposal Group 2 (for Tank Closure Alternatives 2A and 6B)						
	3.5×10^{3}	2	3.67×10^{7}	17,666	200	1×10^{-4}	2007–2100
	Disposal Group 3 (for Tank Closure Alternative 6A)						
	6.4×10^{3}	4	6.64×10^{7}	31,928	200	1×10^{-4}	2007–2165

[a] Increased number of LCFs for the worker population as a result of the radiation dose received under the alternative. If zero, the number in parentheses is the value calculated by multiplying the dose by the risk factor of 0.0006 LCFs per person-rem.

Key: LCF=latent cancer fatality.

Source: SAIC 2007c.

K.2.3.2.2 Noninvolved Workers

Radiological emissions from waste treatment activities could potentially impact noninvolved workers. Waste disposal operations are not expected to result in emissions during normal operations because the waste would be received and disposed of in packages. Under Waste Management Alternative 1: No Action, no additional impacts beyond those included in the baseline would occur. Differences between Waste Management Alternatives 2 and 3 are due to locations and operations of disposal facilities; therefore, the impacts on a noninvolved worker, which are based on treatment facility emissions, would be the same under Waste Management Alternatives 2 and 3.

Emissions from waste management facilities were treated as coming from a single source for purposes of evaluating potential impacts on a noninvolved worker. Additionally, a conservative assumption was made that the emission source would be at ground level. A noninvolved worker was assumed to be about 100 meters (110 yards) to the east-northeast of the emission source. The maximum annual dose to a noninvolved worker would be 2.3×10^{-4} millirem; the increased risk of an LCF from this dose would be less than 1 in 1 billion. Emissions from waste management treatment activities would occur from 2013 through 2051. If the same noninvolved worker were exposed over the duration of the waste treatment activities, the worker would receive a dose of 8.7×10^{-3}; this dose corresponds to an increased lifetime risk of an LCF of 5×10^{-9}, much less than 1 in a million.

K.3 ACCIDENT ANALYSIS

K.3.1 Introduction

Accident analyses for the *TC & WM EIS* alternatives were performed to estimate the impacts on workers and the public from reasonably foreseeable accidents. The analyses were performed in accordance with NEPA guidelines, including the process for the selection of accidents, definition of accident scenarios, and estimation of potential impacts. The sections that follow describe the methodology and assumptions used, as well as the accident selection process, selected accident scenarios, and consequences and risks of the accidents evaluated. The accident scenario descriptions are intended to give the informed reader a general understanding of how the accident source terms were developed and how the releases from one event might compare to another.

K.3.2 Overview of Methodology and Assumptions

K.3.2.1 Modeling and Analysis of Airborne Radiological Releases

The radiological impacts of airborne releases from accidents at the facilities involved in the *TC & WM EIS* alternatives were calculated using the MELCOR Accident Consequences Code System (MACCS) computer code, Version 1.13.1 (MACCS2). A detailed description of the MACCS model is provided in *MELCOR Accident Consequences Code System (MACCS)* (NRC 1990). The enhancements incorporated in MACCS2 are described in the *Code Manual for MACCS2*, Vol. 1, *User's Guide* (Chanin and Young 1997). This section presents the MACCS2 data specific to the accident analyses.

MACCS2 description. The MACCS2 computer code is used to estimate the radiological doses and health effects that could result from postulated accidental releases of radioactive materials to the atmosphere. The specific release characteristics can consist of up to four Gaussian plumes that are often referred to simply as "plumes"; these specifications are designated a "source term."

The radioactive materials released are modeled as being dispersed in the atmosphere while being transported by the prevailing wind. During transport, whether or not there is precipitation, particulate material can be modeled as being deposited on the ground. If contamination levels exceed a user-specified criterion, mitigating actions can be triggered to limit radiation exposures.

Two aspects of the code's structure are fundamental to understanding its calculations: (1) the calculations are divided into modules and phases and (2) the region surrounding the facility is divided into a polar coordinate grid. These concepts are described in the following paragraphs.

MACCS2 is divided into three primary modules: ATMOS, EARLY, and CHRONC. Three phases of exposure are defined as emergency, intermediate, and long-term. The relationship among the code's three modules and three phases of exposure are summarized below.

The ATMOS module performs all of the calculations pertaining to atmospheric transport, dispersion, and deposition, as well as the radioactive decay that occurs before release and while the material is in the atmosphere. It uses a Gaussian plume model with Pasquill-Gifford dispersion parameters. The phenomena treated include building wake effects, buoyant plume rise, plume dispersion during transport, wet and dry deposition, and radioactive decay and ingrowth. The results of the calculations are stored for use by EARLY and CHRONC. In addition to the air and ground concentrations, ATMOS stores information on wind direction, arrival and departure times, and plume dimensions.

The EARLY module models the period immediately following a radioactive release. This period is commonly referred to as the emergency phase. The emergency phase begins at each successive downwind distance point when the first plume of the release arrives. The duration of the emergency phase is specified by the user; it can range from 1 to 7 days. The exposure pathways considered during this period are direct external exposure to radioactive material in the plume (cloud shine), exposure from inhalation of radionuclides in the cloud (cloud inhalation), exposure to radioactive material deposited on the ground (ground shine), inhalation of resuspended material (resuspension inhalation), and skin dose from material deposited on the skin. Mitigating actions that can be specified for the emergency phase include evacuation, sheltering, and dose-dependent relocation.

The CHRONC module performs all of the calculations pertaining to the intermediate and long-term phases. CHRONC calculates the individual health effects that result from both direct exposure to contaminated ground and inhalation of resuspended materials, as well as indirect health effects caused by the consumption of contaminated food and water by individuals who could reside both on and off the computational grid.

The intermediate phase begins at each successive downwind distance point upon conclusion of the emergency phase. The user can configure the calculations with an intermediate phase up to 1 year long. Alternatively, the user can configure the calculations with no intermediate phase, so that the long-term phase begins immediately upon conclusion of the emergency phase.

Intermediate phase models are implemented on the assumption that the radioactive plume has passed and the only exposure sources (ground shine and resuspension inhalation) are from material deposited on the ground. It is for this reason that MACCS2 requires that the total duration of a radioactive release be limited to 4 days. Potential doses from food and water during this period are not considered.

The mitigating action model for the intermediate phase is very simple. If the intermediate phase dose criterion is satisfied, the resident population is assumed to be present and subject to radiation exposure from ground shine and resuspension for the entire intermediate phase. If the intermediate phase exposure exceeds the dose criterion, the population is assumed to have relocated to uncontaminated areas for the entire intermediate phase.

The long-term phase begins at each successive downwind distance point upon conclusion of the intermediate phase. The exposure pathways considered during this period are ground shine, resuspension inhalation, and ingestion of food and water.

The exposure pathways considered are those resulting from material deposited on the ground. A number of protective measures, such as decontamination, temporary interdiction, and condemnation, can be modeled in the long-term phase to reduce doses to user-specified levels. The decisions on mitigating action in the long-term phase are based on two factors: (1) whether land at a specific location and time is suitable for human habitation (habitability) and (2) whether land at a specific location and time is suitable for agricultural production (ability to farm).

All of the calculations of MACCS2 are stored based on a polar coordinate spatial grid. Treatment differs somewhat between calculations of the emergency phase and calculations of the intermediate and long-term phases. The region potentially affected by a release is represented with a (r, θ) grid system centered on the location of the release. The radius, r, represents downwind distance. The angle, θ, is the angular offset from the north, going clockwise.

The user specifies the number of radial divisions as well as their endpoint distances. The angular divisions used to define the spatial grid are fixed in the code. They correspond to the 16 points of the compass; each division is 22.5 degrees wide. The 16 points of the compass are used in the United States to express wind direction. The compass sectors are referred to as the "coarse grid."

Because emergency phase calculations use dose-response models for early fatalities and early injuries that can be highly nonlinear, these calculations are performed on a finer grid basis than the calculations of the intermediate and long-term phases. For this reason, the calculations of the emergency phase are performed with the 16 compass sectors divided into three, five, or seven equal, angular subdivisions. The subdivided compass sectors are referred to as the "fine grid."

Two types of doses may be calculated by the code: acute and lifetime.

Acute doses are calculated to estimate deterministic health effects that can result from high doses delivered at high dose rates. Such conditions may occur in the immediate vicinity of a nuclear facility following hypothetical severe accidents in which confinement and/or containment failure has occurred.

Examples of the health effects based on acute doses are early fatality, prodromal vomiting (a precursory symptom of disease), and hypothyroidism (insufficient production of the thyroid hormone).

Lifetime doses are the conventional measure of detriment used for radiological protection. These are 50-year dose commitments to specific tissues (e.g., red marrow and lungs) or a weighted sum of tissue doses defined by the ICRP and referred to as "effective dose." Lifetime doses may be used to calculate the stochastic (probabilistic) health effect risk resulting from exposure to radiation. MACCS2 uses the calculated lifetime dose in cancer risk calculations.

MACCS2 implementation. As implemented, the MACCS2 model evaluated doses due to inhalation of airborne material, as well as direct (external) exposure to the passing plume. These two modes of exposure represent the major portion of the dose that an individual would receive due to a *TC & WM EIS* alternative facility accident. The longer-term effects of airborne radioactive material deposited on the ground after a postulated accident, including the resuspension and subsequent inhalation of radioactive material and the ingestion of contaminated crops, were not modeled for this EIS. These pathways have been studied and found to contribute insignificantly to the total dose compared with inhalation of radioactive material in the passing plume; they are also controllable through cleanup and other mitigation measures. Hence, the deposition velocity of the radioactive material was set to zero, so that material that might otherwise be deposited on surfaces would remain airborne and available for inhalation. This method results in a higher degree of conservatism compared with dose results that would be obtained if deposition and resuspension were taken into account.

The impacts were assessed for the offsite population surrounding the 200-East and 200-West Areas, FFTF, and the INL MFC; the MEI; and a noninvolved worker. The impacts on involved workers were addressed qualitatively because no adequate method exists for calculating meaningful consequences at or near the location where an accident could occur. Involved workers are also fully trained in emergency procedures, including response to potential accidents.

The offsite population is defined as the general public residing within 80 kilometers (50 miles) of the site. The population distribution for each proposed site is based on U.S. Department of Commerce state population data (Census 2007a, 2007b). These data were fitted to a polar coordinate grid with 16 angular sectors aligned with the 16 compass directions, with radial intervals that extend outward to 80 kilometers (50 miles). The offsite populations within 80 kilometers (50 miles) of the 200-East and 200-West Areas were estimated to be 451,556 and 488,897 persons, respectively. The population within 80 kilometers (50 miles) of FFTF was estimated to be 357,391, and the INL MFC population was estimated to be 205,962. For this analysis, no credit was taken for emergency response evacuations or temporary relocation of the public.

The MEI is defined as a hypothetical individual member of the public who would receive the maximum dose from an accident. This individual is usually assumed to be located at a site boundary. However, because there are public access points within the Hanford boundary, the MEI could be at any of these onsite locations.

The MEI location was determined for each *TC & WM EIS* alternative. The MEI location at Hanford can vary based on the type and location of an accident. For this analysis, the MEI was assumed to be located 8.6 kilometers (5.4 miles) southwest of the 200-East Area facilities, 3.6 kilometers (2.3 miles) south of the 200-West Area facilities, and 6.8 kilometers (4.2 miles) east of FFTF. The MEI for the INL MFC was assumed to be located 5.5 kilometers (3.4 miles) to the south-southeast.

A noninvolved worker is defined as an onsite worker who is not directly involved in the facility activity pertaining to the accident. The noninvolved worker was assumed to be exposed to all or part of the release without any protection. For some scenarios, workers would evacuate the area after becoming aware of the emergency, thereby reducing their exposure potential.

Doses to the offsite population, the MEI, and a noninvolved worker were calculated based on site-specific meteorological conditions. Site-specific meteorology was represented by 1 year of hourly windspeed, atmospheric stability, and rainfall data at each site. The MACCS2 calculations produced statistical distributions based on the meteorological conditions. For these analyses, the results presented were based on mean meteorological conditions, which produce more-realistic consequences than the 95th percentile condition sometimes used in accident analyses for safety analysis reports. The 95th percentile condition represents low-probability meteorological conditions that are not exceeded more than 5 percent of the time.

The health risk coefficient for determining the likelihood of an LCF for low doses or dose rates is 0.0006 LCFs per rem, applied to individual workers and members of the public (see Section K.1.1.3). For high doses or dose rates, a health risk coefficient of 0.0012 applies for individual workers and members of the public. The higher health risk coefficient applies when individual doses exceed 20 rem.

K.3.2.2 Modeling and Analysis of Airborne Chemical Releases

One of the computer models included in the DOE Safety Software Central Registry, the Emergency Prediction Information Code (EPIcode), was selected to obtain estimates of atmospheric dispersion and resultant downwind concentrations of hazardous chemicals (DOE 2004b; Homann 2003). The codes included in the central registry have been determined to be compliant with the DOE Safety Software Quality Assurance requirements. These codes are routinely used by DOE to perform calculations and develop data used to establish the safety basis for DOE facilities and their operation and to support the variety of safety analyses and evaluations developed for these facilities.

EPIcode uses the Gaussian dispersion model to determine plume dispersion. The Gaussian model computes airborne concentrations at a given distance based on: (1) amount released, (2) effective release height, (3) windspeed at the release height, (4) inversion layer, and (5) standard deviation of the integrated concentration distribution both in the crosswind direction (sigma-y) and the vertical direction (sigma-z). Both sigma-y and sigma-z depend on the Pasquill stability class (classification according to the degree of atmospheric turbulence, described below) and the terrain. EPIcode allows selection of either standard (rural) or urban terrain. The standard terrain assumes surface roughness lengths ranging from 0.01 to 0.1 meters (0.03 to 0.3 feet). The urban terrain accounts for increased dispersion due to large urban structures. Standard terrain was conservatively selected for all scenarios even though there are various large structures at Hanford. This choice resulted in higher downwind concentrations.

EPIcode accounts for plume depletion processes, by which very small particles and gases or vapors are deposited on or incorporated within surfaces as a result of turbulent diffusion and Brownian motion (random movement of small particles suspended in liquid or gas caused by collisions with molecules of the surrounding medium). Chemical reactions; impaction; and other biological, chemical, and physical processes combine to keep material that is deposited from becoming re-entrained. As this material is deposited, the plume above becomes depleted. EPIcode uses a source-depletion algorithm to adjust the air concentration in the plume to account for this removal of material. This integrated effect of all removal processes is represented in the plume depletion equation by a deposition velocity term. The code does not account for wind shifts, terrain steering effects, chemical reactions, dense gas effects, or radioactive materials (see Homann 2003).

EPIcode was used to model chemical concentrations in air at each receptor for each release scenario. Each chemical release was assumed to be at ground level. Seven Pasquill stability classes were defined, ranging from A (extremely unstable) to D (neutral) to G (extremely stable). A neutral atmospheric stability (stability class D) and a windspeed of 5 meters (16.4 feet) per second were used for all EPIcode simulations in this document. The most frequent stability class at Hanford is D.

K.3.2.3 Accident Frequencies

Accident frequency or probability reflects the likelihood of occurrence of an unplanned event during operations that could potentially cause the release of hazardous materials and harm the public, workers, and environment. The unit of measure for accident frequency in this EIS is usually expressed as occurrences per unit of time.

Risk is the overall measure of an accident's potential for endangering the health and safety of workers and the public. As explained in Section K.3.7, an accident's risk is calculated by the mathematical product of the accident's frequency of occurrence and its consequences and is expressed in terms of LCFs per year.

Accident scenarios and frequencies used in this EIS were based on extensive studies that are documented in safety analysis reports and related documents. The accident frequencies in these reports typically reflect the effects of mitigating factors designed to prevent or minimize the magnitude of hazardous materials released. The accident frequencies used in this EIS were conservatively adjusted to reflect unmitigated conditions that result in higher releases of hazardous materials, and thus, higher consequences. Because of uncertainties in the factors that affect an accident's frequency, many were initially expressed as a range. For estimating risk, the higher, conservative end of the estimated frequency range was used in the multiplication of frequency and consequences.

K.3.2.4 Secondary Impacts

Secondary impacts occur due to deposition of radioactive material or chemicals from a plume released during an accident. Although further exposure to humans can occur from deposited material, the radiation dose or chemical exposure associated with the passing plume dominates human health impacts. However, for NEPA purposes, other impacts of deposition are also important. These impacts, discussed further in Section K.3.8 (for radiological releases) and Section K.3.9 (for chemical releases), may result in imposition of protective actions and temporary access restrictions to contaminated land or property.

For radiological releases, the MACCS2 code was used to estimate the level of ground contamination caused by deposition from a passing radioactive plume. The level of contamination is measured in units of microcuries per square meter at specified distances from the accident location. Releases were assumed to occur at ground level with no thermal lift. Mean meteorological conditions were assumed and the deposition velocity was set to 0.01 meters (0.03 feet) per second. The EPA level of concern was set to 0.1 microcuries per square meter. For the analyzed chemical release scenarios, a combination of quantitative and qualitative means was used to assess the secondary impacts in Section K.3.9.

K.3.3 Radiological Accident Analyses

In accordance with DOE NEPA guidelines, an EIS should contain a representative set of accidents that includes various types, such as fire, explosion, mechanical impact, criticality, spill, human error, natural phenomena, and external events. DOE's Office of NEPA Policy and Compliance provides guidance for preparing accident analyses in EISs in *Recommendations for Analyzing Accidents Under the National Environmental Policy Act* (DOE 2002). This document clarifies and supplements *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 2004c).

Facility accidents fall into three broad categories: (1) internally initiated operational events, (2) externally initiated events, and (3) natural phenomena. The first category, internally initiated operational events, includes accidents such as fires, explosions, criticalities, spills, floods, mechanical impacts, and human errors. The second category, externally initiated events, includes airplane crashes, land vehicle impacts, and accidents at adjacent facilities that could impact DOE facilities. The third category, natural phenomena, includes earthquakes, tornados, lightning, high winds, floods, fires, and other naturally occurring events. Other accidents could be identified in each category specific to a facility's operations, design, location, and mission. Intentional acts by terrorists or saboteurs are not considered accidents in the context of NEPA; however, potential impacts of international destructive acts are addressed in Section K.3.11.

For this *TC & WM EIS*, a large number of potential accidents were considered in each category. The sources of these accident descriptions, which include identification, definition, and assessment of impacts, are documented in safety analysis reports for the WTP, Pretreatment Facility, LAW Vitrification Facility, and HLW Vitrification Facility. Other documents prepared in support of these safety analysis reports and related EISs were also referenced as needed.

From the large list of accident scenarios, a number were selected that were consistent with NEPA purposes and supportive of public interests and DOE decisions associated with this *TC & WM EIS*. Screening criteria for accident selection and further analysis included the following:

- Applicability (i.e., is the accident scenario applicable to this *TC & WM EIS*?)
- Likelihood of occurrence (i.e., is the accident's occurrence reasonably foreseeable?)
- Material at risk (MAR) (i.e., does the accident scenario involve a significant amount of hazardous MAR as a source term?)
- Magnitude of impacts (i.e., how would the accident's impacts illustrate the range of possible consequences and risks for workers and the public for a particular accident category such as fire or spill?)
- Differentiation of alternatives (i.e., would the accident's impacts help to differentiate between alternatives for decision making purposes?)
- Public interest (i.e., is the accident scenario one that is of particular interest and concern to the public?)

The results of the process of accident selection are provided in Sections K.3.4 for Tank Closure alternatives, K.3.5 for FFTF Decommissioning alternatives, and K.3.6 for Waste Management alternatives. These sections describe the accident scenarios and corresponding source terms developed for the *TC & WM EIS* alternatives. The spectrum of accidents discussed below was used to determine the range of consequences (public and worker doses) and associated risks. Additional assumptions were made when further information was required to clarify the accident condition, update various parameters, or facilitate the evaluation process. The assumptions are referenced in each accident description.

Assuming the occurrence of a postulated accident, the source term is the amount of respirable radioactive material released to the air, in terms of curies or grams. The airborne source term is typically estimated by the following equation:

$$\text{Source term} = MAR \times DR \times ARF \times RF \times LPF$$

where:

MAR	=	material at risk
DR	=	damage ratio
ARF	=	airborne release fraction
RF	=	respirable fraction
LPF	=	leak path factor

The MAR is the amount of radionuclides (in curies of activity or grams for each radionuclide) available to be acted upon by a given physical stress. The MAR is specific to a given process in the facility of interest. It is not necessarily the total quantity of material present, but rather the amount of material in the scenario of interest postulated to be available for release.

The DR is the fraction of material exposed to the effects of the energy, force, or stress generated by the postulated event. For the accident scenarios discussed in this analysis, the value of the DR ranges from 0.1 to 1.0.

The ARF is the fraction of material that becomes airborne due to the accident. In this analysis, ARFs were obtained from applicable source documents or the DOE Handbook, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Vol. 1, *Analysis of Experimental Data* (DOE Handbook 3010-94).

The RF is the fraction of the material with a 10-micron (0.0004-inch) or less aerodynamic-equivalent diameter particle size that could be retained in the respiratory system following inhalation. The RF values are also taken from applicable source documents or the DOE Handbook (DOE Handbook 3010-94).

The LPF accounts for the action of removal mechanisms (e.g., containment systems, filtration, deposition) to reduce the amount of airborne radioactivity ultimately released to occupied spaces in the facility or the environment. The LPF values were taken from applicable sources when possible. Otherwise, an LPF of 1.0 (i.e., no reduction) was assigned. An LPF of 1.0 was also assigned in accident scenarios involving a major failure of confinement barriers.

For example, if for a particular waste process vessel accident, the MAR is 100 curies of a specified radionuclide in a fixed amount of tank waste, the DR is 0.5, the ARF is 0.01, the RF is 0.02, and the LPF is 0.05, the source term would be calculated as follows:

$$\text{Source term} = MAR \times DR \times ARF \times RF \times LPF = 100 \times 0.5 \times 0.01 \times 0.02 \times 0.05 = 0.0005 \text{ curies}$$

In other words, a process vessel contains 100 curies of a radionuclide that is at risk of being released to the environment. Because of an accident, for example, vessel failure, 50 percent (the DR is 0.5) of the vessel's contents are released to the immediate area, 1.0 percent (the ARF is 0.01) becomes airborne, and 2.0 percent (the RF is 0.02) of the airborne material is of respirable size. Depending on the nature of the accident, availability of filtration equipment, and other mitigating factors, 5 percent (the LPF is 0.05) of the respirable airborne material is released to the environment. The net effect is the release of 0.0005 curies of the radionuclide.

K.3.4 Tank Closure Accident Scenarios

This section describes the tank waste storage, retrieval, treatment, and handling accident scenarios applicable to the Tank Closure alternatives. The scenarios, selected in accordance with the process and criteria described in Section K.3.3, are organized according to facility or activity, and their applicability to the alternatives is shown in Table K–65. Many of the accident impacts are based on unmitigated releases, meaning that no credit is taken for HEPA filtration or other design features that may limit the amount of radioactive material released to the environment. Assessing accident impacts based on unmitigated releases is particularly applicable to accident scenarios initiated by seismic events, which were assumed to cause failure of the filtration systems or other mitigating features. In these cases, the lower frequency of the accident reflects the seismic initiating event's effects on mitigating features and accident risk. If these accident scenarios were initiated by events internal to the facility and operations, the HEPA filters and other mitigating features would have a high likelihood of functioning properly, thereby reducing the amount of radioactivity released to the environment. However, the frequency of accident occurrence in these cases would be higher, which would be reflected in the accident's resultant risk. The alphanumeric code following the accident's title (e.g., HL11) corresponds with the accident's description in the tables of this section and in Chapter 4, Section 4.1.11; it is provided to facilitate cross-referencing between tables and accident descriptions.

Table K–65. Tank Closure Alternatives – Applicability of Radiological Accident Scenarios

Accident Scenario[a]	Alternative										
	1	**2A**	**2B**	**3A**	**3B**	**3C**	**4**	**5**	**6A**	**6B**	**6C**
Spray release from jumper pit during waste retrieval–unmitigated (TK51)	–	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Spray leak in transfer line during excavation–unmitigated (PT23)	–	Y	Y	Y	Y	Y	Y	Y	–	Y	Y
Pretreatment Facility waste feed receipt vessel or piping leak–unmitigated (PT22)	–	Y	Y	Y	Y	Y	Y	Y	–	Y	Y
Seismically induced failure of HLW melter feed preparation vessels–unmitigated (6 MTG/day) (HL11)	–	Y	Y	Y	Y	Y	Y	Y	–	Y	Y
Seismically induced failure of HLW melter feed preparation vessels–unmitigated (15 MTG/day) (HL11)	–	–	–	–	–	–	–	–	Y	–	–
HLW molten glass spill caused by HLW melter failure–unmitigated (6 MTG/day) (HL14)	–	Y	Y	Y	Y	Y	Y	Y	-	Y	Y
HLW molten glass spill caused by HLW melter failure–unmitigated (15 MTG/day) (HL14)	–	–	–	–	–	–	–	–	Y	–	–
Seismically induced LAW Vitrification Facility collapse and failure–unmitigated (30 MTG/day) (LA31)	–	Y	–	Y	Y	Y	Y	–	–	–	–
Seismically induced LAW Vitrification Facility collapse and failure–unmitigated (45 MTG/day) (LA31)	–	–	–	–	–	–	–	Y	–	–	–
Seismically induced LAW Vitrification Facility collapse and failure–unmitigated (90 MTG/day) (LA31)	–	–	Y	–	–	–	–	–	–	Y	Y
Seismically induced WTP collapse and failure–unmitigated (HLW 6 MTG/day; LAW 30 MTG/day) (WT41)	–	Y	–	Y	Y	Y	Y	–	–	–	–
Seismically induced WTP collapse and failure–unmitigated (HLW 6 MTG/day; LAW 45 MTG/day) (WT41)	–	–	–	–	–	–	–	Y	–	–	–
Seismically induced WTP collapse and failure–unmitigated (HLW 6 MTG/day; LAW 90 MTG/day) (WT41)	–	–	Y	–	–	–	–	–	–	Y	Y

Table K–65. Tank Closure Alternatives – Applicability of Radiological Accident Scenarios *(continued)*

Accident Scenario[a]	Alternative										
	1	2A	2B	3A	3B	3C	4	5	6A	6B	6C
Seismically induced WTP collapse and failure–unmitigated (HLW 15 MTG/day; LAW 0 MTG/day) (WT41)	–	–	–	–	–	–	–	–	Y	–	–
Cast stone feed receipt tank failure–unmitigated (200-East Area) (CS71)	–	–	–	–	Y	–	Y	Y	–	–	–
Cast stone feed receipt tank failure–unmitigated (200-West Area) (CS71)	–	–	–	–	Y	–	–	–	–	–	–
Mixed TRU waste/MLLW liquid sludge transfer line spray leak–unmitigated (200-East Area) (TR81)	–	–	–	Y	Y	Y	Y	Y	–	–	–
Mixed TRU waste/MLLW liquid sludge transfer line spray leak–unmitigated (200-West Area) (TR81)	–	–	–	Y	Y	Y	Y	Y	–	–	–
Bulk vitrification waste receipt tank failure–unmitigated (200-East Area) (BV61)	–	–	–	Y	–	–	–	–	–	–	–
Bulk vitrification waste receipt tank failure–unmitigated (200-West Area) (BV61)	–	–	–	Y	–	–	Y	Y	–	–	–
Steam reforming feed receipt tank failure–unmitigated (200-West Area) (SRF1)	–	–	–	–	–	Y	–	–	–	–	–
Steam reforming feed receipt tank failure–unmitigated (200-East Area) (SRF1)	–	–	–	–	–	Y	–	–	–	–	–
Seismically induced waste tank dome collapse–unmitigated (TK53)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
IHLW glass canister drop–unmitigated (SH91)	–	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4 and Chapter 4, Section 4.1.11.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant; Y=yes.

K.3.4.1 HLW Vitrification Facility

K.3.4.1.1 Seismically Induced Failure of HLW Melter Feed Preparation Vessels—Unmitigated (HL11)

This accident scenario involves seismically induced structural failure of two HLW melter feed preparation vessels containing the most concentrated waste materials in the HLW Vitrification Facility. The resultant leaks would drain the tanks, creating internal pools of liquid 10 to 34 centimeters (about 4 to 13 inches) deep in each room, with subsequent entrainment of aerosols in the airflow across the liquid surface. HEPA filters were assumed to fail as a result of the seismic event. The MAR would be in 58,300 liters (15,400 gallons) of HLW (BNI 2005). An initial ARF of 0.00005 would apply to the vessels' contents as they spill to the floor. A continuing airborne release of 4×10^{-7} per hour of the spilled material due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for 24 hours. The RFs would be 0.8 for aerosols formed as the waste spills and 1.0 for aerosols entrained from the pool surface (Lindquist 2006a). The LPF would be 1.0 for the unmitigated case.

The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007a). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.1.2 HLW Melter Feed Preparation Vessel Failure—Mitigated (HL12)

This accident scenario involves structural failure of an HLW melter feed preparation vessel caused by internal release mechanisms. The resultant leak would drain the tank in 8 hours, creating an internal pool of liquid 10 to 34 centimeters (about 4 to 13 inches) deep in the room with subsequent entrainment of aerosols in the airflow across the liquid. HEPA filters were assumed to be operational. The MAR would be in the contents of a single vessel, 29,100 liters (7,700 gallons) of HLW received from the Pretreatment Facility (BNI 2005). An initial ARF of 0.00005 would apply to the vessel's contents as they spill to the floor. Continuing airborne release at a rate of 4×10^{-7} of the spilled material per hour due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for 24 hours. The RFs would be 0.8 for aerosols formed as the waste spills and 1.0 for aerosols entrained from the pool surface. The LPF would be 2.5×10^{-5} (Lindquist 2006a). This accident's impacts would be less than those of the seismically induced failure of HLW melter feed preparation vessels (HL11) and were not analyzed further.

K.3.4.1.3 Overflow—Mitigated (HL13)

This accident scenario involves overflow of an HLW melter feed preparation vessel into the melter cave sumps and then into the bermed area of the melter cave; the overflow would be caused by excessive volume transfer from the pretreatment vessel or by transfer of material from the pretreatment vessel when the melter feed preparation vessel is full. The MAR would be in 29,100 liters (7,700 gallons) of HLW received from the Pretreatment Facility (BNI 2005). An initial ARF of 0.00005 would apply to the vessel's contents as they spill to the floor. A continuing airborne release of 4×10^{-7} of the spilled material per hour due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for 24 hours. The RFs would be 0.8 for aerosols formed as the waste spills and 1.0 for aerosols entrained from the pool surface. The LPF would be 2.5×10^{-5} (Lindquist 2006a). This accident's impacts would be less than those of the seismically induced failure of HLW melter feed preparation vessels (HL11) and were not analyzed further.

K.3.4.1.4 HLW Molten Glass Spill Caused by HLW Melter Failure—Unmitigated (HL14)

This accident scenario involves a seismically induced catastrophic failure of the HLW melter shell, causing molten glass at 1,150 °C (2,100 °F) to flow out into the HLW melter cave and pour tunnel. Rapid steam generation from the feed material would continue for 1 hour. The depth of the spilled molten glass would vary from 0.03 to 0.46 meters (0.09 to 1.51 feet), depending on the surface area. A depth of 1 centimeter (0.4 inches) was conservatively assumed to maximize the amount of cesium released from the glass as it cools (BNI 2004). HEPA filters were assumed to have failed as a result of the seismic event, resulting in an unfiltered release of radioactive material. The LPF was thereby assumed to be 1.0. The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007b). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.1.5 HLW Molten Glass Spill Caused by Failed Melter—Mitigated (HL15)

This accident scenario involves a catastrophic failure of the HLW melter shell, causing molten glass at 1,150 °C (2,100 °F) to flow out into the HLW melter cave and pour tunnel. Rapid steam generation from the feed material would continue for 1 hour. The depth of the spilled molten glass would vary from 0.03 to 0.46 meters (0.09 to 1.51 feet), depending on the surface area. A depth of 1 centimeter (0.4 inches) was conservatively assumed to maximize the amount of cesium released from the glass as it cools (BNI 2004). HEPA filters were assumed to be operational, resulting in a filtered release of radioactive material. The LPF was estimated to be 2.5×10^{-5} (Lindquist 2006a). This accident's impacts would be less than those of the unmitigated scenario for the HLW melter failure (HL14) and were not analyzed further.

K.3.4.2 Pretreatment Facility

K.3.4.2.1 Dropped Ultrafilter Module—Mitigated (PT21)

This accident scenario involves a plugged ultrafilter module lifted for replacement using the hot cell crane. The module would be lifted to the maximum height and then a failure of the crane, hook, or lifting device would allow it to fall to the hot cell floor. The dropped module would create a radioactive aerosol that would be released into the hot cell with the potential for migrating into other areas and the environment. The MAR would be in 38.8 liters (10.2 gallons) of HLW. The ARF and RF were estimated to be 0.001 and 0.1, respectively (Woolfolk 2007b). The LPF was estimated to be 2.5×10^{-5} (Lindquist 2006a). This accident's impacts would be less than those of other Pretreatment Facility accidents and were not analyzed further.

K.3.4.2.2 Pretreatment Facility Waste Feed Receipt Vessel or Piping Leak—Unmitigated (PT22)

This accident scenario involves a seismically induced failure of one of four waste feed receipt process vessels or submerged transfer lines. Contributing failure mechanisms include corrosion, erosion, thermal cycling fatigue, faulty welds, or chemical/waste incompatibilities. The entire vessel's contents would spill from the vessel or piping to the floor of the cell due to failure of either the vessel's nozzles or the transfer line within the cell. HEPA filters were assumed to be inoperative, resulting in an unfiltered release of radioactive material. The MAR would be in 1.53 million liters (0.40 million gallons) of untreated waste. An initial ARF of 0.00005 would apply to the vessel's contents as they spill to the floor. A continuing airborne release of 4×10^{-7} of the spilled material per hour due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for 24 hours. The RFs would be 0.8 for aerosols formed as the waste spills and 1.0 for aerosols entrained from the pool surface (Woolfolk 2007b). The LPF would be 1.0 for the unmitigated case (the LPF would be 2.5×10^{-5} for the mitigated case) (Lindquist 2006a). The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007b). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.2.3 Spray Leak in Transfer Line During Excavation—Unmitigated (PT23)

This accident scenario involves failure of the coaxial transfer piping that delivers waste from the tank farms to the Pretreatment Facility due to an excavation accident. The outer pipe wall was postulated to break so that the waste is released directly to the environment.

The MAR would be in a waste stream transferring 1,080 liters (285 gallons) per hour for 8 hours from the tank farms to the Pretreatment Facility. The release rate was estimated to be 0.30 liters (0.08 gallons) per second. The ARF and RF were estimated to be 0.0001 and 1.0, respectively. The LPF for the excavation case was estimated to be 1.0. The frequency of the accident was estimated to be 0.0001 per year (Woolfolk 2007b).

K.3.4.3 LAW Vitrification Facility

K.3.4.3.1 Seismically Induced LAW Vitrification Facility Collapse and Failure—Unmitigated (LA31)

This accident scenario involves a seismically induced failure of LAW vessels, product glass containers, melters, and HEPA filters. The MAR is the sum of the radionuclide inventories in 17 major process vessels (Medsker 2007). The product of ARF × RF was estimated to be 0.00005 (Lindquist 2006a). The

LPF was estimated to be 1.0. The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Medsker 2007). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.4 Waste Treatment Plant

K.3.4.4.1 Seismically Induced Waste Treatment Plant Collapse and Failure—Unmitigated (WT41)

This accident involves a seismically induced catastrophic failure of the WTP. The MAR is all radioactive materials in the WTP vessels, glass containers, melters, filters, transfer pipes, and other equipment. The material was postulated to spill or fall and to be subjected to impact by falling debris. The Pretreatment Facility MAR is the product of the vessel capacities (Woolfolk 2007b) and radionuclide concentrations (Hassan 2007) for 17 pretreatment process streams that contain significant amounts of radioactivity. The LAW Vitrification Facility MAR is the sum of the radionuclide inventories in 17 major process vessels (Medsker 2007). The HLW Vitrification Facility MAR is the product of the process vessel capacities (Woolfolk 2007a) and the radionuclide concentrations (BNI 2005) for seven process streams that contain significant amounts of radioactivity. To represent the different alternatives, the MAR values for the Pretreatment, LAW Vitrification, and HLW Vitrification Facilities were assumed to be proportional to the immobilized high-level radioactive waste (IHLW) and immobilized low-activity waste (ILAW) production rates. Total MAR values were calculated for WTP production rates (IHLW × ILAW) of 6 × 30, 6 × 90, 6 × 45, and 15 × 0 metric tons of glass per day. An initial airborne respirable release fraction (ARF × RF) of 0.00005 would apply to liquid waste that spills to the floor. A continuing airborne release of 4×10^{-7} of the spilled material per hour due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for 24 hours (Lindquist 2006a). The HEPA filtration system was assumed to fail, resulting in unfiltered releases to the environment (an LPF of 1.0). The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007b). For risk calculation purposes, a conservative frequency of 0.0005 was assumed.

K.3.4.5 Tank Waste Storage and Retrieval

K.3.4.5.1 Spray Release from Jumper Pit During Waste Retrieval—Unmitigated (TK51)

This accident scenario involves a spray release of pressurized liquid from a mispositioned jumper in an SST double-contained receiver tank pump pit that services the transfer from the double-contained receiver tank to the double-shell tank or pumps into or out of a receiver tank. A jumper is a short connection pipe that is used in a jumper or pump pit to route tank waste from one line to another when transferring waste to a specific location. It was postulated that a jumper is mispositioned and pinhole leaks develop at both ends of the jumper. All spray particles were assumed to evaporate to less than 10 microns before reaching the ground. All of the spray was considered respirable. The respirable release (MAR × ARF × RF) would be in 52 liters (14 gallons) of untreated tank waste (Shire et al. 1995). The frequency of this accident was estimated to be 0.011 per year (DOE and Ecology 1996).

K.3.4.5.2 Hydrogen Deflagration in Waste Storage Tanks—Mitigated (TK52)

This accident scenario involves hydrogen generated in tank waste that rises into the tank headspace and reaches the concentration necessary for combustion. Ignition would occur in the tank headspace during a 1-hour period when the gas concentration would exceed the lower flammability limit. Turbulence accompanying rapid combustion would suspend waste as aerosols, and pressure would drive some of the particulates out of the ventilation system into the environment. The MAR would be in 500,000 liters (130,000 gallons) of waste tank constituents. The product of ARF × RF was estimated to be 6.5×10^{-6}.

The LPF was estimated to be 0.75 due to mitigation of the aerosol by soil collapsing into the tank (Shire et al. 1995). The estimated impacts of this accident would be represented by other storage and retrieval accident impacts and have not been analyzed further.

K.3.4.5.3 Seismically Induced Waste Tank Dome Collapse—Unmitigated (TK53)

This accident scenario involves radiological and chemical contaminants in the tank headspace that were conservatively assumed to be available for release. The collapse of a portion of the dome and overburden would compress the vapor in the headspace as they descend, enhancing the vapor release rate by a sudden pressure difference. Assumptions for each tank included a respirable concentration of contaminants in the headspace of 10 milligrams per cubic meter, a liquid specific gravity of 1.0, and a headspace volume of 935 cubic meters (1,223 cubic yards). The MAR, representative of all tanks, would be in 0.1 liters (0.026 gallons) of vapor and 410,000 liters (108,000 gallons) of salt cake, sludge, and liquid. The product of ARF × RF was estimated to be 1.0 for aerosols in the headspace and 0.00002 for solids and liquids. The LPF was estimated to be 1.0. Entrainment from the material splashed out of the tank would contribute an additional 4.6×10^{-6} liters per second to the source term (Shire et al. 1995). The reference for this scenario (Shire et al. 1995) cites an earthquake with a frequency of 0.00004 per year as the possible initiator. However, for risk calculation purposes, a conservative frequency of 0.0005 per year was assumed, consistent with the frequency used for earthquake scenarios involving severe damage to the WTP.

K.3.4.5.4 Rapid Exothermic Ferrocyanide-Nitrate Reaction (TK54)

A postulated accident of concern is the occurrence of a sustainable, rapid exothermic ferrocyanide-nitrate (or nitrite) reaction in the stored waste. Such a sustainable, rapid exothermic reaction could produce sufficient heat and evolve gases to pressurize the tank headspace, releasing aerosolized waste from the tank vents and potentially damaging the tank's structure.

Waste tank operations at Hanford during the 1950s used ferrocyanide in a number of waste tanks to scavenge cesium-137 from waste supernatant, which led to the formation of ferrocyanide-containing sludge that settled in layers in a number of waste tanks. As a result of these operations, approximately 140 metric tons of ferrocyanide (as $Fe(CN)^{+4}$) were added to 18 SSTs at Hanford. Ferrocyanide, in sufficiently high concentrations and mixed with oxidizing material such as sodium nitrate/nitrite, can react exothermically or even explode when heated to high temperatures.

The risk posed by the continued storage of ferrocyanide wastes in Hanford underground storage tanks has been studied extensively. Waste sample data coupled with laboratory experiments show that the ferrocyanide has decomposed (aged) to inert chemicals through radiolysis and hydrolysis and that the wastes cannot combust or explode (WHC 1996). As a result, all 18 ferrocyanide tanks are categorized as safe and this event has not been analyzed further.

K.3.4.6 Supplemental Treatment—Bulk Vitrification

K.3.4.6.1 Bulk Vitrification Waste Receipt Tank Failure—Unmitigated (BV61)

This accident scenario involves a seismically induced failure of a waste receipt tank used in the bulk vitrification waste treatment process in either the 200-East or 200-West Area. Contributing failure mechanisms might include corrosion, erosion, thermal cycling fatigue, faulty welds, or chemical/waste incompatibilities. The entire vessel's contents would spill from the vessel or piping to the floor of the cell where the tank is located. HEPA filters were assumed to be inoperative, resulting in an unfiltered release of radioactive material. The MAR would be in 129,000 liters (34,100 gallons) of waste (CH2M HILL 2003b). An initial ARF of 0.00005 would apply to the vessel's contents as they spill to the floor. A continuing airborne release of 4×10^{-7} of the spilled material per hour due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for

24 hours. The RFs would be 0.8 for aerosols formed as the waste spills and 1.0 for aerosols entrained from the pool surface (DOE Handbook 3010-94). The LPF would be 1.0 for the unmitigated case (2.5×10^{-5} for the mitigated case) (Lindquist 2006a). The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007b). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.7 Supplemental Treatment—Cast Stone

K.3.4.7.1 Cast Stone Feed Receipt Tank Failure—Unmitigated (CS71)

This accident scenario involves a seismically induced failure of a feed receipt and storage tank used in the cast stone waste treatment process in either the 200-East or 200-West Area. Contributing failure mechanisms may include corrosion, erosion, thermal cycling fatigue, faulty welds, or chemical/waste incompatibilities. The entire vessel's contents would spill from the vessel or piping to the floor of the cell where the tank is located. HEPA filters were assumed to be inoperative, resulting in an unfiltered release of radioactive material. The MAR would be in 129,000 liters (34,100 gallons) of waste (CH2M HILL 2003b). An initial ARF of 0.00005 would apply to the vessel's contents as they spilled to the floor. A continuing airborne release of 4×10^{-7} of the spilled material per hour due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for 24 hours. The RFs would be 0.8 for aerosols formed as the waste spills and 1.0 for aerosols entrained from the pool surface (DOE Handbook 3010-94). The LPF would be 1.0 for the unmitigated case (2.5×10^{-5} for the mitigated case) (Lindquist 2006a). The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007b). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.8 Supplemental Treatment—Steam Reforming

K.3.4.8.1 Steam Reforming Feed Receipt Tank Failure—Unmitigated (SRF1)

This accident scenario involves a seismically induced failure of a feed receipt tank used in the steam reforming waste treatment process in either the 200-East or 200-West Area. Contributing failure mechanisms may include corrosion, erosion, thermal cycling fatigue, faulty welds, or chemical/waste incompatibilities. The entire vessel's contents would spill from the vessel or piping to the floor of the cell where the tank is located. HEPA filters were assumed to be inoperative, resulting in an unfiltered release of radioactive material. The MAR would be in 129,000 liters (34,100 gallons) of waste (CH2M HILL 2003b). An initial ARF of 0.00005 would apply to the vessel's contents as they spill to the floor. A continuing airborne release of 4×10^{-7} of the spilled material per hour due to entrainment from the pool surface was assumed to contribute to worker exposure for a period of 8 hours and to public exposure for 24 hours. The RFs would be 0.8 for aerosols formed as the waste spills and 1.0 for aerosols entrained from the pool surface (DOE Handbook 3010-94). The LPF would be 1.0 for the unmitigated case (2.5×10^{-5} for the mitigated case) (Lindquist 2006a). The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007b). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.9 Supplemental Treatment—Remote-Handled TRU Waste

K.3.4.9.1 Mixed TRU Waste/Mixed Low-Level Radioactive Waste Liquid Sludge Transfer Line Spray Leak—Unmitigated (TR81)

This accident scenario involves a seismically induced break and spray leak in the TRU waste treatment system in the 200-East or 200-West Area. A spray leak could occur when waste slurry is transferred from the retrieval system to the feed receipt tanks. A small hole or orifice could develop in the transfer line, resulting in a spray leak. The MAR was based on a leak rate of 0.22 liters (0.06 gallons) per second for the duration of the assumed exposure (8 hours for the noninvolved worker, 24 hours for the MEI and population). The ARF was estimated to be 0.0001. The RF and LPF were estimated to be 1.0 (Woolfolk 2007a). The frequency of the accident was estimated to be in the range of 0.00005 to 0.0005 per year (Woolfolk 2007b). For risk calculation purposes, a conservative frequency of 0.0005 per year was assumed.

K.3.4.10 Waste Product Storage and Handling

K.3.4.10.1 IHLW Glass Canister Drop (SH91)

An IHLW glass canister drop was postulated at the 200-East Area IHLW Interim Storage Facilities. The height of the drop was assumed to be 16.8 meters (55 feet). The MAR would be in 1,220 liters (322 gallons) of glass IHLW. The DR was conservatively assumed to be 1. The product of the ARF and RF was estimated to be 0.0000943. The LPF was estimated to be 0.1. The resulting source term for material released to the environment was based on 0.0115 liters (0.003 gallons) of respirable glass particles. The frequency of the initiating event was estimated to be in the range of 0.1 to 0.01 per year (Woolfolk 2007a). With credit given for controls that would lower the frequency of the initiating event and reduce the actual aerosol release, a frequency of 0.001 per year was assumed for risk calculation purposes. The impacts of this accident represent the upper end of the range of waste product storage and handling accidents.

K.3.4.10.2 ILAW Glass Canister Drop (SH92)

An ILAW glass canister drop was postulated at the 200-East Area ILAW Interim Storage Facilities. The height of the drop was assumed to be 9.5 meters (31 feet). The MAR would be in 6,000 kilograms (13,228 pounds) of waste. The DR was estimated to be 0.5, meaning that only 50 percent of the canister's contents would be damaged by the impact. The product of the ARF and RF was estimated to be 0.000048 (BNI 2002). The LPF was estimated to be 1.0. The resulting source term for material released to the environment was based on 0.145 kilograms (0.32 pounds) of waste. The frequency of the accident was assumed to be the same as that of the IHLW canister drop (SH91), 0.001 per year. The estimated impacts of this accident would be less than those of the IHLW glass canister drop (SH91) and were not analyzed further.

K.3.4.10.3 Bulk Vitrification Glass Canister Drop (SH93)

A bulk vitrification glass canister drop was postulated at the 200-East Area storage facility. The height of the drop was assumed to be 2 meters (6.6 feet). The MAR would be in 27,600 kilograms (60,900 pounds) of waste (CH2M HILL 2003b). The DR was estimated to be 0.5, meaning that only 50 percent of the container's contents would be damaged by the impact. The product of the ARF and RF from the impaction stress was estimated to be 9.8×10^{-6} (DOE Handbook 3010-94). The LPF was estimated to be 1.0. The resulting source term for material released to the environment was 0.135 kilograms (0.298 pounds) of waste. The frequency of the accident was assumed to be the same as that of the IHLW canister drop (SH91), 0.001 per year. The estimated impacts of this accident would be less than those of the IHLW glass canister drop (SH91) and were not analyzed further.

K.3.4.10.4 Cast Stone Storage Canister Drop (SH94)

A cast stone storage canister drop was postulated at the 200-East Area storage facility. The height of the drop was assumed to be 2 meters (6.6 feet). The MAR would be in 25,000 kilograms (55,100 pounds) of waste (CH2M HILL 2003c). The DR was estimated to be 0.5, meaning that only 50 percent of the container's contents would be damaged by the impact. The product of the ARF and RF from the impaction stress was estimated to be 9.8×10^{-6} (DOE Handbook 3010-94). The LPF was estimated to be 1.0. The resulting source term for material released to the environment was 0.123 kilograms

(0.27 pounds) of waste. The frequency of the accident was assumed to be the same as that of the IHLW canister drop (SH91), 0.001 per year. The estimated impacts of this accident would be less than those of the IHLW glass canister drop (SH91) and were not analyzed further.

K.3.5 Fast Flux Test Facility Accident Scenarios

This section describes the accident scenarios applicable to the FFTF Decommissioning alternatives. Four of the scenarios involve fires that consume radioactively contaminated sodium metal formerly used as FFTF coolant or reactor coolant system components containing radioactive materials. Two other fire scenarios involve inventories of sodium that was formerly used in other reactors, is now stored at Hanford, and would be converted to sodium hydroxide along with the FFTF sodium for use on site under FFTF Decommissioning Alternatives 2 and 3. The scenarios are attributed to a variety of initiating events, including aircraft crash, material defect, human error, and high winds. Each one might also be initiated by a seismic event of sufficient magnitude to cause severe damage to structures in which the sodium is stored. Applicability of scenarios to the FFTF Decommissioning alternatives is shown in Table K–66. All of the accident impacts were based on unmitigated releases, meaning that no credit is taken for HEPA filtration, structural confinement, or other engineered features that may limit the amount of radioactive material released to the environment. The alphanumeric code following the accident's title (e.g., SSF1) corresponds with the accident's description in the tables of this section and in Chapter 4, Section 4.2.11**;** it is provided to facilitate cross-referencing between tables and accident descriptions.

Table K–66. FFTF Decommissioning Alternatives – Radiological Accident Scenario Applicability

Accident Scenario[a]	Alternative 1	Alternatives 2 and 3			
		Disposition of RH-SCs		Disposition of Bulk Sodium	
		Hanford Option	Idaho Option	Hanford Reuse Option	Idaho Reuse Option
Sodium Storage Facility fire (SSF1)	Y	Y	Y	Y	Y
Hanford sodium storage tank failure (HSTF1)	Y	Y	Y	Y	Y
Remote-handled special component fire (RHSC1)	–	Y	Y	Y	Y
Hallam Reactor sodium fire (HSF1)	Y	Y	Y	Y	Y
Sodium Reactor Experiment sodium fire (SRE1)	Y	Y	Y	Y	Y
INL Sodium Processing Facility storage tank failure (INLSPF1)	–	–	–	–	Y

[a] The alphanumeric code following the accident's title (e.g., SSF1) corresponds with the code in the accident's description in Section K.3.5.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; RH-SCs=remote-handled special components; Y=yes.

K.3.5.1 Accidents in the Hanford 400 Area

K.3.5.1.1 Sodium Storage Facility Fire (SSF1)

This accident scenario involves a postulated aircraft crash into the FFTF Sodium Storage Facility (SSF) that breaches all four sodium storage tanks and ignites the sodium metal within them. Although the SSF tanks would contain contaminated primary coolant mixed with relatively clean secondary coolant, it was conservatively assumed that the radionuclide inventory levels for the primary sodium represent the mix.

The MAR would be the entire 984,000-liter (260,000-gallon) inventory of sodium stored in the SSF (ANL-W and Fluor Hanford 2002). The surface of each tank was assumed to burn at the standard rate for an open pool of sodium on a steel liner, 10.8 grams per square meter per second (8 pounds per square foot per hour) (Himes 1996). The combined surface area for all four tanks is approximately 224 square meters (2,410 square feet) (WHC 1994). These factors would result in a burn rate of approximately 8,700 kilograms per hour (19,200 pounds per hour). Therefore, it would take approximately 105 hours for the entire contents of the tanks to burn. No credit was taken for any mitigation of the release by the building features; the LPF is therefore considered to be 1. Although Hanford safety analyses indicated that the probability of an accidental aircraft crash into a specific hazardous facility is less than 1×10^{-6} per year, the frequency of this scenario was conservatively assumed to be 1×10^{-6} per year (CH2M HILL 2003d).

K.3.5.1.2 Hanford Sodium Storage Tank Failure (HSTF1)

This accident was postulated to result from a large leak due to growth of a metal defect in one SSF storage tank. The contents of the tank would spill onto the steel floor of the secondary containment (an area of approximately 581 square meters [6,250 square feet]) and burn, releasing a sodium hydroxide aerosol plume (WHC 1994). Exposure to the burning pool of sodium was assumed to breach the other three tanks, causing the entire SSF inventory of 984,000 liters (260,000 gallons) of sodium to spill onto the floor and burn (ANL-W and Fluor Hanford 2002). Using the standard burn rate for an open pool of sodium on a steel liner, 10.8 grams per square meter per second (8 pounds per square foot per hour), the burn rate was estimated to be 22,600 kilograms per hour (49,800 pounds per hour), and the fire duration was estimated to be approximately 41 hours (Himes 1996). The estimated frequency of this scenario, based on the frequency of tank leaks, is 0.00001 per year (Bowman 1994).

K.3.5.1.3 Remote-Handled Special Component Fire (RHSC1)

This scenario represents the upper range of impacts from possible accidents involving removal and transport of the FFTF RH-SCs. A handling mishap was postulated to cause a breach of the largest, most radioactive component (the primary cold trap), resulting in exposure of the contained radioactive sodium to water and air. A portion (30 percent) of the sodium was assumed to burn, releasing the radionuclides in that amount of sodium as well as an equal percentage of the total cesium-137 and cobalt-60 inventory estimated to be in the cold trap. Ground-level release to the atmosphere was assumed. The sodium was assumed to have the radioactive characteristics of FFTF primary sodium (ANL-W and Fluor Hanford 2002). The amount of sodium burned would equal 750 kilograms (1,650 pounds). Additionally, 30 percent of the 470 curies of cesium-137 and 70 curies of cobalt-60 retained within the cold trap medium would be released (141 and 21 curies, respectively) (CEES 2006). For purposes of this analysis, this scenario was assumed to be initiated by human error and assigned a frequency of 0.01 per year (Fluor Hanford 2004a). This accident could also occur at the INL MFC under the Idaho Option for disposition of RH-SCs.

K.3.5.2 Accidents in the Hanford 200-West Area

K.3.5.2.1 Hallam Reactor Sodium Fire (HSF1)

Sodium formerly used as coolant in the Hallam Reactor is stored as a solid in five tanks in the 2727-W Building in the Hanford 200-West Area. Two tanks are full, one is half-full, and the remaining two contain only residual heels. In this scenario, the building would be damaged by high winds, causing a roof support beam to puncture a tank, releasing the cover gas. Rainwater would run down the beam and enter the tank, starting a fire from the exothermic reaction between sodium and water. The entire contents of the tank, 59,600 kilograms (131,000 pounds) of sodium, would burn and be released at ground level over a period of 67 hours. The frequency of this accident was estimated to be 0.00002 per year (Himes 1996).

K.3.5.2.2 Sodium Reactor Experiment Sodium Fire (SRE1)

Sodium formerly used as coolant in the Sodium Reactor Experiment (SRE) is stored as a solid in drums in the South Alkali Metal Storage Modules near the 200-West Area Solid Waste Operations Complex (SWOC). In this scenario, a vehicle impacts a single storage module and come to rest inside of it. The module contains 20 drums, each of which holds 168 kilograms (370 pounds) of sodium (Fluor Hanford 2004b). The fuel from the vehicle was assumed to drain into the module reservoir and ignite, burning the total amount of sodium in the 20 drums (3,360 kilograms or 7,410 pounds) in approximately 15 hours. For purposes of this analysis, this scenario was assumed to be initiated by human error and was assigned a frequency of 0.01 per year (Fluor Hanford 2004a).

K.3.5.3 Accidents at Idaho National Laboratory

K.3.5.3.1 INL Sodium Processing Facility Storage Tank Failure (INLSPF1)

The accident associated with disposition of bulk sodium at the INL SPF with the largest expected impacts would be a failure of the secondary sodium drain tank located in the EBR-II secondary sodium boiler building with an accompanying fire. The structure and associated features were assumed to provide no mitigation of the release. Although this storage tank would contain a mixture of bulk sodium, it was conservatively assumed that the radionuclide inventory levels for the FFTF primary sodium represent the mixture. Failure of the tank would result in a spill of its working capacity of 56,800 liters (15,000 gallons) of molten sodium (ANL-W and Fluor Hanford 2002). The burn rate was estimated to be 2,250 kilograms per hour (5,000 pounds per hour) and the duration was estimated to be 24 hours. The estimated frequency of this accident, based on the frequency of tank leaks, is 0.00001 per year (Bowman 1994).

K.3.6 Waste Management Accident Scenarios

The documented safety analysis for solid waste operations (DSASW) (Fluor Hanford 2007) identifies and analyzes a range of potential accidents at the Hanford low-level radioactive waste burial grounds (LLBGs), CWC, T Plant complex, and WRAP. These four facilities compose SWOC, which performs the solid waste management function for Hanford. The accidents analyzed in the DSASW represent a range of severity (consequences) and frequency and provide the basis for SWOC operating controls and limits. The solid waste management operations covered by the DSASW would continue under each of the three Waste Management alternatives examined in this *TC & WM EIS*. Under Waste Management Alternatives 2 and 3, new facilities or expansions of existing facilities would be required and there would be limited shipments of low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) to Hanford from other DOE sites. Accordingly, each of the scenarios analyzed in the current DSASW or some updated and refined version of it would be applicable to each of the Waste Management alternatives. The frequency and human health risk from a particular type of accident may vary somewhat as a function of the volume of waste that is managed and/or the duration (years) of each specific waste management component under each Waste Management alternative. Under Waste Management Alternative 1 (No Action), construction of IDF-East would be discontinued in 2008. Therefore, accidents associated with the onsite disposal of ILAW are not applicable to Waste Management Alternative 1. Scenarios for accidents involving ILAW were taken from *Project 520, Immobilized Low-Activity Waste Disposal Facility, Preliminary Documented Safety Analysis* (Burbank 2002). Applicability of the accident scenarios to the Waste Management alternatives is shown in Table K–67.

Table K–67. Waste Management Alternatives – Accident Scenario Applicability

Accident Scenario[a]	Alternative		
	1	2	3
Single-drum deflagration (SWOC FIR-1)	Y	Y	Y
Medium fire inside facility (SWOC FIR-6)	Y	Y	Y
Glovebox or greenhouse fire (SWOC FIR-8)	Y	Y	Y
Large fire of waste containers outside facility (SWOC FIR-4)	Y	Y	Y
Handling spill of single waste container (SWOC SP-2)	Y	Y	Y
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	Y	Y	Y
Spill of single large-diameter container (SWOC SP-4)	Y	Y	Y
Design-basis seismic event (SWOC NPH-1)	Y	Y	Y
Beyond-design-basis accident (SWOC NPH-2)	Y	Y	Y
Range fire (SWOC EE-1)	Y	Y	Y
Aircraft crash (SWOC EE-2)	Y	Y	Y
Earthmover shears tops off six ILAW containers (ILAW1)	−	Y	Y
Crushing of ILAW containers by falling crane boom (ILAW2)	−	Y	Y

[a] The alphanumeric code following the accident's title (e.g., SWOC FIR-1) corresponds with the code in the accident's description in Section K.3.6.

Key: ILAW=immobilized low-activity waste; Y=yes.

Source: Burbank 2002; Fluor Hanford 2007.

K.3.6.1 Solid Waste Operations Complex Accidents

Appendix D identifies total inventories of waste. However, only a portion of those totals would be subject to the accidents hypothesized in the scenarios at any given time. Waste would be received and managed in accordance with waste acceptance criteria and operational controls established on the basis of the DSASW results. Therefore, the quantities of radioactive material in individual waste packages and the total amounts in specific locations would be controlled such that accident source terms for reasonably foreseeable scenarios would be no greater than those assumed in the DSASW and used in these EIS calculations.

The DSASW describes and analyzes a range of severities for several accident types. Because the potential for all of the scenarios would be present regardless of the Waste Management alternative selected, a detailed examination of each scenario does little to discriminate between the alternatives or inform the decision-making process. Accordingly, only selected representative DSASW scenarios with relatively higher human health impacts are described here for several event types (e.g., fires, spills, natural phenomena). The other DSASW scenarios of each type are summarized with respect to their salient features, frequencies, and consequences. Consistent with the DSASW accident descriptions, the SWOC accident source terms are specified as plutonium-239 dose-equivalent curies (Pu-239 DE-curies), the amount of plutonium-239 (in curies) that would deliver the same radiation dose to an exposed individual or population as the mixture of radionuclides that would actually be released if an accident occurred.

Plutonium-239 Dose-Equivalent Curies (Pu-239 DE-curies)

- Dose equivalence is a method of expressing amounts of radionuclide mixtures in terms of the amount of a single radionuclide that, if inhaled, would produce the same dose to an individual as the mixture.
- Transuranic (TRU) waste managed at the Hanford Site Solid Waste Operations Complex (SWOC) are contaminated with mixtures of several different radionuclides, including plutonium-238, -239, -240, and -241; americium-241; and others.
- SWOC safety documents use a value of 0.165 plutonium-239 dose-equivalent curies per gram of TRU isotopes to calculate doses to workers and the public from accidents involving TRU waste.

K.3.6.1.1 Fires and Deflagrations

K.3.6.1.1.1 Single-Drum Deflagration (SWOC FIR-1)

The single-container (i.e., drum) deflagration event would result from the ignition of accumulated flammable gases (e.g., hydrogen) or a chemical reaction between incompatible materials. This scenario could occur in any SWOC facility, indoors or outdoors, and during many activities. It was postulated to occur at the LLBGs because that location has the greatest number of containers susceptible to the scenario. Ignition of the flammable gases was postulated to result in lid loss and ejection of a fraction of the container's contents, followed by partial or total combustion of both the ejected portion of the waste and the waste remaining in the container. However, the resulting fire was not postulated to propagate to other waste containers. The highest inventory selected for a hypothetical single standard drum at SWOC was selected as 82.5 Pu-239 DE-curies of TRU waste material, of which 5 percent (4.13 Pu-239 DE-curies) was assumed to be ejected by the deflagration. ARF and RF values of 0.001 and 1.0, respectively, apply to the material that is ejected, yielding a source term contribution of 0.0041 Pu-239 DE-curies. Both the ejected material and the material remaining in the container (78.4 Pu-239 DE-curies) would be subject to burning, resulting in additional release of radioactive material (Fluor Hanford 2007).

A DR of 0.18 was assumed for the ejected material because it was calculated that the radiant energy from the deflagration would only be sufficient to ignite 18 percent of the material. The ARFs for ejected plastics (31 percent of ejected material) and nonplastic combustibles (34 percent of ejected material) were assumed to be 0.05 and 0.01, respectively. The RFs and LPFs were assumed to be 1.0 (Fluor Hanford 2007). The contribution to the source term from this material is 0.0145 Pu-239 DE-curies.

For the waste that remains in the container, the DR and LPF were assumed to be 1.0. The combustible portion (65 percent) was treated as packaged waste (ARF of 0.0005, RF of 1.0). The noncombustible portion (35 percent) was assumed to have an ARF of 0.006 and an RF of 0.01. The contribution to the source term from this material is 0.0267 Pu-239 DE-curies (Fluor Hanford 2007).

The cumulative source term would be 0.045 Pu-239 DE-curies. Without credit for any controls, the frequency of this accident was estimated to be greater than 0.001 per year (Fluor Hanford 2007). For purposes of this analysis, the frequency was assumed to be 0.01 per year.

K.3.6.1.1.2 Medium Fire Inside Facility (SWOC FIR-6)

A medium fire is one in which several containers are subject to a fire. The postulated scenario involves failure of the WRAP Automated Stacker/Retrieval System (AS/RS), which would cause a pallet of four drums to fall, breaching the drums and spilling some of their contents. The falling pallet would also sever the AS/RS hydraulic lines, releasing up to 53 liters (14 gallons) of hydraulic fluid. The hydraulic fluid would ignite due to heating from nearby equipment or an electrical short circuit, engulfing the breached drums. An additional 48 drums in the storage rack would be heated by the fire and lose their lids, ejecting part of their contents. Both the ejected contents and the contents remaining in the drum would burn in the fire. The fire would not propagate through the facility.

The MAR for the scenario would be the sum of the 4 drums dropped and the 48 drums enveloped by the burning puddle of hydraulic fluid. The resulting source term would be 0.83 Pu-239 DE-curies. Without credit for any controls, the frequency of this accident was estimated to be greater than 0.01 per year (Fluor Hanford 2007). For purposes of this analysis, the frequency of this accident was estimated to be 0.01 per year.

K.3.6.1.1.3 Glovebox or Greenhouse Fire (SWOC FIR-8)

This scenario was postulated to occur in a WRAP glovebox line (either the TRU waste or TRU waste/LLW line) where a maximum of eight drums would be present. Only two of the drums were considered to represent uncontained waste. The other drums in the TRU waste glovebox would be considered packaged waste and would be represented by a closed, intact container on the transfer car. A variety of initiating events could cause the fire, such as the presence of flammable or combustible materials and ignition sources within the waste being repackaged or electrical or static ignition sources. This postulated fire was assumed to engulf all open waste being processed in the glovebox line. Staged drums outside the glovebox line would not become involved in the fire. The MAR would be the radioactive inventory of eight containers involved in the accident: four containers at 33 Pu-239 DE-curies each, two containers at 12.4 Pu-239 DE-curies each, and two containers at 2.3 Pu-239 DE-curies each. The MAR used to calculate the source term from the glovebox would be combined with the 2.3 Pu-239 DE-curies of MAR from the HEPA filter for a total of 164 Pu-239 DE-curies. The cumulative source term value would be 1.6 Pu-239 DE-curies derived from the burning of the waste material. The glovebox fire accident is one of a group of accidents hypothesized for SWOC. The impacts of such a fire would be larger than those of others such as a greenhouse fire. Without credit for any controls, the frequency of this accident was estimated to be greater than 0.01 per year (Fluor Hanford 2007). For purposes of this analysis, the frequency was assumed to be 0.01 per year.

K.3.6.1.1.4 Large Fire of Waste Containers Outside Facility (SWOC FIR-4)

This scenario postulates that a transport vehicle crashes into an outside stored waste array, causing spills and vehicle damage that create a flammable fuel pool that ignites and burns the stored waste and the transported waste containers. This scenario is based on a fire at the T Plant, but it could occur at any SWOC facility. Waste containers are stored or staged outside in stacks when they need to be transferred to other facilities or when they are received from offsite generators during waste management operations. These waste container pick-up and drop-off activities are typically performed using tractor-trailers that carry up to 80 containers and travel close to the stored or staged waste. Operator error or mechanical failure of the vehicle could cause loss of control, causing the vehicle to travel at high speed into the stored or staged waste array. The high-energy impact was postulated to overturn or otherwise impact the trailer so that the drums on it are thrown violently from the vehicle, impacted, and breached. The 80 containers were assumed to land in a burning fuel pool, and 100 percent of the drum contents were conservatively assumed to burn as unconfined waste. The collision would also impact a stored waste array of 384 drums, breaching 12 containers by direct impact and spilling 100 percent of their contents, which would also burn unconfined. The other 372 drums would experience varying degrees of damage and lid loss, and different portions of their contents would burn as contained or uncontained waste. The total MAR involved in the fire would be 2,310 Pu-239 DE-curies, of which 14 Pu-239 DE-curies would be ultimately released to the atmosphere. The frequency of the initiating event (truck impact) was estimated to be greater than 0.01 per year, but a truck impact resulting in a large fire was estimated to have a frequency of less than 0.01 per year (Fluor Hanford 2007). For purposes of this analysis, the frequency was assumed to be 0.01 per year.

K.3.6.1.1.5 Other Solid Waste Operations Complex Fire/Deflagration Scenarios

The DSASW describes and analyzes an additional seven fire scenarios. Table K–68 shows how the source terms (and therefore, the consequences) of those scenarios compare with the four scenarios detailed above (shown in bold font). The scenarios are arranged by source term, in ascending order.

Table K–68. Fire and Deflagration Scenarios Analyzed in the DSASW

Source Term (Pu-239 DE-curies)	Description	DSASW Designator	Frequency
0.0052	Fire of large-diameter container in T Plant	FIR-10	U
0.0045	**Single-drum deflagration**	**FIR-1**	**A**
0.063	Vapor cloud explosions and boiling liquid expanding vapor explosions	FIR-9	EU
0.83	**Medium fire inside facility**	**FIR-6**	**A**
1.6	Small fire inside facility	FIR-5	A
1.6	Small fire of waste containers outside facility	FIR-2	A
2.0	Medium fire of waste containers outside facility	FIR-3	A
1.6	**Glovebox or greenhouse fire**	**FIR-8**	**A**
7.0	Large fire inside facility	FIR-7	U
7.4	Large fire inside facility with aisle spacing	FIR-7A	U
14	**Large fire of waste containers outside facility**	**FIR-4**	**U**

Note: Entries evaluated in this environmental impact statement are in **bold** text.
Key: A=anticipated (frequency $>10^{-2}$ per year); DSASW=documented safety analysis for solid waste operations; EU=extremely unlikely (10^{-4} per year > frequency > 10^{-6} per year); Pu-239 DE-curies=plutonium-239 dose-equivalent curies; U=unlikely (10^{-2} per year > frequency $>10^{-4}$ per year).

K.3.6.1.2 Spills and Sprays

K.3.6.1.2.1 Handling Spill of Single Waste Container (SWOC SP-2)

Waste containers can be impacted physically or lose confinement from various causes during storage and handling. Material-handling equipment (e.g., forklifts) or other vehicles can inadvertently impact waste containers—puncturing, crushing, or toppling them. Raised or suspended loads can drop onto waste containers as a result of lifting equipment failure or improper rigging. This scenario postulates that waste handling operations cause a single-container spill during retrieval of TRU waste drums from buried stacks of TRU waste. The MAR for this scenario would be 82.5 Pu-239 DE-curies of TRU waste. The DR would be 1.0 for mechanical release from the drop of a corroded drum. The ARF and RF values for external impact on packaged waste in drums would be 0.001 and 0.1, respectively. The resultant source term for the single-container spill would be 0.0083 Pu-239 DE-curies. The frequency of this accident was estimated to be 0.01 per year (Fluor Hanford 2007).

K.3.6.1.2.2 Large Handling Spill of Boxes or Multiple Waste Containers (SWOC SP-3A)

This multiple-container spill was postulated to occur as the result of a large, heavy waste box dropping onto TRU waste containers stored or staged in arrays. The large waste box was assumed to be concrete and large enough to impact several stacked waste containers. Based on the dimensions of the waste box, 48 drums would be directly impacted and two layers of drums directly beneath the impacted drums (48 drums each) would also be damaged, for a total of 144 drums plus the waste box. The MAR would be 82.5 Pu-239 DE-curies for the waste box and 818 Pu-239 DE-curies for the 144 impacted containers. The resultant source term would be 0.041 Pu-239 DE-curies. Without credit for any controls, the frequency of this accident was estimated to be greater than 0.01 per year (Fluor Hanford 2007). For purposes of this analysis, the frequency was assumed to be 0.01 per year.

K.3.6.1.2.3 Spill of Single Large-Diameter Container (SWOC SP-4)

A large-diameter container (LDC) spill was postulated to occur in the 221-T Canyon Building because it is the only location where an LDC is removed from its shipping cask or lifted over other LDCs or blanket fuel assemblies in a storage cell. The drop scenario assumes that the LDC contains dry, high-activity sludge. Based on the largest expected inventory for this sludge mix, the total content (MAR) would be 1,610 Pu-239 DE-curies in 3,800 kilograms (8,380 pounds) of sludge. Applying a conservative ARF and RF of 0.0025, the source term for this scenario would be 0.4 Pu-239 DE-curies. No credit was taken for confinement provided by the T Plant structure or systems. Without credit for any controls, the frequency of this accident was estimated to be greater than 0.01 per year (Fluor Hanford 2007). For purposes of this analysis, the frequency was assumed to be 0.01 per year.

K.3.6.1.2.4 Other Solid Waste Operations Complex Spill/Spray Scenarios

The DSASW describes and analyzes an additional five spill/spray scenarios. Table K–69 shows how the source terms (and therefore, the consequences) of these scenarios compare with the scenarios detailed above (shown in bold font). The scenarios are arranged by source term, in ascending order.

Table K–69. Spill and Spray Scenarios Analyzed in the DSASW

Source Term (Pu-239 DE-curies)	Description	DSASW Designator	Frequency
0.0021	Spray release event	SP-7	A
0.0083	**Handling spill of single waste container**	**SP-2**	**A**
0.012	Waste container spill due to vehicle collision	SP-1	A
0.014	Handling spill of multiple waste containers	SP-3	A
0.017	Glovebox spill due to loss of confinement	SP-6	A
0.024	Spill of multiple large-diameter containers	SP-5	A
0.041	**Large handling spill of boxes or multiple waste containers**	**SP-3A**	**A**
0.4	**Spill of single large-diameter container**	**SP-4**	**A**

Note: Entries evaluated in this environmental impact statement are in **bold** text.
Key: A=anticipated (frequency $>10^{-2}$ per year); DSASW=documented safety analysis for solid waste operations; Pu-239 DE-curies=plutonium-239 dose-equivalent curies.
Source: Fluor Hanford 2007.

K.3.6.1.3 Natural Phenomena

K.3.6.1.3.1 Design-Basis Seismic Event (SWOC NPH-1)

A design-basis seismic event was postulated to impact the four SWOC facilities and result in the release of radioactive materials. All exposed waste containers stored outside would topple. Unstacked waste containers and the bottom tiers of stacked waste containers would not fail because they were assumed to be robust and able to survive a fall of less than 1.2 meters (4 feet). It was conservatively assumed that all stacked waste containers above the first tier would topple and spill. Most waste containers stored inside structures qualified to seismic performance category (PC)-2 parameters (DOE Standard 1021-93) would topple. Waste containers would topple and spill, except for fuel assemblies stored in the pool cell of the 221-T Canyon Building, sludge stored in LDCs in storage arrays in cells in the 221-T Canyon Building, unstacked containers, and the bottom tiers of stacked containers. The event would cause structures not qualified to PC-2 parameters to fail and buildings to collapse, causing waste containers stored inside to spill. Waste containers stored inside would be impacted and breached by falling objects (e.g., lights, fire suppression sprinkler lines) and other overhead equipment not seismically rated in structures that are qualified to PC-2 parameters. The total source term would be the sum of 0.027 Pu-239 DE-curies (LLBGs), 0.35 Pu-239 DE-curies (CWC), 0.005 Pu-239 DE-curies (T Plant), and

0.0038 Pu-239 DE-curies (WRAP), for a total of 0.39 Pu-239 DE-curies. Impacts from this event are larger than those for all other design-basis natural phenomena impacts (lightning, high wind/tornado, flood, volcano, snow loading). The frequency of this accident was estimated to be 0.001 per year (Fluor Hanford 2007).

K.3.6.1.3.2 Beyond-Design-Basis Accident (SWOC NPH-2)

A beyond-design-basis earthquake was postulated to impact the four SWOC facilities and result in the release of radioactive materials. All exposed waste containers stored outside would topple. Unstacked waste containers and the bottom tiers of stacked waste containers would not spill because they were assumed to be robust and able to survive a fall of less than 1.2 meters (4 feet). It was conservatively assumed that all stacked waste containers above the first tier would topple and spill. All structures would collapse, impacting waste containers stored inside and causing them to spill. Waste containers stored inside would be impacted and breached by falling objects (e.g., lights, fire suppression sprinkler lines, structural members) and other overhead equipment. The total source term would be the sum of 0.027 Pu-239 DE-curies (LLBGs), 0.35 Pu-239 DE-curies (CWC), 0.50 Pu-239 DE-curies (T Plant), and 0.57 Pu-239 DE-curies (WRAP), for a total of 1.5 Pu-239 DE-curies. Because this earthquake would be stronger than the design-basis seismic event, the frequency would be lower (less than 0.001). However, a quantitative estimate of the frequency of this event was not made. Therefore, for analysis purposes, the frequency was assumed to be 0.001 for purposes of this analysis (Fluor Hanford 2007).

K.3.6.1.4 External Events

K.3.6.1.4.1 Range Fire (SWOC EE-1)

The postulated range fire would encroach on SWOC facility structures, vehicles, and stacked waste, burning waste containers and releasing radioactive materials. Range fires can impact all SWOC facilities. The CWC was selected to represent the most conservative analysis of impacts of a range fire event because it is the westernmost facility, closest to a large amount of natural vegetation. It also has the largest inventory (17,500 waste containers located in the 2403-WD Waste Storage Building). The 2403-WD Waste Storage Building also was considered more vulnerable than buildings constructed of less combustible materials (i.e., the 221-T Canyon Building, WRAP structure). Because of the lack of combustibles inside the building, not all containers would be affected. The fire was postulated to affect 1,019 drums. The resultant source term would be 7.0 Pu-239 DE-curies. Without credit for any controls, the frequency of this accident was estimated to be greater than 0.01 per year (Fluor Hanford 2007). For the purposes of this analysis, the frequency was assumed to be 0.01 per year.

K.3.6.1.4.2 Aircraft Crash (SWOC EE-2)

An aircraft crash into SWOC facilities was postulated to forcefully impact the CWC 2403-WD Waste Storage Building, penetrate the building, and impact waste containers stacked three tiers high. The impact would breach containers and puncture the aircraft fuel tank, causing a pool fire. The exposed MAR would burn, and the pool fire would cause additional damage and release of MAR through lid loss and partial ejection of contents, lid loss and contained burning, and lid seal failure with pyrolysis (chemical change brought about by the action of heat). The SWOC facilities considered for selection as the crash location with the largest impact were the structures at the LLBGs, CWC, WRAP, and T Plant that contain a relatively high amount of MAR. The CWC 2403-WD Waste Storage Building was selected as the accident location because (1) it contains the largest vulnerable "footprint," (2) it is expected to provide little protection to the MAR, and (3) with 17,500 stacked waste containers, it contains the greatest amount of vulnerable MAR of all SWOC facilities. The aircraft crash impacts would be larger than those for accident scenarios involving other SWOC structures and areas. The total source term is 16 Pu-239 DE-curies. The frequency of this accident was estimated to be 0.00003 per year (Fluor Hanford 2007).

K.3.6.1.5 Criticality

The DSASW analyzes two criticality events: a liquid criticality at the T Plant (CR-1) and a solid waste criticality (CR-2). The DSASW shows that radiation doses to workers in the immediate vicinity might be in the range where severe radiation injury or death could result (337 rem from CR-1 and 467 rem from CR-2 to a worker 100 meters [110 yards] from the accident). The dose to the maximum offsite individual would be 0.12 rem from CR-1 and 0.2 rem from CR-2. Both criticalities were determined to be "beyond extremely unlikely" (because the frequency is less than one in a million per year, they are not considered "reasonably foreseeable" events for the purposes of this *TC & WM EIS*) (Fluor Hanford 2007).

K.3.6.2 ILAW Disposal Accidents

K.3.6.2.1 Earthmover Shears Tops Off Six ILAW Containers (ILAW1)

An earthmover was assumed to be pushing fill dirt over the tops of rows of ILAW containers when the blade shears the tops off of six containers. The blade force exerted by the earthmover was assumed to be entirely expended in shattering and grinding vitrified waste, producing a total release of 94 cubic centimeters (5.7 cubic inches) of ILAW glass particles in the respirable size range. More than 99 percent of the potential dose from the aerosol would be due to releases of strontium-90 (0.00666 curies), plutonium-238 (3.52×10^{-7} curies), plutonium-239 (0.0000115 curies), plutonium-240 (1.96×10^{-6} curies), and americium-241 (0.000122 curies). The estimated frequency of this accident is between 0.01 and 1 per year (Burbank 2002). For purposes of this analysis, it was assigned a frequency value of 0.1.

K.3.6.2.2 Crushing of ILAW Containers by Falling Crane Boom (ILAW2)

A crane is used to lift ILAW containers from the transporter and place them in the burial trench. It was assumed that the crane boom falls into the trench and strikes part of the exposed container array. The impact energy of the falling boom was assumed to be entirely expended in shattering and grinding the vitrified waste, producing a total release of 846 cubic centimeters (52 cubic inches) of ILAW glass particles in the respirable size range. More than 99 percent of the potential dose from the aerosol would be due to releases of strontium-90 (0.0599 curies), plutonium-238 (3.17×10^{-6} curies), plutonium-239 (0.000104 curies), plutonium-240 (0.0000176 curies), and americium-241 (0.0011 curies). The estimated frequency of this accident is between 0.01 and 1 per year (Burbank 2002). For purposes of this analysis, the frequency was assumed to be 0.1 per year.

K.3.7 Radiological Impacts of Accidents

The consequences of a radiological accident to workers and the public can be expressed in a number of ways. Three ways are used in this *TC & WM EIS*. The first is individual dose expressed in terms of rem or millirem for a worker or member of the public and collective dose expressed in terms of person-rem for a population of workers or members of the public. The second is a postexposure effect that reflects the likelihood of an LCF for an exposed individual or the expected number of LCFs in a population of exposed individuals. Individual or public exposure to radiation occurs if there is an accident involving radioactive materials, which leads to the third measure, risk. Risk is the mathematical product of the probability (or frequency) that the accident occurs and the LCF consequences. Risk is calculated as follows:

$$R_i = D_i \times F \times P$$

or

$$R_p = D_p \times F \times P$$

where:

R_i	=	risk of an LCF for an individual receiving a dose D_i
R_p	=	risk of a number of LCFs for a population receiving a collective dose D_p
D_i	=	dose to a worker or member of the public, rem or millirem
D_p	=	collective dose to a population of workers or members of the public, person-rem
F	=	dose-to-LCF conversion factor, which is 0.0006 LCFs per rem (for an individual) or person-rem (for a population)
P	=	probability or frequency of the accident, usually expressed on a per-year basis

Once the source term, the amount of radioactive material released to the environment for each accident scenario, is determined, the radiological consequences are calculated. The calculations and resulting impacts vary depending on how the release is dispersed, what material is involved, and which receptor is being considered.

For example, if the dose to the MEI or worker is 10 rem, the probability of an LCF for an individual is 10 × 0.0006 = 0.006, where 0.0006 is the dose-to-LCF conversion factor. If the MEI or worker receives a dose exceeding 20 rem, the dose-to-LCF conversion factor is doubled to 0.0012. Thus, if the MEI receives a dose of 30 rem, the probability of an LCF is 30 × 0.0012 = 0.036. For an individual, the calculated probability of an LCF would be in addition to the probability of cancer from all other causes.

For the population, the same dose-to-LCF conversion factor is used to estimate the number of LCFs. The calculated number of LCFs in the population is in addition to the number of cancer fatalities that would result from all other causes. The MACCS2 computer code is used to calculate the dose to an average individual living in a particular geographic area (sector) near the site. The individual dose is then multiplied by the number of people in that sector and the appropriate dose-to-LCF conversion factor to estimate the probability of an LCF within the entire sector's population. The probabilities for all sectors are then summed to produce an estimate of the total probability of an LCF (or total number of LCFs) in the population living within 80 kilometers (50 miles) of the site.

K.3.7.1 Radiological Impacts of Tank Closure Accidents

For the Tank Closure No Action Alternative, severe accidents involving waste tanks are represented by a seismically induced waste tank dome collapse. Table K–70 shows the consequences for this accident. Table K–71 shows the frequency and annual cancer risks for this accident.

Table K–70. Tank Closure Alternative – 1 Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.
[b] Based on a population of 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area.
[c] The alphanumeric code following the accident's title (i.e., TK53) corresponds with the code in the accident's description in Section K.3.4.
[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.
[e] Increased likelihood of an LCF for an individual, assuming the accident occurs.
[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.
Key: LCF=latent cancer fatality.

Table K–71. Tank Closure Alternative – 1 Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of Latent Cancer Fatality		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}

[a] The alphanumeric code following the accident's title (i.e., TK53) corresponds with the code in the accident's description in Section K.3.4.
[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.
[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.
[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.
[e] Based on a population of 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area.
Key: LCF=latent cancer fatality.

The following tables (Tables K–72 through K–91) provide the accident consequences for each Tank Closure action alternative. For each alternative, there are two tables showing the impacts. The first table presents the consequences (doses and LCFs) assuming the accident occurs—that is, not reflecting the frequency of accident occurrence. The second table shows accident risks that are obtained by multiplying the LCF values in the first table by the frequency of the corresponding accident.

Table K–72. Tank Closure Alternative – 2A Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (0.0001)	0.043	0.00003
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	0.003	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–73. Tank Closure Alternative – 2A Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.0005	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–74. Tank Closure Alternative – 2B Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.000043	3×10^{-8}	0.57	0 (0.0003)	0.13	0.00008
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	4.3	0.003	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–75. Tank Closure Alternative – 2B Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.0005	1×10^{-11}	0 (2×10^{-7})	4×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–76. Tank Closure Alternative – 3A Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	7×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	6×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (0.0001)	0.043	0.00003
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	0.003	58,000	35	13,000	1
Bulk vitrification waste receipt tank failure – unmitigated (200-East Area) (BV61)	2.8×10^{-8}	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	3.5×10^{-6}	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	2.2×10^{-6}	1×10^{-9}	0.0029	0 (0.00002)	0.0025	1×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	6.6×10^{-6}	4×10^{-9}	0.030	0 (0.00002)	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–77. Tank Closure Alternative – 3A Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6×30 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6×30 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.0005	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Bulk vitrification waste receipt tank failure – unmitigated (200-East Area) (BV61)	0.0005	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	0.0005	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0005	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0005	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

a The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

b The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

c Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

d The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

e Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–78. Tank Closure Alternative – 3B Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (0.0001)	0.043	0.00003
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	0.003	58,000	35	13,000	1
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	2.8×10^{-8}	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Cast stone feed receipt tank failure – unmitigated (200-West Area) (CS71)	3.5×10^{-6}	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	2.2×10^{-6}	1×10^{-9}	0.029	0 (0.00002)	0.0025	1×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	6.6×10^{-6}	4×10^{-9}	0.030	0 (0.00002)	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–79. Tank Closure Alternative – 3B Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT 23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.0005	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	0.0005	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Cast stone feed receipt tank failure – unmitigated (200-West Area) (CS71)	0.0005	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0005	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0005	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–80. Tank Closure Alternative – 3C Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCFs[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (0.0001)	0.043	0.00003
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	0.003	58,000	35	13,000	1
Steam reforming feed receipt tank failure – unmitigated (200-East Area) (SRF1)	2.8×10^{-8}	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Steam reforming feed receipt tank failure – unmitigated (200-West Area) (SRF1)	3.5×10^{-6}	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	2.2×10^{-6}	1×10^{-9}	0.029	0 (0.00002)	0.0025	1×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	6.6×10^{-6}	4×10^{-9}	0.030	0 (0.00002)	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–81. Tank Closure Alternative – 3C Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.0005	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Steam reforming feed receipt tank failure – unmitigated (200-East Area) (SRF1)	0.0005	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Steam reforming feed receipt tank failure – unmitigated (200-West Area) (SRF1)	0.0005	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0005	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0005	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

a The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z ×Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

b The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

c Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

d The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

e Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–82. Tank Closure Alternative – 4 Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.000014	9×10^{-9}	0.19	0 (0.0001)	0.043	0.00003
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	4.3	0.003	58,000	35	13,000	1
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	2.8×10^{-8}	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5.0×10^{-8}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	3.5×10^{-6}	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	2.2×10^{-6}	1×10^{-9}	0.029	0 (0.00002)	0.0025	1×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	6.6×10^{-6}	4×10^{-9}	0.030	0 (0.00002)	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–83. Tank Closure Alternative – 4 Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF: Maximally Exposed Individual[c]	Risk of LCF: Offsite Population[d, e]	Risk of LCF: Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT 23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (30 MTG/day)	0.0005	4×10^{-12}	0 (6×10^{-8})	1×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×30 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	0.0005	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	0.0005	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0005	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0005	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z ×Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–84. Tank Closure Alternative – 5 Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (45 MTG/day)	0.000021	1×10^{-8}	0.29	0 (0.0002)	0.065	0.00004
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×45 MTG/day)	4.3	0.003	58,000	35	13,000	1
Cast stone feed receipt tank failure – unmitigated (200-East Area) (SRF1)	2.8×10^{-8}	2×10^{-11}	0.00038	0 (2×10^{-7})	0.000083	5×10^{-8}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	3.5×10^{-6}	2×10^{-9}	0.016	0 (1×10^{-5})	0.0032	2×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	2.2×10^{-6}	1×10^{-9}	0.029	0 (0.00002)	0.0025	1×10^{-6}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	6.6×10^{-6}	4×10^{-9}	0.030	0 (0.00002)	0.0024	1×10^{-6}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

a The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

b Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

c The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

d The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

e Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

f The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–85. Tank Closure Alternative – 5 Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT 23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (45 MTG/day)	0.0005	6×10^{-12}	0 (9×10^{-8})	2×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×45 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Cast stone feed receipt tank failure – unmitigated (200-East Area) (CS71)	0.0005	8×10^{-15}	0 (1×10^{-10})	3×10^{-11}
Bulk vitrification waste receipt tank failure – unmitigated (200-West Area) (BV61)	0.0005	1×10^{-12}	0 (5×10^{-9})	1×10^{-9}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-East Area) (TR81)	0.0005	6×10^{-13}	0 (9×10^{-9})	7×10^{-10}
Mixed TRU waste/MLLW liquid sludge transfer line spray leak – unmitigated (200-West Area) (TR81)	0.0005	2×10^{-12}	0 (9×10^{-9})	7×10^{-10}
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

a The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z ×Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

b The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

c Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

d The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

e Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MLLW=mixed low-level radioactive waste; MTG/day=metric tons of glass per day; TRU=transuranic; WTP=Waste Treatment Plant.

Table K–86. Tank Closure Alternative – 6A Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (15 MTG/day)	0.029	0.00002	380	0 (0.2)	83	0.1
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (15 MTG/day)	0.046	0.00003	620	0 (0.4)	160	0.2
Seismically induced WTP collapse and failure – unmitigated (WT41) (15 MTG/day)	0.058	0.00004	780	0 (0.5)	180	0.2
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of LCF for an individual, assuming the accident occurs.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–87. Tank Closure Alternative – 6A Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF: Maximally Exposed Individual[c]	Risk of LCF: Offsite Population[d, e]	Risk of LCF: Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (15 MTG/day)	0.0005	9×10^{-9}	0 (0.0001)	0.00005
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (15 MTG/day)	0.0005	1×10^{-8}	0 (0.0002)	0.00009
Seismically induced WTP collapse and failure – unmitigated (WT41) (15 MTG/day)	0.0005	2×10^{-8}	0 (0.0002)	0.0001
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z ×Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–88. Tank Closure Alternative – 6B Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	**LCF**	**Dose (person-rem)**	**LCFs[f]**	**Dose (rem)**	**LCF[e]**
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.004)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.000043	3×10^{-8}	0.57	0 (0.0003)	0.13	0.00008
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	4.3	0.003	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–89. Tank Closure Alternative – 6B Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF: Maximally Exposed Individual[c]	Risk of LCF: Offsite Population[d, e]	Risk of LCF: Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT 23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.0005	1×10^{-11}	0 (2×10^{-7})	4×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–90. Tank Closure Alternative – 6C Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.0013	8×10^{-7}	5.8	0 (0.003)	1.4	0.0008
Spray leak in transfer line during excavation – unmitigated (PT23)	0.007	4×10^{-6}	94	0 (0.06)	24	0.03
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.88	0.0005	12,000	7	2,900	1
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.011	7×10^{-6}	150	0 (0.09)	33	0.04
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.019	0.00001	250	0 (0.1)	63	0.08
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.000043	3×10^{-8}	0.57	0 (0.0003)	0.13	0.00008
Seismically inducted WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	4.3	0.003	58,000	35	13,000	1
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.00021	1×10^{-7}	0.96	0 (0.0006)	0.22	0.0001
IHLW glass canister drop – unmitigated (SH91)	0.00026	2×10^{-7}	3.5	0 (0.002)	0.91	0.0005

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality ; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

Table K–91. Tank Closure Alternative – 6C Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF: Maximally Exposed Individual[c]	Risk of LCF: Offsite Population[d, e]	Risk of LCF: Noninvolved Worker[c]
Spray release from jumper pit during waste retrieval – unmitigated (TK51)	0.011	8×10^{-9}	0 (0.00004)	9×10^{-6}
Spray leak in transfer line during excavation – unmitigated (PT 23)	0.0001	4×10^{-10}	0 (6×10^{-6})	3×10^{-6}
Pretreatment Facility waste feed receipt vessel or piping leak – unmitigated (PT22)	0.0005	3×10^{-7}	0 (0.004)	0.002
Seismically induced failure of HLW melter feed preparation vessels – unmitigated (HL11) (6 MTG/day)	0.0005	3×10^{-9}	0 (0.00005)	0.00002
HLW molten glass spill caused by HLW melter failure – unmitigated (HL14) (6 MTG/day)	0.0005	6×10^{-9}	0 (7×10^{-5})	4×10^{-5}
Seismically induced LAW Vitrification Facility collapse and failure – unmitigated (LA31) (90 MTG/day)	0.0005	1×10^{-11}	0 (2×10^{-7})	4×10^{-8}
Seismically induced WTP collapse and failure – unmitigated (WT41) (6×90 MTG/day)	0.0005	1×10^{-6}	0 (0.02)	0.008
Seismically induced waste tank dome collapse – unmitigated (TK53)	0.0005	6×10^{-11}	0 (3×10^{-7})	7×10^{-8}
IHLW glass canister drop – unmitigated (SH91)	0.001	2×10^{-10}	0 (2×10^{-6})	5×10^{-7}

[a] The alphanumeric code following the accident's title (e.g., TK51) corresponds with the code in the accident's description in Section K.3.4. The term "Z × Y MTG/day," read as "Z by Y MTG/day," refers to a WTP design capacity of Z MTG/day of HLW and Y MTG/day of LAW; for example, 6 × 30, 6 × 45, 6 × 90, or 15 × 0 MTG/day.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; MTG/day=metric tons of glass per day; WTP=Waste Treatment Plant.

K.3.7.2 Radiological Impacts of FFTF Decommissioning Accidents

The accident scenarios involving the stored sodium inventories at Hanford in the 400 Area SSF and the 200-West Area are applicable under any of the FFTF Decommissioning alternatives. Table K–92 shows the consequences of these accidents. Table K–93 shows the annual probability and the cancer risks of the accidents. The Hallam Reactor sodium fire and SRE sodium fire could occur in either the 200-West Area where the sodium is stored, or in the 400 Area after the sodium is transferred there for processing. Tables K–92 and K–93 present the impacts of these accidents occurring in the 200-West Area; the Hanford sodium storage tank failure has the largest impacts of accidents occurring in the 400 Area.

Table K–92. FFTF Decommissioning Alternatives – Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Sodium Storage Facility fire (SSF1)	1.0×10^{-6}	6×10^{-10}	0.048	0 (0.00003)	3.4×10^{-7}	2×10^{-10}
Hanford sodium storage tank failure (HSTF1)	1.1×10^{-6}	6×10^{-10}	0.048	0 (0.00003)	8.7×10^{-7}	5×10^{-10}
Hallam Reactor sodium fire (HSF1)	4.6×10^{-10}	3×10^{-13}	5.9×10^{-6}	0 (4×10^{-9})	2.5×10^{-10}	2×10^{-13}
Sodium Reactor Experiment sodium fire (SRE1)	4.5×10^{-8}	3×10^{-11}	0.00058	0 (3×10^{-7})	1.1×10^{-7}	7×10^{-11}

a The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

b Based on populations of 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area (HSF1 and SRE1) and 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area (SSF1 and HSTF1).

c The alphanumeric code following the accident's title (e.g., SSF1) corresponds with the code in the accident's description in Section K.3.5.

d The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

e Increased likelihood of LCF for an individual, assuming the accident occurs.

f The reported value of the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; LCF=latent cancer fatality.

Table K–93. FFTF Decommissioning Alternatives – Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Sodium Storage Facility fire (SSF1)	1×10^{-6}	6×10^{-16}	0 (3×10^{-11})	2×10^{-16}
Hanford sodium storage tank failure (HSTF1)	1×10^{-5}	6×10^{-15}	0 (3×10^{-10})	5×10^{-15}
Hallam Reactor sodium fire (HSF1)	2×10^{-5}	5×10^{-18}	0 (7×10^{-14})	3×10^{-18}
Sodium Reactor Experiment sodium fire (SRE1)	1×10^{-2}	3×10^{-13}	0 (3×10^{-9})	7×10^{-13}

a The alphanumeric code following the accident's title (e.g., SSF1) corresponds with the code in the accident's description in Section K.3.5.

b The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

c Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

d The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

e Based on populations of 488,897 persons residing within 80 kilometers (50 miles) of the 200-West Area (HSF1 and SRE1) and 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area (SSF1 and HSTF1).

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; LCF=latent cancer fatality.

The sodium storage fire accident scenarios represent a reasonable range of potential accidents for the FFTF Decommissioning No Action Alternative. For the two FFTF Decommissioning action alternatives, additional scenarios are considered for the options for dispositioning RH-SCs and bulk sodium at Hanford or INL. These accidents could occur under either FFTF Decommissioning Alternative 2 or 3.

Under FFTF Decommissioning Alternatives 2 and 3, RH-SCs would be removed from FFTF prior to final disposition of the structures. A fire could occur at the Hanford 400 Area during handling of the RH-SCs. Table K–94 presents the radiological consequences of fire under the Hanford Option for disposition of RH-SCs. The risks of such an accident, determined by multiplying the consequences by the estimated frequency of the accident, are presented in Table K–95. Under the Hanford Reuse Option for disposition of bulk sodium, the accidents listed in Tables K–92 and K–93 represent a reasonable range of accidents, and no additional scenarios need to be evaluated.

Table K–94. FFTF Decommissioning Alternatives 2 and 3, Hanford Option for Disposition of RH-SCs – Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Remote-handled special component fire (RHSC1) at Hanford	0.00011	7×10^{-8}	4.4	0 (0.003)	0.0009	5×10^{-7}

a The dose presented here results from an accident release of radioactive materials to the atmosphere and is from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.
b Based on a population of 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area.
c The alphanumeric code following the accident's title (i.e., RHSC1) corresponds with the code in the accident's description in Section K.3.5.
d The accident listed was analyzed because it had the highest consequences and/or risks in its category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.
e Increased likelihood of LCF for an individual, assuming the accident occurs.
f The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.
Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; LCF=latent cancer fatality; RH-SCs=remote-handled special components.

Table K–95. FFTF Decommissioning Alternatives 2 and 3, Hanford Option for Disposition of RH-SCs – Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Remote-handled special component fire (RHSC1) at Hanford	0.01	7×10^{-10}	0 (0.00003)	5×10^{-9}

a The alphanumeric code following the accident's title (i.e., RHSC1) corresponds with the code in the accident's description in Section K.3.5.
b The accident listed was analyzed because it had the highest consequences and/or risks in its category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.
c Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.
d The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.
e Based on a population of 357,391 persons residing within 80 kilometers (50 miles) of the 400 Area.
Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; LCF=latent cancer fatality; RH-SCs=remote-handled special components.

However, the Idaho Option for either of these activities would introduce new accident scenarios. Under the Idaho Option for disposition of RH-SCs, the RH-SC fire (RHSC1) could occur both at Hanford (during removal) and at INL (during processing). The consequences and risks of an RH-SC fire at Hanford are presented in Tables K–94 and K–95. The radiological consequences of an RH-SC fire at INL are presented in Table K–96. Table K–97 presents the annual risks from an RH-SC fire, taking into account the probability of the accident occurring. The Idaho Reuse Option for disposition of bulk sodium would introduce a new scenario involving failure of the SPF sodium storage tank (INLSPF1) at INL. The consequences if the accident were to occur and the annual risks associated with the accident are presented in Tables K–96 and K–97.

Table K–96. FFTF Decommissioning Alternatives 2 and 3, Idaho Option for Disposition of RH-SCs and Idaho Reuse Option for Disposition of Bulk Sodium – Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Remote-handled special component fire (RHSC1) at INL	0.0001	6×10^{-8}	0.25	0 (0.0002)	0.0036	2×10^{-6}
INL Sodium Processing Facility storage tank failure (INLSPF1)	5.5×10^{-8}	3×10^{-11}	0.0002	0 (1×10^{-7})	3.4×10^{-7}	2×10^{-10}

a The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

b Based on a population of 205,962 persons residing within 80 kilometers (50 miles) of the INL Materials and Fuels Complex.

c The alphanumeric code following the accident's title (e.g., RHSC1) corresponds with the code in the accident's description in Section K.3.5.

d The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

e Increased likelihood of an LCF for an individual, assuming the accident occurs.

f The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: FFTF=Fast Flux Test Facility; INL=Idaho National Laboratory; LCF=latent cancer fatality; RH-SCs=remote-handled special components.

Table K–97. FFTF Decommissioning Alternatives 2 and 3, Idaho Option for Disposition of RH-SCs and Idaho Reuse Option for Disposition of Bulk Sodium – Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Remote-handled special component fire (RHSC1) at INL	0.01	6×10^{-10}	0 (2×10^{-6})	2×10^{-8}
INL Sodium Processing Facility storage tank failure (INLSPF1)	0.00001	3×10^{-16}	0 (1×10^{-12})	2×10^{-15}

a The alphanumeric code following the accident's title (e.g., INLSPF1) corresponds with the code in the accident's description in Section K.3.5.

b The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

c Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

d The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

e Based on a population of 205,962 persons residing within 80 kilometers (50 miles) of the INL Materials and Fuels Complex.

Key: FFTF=Fast Flux Test Facility; INL=Idaho National Laboratory; LCF=latent cancer fatality; RH-SCs=remote-handled special components.

K.3.7.3 Radiological Impacts of Waste Management Accidents

Table K–98 shows the consequences of the accidents associated with the Waste Management No Action Alternative. For the No Action Alternative, the accident scenarios involving the disposal of ILAW in the IDF-East are not applicable. Table K–99 shows the frequency and annual cancer risks for the accidents.

Table K–98. Waste Management Alternative – 1 Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	**LCF[e]**	**Dose (person-rem)**	**LCFs[f]**	**Dose (rem)**	**LCF[e]**
Single-drum deflagration (SWOC FIR-1)	0.00079	5×10^{-7}	3.6	0 (0.002)	0.84	0.0005
Medium fire inside facility (SWOC FIR-6)	0.015	9×10^{-6}	66	0 (0.04)	16	0.009
Glovebox or greenhouse fire (SWOC FIR-8)	0.028	0.00002	130	0 (0.08)	30	0.04
Large fire of waste containers outside facility (SWOC FIR-4)	0.25	0.0002	1,100	1 (0.7)	260	0.3
Handling spill of single waste container (SWOC SP-2)	0.00015	9×10^{-8}	0.66	0 (0.0004)	0.16	0.00009
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	0.00072	4×10^{-7}	3.3	0 (0.002)	0.77	0.0005
Spill of single large-diameter container (SWOC SP-4)	0.007	4×10^{-6}	32	0 (0.02)	7.5	0.004
Design-basis seismic event (SWOC NPH-1)	0.0068	4×10^{-6}	31	0 (0.02)	7.3	0.004
Beyond-design-basis accident (SWOC NPH-2)	0.026	0.00002	120	0 (0.07)	28	0.03
Range fire (SWOC EE-1)	0.12	0.00007	560	0 (0.3)	130	0.2
Aircraft crash (SWOC EE-2)	0.28	0.0002	1,300	1 (0.8)	300	0.4

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.
[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East Area and 200-West Areas, respectively.
[c] The alphanumeric code following the accident's title (e.g., SWOC FIR-1) corresponds with the code in the accident's description in Section K.3.6.
[d] The reported value of the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.
[e] Increased likelihood of an LCF for an individual, assuming the accident occurs.
[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: LCF=latent cancer fatality.

Table K–99. Waste Management Alternative – 1 Annual Cancer Risks from Accidents

Accident[a, b]	Frequency	Risk of LCF		
		Maximally Exposed Individual[c]	Offsite Population[d, e]	Noninvolved Worker[c]
Single-drum deflagration (SWOC FIR-1)	0.01	5×10^{-9}	0 (0.00002)	5×10^{-6}
Medium fire inside facility (SWOC FIR-6)	0.01	9×10^{-8}	0 (0.0004)	0.00009
Glovebox or greenhouse fire (SWOC FIR-8)	0.01	2×10^{-7}	0 (0.0008)	0.0004
Large fire of waste containers outside facility (SWOC FIR-4)	0.01	2×10^{-6}	0 (0.007)	0.003
Handling spill of single waste container (SWOC SP-2)	0.01	9×10^{-10}	0 (4×10^{-6})	9×10^{-7}
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	0.01	4×10^{-9}	0 (0.00002)	5×10^{-6}
Spill of single large-diameter container (SWOC SP-4)	0.01	4×10^{-8}	0 (0.0002)	0.00004
Design-basis seismic event (SWOC NPH-1)	0.001	4×10^{-9}	0 (0.00002)	4×10^{-6}
Beyond-design-basis accident (SWOC NPH-2)	0.001	2×10^{-8}	0 (0.00007)	0.00003
Range fire (SWOC EE-1)	0.01	7×10^{-7}	0 (0.003)	0.002
Aircraft crash (SWOC EE-2)	0.00003	5×10^{-9}	0 (0.00002)	0.00001

[a] The alphanumeric code following the accident's title (e.g., SWOC FIR-1) corresponds with the code in the accident's description in Section K.3.6.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: LCF=latent cancer fatality.

Tables K–100 and K–101 provide the accident consequences for Waste Management Alternatives 2 and 3. Table K–100 presents the consequences (doses and LCFs), assuming the accident occurs, that is, not reflecting the frequency of accident occurrence. Table K–101 shows accident risks obtained by multiplying the LCF values from Table K–100 by the frequency of the accident. Under Alternatives 2 and 3, new facilities or expansions of existing facilities would be required and there would be limited shipments of LLW and MLLW to Hanford from other DOE sites. As noted previously, each of the scenarios analyzed in the current DSASW or some variant of it would be applicable to each of the Waste Management alternatives, although the human health risk from a particular type of accident would depend on the volume of waste that is ultimately managed and the duration (years) of each operation.

Table K–100. Waste Management Alternatives 2 and 3 – Radiological Consequences of Accidents[a]

Accident[c, d]	Maximally Exposed Individual		Offsite Population[b]		Noninvolved Worker	
	Dose (rem)	LCF[e]	Dose (person-rem)	LCFs[f]	Dose (rem)	LCF[e]
Single-drum deflagration (SWOC FIR-1)	0.00079	5×10^{-7}	3.6	0 (0.002)	0.84	0.0005
Medium fire inside facility (SWOC FIR-6)	0.015	9×10^{-6}	66	0 (0.04)	16	0.009
Glovebox or greenhouse fire (SWOC FIR-8)	0.028	0.00002	130	0 (0.08)	30	0.04
Large fire of waste containers outside facility (SWOC FIR-4)	0.25	0.0002	1,100	1 (0.7)	260	0.3
Handling spill of single waste container (SWOC SP-2)	0.00015	9×10^{-8}	0.66	0 (0.0004)	0.16	0.00009
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	0.00072	4×10^{-7}	3.3	0 (0.002)	0.77	0.0005
Spill of single large-diameter container (SWOC SP-4)	0.007	4×10^{-6}	32	0 (0.02)	7.5	0.004
Design-basis seismic event (SWOC NPH-1)	0.0068	4×10^{-6}	31	0 (0.02)	7.3	0.004
Beyond-design-basis accident (SWOC NPH-2)	0.026	0.00002	120	0 (0.07)	28	0.03
Range fire (SWOC EE-1)	0.12	0.00007	560	0 (0.3)	130	0.2
Aircraft crash (SWOC EE-2)	0.28	0.0002	1,300	1 (0.8)	300	0.4
Earthmover shears tops off six ILAW containers (ILAW1)	3.4×10^{-6}	2×10^{-9}	0.016	0 (9×10^{-6})	0.0036	2×10^{-6}
Crushing of ILAW containers by falling crane boom (ILAW2)	0.000031	2×10^{-8}	0.14	0 (0.00008)	0.033	0.00002

[a] The doses presented here result from accident releases of radioactive materials to the atmosphere and are from direct exposure to the plume and inhalation only. Doses from other pathways, such as consumption of foodstuffs and exposure to radioactive material deposited on the ground, are small by comparison.

[b] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

[c] The alphanumeric code following the accident's title (e.g., SWOC FIR-1) corresponds with the code in the accident's description in Section K.3.6.

[d] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[e] Increased likelihood of an LCF for an individual, assuming the accident occurs.

[f] The reported value is the projected number of LCFs in the population, assuming the accident occurs, and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

Key: ILAW=immobilized low-activity waste; LCF=latent cancer fatality.

Table K–101. Waste Management Alternatives 2 and 3 – Annual Cancer Risks from Accidents

		Risk of LCF		
Accident[a, b]	**Frequency**	**Maximally Exposed Individual[c]**	**Offsite Population[d, e]**	**Noninvolved Worker[c]**
Single-drum deflagration (SWOC FIR-1)	0.01	5×10^{-9}	0 (0.00002)	5×10^{-6}
Medium fire inside facility (SWOC FIR-6)	0.01	9×10^{-8}	0 (0.0004)	0.00009
Glovebox or greenhouse fire (SWOC FIR-8)	0.01	2×10^{-7}	0 (0.0008)	0.0004
Large fire of waste containers outside facility (SWOC FIR-4)	0.01	2×10^{-6}	0 (0.007)	0.003
Handling spill of single waste container (SWOC SP-2)	0.01	9×10^{-10}	0 (4×10^{-6})	9×10^{-7}
Large handling spill of boxes or multiple waste containers (SWOC SP-3A)	0.01	4×10^{-9}	0 (0.00002)	5×10^{-6}
Spill of single large-diameter container (SWOC SP-4)	0.01	4×10^{-8}	0 (0.0002)	0.00004
Design-basis seismic event (SWOC NPH-1)	0.001	4×10^{-9}	0 (0.00002)	4×10^{-6}
Beyond-design-basis accident (SWOC NPH-2)	0.001	2×10^{-8}	0 (0.00007)	0.00003
Range fire (SWOC EE-1)	0.01	7×10^{-7}	0 (0.003)	0.002
Aircraft crash (SWOC EE-2)	0.00003	5×10^{-9}	0 (0.00002)	0.00001
Earthmover shears tops off six ILAW containers (ILAW1)	0.1	2×10^{-10}	0 (9×10^{-7})	2×10^{-7}
Crushing of ILAW containers by falling crane boom (ILAW2)	0.1	2×10^{-9}	0 (8×10^{-6})	2×10^{-6}

[a] The alphanumeric code following the accident's title (e.g., SWOC FIR-1) corresponds with the code in the accident's description in Section K.3.6.

[b] The accidents listed were analyzed because they had the highest consequences and/or risks in their category (e.g., leak, spill, mechanical impact, natural phenomena). In some instances, more than one accident is in a category to include similar accidents at different facilities. For some categories (e.g., criticality, flooding), no accidents are listed because either none are applicable or the risks of accidents in the categories are very low.

[c] Increased risk to the individual of an LCF, taking into account the probability (frequency) of the accident.

[d] The reported value is the projected number of LCFs in the population, based on the accident probability (frequency), and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per person-rem) is shown in parentheses.

[e] Based on populations of 451,556 and 488,897 persons residing within 80 kilometers (50 miles) of the 200-East and 200-West Areas, respectively.

Key: ILAW=immobilized low-activity waste; LCF=latent cancer fatality.

K.3.8 Secondary Impacts of Accidents

As previously described in this appendix, technological emergencies or terrorist attacks involving release of radionuclides could produce airborne plumes and cause inhalation impacts on workers and the public. Secondary impacts on human health and other resource areas (e.g., land use, ecology) could also result from the deposition of radioactive material on the ground. The magnitude of any secondary impacts depends on the characteristics of the release, the meteorological conditions at the time of the event, and the type of land area affected. In general, the concentration of radioactive material deposited on the ground will decrease with increasing distance from the point of release. Low windspeeds will usually result in more deposition near the release point and less deposition at greater distances, whereas higher windspeeds may increase the distance at which ground concentration exceeds levels of concern. The occurrence of rain or snow at the time of the release may accelerate deposition and cause higher concentrations in areas where precipitation has fallen. The radiation dose and associated human health impacts on workers and the public resulting from resuspension (inhalation exposure), ingestion, or ground shine (direct exposure) would not significantly add to the impacts from exposure to the passing plume. However, deposition of radionuclides may also have impacts on land use, socioeconomics, environmental justice, ecology, and other environmental resource areas.

After the initial phase of response to an emergency, EPA may lead efforts to protect human health and the environment from adverse impacts. Working with various stakeholders, EPA may provide technical advice and response support to state, tribal, and local governments; the site or facility owner/operator; and Federal agencies. EPA also has the authority to order private-party cleanup and to oversee and monitor emergency response by others (EPA 2000b). EPA has concluded that soil concentration levels (i.e., deposition) on the order of 0.1 to 1 microcuries per square meter "represent a proper level for concern and initiation of protective actions and temporary access restrictions. A realistic assessment would be expected to lead to less restrictive conclusions" (Burley 1990). Actions and restrictions may take the form of interdiction of agricultural products and limitations on commercial and residential activities, which could in turn affect employment. Cleanup of contaminated areas or property use restrictions may involve substantial monetary cost and loss of beneficial use of property for commercial, residential, agricultural, recreational, institutional, or other purposes. Impacts on water, biological, ecological, and cultural resources are also possible in areas with contamination in excess of the EPA level of 0.1 microcuries per square meter.

A full quantitative assessment of secondary impacts would involve characterizing the amount and current use of onsite and offsite land affected by each accident, as well as the cost of any use restrictions, mitigation efforts, and cleanup. The magnitude of secondary impacts would, in general, be proportional to the amount of radioactive material released and to the direct human health impacts reported in detail in this appendix. A full quantitative analysis of secondary impacts therefore was not performed for this *TC & WM EIS*. Instead, the distances at which the EPA contamination limits would be exceeded are reported as a semi-quantitative expression of the secondary impacts of representative tank closure, FFTF decommissioning, and waste management accidents.

K.3.8.1 Secondary Impacts of Tank Closure Accidents

Severe accidents, such as the seismically induced WTP collapse and failure (WT41), could produce large secondary impacts because of the large release. However, the frequency of this accident is low (1 chance in 2,000 years); therefore, the risk of secondary impacts would be low. In addition, a seismic event could cause simultaneous releases from other Hanford facilities and additional injuries and fatalities that are not associated with exposure to radioactivity. For these reasons, severe accidents are not good examples for estimating secondary impacts.

An accident associated with operations is the spray release from a jumper pit during waste retrieval (TK51). This accident has a higher frequency of occurrence (about 1 chance in 100 years) than a severe accident and serves as a good example for estimating secondary impacts. The analysis of this accident indicates that the 0.1-microcurie-per-square-meter limit would be exceeded out to a distance of 12.9 kilometers (8 miles), while the 1.0-microcurie-per-square-meter limit would be exceeded out to a distance of 3.2 kilometers (2 miles) from the release location. The specific area affected would depend upon the wind direction at the time, duration of the release, and deposition velocity. For this analysis, a 1-hour release and a 0.01-meter-per-second deposition velocity were assumed for all relevant radionuclides. Longer release durations and/or slower deposition velocities would produce larger affected areas. At Hanford, the prevailing wind direction is from the northwest to the southeast. If this accident were to occur at a time of the prevailing wind direction, the secondary impacts and post-accident cleanup would occur in areas within the site boundary. In the event that the wind direction at the time of the accident were from the east to the west, it would be possible for the 0.1-microcurie-per-square-meter limit to be exceeded a short distance off site, depending on wind and deposition velocities.

Based on information in safety documentation for the WTP, postulated accidents with a higher frequency of occurrence would have smaller releases; therefore, their secondary impacts would likely be within the Hanford boundary. In the event of a lower-frequency/higher-consequence accident, the limits could be exceeded off site, but the risk of secondary impacts would be low.

K.3.8.2 Secondary Impacts of Fast Flux Test Facility Accidents

An RH-SC fire (RHSC1) has an estimated frequency of occurring about once in 100 years and would produce the largest release of radioactive material of all the analyzed FFTF accident scenarios. The analysis of this accident indicates that the 0.1-microcurie-per-square-meter limit would be exceeded out to a distance of 38.2 kilometers (23.7 miles), while the 1.0-microcurie-per-square-meter limit would be exceeded out to a distance of 0.35 kilometers (0.22 miles) from the release location. The specific area affected would depend upon the wind direction at the time, duration of the release, and deposition velocity. For this analysis, an 8-hour release and a 0.01-meter-per-second deposition velocity were assumed for all relevant radionuclides. Longer release durations and/or slower deposition velocities would produce larger affected areas. Regardless of the wind direction at the time of this accident, the secondary impacts and post-accident cleanup would likely extend to areas outside the Hanford boundary. However, the most heavily impacted areas (with deposition greater than the 1.0-microcurie-per-square-meter limit) would be entirely within the site boundary. The SSF fire (SSF1) would result in the 0.1-microcurie-per-square-meter limit being exceeded out to a distance of 22.2 kilometers (13.8 miles), while the 1.0-microcurie-per-square-meter limit would be exceeded out to a distance of 1.75 kilometers (1.1 miles) from the release location. However, the estimated frequency of SSF1 is much lower than that of RHSC1 (about 1 in 1 million years for SSF1 versus 1 in 100 years for RHSC1).

K.3.8.3 Secondary Impacts of Waste Management Accidents

A large fire of waste containers outside a facility (SWOC FIR-4) at the 200-West Area SWOC has an estimated frequency of occurring about once in 100 years; this fire would cause the 0.1-microcurie-per-square-meter limit to be exceeded out to a distance of 12 kilometers (7.5 miles) from the point of release, while the 1.0-microcurie-per-square-meter limit would be exceeded out to a distance of 0.1 kilometers (0.06 miles) from the release location. The specific area affected would depend upon the wind direction at the time, duration of the release, and deposition velocity. For this analysis, a 1-hour release and a 0.01-meter-per-second deposition velocity were assumed for all relevant radionuclides. Longer release durations and/or slower deposition velocities would produce larger affected areas. Depending on the wind direction at the time of this accident, the secondary impacts and post-accident cleanup might extend a few kilometers beyond the Hanford boundary. However, the most heavily impacted areas (with deposition greater than the 1.0-microcurie-per-square-meter limit) would be entirely within the site boundary. The aircraft crash at SWOC with ensuing fire (SWOC EE-2) would result in the 0.1-microcurie-per-square-meter limit being exceeded at a distance of 14.5 kilometers (9.0 miles). However, the estimated frequency of SWOC EE-2 is much lower than that of SWOC FIR-4 (about 3 in 100,000 years for SWOC EE-2 versus 1 in 100 years for SWOC FIR-4).

K.3.9 Chemical Impacts of Accidents

The evaluation of chemical impacts of potential accidents at Hanford considers the accidental release of two kinds of chemicals or toxic materials: (1) those chemicals used in the treatment process or supporting operations and (2) potentially toxic materials that are constituents of the treated waste.

K.3.9.1 Chemical Impacts of Tank Closure Accidents

A project report issued in September 2002, *Determination of Extremely Hazardous Substances* (Lindquist 2006b), documents the process by which chemicals used in the WTP were evaluated to determine which would be treated as "extremely hazardous substances." This identification plays a part in the regulatory process that will be applied to the WTP management of chemical safety.

Chemicals stored in substantial quantities and used for the vitrification process or supporting operations were addressed in determining which WTP chemicals might be considered extremely hazardous substances, whereas quantities of chemicals contained within the process streams or chemicals created as byproducts of the process were not considered. The evaluation resulted in two chemicals (anhydrous ammonia and 12.2 molar nitric acid) being declared "extremely hazardous substances" (Lindquist 2006b). Table K–102 presents a summary of chemicals that would be used at the WTP and their approximate quantities and locations.

Table K–102. Summary of Chemicals at the Waste Treatment Plant Complex

Chemical Name	Formula	Concentration	Quantity[a, b]			
			Pretreatment Facility	Balance of Facilities at WTP Complex	LAW Vitrification Facility	HLW Vitrification Facility
Alkyl epoxy carboxylate	Proprietary	N/A[c]	–	550 gal	–	–
Aluminum silicate	$A1_2SiO_5$	100%	–	2,175 ft^3	–	–
Ammonia, anhydrous	NH_3	100%	–	12,000 gal	–	–
Antifoam 1520	(Emulsion)	N/A[c]	1,500 gal		–	–
Argon	Ar	100%	–	–	120 ft^3	5,372 ft^3 at 2,400 psig
Borax	$Na_2B_4O_7{\cdot}10H_2O$	100%	–	2,150 ft^3	–	–
Boric acid	H_3BO_3	100%	–	3,000 ft^3	–	–
Calcium silicate	$CaSiO_3$	100%	–	3,000 ft^3	–	–
Carbon (activated)	C	70 wt%	–	–	446 ft^3	1,320 ft^3
Carbon dioxide	CO_2	100%	–	–	28 tons	–
Cerium nitrate	$Ce(NO_3)_3{\cdot}H_2O$	0.5 M	–	–	–	550 gal
Ferric oxide	Fe_2O_3	100%	–	1,000 ft^3	–	–
Hydrogen peroxide	H_2O_2	30%	–	–	–	5 gal
Ion exchange resins	SuperLig®[644]	100%	1,200 gal	–	–	–
Lithium carbonate	Li_2CO_3	100%	–	2,500 ft^3	–	–
Magnesium silicate	$MgSiO_3$	100%	–	1,000 ft^3	–	–
Nitric acid	HNO_3	12.2 M	–	21,000 gal	–	–
Nitric acid	HNO_3	5 M	–	1,800 gal	–	–
Nitric acid	HNO_3	2 M	–	2,900 gal	–	1,300 gal
Nitric acid	HNO_3	0.5 M	14,000 gal	–	–	1,500 gal
Nitrogen	N_2	100%	2,688 ft^3 at 2,100 psig	–	–	–
Silica	SiO_2	100%	–	8,500 ft^3	–	–
Silver mordenite	AgZ	18 wt%	–	–	–	414 ft^3
Sodium bromide	NaBr	40%	–	400 gal	–	–
Sodium carbonate	Na_2CO_3	100%	–	1,500 ft^3	–	–
Sodium hydroxide	NaOH	19 M	–	21,000 gal	–	–
Sodium hydroxide	NaOH	5 M	–	3,900 gal	5,100 gal	1,400 gal
Sodium hydroxide	NaOH	2 M	–	2,700 gal	–	–

Table–102. Summary of Chemicals at the Waste Treatment Plant Complex *(continued)*

Chemical Name	Formula	Concentration	Quantity[a, b]			
			Pretreatment Facility	Balance of Facilities at WTP Complex	LAW Vitrification Facility	HLW Vitrification Facility
Sodium hydroxide	$NaOH$	0.25 M	–	1,200 gal	–	–
Sodium hydroxide	$NaOH$	0.1 M	3,042 gal	–	–	–
Sodium hypochlorite	$NaOCl$	12%	–	1,100 gal	–	–
Sodium permanganate	$NaMnO_4$	40 wt%	–	2,000 gal	–	–
Strontium nitrate	$Sr(NO_3)_2$	40 wt%	–	4,000 gal	–	–
Sucrose	$C_{12}H_{22}O_{11}$	100%	–	1,800 ft^3	–	–
Titanium dioxide	TiO_2	100%	–	1,000 ft^3	–	–
Zinc oxide	ZnO	100%	–	2,500 ft^3	–	–
Zirconium silicate	$ZrSiO_4$	100%	–	1,000 ft^3	–	–

[a] Quantities are approximate and based on current design estimates. A dash (–) indicates that significant quantities of the chemical would not be present in the indicated portion of the WTP (Lindquist 2006b).
[b] Mixtures of glass formers exist in LAW and HLW, but are not listed.
[c] The named product is a proprietary compound or mixture.
Note: To convert gallons to liters, multiply by 3.7854; cubic feet to cubic meters, by 0.028317.
Key: %=percent; ft^3=cubic feet; gal=gallon; HLW=high-level radioactive waste; LAW=low-activity waste; M=molar (moles per liter); N/A=not applicable; psig=pounds per square inch gauge; wt%=weight-percent; WTP=Waste Treatment Plant.
Source: Lindquist 2006b.

K.3.9.1.1 Ammonia

Anhydrous ammonia is a gas stored as a liquid under pressure; its normal boiling point at 1 standard atmosphere unit of pressure is –33 °C (–28 °F). Therefore, under most conditions, it rapidly returns to its gaseous state upon release to the environment. Inhalation may cause irritation (possibly severe), lack of sense of smell, nausea, vomiting, chest pain, difficulty breathing, headache, and lung damage; inhalation may be fatal. Skin contact may cause irritation (possibly severe), blisters, and frostbite. Eye contact may cause irritation (possibly severe), frostbite, tearing, blindness, and glaucoma. Ingestion may cause irritation (possibly severe), difficulty breathing, and kidney damage.

Ammonia is a negligible fire hazard and a moderate explosion hazard. Containers could rupture or explode if exposed to heat.

It is incompatible with acids, combustible materials, metals, oxidizing materials, metal salts, halo carbons, amines, reducing agents, cyanides, and bases. When used at the HLW Vitrification Facility within the WTP, it may react with boric acid, cerium nitrate, hydrogen peroxide, lithium carbonate, nitric acid, or sucrose to produce heat. The reaction with hydrogen peroxide may also liberate toxic gas, and the reaction with cerium nitrate may liberate flammable gas. However, because anhydrous ammonia is a gas stored as a liquid under pressure, it returns to the gaseous state upon release at ambient pressure. All of the HLW chemicals that might cause a reaction are in the form of either solids as powders or liquids. As a result, there is very limited potential for these materials to mix and produce a reaction, and potential reactions would be limited by the surface area available for contact.

A catastrophic failure of the 45,400-liter (12,000-gallon) storage tank (with an operating capacity of approximately 43,500 liters [11,500 gallons]) containing anhydrous ammonia could rapidly release its entire contents as ammonia gas (Lindquist 2006b). The gas was assumed to be released directly to the atmosphere over a period of 30 minutes. This assumption does not credit the mitigative effects of the control equipment or the building that houses the storage tanks, which would limit the amount of ammonia released to the atmosphere.

K.3.9.1.2 Nitric Acid

In its concentrated form, nitric acid is an acute inhalation hazard. It is not combustible, but it is a strong oxidizer, and the heat produced by its reaction with reducing agents or combustibles may cause irritation. It can react with metals to release nitrogen oxides and flammable hydrogen gas. It may react explosively with combustible organic or readily oxidizable materials.

Nitric acid is present in various concentrations in the Pretreatment Facility, Wet Chemical Storage Facility, and HLW Vitrification Facility. At the Wet Chemical Storage Facility, nitric acid in any concentration could react with any concentration of sodium hydroxide to produce heat. The reaction between the highest concentrations of nitric acid and highest concentrations of sodium hydroxide could generate extreme heat, resulting in fire. In the HLW Vitrification Facility, nitric acid could react with ammonia, boric acid, cerium nitrate, hydrogen peroxide, lithium carbonate, sodium hydroxide, or sucrose to generate heat. Reactions between concentrated nitric acid and lithium carbonate or sucrose could generate heat and flammable gas, igniting byproducts of the reaction and causing a fire. During pretreatment, weak concentrations of nitric acid (0.5 molar) and sodium hydroxide (0.1 molar) could react to create heat. The reaction between ion exchange resins and weak nitric acid is part of the process to remove captured cesium; however, reaction of the resin with concentrated nitric acid (greater than 10 molar) is vigorous and exothermic and releases large quantities of carbon monoxide gas.

The consequences of a spill release involving 12.2 molar nitric acid from the storage tank at the balance of facilities at the WTP complex has been investigated (Graves 2003) and is considered representative of a severe accident involving this material. The consequences of chemical spills in the balance of facilities would be less than those of a spill of the entire contents of the 79,500-liter (21,000-gallon) 12.2 molar nitric acid storage vessel (with an operating capacity of approximately 64,400 liters [~17,000 gallons]). This vessel is surrounded by a berm that is designed to contain at least 100 percent of the largest volume of the largest tank within it. A number of different mechanisms that could result in the total or partial loss of contents of this storage vessel have been identified. As the storage area is covered but open on all sides, the vapor would be released directly to the atmosphere. Parameters used in developing inputs for the dispersion code are shown in Table K–103.

Table K–103. Balance-of-Facilities Nitric Acid Spill Dispersion Modeling Parameters

Item	Value
Operating volume	64,400 liters (17,000 gallons)
Maximum capacity	79,500 liters (21,000 gallons)
Area of berm	160 square meters (23 feet × 75 feet = 1,725 square feet)
Nitric acid storage temperature	20 °C (68 °F)
Diameter of storage tank	3.7 meters (12 feet)
Molecular weight of nitric acid	63.01 grams per mole
Density of 12.2 molar nitric acid at 20 °C (68 °F)	1,350.5 grams per liter (84 pounds per cubic foot) (Perry and Green 1984)
Concentration (weight-percent) of 12.2 molar nitric acid	57 percent
Vapor pressure at 35 °C (95 °F)	1.69 millimeters (0.07 inches) of mercury (Perry and Green 1984)

Key: °C=degrees Celsius; °F=degrees Fahrenheit.

The temperature of the spilled pool was assumed to be 35 °C (95 °F). This temperature corresponds to a hot summer day and yields a conservative value for vapor pressure. The surface area of the spill is equal to the area of the berm minus the area of the storage tank:

$$A_{spill} = 1{,}725 \text{ square feet} - [(12 \text{ feet}/2)^2 (3.14)] = 1{,}610 \text{ square feet (150 square meters)}.$$

K.3.9.1.3 Direct Human Health Impacts

Two chemicals, nitric acid and ammonia, were selected to represent all chemicals and would have the largest expected impacts due to accident releases. The selection of these two chemicals was based on the large quantities that are potentially available for release and their chemical properties and health effects. For both chemicals, an accident scenario was postulated in which a break in a tank or piping occurs, allowing the chemical to be released over a short period. The cause of the break could be mechanical failure, corrosion, mechanical impact, or natural phenomena. The frequency of the accident is in the range of 0.001 to 0.01 per year. Nitric acid would form a pool within a berm surrounding the tank and, by evaporation, be released as a plume that disperses into the environment. Ammonia would be released from its storage tank in a gaseous form. The chemical plume would move away from its point of release in a prevailing wind direction and could potentially impact workers and the public.

Table K–104 shows the estimated concentrations of each chemical at specified distances for comparison with the 60-minute AEGL-2 and -3 (EPA 2009). The levels of concern for ammonia are 160 ppm for AEGL-2 and 1,100 ppm for AEGL-3. The levels of concern for nitric acid are 24 ppm for AEGL-2 and 92 ppm for AEGL-3. The results indicate that AEGL-2 and AEGL-3 thresholds would not be exceeded beyond the nearest site boundary. For the noninvolved worker 100 meters (110 yards) from the accident, both the AEGL-2 and AEGL-3 thresholds would be exceeded for the ammonia release, but not for the nitric acid release.

Table K–104. Tank Closure Accidents – Chemical Impacts

Chemical	Quantity Released (gallons)	AEGL-2[a]		AEGL-3[b]		Concentration (ppm)	
		Limit (ppm)	Distance to Limit (meters)	Limit (ppm)	Distance to Limit (meters)	Noninvolved Worker at 100 meters	Nearest Site Boundary at 8,600 meters
Ammonia	11,500	160	2,450	1,100	730	41,000	27.0
Nitric acid	17,000	24	<30	92	<30	4.7	0.004

[a] AEGL-2 (60-minute) is the airborne concentration (expressed as ppm or milligrams per cubic meter) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape (EPA 2009).

[b] AEGL-3 (60-minute) is the airborne concentration (expressed as ppm or milligrams per cubic meter) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death (EPA 2009).

Note: To convert gallons to liters, multiply by 3.7854; meters to yards, by 1.0936.

Key: AEGL=Acute Exposure Guideline Levels; ppm=parts per million.

K.3.9.1.4 Secondary Impacts

Ammonia releases are fairly common events. Each year, about 40 releases resulting in injuries or evacuation occur in the state of Washington alone (WSDOH 2008). Ammonia is a gas at normal ambient temperatures that disperses into the atmosphere following its release. If a large release occurs, the gas may burn the leaves of nearby downwind vegetation but will not affect the roots, so damaged plants may fully recover. If ammonia were directly spilled into surface water or if water used by a fire department to suppress an ammonia vapor cloud were allowed to reach surface water, aquatic life could be harmed. After a release of ammonia, the vapors react with moisture in the air to form ammonium, which eventually returns to Earth in rainfall. Deposition of ammonium may be heavy near the location of release if it rains during or shortly after the release, before the plume has dispersed. Ammonium rarely accumulates in soil because whatever is not taken up by plant roots is rapidly converted by bacteria into nitrates. Nitrates in the soil are taken up by plants or leach vertically through the root zone (MDOA 2008).

The only secondary impacts expected from a large ammonia release at Hanford would be possible temporary damage to green vegetation in the plume path, followed by enhanced growth of all plants in the same area as a result of the infusion of nitrates into the typically nitrogen-poor desert soils. Because essentially all of the annual precipitation that falls on the site is taken up by plant roots or evaporates directly from the soil, leaching of nitrates through the vadose zone to the water table is not expected to present a discernable environmental impact.

Nitric acid released to the atmosphere as a gas is removed by deposition processes. The estimated half-life for dry deposition of nitric acid is 1.5 to 2 days, and it is efficiently scrubbed from the atmosphere by precipitation. Nitric acid reacts with gaseous ammonia in the atmosphere to form particulate or aerosol nitrate, which in turn is removed by wet and dry deposition of the particles. The average half-life and lifetime for particles in the atmosphere is about 3.5 to 10 days (DEWHA 2005). During the timeframe suggested by these removal rates, a nitric acid plume from the analyzed WTP release is expected to disperse widely over the region rather than be concentrated on or near the release site. The effect of nitrates produced and subsequently deposited on the soil would be the same as described previously for those derived from an ammonia release.

Concentrated acidic rainfall during or shortly after a nitric acid release (before the plume disperses) might harm vegetation and crops in areas near the site. However, effects lasting more than a single growing season are not expected because the surface soils of the Columbia Basin typically range from neutral to quite alkaline (with pH values of 7 or higher) and contain significant amounts of carbonates. They therefore have the capacity to neutralize acids without significant changes in soil pH. In fact, farmers and gardeners in the region frequently apply elemental sulfur and fertilizers containing iron sulfate, ammonium sulfate, or aluminum sulfate specifically to reduce soil pH to a more-favorable range for crops (WSU 2004).

K.3.9.2 Chemical Impacts of Fast Flux Test Facility Accidents

During FFTF decommissioning activities, the only chemical capable of creating a significant airborne hazard resulting from an accidental release is the sodium formerly used as a reactor coolant. Three inventories of bulk sodium are addressed under the FFTF Decommissioning alternatives covered by this EIS. These inventories include the FFTF bulk sodium stored in the SSF, the Hallam Reactor sodium stored in the 2727-W Building, and the SRE sodium stored in the South Alkali Metal Storage Modules in the 200-West Area. Under the FFTF Decommissioning alternatives proposed and analyzed in this EIS, these inventories would be either stored for the foreseeable future or processed at INL or Hanford into a 50 weight-percent solution of sodium hydroxide for use at Hanford.

Bulk sodium in its solid or molten form does not represent a significant airborne hazard. However, metallic sodium reacts violently with a broad range of materials, including water. On contact with water, it will ignite and produce hydrogen. Metallic sodium is highly flammable and may ignite spontaneously on exposure to moisture in the air. If sodium is burned in air, the resulting combustion byproducts are mostly sodium oxide, with a small percentage of sodium carbonate and a very small percentage of sodium hydroxide. Because of the ability of sodium oxide to react with water in the air (or in the human respiratory tract) to form sodium hydroxide, all of the sodium released from a fire was assumed to come off as sodium hydroxide; 1 gram (0.35 ounces) of sodium would produce 1.74 grams (0.61 ounces) of sodium hydroxide (Himes 1996).

An accidental spill and evaporative release of the 50 weight-percent sodium hydroxide produced under the Hanford and Idaho Reuse Options of FFTF Decommissioning Alternatives 2 and 3 would not represent an airborne hazard. As evaporation occurred, the water in solution would escape, leaving an even more-concentrated solution of sodium hydroxide behind. Eventually, the sodium hydroxide would dry out to the point that it formed crystalline sodium hydroxide. Sodium hydroxide would also be produced during component cleaning and residual sodium residuals treatment. This waste material would be pumped from the point of generation to collection, storage, or treatment tanks for processing. A spray release could occur during pumping operations, which would create an airborne release. However, the pumping operation would have to occur at pressures of 100 pounds per square inch or more to generate aerosols that are an inhalation concern. It is not anticipated that pressures of 100 pounds per square inch or more will be used in any of the operations planned under any of the FFTF Decommissioning alternatives.

Because the sodium metal is contaminated with radioactive material, any airborne release caused by a fire would cause radiological as well as chemical impacts. For each sodium fire scenario analyzed as part of the radiological impacts of facility accidents, there is also a chemical impact. Therefore, the accident scenarios analyzed in this section of this appendix are the same as those analyzed in Section K.3.5.

As with the analysis of radiological impacts due to accidents, analysis of chemical impacts due to accidents was based on unmitigated releases, meaning that no credit was taken for HEPA filtration, structural confinement, or other engineered features that may limit the amount of the chemical released to the environment. Although a fire normally implies some degree of thermal lofting, which would reduce ground-level air concentrations, the intensity of the fire, and therefore the degree of the lofting, cannot be predicted. For this reason, fire scenarios were conservatively assumed to be ground-level sources for purposes of estimating direct receptor exposures. Results of sodium fire studies indicate that rapid agglomeration and fallout of the combustion particles occur in the first 50 to 100 meters (55 to 110 yards) of transport (Himes 1996). This process would greatly reduce the downwind air concentrations; however, because of the difficulty in quantifying this effect, it was not included as a factor in the release model. Because of the conservative assumptions discussed above, air concentration results near the source may exceed 100 milligrams per cubic meter, commonly thought to be the highest particulate concentration that can be supported in the air at a point away from the source (Himes 1996).

The alphanumeric code following the accident's title (e.g., SSF1) corresponds with the code in the accident's description in the tables of this section and in Chapter 4, Section 4.2.11; it is provided to facilitate cross-referencing between tables and accident descriptions.

K.3.9.2.1 Accidents in the Hanford 400 Area

K.3.9.2.1.1 Sodium Storage Facility Fire (SSF1)

This accident scenario involves a postulated aircraft crash into the FFTF SSF, breaching all four sodium storage tanks and igniting the sodium metal within them. This accident would result in a release rate of approximately 8,730 kilograms per hour (19,200 pounds per hour). Assuming an ARF of 0.35 and a yield of 1.74 grams of sodium hydroxide per gram of sodium burned (Himes 1996), the resulting production rate of airborne sodium hydroxide particulate would be 8,700 kilograms per hour (19,200 pounds per hour) × 0.35 × 1.74 = 5,320 kilograms per hour (11,700 pounds per hour).

A complete description of this scenario can be found in Section K.3.5.1.1.

K.3.9.2.1.2 Hanford Sodium Storage Tank Failure (HSTF1)

This accident was postulated to result from a large leak due to growth of a metal defect in one SSF storage tank. The tank was assumed to be initially filled with molten sodium and the entire inventory of the tank was assumed to discharge onto the steel floor of the secondary containment and burn. Exposure to the burning pool of sodium was assumed to breach the other three tanks, causing the sodium to leak into the burning pool. The resulting burn rate was estimated to be 22,600 kilograms per hour (49,800 pounds per hour), and the fire duration was estimated to be approximately 42 hours. Using an ARF of 0.35 and a yield of 1.74 grams of sodium hydroxide per gram of sodium burned (Himes 1996), the resulting production rate of airborne sodium hydroxide particulate would be 22,600 kilograms per hour (49,800 pounds per hour) × 0.35 × 1.74 = 13,700 kilograms per hour (30,000 pounds per hour).

A complete description of this scenario can be found in Section K.3.5.1.2.

K.3.9.2.1.3 Remote-Handled Special Component Fire (RHSC1)

This scenario represents possible accidents involving removal and transport of the FFTF RH-SCs that would have the largest impacts. A handling mishap was postulated to cause a breach of the largest component (the primary cold trap) and exposure of the contained sodium to water and air. As a result, a portion (30 percent) of the sodium, 750 kilograms (1,650 pounds), would burn. Assuming that the diameter of the primary cold trap is approximately 1.53 meters (5 feet), the surface area of the burning sodium would be approximately 1.84 square meters (19.64 square feet). Using the standard burn rate for an open pool of sodium on a steel liner, 10.8 grams per square meter per second (8 pounds per square foot per hour) (Himes 1996), the burn rate was estimated to be 71.5 kilograms per hour (157 pounds per hour), and the fire duration was estimated to be approximately 36 hours. Using the sodium burn release parameters previously listed, the resulting production rate of airborne sodium hydroxide particulate would be 71.5 kilograms per hour (157 pounds per hour) × 0.35 × 1.74 = 43.5 kilograms per hour (96 pounds per hour). The release rate for this event is less than 1 percent of that for the Hanford sodium storage tank failure. Because the consequences of a chemical release are directly proportional to the release rate, the consequences of this release would be a very small fraction of those from either the Hanford sodium storage tank failure or the SSF fire discussed above. As impacts of this event would be less than those of the preceding events, it was not analyzed further.

A complete description of this scenario can be found in Section K.3.5.1.3.

K.3.9.2.2 Accidents in the Hanford 200-West Area

K.3.9.2.2.1 Hallam Reactor Sodium Fire (HSF1)

Sodium formerly used as coolant in the Hallam Reactor is stored as a solid in five tanks in the 2727-W Building in the Hanford 200-West Area. Two tanks are full, one is half-full, and the remaining two contain only residual heels. In this scenario, the building and a tank would be breached, allowing water to enter a tank, causing a fire to start. The entire contents of the full tank, 59,600 kilograms (131,000 pounds) of sodium, would burn and be released at ground level over a period of 67 hours. The postulated maximum release rate corresponds to a sodium pool fire with a size equal to the area of the internal tank dimensions, i.e., a 3.66 meter-diameter by 6.10-meter effective length (12-foot diameter by 20-foot length), equivalent to 22.3 square meters (240 square feet). Using the sodium burn release parameters previously listed (Himes 1996), the resulting production rate of airborne sodium hydroxide particulate would be 22.3 square meters × 38.88 kilograms per square meter per hour (240 square feet × 8 pounds per square foot per hour) × 0.35 × 1.74 = 531 kilograms per hour (1,170 pounds per hour).

A complete description of this scenario can be found in Section K.3.5.2.1.

K.3.9.2.2.2 Sodium Reactor Experiment Sodium Fire (SRE1)

Sodium formerly used as coolant in the SRE is stored as a solid in drums in the South Alkali Metal Storage Modules near the 200-West Area CWC. In this scenario, a vehicle would impact a single storage module, causing a fire, which would involve 20 drums consisting of a total of 3,360 kilograms (7,410 pounds) of sodium. The burning area was estimated to be equivalent to the 5.9-square-meter (63-square-foot) footprint of the single storage module. Using the sodium burn release parameters previously listed (Himes 1996), the resulting production rate of airborne sodium hydroxide particulate would be 5.9 square meters × 38.88 kilograms per square meter per hour (63.5 square feet × 8 pounds per square foot per hour) × 0.35 × 1.75 = 141 kilograms per hour (311 pounds per hour).

A complete description of this scenario can be found in Section K.3.5.2.2.

K.3.9.2.3 Accidents at Idaho National Laboratory

K.3.9.2.3.1 INL Sodium Processing Facility Storage Tank Failure (INLSPF1)

The accident with the largest impacts from disposition of bulk sodium at the INL SPF would be a failure of the secondary sodium drain tank located in the EBR-II secondary sodium boiler building with an accompanying fire. Failure of the tank would result in a spill of its working capacity of molten sodium. The burn rate of the resulting fire was estimated to be 2,250 kilograms per hour (5,000 pounds per hour). Using the sodium burn release parameters previously listed (Himes 1996), the resulting production rate of airborne sodium hydroxide particulate would be 2,250 kilograms per hour (5,000 pounds per hour) × 0.35 × 1.75 = 1,380 kilograms per hour (3,020 pounds per hour).

A complete description of this scenario can be found in Section K.3.5.3.1.

K.3.9.2.4 Direct Human Health Impacts

A sodium fire produces a heavy, opaque, white plume. Contact with the plume in high concentrations near the source of release is immediately irritating and can cause burns to the upper respiratory tract, exposed skin, and surface of the eyes. The recognizable and characteristic heavy white plume, coupled with the immediate and severe health effects, create a self-evacuation effect for personnel in close proximity to a release.

Table K–105 shows the estimated concentrations of particulate sodium hydroxide for each accident scenario analyzed. As AEGL values have not been developed for sodium hydroxide, the American Industrial Hygiene Association ERPG levels 2 and 3 were compared to the concentrations at specific distances as an indicator of human health impacts. The guideline levels for sodium hydroxide are 5 milligrams per cubic meter for ERPG-2 and 50 milligrams per cubic meter for ERPG-3 (DOE 2008). The results indicate that, for the Hanford sodium storage tank failure scenario, the ERPG-2 value is slightly exceeded beyond the site boundary. For the remaining scenarios, the ERPG-2 and ERPG-3 thresholds would not be exceeded beyond the nearest site boundary. For the noninvolved worker 100 meters (110 yards) from an accident, both the ERPG-2 and ERPG-3 thresholds would be exceeded for all scenarios analyzed.

Table K–105. Fast Flux Test Facility Accidents – Chemical Impacts

Scenario	Distance to Site Boundary (meters)	Release Rate (kg/hr)	ERPG-2[a]		ERPG-3[b]		Concentration (mg/m^3)	
			Limit (mg/m^3)	Distance to Limit (meters)	Limit (mg/m^3)	Distance to Limit (meters)	Noninvolved Worker at 100 Meters	Site Boundary
Sodium Storage Facility fire (SSF1)	6,800	5,320	5	3,700	50	850	2,400	2.2
Hanford sodium storage tank failure (HSTF1)	6,800	13,800	5	7,350	50	1,520	6,200	5.6
Hallam Reactor sodium fire (HSF1)	4,300	531	5	855	50	233	240	0.41
Sodium Reactor Experiment sodium fire (SRE1)	3,500	141	5	395	50	113	63	0.14
INL Sodium Processing Facility storage tank failure (INLSPF1)	5,500	1,380	5	1,530	50	390	620	0.75

a ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

b ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

Note: To convert meters to yards, multiply by 1.0936; kilograms to pounds, by 2.2046.

Key: ERPG=Emergency Response Planning Guideline; Hanford=Hanford Site; INL=Idaho National Laboratory; kg/hr=kilograms per hour; mg/m^3=milligrams per cubic meter.

K.3.9.2.5 Secondary Impacts

Section K.3.8.2 presents the secondary radiological impacts of FFTF accidents. The SSF fire (SSF1) was estimated to produce ground deposition of radionuclides exceeding 1.0 microcurie per square meter to a distance of 1.75 kilometers (1.1 miles) and 0.1 microcuries per square meter to a distance of 22.2 kilometers (13.8 miles) from the release location. These ground contamination levels were calculated using the sum of all radionuclide concentrations in FFTF primary sodium (i.e., the sum 5.6×10^{-9} curies per gram of sodium-22, 4.8×10^{-11} curies per gram of cesium-137, and 5.2×10^{-8} curies per gram of tritium). Dividing the calculated ground contamination level by the total sodium activity concentration (5.8×10^{-8} curies per gram) indicates that the 0.1-microcurie-per-square-meter contamination level corresponds to deposition of 1.72 grams of sodium per square meter (3.0 grams of sodium hydroxide per square meter). The sodium hydroxide deposition corresponding to 1.0 microcurie per square meter is 10 times greater (30 grams per square meter).

In areas where high levels of dry deposition have occurred, airborne (resuspended) particles of sodium hydroxide could cause skin, eye, and respiratory system irritation and other acute toxic effects associated with inhalation of sodium hydroxide aerosol. These effects might necessitate evacuation or relocation of people from heavily contaminated areas. Sodium hydroxide is very soluble in water. Once dissolved, it would be transported into the soil, where it would be rapidly neutralized by organic chemicals (Salocks and Kaley 2003). Therefore, evacuation or relocation would likely be necessary only until a significant precipitation event occurs. Significant precipitation events on or near Hanford are infrequent during the typically dry period between late spring and mid-autumn, and the duration of an evacuation or relocation might be weeks or even months if the release were to occur during those seasons.

Heavy precipitation events that could produce strongly alkaline runoff into streams and rivers are infrequent in the vicinity of Hanford. However, a strongly alkaline solution that could be formed by the dissolution of sodium hydroxide in rain or irrigation water could harm the foliage or tender shoots of growing plants. Sodium hydroxide does not accumulate in the food chain (ATSDR 2002).

Significant long-term effects on soil fertility or productivity could occur in those areas where the deposition is heavy enough to cause a pronounced increase in soil pH. Most surface soils on and near Hanford are slightly to moderately alkaline (WSU 2008), and a large addition of sodium hydroxide might increase the pH to a level that causes essential minerals and nutrients to become less available to plants or the growth of beneficial microorganisms to be inhibited (SUNY ESF 2008). Soil texture and the ability of water and plant roots to penetrate it can also be negatively affected by excessive sodium. However, these effects can be remediated by addition of various fertilizers and soil amendments (Warrence, Bauder, and Pearson 2002).

K.3.9.3 Chemical Impacts of Waste Management Accidents

Hazardous waste at the SWOC exists in the contents of TRU waste containers and suspect TRU waste[2] containers and in sodium in storage modules at the CWC. The future disposition of the bulk sodium stored at the CWC is addressed in the FFTF Decommissioning alternatives. The consequences of accidents involving this inventory of hazardous material are addressed in Section K.3.9.2, "Chemical Impacts of Fast Flux Test Facility Accidents."

To estimate the potential impacts of an accidental release of the hazardous chemicals at SWOC, SWOC waste containers were evaluated using the methodologies of both the DOE safety analysis and emergency management programs to identify which hazardous chemicals should be subjected to quantitative analyses.

K.3.9.3.1 Safety Analysis Evaluation of Chemical Hazards

The DSASW (Fluor Hanford 2007) identifies a list of known hazardous chemical constituents that may be present in retrieved TRU waste and suspect TRU waste containers. The list was generated in 1992 by performing a survey of the *Solid Waste Information and Tracking System (SWITS)* database. The query identified nearly 400 chemicals known to exist in the containers present at SWOC through 1991. Because of the relative constancy of waste streams since the list was generated, it was assumed that the types and quantities of hazardous materials currently present in the SWOC containers are consistent with the types and quantities on the list (Fluor Hanford 2007). Using a set of criteria intended to identify hazardous materials that could potentially result in significant impacts on workers and the public, the list of 400 was condensed to a list of 24 hazardous materials. This condensed list is presented in Table K–106. The inventories of the materials on the condensed list were updated with the most current information and served as the starting point for the identification of materials requiring additional analysis in the DSASW. The DSASW notes that the material list and associated inventories are not intended to be inclusive of all hazardous chemicals that might be present in solid waste containers at SWOC, but the list is representative of the wide assortment of materials anticipated to be retrieved, handled, stored, and processed and results in a conservative estimate of impacts (Fluor Hanford 2007).

[2] Suspect TRU waste is radioactive waste that is thought to be TRU waste, but for which adequate characterization data are not yet available to confirm the classification.

Table K–106. Potential Hazardous Materials in Waste Feed Streams

Hazardous Material (CASRN)	Number of Containers with Amount Listed[a]	Maximum Amount in a Single Container (kilograms)	Median (kilograms)	Maximum Amount in a Single Location (kilograms)
Ammonia (7664-41-7)	5	2.61	0.45	2.94
Ammonium nitrate (6484-52-2)	3	32.5	7.4	32.5
Beryllium (7440-41-7)	118	7	1.814	7
Cadmium (7440-43-9)	157	93.54	0.0003	195.2
Cyclohexane (110-82-7)	4	18.1	2.22	18.1
Dioxane (123-91-1)	1	25.22	25.22	25.22
Hydrogen peroxide (7722-84-1)	4	0.50	0.10	1.85
Manganese (7439-96-5)	2	0.06	0.04	0.06
Mercury (7439-97-6)	184	31.8	0.041	661.5
Naphthylamine (91-59-8)	1	102.1	102.1	102.1
Nitric acid (7697-37-2)	149	130	0.02	411.6
Phosphoric acid (7664-38-2)	44	76.26	3.0	1,884.12
Propane (74-98-6)	1	3.35	0.90	5.9
Sodium (7440-23-5)	2	23.16	1.28	392.1
Sodium hydroxide (1310-73-2)	3,011	105.25	0.0004	3,247.3
Sodium hypochlorite (7681-52-9)	1	0.36	0.0075	0.36
Sodium oxide (12401-86-4)	16	48.26	48.26	724.4
Styrene (100-42-5)	6	15.46	0.556	15.46
Tetrahydrofuran (109-99-9)	6	2.98	0.0007	2.98
Uranium oxide (1344-57-6)	342	351.6	1.325	1,391.3
Uranyl nitrate hexahydrate (13520-83-7)	7	6.1	0.7	6.1
Vinyl chloride/ resins (75-01-4)	11	254	0.4536	1,135.5
Vinyl ester/acetate resins (9003-22-9)	4	2.75	0.95	2.75
Zirconium (7440-67-7)	187	13.8	11.64	1,168.4

[a] The number of individual containers for which the amount of the constituent was listed in the *Solid Waste Information and Tracking System (SWITS)* database. In some cases, records indicate contents only as a total for a group of containers.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: CASRN=Chemical Abstracts Service Registry Number.

Source: Fluor Hanford 2007:Table 3D-1.

The methodology used in the DSASW to evaluate danger associated with hazardous materials in retrieved TRU waste and suspect TRU waste involved comparison of the values of maximum inventories at a single location from Table K–106 with the reportable quantities, threshold quantities (TQs), and threshold planning quantities (TPQs) provided in applicable Federal regulations; see Table K–107 for a summary comparison. The goal of this process was to identify the hazardous waste material inventories that represent significant potential risks and select them for more-detailed analysis within the DSASW and comparison with the risk guidelines.

The first step of the screening process used in the DSASW included a comparison of values of maximum hazardous material inventories at a single location (see Table K–107) with the reportable quantity values presented in Table 302.4 of Title 40 of the CFR, Part 302, "Designation, Reportable Quantities, and Notification." The Hanford safety analysis methodology requires that a qualitative assessment of the adequacy of controls be performed for chemical waste constituents that exceed reportable quantity values. As shown in Table K–107, this screening process concluded that the following chemical inventories at a single location exceed their respective reportable quantity values: beryllium, cadmium, mercury, naphthylamine (conservatively assumed to be beta, but alpha is also exceeded), sodium, sodium hydroxide, and vinyl chloride/resins. The results of the qualitative assessment of control adequacy determined that existing safety management programs would provide adequate protection for all receptors. The significant safety management programs are those designated for hazardous material protection (training, communication program), radioactive and hazardous waste management, operational safety (conduct of operations, fire protection), emergency preparedness (protective actions), and institutional safety (industrial safety). As a result, no quantitative accident analysis was performed in the DSASW for these chemicals (Fluor Hanford 2007).

Table K–107. Reportable Quantities

Hazardous Material (CASRN)	Maximum Amount in a Single Location (kilograms)	Reportable Quantity[a]	Threshold Quantity[b]	Threshold Planning Quantity[c]	Threshold Quantity for Accidental Release Prevention[d]
Ammonia (7664-41-7)	2.94	45.4 kilograms (100 pounds)	4,540 kilograms (10,000 pounds)	227 kilograms (500 pounds)	9,074 kilograms (20,000 pounds)
Ammonium nitrate (6484-52-2)	32.5	NR	NR	NR	NR
Beryllium (7440-41-7)	7	4.54 kilograms (10 pounds)	NR	NR	NR
Cadmium (7440-43-9)	195.2	4.54 kilograms (10 pounds)	NR	NR	NR
Cyclohexane (110-82-7)	18.1	454 kilograms (1,000 pounds)	NR	NR	NR
Dioxane (123-91-1)	25.22	45.4 kilograms (100 pounds)	NR	NR	NR
Hydrogen peroxide (7722-84-1)	1.85	NR	3,400 kilograms (7,500 pounds)	454 kilograms (1,000 pounds)	NR
Manganese (7439-96-5)	0.06	0.45 kilograms (1 pound)	NR	NR	NR
Mercury (7439-97-6)	661.5	0.45 kilograms (1 pound)	NR	NR	NR
Naphthylamine (91-59-8)	102.1	4.54 kilograms (10 pounds)	NR	NR	NR
Nitric acid (7697-37-2)	411.6	454 kilograms (1,000 pounds)	227 kilograms[e] (500 pounds)	NR	6,805 kilograms[f] (15,000 pounds)
Phosphoric acid (7664-38-2)	1,884.12	2,270 kilograms (5,000 pounds)	NR	NR	NR
Propane (74-98-6)	5.9	454 kilograms (1,000 pounds)	NR	NR	
Sodium (7440-23-5)	392.1	4.54 kilograms (10 pounds)	NR	NR	NR
Sodium hydroxide (1310-73-2)	3,247.3	454 kilograms (1,000 pounds)	NR	NR	NR
Sodium hypochlorite (7681-52-9)	0.36	45.4 kilograms (100 pounds)	NR	NR	NR
Sodium oxide (12401-86-4)	724.4	NR	NR	NR	NR
Styrene (100-42-5)	15.46	454 kilograms (1,000 pounds)	NR	NR	NR
Tetrahydrofuran (109-99-9)	2.98	454 kilograms (1,000 pounds)	NR	NR	NR

Table K–107. Reportable Quantities *(continued)*

Hazardous Material (CASRN)	Maximum Amount in a Single Location (kilograms)	Reportable Quantity[a]	Threshold Quantity[b]	Threshold Planning Quantity[c]	Threshold Quantity for Accidental Release Prevention[d]
Uranium oxide (1344-57-6)	1,391.3	NR	NR	NR	NR
Uranyl nitrate hexahydrate (13520-83-7)	6.1	45.4 kilograms (100 pounds)	NR	NR	NR
Vinyl chloride/ resins (75-01-4)	1,135.5	0.45 kilograms (1 pound)	NR	NR	4,540 kilograms (10,000 pounds)
Vinyl ester/acetate resins (9003-22-9)	2.75	2,270 kilograms (5,000 pounds)	NR	454 kilograms (1,000 pounds)	6,805 kilograms (15,000 pounds)
Zirconium (7440-67-7)	1,168.4	NR	NR	NR	NR

[a] Reportable quantity values taken from Table 302.4 of Title 40 of the *Code of Federal Regulations* (CFR), Section 302.4.
[b] Threshold quantity values taken from Appendix A of 29 CFR 1910.119.
[c] Threshold planning quantity values taken from Appendix A of 40 CFR 355.40.
[d] Threshold quantity values for accidental release prevention taken from Tables 1 and 3 of 40 CFR 68.130.
[e] A threshold quantity of 500 pounds (227 kilograms) is provided for 94.5 percent nitric acid (white fuming) in 29 CFR 1910.119. The Solid Waste Operations Complex waste stream does not include significant inventories of nitric acid at this concentration.
[f] The threshold quantity from 40 CFR 68, is for 80 percent nitric acid.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: CASRN=Chemical Abstracts Service Registry Number; NR=not reported—no reportable quantity, threshold quantity, or threshold planning quantity value was listed for these chemicals.

Source: Fluor Hanford 2007:Table 3D-2.

The next step of the DSASW screening process included a comparison of the maximum hazardous material inventories at single location (see Table K–107) with the TQ values presented in 29 CFR 1910.119 Appendix A, "Process Safety Management of Highly Hazardous Chemicals." Appendix A of 29 CFR 1910.119 provides a list of highly hazardous chemicals, toxics, and reactives with the potential to cause a catastrophic event when present at or above the TQ value. As shown in Table K–107, the maximum hazardous material inventories at a single location are below the respective TQ values for those chemicals that have a TQ listed in the appendix. Therefore, a process hazard analysis pursuant to 29 CFR 1910.119 was not required.

The maximum hazardous material inventories at a single location were then compared with the TPQ values presented in 40 CFR 355 Appendix A, "Emergency Planning and Notification," and the TQ values in of 40 CFR 68 Table 1, "Chemical Accident Prevention Provisions." Hazardous constituents of waste containers that did not exceed a TPQ or TQ value from the CFR sections listed above or that did not have a TPQ or TQ value listed were screened from further analysis based on the conclusion that these materials are not deemed to be highly hazardous materials by OSHA or EPA; thus, no further hazards assessments are required by the CFR.

The Hanford safety analysis methodology for assessing hazards associated with chemical waste constituents specifies that a quantitative analysis to compare potential exposures with evaluation guidelines be considered if a TQ (29 CFR 1910.119) or TPQ value (40 CFR 355) is exceeded. The methodology does not explicitly require a comparison with the 40 CFR 68 TQ values or direct actions if these values are exceeded. None of the maximum hazardous material inventories at a single location exceeded the TQ value from 29 CFR or 40 CFR or the TPQ value from 40 CFR. Consequently, it was not necessary to perform a quantitative analysis in the DSASW for any of the hazardous materials listed in Table K–107.

K.3.9.3.2 Emergency Management Evaluation of Chemical Hazards

In addition to evaluating chemical hazards found in the SWOC waste according to the safety analysis methodology, chemical hazards were evaluated using the methodology provided for the DOE Comprehensive Emergency Management Program, as required in DOE Order 151.1C, *Comprehensive Emergency Management System*. This methodology is intended to identify specific hazardous materials that, if released, could (1) cause impacts that would immediately threaten or endanger personnel and emergency responders in close proximity to the event, (2) potentially disperse beyond the immediate vicinity in quantities that threaten the health and safety of onsite personnel or the public, and (3) potentially disperse at a rate sufficient to require a time-urgent response to implement protective actions for workers and the public. Identified materials are quantitatively analyzed in an Emergency Preparedness Hazards Assessment to determine if they will be included as part of the technical planning basis for the DOE facility or activity.

The screening process prescribed by DOE Order 151.1C examines potential chemical hazards and eliminates materials from further consideration if they (1) are commonly used by the public, (2) are not readily dispersed in the atmosphere, (3) are not hazardous (toxic) to humans, or (4) exist in limited quantities. Because of the nature of the hazardous material within the waste found at SWOC, the "public use" exclusion does not apply.

The degree to which a substance represents an acute airborne hazard to humans is somewhat dependent on whether the material is in a form that can be readily dispersed. Solids that cannot be reduced to small particles by some mechanism are generally excluded from quantitative analysis. Liquids with a low vapor pressure (less than about 1 millimeter of mercury) are also excluded from quantitative analysis. However, waste packaging requirements generally prohibit free liquids from being disposed of in waste containers. Therefore, significant quantities of liquids that would create an airborne hazard due to evaporation are not likely to exist within SWOC waste containers. Most materials found in SWOC waste containers are powders consisting of a small percentage of particles of respirable size (less than about 10 microns in diameter) that are small enough to be transported a significant distance in air before they are removed due to gravitational settling. Also, most powders found in waste are contained in secondary containers (e.g., bags, cans, boxes). Therefore, mechanical impact or container spills are not expected to result in a significant airborne release of powders. The methodology used in the DSASW to produce the condensed list of chemicals shown in Table K–106 eliminated waste configurations that were not in a dispersible form, such as stabilized waste, grouted monoliths, waste containers in concrete high-integrity containers, waste containers in concrete culverts with lids in place, EBR-II casks in concrete storage vaults with lids in place, and alpha and mixed fission product caissons. As the waste forms that were obviously nondispersible have already been eliminated and little specific information was provided about the physical form of the materials listed, it was assumed that all materials listed were dispersible; thus, none were eliminated based on this criterion.

The DOE Hazardous Materials Emergency Management Program is primarily concerned with materials that cause significant adverse human health impacts as a result of acute exposures. In the chemical screening process, the National Fire Protection Association (NFPA) health hazard rating assigned to a chemical is used to indicate whether the possibility of adverse health effects is significant enough to warrant quantitative evaluation (DOE Order 151.1C). Chemicals with an NFPA health hazard rating of 0, 1, or 2 were presumed not to represent significant acute toxic health hazards to humans and were generally excluded from further analysis.

The DOE emergency management screening methodology specifies that hazardous materials should be eliminated as candidates for analysis if the materials are stored and used only in small quantities. A small quantity is considered a quantity that can be "easily and safely manipulated by one person" (DOE Order 151.1C). DOE guidance that accompanies the DOE emergency management order suggests that the following values are consistent with the intent of the order: approximately 19 liters (5 gallons) for liquids, 18 kilograms (40 pounds) for solids, or 4.5 kilograms (10 pounds) for compressed gases (DOE Guide 151.1-2).

The results of applying the screening process discussed above are shown in Table K–108; the following chemicals would have been retained for further analysis based on emergency screening: cadmium, mercury, naphthylamine, nitric acid, phosphoric acid, sodium, sodium hydroxide, sodium oxide and uranium oxide. In the following discussion, these materials are subjected to the same analysis considerations used in an Emergency Preparedness Hazards Assessment to determine whether a material poses a significant hazard such that a quantitative analysis of the potential human health impacts would be included in a technical planning basis for a facility or activity.

Table K–108. Results of Emergency Management Screening

Hazardous Material (CASRN)	Maximum Amount in a Single Location (kilograms)	NFPA Health Hazard Rating[a]	Screening Results
Ammonia (7664-41-7)	2.94	3	Q
Ammonium nitrate (6484-52-2)	32.5	1	H
Beryllium (7440-41-7)	7	3	Q
Cadmium (7440-43-9)	195.2	4	R
Cyclohexane (110-82-7)	18.1	1	H
Dioxane (123-91-1)	25.22	2	H
Hydrogen peroxide (7722-84-1)	1.85	3	Q
Manganese (7439-96-5)	0.06	1	Q/H
Mercury (7439-97-6)	661.5	3	R
Naphthylamine (91-59-8)	102.1	NF	R
Nitric acid (7697-37-2)	411.6	3	R
Phosphoric acid (7664-38-2)	1,884.12	3	R
Propane (74-98-6)	5.9	1	Q/H
Sodium (7440-23-5)	392.1	3	R
Sodium hydroxide (1310-73-2)	3,247.3	3	R
Sodium hypochlorite (7681-52-9)	0.36	3	Q
Sodium oxide (1313-59-3)	724.4	3	R
Styrene (100-42-5)	15.46	2	Q/H
Tetrahydrofuran (109-99-9)	2.98	2	Q/H
Uranium oxide (1344-57-6)	1,391.3	3	R
Uranyl nitrate hexahydrate (13520-83-7)	6.1	1	Q/H
Vinyl chloride/resins (75-01-4)	1,135.5	2	H
Vinyl ester/acetate resins (9003-22-9)	2.75	2	Q/H
Zirconium (7440-67-7)	1,168.4	2	H

[a] NFPA health hazard ratings were obtained from the Savannah River Site database of hazard ratings (WSRC 2005).

Key: CASRN=Chemical Abstracts Service Registry Number; H=eliminated from further analysis based on health hazard rating criteria; NF=value not found; NFPA=National Fire Protection Association; Q=eliminated from further analysis based on quantity criteria; R=retained for further consideration.

K.3.9.3.2.1 Cadmium

Cadmium, a metal, was most likely used at Hanford in the form of sheets, foil, or wire. In these forms the material is nondispersible and could be screened from further consideration. However, it can also be found in granular or powder form; under accident conditions it was assumed to respond to dispersion like a noncombustible contaminated solid. Table K–106 shows that the maximum amount in a single location is 195.2 kilograms (430.3 pounds) and the maximum amount in a single container is 93.54 kilograms (206.2 pounds). Therefore, the maximum quantity of cadmium at a single location is found in multiple containers. The accident event most likely to cause the maximum release from multiple containers is a fire event. Using the source term methodology employed in the DSASW for radiological releases, the ARF for a noncombustible contaminated solid (i.e., powders of nonreactive compounds) is 0.006, the RF is 0.01, and the DR for fire is 1.0 (Fluor Hanford 2007). Assuming the entire inventory at the location was involved in a fire, the resulting airborne release would be 0.006 × 0.01 × 1.0 × 195.2 kilograms (430.3 pounds) = 0.00117 kilograms (0.026 pounds). Under average meteorological dispersal conditions (i.e., 5 meters [16.4 feet] per second and D stability), the airborne concentration 100 meters (110 yards) from a fire would be 0.021 milligrams per cubic meter. TEELs 1, 2, and 3 for cadmium are 0.03, 1.25, and 9 milligrams per cubic meter (DOE 2008). Because the consequences of an airborne release from an accident would not exceed 10 percent of the TEEL-2 value at 100 meters (110 yards), the results of a quantitative accident analysis would not be included in the emergency management technical planning basis for the facility according to the Hanford criteria used to implement the DOE Comprehensive Emergency Management Program (DOE Order 151.1C).

K.3.9.3.2.2 Mercury

Mercury is a silver-white, odorless, heavy transition metal; it is one of five elements that are liquid at or near room temperature and pressure. Long-term exposure to mercury vapors presents a severe health hazard. Short-term overexposure to high concentrations of mercury vapors can lead to breathing difficulty, coughing, acute chemical pneumonia, and pulmonary edema (fluid accumulation in the lungs/swelling). Mercury has a vapor pressure of 0.002 millimeters of mercury at 25 °C (77 °F); because it has a low vapor pressure, it evaporates extremely slowly. As a result, it would not be considered a significant acute airborne release hazard during a container spill, failure, or mechanical damage. Therefore, a fire event involving waste containers would be the most likely to cause an airborne release. Mercury is not flammable, but if heated to high temperatures will decompose into toxic vapors of mercury and mercury oxide. Using the same source term methodology employed previously, the ARF for packaged waste is 0.0005, the RF is 1.0, and the DR for fire is 1.0 (Fluor Hanford 2007). Assuming the entire inventory at a single location was involved in a fire, the resulting airborne release would be 0.0005 × 1.0 × 1.0 × 661.5 kilograms (1,460 pounds) = 0.331 kilograms (0.73 pounds). Under average meteorological dispersal conditions (e.g., 5 meters [16.4 feet] per second and D stability), the airborne concentration 100 meters (110 yards) from a fire would be 0.6 milligrams per cubic meter. The ERPG-1, -2, and -3 values for mercury vapor are 0.3, 2.05, and 4.1 milligrams per cubic meter, and the TEEL-1, -2, and -3 values for mercury oxide are 0.15, 1.08, and 10.8 milligrams per cubic meter (DOE 2008). As the consequences of an airborne release from an accident would not exceed either the ERPG-2 value for mercury vapor or the TEEL-2 value for mercury oxide at 100 meters (110 yards), emergency planning for response to the release would be needed only within the local area (i.e., within SWOC) according to the Hanford criteria to implement in the DOE Comprehensive Emergency Management Program (DOE Order 151.1C).

K.3.9.3.2.3 Naphthylamine

2-Naphthylamine is a white to red, shiny, flake-like solid that darkens on exposure to light. This substance is a known human carcinogen; chronic exposure has been shown to cause bladder cancer. The following acute health effects may occur immediately or shortly after exposure: contact can irritate the skin and eyes and high levels can interfere with the ability of blood to carry oxygen, causing headaches, fatigue, dizziness, and blue coloring of the skin and lips (NJDHSS 2004). The TEEL-1, -2, and -3 values for this substance are 5, 35, and 300 milligrams per cubic meter, respectively (DOE 2008); these values are relatively high because temporary exposure causes generally mild acute effects that are not life threatening. Although no NFPA health hazard rating was found for this chemical, relevant data indicated that it is a health hazard because chronic exposure can cause cancer. The DOE emergency management program is primarily concerned with protecting workers and the public from acute health effects; thus, this material would be excluded from consideration in a facility technical planning basis because its primary health hazard (cancer) results from chronic exposure.

K.3.9.3.2.4 Nitric Acid

Nitric acid is extremely hazardous; it is corrosive, reactive, an oxidizer, and a poison. It is corrosive to the respiratory track if inhaled and can cause breathing difficulties and lead to pneumonia and pulmonary edema, which may be fatal. Nitric acid was used in a number of processing operations across Hanford in concentrations ranging from approximately 50 percent to 70 percent. The 60-minute AEGL-1, -2, and -3 values for nitric acid are 1.37, 61.8, and 237 milligrams per cubic meter, respectively (EPA 2009). These values were developed for white fuming nitric acid, which is a much more highly concentrated (with a higher percentage) nitric acid. It is most commonly found in liquid form; however, because free-standing liquids are prohibited in waste containers, it is most likely carried in absorbent materials within the waste. Nitric acid is not flammable but will decompose into toxic oxides of nitrogen when exposed to high temperatures. However, many of the materials found in waste containers (e.g., cellulose, plastics, rubber) also decompose to toxic oxides of nitrogen when exposed to high temperatures; many of these materials generate larger volumes of the toxic gases than nitric acid. The most severe dispersal condition would be a liquid spill. For purposes of estimating consequences of a severe release, it was assumed that all of the nitric acid listed in Table K–106 is in liquid form at an approximate percentage of 70 percent. At 25 °C (77 °F), 70 percent nitric acid has a partial pressure of 4.1 millimeters of mercury (Perry and Green 1984), and, assuming a spill depth of 1 centimeter (0.39 inches), would result in a pool surface area of approximately 27.4 square meters (295 square feet). Using this information and the EPIcode to model a liquid spill release results in a concentration of 6.7 milligrams per cubic meter at a distance of 100 meters (110 yards) from an accident. As the consequences of an artificially severe airborne release from an accident would not exceed the AEGL-2 value at 100 meters (110 yards), emergency planning for response to the release would be needed only within the local area (i.e., within SWOC) according to the Hanford criteria used to implement the DOE Comprehensive Emergency Management Program (DOE Order 151.1C).

K.3.9.3.2.5 Phosphoric Acid

Phosphoric acid is a clear, colorless, syrupy liquid. Inhalation is not an expected hazard unless the material is released as an aerosol spray or heated to a high temperature. Mist or vapor inhalation can cause irritation to the nose, throat, and upper respiratory tract. Severe exposures can lead to chemical pneumonitis (inflammation of lung tissue). The vapor pressure is very low, 0.03 millimeters of mercury at 20 degrees Celsius (68 degrees Fahrenheit); therefore, it is not an airborne dispersal hazard due to its extremely slow evaporation (Mallinckrodt 2006). It is most commonly found in liquid form; however, because free-standing liquids are prohibited in waste containers, it is most likely carried in absorbent materials within the waste. The most likely means for phosphoric acid to be released to the air would be during a fire involving waste containers. The same source term methodology employed above is used to obtain an estimate of the consequences 100 meters (110 yards) from a fire. The ARF for packaged waste is 0.0005, the RF is 1.0, and the DR is 1.0 (Fluor Hanford 2007). Assuming the entire inventory at a single location was involved in a fire, the resulting airborne release would be $0.0005 \times 1.0 \times 1.0 \times 1{,}884.12$ kilograms (4,160 pounds) = 0.942 kilograms (2.08 pounds). Under average meteorological dispersal conditions (e.g., 5 meters [5.5 yards] per second and D stability), the airborne concentration 100 meters (110 yards) from a fire would be 0.17 milligrams per cubic meter. The TEEL-1, -2, and -3 values for phosphoric acid are 3, 500, and 500 milligrams per cubic meter, respectively (DOE 2008). As the consequences of an airborne release do not exceed 10 percent of the TEEL-2 value at 100 meters (110 yards) from an accident, the results of a quantitative accident analysis would not be included in the emergency management technical planning basis for the facility according to the Hanford criteria used to implement the DOE Comprehensive Emergency Management Program (DOE Order 151.1C).

K.3.9.3.2.6 Sodium Metal

As previously stated, the future disposition of the bulk sodium stored at the CWC is addressed in the discussion of the FFTF Decommissioning alternatives. The consequences of accidents involving this inventory of hazardous material are addressed in Section K.3.9.2, "Chemical Impacts of Fast Flux Test Facility Accidents."

K.3.9.3.2.7 Sodium Hydroxide

Sodium hydroxide is an odorless white solid usually found in the form of pellets or flakes. It was often used at Hanford in the form of a water-based solution. It is a severe irritant; effects from inhalation of sodium hydroxide dust or mist vary from mild irritation to serious damage of the upper respiratory tract, depending on severity of exposure. Symptoms may include sneezing, sore throat, and runny nose. Pneumonitis may occur following a severe acute exposure. Either in a water-based solution or as a solid, sodium hydroxide has a negligible vapor pressure; therefore, it is not a potential airborne hazard due to extremely slow evaporation. It is not flammable and is not considered a fire or explosion hazard. However, small particles of the solid could be suspended in the air during a fire if the material were absorbed in, packaged in, or in close contact with burning waste materials. Using the methodology referenced above for packaged waste and assuming that the entire maximum inventory at a single location is involved in a fire, the amount of material released to the atmosphere would be 0.0005 × 1.0 × 1.0 × 3,247.3 kilograms (7,170 pounds) = 1.62 kilograms (3.58 pounds). Under average meteorological dispersal conditions (e.g., 5 meters [5.5 yards] per second and D stability), the airborne concentration 100 meters (110 yards) from a fire would be 0.29 milligrams per cubic meter. The ERPG-1, -2, and -3 values for sodium hydroxide are 0.5, 5, and 50 milligrams per cubic meter, respectively (DOE 2008). As the consequences of an airborne release from an accident would not exceed 10 percent of the ERPG-2 value at 100 meters (110 yards), the results of a quantitative accident analysis would not be included in the emergency management technical planning basis for the facility according to the Hanford criteria used to implement the DOE Comprehensive Emergency Management Program (DOE Order 151.1C).

K.3.9.3.2.8 Sodium Oxide

Sodium oxide is a white granular material; it reacts with water to produce sodium hydroxide and heat. When sodium oxide fumes or dust are inhaled, it comes into contact with the water in the respiratory tract and may result in severe burns, injury, or death. It is a noncombustible material, but it may decompose upon heating to produce corrosive and/or toxic fumes. However, many of the materials found in waste containers (e.g., cellulose, plastics, rubber) also decompose to toxic fumes when exposed to high temperatures; many of these materials would generate larger volumes of the toxic gases than sodium oxide when heated. The most likely means for sodium oxide to be released to the air would be a fire involving waste containers. The same source term methodology employed above was used to obtain an estimate of the consequences 100 meters (110 yards) from a fire resulting in the release of sodium oxide. The ARF for packaged waste is 0.0005, the RF is 1.0, and the DR for fire is 1.0 (Fluor Hanford 2007). Assuming the entire inventory at a single location was involved in a fire, the resulting airborne release would be 0.0005 × 1.0 × 1.0 × 724.4 kilograms (1,600 pounds) = 0.362 kilograms (0.80 pounds). Under average meteorological dispersal conditions (i.e., 5 meters [5.5 yards] per second and D stability), the airborne concentration 100 meters (110 yards) from a fire would be 0.65 milligrams per cubic meter. The TEEL-1, -2, and -3 values for sodium oxide are 0.25, 2.5, and 25 milligrams per cubic meter, respectively (DOE 2008). As the consequences of an airborne release from an accident would not exceed the TEEL-2 value at 100 meters (110 yards), emergency planning for response to the release would be needed only within the local area (i.e., within SWOC) according to the Hanford criteria used to implement the DOE Comprehensive Emergency Management Program (DOE Order 151.1C).

K.3.9.3.2.9 Uranium Oxide

Uranium oxide (uranium black oxide) is a black, radioactive, crystalline powder. It occurs naturally in the mineral uraninite and, if produced from enriched uranium, it is used in nuclear fuel rods in nuclear reactors. Prior to 1960, it was used as yellow and black color in ceramic glazes and glass. Depleted uranium oxide can be used as a material for radiation shielding. The form found primarily in the mixed waste containers is depleted. Using the methodology referenced above for packaged waste and assuming that the maximum inventory at a single location is involved in a fire, the amount of material released to the atmosphere would be 0.0005 × 1.0 × 1.0 × 1,391.3 kilograms (3,072 pounds) = 0.7 kilograms (1.55 pounds). Under average meteorological dispersal conditions (i.e., 5 meters [5.5 yards] per second and D stability), the airborne concentration 100 meters (110 yards) from a fire would be 1.3 milligrams per cubic meter. The ERPG-1, -2, and -3 values for uranium oxide (uranium black oxide) are 0.681, 10, and 30 milligrams per cubic meter, respectively (DOE 2008). As the consequences of an airborne release from an accident would not exceed the ERPG-2 value at 100 meters (110 yards), emergency planning for response to the release would be needed only within the local area (i.e., within SWOC) according to the Hanford criteria used to implement the DOE Comprehensive Emergency Management Program (DOE Order 151.1C).

K.3.9.3.3 Impacts

The chemicals listed as known chemical hazardous constituents that may be present in retrieved TRU waste and suspect TRU waste containers (see Table K–106 above) were examined using the methodologies for identifying hazardous chemicals that should be subjected to quantitative analyses in both the DOE safety analysis and emergency management programs. With the exception of sodium metal, which is addressed in Section K.3.8.2, none of the chemicals listed would require analysis or inclusion in a documented facility safety analysis or Emergency Preparedness Hazards Assessment because their forms, quantities, and associated health hazards do not warrant such analysis.

The chemical hazards in the waste management containers are generally mixed together with the radiological hazards. Radiological accident scenarios analyzed in Section K.3.6, "Waste Management Accident Scenarios," would be expected to release both radioactive and chemical materials. Based on the discussions above, the scenario most likely to release a significant quantity of hazardous chemicals is a fire event involving multiple waste containers. Of the radiological scenarios analyzed in Section K.3.6, the large fire of waste containers outside a facility (SWOC FIR-4) most closely resembles the maximum foreseeable scenario postulated for the release of a chemical hazard. The dose consequence to the noninvolved worker 100 meters (110 yards) from this event would be 260 rem, and doses from the other fire scenarios analyzed would range from approximately 1 rem to a maximum of 300 rem (see Tables K–98 and K–100).

The evaluation of chemical exposures shows that exposures to the noninvolved worker do not exceed the AEGLs (i.e., 60-minute AEGL-2 value) established by EPA and implemented by DOE as the trigger points for planning protective measures for the public in the event of a large release of hazardous chemicals. The equivalent radiological dose threshold established by EPA for planning protective measures in the event of a large release of radioactive material is 1 rem. From the results of the radiological analysis and the chemical evaluations, it is clear that the potential health impacts of the radioactive components of the waste far outweigh those of the chemical components. Therefore, further quantitative analysis to determine potential human health impacts due to an accidental release of hazardous chemicals from within the mixed waste is not necessary.

K.3.10 Impacts on Workers

In the event of an accident involving the release of radioactive material or toxic chemicals, onsite workers would be at risk of exposure and potentially harmful health effects. For the purposes of this EIS, the onsite worker population varies from approximately 2,000 to about 20,000, depending on the alternative.

The harmful impacts of an accidental release of radiological or chemical materials were assessed in terms of the probability (or frequency) of an accident's occurrence and consequences if the accident were to occur. For radiological accidents, the consequences are expressed in terms of radiation dose and the resulting risk of an LCF. For chemical accidents, the consequences are expressed in terms of the chemical concentrations in the air (ppm or milligrams per cubic meter) to which a worker might be exposed compared to the applicable concentration threshold (limit) at which certain health effects are expected. Depending on the severity of an accident, the consequences may also include prompt fatalities, particularly for involved workers close to the accident.

For this EIS, the impacts on an individual noninvolved worker located 100 meters (110 yards) from an accident were analyzed for a range of accidents. However, the impacts on the populations of involved and noninvolved workers were not analyzed for two reasons. First, the impacts on the populations of involved and noninvolved workers would depend on the distribution of the population, including the distance of each group from the accident location and whether each individual is indoors or outdoors. This information is too dynamic to properly model. Second, because Hanford tank closure facilities where involved workers would be located have not yet been constructed, no useful estimates of involved worker locations and protective features are available. That information is needed to accurately estimate accident impacts.

Alternatives with the least number of involved workers would generally have the lowest worker population impacts in the event of an accident. Workers nearest the accident would be the most vulnerable to harmful health effects and fatalities. Prior to initiation of operations, analyses would be conducted and documented in safety analysis reports and hazard assessment documents to ensure worker protection and safety during operations. Furthermore, technical safety requirements would be defined in conjunction with safety analysis reports for all facilities to minimize the risk to workers from potential accidents.

K.3.11 Assessment of Intentional Destructive Acts

Recent world events draw attention to the possibility of acts of sabotage and terrorism against U.S. interests, domestic and abroad. To protect against such actions, safeguards and security measures are employed at all DOE facilities. Because of the significance of its nuclear and chemical facilities as potential targets of such actions and for the purposes of this EIS, DOE has assessed the potential impacts of a deliberate airplane or vehicular crash into Hanford facilities.

K.3.11.1 Safeguards and Security

DOE has acted strongly and proactively to understand and to preclude or mitigate the threats posed by intentional destructive acts. In accordance with DOE Orders 470.4A and 470.3B, DOE conducts vulnerability assessments and risk analyses of facilities and equipment under its jurisdiction to evaluate the physical protection elements, technologies, and administrative controls needed to protect DOE assets. DOE Order 470.4A establishes the roles and responsibilities for the conduct of DOE's Safeguards and Security Program. DOE Order 470.3B (a) specifies those national security assets that require protection; (b) outlines threat considerations for safeguards and security programs to provide a basis for planning, design, and construction of new facilities or modifications to existing facilities; and (c) provides an adversary threat basis for evaluating the performance of safeguards and security systems. DOE also protects against espionage, sabotage, and theft of radiological, chemical, or biological materials; classified information and matter; nonnuclear weapon components; and critical technologies.

No environmental impacts are expected because of compliance with DOE safeguard and security provisions based on the adequacy of the existing Hanford security provisions. Before startup of any new or substantially modified operations, DOE would conduct an indepth, site-specific safeguards and security inspection to ensure that existing safeguards and security programs satisfy DOE requirements. Any inadequacies would be resolved before the startup of the operations. Although it is not anticipated, if the safeguards and security review determined that additional security provisions were required, DOE would perform the appropriate NEPA review.

K.3.11.2 Assessment of Potential Impacts

The tank closure accident with the highest consequences and risks for all Tank Closure action alternatives is the unmitigated, seismically induced WTP collapse and failure (WT41). For the Tank Closure No Action Alternative, the unmitigated, seismically induced waste tank dome collapse (TK53) has the highest consequences and risks. The FFTF accident with the highest consequences and risks for all FFTF Decommissioning action alternatives is the RH-SC fire (RHSC1). For the FFTF Decommissioning No Action Alternative, the Hanford sodium storage tank failure (HSTF1) has the highest consequences and risks. The waste management accident with the highest consequences and risks for both the Waste Management No Action Alternative and the two action alternatives is the aircraft crash (SWOC EE-2). The accident scenarios are described in Sections K.3.4 through K.3.6.

A number of release scenarios that might be initiated by acts of terror or sabotage were considered with regard to how or whether they might aid in the comparison of EIS alternatives. The potential for and consequences of some intentional destructive act (IDA) scenarios are essentially the same under each of the alternatives. Because analysis of such acts would do little to aid or inform the decisionmaking process, scenarios were selected based primarily on whether the likelihood or consequences of the event would be substantially different under some EIS alternatives than under others. Primary considerations for selecting scenarios to be analyzed included the following:

- Quantities of radioactive or toxic material associated with each alternative
- Location(s) where the hazardous material is used or stored
- Degree of inherent physical protection against destructive acts that is associated with each alternative (for example, material that is kept in an underground vault under one alternative, but is stored above ground at some time under another)
- Properties of the material that affect its toxicity and/or dispersibility
- Proximity of a postulated release event to the MEI and/or general population (and hence, the health consequences of any given release to the environment)

Five scenarios caused by IDAs were selected for analysis: IDA-1 through IDA-5.

Explosive Device in Underground Waste Tank (IDA-1). It was postulated that explosions occur that displace a large portion of the soil overburden, breach the tank dome, and disperse a portion of the tank waste into the atmosphere. To maximize the radiological impact, all the tank waste was assumed to be solid (salt cake, sludge). In accordance with the recommendation of DOE Handbook 3010-94, the respirable release would be less than the TNT-equivalent weight of the explosive charge. The release was modeled as a ground-level release without mitigation (LPF of 1).

The assumptions and parameter values used to analyze the seismically induced waste tank dome collapse scenario (TK53) and explosive device in underground waste tank scenario (IDA-1) are summarized and compared in Table K–109. The results indicate that the impacts of an explosive device in an underground waste tank would be about four times greater than those of the seismically induced waste tank dome collapse.

Table K–109. Comparison of Seismically Induced Waste Tank Dome Collapse (TK53) and Explosive Device in Underground Waste Tank (IDA-1)

Scenario Assumption or Parameter	Seismically Induced Waste Tank Dome Collapse (TK53)	Intentional Destructive Act: Explosive Device in Underground Waste Tank (IDA-1)
Affected structures/buildings	One single-shell tank	One single-shell tank
Degree of structural damage	Collapse of dome with overburden falling into tank	Explosion that clears overburden followed by in-tank explosion that breaches tank dome and disperses waste
Material at risk	Contents of a typical single-shell tank	Contents of a typical single-shell tank
Damage ratio	1.0	1.0
Release mechanisms considered	Expulsion of headspace vapor and aerosols, splash of liquid, resuspension (entrainment) from exposed waste	Expulsion of headspace vapor and aerosols, explosive dispersal of solid waste
Release fraction (ARF × RF)	Headspace aerosols: 100 milligrams per cubic meter × 1,000 cubic meters Splash: 0.002 Entrainment – public (24 hour): 9.6×10^{-6} Entrainment – worker (8 hour): 3.2×10^{-6}	Headspace aerosols: 100 milligrams per cubic meter × 1,000 cubic meters (insignificant contributor to dose) Explosive dispersal: Respirable aerosols equal to TNT-equivalent weight of explosive
Release height	Ground level	Ground level
Mitigation	None (LPF=1)	None (LPF=1)
Consequences Population dose/risk MEI dose/risk Noninvolved worker dose/risk	 0.96 person-rem/0 (0.0006) LCFs 0.00021 rem/1×10^{-7} LCFs 0.22 rem/0.0001 LCFs	 3.8 person-rem/0 (0.0023) LCFs 0.00083 rem/5×10^{-7} LCFs 0.88 rem/0.0005 LCFs

Note: To convert kilograms to pounds, multiply by 2.2046; cubic meters to cubic feet, by 35.315.

Key: ARF=airborne release fraction; IDA=Intentional Destructive Act; LCF=latent cancer fatality; LPF=leak path factor; MEI=maximally exposed individual; RF=respirable fraction; TNT=trinitrotoluene.

Aircraft or Ground Vehicle Impact on WTP (IDA-2). A vehicle or aircraft crash and/or explosions initiated by an insider were postulated. It was assumed that these acts are sufficiently energetic to breach a portion of the exterior wall of the HLW Vitrification Facility. The HLW melter feed preparation vessels in the HLW vitrification process cell are protected by reinforced concrete radiation shielding walls 0.91 to 1.52 meters (3 to 5 feet) thick. For purposes of this analysis, it was postulated that the shield wall was penetrated and the two vessels were breached, causing the contents of 58,300 liters (15,400 gallons) of HLW melter feed to be spilled into the cell (BNI 2005). At the same time, aircraft or vehicle fuel was assumed to enter the cell and burn. The spilled radioactive waste slurry was assumed to heat to the boiling point. A boiling ARF × RF value of 0.001 (DOE Handbook 3010-94) was assumed, as well as the release of radioactive material to the environment through holes in the building walls (LPF of 1.0).

The assumptions and parameter values used to analyze the WTP collapse and IDA scenarios are summarized and compared in Table K–110. The results indicate that the impacts of a deliberate airplane or ground transport vehicle crash into the WTP would be about one order of magnitude lower than those for WT41, the seismically induced collapse and failure of the entire WTP.

Table K–110. Comparison of Seismically Induced WTP Collapse and Failure (WT41) and Aircraft or Ground Vehicle Impact on WTP (IDA-2)

Scenario Assumption or Parameter	Seismically Induced WTP Collapse and Failure (WT41 – 6×30)	Intentional Destructive Act: Aircraft or Ground Vehicle Impact on WTP (IDA-2)
Affected WTP structures/buildings	Pretreatment, LAW Vitrification, and HLW Vitrification Facilities	HLW Vitrification Facility
Degree of structural damage	Total structural failure, breach of external walls and cell walls	Penetration of external wall and cell wall
Material at risk	Contents of all tanks and vessels in all three buildings	Contents of HLW melter feed preparation vessels only
Damage ratio	1.0	1.0
Release mechanisms considered	Spill and resuspension (entrainment) from pool	Spill and boiling from burning 2,000 gallons of diesel or jet fuel in cell[a]
Release fraction (ARF × RF)	Spill: 0.00005 Entrainment – public (24 hour): 9.6×10^{-6} Entrainment – worker (8 hour): 3.2×10^{-6}	Spill: 0.00004 Boiling: 0.001
Release height	Ground level	Ground level
Mitigation	None (LPF=1)	None (LPF=1)
Consequences Population dose/risk MEI dose/risk Noninvolved worker dose/risk[b]	 58,000 person-rem/35 LCFs 4.3 rem/0.0026 LCFs 13,000 rem/1 LCF	 3,400 person-rem/2 LCFs 0.25 rem/0.00015 LCFs 860 rem/1 LCF

[a] Heavy construction equipment (crawlers, earthmovers, etc.) typically have fuel tanks with a capacity of a few hundred gallons or less. The Boeing 737, a common commercial aircraft of a size that a skilled pilot might be able to fly into a preexisting breach in the external wall of the HLW Vitrification Facility, has a fuel capacity of about 6,800 gallons. Of that, about 45 percent is carried within the wings, which would likely be sheared off on impact and not penetrate intact into the cell. Depending on the takeoff fuel load and distance flown, the center tank might contain somewhat less than 4,000 gallons, half of which was assumed to enter the cell before being ignited

[b] Increased likelihood of an LCF for an individual, assuming the event occurs; value cannot exceed 1.

Note: To convert gallons to liters, multiply by 3.7854.

Key: ARF=airborne release fraction; HLW=high-level radioactive waste; LAW=low-activity waste; LCF=latent cancer fatality; LPF=leak path factor; MEI=maximally exposed individual; RF=respirable fraction; WTP=Waste Treatment Plant.

Intentional Breach of WTP Ammonia Tank (IDA-3). Under all Tank Closure alternatives except the No Action Alternative, the WTP would be completed and a 45,000-liter (12,000-gallon) (nominal capacity) tank of anhydrous ammonia would be part of the WTP (Lindquist 2006a). Section K.3.9.1.1 analyzes a tank failure that releases the tank's entire contents (43,500 liters, or 11,500 gallons) over a period of 30 minutes, approximating the leak rate from a 2.5-centimeter-diameter (1-inch-diameter) hole in the tank. An event that causes a near-instantaneous release of the entire tank's contents would produce the highest release rate and the greatest potential health impact. An IDA was postulated whereby an explosion caused massive damage to the WTP ammonia tank. The entire 43,500 liters (11,500 gallons) of liquid ammonia was assumed to be vaporized over a period of 1 minute. Typical (average) atmospheric dispersion conditions were assumed. The results of the 30-minute accident release and the explosion are summarized and compared in Table K–111.

Table K–111. Comparison of Ammonia Tank Failure Accident with Intentional Destructive Act (IDA-3)

Scenario	Quantity Released (liters)	AEGL-2[a]		AEGL-3[b]		Concentration (ppm)	
		Limit (ppm)	Distance to Limit (meters)	Limit (ppm)	Distance to Limit (meters)	Noninvolved Worker at 100 Meters	Nearest Site Boundary at 8,600 Meters
Tank failure (30-minute release)	43,500	160	2,450	1,100	780	41,000	27.0
Explosion (1-minute release)	43,500	160	22,000	1,100	8,000	>500,000	950

a **AEGL-2** (60-minute) is the airborne concentration (expressed as ppm or milligrams per cubic meter) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape (EPA 2009).

b **AEGL-3** (60-minute) is the airborne concentration (expressed as ppm or milligrams per cubic meter) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death (EPA 2009).

Note: To convert liters to gallons, multiply by 0.26417; meters to yards, by 1.0936.

Key: AEGL=Acute Exposure Guideline Levels; ppm=parts per million.

Explosion in FFTF Primary Cold Trap (IDA-4). The doses associated with an accident that releases the primary cold trap radionuclide inventory have been shown to be about 100 times greater than the impacts from burning the entire Hanford bulk sodium inventory. Furthermore, a deliberate high-energy dispersal of the cold trap inventory might release substantially more of the material than the 30 percent assumed to be released under accident conditions (scenario RHSC1). The potential for an IDA to occur in the 400 Area or at one of two other destinations (Hanford 200 Area or INL) provides an opportunity for comparing the FFTF Decommissioning No Action Alternative with both the Hanford and Idaho Reuse Options for disposition of bulk sodium. Accordingly, an IDA was postulated whereby the FFTF primary cold trap, containing 2,700 liters (710 gallons) of sodium, 470 curies of cesium-137, and 70 curies of cobalt-60 (ANL-W and Fluor Hanford 2002), was destroyed by an explosive/incendiary device during removal or handling. All the radioactive material was assumed to aerosolize and be released to the atmosphere. The results of the accident scenario (RHSC1) and the deliberate act scenario (IDA-4) are summarized and compared in Table K–112.

Large Aircraft Crash at SWOC Storage Building (IDA-5). The potential for IDAs that disperse radioactive or toxic materials to the environment would be eliminated only when the waste is finally disposed of (buried on site or transported off site). Varying amounts of radioactive material would remain vulnerable to dispersal as long as wastes are being generated by tank closure and other onsite operations or are being received from offsite sources for disposal at Hanford. Waste Management alternatives are not distinguished from each other by quantitative analysis of hypothetical IDAs that could occur under any of them. However, the scale of potential impacts from an IDA directed at waste management operations can be understood by a simple extrapolation from the most severe accident analyzed, the aircraft crash (EE-2) (Fluor Hanford 2007). That scenario involves damage to 960 out of 17,500 waste containers in a SWOC storage building. The estimated mean population dose from that release would be 1,300 person-rem, and 1 LCF would be expected as a result. The dose to the MEI was estimated to be 0.28 rem, and the dose to the noninvolved worker was estimated to be 300 rem. The most pessimistic extrapolation from that scenario would involve a larger airplane, more fuel, and a comparable degree of damage to all 17,500 containers. About 18 times as much radioactive material would thereby be released, and the consequences would be proportionately greater (24,000 person-rem to the population, 5.1 rem to the MEI, and 5,400 rem to the noninvolved worker). However, as pointed out in the DSASW, a larger fire would tend to produce a more-buoyant plume, resulting in greater dispersion in the atmosphere and a lower dose to the MEI for each unit of radioactive material released.

Table K–112. Comparison of Fire in FFTF Primary Cold Trap Breach due to Accident Scenario (RHSC1) and Deliberate Explosion Scenario (IDA-4)

Scenario Assumption or Parameter	Breach of Primary Cold Trap with Remote-Handled Special Component Fire (RHSC1)	Intentional Destructive Act: Explosion in FFTF Primary Cold Trap (IDA-4)
Cold trap contents	2,700 liters sodium 470 curies cesium-137 70 curies cobalt-60	2,700 liters sodium 470 curies cesium-137 70 curies cobalt-60
Damage mode, degree of damage	Handling mishap with breach of cold trap shell	Total disassembly of cold trap by explosive/incendiary device
Damage ratio	1.0	1.0
Release fraction (ARF × RF)	0.3	1.0
Release height	Ground level	Ground level
Mitigation	None (LPF=1)	None (LPF=1)
Consequences		
Population dose/risk	4.4 person-rem/0 (0.003) LCFs	12 person-rem/0 (0.007) LCFs
MEI dose/risk	0.00011 rem/7×10^{-8} LCFs	0.00029 rem/2×10^{-7} LCFs
Noninvolved worker dose/risk	0.0009 rem/5×10^{-7} LCF	0.0096 rem/6×10^{-6} LCFs

Note: To convert liters to gallons, multiply by 0.26417.

Key: ARF=airborne release fraction; FFTF=Fast Flux Test Facility; LCF=latent cancer fatality; LPF=leak path factor; MEI=maximally exposed individual; RF=respirable fraction.

K.3.12 Analysis Conservatism, Uncertainty, and Design Changes

The analysis of accidents was based on calculations relevant to hypothetical sequences of events and models of the effects of these events. The models make use of a variety of information and assumptions, including estimates of event frequencies and source terms, assumed pathways for environmental transport and exposure, and risk factors relating exposure to effects on human health and the environment. Within the scope of the analysis, the inputs are as realistic as possible. However, uncertainties associated with each selected input value and model assumption contribute to overall uncertainty in the results. The uncertainty associated with the result of each individual analysis was not estimated, but from one alternative to the next, the overall uncertainties associated with the analyses were estimated to be about the same.

In many cases, the scarcity of experience with the postulated accidents leads to uncertainty in the calculation of the consequences and frequencies. This fact has promoted the use of models or input values that yield conservative estimates of consequences and frequency. Due to the layers of conservatism built into the accident analysis for the spectrum of postulated accidents, the estimated consequences and risks to the public and workforce represent the upper limit for the individual classes of accidents. The uncertainties associated with the accident frequency estimates are enveloped by the conservatism of the analysis.

Of particular interest are the uncertainties in the estimates of cancer fatalities from exposure to radioactive materials. As discussed in Section K.1, the numerical values of the health risk estimators used in this *TC & WM EIS* were obtained by linear extrapolation from the nominal risk estimate for lifetime total cancer mortality resulting from exposures of 10 rad. Because the health risk estimators were multiplied by conservatively calculated radiological doses to predict fatal cancer risks, the fatal cancer values presented in this EIS are overestimates.

For the purposes of this EIS, the impacts calculated from the linear model were treated as an upper-limit, consistent with the widely used methodologies for quantifying radiogenic health impacts. This does not imply that health effects are expected. Moreover, in cases where the upper-limit estimators predicted more than 1 LCF, this does not imply that the LCF risk can be determined for a specific individual.

Following the Record of Decision and selection of alternatives, actions could be taken during implementation of the alternatives that would change the basis for the analyses and results presented in the final EIS. Under DOE NEPA requirements, any such changes are subject to NEPA review to determine whether additional NEPA analyses or evaluations are necessary. Additionally, in accordance with DOE safety requirements, facility designs, modifications, and changes in operations are subject to a safety review process to safeguard the health and safety of workers and the public during operations. The process includes hazards assessments, safety analyses, and operational safety requirements that define conditions and requirements for a safe operating envelope and an authorization basis. Following construction and startup of operations, any change in facility design and operations would be reviewed for compliance with the authorization basis for operations. If deemed necessary, further safety studies would be conducted, which could influence planned design changes, identify mitigation measures, and revise the operational safety requirements for continued safeguarding of public health and safety.

K.4 INDUSTRIAL SAFETY

This section provides supporting information for estimating the industrial safety impacts presented in Chapter 4 of this *TC & WM EIS*. Tables in Appendix I list the work phases, activities specific to each phase, total labor hours for each activity, and the total number of years a work activity would be conducted. Using the historical accident and fatality incident rates and total labor hours, the potential impacts on worker safety were evaluated.

Two categories of industrial safety impacts, total recordable cases (TRCs) and fatalities, are represented in Chapter 4 of this EIS. TRCs include work-related death or illness or injury that results in loss of consciousness, restriction of work or motion, transfer to another job, or requires medical treatment beyond first aid. A fatal occurrence is a work-related injury or illness that causes the death of the employee.

DOE and contractor TRC and fatality incident rates were obtained from the CAIRS database (DOE 2007b, 2007c). The CAIRS database is used to collect and analyze DOE and DOE contractor reports of injuries, illnesses, and other accidents that occur during DOE operations. General industry data were obtained from information maintained by the U.S. Bureau of Labor Statistics (BLS 2008, 2009).

A review of the data from 2001 through 2006 indicates that occupational injuries and illnesses incurred at Hanford have decreased. The ORP incidence of TRCs has decreased from 2.02 to 2.0 per 200,000 labor hours over this period. This rate includes all labor categories (e.g., construction, operations, engineering, etc.) associated with tank farm management and operations. During the same period, ORP has not experienced a fatality.

A number of occupational incidence rates were available for use in estimating the industrial safety impacts of the alternatives considered in this *TC & WM EIS*. The rates vary between 1.3 and 6.7 incidents per 200,000 labor hours, as shown in Table K–113. This table provides the four most relevant sources of data for this EIS: ORP data, Idaho Operations Office data, DOE and contractor data, and private industry data maintained by the U.S. Bureau of Labor Statistics.

Table K–113. Total Recordable Cases and Fatality Incident Rates

Labor Category	Total Recordable Case Rate[a]	Fatality Rate[b]
DOE and contractor	1.88	0.26
Construction (DOE and contractor)	2.4	0.0
Operations/production (DOE and contractor)	1.3	0.0
DOE Office of River Protection	2.0	0.0
Idaho Operations Office	1.5	0.0
Private industry (BLS)	5.0	4.0
Construction (private industry) (BLS)	6.7	11.8

[a] Average illness and injury cases per 200,000 labor hours from 2001–2006.
[b] Average fatality rate per 100,000 employee years from 2001–2006.
Key: BLS=U.S. Bureau of Labor Statistics; DOE=U.S. Department of Energy.
Sources: BLS 2008, 2009; DOE 2007b, 2007c.

The ORP TRC rate of 2.0 per 200,000 labor hours was selected as representative of the types of work associated with the alternatives under consideration. It includes contributions from all labor categories (e.g., construction, operations, engineering, etc.) and is slightly higher than the 1.88 rate experienced by the DOE-wide facilities. The incident rate for private industry was deemed not representative of typical DOE project experience. One set of alternatives identifies activities taking place at INL. A different TRC rate specifically for Idaho operations was used in these calculations.

As ORP has not experienced a fatality during recent history, the DOE and contractor rate (for all labor categories) of 0.26 per 100,000 employee years was adopted as representative of fatal occurrences. The impacts of illness and injury can be calculated using the total project labor hours and the selected rate shown in Table K–113. The total labor hours were calculated from the scaled data sets (SAIC 2007a, 2007b, 2007c, 2008) and are listed in the Appendix I tables for each of the alternatives. The subtotal for each type of activity (i.e., construction, operations, deactivation, and closure) is also provided.

Using the incident rates selected above and the projected labor hours provided in Appendix I**,** the occupational safety impacts associated with each of the alternatives were calculated. These impacts were calculated by multiplying the total labor hours by the TRC rate and dividing by 200,000 (i.e., incidence per 200,000 labor hours).

The number of fatalities per year for an activity can be calculated by multiplying the projected number of employees involved in that activity by the selected fatality rate shown in Table K–113 and dividing by 100,000. When the estimated number of fatalities per year is less than 1, no fatalities would be expected. For example, the number of labor hours for WTP operations under Tank Closure Alternative 3B is 77.6 million and the WTP is expected to operate for 22 years (see Appendix I, Table I–18). Dividing 77.6 million hours (total hours) by 22 years (years of operation) equals 3.53 million hours per year. Dividing hours per year of operation by labor hours per year (2,000) equals a WTP workforce of 1,764 FTE workers for each year of operation. Finally, multiplying workers per year by the fatality rate of 0.26 and dividing the product by 100,000 equals 0.0046, the number of fatalities projected per year of WTP operation. Chapter 4, Tables 4–98, 4–127, and 4–150 provide the projected number of TRCs and fatalities for Tank Closure, FFTF Decommissioning, and Waste Management alternatives, respectively.

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