Appendix A
Nonproliferation and Export Control Policy Fact Sheet

This appendix contains a copy of the fact sheet on the President's Nonproliferation and Export Control Policy released by the White House on September 27, 1993. The fact sheet describes the major principles that guide the policy and the key elements of the policy.

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release September 27, 1993

FACT SHEET

NONPROLIFERATION AND EXPORT CONTROL POLICY

The President today established a framework for U.S. efforts to prevent the proliferation of weapons of mass destruction and the missiles that deliver them. He outlined three major principles to guide our nonproliferation and export control policy:

- Our national security requires us to accord higher priority to nonproliferation, and to make it an integral element of our relations with other countries.

- To strengthen U.S. economic growth, democratization abroad and international stability, we actively seek expanded trade and technology exchange with nations, including former adversaries, that abide by global nonproliferation norms.

- We need to build a new consensus -- embracing the Executive and Legislative branches, industry and public, and friends abroad -- to promote effective nonproliferation efforts and integrate our nonproliferation and economic goals.

The President reaffirmed U.S. support for a strong, effective nonproliferation regime that enjoys broad multilateral support and employs all of the means at our disposal to advance our objectives.

Key elements of the policy follow.

Fissile Material

The U.S. will undertake a comprehensive approach to the growing accumulation of fissile material from dismantled nuclear weapons and within civil nuclear programs. Under this approach, the U.S. will:

- Seek to eliminate where possible the accumulation of stockpiles of highly-enriched uranium or plutonium to ensure that where these materials already exist they are subject to the highest standards of safety, security, and international accountability.

- Propose a multilateral convention prohibiting the production of highly-enriched uranium or plutonium for nuclear explosives purposes or outside of international safeguards.

- Encourage more restrictive regional arrangements to constrain fissile material production in regions of instability and high proliferation risk.

- Submit U.S. fissile material no longer needed for our deterrent to inspection by the International Atomic Energy Act.

- Pursue the purchase of highly-enriched uranium from the former Soviet Union

and other countries and its conversion to peaceful use as reactor fuel.

- Explore means to limit the stockpiling of plutonium from civil nuclear programs, and seek to minimize the civil use of highly-enriched uranium.

- Initiate a comprehensive review of long-term options for plutonium disposition, taking into account technical, nonproliferation, environmental, budgetary and economic considerations. Russia and other nations with relevant interests and experience will be invited to participate in this study.

The United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes. The United States, however, will maintain its existing commitments regarding the use of plutonium in civil nuclear programs in Western Europe and Japan.

Export Controls

To be truly effective, export controls should be applied uniformly by all suppliers. The United States will harmonize domestic and multilateral controls to the greatest extent possible. At the same time, the need to lead the international community or overriding national security or foreign policy interests may justify unilateral export controls in specific cases. We will review our unilateral dual-use export controls and policies, and eliminate them unless such controls are essential to national security and foreign policy interests.

We will streamline the implementation of U.S. nonproliferation export controls. Our system must be more responsible and efficient, and not inhibit legitimate exports that play a key role in American economic strength while preventing exports that would make a material contribution to the proliferation of weapons of mass destruction and the missile that deliver them.

Nuclear Proliferation

The U.S. will make every effort to secure the indefinite extension of the Non-Proliferation Treaty in 1995. We will seek to ensure that the International Atomic Energy Agency has the resources needed to implement its vital safeguards responsibilities, and will work to strengthen the IAEA's ability to detect clandestine nuclear activities.

Missile Proliferation

We will maintain our strong support for the Missile Technology Control Regime. We will promote the principles of the MTCR Guidelines as a global missile nonproliferation norm and seek to use the MTCR as a mechanism for taking joint action to combat missile proliferation. We will support prudent expansion of the MTCR's membership to include additional countries that subscribe to international nonproliferation standards, enforce effective export controls and abandon offensive ballistic missile programs. The United States will also promote regional efforts to reduce the demand for missile capabilities.

The United States will continue to oppose missile programs of proliferation concern, and will exercise particular restraint in missile-related cooperation. We will continue to retain a strong presumption of denial against exports to any country of complete space launch vehicles or major components.

The United States will not support the development or acquisition of space-launch vehicles in countries outside the MTCR.

For MTCR member countries, we will not encourage new space launch vehicle programs, which raise questions on both nonproliferation and economic viability grounds. The United States will, however, consider exports of MTCR-controlled items to MTCR member countries for peaceful space launch programs on a case-by-case basis. We will review whether additional constraints or safeguards could reduce the risk of misuse of space launch technology. We will seek adoption by all MTCR partners of policies as vigilant as our own.

Chemical and Biological Weapons

To help deter violations of the Biological Weapons Convention, we will promote new measures to provide increased transparency of activities and facilities that could have biological weapons applications. We call on all nations -- including our own -- to ratify the Chemical Weapons Convention quickly so that it may enter into force by January 13, 1995. We will work with others to support the international Organization for the Prohibition of Chemical Weapons created by the Convention.

Regional Nonproliferation Initiatives

Nonproliferation will receive greater priority in our diplomacy, and will be taken into account in our relations with countries around the world. We will make special efforts to address the proliferation threat in regions of tension such as the Korean peninsula, the Middle East and South Asia, including efforts to address the underlying motivations for weapons acquisition and to promote regional confidence-building steps.

In Korea, our goal remains a non-nuclear peninsula. We will make every effort to secure North Korea's full compliance with its nonproliferation commitments and effective implementation of the North-South denuclearization agreement.

In parallel with our efforts to obtain a secure, just, and lasting peace in the Middle East, we will promote dialogue and confidence-building steps to create the basis for a Middle East free of weapons of mass destruction. In the Persian Gulf, we will work with other suppliers to contain Iran's nuclear, missile, and CBW ambitions, while preventing reconstruction of Iraq's activities in these areas. In South Asia, we will encourage India and Pakistan to proceed with multilateral discussions of nonproliferation and security issues, with the goal of capping and eventually rolling back their nuclear and missile capabilities.

In developing our overall approach to Latin America and South Africa, we will take account of the significant nonproliferation progress made in these regions in recent years. We will intensify efforts to ensure that the former Soviet Union, Eastern Europe and China do not contribute to the spread of weapons of mass destruction and missiles.

Military Planning and Doctrine

We will give proliferation a higher profile in our intelligence collection and analysis and defense planning, and ensure that our own force structure and military planning address the potential threat from weapons of mass destruction and missile around the world.

Conventional Arms Transfers

We will actively seek greater transparency in the area of conventional arms transfers and promote regional confidence-building measures to encourage restraint on such transfers to regions of instability. The U.S. will undertake a comprehensive review of conventional arms transfer policy, taking into account national security, arms control, trade, budgetary and economic competitiveness consideration.

Appendix B
Nonproliferation of Weapons of Mass Destruction and the Means of Their Delivery

THE WHITE HOUSE

Office of the Press Secretary

JOINT STATEMENT
BY THE PRESIDENT OF THE RUSSIAN FEDERATION
AND
THE PRESIDENT OF THE UNITED STATES OF AMERICA
ON NON-PROLIFERATION OF WEAPONS OF MASS DESTRUCTION
AND THE MEANS OF THEIR DELIVERY

President Clinton and President Yeltsin, during their meeting in Moscow on January 14, 1994, agreed that the proliferation of weapons of mass destruction and their missile delivery systems represents an acute threat to international security in the period following the end of the Cold War. They declared the resolve of their countries to cooperate actively and closely with each other, and also with other interested states, for the purpose of preventing and reducing this threat.

The Presidents noted that the proliferation of nuclear weapons creates a serious threat to the security of all states, and expressed their intention to take energetic measures aimed at prevention of such proliferation.

- Considering the Treaty on the Non-proliferation of Nuclear Weapons as the basis for efforts to ensure the nonproliferation of nuclear weapons, they called for its indefinite and unconditional extension at conference of its participants in 1995, and they urged that all states that have not yet done so accede to this treaty.

- They expressed their resolve to implement effective measures to limit and reduce nuclear weapons. In this connection, they advocated the most rapid possible entry into force of the START I and START II treaties.

- They agreed to review jointly appropriate ways to strengthen security assurances for the states which have renounced the possession of the nuclear weapons and that comply strictly with their nonproliferation obligations.

- They expressed their support for the International Atomic Energy Agency in its efforts to carry out its safeguards responsibilities. They also expressed their intention to provide assistance to the Agency in the safeguards field, including through joint efforts of their relevant laboratories to improve safeguards.

- They supported the Nuclear Suppliers Group, and agreed with the need for effective implementation of the principle of full-scope IAEA safeguard as a condition for nuclear exports with the need for export controls on dual-use materials and technology in the nuclear field.

- They reaffirmed their countries' commitment to the conclusion as soon as possible.

Appendix C
Air Quality and Noise

C.1 AIR QUALITY

C.1.1 INTRODUCTION

This appendix provides detailed data that support impact assessments to air quality and noise addressed in Sections 3.3.3, 3.4.3, 3.5.3, and 3.6.3, Affected Environment, and 4.3.1.2, 4.3.2.2, 4.3.3.2, 4.3.4.2, and 4.6.2.2, Environmental Consequences. The data presented include emission inventories from site-related activities and highly enriched uranium (HEU) blending facilities. Section C.1.2 presents the methodology and models used in the air quality assessment. Section C.1.3 presents supporting data applicable to each site. The tables included in Sections C.1.4 through C.1.7 contain information applicable to the air quality assessments at each site, and the figures contain wind rose data at each site. Section C.2 presents the emission rates for the blending facilities considered as alternatives. Section C.3 presents noise data for those sites where noise regulations apply.

C.1.2 METHODOLOGY AND MODELS

The assessment of potential impacts to air quality is based on the comparison of proposed project effects with applicable standards and guidelines. The Industrial Source Complex Short-Term Model Version 2 (ISCST2) is used to estimate concentrations of pollutants from emission sources at each site.

The air quality modeling analysis performed for the candidate sites is considered to be a screening level analysis that incorporates conservative assumptions applied to each site so that the impacts associated with the respective alternatives can be compared among the sites. These conservative assumptions will tend to overestimate the pollutant concentrations at each site.

The assumptions incorporated into the air quality analysis at each site are as follows: major source criteria pollutant emissions were modeled using actual source locations and stack parameters to determine no action criteria pollutant concentrations; toxic/hazardous pollutant emissions were modeled from a single source centrally located within the complex of facilities on each site assuming a 10-meter (m) (32.8-feet [ft]) stack height, a stack diameter of 0.3 m (1 ft), a stack exit temperature equal to ambient temperature, and a stack exit velocity equal to 0.03 meter per second (m/s) (0.1 ft/s), unless otherwise specified.

These assumptions will tend to overestimate pollutant concentrations since no credit is given to spatial and temporal variations of emission sources. More technical information can be found in the Environmental Protection Agency's (EPA's) *User's Guide for the Industrial Source Complex (ISC2) Dispersion Models*, EPA-450/4-92-008a, March 1992.

C.1.3 SUPPORTING DATA

C.1.3.1 Overview

This section presents supporting information for each of the four candidate sites considered for blending HEU to low-enriched uranium (LEU). Table C.1.3.1–1 presents the air quality standards applicable to each site. Subsequent sections present supporting information used in the air quality analysis at Oak Ridge Reservation (ORR), Savannah River Site (SRS), Babcock & Wilcox Facility (B&W) at Lynchburg, Virginia, and Nuclear Fuel Services, Inc. (NFS) at Erwin, Tennessee.

C.1.4 OAK RIDGE RESERVATION

This section provides information on meteorology and climatology, emission rates, modeling assumptions, atmospheric dispersion characteristics, and annual mean wind speeds and direction frequencies (Figure C.1.4–1) at ORR. Table C.1.4–1 presents emission rates of criteria and toxic/hazardous pollutants at ORR. This information supports data presented in the Environmental Consequences section for air quality.

Meteorology and Climatology. The wind direction above the ridge tops and within the valley at ORR tends to follow the orientation of the valley. On an annual basis, the prevailing winds at the National

Table C.1.3.1–1. Ambient Air Quality Standards Applicable to the Candidate Sites

Pollutant	Averaging Time	Primary NAAQS[a] ($\mu g/m^3$)	Secondary NAAQS ($\mu g/m^3$)	South Carolina (SRS) ($\mu g/m^3$)	Tennessee (ORR & NFS) ($\mu g/m^3$)	Virginia (B&W) ($\mu g/m^3$)
Criteria Pollutants						
Carbon monoxide (CO)	8 hours	10,000	[b]	10,000	10,000	10,000
	1 hour	40,000	[b]	40,000	40,000	40,000
Lead (Pb)	Calendar Quarter	1.5	1.5	1.5	1.5	1.5
Nitrogen dioxide (NO_2)	Annual	100	100	100	100	100
Ozone (O_3)	1 hour	235	235	235	235	235
Particulate matter (PM_{10})	Annual	50	50	50	50	50
	24 hours	150	150	150	150	150
Sulfur dioxide (SO_2)	Annual	80	[b]	80	80	80
	24 hours	365	[b]	365	365	365
	3 hours	[b]	1,300	1,300	1,300	1,300
State Mandated Pollutants						
Total suspended particulates (TSP)	Annual	[b]	[b]	75	[b]	60
	24 hours	[b]	[b]	[b]	150	150
Gaseous fluorides (as HF)	1 month	[b]	[b]	0.8	1.2	[b]
	1 week	[b]	[b]	1.6	1.6	[b]
	24 hours	[b]	[b]	2.9	2.9	[b]
	12 hours	[b]	[b]	3.7	3.7	[b]
	8 hours	[b]	[b]	[b]	250	[b]

[a] The National Ambient Air Quality Standards, other than those for ozone, particulate matter, and those based on annual averages, are not to be exceeded more than once per year. The ozone standard is attained when the expected number of days per year with maximum hourly average concentrations above the standard is less than or equal to one. The 24-hour particulate matter standard is attained when the expected number of days with a 24-hour average concentration above the standard is less than or equal to one. The annual arithmetic mean particulate matter standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard.

[b] There is no standard.

Note: NAAQS=National Ambient Air Quality Standards; µg=micrograms; m^3=cubic meters.

Source: 40 CFR 50; SC DHEC 1992b; TN DEC 1994a; TN DHE 1991a; VA APCB 1993a.

Weather Service (NWS) station in the city of Oak Ridge are either up-valley, from west to southwest, or down-valley, from east to northeast. Figure C.1.4–1 shows mean wind speeds and direction frequencies for 1990 measured at the 30-m (98-ft) level of the ORR meteorology tower. The prevailing wind directions are from the southwest and northeast quadrants. Annual mean wind speeds measured in the region are relatively low, averaging 2 m/s (4.4 mph) at the 14-m (46-ft) level at the Oak Ridge NWS station and 2.1 m/s (4.7 miles per hour [mph]) at the 10-m (32.8-ft) level at the ORR Bethel Valley monitoring station.

The average annual temperature at ORR is 13.7 Celsius (°C) (56.6 Fahrenheit [°F]); temperatures vary from an average daily minimum of -3.8 °C (25.1 °F) in January to an average daily maximum of 30.4 °C (86.7 °F) in July. Relative humidity readings taken four times per day range from 51 percent in April to 92 percent in August and September (NOAA 1994c:3).

The average annual precipitation measured at ORR in Bethel Valley is 131 centimeters (cm) (51.6 inches [in]), while the average annual precipitation for the Oak Ridge NWS station is 137 cm (53.8 in). The maximum monthly precipitation recorded at the Oak Ridge NWS station was 48.9 cm (19.3 in) in July 1967, while the maximum rainfall in a 24-hour period observed was recorded in August 1960 at 19 cm (7.5 in). The average annual snowfall as measured at the Oak Ridge NWS station is 24.9 cm (9.8 in).

Damaging winds are uncommon in the region. Peak gusts recorded in the area range from 26.8 to

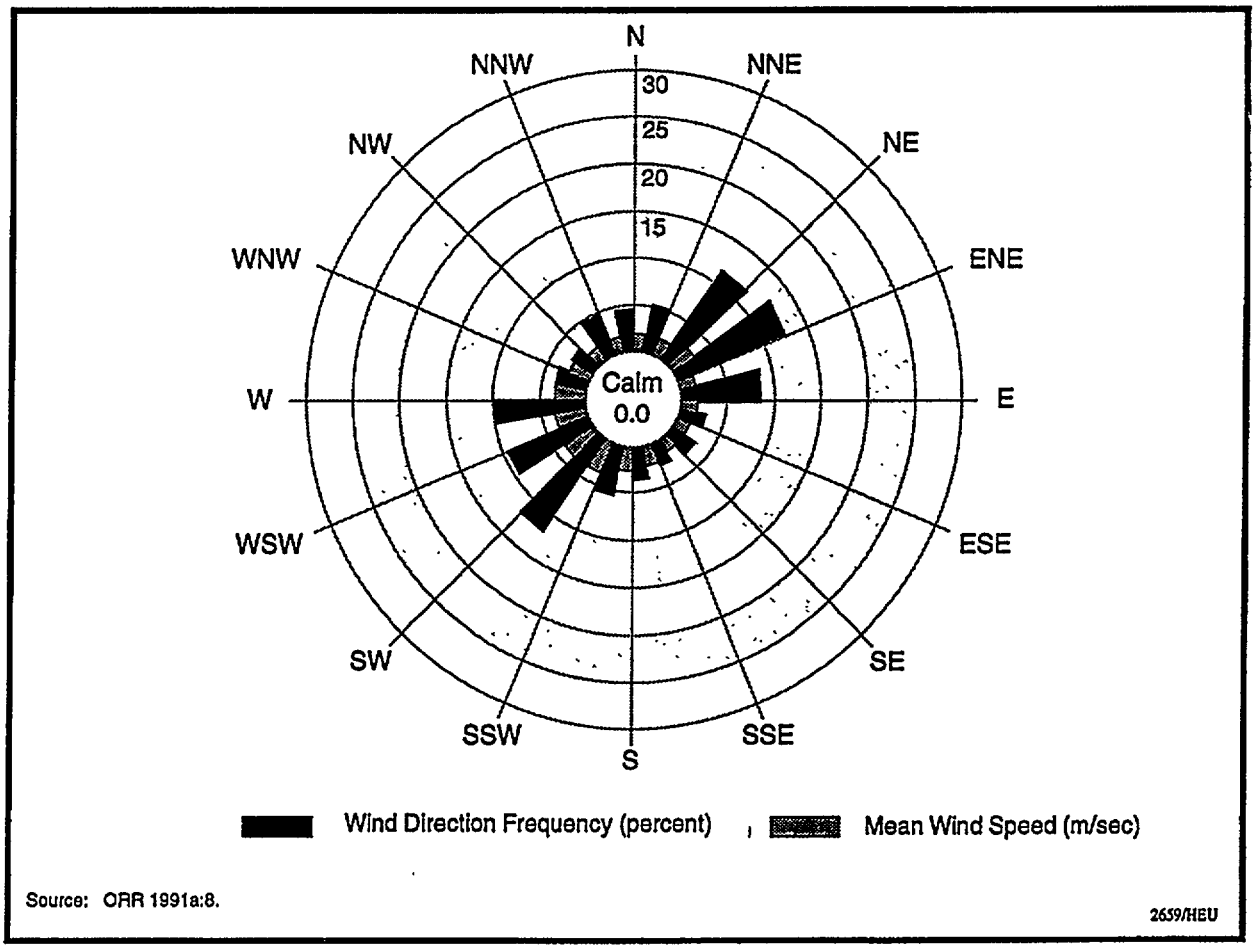

Figure C.1.4–1. Oak Ridge Reservation Meteorological Data, 1990.

30.8 m/s (60 to 68.9 mph) for the months of January through July; from 21.9 to 26.8 m/s (49 to 60 mph) for August, September, and December; and 16.1 to 20.1 m/s (36 to 45 mph) in October and November (ORNL 1982a:2-72). The fastest mile wind speed (the 1.6 kilometer [km] [1-mile (mi)] passage of wind with the highest speed for the day) recorded at the Oak Ridge NWS station for the period of record 1958 through 1979 was 26.4 m/s (59.1 mph) in January 1959 (NOAA 1994c:3).

The extreme mile wind speed at a height of 9.1 m (30 ft) that is predicted to occur near ORR once in 100 years is approximately 40.2 m/s (89.9 mph). The approximate values for occurrence intervals of 10, 25, and 50 years are 29.1 m/s (65.1 mph), 33.1 m/s (74 mph), and 34 m/s (76.1 mph), respectively.

Between 1916 and 1972 there were 25 tornadoes reported in the counties of Tennessee, having borders within about 64.4 km (40 mi) of ORR. The probability of a tornado striking a particular point in the vicinity of ORR is estimated to be 6.0×10^{-5} per year. The recurrence interval associated with this probability is 16,550 years (ORNL 1981a:3.3-7).

On February 21, 1993, a tornado passed through the northeastern edge of ORR and caused considerable damage to a number of structures in the nearby Union Valley Industrial Park. Damage from this tornado to ORR was relatively light. The wind speeds associated with this tornado ranged from 17.9 m/s (40 mph) to those approaching 58.1 m/s (130 mph) (OR DOE 1993c:iii).

Emission Rates. Table C.1.4–1 presents the emission rates of criteria and toxic/hazardous pollutants at ORR. The toxic/hazardous pollutant emissions presented in the table represent those pollutants with estimated concentrations at or beyond the ORR boundary that exceed 1 percent of Tennessee Department of Environment and Conservation (TDEC) air quality standards. These emission rates were used as input into the ISCST2 model to estimate pollutant concentrations.

Modeling Assumptions. Additional model input used to estimate maximum pollutant concentrations at or beyond the ORR site boundary include the following: criteria pollutant emissions were modeled from actual stack locations using actual stack heights, stack diameter, exit velocity, and exit temperature that were taken from operating permits issued by the Tennessee Air Pollution Control Board pursuant to the *Tennessee Air Quality Act*; toxic/hazardous pollutant emissions were modeled from a centrally located stack in the Y–12 complex at a height of 10 m (32.8 ft), a stack diameter of 0.3 m (1 ft), an exit velocity of 0.03 m/s (0.1 ft/s), and an exit temperature equal to ambient temperature.

Table C.1.4–1. Emission Rates of Criteria and Toxic/Hazardous Pollutants at Oak Ridge Reservation, 1992

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	94,648
Lead (Pb)	[a]
Nitrogen dioxide (NO_2)	887,911
Particulate matter (PM_{10})[b]	21,655
Sulfur dioxide (SO_2)	1,674,980
Total suspended particulates (TSP)[b]	21,655
Toxic/Hazardous Pollutants	
Chlorine	1,651
Hydrogen chloride	7,004
Nitric acid	9,526
Sulfuric acid	2,459

[a] No source indicated.

[b] It is conservatively assumed that PM_{10} emissions are TSP emissions.

Note: kg=kilogram; yr=year.

Source: OR DOE 1993a.

Atmospheric Dispersion Characteristics. Data collected at the ORR meteorological monitoring station (Y–12 Plant east tower) for the calendar year 1990 indicate that unstable conditions occur approximately 23 percent of the time, neutral conditions approximately 31 percent of the time, and stable conditions approximately 46 percent of the time, on an annual basis.

Annual Mean Wind Speeds and Direction Frequencies. The Oak Ridge meteorological data for wind speed and direction for 1990 are presented in Figure C.1.4–1 as a wind rose. As shown in this figure, the maximum wind direction frequency is from the east-northeast with a secondary maximum from the

northeast. The mean wind speed from the east-northeast is 1.7 m/s (3.8 mph) and from the northeast is 2.3 m/s (5.1 mph), while the maximum mean wind speed is 3.3 m/s (7.4 mph) from the southwest.

C.1.5 SAVANNAH RIVER SITE

This section provides information on climatology and meteorology, modeling assumptions, atmospheric dispersion characteristics, and annual mean wind speeds and direction frequencies (Figure C.1.5–1) at SRS.

Meteorology and Climatology. Figure C.1.5–1 shows annual mean wind speeds and wind direction frequencies for 1991 measured at the 60-m (200-ft) level of the SRS H–Area Weather Station. The wind data from the site indicate that there is no predominant wind direction at SRS. The highest directional frequency is from the northeast. The average annual wind speed measured is 2.9 m/s (6.5 mph) and average monthly wind speeds range from 2.4 m/s (5.4 mph), from June through August, to 3.5 m/s (7.8 mph) in February.

The average annual temperature at SRS is 17.3 °C (63.2 °F); average daily temperatures vary from 0 °C (32 °F) in January to 33.2 °C (91.7 °F) in July. Relative humidity readings taken four times per day range from 45 percent in April to 92 percent in August and September.

The average annual precipitation at SRS is 113 cm (44.5 in). Precipitation is distributed fairly evenly throughout the year, with the highest precipitation in summer (32.7 cm [12.9 in]) and the lowest in autumn (21.2 cm [8.3 in]). Although snow can fall from November through April, the average annual snowfall is only 2.8 cm (1.1 in); large snowfalls are rare.

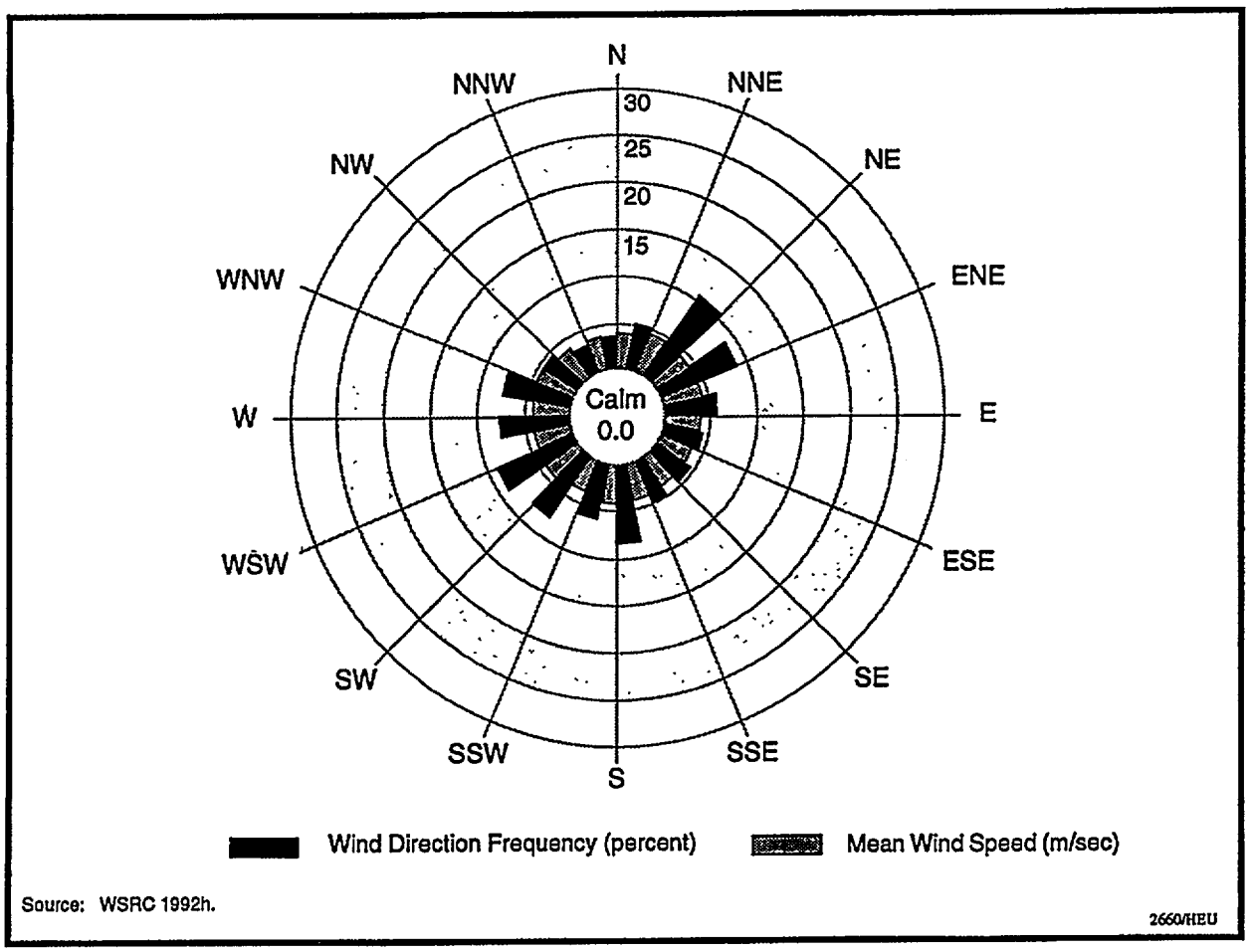

Figure C.1.5–1. Savannah River Site Meteorological Data, 1991.

Winter storms in the SRS area occasionally bring strong and gusty surface winds with speeds as high as 22.8 m/s (51 mph). Thunderstorms can generate winds with speeds as high as 21.5 m/s (48.1 mph) and even stronger gusts. The fastest 1-minute wind speed recorded at Augusta between 1952 and 1993 was 27.7 m/s (62 mph) (NOAA 1994c:3).

The average number of thunderstorm days per year at SRS is 56. From 1954 to 1983, 37 tornadoes were reported for a 1-degree square of latitude and longitude that includes SRS. This frequency of occurrence amounts to an average of about one tornado per year. The estimated probability of a tornado striking a point at SRS is 7.1×10^{-5} per year (NRC 1986a:32). Since operations began at SRS in 1953, six tornadoes have been confirmed on the site or near SRS. Nothing more than light damage was reported in any of these storms, except for a tornado in October 1989. That tornado caused considerable damage to timber resources in an undeveloped wooded area of SRS (WSRC 1990b:1).

From 1899 to 1980, 13 hurricanes occurred in Georgia and South Carolina, for an average frequency of about one hurricane every 6 years. Three hurricanes were classified as major. Because SRS is about 160 km (99.4 mi) inland, the winds associated with hurricanes have usually diminished below hurricane force (greater than or equal to a sustained speed of 33.5 m/s [75 mph]) before reaching the site (DOE 1992e:4-115).

Emission Rates. Table C.1.5–1 presents the emission rates of criteria pollutants at SRS. Toxic/hazardous pollutant emissions presented in the table represent those pollutants with estimated concentrations at or beyond the SRS boundary that exceed 1 percent of South Carolina State standards (SRS 1993a:4).

Modeling Assumptions. Emission rates for criteria and toxic/hazardous pollutants were based on actual site emissions data for the year 1990. Additional model input used to estimate maximum criteria and toxic/hazardous pollutant concentrations at or beyond the SRS site boundary includes the following: pollutant emissions modeled from actual stack heights, actual effective stack diameters, actual exit velocity, and actual exit temperature.

Table C.1.5–1. Emission Rates of Criteria and Toxic/Hazardous Pollutants at Savannah River Site, 1990

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	404,449
Lead (Pb)	509
Nitrogen dioxide (NO_2)	4,278,380
Particulate matter (PM_{10})	1,963,180
Sulfur dioxide (SO_2)	9,454,199
Total suspended particulates (TSP)	4,430,890

Toxic/Hazardous Pollutants	Point & Volume Source (kg/yr)	Area Source (kg/yr/m^2)
3,3-Dichlorobenzidine	211	[a]
Acrolein	[a]	1.94×10^{-3}
Benzene	129,772	0.21
Bis (chloromethyl) ether	211	[a]
Cadmium oxide	243	[a]
Chlorine	21,147	10.1
Chloroform	1,035,006	13.6
Cobalt	5,970	4.58×10^{-4}
Formic acid	46,949	[a]
Manganese	27,882	2.61
Mercury	918	1.15×10^{-3}
Nickel	23,023	6.02
Nitric acid	1,151,526	[a]
Parathion	[b]	[b]
Phosphoric acid	14,860	[a]

[a] No sources indicated.
[b] Data not available.
Note: kg=kilogram; yr=year; m^2=square meter.
Source: SRS 1993a:4; SRS 1995a:10.

Atmospheric Dispersion Characteristics. Data collected at the SRS meteorological monitoring station for 1991 indicate that unstable conditions occur approximately 38 percent of the time, neutral conditions approximately 43 percent of the time, and stable conditions approximately 19 percent of the time, on an annual basis.

Annual Mean Wind Speeds and Direction Frequencies. The SRS meteorological data for wind speed and direction for 1991 are presented in Figure C.1.5–1 as a wind rose. As shown in this figure, the maximum wind direction frequency is

from the northeast with a secondary maximum from the east-northeast. The mean wind speed from the northeast is 3.8 m/s (8.5 mph) and from the east-northeast is 3.8 m/s (8.5 mph), while the maximum mean wind speed is 4.1 m/s (9.2 mph) from the west-northwest.

C.1.6 BABCOCK & WILCOX

This section provides information on climatology and meteorology, emission rates, modeling assumptions, atmospheric dispersion characteristics, and annual mean wind speeds and direction frequencies (Figure C.1.6–1) at B&W located at Lynchburg, Virginia.

Meteorology and Climatology. The climate of the Lynchburg area has mild summers and winters. Rainfall is fairly evenly distributed throughout the year, but there is a distinct summertime rainfall, occasioned by afternoon thunderstorms. There are occasional snow showers, but the mountains to the immediate west act as a barrier and shelter the area from many storms and high winds. The mountains also act as a barrier to extremely cold weather. Temperatures have fallen below zero only on a few days, and 37.8 °C (100 °F) heat is almost as rare, although this mark has been exceeded in the months of May through September (NOAA 1994b:7).

The average annual temperature at the Lynchburg NWS station is 13.3 °C (55.9 °F); temperatures may vary from an average daily minimum of -4.1 °C (24.7 °F) in January to an average daily maximum of 30 °C (86 °F) in July. Relative humidity readings taken three times per day range from 45 percent in April to 89 percent in August (NOAA 1994b:3).

The annual precipitation at the Lynchburg NWS station is 104 cm (40.9 in). The maximum monthly precipitation recorded at the Lynchburg NWS station was 29 cm (11.4 in) in October 1976, while the maximum precipitation observed in a 24-hour period was 15.9 cm (6.3 in) recorded in June 1972. The average annual snowfall as measured at the Lynchburg NWS station is 46 cm (18.1 in).

Prevailing wind directions at B&W are predominantly from the southwest with a mean speed of 3.4 m/s (7.7 mph). The fastest mile wind speed recorded at the Lynchburg NWS station for the period of record 1944 through 1993 was 25 m/s (55.9 mph) in May 1958. Peak gust wind recorded was 33.1 m/s (74 mph) in June 1993 (NOAA 1994b:3).

Severe weather in the Lynchburg area is generally limited to thunderstorms with a low probability of tornadoes. The average number of thunderstorm days per year at Lynchburg is 40.5 (NOAA 1994b:3). The probability of a tornado actually striking the site is 3.0×10^{-4} per year, with a recurrence interval of 3,333 years (BW NRC 1986a:3-4).

Emission Rates. Table C.1.6–1 presents the emission rates of criteria and toxic/hazardous pollutants determined from the AIRS Facility Subsystem (AFS) Plant Emissions Inventory maintained by the Commonwealth of Virginia, Department of Environmental Quality, Air Division. Toxic/hazardous pollutant emissions presented in the table were obtained from the Toxic Chemical Release Form R required by Section 313 of the *Emergency Planning and Community Right-to-Know Act* of 1986, also known as Title III of the *Superfund Amendments and Reauthorization Act*. These emission rates were used as input into the ISCST2 model to estimate pollutant concentrations.

Modeling Assumptions. Additional model input used to estimate maximum pollutant concentrations at or beyond the B&W site boundary includes the following: criteria pollutant emissions were modeled using actual stack locations and heights, stack diameters, exit velocity, and exit temperature; toxic/hazardous pollutant emissions were modeled from a centrally located stack within the complex of facilities at a height of 10 m (32.8 ft), a stack diameter of 0.3 m (1 ft), an exit velocity of 0.03 m/s (0.1 ft/s), and an exit temperature equal to ambient temperature.

Atmospheric Dispersion Characteristics. Meteorological data collected at Lynchburg NWS for 1994 indicate that unstable atmospheric conditions occur approximately 18 percent of the time, neutral conditions approximately 76 percent of the time, and stable conditions approximately 6 percent of the time.

The wind speed and direction data at Lynchburg NWS are recorded during daylight hours only. The inclusion of observations during nighttime hours would increase the percentage of stable conditions significantly. This increase of stable conditions would tend to raise the

Table C.1.6–1. Emission Rates of Criteria and Toxic/Hazardous Pollutants at Babcock & Wilcox, 1994

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	1,678
Lead (Pb)	[a]
Nitrogen dioxide (NO_2)	36,760
Particulate matter (PM_{10})	176
Sulfur dioxide (SO_2)	2,447
Total suspended particulates (TSP)	232
Toxic/Hazardous Pollutants	
Copper compounds	218
Nitric acid	213
Sulfuric acid	53
Trichloroethylene	14,697

[a] No source indicated.

Note: kg=kilogram; yr=year.

Source: BW EPA 1995a; VA DEQ 1995b.

concentrations of pollutants at or beyond the site boundary. The calculated concentrations of pollutants are such a small percentage of the standards that any increase due to meteorological conditions would still be well below the standards.

Annual Mean Wind Speeds and Direction Frequencies. The Lynchburg NWS meteorological data for wind speed and direction for 1994 are presented in Figure C.1.6–1 as a wind rose. As shown in this figure, the maximum wind direction frequency is from the south-southwest with a secondary maximum from the southwest. The mean wind speed from the south-southwest is 1.7 m/s (3.8 mph) and from the southwest is 1.8 m/s (4 mph), while the maximum mean wind speed is 2.1 m/s (4.7 mph) from the west.

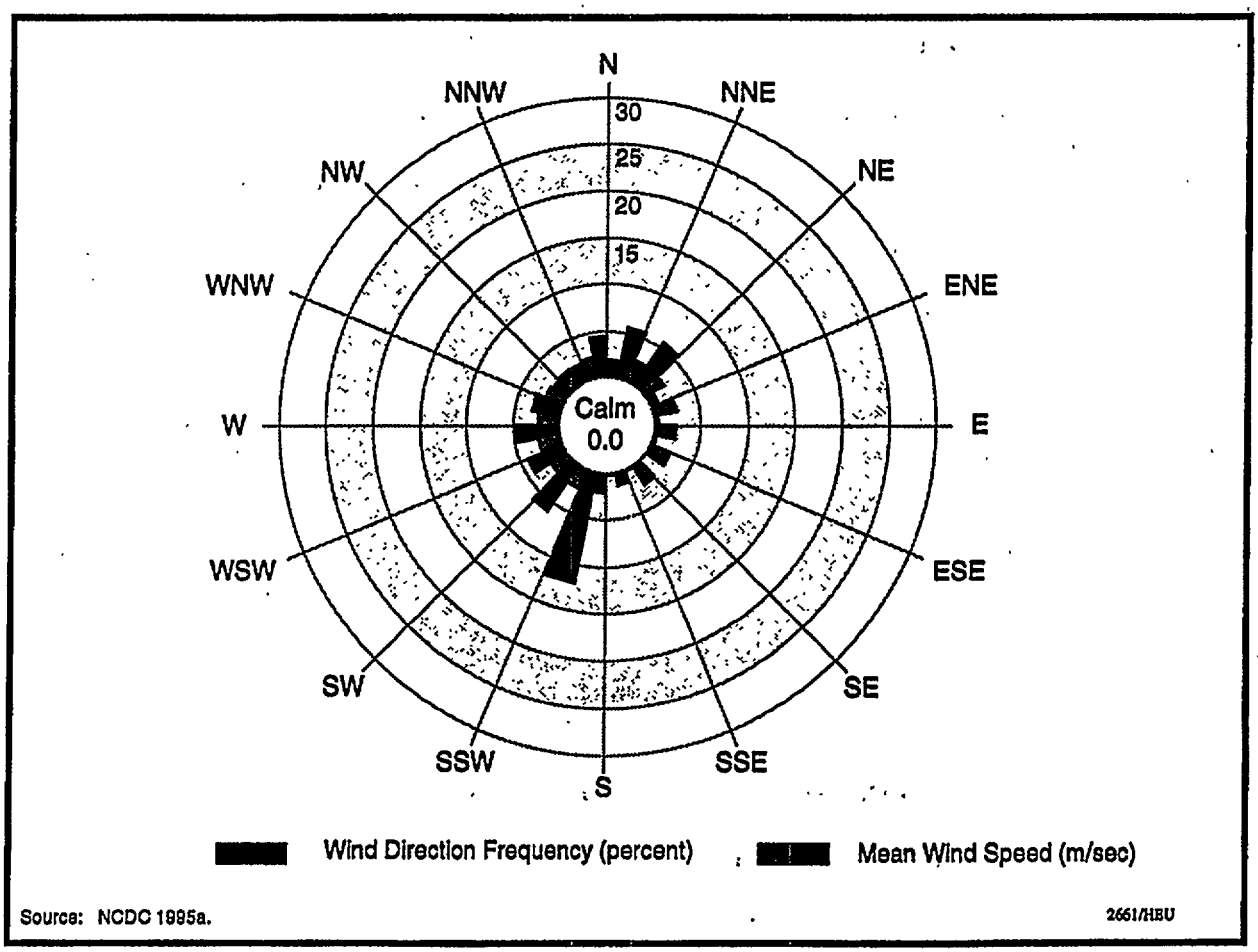

Figure C.1.6–1. Lynchburg, Virginia–National Weather Service Meteorological Data, 1994.

C.1.7 Nuclear Fuel Services, Inc.

This section provides information on climatology and meteorology, emission rates, modeling assumptions, atmospheric dispersion characteristics, and annual mean wind speeds and direction frequencies (Figure C.1.7–1) at NFS located at Erwin, Tennessee.

Climatology and Meteorology. The climate of the Erwin vicinity is characterized by warm, humid summers and relatively mild winters. Cooler, drier weather in the area is usually associated with polar continental air masses, whereas warmer, wetter weather is associated with gulf maritime air masses.

The average annual temperature in the Erwin area is 13.1 °C (55.5 °F); temperatures may vary from an average daily minimum of -4.3 °C (24.3 °F) in January to an average daily maximum of 29.2 °C (84.6 °F) in July. Relative humidity readings taken four times per day range from 51 percent in April to 93 percent in August and September (NOAA 1994c:3).

The annual precipitation in the Erwin area is 103 cm (40.7 in). The maximum monthly precipitation recorded near Erwin was 24.7 cm (9.7 in) in July 1949, while the maximum precipitation observed in a 24-hour period was 9.3 cm (3.7 in) recorded in October 1964. The average annual snowfall as measured near Erwin is 40.1 cm (15.8 in).

The annual average wind speed is approximately 2.5 m/s (5.5 mph). The fastest mile wind speed recorded at the Bristol, Johnson City, Kingsport NWS station was 22.4 m/s (50.1 mph) in May 1951. Peak gust wind recorded was 28.2 m/s (63.1 mph) in April 1991 (NOAA 1994c:3).

The average number of thunderstorm days per year near Erwin is 42.8 (NOAA 1994c:3).

Severe storms are infrequent in the Erwin region, which is east of the center of tornado activity, south of most blizzard conditions, and too far inland to be often affected by hurricanes. Only one tornado has been recorded in Unicoi County since 1950 (NRC 1991a:3-1, 3-3).

Emission Rates. Table C.1.7–1 presents the emission rates of criteria pollutants determined from operating permits issued between 1981 and 1994 by the Tennessee Air Pollution Control Board pursuant to the *Tennessee Air Quality Act*. Toxic/hazardous pollutant emissions presented in the table were obtained from the Toxic Chemical Release Form R required by Section 313 of the *Emergency Planning and Community Right-to-Know Act* of 1986, also known as Title III of the *Superfund Amendments and Reauthorization Act*. These emission rates were used as input into the ISCST2 model to estimate pollutant concentrations.

Table C.1.7–1. Emission Rates of Criteria and Toxic/Hazardous Pollutants at Nuclear Fuel Services, 1994

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	7,146
Lead (Pb)	[a]
Nitrogen dioxide (NO_2)	33,865
Particulate matter (PM_{10})[b]	1,558
Sulfur dioxide (SO_2)	1,081
Total suspended particulates (TSP)[b]	1,558
Volatile organic compounds (VOC)	6,918
Hydrogen fluoride (HF)	405
Toxic/Hazardous Pollutants	
Ammonia	9,573
Nitric acid	242

[a] No source indicated.

[b] It is conservatively assumed that all PM_{10} emissions are TSP emissions.

Note: kg=kilogram; yr=year.

Source: NF DEC nda; NF EPA 1994a.

Modeling Assumptions. Additional model input used to estimate maximum pollutant concentrations at or beyond the NFS site boundary includes: criteria pollutant emissions modeled from stack 416 at a height of 33 m (108 ft), a stack diameter of 1.52 m (5 ft), an exit velocity of 11.57 m/s (38 ft/s) (NF NRC 1991a:2-14), and an exit temperature of 177 °C (350 °F); toxic/hazardous pollutant emissions were modeled from a centrally located stack in the Building 300 complex at a height of 10 m (32.8 ft), a stack diameter of 0.3 m (1 ft), an exit velocity of 0.03 m/s (0.1 ft/s), and an exit temperature equal to ambient temperature.

Atmospheric Dispersion Characteristics. Meteorological data collected at NFS for the period March 1994 through February 1995 indicate that unstable atmospheric conditions occur approximately

77 percent of the time, neutral conditions approximately 22 percent of the time, and stable conditions approximately 1 percent of the time.

Annual Mean Wind Speeds and Direction Frequencies. The onsite meteorological data for wind speed and direction for the period March 1994 through February 1995 are presented in Figure C.1.7–1 as a wind rose. As shown in this figure, the maximum wind direction frequency is from the south-southwest with a secondary maximum from the north-northwest. The mean wind speed from the south-southwest is 3 m/s (6.7 mph) and from the north-northwest is 3 m/s (6.7 mph), while the maximum mean wind speed is 3.6 m/s (8.1 mph) from the south-southeast.

C.2 AIR QUALITY IMPACTS OF BLENDING FACILITIES

Potential ambient air quality impacts of the emissions that result from operating the HEU conversion and blending facilities at each site were analyzed using ISCST2 as described in Section C.1.2. The source of the blending facility emissions is assumed to be that which is described under the section, Modeling Assumptions, for each of the candidate sites. The model input data include the emission inventories for each of the blending facilities as presented in Tables C.2–1 through C.2–4.

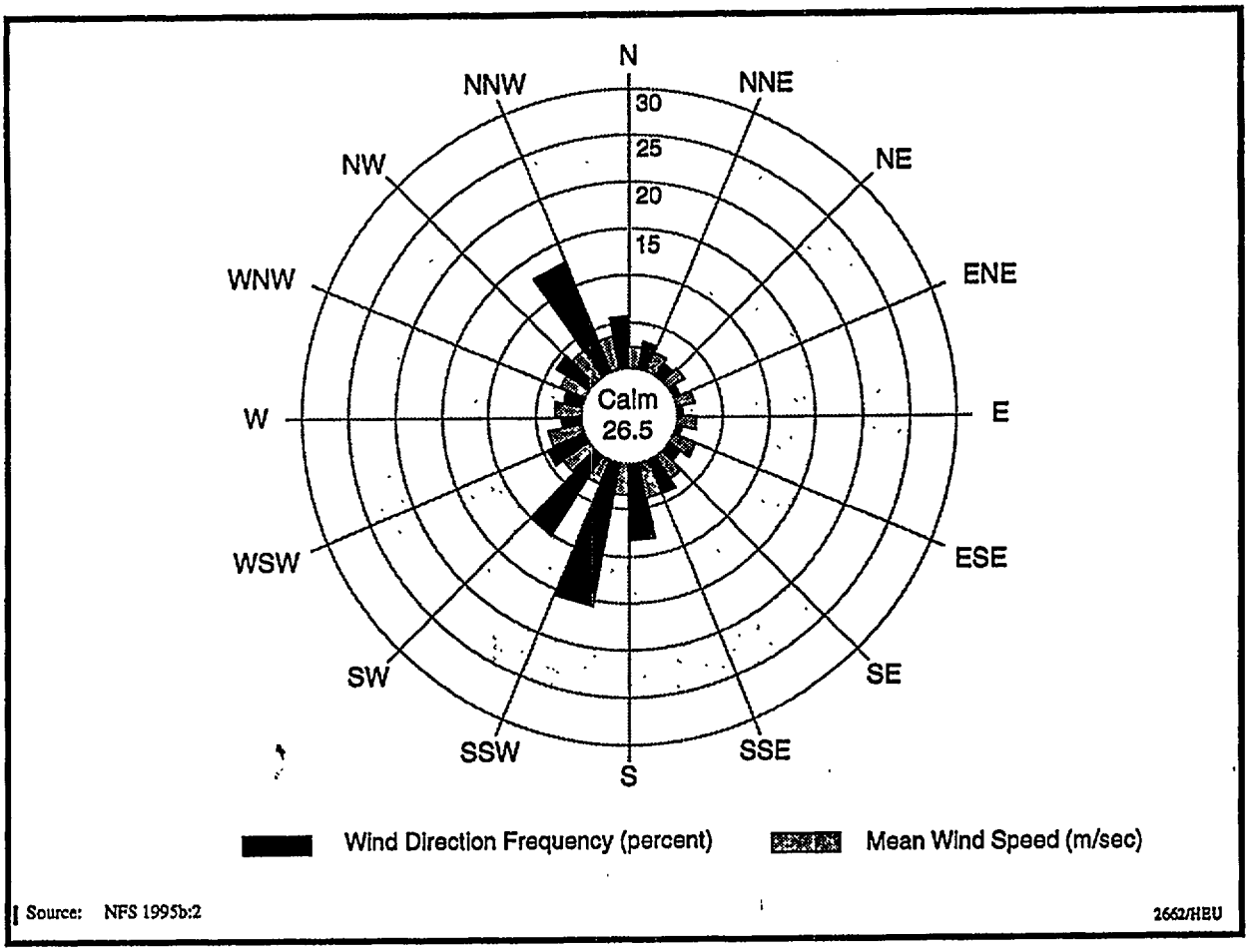

Figure C.1.7–1. Nuclear Fuel Services, Meteorological Data, March 1994 through February 1995.

Table C.2–1. Emission Rates of Pollutants for a Conversion and Blending Facility— Highly Enriched Uranium to Low-Enriched Uranium as Uranyl Nitrate Hexahydrate for the Department of Energy Sites

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	2,160
Lead (Pb)	[a]
Nitrogen dioxide (NO_2)	7,300
Ozone (O_3)[b]	215
Particulate matter (PM_{10})	170
Sulfur dioxide (SO_2)	13,500
Total suspended particulates (TSP)	37,000

[a] No emissions from this process.

[b] Based on estimated generation of volatile organic compounds (VOCs).

Note: kg=kilogram; yr=year.

Source: OR LMES 1995b.

[Table deleted.]

Table C.2–2. Emission Rates of Pollutants for a Conversion and Blending Facility— Highly Enriched Uranium to Low-Enriched Uranium as Metal for the Y–12 Plant

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	1,260
Lead (Pb)	[a]
Nitrogen dioxide (NO_2)	2,600
Ozone (O_3)[b]	106
Particulate matter (PM_{10})	125
Sulfur dioxide (SO_2)	4,700
Total suspended particulates (TSP)	13,000

[a] No emissions from this process.

[b] Based on estimated generation of VOCs.

Note: kg=kilogram; yr=year.

Source: OR LMES 1995c.

[Table deleted.]

C.3 NOISE

C.3.1 INTRODUCTION

This section provides a summary of local noise regulations. A qualitative discussion of operation noise sources and the potential for noise impacts is provided in Sections 3.3.3, 3.4.3, 3.5.3, and 3.6.3, Affected Environment, and 4.3.1.2, 4.3.2.2, 4.3.3.2, 4.3.4.2, and 4.6.2.2, Environmental Consequences.

Table C.2–3. Emission Rates of Pollutants for a Conversion and Blending Facility— Highly Enriched Uranium to Low-Enriched Uranium as Uranyl Nitrate Hexahydrate for Two Commercial Sites

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	2,172
Lead (Pb)	[a]
Nitrogen dioxide (NO_2)	1,089
Ozone (O_3)[b]	200
Particulate matter (PM_{10})[c]	169
Sulfur dioxide (SO_2)	1,956
Total suspended particulates (TSP)[c]	169

[a] No emissions for this process.

[b] Based on estimated generation of VOCs.

[c] It is conservatively assumed that all PM_{10} emissions are TSP emissions.

Note: kg=kilogram; yr=year.

Source: OR LMES 1995b; ORR 1995a:9.

Table C.2–4. Emission Rates of Pollutants for a Conversion and Blending Facility— Highly Enriched Uranium to Low-Enriched Uranium as Uranium Hexafluoride for Two Commercial Sites

Pollutant	Emission Rate (kg/yr)
Carbon monoxide (CO)	2,258
Lead (Pb)	[a]
Nitrogen dioxide (NO_2)	1,433
Ozone (O_3)[b]	200
Particulate matter (PM_{10})[c]	203
Sulfur dioxide (SO_2)	2,934
Total suspended particulates (TSP)[c]	203
Gaseous fluorides (as HF)	[d]

[a] No emissions for this process.

[b] Based on estimated generation of VOCs.

[c] It is conservatively assumed that all PM_{10} emissions are TSP emissions.

[d] Trace.

Note: kg=kilogram; yr=year.

Source: OR LMES 1995a; ORR 1995a:9.

The Occupational Safety and Health Administration (OSHA) standards for occupational noise exposure (29 CFR 1910) are applicable for worker protection at the site.

C.3.2 SUPPORTING DATA

This section provides a discussion of local noise regulations and presents any available sound level monitoring data for the sites. There are no community noise regulations applicable to B&W and NFS.

C.3.2.1 Oak Ridge Reservation

Maximum allowable noise limits for the city of Oak Ridge are presented in Table C.3.2.1–1.

Table C.3.2.1–1. City of Oak Ridge Maximum Allowable Noise Limits Applicable to Oak Ridge Reservation

Adjacent Use	Where Measured	Maximum Sound Level (dBA)
All residential districts	Common lot line	50
Neighborhood business district	Common lot line	55
General business district	Common lot line	60
Industrial district	Common lot line	65
Major street	Street lot line	75
Secondary residential street	Street lot line	60

Note: dBA=decibel, A-weighted.

Source: OR City 1985a.

C.3.2.2 Savannah River Site

Ambient sound level data collected at SRS in 1989 and 1990 are summarized in *Sound-Level Characterization of the Savannah River Site* (NUS-5251, August 1990). The States of Georgia and South Carolina, and the counties where SRS is located, have not yet established noise regulations that specify acceptable community noise levels except for a provision of the Aiken County Nuisance Ordinance, which limits daytime and nighttime noise by frequency band (Table C.3.2.2–1).

Table C.3.2.2–1. Aiken County Maximum Allowable Noise Levels[a]

Frequency Band (Hz)	Nighttime (9:00 p.m.-7:00 a.m.) Sound Pressure Levels (dB)	
	Nonresidential Lot Line	Residential Lot Line
20-75	69	65
75-150	60	50
150-300	56	43
300-600	51	38
600-1,200	42	33
1,200-2,400	40	30
2,400-4,800	38	28
4,800-10,000	35	20

[a] For daytime (7:00 a.m.-9:00 p.m.) sound pressure levels, apply one of the following corrections (dB) to the nighttime levels above: daytime operation only, +5; source operates less than 20 percent of any 1-hour period, +5; source operates less than 5 percent of any 1-hour period, +10; source operates less than 1 percent of any 1-hour period, +15; noise of impulsive character, -5; noise of periodic character, -5.

Note: dB=decibel; Hz=Hertz.

Source: SR County 1991a.

Appendix D
Biotic Resources

D.1 INTRODUCTION

This appendix includes a listing of the scientific names of common, nonthreatened, and nonendangered plant and animal species found in the text. Additionally, tables are presented listing flora and fauna identified by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and State governments as threatened, endangered, or other special status. Special status species include State classifications such as species of concern, or species in need of management. [Text deleted.] The threatened, endangered, and special status lists include all such species as could potentially occur in a site area regardless of their residence status (that is, breeding, year round, summer, winter, or migratory) or likelihood of being affected by project actions. Table D.1–1 lists nonthreatened and nonendangered plant and animal species for the four sites. Tables D.1–2 through D.1–5 list Federal- and State-listed threatened, endangered, and other species' status for all four sites. All tables list species in alphabetical order by common name.

Table D.1–1. Scientific Names of Common Nonthreatened and Nonendangered Plant and Animal Species Referred to in the Text

Common Name	Scientific Name	Common Name	Scientific Name
Mammals		**Fish (continued)**	
Beaver	*Castor canadensis*	Catfish	*Ictalurus spp.*
Black bear	*Ursus americanus*	Central stoneroller	*Campostoma*
Eastern cottontail	*Sylvilagus floridanus*	Common carp	*Cyprinus carpio*
Eastern gray squirrel	*Sciurus carolinensis*	Crappie	*Pomoxis spp.*
Feral hog	*Sus scrofa*	Drum	*Aplodinotus sp.*
Gray fox	*Urocyon cinereoargenteus*	Herring	*Alosa sp.*
House mouse	*Mus musculus*	Hickory shad	*Alosa mediocris*
Mink	*Mustela vison*	Lake chubsucker	*Erimyzon sucetta*
Opossum	*Didelphis marsupialis*	Largemouth bass	*Micropterus salmoides*
Raccoon	*Procyon lotor*	Mosquitofish	*Gambusia affinis*
Red fox	*Vulpes vulpes*	Mud sunfish	*Acantharchus pomotis*
White-footed mouse	*Peromyscus leucopus*	Olive darter	*Percina squamata*
Whitetail deer	*Odocoileus virginianus*	Pickerel	*Esox spp.*
Birds		Redfin pickerel	*Esox americanus*
Carolina chickadee	*Parus carolinensis*	Sauger	*Stizostedion canadense*
Common crow	*Corvus brachyrhynchos*	Shad	*Clupeidae*
European starling	*Sturnus vulgaris*	Smallmouth bass	*Micropterns dolomieu*
Great horned owl	*Bubo virginianus*	Spotted bass	*Micropterus punctulatus*
Mourning dove	*Zenaida macroura*	Striped bass	*Morone saxatilis*
Northern bobwhite	*Colinus virginianus*	Sunfish	*Lepomis spp.*
Northern cardinal	*Cardinalis cardinalis*	White crappie	*Pomoxis annularis*
Red-tailed hawk	*Buteo jamaicensis*	**Plants**	
Ruffed grouse	*Bonasa umbellus*	Hemlock	*Tsuga canadensis*
Wild turkey	*Meleagris gallopavo*	Hickory	*Carya spp.*
Reptiles		Loblolly pine	*Pinus taeda*
Eastern box turtle	*Terrapene carolina*	Longleaf pine	*Pinus palustris*
Eastern garter snake	*Thamnophis sirtalis*	Oak	*Quercus spp.*
Amphibians		Post oak	*Quercus stelata*
American toad	*Bufo americanus*	Red oak	*Quercus rubra*
Slimy salamander	*Plethodon glutinosus*	Shortleaf pine	*Pinus echinata*
Fish		Slash pine	*Pinus elliottii*
American shad	*Alosa sapidissima*	Virginia pine	*Pinus virginiana*
Black crappie	*Pomoxis nigromaculatus*	White oak	*Quercus alba*
Bluegill	*Lepomis macrochirus*	White pine	*Pinus strobus*
Bream	*Lepomis spp.*	Yellow-poplar	*Liriodendron tulipfera*

Table D.1–2. Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found on the Site or in the Vicinity of Oak Ridge Reservation

Common Name	Scientific Name	Status[a] Federal	Status[a] State
Mammals			
Alleghany woodrat	*Neotoma magister*	NL	D
Eastern cougar[b]	*Felis concolor couguar*	E	E
Eastern small-footed bat	*Myotis leibii*	NL	D
Gray bat[b]	*Myotis grisescens*	E	E
Indiana bat[b]	*Myotis sodalis*	E	E
Rafinesque's big-eared bat	*Plecotus rafinesquii*	NL	D
River otter	*Lutra canadensis*	NL	T
Smoky shrew	*Sorex fumeus*	NL	D
Southeastern shrew	*Sorex longirostris*	NL	D
Birds			
American peregrine falcon[b]	*Falco peregrinus anatum*	E	E
Appalachian Bewick's wren	*Thryomanes bewickii altus*	NL	T
Arctic peregrine falcon	*Falco peregrinus tundrius*	E (S/A)	E
Bachman's sparrow	*Aimophila aestivalis*	NL	E
Bald eagle[b,c]	*Haliaeetus leucocephalus*	T	T
Barn owl[d]	*Tyto alba*	NL	D
Cooper's hawk[d]	*Accipiter cooperii*	NL	D
Grasshopper sparrow	*Ammodramus savannarum*	NL	D
Northern harrier	*Circus cyaneus*	NL	D
Osprey[d]	*Pandion haliaetus*	NL	T
Red-cockaded woodpecker	*Picoides borealis*	E	E
Sharp-shinned hawk[d]	*Accipiter striatus*	NL	D
Swainson's warbler	*Limnothlypis swainsonii*	NL	D
Reptiles			
Eastern slender glass lizard	*Ophisaurus attenuatus longicaudus*	NL	D
Northern pine snake	*Pituophis melanoleucus melanoleucus*	NL	T
Amphibians			
[Text deleted.]			
Hellbender[d]	*Cryptobranchus alleganiensis*	NL	D
Tennessee cave salamander	*Gyrinophilus palleucus*	NL	T
Fish			
Alabama shad	*Alosa alabamae*	NL	D
Amber darter	*Percina antesella*	E	E
Blue sucker	*Cycleptus elongatus*	NL	T
Flame chub	*Hemitremia flammea*	NL	D
Frecklebelly madtom	*Noturus munitus*	NL	T
Highfin carpsucker	*Carpiodes velifer*	NL	D
Spotfin chub[b]	*Cyprinella monacha*	T	E
Tennessee dace[d]	*Phoxinus tennesseensis*	NL	D
Yellowfin madtom[b]	*Noturus flavipinnis*	T	E

Table D.1–2. Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found on the Site or in the Vicinity of Oak Ridge Reservation—Continued

Common Name	Scientific Name	Status[a]	
		Federal	State
Invertebrates			
Alabama lampmussel[b]	*Lampsilis virescens*	E	E
Appalachian monkeyface pearlymussel[b]	*Quadrula sparsa*	E	E
Birdwing pearlymussel[b]	*Conradilla caelata*	E	E
Cumberland bean pearlymussel[b]	*Villosa trabalis*	E	E
Cumberland monkeyface pearlymussel[b]	*Quadrula intermedia*	E	E
Dromedary pearlymussel[b]	*Dromus dromas*	E	E
Fine-rayed pigtoe[b]	*Fusconaia cuneolus*	E	E
Green-blossom pearlymussel[b]	*Epioblasma torulosa gubernaculum*	E	E
Orange-footed pearlymussel[b]	*Plethobasus cooperianus*	E	E
Painted snake coiled forest snail	*Anguispira picta*	T	E
Pale lilliput pearlymussel[b]	*Toxolasma cylindrellus*	E	E
Pink mucket pearlymussel[b]	*Lampsilis abrupta*	E	E
Rough pigtoe[b]	*Pleurobema plenum*	E	E
Shiny pigtoe[b]	*Fusconaia cor*	E	E
Tan riffleshell[b]	*Epioblasma walkeri*	E	E
Tubercled-blossom pearlymussel[b]	*Epioblasma torulosa torulosa*	E	E
Turgid-blossom pearlymussel[b]	*Epioblasma turgidula*	E	E
White wartyback pearlymussel[b]	*Plethobasus cicatricosus*	E	E
Yellow-blossom pearlymussel[b]	*Epioblasma florentina florentina*	E	E
Plants			
American barberry	*Berberis canadensis*	NL	SpC
American ginseng[d]	*Panax quinquefolius*	NL	T
Appalachian bugbane[d]	*Cimicifuga rubifolia*	NL	T
Auriculate false-foxglove	*Tomanthera auriculata*	NL	E
Branching whitlowgrass	*Draba ramosissima*	NL	SpC
Butternut[d]	*Juglans cinerea*	NL	T
Canada (wild yellow) lily[d]	*Lilium canadense*	NL	T
Carey's saxifrage[d]	*Saxifraga careyana*	NL	SpC
Fen orchid[d]	*Liparis loeselii*	NL	E
Golden seal[d]	*Hydrastis canadensis*	NL	T
Gravid sedge[d]	*Carex gravida*	NL	SpC
Heartleaf meehania	*Meehania cordata*	NL	T
Heller's catfoot	*Gnaphalium helleri*	NL	SpC
Lesser ladies' tresses[d]	*Spiranthes ovalis*	NL	SpC
Michigan lily[d]	*Lilium michiganense*	NL	T
Mountain honeysuckle	*Lonicera dioica*	NL	SpC
Mountain witch alder[d]	*Fothergilla major*	NL	T
Northern bush honeysuckle[d]	*Diervilla lonicera*	NL	T
Nuttall waterweed[d]	*Elodea nuttallii*	NL	SpC
Pink lady's-slipper[d]	*Cypripedium acaule*	NL	E

Table D.1–2. Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found on the Site or in the Vicinity of Oak Ridge Reservation—Continued

Common Name	Scientific Name	Status[a]	
		Federal	State
Plants (continued)			
Prairie goldenrod	*Solidago ptarmicoides*	NL	E
Purple fringeless orchid[d]	*Platanthera peramoena*	NL	T
Slender blazing star	*Liatris cylindracea*	NL	E
Spreading false foxglove[d]	*Aureolaria patula*	NL	T
Swamp lousewort	*Pedicularis lanceolata*	NL	T
Tall larkspur[d]	*Delphinium exaltatum*	NL	E
Tennessee purple coneflower[b]	*Echinacea tennesseenis*	E	E
Tubercled rein-orchid[d]	*Platanthera flava var. herbiola*	NL	T
Virginia spirea	*Spiraea virginiana*	T	E
Whorled mountainmint	*Pycnanthemum verticillatum*	NL	E-P

[a] Status codes: D=deemed in need of management; E=endangered; NL=not listed; P=possibly extirpated; S/A=protected under the similarity of appearances provision of the *Endangered Species Act*; SpC=special concern; T=threatened.

[b] USFWS Recovery Plan exists for this species.

[c] Observed near ORR on Melton Hill and Watts Bar Lakes.

[d] Recent record of species occurrence on ORR.

Source: 50 CFR 17.11; 50 CFR 17.12; DOE 1995w; OR DOE 1990a; OR FWS 1992b; OR NERP 1993a; ORNL 1981a; ORNL 1984b; ORNL 1988c; TN DEC 1995a; TN DEC 1995b; TN DEC 1995c; TN DEC 1995d; TN WRC 1991a; TN WRC 1991b.

Table D.1–3. Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found on the Site or in the Vicinity of Savannah River Site

Common Name	Scientific Name	Status[a] Federal	Status[a] State
Mammals			
Meadow vole	*Microtus pennsylvanicus*	NL	SC
Rafinesque's big-eared bat[b]	*Plecotus rafinesquii*	NL	SE
Southern Appalachian eastern woodrat[b]	*Neotoma floridana haematoreia*	NL	SC
Spotted skunk[b]	*Spilogale putorius*	NL	SC
Star-nosed mole[b]	*Condylura cristata parva*	NL	SC
Swamp rabbit	*Sylvilagus aquaticus*	NL	SC
Birds			
American peregrine falcon[b,c]	*Falco peregrinus anatum*	E	SE
American swallow-tailed kite	*Elanoides forficatus*	NL	SE
Appalachian Bewick's wren[b]	*Thryomanes bewickii altus*	NL	ST
Arctic peregrine falcon[b]	*Falco peregrinus tundrius*	E (S/A)	ST
[Text deleted.]			
Bald eagle[b,c]	*Haliaeetus leucocephalus*	T	SE
Barn owl[b]	*Tyto alba*	NL	SC
Common ground dove[b]	*Columbina passerina*	NL	ST
Cooper's hawk[b]	*Accipiter cooperii*	NL	SC
[Text deleted.]			
Kirtland's warbler[b]	*Dendroica kirtlandii*	E	SE
Mississippi kite[b]	*Ictinia mississippiensis*	NL	SC
Red-cockaded woodpecker[b,c]	*Picoides borealis*	E	SE
Red-headed woodpecker[b]	*Melanerpes erythrocephalus*	NL	SC
Swainson's warbler[b]	*Limnothlypis swainsonii*	NL	SC
Wood stork[b]	*Mycteria americana*	E	SE
Reptiles			
American alligator[b]	*Alligator mississippiensis*	T (S/A)	NL
Carolina swamp snake[b]	*Seminatrix pygaea*	NL	SC
Eastern coral snake[b]	*Micrurus fulvius fulvius*	NL	SC
Green water snake[b]	*Nerodia cyclopion*	NL	SC
[Text deleted.]			
Spotted turtle[b]	*Clemmys guttata*	NL	SC
Amphibians			
Carolina crawfish frog[b]	*Rana areolata capito*	NL	SC
Eastern bird-voiced treefrog[b]	*Hyla avivoca ogechiensis*	NL	SC
Eastern tiger salamander[b]	*Ambystoma tigrinum tigrinum*	NL	SC
Northern cricket frog[b]	*Acris crepitans crepitans*	NL	SC
Pickerel frog[b]	*Rana palustris*	NL	SC
Upland chorus frog[b]	*Pseudacris triseriata feriarum*	NL	SC

Table D.1–3. Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found on the Site or in the Vicinity of Savannah River Site—Continued

Common Name	Scientific Name	Status[a] Federal	Status[a] State
Fish			
[Text deleted.]			
Shortnose sturgeon[b,c]	*Acipenser brevirostrum*	E	SE
Invertebrates			
[Text deleted.]			
Brother spike mussel	*Elliptio fraterna*	NL	SE
Plants			
[Text deleted.]			
Beak-rush[b]	*Rhynchospora inundata*	NL	SC
Beak-rush[b]	*Rhynchospora tracyi*	NL	SC
Bog spice bush[b]	*Lindera subcoriacea*	NL	RC
[Text deleted.]			
Cypress stump sedge[b]	*Carex decomposita*	NL	SC
Durand's White Oak[b]	*Quereus durandi*	NL	SC
Dwarf bladderwort[b]	*Utricularia olivacea*	NL	SC
Dwarf burhead[b]	*Echinodorus parvulus*	NL	SC
Elliott's croton[b]	*Croton elliottii*	NL	SC
Few-fruited sedge[b]	*Carex oligocarpa*	NL	SC
Florida bladderwort[b]	*Utricularia floridana*	NL	SC
Florida false loosestrife[b]	*Ludwigia spathulata*	NL	SC
Gaura[b]	*Gaura biennis*	NL	SC
Green-fringed orchid[b]	*Platanthera lacera*	NL	SC
Leafy pondweed[b]	*Potamogeton foliosus*	NL	SC
Loose water-milfoil[b]	*Myriophyllum laxum*	NL	RC
Milk-pea[b]	*Astragalus villosus*	NL	SC
Nailwort[b]	*Paronychia americana*	NL	SC
Nestronia[b]	*Nestronia umbellula*	NL	SC
Nutmeg hickory[b]	*Carya myristiciformis*	NL	RC
Oconee azalea[b]	*Rhododendrom flammeum*	NL	SC
Pink tickseed[b]	*Coreopsis rosea*	NL	RC
Quill-leaved swamp potato[b]	*Sagittaria isoetiformis*	NL	SC
Sandhill lily[b]	*Nolina georgiana*	NL	SC
Smooth coneflower[b]	*Echinacea laevigata*	E	-[d]
Trepocarpus[b]	*Trepocarpus aethusae*	NL	SC
Wild water-celery[b]	*Vallisneria americana*	NL	SC
Yellow cress[b]	*Rorippa sessiliflora*	NL	SC
Yellow wild indigo[b]	*Baptisia lanceolata*	NL	SC

[a] Status codes: E=endangered; NL=not listed; RC=regional of concern (unofficial, plants only); S/A=protected under the similarity of appearances provision of the *Endangered Species Act*; SC=state of concern; SE=State endangered (official state list-animals only); ST=State threatened (official state list-animals only); T=threatened.

[b] Species occurrence recorded on SRS.

[c] USFWS Recovery Plan exists for this species.

[d] There is no official threatened or endangered status for plant species; defer to Federal standard.

Source: 50 CFR 17.11; 50 CFR 17.12; DOE 1992e; SC WD 1995a; SR NERP 1990b; WSRC 1989e; WSRC 1993b.

Table D.1–4. Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found on the Site or in the Vicinity of the Babcock & Wilcox Facility

Common Name	Scientific Name	Status[a] Federal	Status[a] State
Mammals			
Eastern cougar[b]	*Felis concolor couguar*	E	E
Indiana bat	*Myotis sodalis*	E	E
River otter	*Lutra canadensis*	NL	SpC
Virginia big-eared bat	*Plecotus townsendii virginianus*	E	E
Birds			
Alder flycatcher	*Empidonax alnorum*	NL	SpC
Appalachian Bewick's wren	*Thryomanes bewickii altus*	NL	E
Bachman's sparrow	*Aimophila aestivalis*	NL	T
Bald eagle[b]	*Haliaeetus leucocephalus*	T	E
Barn-owl	*Tyto alba*	NL	SpC
Brown creeper	*Certhia americana*	NL	SpC
[Text deleted.]			
Common moorhen	*Gallinula chloropus cachinnans*	NL	SpC
Dickcissel	*Spiza americana*	NL	SpC
Golden-crowned kinglet	*Regulus satrapa*	NL	SpC
Golden-winged warbler	*Vermivora chrysoptera*	NL	SpC
Henslow's sparrow	*Ammodramus henslowii*	NL	T
Hermit thrush	*Catharus guttatus*	NL	SpC
[Text deleted.]			
Long-eared owl	*Asio otus*	NL	SpC
Magnolia warbler	*Dendroica magnolia*	NL	SpC
Migrant loggerhead shrike	*Lanius ludovicianus migrans*	NL	T
Mourning warbler	*Oporornis philadelphia*	NL	SpC
Northern harrier	*Circus cyaneus*	NL	SpC
Northern saw-whet owl	*Aegolius acadicus*	NL	SpC
Peregrine falcon[b]	*Falco peregrinus*	E (S/A)	E
Purple finch	*Carpodacus purpureus*	NL	SpC
Red-breasted nuthatch	*Sitta canadensis*	NL	SpC
Red crossbill	*Loxia curvirostra*	NL	SpC
Sedge wren	*Cistothorus platensis*	NL	SpC
Swainson's warbler	*Limnothlypis swainsonii*	NL	SpC
Winter wren	*Troglodytes troglodytes*	NL	SpC
Yellow-bellied flycatcher	*Empidonax flaviventris*	NL	SpC
Reptiles			
Canebrake rattlesnake	*Crotalus horridus atricaudatus*	NL	E

[a] Status codes: E=endangered; NL=not listed; S/A=protected under the similarity of appearances provision of the *Endangered Species Act*; SpC=special concern; T=threatened.

[b] USFWS Recovery Plan exists for this species.

Source: 50 CFR 17.11; VA DGIF 1993a; VA DGIF 1993b.

Table D.1–5. Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found on the Site or in the Vicinity of the Nuclear Fuel Services Facility

Common Name	Scientific Name	Status[a]	
		Federal	State
Mammals			
Eastern cougar[b]	*Felis concolor couguar*	E	E
Gray bat[b]	*Myotis grisescens*	E	E
Indiana bat[b]	*Myotis sodalis*	E	E
River otter	*Lutra canadensis*	NL	T
Birds			
Appalachian Bewick's wren	*Thryomanes bewickii altus*	NL	T
Bachman's sparrow	*Aimophila aestivalis*	NL	E
Bald eagle[b]	*Haliaeetus leucocephalus*	T	T
[Text deleted.]			
Common raven	*Corvus corax*	NL	T
Cooper's hawk	*Accipiter cooperii*	NL	D
Golden eagle	*Aquila chrysaetos*	NL	T
Grasshopper sparrow	*Ammodramus savannarum*	NL	D
Northern harrier	*Circus cyaneus*	NL	D
Osprey	*Pandion haliaetus*	NL	T
Peregrine falcon[b]	*Falcon peregrinus*	E (S/A)	E
Red-cockaded woodpecker[b]	*Picoides borealis*	E	E
Sharp-shinned hawk	*Accipiter striatus*	NL	D
Reptiles			
Northern pine snake	*Pituophis melanoleucus melanoleucus*	NL	T
Amphibians			
Tennessee cave salamander	*Gyrinophilus palleucus*	NL	T
Fish			
Highfin carpsucker	*Carpiodes velifer*	NL	D
Sharphead darter	*Etheostoma acuticeps*	NL	D

[a] Status codes: D=deemed in need of management; E=endangered; NL=not listed; S/A=protected under the similarity of appearances provision of the *Endangered Species Act*; T=threatened.

[b] USFWS Recovery Plan exists for this species.

Source: 50 CFR 17.11; NF NRC 1991a; TN DEC 1995a.

Appendix E
Human Health

E.1 INTRODUCTION

Supplemental information on the potential impacts to humans from the normal operational releases of radioactivity and hazardous chemicals from the various blending technologies and their associated facilities is presented in this appendix. This information is intended to support assessments of normal operation for the highly enriched uranium (HEU) blending options described in the public and occupational health subsections of Sections 4.2 through 4.3 of this environmental impact statement (EIS). Section E.2 provides information on radiological impacts during normal operations, while Section E.3 provides information on hazardous chemical impacts during normal operations. Section E.4 provides information on health effects studies. Section E.5 describes radiological and hazardous chemical impacts during accident conditions.

E.2 RADIOLOGICAL IMPACTS TO HUMAN HEALTH

Section E.2 presents supporting information on the potential radiological impacts to humans during normal site operations. This section provides background information on the nature of radiation (Section E.2.1), the methodology used to calculate radiological impacts (Section E.2.2), and radiological releases from potential sites that could assume HEU blending processes (Section E.2.3).

E.2.1 BACKGROUND

E.2.1.1 Nature of Radiation and Its Effects on Humans

What is Radiation? Humans are constantly exposed to radiation from the solar system and from the earth's rocks and soil. This radiation contributes to the natural background radiation that has always surrounded us. But there are also man-made sources of radiation, such as medical and dental x-rays, household smoke detectors, and materials released from nuclear and coal-fired powerplants.

All matter in the universe is composed of atoms, and radiation comes from the activity of these tiny particles. Atoms are made up of even smaller particles (protons, neutrons, and electrons). The number and arrangement of these particles distinguishes one atom from another.

Atoms of different types are known as elements. There are over 100 natural and man-made elements. Some of these elements, such as uranium, radium, plutonium, and thorium, share a very important quality: they are unstable. As they change into more stable forms, invisible waves of energy or particles, known as ionizing radiation, are released. Radioactivity is the emitting of this radiation.

Ionizing radiation refers to the fact that this energy force can ionize, or electrically charge atoms by stripping off electrons. Ionizing radiation can cause a change in the chemical composition of many things, including living tissue (organs), which can affect the way they function.

The effects on people of radiation that is emitted during disintegration (decay) of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. Alpha particles are the heaviest of these direct types of ionizing radiation, and, despite a speed of about 16,000 kilometers per second (km/s) (9,940 miles per second [mi/s]), they can travel only several centimeters in the air. Alpha particles lose their energy almost as soon as they collide with anything. They can easily be stopped by a sheet of paper or the skin's surface.

Beta particles are much lighter than alpha particles. They can travel as fast as 160,000 km/s (99,400 mi/s) and can travel in the air for a distance of about 3 meters (m) (9.8 feet [ft]). Beta particles can pass through a sheet of paper but may be stopped by a thin sheet of aluminum foil or glass.

Gamma and x-rays, unlike alpha or beta particles, are waves of pure energy. Gamma rays travel at the speed of light (300,000 km/s [186,000 mi/s]). Gamma

radiation is very penetrating and requires a thick wall of concrete, lead, or steel to stop it.

The neutron is another particle that contributes to radiation exposure, both directly and indirectly. Indirect exposure is associated with the gamma rays and alpha particles that are emitted following neutron capture in matter. A neutron has about one quarter the weight of an alpha particle and can travel at speeds of up to 39,000 km/s (24,200 mi/s). Neutrons are more penetrating than beta particles, but less than gamma rays.

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. For example, a quantity of iodine-131, a material that has a half-life of 8 days, will lose 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. Eventually, the radioactivity will essentially disappear. 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 a radioactive element gives up its radioactivity, it often changes to an entirely different element, one that may or may not be radioactive. Eventually, a stable element is formed. This transformation may take place in several steps and is known as a decay chain. Radium, for example, is a naturally occurring radioactive element with 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 to polonium and, through a series of steps, to bismuth, and ultimately to lead.

Units of Radiation Measure. Scientists and engineers use a variety of units to measure radiation. These different units can be used to determine the amount, type, and intensity of radiation. Just as heat can be measured in terms of its intensity or its effects using units of calories or degrees, amounts of radiation can be measured in curies, rads, or rems.

The curie, named after the French scientists Marie and Pierre Curie, describes the "intensity" of a sample of radioactive material. The rate of decay of 1 gram of radium is the basis of this unit of measure. It is equal to 3.7×10^{10} disintegrations (decays) per second.

The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The rad is the unit of measurement for the physical absorption of radiation. Much like sunlight heats the pavement by giving up an amount of energy to it, radiation gives up rads of 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.

A roentgen equivalent man (rem) is a measurement of the dose from radiation based on its biological effects. The rem is used to measure the effects of radiation on the body, much like degrees Celsius can be used to measure the effects of sunlight heating pavement. Thus, 1 rem of one type of radiation is presumed to have the same biological effects as 1 rem of any other type of radiation. This standard allows comparison of the biological effects of radionuclides that emit different types of radiation.

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

The three types of doses calculated in this EIS include an external dose, an internal dose, and a combined external and internal dose. Each type of dose is discussed below.

External Dose. The external dose can arise from several different pathways. The radiation causing the exposure is external to the body in all of these pathways. In this EIS, these pathways include exposure to a cloud of radiation passing over the receptor, standing on ground that is contaminated with radioactivity, swimming in contaminated water, and boating in contaminated water. The appropriate measure of dose is called the effective dose equivalent. It should be noted that if the receptor departs from the source of radiation exposure, his

dose rate will be reduced. It is assumed that external exposure occurs uniformly during the year.

Internal Dose. The internal dose arises from a radiation source entering the human body through either ingestion of contaminated food and water or inhalation of contaminated air. In this EIS, pathways for internal exposure include ingestion of crops contaminated either by airborne radiation depositing on the crops or by irrigation of crops using contaminated water sources, ingestion of animal products from animals that ingested contaminated food, ingestion of contaminated water, inhalation of contaminated air, and absorption of contaminated water through the skin during swimming. Unlike external exposures, once the radiation enters the body, it remains there for various periods of time, depending on decay and biological elimination rates. The unit of measure for internal doses is the committed dose equivalent. It is the internal dose that each body organ receives from 1 "year intake" (ingestion plus inhalation). Normally, a 50- or 70-year dose-commitment period is used (that is, the 1-year intake period plus 49 or 69 years). The dose rate increases during the 1 year of intake. After the 1 year of intake, the does rate slowly declines as the radioactivity in the body continues to produce a dose. The integral of the dose rate over the 50 or 70 years gives the committed dose equivalent. In this EIS, a 50-year dose-commitment period was used.

The various organs of the body have different susceptibilities to harm from radiation. The quantity that takes these different susceptibilities into account to provide a broad indicator of the risk to the health of an individual from radiation is called the committed effective dose equivalent. It is obtained by multiplying the committed dose equivalent in each major organ or tissue by a weighting factor associated with the risk susceptibility of the tissue or organ, then summing the totals. It is possible that the committed dose equivalent to an organ is larger than the committed effective dose equivalent if that organ has a small weighting factor. The concept of committed effective dose equivalent applies only to internal pathways.

Combined External and Internal Dose. For convenience, the sum of the committed effective dose equivalent from internal pathways and the effective dose equivalent from external pathways is also called the committed effective dose equivalent in this EIS (note that in DOE Order 5400.5, this quantity is called the effective dose equivalent).

The units used in this EIS for committed dose equivalent, effective dose equivalent, and committed effective dose equivalent to an individual are the rem and mrem (1/1000 of 1 rem). The corresponding unit for the collective dose to a population (the sum of the doses to members of the population, or the product of the number of exposed individuals and their average dose) is the person-rem.

Sources of Radiation. The average person in the United States receives a total of about 350 millirem per year (mrem/yr) from all sources of radiation, both natural and man-made. The sources of radiation can be divided into six different categories: cosmic radiation, terrestrial radiation, internal radiation, consumer products, medical diagnosis and therapy, and other sources. Each category is discussed below.

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 are cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. For the sites considered in this EIS, the cosmic radiation ranged from about 27 to 45 mrem/yr. The average annual dose to the people in the United States is about 27 mrem.

External terrestrial radiation is the radiation emitted from the radioactive materials in the earth's rocks and soils. The average annual dose from external terrestrial radiation is about 28 mrem. The external terrestrial radiation for the sites in this EIS ranged from about 28 to 70 mrem/yr.

Internal radiation arises from the human body metabolizing natural radioactive material that has entered the body by inhalation or ingestion. Natural radionuclides in the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, potassium, rubidium, and carbon. The major contributor to the annual dose equivalent for internal radioactivity are the short-lived decay products of radon, which contribute about

200 mrem/yr. The average dose from other internal radionuclides is about 39 mrem/yr.

Consumer products also contain sources of ionizing radiation. In some products, like smoke detectors and airport x-ray machines, the radiation source is essential to the products' operation. In other products, such as television and tobacco, the radiation occurs incidentally to the product function. The average annual dose is about 10 mrem.

Radiation is an important diagnostic medical tool and cancer treatment. Diagnostic x-rays result in an average annual exposure of 39 mrem. Nuclear medical procedures result in an average annual exposure of 14 mrem.

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, such as uranium mines, mills and fuel processing plants, nuclear power plants, and transportation routes, has been estimated to be less than 1 mrem/yr. Radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive material from Department of Energy (DOE) and Nuclear Regulatory Commission (NRC) facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials contributes less than 1 mrem/yr to the average dose to an individual. Air travel contributes approximately 1 mrem/yr to the average dose.

The collective (or population) dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each received a dose of 1 millirem (0.001 rem), the collective dose is 1,000 persons x 0.001 rem = 1 person-rem. Alternatively, the same collective dose (1 person-rem) results from 500 people, each of whom received a dose of 2 millirem (500 persons x 2 millirem = 1 person-rem).

Limits of Radiation Exposure. The amount of man-made radiation that the public may be exposed to is limited by Federal regulations. Although most scientists believe that radiation absorbed in small doses over several years is not harmful, U.S. Government regulations assume that the effects of all radiation exposures are cumulative.

The exposure to a member of the general public from DOE facility releases into the atmosphere is limited by the Environmental Protection Agency (EPA) to an annual dose of 10 mrem, in addition to the natural background and medical radiation normally received (40 CFR 61, Subpart H). DOE also limits to 10 mrem the dose annually received from material released into the atmosphere (DOE Order 5400.5). EPA and DOE also limit the annual dose to a member of the general public from radioactive releases to drinking water to 4 mrem (40 CFR 141; DOE Order 5400.5). The annual dose from all radiation sources from a site is limited by the EPA to 25 mrem (40 CFR 190). The DOE annual limit of radiation dose to a member of the general public from all DOE facilities is 100 mrem total from all pathways (DOE Order 5400.5).

The NRC limits depend on whether the site contains nuclear power reactors or other NRC-licensed facilities. For other-than-power-reactors, the EPA limits discussed above apply. For power-reactor sites, the guideline dose values that demonstrate compliance with the as low as reasonably achievable (ALARA) philosophy apply. These limit the annual doses to a member of the public to 5 mrem from airborne emissions and to 3 mrem (per reactor) from liquid releases (10 CFR 50 Appendix I). The annual total dose limit from all pathways combined is the same as the EPA limit of 25 mrem (40 CFR 190). For people working in an occupation that involves radiation, DOE and the NRC limit doses to 5 rem (5,000 mrem) in any one year (10 CFR 20; 10 CFR 835).

E.2.1.2 Health Effects

Radiation exposure and its consequences are topics of interest to the general public. For this reason, this EIS places much emphasis on the consequences of exposure to radiation, even though the effects of radiation exposure under most circumstances evaluated in this EIS are small. This section explains the basic concepts used in the evaluation of radiation effects in order to provide the background for later discussion of impacts.

Radiation can cause a variety of ill-health effects in people. The most significant ill-health effect to depict

the consequences of environmental and occupational radiation exposure is induction of cancer fatalities. This effect is referred to as "latent" cancer fatalities because the cancer may take many years to develop and for death to occur and may not actually be the cause of death. In the discussions that follow, it should be noted that all fatal cancers are latent and the term "latent" is not used.

Health impacts from radiation exposure, whether from sources external or internal to the body, generally are identified as "somatic" (affecting the individual exposed) or "genetic" (affecting descendants of the exposed individual). Radiation is more likely to produce somatic effects than genetic effects. Therefore, for this EIS, only the somatic risks are presented. The somatic risks of most importance are the induction of cancers. Except for leukemia, which can have an induction period (time between exposure to carcinogen and cancer diagnosis) of as little as 2 to 7 years, most cancers have an induction period of more than 20 years.

For a uniform irradiation of the body, the incidence of cancer varies among organs and tissues; the thyroid and skin demonstrate a greater sensitivity than other organs. However, such cancers also produce relatively low mortality rates because they are relatively amenable to medical treatment. Because of the readily available data for cancer mortality rates and the relative scarcity of prospective epidemiologic studies, somatic effects leading to cancer fatalities rather than cancer incidence are presented in this EIS. The number of cancer fatalities can be used to compare the risks among the various alternatives.

The fatal cancer risk estimators presented in this appendix for radiation technically apply only to low-Linear Energy Transfer radiation (gamma rays and beta particles). However, on a per rem rather than a per rad basis, the fatal risk estimators are higher for this type of radiation than for high-Linear Energy Transfer radiation (alpha particles). In this EIS, the low-Linear Energy Transfer risk estimators are conservatively assumed to apply to all radiation exposures.

The National Research Council's Committee on the Biological Effects of Ionizing Radiations (BEIR) has prepared a series of reports to advise the U.S. Government on the health consequences of radiation exposures. The latest of these reports, *Health Effects of Exposure to Low Levels of Ionizing Radiation BEIR V*, published in 1990, provides the most current estimates for excess mortality from leukemia and cancers other than leukemia expected to result from exposure to ionizing radiation. The BEIR V report updates the models and risk estimates provided in the earlier report of the BEIR III Committee, *The Effects of Populations of Exposure to Low Levels of Ionizing Radiation*, published in 1980. BEIR V models were developed for application to the U.S. population.

BEIR V provides estimates that are consistently higher than those in BEIR III. This is attributed to several factors, including the use of a linear dose response model for cancers other than leukemia, revised dosimetry for the Japanese atomic bomb survivors, and additional followup studies of the atomic bomb survivors and other cohorts. BEIR III employs constant relative and absolute risk models, with separate coefficients for each of several sex-and-age-at-exposure groups, while BEIR V develops models in which the excess relative risk is expressed as a function of age at exposure, time after exposure, and sex for each of several cancer categories. BEIR III models were based on the assumption that absolute risks are comparable between the atomic bomb survivors and the U.S. population, while BEIR V models were based on the assumption that the relative risks are comparable. For a disease such as lung cancer, where baseline risks in the United States are much larger than those in Japan, the BEIR V approach leads to larger risk estimates than the BEIR III approach.

The models and risk coefficients in BEIR V were derived through analyses of relevant epidemiologic data including the Japanese atomic bomb survivors, ankylosis spondylitis patients, Canadian and Massachusetts fluoroscopy patients (breast cancer), New York postpartum mastitis patients (breast cancer), Israel Tinea Capitis patients (thyroid cancer), and Rochester thymus patients (thyroid cancer). Models for leukemia, respiratory cancer, digestive cancer, and other cancers used only the atomic bomb survivor data, although results of analyses of the ankylosis spondylitis patients were considered. Atomic bomb survivor analyses were based on revised dosimetry with an assumed Relative Biological Effectiveness of 20 for neutrons and were restricted to doses of less than 400 rads. Estimates of

risks of fatal cancers other than leukemia were obtained by totaling the estimates for breast cancer, respiratory cancer, digestive cancer, and other cancers.

Risk Estimates for Doses Received During an Accident. BEIR V includes risk estimates for a single exposure of 10 rem to a population of 100,000 people (10^6 person-rem). In this case, fatality estimates for leukemia, breast cancer, respiratory cancer, digestive cancer, and other cancers are given for both sexes and nine age-at-exposure groups. These estimates, based on the linear model, are summarized in Table E.2.1.2–1. The average risk estimate from all ages and both sexes is 885 excess cancer fatalities per million person-rem. This value has been conservatively rounded up to 1,000 excess cancer fatalities per million person-rem

Although values for other health effects are not presented in this EIS, the risk estimators for non-fatal cancers and for genetic disorders to future generations are estimated to be approximately 200 and 260 per million person-rem, respectively. These values are based on information presented in *1990 Recommendations of the International Commission on Radiological Protection* (International Commission on Radiological Protection [ICRP] Publication 60) and are seen to be 20 and 26 percent, respectively, of the fatal cancer estimator. Thus, for example, if the number of excess fatal cancers is projected to be "X," the number of excess genetic disorders would be 0.26 times "X."

Risk Estimates for Doses Received During Normal Operation. For low doses and dose rates, a linear-quadratic model was found to provide a significantly better fit to the data for leukemia than a linear one, and leukemia risks were based on a linear-quadratic function. This reduces the effects by a factor of 2 over estimates that are obtained from the linear model. For other cancers, linear models were found to provide an adequate fit to the data and were used for extrapolation to low doses. However, the BEIR V Committee recommended reducing these linear estimates by a factor between 2 and 10 for doses received at low dose rates (20 rem total). For this EIS, a risk reduction factor of 2 was adopted for conservatism.

Based on the above discussion, the resulting risk estimator would be equal to one-half the value

Table E.2.1.2–1. Lifetime Risks per 100,000 Persons Exposed to a Single Exposure of 10 Rem

	Type of Fatal Cancer		
Gender	Leukemia[a]	Cancers Other Than Leukemia	Total Cancers
Male	220	660	880
Female	160	730	890
Average	190	695	885[b]

[a] These are the linear estimates and are double the linear-quadratic estimates provided in BEIR V for leukemia at low doses and dose rates.

[b] This value has been rounded up to 1,000 excess cancer fatalities per million person-rem.

Source: NAS 1990a.

observed for accident situations or approximately 500 excess fatal cancer per million person-rem (0.0005 excess fatal cancer per person-rem). This is the risk value used in this EIS to calculate fatal cancers to the general public during normal operations. For workers, a value of 400 excess fatal cancers per million person-rem (0.0004 excess fatal cancer per person-rem) is used in this EIS. This lower value reflects the absence of children in the workforce. Again, based on information provided in ICRP Publication 60, the health risk estimators for non-fatal cancers and genetic disorders among the public are 20 and 26 percent, respectively, of the fatal cancer risk estimator. For workers, they are both 20 percent of the fatal cancer risk estimator. For this EIS, only fatal cancers are presented.

The risk estimates may be applied to calculate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to natural background radiation (0.3 rem/yr), 15 latent cancer fatalities per year of exposure would be inferred to be caused by the radiation (100,000 persons x 0.3 rem/yr x 0.0005 latent cancer fatalities per person-rem = 15 latent cancer fatalities per year).

Sometimes, calculations of the number of excess cancer fatalities associated with radiation exposure do not yield whole numbers and, especially in environmental applications, may yield numbers less than 1.0. For example, if a population of 100,000 were exposed as above, but to a total dose of only 0.001 rem, the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05

(100,000 persons x 0.001 rem x 0.0005 latent cancer fatalities/person-rem = 0.05 latent fatal cancers).

[Text deleted.] Since 0.05 is not an integral number, the interpreting of nonintegral numbers of latent cancer fatalities needs to be defined. The answer is to interpret the result as a statistical estimate. That is, 0.05 is the average number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. In most groups, no person (zero people) would incur a latent cancer fatality from the 0.001 rem dose each member would have received. In a small fraction of the groups, one latent fatal cancer would result; in exceptionally few groups, two or more latent fatal cancers would occur. The *average* number of deaths over all the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is 1/4, or 0.25). The most likely outcome is zero latent cancer fatalities.

These same concepts apply to estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The "number of latent cancer fatalities" corresponding to a single individual's exposure over a (presumed) 72-year lifetime to 0.3 rem/yr is the following:

- 1 person x 0.3 rem/yr x 72 years x 0.0005 latent cancer fatalities/person-rem = 0.011 latent cancer fatalities.

Again, this should be interpreted in a statistical sense; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.1-percent chance that the individual might incur a latent fatal cancer caused by the exposure. Presented another way, this method estimates that approximately 1.1 percent of the population might die of cancers induced by the background radiation.

E.2.2 Methodology for Estimating Radiological Impacts of Normal Operation

The radiological impacts of normal operation of reactors and support facilities were calculated using Version 1.485 of the GENII computer code (GENII–*The Hanford Environmental Radiation Dosimetry Software System* [December 1988]). Site-specific and technology-specific input data were used, including location, meteorology, population, food production and consumption, and source terms. The GENII code was used for analysis of normal operations and design basis accidents. Section E.2.2.1 briefly describes GENII and outlines the approach used for normal operations.

E.2.2.1 GENII Computer Code

The GENII computer model, developed by Pacific Northwest Laboratory for DOE, is an integrated system of various computer modules that analyze environmental contamination resulting from acute or chronic releases to, or initial contamination in, air, water, or soil. The model calculates radiation doses to individuals and populations. The GENII computer model is well documented for assumptions, technical approach, methodology, and quality assurance issues. The GENII computer model has gone through extensive quality assurance and quality control steps. These include the comparison of results from model computations against those from hand calculations, and the performance of internal and external peer reviews. Recommendations given in these reports were incorporated into the final GENII computer model, as deemed appropriate.

For this EIS, only the ENVIN, ENV, and DOSE computer modules were used. The codes are connected through data transfer files. The output of one code is stored in a file that can be used by the next code in the system. In addition, a computer code called CREGENII was prepared to aid the user with the preparation of input files into GENII.

CREGENII. The CREGENII code helps the user, through a series of interactive menus and questions, prepare a text input file for the environmental dosimetry programs. In addition, CREGENII prepares a batch processing file to manage the file handling needed to control the operations of subsequent codes and to prepare an output report.

ENVIN. The ENVIN module of the GENII code controls the reading of the input files prepared by CREGENII and organizes the input for optimal use in the environmental transport and exposure module, ENV. The ENVIN code interprets the basic input, reads the basic GENII data libraries and other optional input files, and organizes the input into

sequential segments on the basis of 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 can generate tables of atmospheric dispersion parameters that will be used in later calculations. If the finite plume air submersion option is requested in addition to the atmospheric dispersion calculations, preliminary energy-dependent finite plume dose factors also are prepared. 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 code reads the input files from ENVIN and then, for each radionuclide chain, sequentially performs the precalculations to establish the conditions at the start of the exposure scenario. Environmental concentrations of radionuclides are established at the beginning of the scenario by assuming decay of preexisting sources, considering biotic transport of existing subsurface contamination, and defining soil contamination from continuing atmospheric or irrigation depositions. Then, for each year of postulated exposure, the code estimates air, surface soil, deep soil, groundwater, and surface water concentrations of each radionuclide in the chain. Human exposures and intakes of each radionuclide are calculated for the following: (1) pathways of external exposure from atmospheric plumes, (2) inhalation, (3) external exposure from contaminated soil, sediments, and water, (4) external exposure from special geometries (that is, shielding parameters promulgated from topographic/geologic trends), and (5) internal exposures from consumption of terrestrial foods, aquatic foods, drinking water, animal products, and inadvertent intake of soil. The intermediate information on annual media concentrations and intake rates are written to data transfer files. Although these may be accessed directly, they are usually used as input to the DOSE module of GENII.

GENII is a general purpose computer code used to model dispersion, transport, and long-term exposure effects of specific radionuclides and pathways. [Text deleted.] GENII was chosen because it can model both air and surface transport pathways and is not restricted to any radionuclides.

DOSE. The DOSE module reads the annual intake and exposure rates defined by the ENV module and converts the data to radiation dose. External dose is calculated with precalculated factors from the EXTDF module or from a data file prepared outside of GENII. Internal dose is calculated with precalculated factors from the INTDF module.

EXTDF. The EXTDF module calculates the external dose-rate factors for submersion in an infinite cloud of radioactive materials, immersion in contaminated water, and direct exposure to plane or slab sources of radionuclides. EXTDF was not used. Instead, the dose rate factors listed in *External Dose Rate Factors for Calculation of Dose to the Public* (DOE/EH-0070, July 1988) were used for this EIS.

INTDF. Using *Limits for Intakes of Radionuclides by Workers* (ICRP Publication 30) model, the INTDF module calculates the internal (inhalation and ingestion) dose conversion factors of radionuclides for specific organs. The factors generated by INTDF were used for the calculations presented in this EIS.

E.2.2.2 Data and Assumptions

In order to perform the dose assessments for this EIS, different types of data must be collected and/or generated. In addition, calculational assumptions have to be made. This section discusses the data collected and/or generated for use in the dose assessment and assumptions made for this EIS.

Meteorological Data. The meteorological data used for both DOE sites were in the form of joint frequency data files. A joint frequency data file is a table listing the fractions of time the wind blows in a certain direction, at a certain speed, and within a certain stability class. The joint frequency data files were based on measurements over a 1-year period at various locations and at different heights at these two

sites. Average meteorological conditions (averaged over the 1-year period) were used for normal operation. For use in design basis accidents, the 50 percentile option was used. For the other two sites, the meteorological data presented in *Environmental Assessment for Renewal of Special Nuclear Material License No. SNM-42, Babcock & Wilcox Company, Naval Nuclear Fuel Division, Lynchburg, Virginia* (Docket No. 70-27, August 1991) and *Environmental Assessment for Renewal of Special Nuclear Material License No. SNM-124, Nuclear Fuel Services, Inc., Erwin Plant, Erwin, Tennessee* (Docket No. 70-143, August 1991) were used.

Population Data. Population distributions were based on *1990 Census of Population and Housing* data. Projections were determined for the year 2010 for areas within 80 km (50 mi) of the proposed facilities at each candidate site. The site population in 2010 was assumed to be representative of the population over the operational period evaluated and was used in the impact assessments. The population was spatially distributed on a circular grid with 16 directions and 10 radial distances up to 80 km (50 mi). The grid was centered on the facility from which the radionuclides were assumed to be released.

Source Term Data. The source terms (quantities of radionuclides released into the environment over a given period) were estimated on the basis of latest conceptual designs of facilities, and experience with similar facilities. The source terms used to generate the estimated impacts of normal operation are provided in Section E.2.3 for the potential sites that could assume HEU blending process facilities. Source terms for site-dependent facilities are included within this section.

Food Production and Consumption Data. Data from the *1987 Census of Agriculture* were used to generate site-specific data for food production. Food production was spatially distributed on the same circular grid as was used for the population distributions. The consumption rates were those used in GENII for the maximum individual and average individual. People living within the 80-km (50-mi) assessment area were assumed to consume only food grown in that area.

Calculational Assumptions. Dose assessments were performed for members of the general public and workers. Dose assessments for members of the public were performed for two different types of receptors considered in this EIS: a maximally exposed offsite individual and the general population living within 80 km (50 mi) of the facility. It was assumed that the maximally exposed individual (MEI) was located at a position on the site boundary that would yield the highest impacts during normal operation of a given alternative. If more than one facility was assumed to be operating at a site, the dose to this individual from each facility was calculated. The doses were then summed to give the total dose to this individual. An 80-km (50-mi) population dose was calculated for each operating facility at a site. These doses then were added to give the total population dose at that site.

To estimate the radiological impacts from normal operation of HEU blending facilities, additional assumptions and factors were considered in using GENII, as follows:

- No prior deposition of radionuclides on ground surfaces was assumed.
- For the maximally exposed offsite individual, the annual exposure time to the plume and to soil contamination was 0.7 years (NRC 1977b:1.109-68).
- For the population, the annual exposure time to the plume and to soil contamination was 0.5 years (NRC 1977b:1.109-68).
- A semi-infinite/finite plume model was used for air immersion doses. Other pathways evaluated were ground exposure, inhalation, ingestion of food crops and animal products contaminated by either deposition of radioactivity from the air or irrigation, ingestion of fish and other aquatic food raised in contaminated water, swimming and boating in contaminated surface water, and drinking contaminated water. It should be noted that not all pathways were available at every site.
- For atmospheric releases, it was assumed that ground level releases would occur for

all HEU blending facilities. For site-dependent facilities, reported release heights were used and assumed to be the effective stack height. Ignoring plume rise makes the resultant doses conservative.

- The calculated doses were 50-year committed doses from 1 year of intake.
- Resuspension of particulates was not considered because calculations of dust loading in the atmosphere showed that this pathway was negligible compared with others.

The exposure, uptake, and usage parameters used in the GENII model are provided in Tables E.2.2.2–1 through E.2.2.2–4.

Annual average doses to workers for no action at Oak Ridge Reservation (ORR) and Savannah River Site (SRS) were based on measured values received by radiation workers during 1992. At Babcock and Wilcox (B&W) and Nuclear Fuel Services (NFS), annual average doses to workers for no action were based on measured values received by radiation workers during 1993. The average no action dose received by a worker at these sites in future years was assumed to remain the same as the average during these earlier years. The total workforce dose in future years was calculated by multiplying the average worker dose by a projected future number of workers.

Doses to workers directly associated with HEU blending process technologies and associated facilities were taken from the reports prepared by Lockheed Martin Energy Systems, Inc. To obtain the total workforce dose at a site with a particular HEU blending process technology and associated facilities in operation, the site dose from no action was added to that from the technology and facility being evaluated. The average dose to a site worker was then calculated by dividing this dose by the total number of radiation workers at the site.

All doses to workers include a component associated with the intake of radioactivity into the body and another component resulting from external exposure to direct radiation.

E.2.2.3 Health Effects Calculations

Doses calculated by GENII were used to estimate health effects using the risk estimators presented in Section E.2.1.2. The incremental cancer fatalities in the general population and in groups of workers from radiation exposure were therefore estimated by multiplying the collective combined effective dose equivalent by 0.0005 and 0.0004 fatal cancers/person-rem, respectively. In this EIS, the collective combined effective dose equivalent is the sum of the collective committed effective dose equivalent (internal dose) and the collective effective dose equivalent (external dose) (see Section E.2.1.1).

Although health risk factors are statistical factors and therefore not strictly applicable to individuals, they have been used in the past to estimate the incremental risk to an individual from exposure to radiation. Therefore, the factors of 0.0005 and 0.0004 per rem of individual committed effective dose equivalent for a member of the public and for a worker, respectively, have also been used in this EIS to calculate the individual's incremental fatal cancer risk from exposure to radiation.

For the public, the health effects expressed in this EIS are the risk of fatal cancers to the maximally exposed individual and the number of fatal cancers to the 80-km (50-mi) population from exposure to radioactivity released from any site over the assumed operational period. For workers, the health effects expressed are the risk to the average worker at a site and the number of fatal cancers to all workers at that site from the associated period of site operations.

Table E.2.2.2–1. GENII Annual Exposure Parameters to Plumes and Soil Contamination

Maximal Individual				General Population			
External Exposure		Inhalation of Plume		External Exposure		Inhalation of Plume	
Plume (hours)	Soil Contamination (hours)	Exposure Time (hours)	Breathing Rate (cm^3/s)	Plume (hours)	Soil Contamination (hours)	Exposure Time (hours)	Breathing Rate (cm^3/s)
6,140	6,140	6,140	270	4,380	4,380	4,380	270

Note: cm^3=cubic centimeters.

Source: HNUS 1995a.

Table E.2.2.2–2. GENII Annual Usage Parameters for Consumption of Terrestrial Food

	Maximum Individual				General Population			
Food Type	Growing Time (days)	Yield (kg/m^2)	Holdup Time (days)	Consumption Rate (kg/yr)	Growing Time (days)	Yield (kg/m^2)	Holdup Time (days)	Consumption Rate (kg/yr)
Leafy Vegetables	90	1.5	1	30	90	1.5	14	15
Root Vegetables	90	4	5	220	90	4	14	140
Fruit	90	2	5	330	90	2	14	64
Grains/Cereals	90	0.8	180	80	90	0.8	180	72

Note: kg=kilograms; m^2=square meter

Source: HNUS 1995a.

Table E.2.2.2–3. GENII Annual Usage Parameters for Consumption of Animal Products

	Maximum Individual									
	Human		Stored Feed				Fresh Forage			
Food Type	Consumption Rate (kg/yr)	Holdup Time (days)	Diet Fraction	Growing Time (days)	Yield (kg/m^3)	Storage Time (days)	Diet Fraction	Growing Time (days)	Yield (kg/m^3)	Storage Time (days)
Beef	80	15	0.25	90	0.8	180	0.75	45	2	100
Poultry	18	1	1	90	0.8	180				
Milk	270	1	0.25	45	2	100	0.75	30	1.5	0
Eggs	30	1	1	90	0.8	180				
	General Population									
Beef	70	34	0.25	90	0.8	180	0.75	45	2	100
Poultry	8	34	1	90	0.8	180				
Milk	230	4	0.25	45	2	100	0.75	30	1.5	0
Eggs	20	18	1	90	0.8	180				

Note: kg=kilograms; m^3=cubic meters.

Source: HNUS 1995a.

Table E.2.2.2–4. GENII Annual Usage Parameters for Aquatic Activities

	Maximum Individual			General Population		
Activity	Transit Time to Usage Point (days)	Holdup Time (days)	Usage Rate (per year)	Transit Time to Usage Point (days)	Holdup Time (days)	Usage Rate
Drinking Water	0	0	730 l	0	0	Site dependent
Swimming	0	0	100 hr	0	0	Site dependent
Boating	0	0	100 hr	0	0	Site dependent
Shoreline	0	0	500 hr	0	0	Site dependent
Ingestion of Fish	0	0	40 kg	0	0	Site dependent
Ingestion of Mollusks	0	0	6.9 kg	0	0	Site dependent
Ingestion of Crustaceans	0	0	6.9 kg	0	0	Site dependent
Ingestion of Plants	0	0	6.9 kg	0	0	Site dependent

Source: HNUS 1995a.

E.2.3 NORMAL OPERATION RELEASES

This section presents source terms and descriptions of radiological releases to the environment from normal operation of the four potential sites (ORR, SRS, B&W, NFS), which could assume incumbent HEU blending process operations. Each site-specific table presents the source terms for each individual facility located on its particular site, as annotated in site environmental reports and referenced datacalls.

In addition, the source terms associated with the technology-specific blending process operations themselves are presented in Table E.2.3–1. It should be noted that the volume of radioisotopes released from the actual blending processes is small compared to that of normal site operation releases (as illustrated in Tables E.2.3–2 through E.2.3–8).

All of the aforementioned values were used in support of the public radiological dose (and subsequent cancer risk) calculations, which are presented in Sections 4.2 and 4.3.

The "site-specific" source terms are assumed to be the no action quantities that would exist at the time HEU blending operations would supposedly commence at the given sites; these source terms were utilized in the promulgation of the no action doses that are given in the respective environmental reports and referenced datacalls, and are also presented in Sections 4.2 and 4.3.

For further information on how source terms relate to radiological dose, see Section E.2.1.

Table E.2.3–1. Annual Atmospheric Radioactive Releases[a] From the Various Blending Process Technologies (curies)

	Technology		
Isotope	Metal	UF_6	UNH
U-235	1.1×10^{-5}	1.1×10^{-4}	6.9×10^{-5}
U-238	2.5×10^{-4}	6.2×10^{-4}	3.2×10^{-4}

[a] There are no liquid releases anticipated from the various blending technology processes.

Note: UF_6 = uranium hexaflouride; UNH = uranyl nitrate hexahydrate.

Source: OR LMES 1995a; OR LMES 1995b; OR LMES 1995c.

Table E.2.3–2. Annual Atmospheric Radioactive Releases From the Oak Ridge Reservation (curies)

	Site Facility		
Isotope	ORNL	K–25	Y–12
H-3	240	-	-
Be-7	3.8×10^{-4}	-	-
K-40	-	4.0×10^{-2}	-
Ar-41	1,800	-	-
Co-57	-	1.2×10^{-4}	-
Co-60	2.6×10^{-6}	4.4×10^{-3}	-
Sr-90[a]	3.8×10^{-4}	-	-
Tc-99	-	1.2×10^{-1}	-
Ru-106	-	4.5×10^{-3}	-
Cd-109	-	7.6×10^{-3}	-
I-129	2.5×10^{-4}	-	-
I-130	5.5×10^{-5}	-	-
I-131	5.3×10^{-2}	-	-
I-132	9.3×10^{-1}	-	-
I-133	2.0×10^{-1}	-	-
I-135	4.7×10^{-1}	-	-
Xe-135	50	-	-
Xe-138	71	-	-
Cs-134	5.2×10^{-7}	-	-
Cs-137	5.1×10^{-4}	5.0×10^{-3}	-
Cs-138	71	-	-
Ba-140	4.8×10^{-4}	-	-
Ce-141	-	2.0×10^{-4}	-
Eu-152	1.6×10^{-6}	-	-
Eu-154	2.5×10^{-6}	-	-
Eu-155	5.2×10^{-6}	-	-
Os-191	1.7×10^{-1}	-	-
Pb-212	3.7×10^{-1}	-	-
Th-228	1.5×10^{-6}	3.8×10^{-4}	-
Th-230	5.7×10^{-8}	5.9×10^{-5}	-
Th-232	3.3×10^{-8}	1.1×10^{-4}	-
Th-234	-	1.8×10^{-2}	-
U-234[b]	8.6×10^{-6}	4.0×10^{-3}	4.7×10^{-2}
U-235[b]	4.7×10^{-7}	1.8×10^{-4}	1.5×10^{-3}
U-236[b]	3.8×10^{-8}	-	1.9×10^{-4}
U-238[b]	2.8×10^{-5}	4.2×10^{-3}	6.5×10^{-3}
Np-237	-	5.7×10^{-4}	-
Pu-238	2.8×10^{-6}	2.5×10^{-4}	-
Pu-239	8.0×10^{-6}	-	-
Am-241	4.6×10^{-6}	-	-
Cm-244	7.3×10^{-5}	-	-

[a] Gross beta total is included within this value; total Sr is assumed to be Sr-90.

[b] Gross alpha total is included within these values.

Source: OR DOE 1994c.

Table E.2.3–3. Annual Atmospheric Radioactive Releases From the Savannah River Site (curies)

Isotope	Site Facility					
	DWPF[a]	SRTC	K-Reactor	L-Reactor	F-Canyon	H-Canyon
H-3	20	-	35,000	1,900	-	-
C-14	$2.1x10^{-2}$	-	-	-	$1.5x10^{-2}$	$2.1x10^{-3}$
S-35	-	-	-	-	-	-
Ar-41	-	-	-	-	-	-
Cr-51	-	-	-	-	-	-
Co-60	$6.1x10^{-8}$	-	-	-	-	-
Ni-63	-	-	-	-	-	-
Se-79	$8.8x10^{-9}$	-	-	-	-	-
Sr-89	-	-	-	-	-	-
Sr-90[b]	$2.3x10^{-5}$	$1.2x10^{-5}$	$2.0x10^{-6}$	$1.8x10^{-4}$	$1.6x10^{-3}$	$2.5x10^{-4}$
Y-90	$2.4x10^{-5}$	-	-	-	-	-
Y-91	-	-	-	-	-	-
Zr-95	-	-	-	-	-	-
Nb-95	-	-	-	-	-	-
Tc-99	$3.8x10^{-7}$	-	-	-	-	-
Ru-106	$3.2x10^{-5}$	-	-	$4.0x10^{-6}$	-	-
Rh-106	-	-	-	-	-	-
Sn-126	$6.9x10^{-8}$	-	-	-	-	-
Sb-125	$6.7x10^{-7}$	-	-	-	-	-
Te-125m	$1.0x10^{-5}$	-	-	-	-	-
Te-127m	$4.5x10^{-9}$	-	-	-	-	-
Te-127	$4.4x10^{-9}$	-	-	-	-	-
I-129	$8.2x10^{-5}$	-	-	-	$2.5x10^{-3}$	$2.4x10^{-3}$
I-131	-	$5.9x10^{-5}$	-	-	$2.9x10^{-6}$	$8.6x10^{-5}$
I-133	-	$2.0x10^{-3}$	-	-	-	-
I-135	-	-	-	-	-	-
Xe-135	-	$3.2x10^{-2}$	-	-	-	-
Cs-134	$2.9x10^{-5}$	-	-	-	$1.4x10^{-6}$	-
Cs-135	$9.4x10^{-7}$	-	-	-	-	-
Cs-137	$4.1x10^{-3}$	$1.5x10^{-6}$	$1.1x10^{-6}$	$1.0x10^{-4}$	$4.6x10^{-4}$	$4.0x10^{-5}$
Ce-144	$3.0x10^{-6}$	-	-	-	-	-
Pr-144	$3.0x10^{-6}$	-	-	-	-	-
Pm-147	$7.6x10^{-6}$	-	-	-	-	-
Sm-151	$1.6x10^{-7}$	-	-	-	-	-
Eu-152	$1.4x10^{-9}$	-	-	-	-	-
Eu-154	$2.3x10^{-7}$	-	-	-	-	-
Eu-155	$1.6x10^{-7}$	-	-	-	-	-
U-235	-	$2.9x10^{-8}$	-	-	$1.8x10^{-3}$	$9.5x10^{-5}$
Pu-238	$7.9x10^{-7}$	$1.0x10^{-8}$	-	-	$3.3x10^{-4}$	$8.8x10^{-4}$
Pu-239[c]	$7.1x10^{-9}$	$9.4x10^{-6}$	$4.4x10^{-8}$	$4.1x10^{-6}$	$8.6x10^{-4}$	$1.8x10^{-4}$
Pu-240	$4.8x10^{-9}$	-	-	-	-	-
Pu-241	$7.7x10^{-7}$	-	-	-	-	-
Am-241	$8.6x10^{-9}$	$1.3x10^{-6}$	-	-	$6.1x10^{-5}$	$8.1x10^{-5}$
Cm-244	$2.7x10^{-8}$	$6.8x10^{-6}$	-	-	$4.3x10^{-5}$	$6.5x10^{-6}$

Table E.2.3–3. Annual Atmospheric Radioactive Releases From the Savannah River Site (curies)—Continued

Isotope	Site Facility					
	CIF[a]	H-3 Facilities	RBOF	M-Area	F-Area Waste	H-Area Waste
H-3	1,200	94,000	-	-	-	1.7
C-14	-	-	-	-	-	-
S-35	-	-	-	-	-	-
Ar-41	-	-	-	-	-	-
Cr-51	$1.5x10^{-2}$	-	-	-	-	-
Co-60	$1.4x10^{-4}$	-	-	-	$5.9x10^{-9}$	-
Ni-63	-	-	-	-	-	-
Se-79	-	-	-	-	-	-
Sr-89	$6.0x10^{-4}$	-	-	-	-	-
Sr-90[b]	$2.2x10^{-2}$	-	-	$8.3x10^{-5}$	-	-
Y-90	$7.6x10^{-5}$	-	-	-	-	-
Y-91	$4.5x10^{-4}$	-	-	-	-	-
Zr-95	$4.7x10^{-4}$	-	-	-	-	-
Nb-95	$1.5x10^{-3}$	-	-	-	-	-
Tc-99	-	-	-	-	-	-
Ru-106	$1.8x10^{-4}$	-	-	-	-	$5.8x10^{-9}$
Rh-106	$1.8x10^{-4}$	-	-	-	-	-
Sn-126	-	-	-	-	-	-
Sb-125	-	-	-	-	-	-
Te-125m	-	-	-	-	-	-
Te-127m	-	-	-	-	-	-
Te-127	-	-	-	-	-	-
I-129	-	-	-	-	-	-
I-131	-	-	-	-	-	-
I-133	-	-	-	-	-	-
I-135	-	-	-	-	-	-
Xe-135	-	-	-	-	-	-
Cs-134	-	-	-	-	-	$1.1x10^{-7}$
Cs-135	-	-	-	-	-	-
Cs-137	$2.4x10^{-4}$	-	$2.1x10^{-7}$	-	$3.8x10^{-6}$	$2.2x10^{-5}$
Ce-144	$2.3x10^{-4}$	-	-	-	-	-
Pr-144	$2.3x10^{-4}$	-	-	-	-	-
Pm-147	$9.1x10^{-4}$	-	-	-	-	-
Sm-151	-	-	-	-	-	-
Eu-152	-	-	-	-	-	-
Eu-154	-	-	-	-	-	-
Eu-155	-	-	-	-	-	-
U-235	-	-	-	$1.6x10^{-5}$	$2.4x10^{-6}$	-
Pu-238	$1.4x10^{-4}$	-	-	-	$3.4x10^{-7}$	-
Pu-239[c]	$5.2x10^{-7}$	-	-	$3.5x10^{-6}$	$2.7x10^{-7}$	-
Pu-240	-	-	-	-	-	-
Pu-241	-	-	-	-	-	-
Am-241	-	-	-	-	$1.0x10^{-7}$	-
Cm-244	-	-	-	-	-	-

Table E.2.3–3. Annual Atmospheric Radioactive Releases From the Savannah River Site (curies)—Continued

Isotope	Site Facility			
	Diffuse & Fugitive	C-Reactor	P-Reactor	D-Area
H-3	43	150	1,300	450
C-14	4.0×10^{-6}	-	-	-
S-35	2.0×10^{-6}	-	-	-
Ar-41	-	-	-	-
Cr-51	-	-	-	-
Co-60	3.3×10^{-17}	-	-	-
Ni-63	2.0×10^{-7}	-	-	-
Se-79	-	-	-	-
Sr-89	-	-	-	-
Sr-90[b]	1.1×10^{-4}	-	-	7.2×10^{-6}
Y-90	-	-	-	-
Y-91	-	-	-	-
Zr-95	2.4×10^{-14}	-	-	-
Nb-95	-	-	-	-
Tc-99	-	-	-	-
Ru-106	-	-	-	-
Rh-106	-	-	-	-
Sn-126	-	-	-	-
Sb-125	-	-	-	-
Te-125m	-	-	-	-
Te-127m	-	-	-	-
Te-127	-	-	-	-
I-129	6.9×10^{-7}	-	-	-
I-131	-	-	-	-
I-133	-	-	-	-
I-135	-	-	-	-
Xe-135	-	-	-	-
Cs-134	1.4×10^{-17}	-	-	-
Cs-135	-	-	-	-
Cs-137	4.3×10^{-11}	-	-	-
Ce-144	1.1×10^{-13}	-	-	-
Pr-144	-	-	-	-
Pm-147	-	-	-	-
Sm-151	-	-	-	-
Eu-152	-	-	-	-
Eu-154	3.4×10^{-13}	-	-	-
Eu-155	1.6×10^{-13}	-	-	-
U-235	4.7×10^{-5}	-	-	-
Pu-238	4.6×10^{-12}	-	-	-
Pu-239[c]	4.7×10^{-7}	-	-	8.4×10^{-7}
Pu-240	-	-	-	-
Pu-241	-	-	-	-
Am-241	8.9×10^{-13}	-	-	-
Cm-244	7.3×10^{-12}	-	-	-

[a] Values are projected; facility presently not in operating status.

[b] Gross beta total is included within this value; total Sr is assumed to be Sr-90.

[c] Gross alpha total is included within these values.

Note: CIF=Consolidated Inceneration Facility; DWPF=Defense Waste Processing Facility; RBOF=Receiving Basin Offsite Fuel; SRTC=Savannah River Technology Center.

Source: WSRC 1994f.

Table E.2.3–4. Annual Atmospheric[a] Radioactive Releases From the Babcock & Wilcox Site (curies)

Isotope	Site facility		
	NNFD[b]	CNFP	LTC
Co-60	-	3.2×10^{-5}	-
Kr-85	-	-	13.4
Sr-90	-	-	4.9×10^{-6}
U-234	-	4.0×10^{-6}	-
U-235	-	2.2×10^{-7}	1.8×10^{-7}
U-238	-	9.3×10^{-7}	-

[a] There was a release of 0.016 curies in 1994 due to liquid effluents from NNFD.

[b] Specific radionuclide release terms for this facility were not utilized in support of the impact analyses presented in Chapter 4 of this EIS, due to doses being directly supplied from B&W.

Note: NNFD=Naval Nuclear Fuel Division; CNFP=Commercial Nuclear Fuel Plant; LTC=Lynchburg Technology Center.

Source: BW 1995b:1; BW NRC 1991a.

Table E.2.3–5. Annual Atmospheric Radioactive Releases From the Nuclear Fuel Services Site (curies)

Isotope	Release
Th-228	6.62×10^{-7}
Th-230	2.10×10^{-7}
Th-232	7.33×10^{-7}
U-234	7.12×10^{-5}
U-235	1.21×10^{-6}
U-236	7.23×10^{-9}
U-238	5.23×10^{-7}
Pu-238	2.71×10^{-9}
Pu-239	1.45×10^{-9}
Pu-240	1.31×10^{-9}
Pu-241	1.78×10^{-7}
Pu-242	1.86×10^{-12}
Am-241	1.67×10^{-9}

Source: NFS 1995b:2.

Table E.2.3–6. Annual Liquid Radioactive Releases from the Oak Ridge Reservation Site (curies)

Isotope	Site Facility		
	ORNL	K–25	Y–12
H-3	1.8×10^{3}	-	-
K-40	-	1.9×10^{-2}	-
Co-60	4.0×10^{-2}	-	-
Sr-90	6.6×10^{0}	-	-
Tc-99	-	3.0×10^{-2}	-
Ru-106	-	3.8×10^{-2}	-
Cs-137	5.5×10^{-1}	1.2×10^{-3}	-
Ce-143	-	2.0×10^{-1}	-
Th-228	-	2.0×10^{-1}	-
Th-230	-	2.4×10^{-5}	-
Th-232	-	-	-
Th-234	-	3.6×10^{-2}	-
U-234	1.8×10^{-2}	7.7×10^{-3}	1.5×10^{-1}
U-235	9.5×10^{-4}	1.4×10^{-2}	4.6×10^{-3}
U-236	-	5.8×10^{-4}	6.1×10^{-4}
U-238	5.6×10^{-2}	6.0×10^{-3}	2.1×10^{-2}
Np-237	-	1.2×10^{-3}	-
Pu-238	-	1.6×10^{-4}	-
Pu-239	-	-	-

Source: OR DOE 1994c.

Table E.2.3–7. Annual Liquid Radioactive Releases From the Savannah River Site (curies)

Isotope	Release
H-3	1.3×10^{4}
Sr-90	4.8×10^{-1}
I-129	2.2×10^{-2}
Cs-137	2.5×10^{-1}
Pm-147	7.0×10^{-3}
U-235	1.1×10^{-5}
Pu-239	9.6×10^{-3}

Source: WSRC 1994f.

Table E.2.3–8. Annual Liquid Radioactive Releases From the Nuclear Fuel Services Site (curies)

Isotope	Release
Tc-99	3.0×10^{-3}
Th-228	1.1×10^{-4}
Th-230	1.0×10^{-4}
Th-232	8.4×10^{-5}
Th-234	3.5×10^{-3}
U-234	1.7×10^{-2}
U-235	5.1×10^{-4}
U-238	2.4×10^{-3}
Pu-238	1.2×10^{-4}
Pu-239	5.6×10^{-4}

Source: NFS 1995b:2.

E.3 HAZARDOUS CHEMICAL IMPACTS TO HUMAN HEALTH

E.3.1 BACKGROUND

Two general types of adverse human health effects are assessed for hazardous chemical exposure in this EIS. These are carcinogenic and noncarcinogenic effects. For this reason, two tables were developed to assist the risk assessor in the evaluation process. Table E.3.2–1, Chemical Toxicity Profiles, characterizes each chemical in terms of physical properties, potential exposure routes, and the effects on target tissues/organs that might be expected. It is to be used qualitatively by the risk assessor to determine how exposure might occur (exposure route), what tissue or organ system might be impacted (for example, central nervous system dysfunction and liver cancer), and whether the chemical might possess other properties affecting its bioavailability in a given matrix (for example, air, water, or soil). Table E.3.3–1, Exposure Limits, provides the risk assessor with the necessary information to calculate risk or expected adverse effects should an individual be exposed to a hazardous chemical for a long time at low levels (chronic exposure) or to higher concentrations for a short time (acute exposure). Where a dose effect calculation is required (mg/kg/day), the Reference Dose (RfD) is applicable, and where an inhalation concentration effect is required, the Reference Concentration (that is, RfC in mg/m^3) is applicable for chronic exposures. The Permissible Exposure Limit (PEL) values, which regulate worker exposures over 8-hour periods, determine the concentration allowed for occupational exposures that would be without adverse acute effects. Other values, such as the Threshold Limit Value (TLV) are presented because they are prepared by the American Conference of Governmental Industrial Hygienists (ACGIH) for guidance on exposures of 8-hour periods and can be used to augment PELs or serve as exposure levels in the absence of a PEL. All currently regulated chemicals associated with each site and every hazardous chemical are presented in Table E.3.2–1.

It was assumed that under normal operation conditions, members of the public would only receive chronic exposures at low levels in the form of air emissions from a centrally located source term at each site; since hazardous chemicals are not released into surface or groundwaters or onto soil, inhalation is assumed to be the only route of exposure; however, all chemical quantities are accounted for as air emissions that are several orders of magnitude greater than all other possible routes combined. It was further assumed that the MEI member of the public would be at the site boundary, and this assumption was used when calculating all public exposures, which under normal operating conditions are expected to be chronic and at very low levels. For worker exposures to hazardous chemicals, it was assumed that individuals were exposed only to low air emission concentrations during an 8-hour day for a 40-hour week for a maximum working lifetime of 40 years. The point of exposure chosen was 100 m (328 ft) from a centrally located source term, since the precise placement of source terms onsite could not be made. Further, it could not be determined where the involved and noninvolved workers would be relative to the emission sources.

For every site involved in the analysis, Hazard Indexes (HIs) were calculated for every alternative action relative to the site. The exposure concentrations of hazardous chemicals for the public and the onsite workers were developed using the Industrial Source Complex Short-Term (ISCST) model for point, area, and volume sources. This model, which estimates dispersion of emissions from these sources, has been field tested and recommended by EPA. The modeled concentrations were compared with the RfC and PEL values unique to each chemical to yield Hazard Quotients (HQs) for the public and onsite workers, respectively. The HQs were summed to give the HIs for each alternative action at each site, as well as total HIs (that is, no action HI + alternative HI). For cancer risk estimation, the inhaled concentrations were converted to doses in mg/kg/day, which were then multiplied by the slope factors unique to each identified carcinogen. The risks for all carcinogens associated with each alternative (incremental risk) at each site were summed, and the no action cancer risk for each site was added in order to show the total risk should that alternative action be implemented at a given site.

E.3.2 CHEMICAL TOXICITY PROFILES

Table E.3.2–1 provides the reader with pertinent facts about each chemical that is included in the risk assessment of this EIS. This includes the Chemical Abstracts Service (CAS) number, which aids in the search for information available on any specific chemical and ensures a positive identity regardless of which name or synonym is used. It also contains physical information (that is, solubility, vapor pressure, and flammability) as well as presents incompatibility data that are useful in determining whether a hazard might exist and the nature of the hazard. The route of exposure, target organs/tissues, and carcinogenicity provide an abbreviated summary of how individuals may get exposed, what body functions could be affected, and whether chronic exposure could lead to increased cancer incidence in an exposed population.

E.3.3 REGULATED EXPOSURE LIMITS

Hazardous chemicals are regulated by various agencies in order to provide protection to the public (EPA) and to workers (Occupational Safety and Health Administration [OSHA]), while others (National Institute for Occupational Safety and Health [NIOSH] and the ACGIH) provide guidelines. The RfDs and RfCs set by EPA represent exposure limits for long-term (chronic) exposure at low doses and concentrations, respectively, that can be considered safe from adverse noncancer effects. The PEL represents concentration levels set by OSHA that are safe for 8-hour exposures for the working lifetime without causing adverse noncancer effects. The slope factor or the unit risk are used to convert the daily uptake of a carcinogenic chemical averaged over a lifetime to the incremental risk of an individual developing cancer. Table E.3.3–1 presents the information on exposure limits used to develop HQs for each of the hazardous chemicals and the HIs derived from their summation, and the slope factors used to calculate cancer risk for each chemical at the exposure concentrations identified at the various sites or associated with a proposed alternative action.

Table E.3.2–1. Chemical Toxicity Profiles

Compound	CAS No.	Solubility	Vapor Pressure	Flammability[a]	Incompatibilities	Route of Exposure[b]	Target Organs	Carcinogenicity[c]
1,1,1-Trichloroethane (TCA; methyl chloroform)	71-55-6	0.4%[d]	100 mm[d]	Combustible liquid, burns with difficulty[d]	Strong caustics; strong oxidizers; chemically active metals (for example, Zn, Al, Mg powders, Na, K); water[d]	Inh, ing, con[d]	CNS, eyes, skin, CVS, liver[d]	EPA Group D[e]
Acetic acid	64-19-7	Miscible[e]	11 mm[d]	Class II[d]	Strong oxidizers, strong caustics, corrosive to metals[d]	Inh, con[d]	Eyes, skin, resp sys, teeth[d]	Not classified
Ammonia	7664-41-7	34%[d]	8.5 atm[d]	Treat as a flammable gas[d]	Strong oxidizers, acids, halogens, salts of Ag and Zn[d]	Inh, ing (soln), con (soln/liq)[d]	Eyes, skin, resp sys[d]	EPA Group D[f]
Benzene	71-43-2	0.07%[d]	75 mm[d]	Class IB Flammable liquid[d]	Strong oxidizers, many fluorides and perchlorates, nitric acid[d]	Inh, abs, ing, con[d]	Eyes, skin, resp sys, blood, CNS, bone marrow (Leukemia)[d]	EPA Group A[f]
Carbon monoxide	630-08-0	2%[d]	>35 atm[d]	Flammable gas[d]	Strong oxidizers, bromine trifluoride, chlorine trifluoride, Li[d]	Inh, con (liq)[d]	CVS, lungs, blood, CNS[d]	Not classified
Chlorine	7782-50-5	0.7%[d]	6.8 atm	Nonflammable gas[d]	Reacts explosively or forms explosive compds with many common substances (for example, acetylene, ether, turpentine, ammonia, fuel gas, hydrogen, finely divided metals)[d]	Inh, con[d]	Eyes, skin, resp sys[d]	EPA Group D[f]
Chloroform	67-66-3	0.5%[d] (77 °F)	160 mm[d]	Noncombustible liquid[d]	Strong caustics, chemically active metals (for example, Al or Mg powder), K, strong oxidizers[d]	Inh, abs, ing, con[d]	Liver, kidneys, heart, skin, CNS[d] (In animals: liver and kidney cancer)	EPA Group B2[f]
Chromium (Trivalent)	7440-47-3	Varies with cmpd[d]	Varies with cmpd[d]	Varies with cmpd[d]	Varies with cmpd[d]	Inh, ing, con[d]	Eyes, skin[d]	Not classified

Table E.3.2–1. Chemical Toxicity Profiles—Continued

Compound	CAS No.	Solubility	Vapor Pressure	Flammability[a]	Incompatibilities	Route of Exposure[b]	Target Organs	Carcinogenicity[c]
Cobalt (metal dust and fume)	7440-48-4	Insoluble[d]	0 mm (approx)[d]	Noncombustible solid in bulk form; fine dust burns at high temp[d]	Strong oxidizers, ammonium nitrate[d]	Inh, ing, con[d]	Eyes, resp sys [d]	
Copper (dusts and mists)	7440-50-8	Insoluble[d]	0 mm (approx)[d]	Noncombustible solid in bulk; fine powder may ignite[d]	Oxidizers, alkalis, sodium azide, acetylene[d]	Inh, ing, con[d]	Eyes, skin, resp sys, liver, kidneys (Increase risk with Wilson's disease)[d]	EPA Group C[f]
[Text deleted.]								
Hydrogen chloride	7647-01-0	67%[d] (86 F)	40.5 atm[d]	Nonflammable gas[d]	Hydroxides, amines, alkalis, copper, brass, Zn. Highly corrosive to most metals[d]	Inh, ing (soln), con[d]	Resp sys, skin, eyes[d]	Not classified
Hydrogen fluoride	7664-39-3	Miscible[d]	783 atm[d]	Nonflammable gas[d]	Metals, water or steam. (Corrosive to metals. Will attack glass and concrete)[d]	Inh, abs(liq), ing (soln), con[d]	Eyes, resp sys, bones, skin[d]	Not classified
[Text deleted.]								
Mercury (Cmpds except organo alkyls; as Hg)	7439-97-6	Insoluble[d]	0.0012 mm[d]	Metal: Non-combustible liquid[d]	Acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, Li, Rb, Cu[d]	Inh, abs, con[d]	Eyes, skin, resp sys, CNS, kidneys[d]	EPA Group D[f]
Methanol (methyl alcohol)	67-56-1	Miscible[d]	96 mm[d]	Class IB Flammable liquid[d]	Strong oxidizers[d]	Inh, abs, ing, con[d]	Eyes, skin, resp sys, CNS, GI tract[d]	Not classified
[Text deleted.]								
Nickel (refinery dust)	7440-02-0	Insoluble[d]	0 mm (approx)[d]	Metal: combustible solid, Ni sponge catalyst ignites spontaneously in air[d]	Strong acids, S, Se, wood and other combustibles, nickel nitrate[d]	Inh, ing, con[d]	Lungs, skin, nasal cavities (lung and nasal cancer)	EPA Group A
Nitric acid	7697-37-2	Miscible[d]	48 mm[d]	Noncombustible liquid, but increases flammability of combustible materials[d]	Combustible materials; metallic powders; hydrogen sulfide; carbides; alcohols[d] (Corrosive to metals)	Inh, ing, con[d]	Eyes, resp sys, skin, teeth[d]	Not classified

Table E.3.2–1. Chemical Toxicity Profiles—Continued

Compound	CAS No.	Solubility	Vapor Pressure	Flammability[a]	Incompatibilities	Route of Exposure[b]	Target Organs	Carcinogenicity[c]
[Text deleted.]								
Phosphoric acid	7664-38-2	Miscible[d]	0.03 mm[d]	Noncombustible liquid[d]	Strong caustics, most metals (Do not mix with solutions containing bleach or ammonia)[d]	Inh, ing, con[d]	Eyes, skin, resp sys[d]	Not classified
Sulfuric acid	7664-93-9	Miscible[d]	0.001 mm	Noncombustible liquid, but capable of igniting finely divided combustible materials[d]	Organic materials, chlorates, carbides, fulminates, water, powdered metals[d]	Inh, ing, con[d]	Resp sys, eyes, skin, teeth[d]	Not classified
Toluene	108-88-3	0.07% (74 F)[d]	21 mm[d]	Class IB Flammable liquid[d]	Strong oxidizers[d]	Inh, abs, ing, con[d]	CNS, eyes, resp sys, liver, kidneys, skin[d]	EPA Group D[g]
Trichloroethylene (TCE)	79-01-6	0.0001% (77 F)[d]	58 mm[d]	Combustible liquid, but burns with difficulty[d]	Strong caustics and alkalis; chemically active metals (for example, B.A., Li, Na, Mg, Ti, and Be)[d]	Inh, abs, ing, con[d]	Eyes, resp sys, heart, liver, kidneys, CNS, skin (In animals: liver and kidney cancer)[d]	EPA Group B2[f]
Uranium (Metal; insoluble cmpds)[d]	7440-61-1	Insoluble[d]	0 mm (approx)[d]	Combustible solid[d]	Carbon dioxide, carbon tetrachloride, nitric acid, fluorine[d]	Inh, ing, con[d]	Skin, kidneys, bone marrow, lymphatic sys, (lung cancer)[d]	EPA Group A[h]
[Text deleted.]								
[Text deleted.]								

[a] Flammable liquids are classified by OSHA (29 CFR 1910.106) as follows: Class IA-Fl.P below 73 °F and BP below 100 °F; Class IB-Fl.P below 73 °F and BP at or above 100 °F; Class IC-Fl.P at or above 73 °F and below 100 °F; Class II-Fl.P at or above 100 °F and below 140 °F; Class IIIA-Fl.P at or above 140 °F and below 200 °F; Class IIIB-Fl.P at or above 200 °F (DHHS 1992a).

[b] Routes of exposure abbreviated as follows: inh = inhalation, abs = skin absorption, ing = ingestion, con = skin and/or eye contact.

[c] EPA Groups for Carcinogenicity are Classified as Follows: EPA Group A: Human Carcinogen; EPA Group B1: Probable Human Carcinogen-limited evidence in human studies; EPA Group B2: Probable Human Carcinogen-sufficient evidence from animal studies, inadequate evidence or no data from human studies; EPA Group C: Possible Human Carcinogen; EPA Group D: Not Classifiable as to Human Carcinogenicity.

[d] NIOSH 1994a.

[e] EPA 1993a.

[f] ORNL 1994b.

[g] ORNL 1994a.

[h] EPA 1994a.

Note: °F=Fahrenheit.

Table E.3.3–1. Exposure Limits

Compound	Chemical Abstracts Service No.	Reference Dose (oral) (mg/kg/day)	Reference Concentration (inhalation) (mg/m^3)	Cancer Class[a]	Slope Factor $(mg/kg/day)^{-1}$	Occupational Exposure Level[b, c]
1,1,1-Trichloroethane (TCA; methyl chloroform)	71-55-6	0.035[d]	1.0[e]	EPA Group D[f]	None found	OSHA-PEL: 1,900 mg/m^3 ACGIH-TLV: 1,910 mg/m^3, STEL: 2,460 mg/m^3 NIOSH-REL: 1,900 mg/m^3, (ceiling, 15 min.) IDLH: 3,885 mg/m^3
Acetic acid	64-19-7	0.175[g]	0.6125[h]	Not classified	None found	OSHA-PEL: 25 mg/m^3 ACGIH-TLV: 25 mg/m^3, STEL: 37 mg/m^3 NIOSH-REL: 25 mg/m^3, STEL: 37 mg/m^3, IDLH: 125 mg/m^3
[Text deleted.]						
Ammonia	7664-41-7	0.0286[i] (34 mg/l, chronic)[j]	0.1[f]	EPA Group D[d]	None found	OSHA-STEL: 35 mg/m^3 ACGIH-TLV: 17 mg/m^3, STEL: 24 mg/m^3 MOSH-REL: 18 mg/m^3, STEL: 27 mg/m^3, IDLH: 213 mg/m^3
Benzene	71-43-2	2.28×10^{-2}[g]	0.0796[h]	EPA Group A[f]	0.029 (oral)[f] 0.029 (inhal)[j]	OSHA-PEL: 3.25 mg/m^3, STEL: 16.25 mg/m^3, ACGIH-TLV: 32 mg/m^3, NIOSH-REL: 0.325 mg/m^3, STEL: 3.25 mg/m^3, IDLH: 5 mg/m^3
Carbon monoxide	630-08-0	0.385[g]	1.35[h]	Not classified	None found	OSHA-PEL: 55 mg/m^3 ACGIH-TLV: 29 mg/m^3 NIOSH-REL: 40 mg/m^3, IDLH: 1,392 mg/m^3
Chlorine	7782-50-5	0.1[f]	0.35[h]	EPA Group D[d]	None found	OSHA-PEL: 3 mg/m^3 (ceiling) ACGIH-TLV: 1.5 mg/m^3, STEL: 2.9 mg/m^3 NIOSH-REL: 1.45 mg/m^3 (ceiling, 15 min.), IDLH: 29.5 mg/m^3
Chloroform	67-66-3	0.01[f]	0.035[h]	EPA Group B2[f]	6.1×10^{-3} (oral)[f] 0.081 (inhal)[j]	OSHA-PEL: 240 mg/m^3 (ceiling) ACGIH-TLV: 49 mg/m^3 NIOSH-REL: 9.78 mg/m^3 (60 min.), IDLH: 2480 mg/m^3
Chromium (Trivalent)	16065-83-1	1.0[f]	3.5[h]	Not classified	None found	OSHA-PEL: 0.5 mg/m^3 ACGIH-TLV: 0.5 mg/m^3 NIOSH-REL: 0.5 mg/m^3, IDLH: 25 mg/m^3

Table E.3.3–1. Exposure Limits—Continued

Compound	Chemical Abstracts Service No.	Reference Dose (oral) (mg/kg/day)	Reference Concentration (inhalation) (mg/m^3)	Cancer Class[a]	Slope Factor (mg/kg/day)$^{-1}$	Occupational Exposure Level[b, c]
Cobalt (metal dust and fume)	7440-48-4	7×10^{-4} [g]	2.45×10^{-3} [h]	Not classified	None found	OSHA-PEL: 0.1 mg/m^3 ACGIH-TLV: 0.05 mg/m^3 NIOSH-REL: 0.05 mg/m^3, IDLH: 20 mg/m^3
Copper (dusts and mists)	7440-50-8	7×10^{-3} [g]	0.0245[h]	EPA Group D[f]	None found	OSHA-PEL: 1 mg/m^3 ACGIH-TLV: 1 mg/m^3 NIOSH-REL: 1 mg/m^3, IDLH: 100 mg/m^3
[Text deleted.]						
Hydrogen chloride	7647-01-0	2×10^{-3} [i]	7×10^{-3} [f]	Not classified	None found	OSHA-PEL: 7 mg/m^3 ACGIH-TLV: 7.5 mg/m^3 (ceiling) NIOSH-REL: 7 mg/m^3, IDLH: 76 mg/m^3
Hydrogen fluoride	7664-39-3	0.06[e]	0.21[h]	Not classified	None found	OSHA-PEL: 2.49 mg/m^3 ACGIH-TLV: 2.6 mg/m^3 (ceiling) NIOSH-REL: 2.5 mg/m^3, 5.0 mg/m^3 (ceiling, 15 min), IDLH: 24.9 mg/m^3
[Text deleted.]						
Mercury (vapor + compound)	7439-97-6	3×10^{-4} (inorganic, chronic)[j]	3×10^{-4} [e]	EPA Group D[f]	None found	OSHA-PEL: 0.1 mg/m3 (ceiling), ACGIH-TLV: 0.05 mg/m3, NIOSH-REL: 0.05 mg/m3 (skin), IDLH: 10 mg/m3
Methanol (methyl alcohol)	67-56-1	0.5[f]	1.75[h]	Not classified	None found	OSHA-PEL: 260 mg/m^3 ACGIH-TLV: 262 mg/m^3 (skin), STEL: 328 mg/m^3 NIOSH-REL: 260 mg/m^3, STEL: 325 mg/m^3 (skin), IDLH: 7,980 mg/m^3
[Text deleted.]						
Nickel (refinery dust)	7440-02-0	0.007[g]	0.0245[h]	EPA Group A[k]	0.84 (inhal)[h]	OSHA-PEL: 1 mg/m^3 (metal and other compds) ACGIH-TLV: 1 mg/m^3 NIOSH-REL: 0.015 mg/m^3
Nitric acid	7697-37-2	0.035[e]	0.1225[h]	None	None	OSHA-PEL: 5 mg/m^3 (metal and other cmpds) ACGIH-TLV: 5.2 mg/m^3, STEL: 10 mg/m^3 NIOSH-REL:5 mg/m^3, STEL: 10 mg/m^3 IDLH:65.5 mg/m^3
[Text deleted.]						

Table E.3.3–1. Exposure Limits—Continued

Compound	Chemical Abstracts Service No.	Reference Dose (oral) (mg/kg/day)	Reference Concentration (inhalation) (mg/m^3)	Cancer Class[a]	Slope Factor $(mg/kg/day)^{-1}$	Occupational Exposure Level[b, c]
Phosphoric acid	7664-38-2	0.007[g]	0.0245[h]	Not classified	None found	OSHA-PEL: 1 mg/m^3, ACGIH-TLV: 1 mg/m^3, STEL: 3 mg/m^3, NIOSH-REL: 1 mg/m^3, STEL: 3 mg/m^3, IDLH: 1,000 mg/m^3
Sulfuric acid	7664-93-9	0.007[g]	2.45×10^{-2} [h]	Not classified	None found	OSHA-PEL: 1 mg/m^3 ACGIH-TLV: 1 mg/m^3, STEL: 3 mg/m^3 NIOSH-REL: 1 mg/m^3, IDLH: 15 mg/m^3
Toluene	108-88-3	0.2[f]	0.4[f]	EPA Group D[f]	None found	OSHA-PEL: 766 mg/m^3, STEL: 1,149 mg/m^3, (ceiling) ACGIH-TLV: 188 mg/m^3 (skin) NIOSH-REL: 375 mg/m^3, STEL: 560 mg/m^3, IDLH: 1,915 mg/m^3
Trichloroethylene (TCE)	79-01-6	3.82[g]	13.377[h]	EPA Group B2[d]	6.0×10^{-3} (inhal)[j]	OSHA-PEL: 546 mg/m^3, 1,092 mg/m^3 (ceiling) ACGIH-TLV: 269 mg/m^3, STEL: 1,070 mg/m^3 NIOSH-REL: 5,460 mg/m^3
Uranium 235 + 238	7440-61-1	3.0×10^{-3} [f]	0.0105[h]	EPA Group A[d]	Inhalation[j] (Risk/pCi) U^{235} 2.5×10^{-8} U^{238} 2.4×10^{-8} Average SF: 2.45×10^{-8}	OSHA-PEL: 0.25 mg/m^3 (insol cpds/metal) ACGIH-TLV: 0.2 mg/m^3, STEL: 0.6 mg/m^3 (insol cpds/metal) NIOSH-REL: 0.2 mg/m^3, STEL: 0.6 mg/m^3 (insol cpds/metal), IDLH: 10 mg/m^3 (as U)

[Text deleted.]

[a] EPA Groups for carcinogenicity are classified as follows: EPA Group A: Human Carcinogen; EPA Group B1: Probable Human Carcinogen - limited evidence in human studies; EPA Group B2: Probable Human Carcinogen - sufficient evidence from animal studies, inadequate evidence or no data from human studies; EPA Group C: Possible Human Carcinogen; EPA Group D: Not Classifiable as to Human Carcinogenicity.

[b] OSHA and NIOSH exposure levels were taken from NIOSH 1994a unless otherwise indicated.

[c] American Conference of Governmental Industrial Hygienists (ACGIH) exposure levels were taken from ACGIH nda unless otherwise indicated.

[d] EPA 1993a.

[e] PNL, 1995a.

[f] ORNL 1994b.

[g] Reference Dose calculated from OSHA-PEL, formula from the Center for Risk Management, Oak Ridge National Laboratories (ORNL 1992d).

[h] Reference Concentration calculated from Reference Dose, formula from the Center for Risk Management, Oak Ridge National Laboratories (ORNL 1992d).

[i] Reference Dose calculated from Reference Concentration, formula from the Center for Risk Management, Oak Ridge National Laboratories (ORNL 1992d).

[j] EPA 1994a.

[k] ORNL 1994a.

Note: mg=milligram; kg=kilogram.

E.3.4 HAZARDOUS CHEMICAL RISK/ EFFECTS CALCULATIONS

Tables E.3.4–1 through E.3.4–15 show the chemicals associated with the various alternative activities (that is, no action or blend to low enriched uranium) and Tables E.3.4–16 through E.3.4–19 summarize the alternatives for each of the four sites and give the totals associated with the activities if implemented at each of the four sites (that is, ORR, SRS, B&W, and NFS). Table E.3.4–20 contains the emission rates and the corresponding PELs for hazardous chemicals for the In-Tank Precipitation Facility and the Consolidated Incineration Facility at SRS. The terms associated with calculations are given in the footnotes for each table so that verification of each calculated value can be made.

Table E.3.4–1. Risk Assessments From Exposure to Hazardous Chemicals at Oak Ridge Reservation: No Action

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 hours[f] (mg/m^3)
1,1,1-Trichloroethane	1	1,900	–	$7.26x10^{-6}$	$4.63x10^{-3}$	$7.26x10^{-6}$	$2.29x10^{-6}$	0	0
Acetic acid	0.6125	25	–	$3.30x10^{-8}$	$1.98x10^{-5}$	$5.39x10^{-8}$	$7.93x10^{-7}$	0	0
Carbon monoxide	1.35	55	–	$3.14x10^{-3}$	1.88	$2.32x10^{-3}$	$3.42x10^{-2}$	0	0
Chlorine	0.35	3	–	$5.78x10^{-5}$	$3.47x10^{-2}$	$1.65x10^{-4}$	$1.16x10^{-2}$	0	0
Hydrogen chloride	0.007	7	–	$2.12x10^{-4}$	$1.27x10^{-1}$	$3.03x10^{-2}$	$1.82x10^{-2}$	0	0
Hydrogen fluoride	0.21	2.49	–	$2.31x10^{-6}$	$1.39x10^{-3}$	$1.10x10^{-5}$	$5.57x10^{-4}$	0	0
Methanol	1.75	260	–	$8.72x10^{-4}$	$5.23x10^{-1}$	$4.98x10^{-4}$	$2.01x10^{-3}$	0	0
Nitric acid	0.1225	5	–	$3.14x10^{-4}$	$1.88x10^{-1}$	$2.56x10^{-3}$	$3.76x10^{-2}$	0	0
Sulfuric acid	0.0245	1	–	$8.25x10^{-5}$	$4.95x10^{-2}$	$3.37x10^{-3}$	$4.95x10^{-2}$	0	0
VOC (toluene)	0.4	766	–	$1.22x10^{-4}$	$7.33x10^{-2}$	$3.05x10^{-4}$	$9.57x10^{-5}$	0	0
Health Risk									
Hazard Index[g]						$3.95x10^{-2}$	$1.54x10^{-1}$		
Total Cancer Risk[h]								0	0

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Source: OR MMES 1995i.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Table E.3.4–2. Risk Assessments From Exposure to Hazardous Chemicals at Savannah River Site: No Action

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI [b,c] (mg/m^3)	Worker 100 Meters 8 hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 hours[f] (mg/m^3)
Benzene	0.0796	3.25	0.029	$1.25x10^{-6}$	$1.37x10^{-2}$	$1.57x10^{-5}$	$4.20x10^{-3}$	$1.04x10^{-8}$	$1.53x10^{-5}$
Carbon monoxide	1.35	55	–	$5.41x10^{-3}$	59.1	$4.01x10^{-3}$	1.07	0	0
Chlorine	0.35	3	–	$9.27x10^{-9}$	$1.01x10^{-4}$	$2.65x10^{-8}$	$3.37x10^{-5}$	0	0
Chloroform	0.035	240	0.0061	$4.79x10^{-6}$	$5.24x10^{-2}$	$1.37x10^{-4}$	$2.18x10^{-4}$	$8.36x10^{-9}$	$1.24x10^{-5}$
Cobalt	0.00245	0.1	–	$7.46x10^{-9}$	$8.15x10^{-5}$	$3.05x10^{-6}$	$8.15x10^{-4}$	0	0
Hydrogen fluoride	0.21	2.49	–	$4.29x10^{-8}$	$4.69x10^{-4}$	$2.04x10^{-7}$	$1.88x10^{-4}$	0	0
Mercury (vapor)	0.0003	0.1	–	$1.89x10^{-7}$	$2.06x10^{-3}$	$6.29x10^{-4}$	$2.06x10^{-2}$	0	0
Nickel (vapor & compounds)	0.0245	1	0.84	$4.31x10^{-8}$	$4.70x10^{-4}$	$1.76x10^{-6}$	$4.70x10^{-4}$	$1.03x10^{-8}$	$1.53x10^{-5}$
Nitric acid	0.1225	5	–	$3.73x10^{-6}$	$4.07x10^{-2}$	$3.04x10^{-5}$	$8.15x10^{-3}$	0	0
Phosphoric acid	0.0245	1	–	$1.50x10^{-7}$	$1.63x10^{-3}$	$6.11x10^{-6}$	$1.63x10^{-3}$	0	0

Table E.3.4–2. Risk Assessments From Exposure to Hazardous Chemicals at Savannah River Site: No Action—Continued

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 hours[f] (mg/m^3)
Benzene (DWPF)[g]	0.0796	3.25	0.029	1.23×10^{-5}	1.35×10^{-1}	1.55×10^{-4}	4.15×10^{-2}	1.02×10^{-7}	1.51×10^{-4}
Hydrogen fluoride (DWPF)[g]	0.21	2.49	–	8.39×10^{-12}	9.16×10^{-8}	3.99×10^{-11}	3.68×10^{-8}	0	0
Mercury (DWPF)[g]	0.0003	0.1	–	5.17×10^{-8}	5.65×10^{-4}	1.72×10^{-4}	5.65×10^{-3}	0	0
Mercury oxide (DWPF)[g]	0.0003	0.1	–	6.36×10^{-18}	6.95×10^{-14}	2.12×10^{-14}	6.95×10^{-13}	0	0
Nickel compounds (DWPF)[g]	0.0245	1	0.84	3.16×10^{-16}	3.45×10^{-12}	1.29×10^{-14}	3.45×10^{-12}	7.60×10^{-17}	1.12×10^{-13}
Health Risk									
Hazard Index[h]						5.16×10^{-3}	1.16		
Total Cancer Risk[i]								1.31×10^{-7}	1.94×10^{-4}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=(emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] The Defense Waste Processing Facility (DWPF), In-Tank Precipitation (ITP) facility, and Consolidated Incineration Facility (CIF) were not in operation during 1994, but potential emissions from DWPF based on limited trials are used to generate DWPF potential emissions.

The ITP and CIF data were not included because only the inventory of chemicals to be processed through these facilities was available. Table E.3.4–20 presents the list of possible ITP/CIF chemicals and their regulated levels.

[h] Hazard index=sum of individual hazard quotients.

[i] Total cancer risk=sum of individual cancer risks.

Note: 1994 actual emissions scaled to the year 2005. Scaling Factor=1.0 for all except: Bechtel (0.6), Separations (0.8), Power (0.8), and Reactors (0.1).

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: SRS 1995a:2; SRS 1996a:1.

Table E.3.4–3. Risk Assessments From Exposure to Hazardous Chemicals at Babcock & Wilcox: No Action

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Onsite 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Chromium compounds (III)	3.5	0.5	–	5.96×10^{-10}	1.03×10^{-5}	1.70×10^{-10}	2.07×10^{-5}	0	0
Cobalt compounds	0.00245	0.1	–	5.96×10^{-10}	1.03×10^{-5}	2.43×10^{-7}	1.03×10^{-4}	0	0
Copper compounds	0.0245	1	–	1.43×10^{-7}	2.48×10^{-3}	5.84×10^{-6}	2.48×10^{-3}	0	0
Hydrogen chloride	0.007	7	–	1.43×10^{-8}	2.48×10^{-4}	2.04×10^{-6}	3.54×10^{-5}	0	0
Hydrogen fluoride	0.21	2.49	–	2.98×10^{-9}	5.17×10^{-5}	1.42×10^{-8}	2.08×10^{-5}	0	0
Nickel compounds	0.0245	1	0.84	8.94×10^{-10}	1.55×10^{-5}	3.65×10^{-8}	1.55×10^{-5}	2.15×10^{-10}	5.04×10^{-7}
Nitric acid	0.1225	5	–	1.40×10^{-7}	2.43×10^{-3}	1.14×10^{-6}	4.86×10^{-4}	0	0
Sulfuric acid	0.0245	1	–	3.49×10^{-8}	6.05×10^{-4}	1.42×10^{-6}	6.05×10^{-4}	0	0
Trichloroethylene (TCE)	13.377	546	0.006	9.66×10^{-6}	1.67×10^{-1}	7.22×10^{-7}	3.07×10^{-4}	1.66×10^{-8}	3.89×10^{-5}
Health Risk									
Hazard Index[g]						1.15×10^{-5}	4.07×10^{-3}		
Total Cancer Risk[h]	–							1.68×10^{-8}	3.94×10^{-5}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.
[b] MEI=maximally exposed individual of the public.
[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.
[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.
[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).
[f] Lifetime cancer risk for workers=(emissions for 8 hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).
[g] Hazard index=sum of individual hazard quotients.
[h] Total cancer risk=sum of individual cancer risks.
Note: mg=milligram; m^3=cubic meter; kg=kilogram.
Source: VA DEQ 1995a.

Table E.3.4–4. Risk Assessments From Exposure to Hazardous Chemicals at Nuclear Fuel Services: No Action

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Onsite 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Ammonia	0.1	35	–	9.17×10^{-3}	1.50×10^{-1}	9.17×10^{-2}	4.27×10^{-3}	0	0
Hydrogen fluoride	0.21	2.49	–	3.88×10^{-4}	6.33×10^{-3}	1.85×10^{-3}	2.54×10^{-3}	0	0
Nitric acid	0.1225	5	–	2.32×10^{-4}	3.78×10^{-3}	1.89×10^{-3}	7.56×10^{-4}	0	0
Health Risk									
Hazard Index[g]						9.55×10^{-2}	7.57×10^{-3}		
Total Cancer Risk[h]								0	0

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: NFS 1995b:2.

Table E.3.4–5. Risk Assessments From Exposure to Hazardous Chemicals at Oak Ridge Reservation: Blend to 4-Percent Uranyl Nitrate Hexahydrate for Commercial Reactor Fuel

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	$3.70x10^{-4}$	$6.22x10^{-2}$	$2.74x10^{-4}$	$1.13x10^{-3}$	0	0
Uranium-235	0.0105	0.25	$2.5x10^{-8}$	$5.73x10^{-9}$	$9.62x10^{-7}$	$5.46x10^{-7}$	$3.85x10^{-6}$	$4.17x10^{-17}$	$9.31x10^{-16}$
Uranium-238	0.0105	0.25	$2.4x10^{-8}$	$1.71x10^{-7}$	$2.87x10^{-5}$	$1.63x10^{-5}$	$1.15x10^{-4}$	$1.17x10^{-15}$	$2.66x10^{-14}$
VOC (toluene)	0.4	766	–	$3.70x10^{-5}$	$6.22x10^{-3}$	$9.26x10^{-5}$	$8.12x10^{-6}$	0	0
Health Risk									
Hazard Index[g]						$3.84x10^{-4}$	$1.26x10^{-3}$		
Total Cancer Risk[h]								$1.21x10^{-15}$	$2.75x10^{-14}$

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.
[b] MEI=maximally exposed individual of the public.
[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.
[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.
[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).
[f] Lifetime Cancer Risk for Workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).
[g] Hazard index=sum of individual hazard quotients.
[h] Total cancer risk=sum of individual cancer risks.
Note: mg=milligram; m^3=cubic meter; kg=kilogram.
Source: OR LMES 1995b.

Table E.3.4–6. Risk Assessments From Exposure to Hazardous Chemicals at Savannah River Site: Blend to 4-Percent Uranyl Nitrate Hexahydrate for Commercial Reactor Fuel

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	$4.12x10^{-5}$	$5.57x10^{-2}$	$3.05x10^{-5}$	$1.01x10^{-3}$	0	0
Uranium-235	0.0105	0.25	$2.5x10^{-8}$	$6.37x10^{-10}$	$8.61x10^{-7}$	$6.06x10^{-8}$	$3.44x10^{-6}$	$4.55x10^{-18}$	$8.33x10^{-16}$
Uranium-238	0.0105	0.25	$2.4x10^{-8}$	$1.90x10^{-8}$	$2.56x10^{-5}$	$1.81x10^{-6}$	$1.03x10^{-4}$	$1.30x10^{-16}$	$2.38x10^{-14}$
VOC (toluene)	0.4	766	–	$4.12x10^{-6}$	$5.57x10^{-3}$	$1.03x10^{-5}$	$7.27x10^{-6}$	0	0
Health Risk									
Hazard Index[g]						$4.26x10^{-5}$	$1.13x10^{-3}$		
Total Cancer Risk[h]								$1.35x10^{-16}$	$2.47x10^{-14}$

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995b.

Table E.3.4–7. Risk Assessments From Exposure to Hazardous Chemicals at Babcock & Wilcox: Blend to 4-Percent Uranyl Nitrate Hexahydrate for Commercial Reactor Fuel

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	1.34×10^{-6}	2.32×10^{-2}	9.89×10^{-7}	4.21×10^{-4}	0	0
Uranium-235	0.0105	0.25	2.5×10^{-8}	2.07×10^{-11}	3.58×10^{-7}	1.97×10^{-9}	1.43×10^{-6}	1.48×10^{-19}	3.47×10^{-16}
Uranium-238	0.0105	0.25	2.4×10^{-8}	6.15×10^{-10}	1.07×10^{-5}	5.86×10^{-8}	4.27×10^{-5}	4.22×10^{-18}	9.91×10^{-15}
VOC (toluene)	0.4	766	–	1.34×10^{-7}	2.32×10^{-3}	3.34×10^{-7}	3.02×10^{-6}	0	0
Health Risk									
Hazard Index[g]						1.38×10^{-6}	4.68×10^{-4}		
Total Cancer Risk[h]								4.37×10^{-18}	1.03×10^{-14}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.
[b] MEI=maximally exposed individual of the public.
[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.
[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.
[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).
[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).
[g] Hazard index=sum of individual hazard quotients.
[h] Total cancer risk=sum of individual cancer risks.
Note: mg=milligram; m^3=cubic meter; kg=kilogram.
Source: OR LMES 1995b.

Table E.3.4–8. Risk Assessments From Exposure to Hazardous Chemicals at Nuclear Fuel Services: Blend to 4-Percent Uranyl Nitrate Hexahydrate for Commercial Reactor Fuel

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	1.95×10^{-3}	3.18×10^{-2}	1.44×10^{-3}	5.77×10^{-4}	0	0
Uranium-235	0.0105	0.25	2.5×10^{-8}	3.01×10^{-8}	4.91×10^{-7}	2.87×10^{-6}	1.96×10^{-6}	2.15×10^{-16}	4.75×10^{-16}
Uranium-238	0.0105	0.25	2.4×10^{-8}	8.97×10^{-7}	1.46×10^{-5}	8.54×10^{-5}	5.85×10^{-5}	6.16×10^{-15}	1.24×10^{-14}
VOC (toluene)	0.4	766	–	1.95×10^{-4}	3.18×10^{-3}	4.87×10^{-4}	4.15×10^{-6}	0	0
Health Risk									
Hazard Index[g]						2.02×10^{-3}	6.42×10^{-4}		
Total Cancer Risk[h]								6.37×10^{-15}	1.41×10^{-14}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks..

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995b

Table E.3.4–9. Risk Assessments From Exposure to Hazardous Chemicals at Babcock & Wilcox: Blend to 4-Percent Uranium Hexafluoride for Commercial Reactor Fuel

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	$1.34x10^{-6}$	$2.32x10^{-2}$	$9.89x10^{-7}$	$4.21x10^{-4}$	0	0
Uranium-235	0.0105	0.25	$2.5x10^{-8}$	$3.28x10^{-11}$	$5.68x10^{-7}$	$3.12x10^{-9}$	$2.27x10^{-6}$	$2.34x10^{-19}$	$5.50x10^{-16}$
Uranium-238	0.0105	0.25	$2.4x10^{-8}$	$1.20x10^{-9}$	$2.07x10^{-5}$	$1.14x10^{-7}$	$8.29x10^{-5}$	$8.21x10^{-18}$	$1.93x10^{-14}$
VOC (toluene)	0.4	766	–	$1.34x10^{-7}$	$2.32x10^{-3}$	$3.34x10^{-7}$	$3.02x10^{-6}$	0	0
Health Risk									
Hazard Index[g]						$1.44x10^{-6}$	$5.09x10^{-4}$		
Total Cancer Risk[h]								$8.44x10^{-18}$	$1.98x10^{-14}$

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.
[b] MEI=maximally exposed individual of the public.
[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.
[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.
[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).
[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).
[g] Hazard index=sum of individual hazard quotients.
[h] Total cancer risk=sum of individual cancer risks.
Note: mg=milligram; m^3=cubic meter; kg=kilogram.
Source: OR LMES 1995a.

Table E.3.4–10. Risk Assessments From Exposure to Hazardous Chemicals at Nuclear Fuel Services: Blend to 4-Percent Uranium Hexafluoride for Commercial Reactor Fuel

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	1.95×10^{-3}	3.18×10^{-2}	1.44×10^{-3}	5.77×10^{-4}	0	0
Uranium-235	0.0105	0.25	2.5×10^{-8}	4.78×10^{-8}	7.80×10^{-7}	4.55×10^{-6}	3.12×10^{-6}	3.42×10^{-16}	7.54×10^{-16}
Uranium-238	0.0105	0.25	2.4×10^{-8}	1.74×10^{-6}	2.84×10^{-5}	1.66×10^{-4}	1.14×10^{-4}	1.20×10^{-14}	2.64×10^{-14}
VOC (toluene)	0.4	766	–	1.95×10^{-4}	3.18×10^{-3}	4.87×10^{-4}	4.15×10^{-6}	0	0
Health Risk									
Hazard Index[g]						2.10×10^{-3}	6.98×10^{-4}		
Total Cancer Risk[h]								1.23×10^{-14}	2.72×10^{-14}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995a.

Table E.3.4–11. Risk Assessments From Exposure to Hazardous Chemicals at Oak Ridge Reservation: Blend to 0.9-Percent Uranyl Nitrate Hexahydrate and Discard as Waste

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	3.70×10^{-4}	6.22×10^{-2}	2.74×10^{-4}	1.13×10^{-3}	0	0
Uranium-235	0.0105	0.25	2.5×10^{-8}	5.73×10^{-9}	9.62×10^{-7}	5.46×10^{-7}	3.85×10^{-6}	4.10×10^{-17}	9.31×10^{-16}
Uranium-238	0.0105	0.25	2.4×10^{-8}	1.71×10^{-7}	2.87×10^{-5}	1.63×10^{-5}	1.15×10^{-4}	1.17×10^{-15}	2.66×10^{-14}
VOC (toluene)	0.4	766	–	3.70×10^{-5}	6.22×10^{-3}	9.26×10^{-5}	8.12×10^{-6}	0	0
Health Risk									
Hazard Index[g]						3.84×10^{-4}	1.26×10^{-3}		
Total Cancer Risk[h]								1.21×10^{-15}	2.75×10^{-14}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995d.

Table E.3.4–12. Risk Assessments From Exposure to Hazardous Chemicals at Savannah River Site: Blend to 0.9-Percent Uranyl Nitrate Hexahydrate and Discard as Waste

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	$4.12x10^{-5}$	$5.57x10^{-2}$	$3.05x10^{-5}$	$1.01x10^{-3}$	0	0
Uranium-235	0.0105	0.25	$2.5x10^{-8}$	$6.37x10^{-10}$	$8.61x10^{-7}$	$6.06x10^{-8}$	$3.44x10^{-6}$	$4.55x10^{-18}$	$8.33x10^{-16}$
Uranium-238	0.0105	0.25	$2.4x10^{-8}$	$1.90x10^{-8}$	$2.56x10^{-5}$	$1.81x10^{-6}$	$1.03x10^{-4}$	$1.30x10^{-16}$	$2.38x10^{-14}$
VOC (toluene)	0.4	766	–	$4.12x10^{-6}$	$5.57x10^{-3}$	$1.03x10^{-5}$	$7.27x10^{-6}$	0	0
Health Risk									
Hazard Index[g]						$4.26x10^{-5}$	$1.13x10^{-3}$		
Total Cancer Risk[h]								$1.35x10^{-16}$	$2.47x10^{-14}$

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995d.

Table E.3.4–13. Risk Assessments From Exposure to Hazardous Chemicals at Babcock & Wilcox: Blend to 0.9-Percent Uranyl Nitrate Hexahydrate and Discard as Waste

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	1.34×10^{-6}	2.32×10^{-2}	9.89×10^{-7}	4.21×10^{-4}	0	0
Uranium-235	0.0105	0.25	2.5×10^{-8}	2.07×10^{-11}	3.58×10^{-7}	1.97×10^{-9}	1.43×10^{-6}	1.48×10^{-19}	3.47×10^{-16}
Uranium-238	0.0105	0.25	2.4×10^{-8}	6.15×10^{-10}	1.07×10^{-5}	5.86×10^{-8}	4.27×10^{-5}	4.22×10^{-18}	9.91×10^{-15}
VOC (toluene)	0.4	766	–	1.34×10^{-7}	2.32×10^{-3}	3.34×10^{-7}	3.02×10^{-6}	0	0
Health Risk									
Hazard Index[g]						1.38×10^{-6}	4.68×10^{-4}		
Total Cancer Risk[h]								4.37×10^{-18}	1.03×10^{-14}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995d.

Table E.3.4–14. Risk Assessments From Exposure to Hazardous Chemicals at Nuclear Fuel Services: Blend to 0.9-Percent Uranyl Nitrate Hexahydrate and Discard as Waste

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	1.95×10^{-3}	3.18×10^{-2}	1.44×10^{-3}	5.77×10^{-4}	0	0
Uranium-235	0.0105	0.25	2.5×10^{-8}	3.01×10^{-8}	4.91×10^{-7}	2.87×10^{-6}	1.96×10^{-6}	2.15×10^{-16}	4.75×10^{-16}
Uranium-238	0.0105	0.25	2.4×10^{-8}	8.97×10^{-7}	1.46×10^{-5}	8.54×10^{-5}	5.85×10^{-5}	6.16×10^{-15}	1.36×10^{-14}
VOC (toluene)	0.4	766	–	1.95×10^{-4}	3.18×10^{-3}	4.87×10^{-4}	4.15×10^{-6}	0	0
Health Risk									
Hazard Index[g]						2.02×10^{-3}	6.42×10^{-4}		
Total Cancer Risk[h]								6.37×10^{-15}	1.41×10^{-14}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995d.

Table E.3.4–15. Risk Assessments From Exposure to Hazardous Chemicals at Oak Ridge Reservation: Blend to 0.9-Percent Uranyl Metal and Discard as Waste

	Regulated Exposure Limits/Risk Factors			Emissions Concentrations		Hazard Quotient		Cancer Risk	
Chemical	RfC (mg/m^3)	PEL[a] (mg/m^3)	Slope Factor $(mg/kg/day)^{-1}$	Boundary Annual MEI[b] (mg/m^3)	Worker 100 Meters 8 hours (mg/m^3)	Boundary Annual MEI[b,c] (mg/m^3)	Worker 100 Meters 8 Hours[d] (mg/m^3)	Boundary Annual MEI[b,e] (mg/m^3)	Worker 100 Meters 8 Hours[f] (mg/m^3)
Carbon monoxide	1.35	55	–	2.22×10^{-4}	4.26×10^{-2}	1.65×10^{-4}	7.74×10^{-4}	0	0
Uranium-235	0.0105	0.25	2.5×10^{-8}	9.10×10^{-10}	1.74×10^{-7}	8.66×10^{-8}	6.97×10^{-7}	6.50×10^{-18}	1.69×10^{-16}
Uranium-238	0.0105	0.25	2.4×10^{-8}	1.34×10^{-7}	2.56×10^{-5}	1.27×10^{-5}	1.03×10^{-4}	9.18×10^{-16}	2.38×10^{-14}
VOC (toluene)	0.4	766	–	1.85×10^{-5}	3.55×10^{-3}	4.63×10^{-5}	4.63×10^{-6}	0	0
Health Risk									
Hazard Index[g]						2.24×10^{-4}	8.82×10^{-4}		
Total Cancer Risk[h]								9.25×10^{-16}	2.40×10^{-14}

[a] See Appendix E, Table E.3.3–1 for the OSHA-PEL, ACGIH-TLV, NIOSH-REL, and other exposure limit values.

[b] MEI=maximally exposed individual of the public.

[c] Hazard quotient for MEI=boundary annual emissions/reference concentration.

[d] Hazard quotient for workers=100-meter, 8-hr emissions/permissible exposure limit.

[e] Lifetime cancer risk for MEI=emissions concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[f] Lifetime cancer risk for workers: (Emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor).

[g] Hazard index=sum of individual hazard quotients.

[h] Total cancer risk=sum of individual cancer risks.

Note: mg=milligram; m^3=cubic meter; kg=kilogram.

Source: OR LMES 1995c.

[Table deleted.]

Table E.3.4–16. Risk Assessments From Exposure to Hazardous Chemicals at Oak Ridge Reservation

Alternatives	Hazard Index		Cancer Risk	
	Boundary Annual MEI[a,b]	Worker[c] 100 Meters 8 Hours	Boundary Annual MEI[a,d]	Worker[e] 100 Meters 8 Hours
No Action	3.95×10^{-2}	0.154	0	0
Blend to LEU as 4% UNH for commercial reactor fuel	3.84×10^{-4}	1.26×10^{-3}	1.21×10^{-15}	2.75×10^{-14}
Blend to LEU as 0.9% UNH and discard as waste	3.84×10^{-4}	1.26×10^{-3}	1.21×10^{-15}	2.75×10^{-14}
Blend to LEU as 0.9% metal and discard as waste	2.24×10^{-4}	8.82×10^{-4}	9.25×10^{-16}	2.40×10^{-14}
No Action + Alternative				
No Action + 4% UNH	3.99×10^{-2}	0.155	1.21×10^{-15}	2.75×10^{-14}
No Action + 0.9% UNH	3.99×10^{-2}	0.155	1.21×10^{-15}	2.75×10^{-14}
No Action + 0.9% metal	3.97×10^{-2}	0.155	9.25×10^{-16}	2.40×10^{-14}

[a] MEI=maximally exposed individual of the public.

[b] Hazard index=sum of Individual Hazard Quotients (noncancer adverse health effects) for MEI.

[c] Hazard index=sum of Individual Hazard Quotients (noncancer adverse health effects) for Workers.

[d] Lifetime cancer risk=(Emissions Concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[e] Lifetime cancer risk=(emissions for 8 hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor [exposed]) x (0.571 [Fraction of lifetime working]) x (Slope Factor).

Note: UNH=uranyl nitrate hexahydrate.

Source: OR LMES 1995b; OR LMES 1995c; OR LMES 1995d; OR MMES 1995i.

Table E.3.4–17. Risk Assessments From Exposure to Hazardous Chemicals at Savannah River Site

Alternatives	Hazard Index		Cancer Risk	
	Boundary Annual MEI[a,b]	Worker[c] 100 Meters 8 Hours	Boundary Annual MEI[a,d]	Worker[e] 100 Meters 8 Hours
No Action	5.16×10^{-3}	1.16	1.31×10^{-7}	1.94×10^{-4}
Blend to LEU as 4% UNH for commercial reactor fuel	4.26×10^{-5}	1.13×10^{-3}	1.35×10^{-16}	2.47×10^{-14}
Blend to LEU as 0.9% UNH and discard as waste	4.26×10^{-5}	1.13×10^{-3}	1.35×10^{-16}	2.47×10^{-14}
[Text deleted.]				
No Action + Alternative				
No Action + 4% UNH	5.20×10^{-3}	1.16	1.31×10^{-7}	1.94×10^{-4}
No Action + 0.9% UNH	5.20×10^{-3}	1.16	1.31×10^{-7}	1.94×10^{-4}
[Text deleted.]				

[a] MEI=maximally exposed individual of the public.

[b] Hazard index=sum of Individual Hazard Quotients (noncancer adverse health effects) for MEI.

[c] Hazard index=sum of Individual Hazard Quotients (noncancer adverse health effects) for Workers.

[d] Lifetime cancer risk=(Emissions Concentrations) x (0.286 [converts concentrations to doses]) x (Slope Factor).

[e] Lifetime cancer risk=(emissions for 8 hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (Slope Factor [exposed]) x (0.571 [Fraction of lifetime working]) x (Slope Factor).

Note: UNH=uranyl nitrate hexahydrate.

Source: OR LMES 1995b; OR LMES 1995d; SRS 1995a:2: SRS 1996a:1.

Table E.2.3–8. Mixed Low-Level Waste and Low-Level Waste Treatment Facilities at Idaho National Engineering Laboratory

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity[a] (m^3/yr)	Comment
High Efficiency Particulate Air Filter Leach (CPP-659)	Acid leach	HLW, TRU, mixed LLW-contact-handled, remote-handled, alpha, solid, debris	LLW solid to RWMC, concentrated liquid to tank farm, nonhazardous to sanitary landfill	11	Under modification; RCRA final 1990; interim NESHAP to 1999
ICPP debris treatment and containment	Water wash, carbon dioxide, abrasion	HLW, TRU, mixed LLW-contact-handled, remote-handled alpha, solid, debris	Mixed LLW, HLW, TRU solid, liquid	227	Water wash operational, carbon dioxide existing, plan to use.
Advanced Mixed Waste Treatment Project	Amalgamation, compaction, incineration, macroencapsulation, stabilization, thermal desorption, vitrification	Mixed TRU, mixed LLW, contact-handled, remote-handled alpha	Mixed TRU, mixed LLW, LLW solid	26,900	Unapproved, planned
INEL waste treatment, 40 CFR 262.34	Absorption, neutralization, solidification	Mixed LLW-contact-handled, aqueous liquid, solid, debris	Mixed LLW, LLW	Planned	Operational
Liquid Effluent Treatment and Disposal Facility	Fractionation, evaporation	Mixed LLW-contact-handled, remote-handled liquid (PEW evaporator)	Mixed LLW-contact-handled, remote-handled liquid to acid recycle for New Waste Calcining Facility, or tank farm	12,200	Operational; RCRA final 1990; NESHAP final and State Prevention of Significant Deterioration 1988
Mixed LLW Treatment Facility	Amalgamation, decontamination, incineration, macroencapsulation, neutralization, precipitation, sizing, stabilization	Mixed LLW-contact-handled liquid, solid	Mixed LLW-contact-handled	401	Approved, planned
New Waste Calcining Facility	Calcification	Mixed LLW, HLW, mixed TRU remote-handled liquid	HLW-remote-handled solid	470	Operational; RCRA interim 1990
Portable Water Treatment System	Adsorption, filtration, neutralization	Mixed LLW-contact-handled, aqueous liquid	Mixed LLW	126	Existing, plan to use.

Table E.2.3–8. Mixed Low-Level Waste and Low-Level Waste Treatment Facilities at Idaho National Engineering Laboratory—Continued

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity[a] (m^3/yr)	Comment
Remote Mixed Waste Treatment Facility	Melt, drain, evaporate	Mixed LLW remote-handled, alpha	Mixed LLW, remote-handled, alpha	42	Unapproved, planned
Sodium Processing Facility	Water reaction	Mixed LLW contact-handled	Mixed LLW contact-handled, decontaminated sodium	698	Existing, needs modification
TAN cask dismantlement	Disassembly, recovery	Mixed LLW contact-handled	Mixed LLW contact-handled	11	Operational
Waste Reduction Operations Complex	Amalgamation	Mixed LLW contact-handled, solid	LLW solid	0.4	Planned, approved
Waste Reduction Operations Complex	Debris sizing	Mixed LLW, LLW contact-handled, solid	Mixed LLW, LLW solid	23	Planned, approved
Waste Reduction Operations Complex	Neutralization	Mixed LLW contact-handled	LLW	4.2	Planned, approved
Waste Experimental Reduction Facility	Incineration, stabilization, macroencapsulation	Mixed LLW contact-handled, liquid, solid	LLW, mixed LLW solid to RWMC (stabilized solids and grout)	Input 49,610; output 236 grout and 2,770 stabilized solids to RWMC	Interim NESHAP 1987, 1992; RCRA interim 1987, 1992; State final 1992. Shut down. Expect operation in 1996.
Waste immobilization	Vitrification or ceramic fusion	HLW, mixed TRU, mixed LLW solid	HLW solid ceramic	3,020	Unapproved, planned

[a] For those facilities already in use, this is a normal operating capacity, whereas for facilities under design or construction, this is a design capacity. Schedules and capacities for facilities under design or construction are subject to changes such as availability of funds, results of treatability studies, and permit issuance.

[Text deleted.]

Source: IN DOE 1995d.

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Table E.3.4–20. In-Tank Precipitation Facility and Consolidated Incineration Facility Chemicals and Regulated Levels—Continued

Chemical	Maximum Emission Rate (lb/hr)	PEL (mg/m^3)
Chromium (hexavalent) compounds	0.009	1
Cresols (m-, o-, p-)	0.0531	22
Cumene	0.0531	245
Dibutyl phthalate	0.0531	5
Dichloroethyl ether	0.0531	90
Dimethyl phthalate	0.0531	5
Dimethyl sulfate	0.0531	5
Dioxane	0.0531	360
Epichlorohydrin	0.0531	19
Ethyl benzene	0.0531	435
Ethylene dibromide	0.0531	156.2
Ethylene dichloride	0.0531	411
Ethylene glycol	0.0531	286
Ethylene imine (aziridine)	0.0531	–
Ethylene oxide	0.0531	1.83
Ethylene thiourea	0.0531	–
Formic acid	0.0531	9
Furfural	0.0531	20
Heptachlor	0.217	0.5
Hexachlorobenzene	0.0531	–
Hexachlorobutadiene	0.0531	–
Hexachloroethane	0.0531	10
Hexachlorocyclopentadiene	0.0531	1.3
Hydrazine	0.0531	–
Hydrochloric acid	4	7
Hydrogen cyanide	3.81	11
Hydrogen fluoride	3.81	2.49
Lead	0.09	0.05
Lindane (all isomers)	0.0531	0.5
Maleic anhydride	0.0531	1
Mercury (vapor)	0.02	0.1
MEK	0.0531	–
Methanol	0.0531	260
Methoxychlor	0.0531	15
Methyl chloride	0.0531	210
Methylene chloride	0.0531	1765
Methyl hydrazine	0.0531	0.35
Methyl iodide	0.0531	28
Methyl methacrylate	0.0531	410
MIBK	0.0531	–
Napthalene	0.0531	50
Nickel oxide	0.054	–
Nitrobenzene	0.0531	5

Table E.3.4–20. In-Tank Precipitation Facility and Consolidated Incineration Facility Chemicals and Regulated Levels—Continued

Chemical	Maximum Emission Rate (lb/hr)	PEL (mg/m^3)
Parathion	0.217	0.1
Pentachloronitrobenzene	0.0531	–
Pentachlorophenol	0.0531	0.5
Phenol	0.0531	19
Phosgene	0.0531	0.4
Phthalic anhydride	0.0531	12
Selenium	0.0011	0.2
Sodium hydroxide	0.05	2
Tetrachloroethylene	0.0531	689
Toluene	0.0531	766
Toxaphene	0.217	0.5
Trichloroethylene (TCE)	0.0531	546
Vinyl chloride	0.0531	–
Vinylidine chloride	0.0531	–

* These rates are the maximum potential emissions and would be in compliance with the most stringent applicable standards (for example, SC DHEC Standards).

Note: The Consolidated Incineration Facility incinerates a wide range of combustible hazardous mixed and low-level wastes so that the chemicals included in this table would become innocuous. The In-Tank Precipitation Facility is part of the pre-treatment to remove metals/metal salts from materials potentially released from the Defense Waste Processing Facility. When these facilities are integrated into the Defense Waste Processing Facility, hazardous chemical releases are expected to be reduced by several orders of magnitude.

Note: lb=pound; hr=hour; mg=milligram; m^3=cubic meter.

Source: SR DOE 1995b; SR DOE 1996a.

E.4 HEALTH EFFECTS STUDIES: EPIDEMIOLOGY

Various epidemiologic studies have been conducted at some of the sites evaluated in this EIS due to concern regarding potential adverse health effects associated with the manufacture and testing of nuclear weapons. With a few exceptions, most epidemiological studies of the populations living near the site have been descriptive in nature and are what epidemiologists refer to as "ecologic" or "correlational" studies. Occupational epidemiologic studies (that is, studies of works) have been mostly analytical. The various epidemiologic studies, along with their assumptions and limitation are described in Section E.4.2 through E.4.5. These studies focus on the workforce and residents of communities surrounding DOE and commercial sites. The epidemiology articles related to the disposition of surplus HEU include studies conducted at ORR, SRS, B&W, and NFS and in communities surrounding these sites. Currently, the only action being taken with surplus HEU is interim storage, which takes place only at the Y–12 Plant at Oak Ridge, Tennessee. A number of options are under consideration, which may affect activities at the Y–12 facility and the SRS. Two other locations that are not DOE facilities, but may be affected, are B&W and NFS.

E.4.1 STUDY DESIGNS

Adverse health effects associated with ionizing radiation exposure were first identified about 60 years ago. Studies published in the 1930s first documented cancer among painters who used radium to paint watch dials from 1910 to 1920. Radiation therapy for disease has been used since the 1930s, and studies have shown that the risk of cancer is related to the amounts of radiation received. Nuclear weapons research and manufacture, and consequent exposure to radiation, began in the late 1930s. Exposure to radionuclides has changed over time, with higher levels occurring in the early days of research and production. Due to concern regarding potential adverse health effects, numerous epidemiologic studies have been conducted among workers who manufactured and tested nuclear weapons. More recently, concerns about offsite radiologic contaminants have resulted in health studies among communities that surround DOE facilities. The following section gives an overview of epidemiology followed by a review of epidemiologic studies for sites evaluated in this EIS.

Epidemiology is the study of the distribution and determinants of disease in human populations. The distribution of disease is considered in relation to time, place, and person. Relevant population characteristics should include the age, race, and sex distribution of a population, as well as other characteristics related to health, such as social characteristics (for example, income and education), occupation, susceptibility to disease, and exposure to specific agents. Determinants of disease include the causes of disease, as well as factors that influence the risk of disease.

E.4.1.1 Ecologic Studies

Ecologic studies compare the frequency of a disease in groups of people in conjunction with simple descriptive studies of geographical information in an attempt to determine how health events among populations vary with levels of exposure. These groups may be identified as the residents of a neighborhood, a city, or a county where demographic information and disease or mortality data are available. Exposure to specific agents may be defined in terms of residential location or proximity to a particular area, such as distance from a waste disposal site. An example of an ecologic study would be an examination of the rate of heart disease among community residents in relation to the quality of their drinking water.

The major disadvantage of ecologic studies is that the measure of exposure is based on the average level of exposure in the community, when what is needed is each individual's exposure. Ecologic studies do not take into account other factors, such as age and race, that may also be related to disease. These types of studies may lead to incorrect conclusions, known as "ecologic fallacies." For the above example, it would be incorrect to assume that the level of water hardness influences the risk of getting heart disease. Despite the obvious problems with ecologic studies, they can be a useful first step in identifying possible associations between risk of disease and environmental exposures. However, because of their potential for bias ecologic studies should never be

considered as more than an initial step in an investigation of the cause of a disease.

E.4.1.2 Cohort Studies

The cohort study design is a type of epidemiologic study frequently used to examine occupational exposures within a defined workforce. A cohort study requires a defined population that can be classified as being exposed or not exposed to an agent of interest, such as radiation or chemicals that influence the probability of occurrence of a given disease. Characterization of the exposure may be qualitative (for example, high, low, or no exposure) or very quantitative (for example, radiation measured in rem, chemicals in parts per million). Surrogates for exposure, such as job titles, are frequently used in the absence of quantitative exposure data.

Individuals included in the study population are tracked for a period of time and fatalities recorded. In general, overall fatality rates and cause-specific fatality rates have been determined for workers at the EIS sites. Fatality rates for the exposed worker population are compared with fatality rates for workers who did not have the exposure (internal comparison), or are compared with expected fatality rates based on the U.S. population or State fatality rates (external comparison). If the fatality rates differ from what is expected, an association is said to exist between the disease and exposure. In cohorts where the exposure has not been characterized, excess mortality can be identified. However, these fatalities cannot be attributed to a specific exposure, and additional studies may be warranted. More recent studies have looked at other disease endpoints, such as overall and cause-specific cancer incidence (newly diagnosed) rates.

Most cohort studies at the EIS sites have been historical cohort studies (that is, the exposure occurred some time in the distant past). These studies rely on past records to document exposure. This type of study can be problematic if exposure records are incomplete or were destroyed. Cohort studies require extremely large populations that have been followed for 20 to 30 years. They are generally difficult to conduct and are very expensive. These studies are not well suited to studying diseases that are rare. Cohort studies do, however, provide a direct estimate of the risk of fatality from a specific disease, and allow an investigator to look at many disease endpoints.

E.4.1.3 Case-Control Studies

The case-control study design starts with the identification of persons with the disease of interest (case) and a suitable comparison (control) population of persons without the disease. Controls must be persons who are at risk for the disease and are representative of the population that generated the cases. The selection of an appropriate control group is often quite problematic. Cases and controls are then compared with respect to the proportion of individuals exposed to the agent of interest. Case-control studies require fewer persons than cohort studies, and, therefore, are usually less costly and less time consuming, but are limited to the study of one disease (or cause of fatality). This type of study is well suited for the study of rare diseases and is generally used to examine the relationship between a specific disease and exposure.

E.4.1.4 Definitions

Unfamiliar terms frequently used in epidemiologic studies, including those used in this document, are defined below.

Age, gender, and cigarette smoking are the principal determinants of mortality. Standardization is a statistical method used to control for the effects of age, gender, or other characteristics so that fatality rates may be compared among different population groups. There are two ways to standardize rates: the indirect method and the direct method. In general, the indirect method of standardization is most frequently used.

- Indirect standardization: The disease rates in the reference (comparison) population are multiplied by the number of individuals in the same age and gender groups in the study population to obtain the expected rate of disease for the study population.

- Direct standardization: The disease rates in the study population are multiplied by the number of individuals in the same age and gender groups in the reference

(comparison) population. This gives the expected rates of disease for the reference population if these rates had prevailed in that group.

Standardized mortality ratio (SMR): The SMR is the ratio of the number of fatalities observed in the study population to the number of *expected* fatalities. The expected number of fatalities is based on a reference (or comparison population). Fatality rates for the U.S. (or State) population are most frequently used as the comparison to obtain expected rates. An SMR of 1 indicates a similar risk of disease in the study population compared with the reference population. An SMR greater than 1 indicates excess risk of disease in the study population compared with the reference group, and an SMR less than 1 indicates a deficit of disease.

Relative risk: The ratio of the risk of disease among the exposed population to the risk of disease in the unexposed population. Relative risks are estimated from cohort studies.

Odds ratio: The ratio of the odds of disease if exposed to the odds of disease if not exposed. Under certain conditions, the odds ratio approximates the relative risk. Odds ratios are estimated from case-control studies.

E.4.2 OAK RIDGE RESERVATION, OAK RIDGE, TN

E.4.2.1 Surrounding Communities

The population-based National Cancer Institute mortality survey for selected nuclear facilities (NIH Publication No. 90-874, July 1990; JAMA 1991a:1403-1408) examined the cancer mortality within a 50-mile radius around several nuclear facilities, including Anderson and Roane counties. No excess cancer mortality was observed in the population living in the exposed counties when compared to the U.S. white male population, nor when compared to the population of the control counties (Blount, Bradley, Coffee, Jefferson, Hamblen, TN, and Henderson, NC), nor when time trends were assessed.

Tennessee Medical Management, Inc., used data from the Tennessee Cancer Reporting System to compare mortality and incidence data for counties near Oak Ridge, Tennessee to the U.S. population for the 3-year period 1988 to 1990 (TMM 1993a). For Oak Ridge, total fatalities from all causes was significantly lower than expected. For Anderson County, the observed number of fatalities from uterine cancer and from cancer of respiratory and intrathoracic organs was statistically greater than expected, and the number of fatalities from brain cancer, breast cancer, and the "all other sites" category were lower than expected for Anderson County. For Roane County, the number of fatalities from cancer of the respiratory and intrathoracic organs was statistically greater than expected; the number of fatalities from cancer of the digestive organs and the peritoneum, from uterine cancer and from lip, oral cavity, and pharynx cancer was lower than expected.

Tennessee Medical Management, Inc., examined new (incident) cancer cases and identified the following statistically significant: For Anderson County, the observed numbers of cases of cancer of the prostate, lung, and bronchus were greater than expected. Leukemia, stomach and small intestine cancers, and cancers of the colon and intestinal tract were lower than expected. For Roane County, the number of cases of cancer of the lung and bronchus was greater than expected. Non-Hodgkins lymphoma, female breast cancer, esophageal cancer, cancer of the pancreas, and cancer in all sites were lower than expected. The only consistent excess reported for both cancer mortality and cancer incidence was for cancer of respiratory and intrathoracic organs.

Because of a concern for possible contamination of the population by mercury, the Tennessee Department of Environment and Conservation (previously the Tennessee Department of Health and Environment) conducted a pilot study in 1984 (TN DHE 1984a). The study showed no difference in urine or hair mercury exposures (residence or activity in contaminated of fish caught in the contaminated areas) compared to those with little potential exposure. Mercury levels in some soils measured as high as 2,000 parts per million (ppm). Analysis of a few soil samples showed that most of the mercury in the soil, however, was inorganic, thereby lowering the probability of bioaccumulation and health effects. Examination of the long-term effects of exposure to mercury and other chemicals continues.

E.4.2.2 State Health Agreement Program

Under the State Health Agreement program managed by the DOE's Office of Epidemiologic Studies, a grant was awarded to the Tennessee Department of Environment and Conversation (previously the Tennessee Department of Health and Environment). The purpose of the grant was to determine the extent of exposure to contaminants among workers and residents of the surrounding community as a result of ORR operations, and to assess the current status of health outcomes and determine their potential association with these exposures.

A dose reconstruction feasibility study began in 1992, with the contract awarded by the State of Tennessee to ChemRisk. After performing an extensive review of Oak Ridge documents ChemRisk concluded that sufficient information exists to reconstruct past releases and offsite doses caused by radioactive and hazardous materials. They also concluded that doses from mercury, polychlorinated biphenyl (PCBs), radioactive iodine, and radioactive cesium may have been great enough to cause harmful health effects in the offsite population. Based on this information, a full dose reconstruction study was initiated in August 1994.

Other activities supported under the grant include development of a birth defects registry; a quality improvement program for the Tennessee cancer registry; a review and evaluation of the DOE occupational medical program; and the implementation of a community participation/public information program.

Technical support to the State health department is provided by a 12 member Oak Ridge Health Agreement Steering Panel. The Health Advisory Panel provides direction and oversight to those working on health studies, ensures public input, and informs the public of activities related to the health studies. A representative of the Centers for Disease Control and Prevention's National Center for Environmental Health is a member of the advisory panel. A representative from DOE serves as an *ex-officio* member.

E.4.2.3 Workers

Between 1943 and 1985, there were 118,588 male and female individuals of all races who were ever employed in any of the Oak Ridge facilities. These included Oak Ridge National Laboratory (ORNL) for nuclear research (also called the X–10 Facility), Y–12 under management of the Tennessee-Eastman Corporation (1943 to 1947) which produced enriched uranium by the electromagnetic separation process, Y–12 under management of Union Carbide (1948 to 1984) which fabricated and certified nuclear weapons parts, and K–25 (Oak Ridge Gaseous Diffusion Plant) which produced enriched uranium through the gaseous process. Analyses at the Oak Ridge facilities have been carried out mostly for white males, and for specific cohorts taking into consideration time-related exposure risks.

Oak Ridge National Laboratory. The mortality experience of 8,375 white males employed at least a month between 1943 and 1972 at ORNL was compared with the U.S. white male population using SMR analyses in a 1985 paper by Checkoway, et al. (BJIM 1985a;525-533). Increases in fatalities from leukemia (SMR=1.49, 16 observed, 95 percent confidence interval [CI] for range 0.31-4.38), cancer of the prostate (SMR=1.16, 14 observed, 11.9 expected), and Hodgkin's disease (SMR=1.10, 5 observed, 3.7 expected) were observed, although none were statistically significant. Dose response analyses were performed for all causes of fatalities combined, all cancers combined, leukemia, and prostate cancer comparing exposed worker fatality rates with non-exposed worker fatality rates. Dosimetry data were available for the entire period of the study with the total population external radiation dose measuring 13,500 person-rem. No dose response gradients were observed. Fatality rates were calculated for 11 different job categories by length of time in each job in an attempt to determine whether specific work environments were related to cancer and leukemia. Leukemia mortality was observed to be related to length of employment in engineering and maintenance jobs.

Followup of this cohort was expanded through 1984 in an updated study by Wing et al. (JAMA 1991a:1397-1402). Again, fatality rates in the worker population were compared with those in the U.S. population. Non-statistically significant increases

were noted for cancers of the pancreas (SMR=1.09, 25 observed, 95 percent CI for range 0.71-1.61), prostate (SMR=1.05, 26 observed, 95 percent CI for range 0.68-1.53), brain (SMR=1.04, 15 observed, 95 percent CI for range 0.58-1.72), and lymphosarcoma and/or reticulosarcoma (SMR=1.05, 9 observed, 95 percent CI for range 0.48-1.99). There was a significant increase in fatalities from leukemia (SMR=1.63, 28 observed, 95 percent CI for range 1.08-2.35). The total population external radiation dose was 14,400 person-rem. Dose response analyses performed for all causes except cancer, lung cancer, and leukemia did not demonstrate a relationship between level of external radiation and increased risk of fatality from these outcomes. There was a significant dose response relationship (4.94 percent per rem) between cancer fatalities and level of external radiation dose using models with a 20-year lag. A subgroup of workers who were monitored for internal contamination had non-statistically elevated SMRs for cancer of the prostate (SMR=1.12, 10 observed, 95 percent CI for range 0.53-2.05) and lymphosarcoma and/or reticulosarcoma (SMR=1.65, 6 observed, 95 percent CI for range 0.60-3.59). The workers monitored for internal contamination had a statistically significant elevated SMR for leukemia (SMR=2.23 16 observed, 95 percent CI for range 1.27-3.62).

A second publication on the above data set examined the effect of controlling for a number of possible selection and confounding factors on the risk coefficient for all cancer dose responses (AJIM 1993a:265-279). Models were adjusted for the following variables with little change in the previously reported risk coefficients: employment during the World War II era, short-term employment, job category, and exposure to beryllium, lead, and mercury. The authors concluded that the previously calculated dose response estimate was fairly stable when adjustments were made for a wide range of potential confounders that were not explored in the earlier study.

Y–12 Plant. The Y–12 Plant is a nuclear weapons materials fabrication plant where the radiologic exposure of greatest concern is internal exposure from the inhalation of uranium compounds. The Tennessee Eastman Corporation managed the plant from 1943 to 1947. Polednak and Frome reported a followup through 1974 of all 18,869 white male workers employed at Y–12 from 1943 to 1947 (JOM 1981a:169-178). The workers included those exposed to internal (alpha) and external (beta) radiation through the inhalation of uranium dusts, electrical workers who performed maintenance in the exposed areas, and other non-exposed workers. Individual measures of exposure were not available for any members of this cohort, so exposure levels were inferred from plant areas of work and jobs. High average air levels of uranium dust were documented in departments employing chemical workers. Elevated SMRs were observed for mental, psychoneurotic, personality disorders (SMR=1.36, 33 observed, 24.2 expected), emphysema (SMR=1.16, 100 observed, 85.89 expected), diseases of the bones and organs of movement (SMR=1.22, 11 observed, 8.49 expected), lung cancer (SMR=1.09, 324 observed, 296.47 expected), and external causes of fatality (SMR=1.09, 623 observed, 571.77 expected). The lung cancer SMR was greater among workers employed for 1 year or more compared with workers employed less than 1 year and was more pronounced in workers hired at the age of 45 or older (SMR=1.51; 95 percent CI for range 1.01-2.31). Of the workers employed after the age of 44, the SMR for lung cancer was greatest for electrical workers (SMR=1.55, 7 observed, Freeman-Tukey deviation [D] is 1.11), alpha chemistry workers (SMR=3.02, 7 observed, D is 2.27) and beta process workers (SMR=1.51, 11 observed, D is 1.30).

During the early operation of the Y–12 Plant, from 1942 to 1947, a group of male workers was exposed to phosgene gas on a chronic basis (N=694), and a smaller group of males received acute exposures (N=106) along with a group of females (N=91) (ER 1980a:357-367; TIH 1985a:137-147). A control group of 9,280 workers who also worked at Y–12 during the same era, but who did not have phosgene exposure, was also described. All groups were followed through the end of 1978. The SMRs for the chronically exposed group and the control group were similar for all causes examined. There was no evidence of increased mortality from respiratory diseases in this group, and the SMR for lung cancer, while elevated, was similar to the lung cancer SMR for workers in the rest of the plant. Among those with acute exposures, the SMR for respiratory diseases was elevated (SMR=2.66, 5 observed, confidence factor not provided), and this elevation may be related to residual lung damage from the acute

phosgene exposure. It was difficult to trace the vital status of the 91 women; therefore, description of these highly-exposed workers was limited to listing the frequency of their initial symptoms after exposure. As expected, nausea, vomiting, and cough were the most frequently reported symptoms. Unexpectedly, the women experienced a lower frequency of pneumonitis than their male counterparts.

The portion of the Y–12 cohort employed between 1947 and 1974 was described in a study by Checkoway et al. (AJE 1988a:255-366). This study included 6,781 white male workers first employed at Y–12 between 1947 and 1974 who were employed for at least 30 days. Mortality data were collected for the cohort through the end of 1979 and were used to perform SMR and cause-specific dose-response analyses. Non-statistically significant increases were observed for all cancers (SMR=1.01, 196 observed, 95 percent CI for range 0.88-1.17), diseases of the blood-forming organs (SMR=1.48, 3 observed, 95 percent CI for range 0.31-4.38), kidney cancer (SMR=1.22, 6 observed, 95 percent CI for range 0.45-2.66), brain cancer (SMR=1.80, 14 observed, 95 percent CI for range 0.98-3.03), and other lymphatic cancers (SMR=1.86, 9 observed, 95 percent CI for range 0.85-3.53). A statistically significant increase in fatalities from lung cancer (SMR=1.36, 89 observed; 95 percent CI for range 1.09-1.67) was observed compared with the U.S. lung cancer rates, but not with Tennessee lung cancer rates (SMR=1.18, 95 percent CI for range 0.95-1.45). Dose-response analyses for lung cancer and internal alpha radiation dose and external gamma radiation dose did not reveal a positive relationship for a 0-year or 10-year lag. Examination of lung cancer rates distributed across both internal and external dose categories suggested a dose-response with external radiation dose among individuals who had 5 rem or more of internal dose. Brain cancer was not related to the level of internal or external radiation dose.

The Y–12 cohort studied by Checkoway was updated through the end of 1990 by Loomis and Wolf and included African-American and white female workers (AJIM 1996a:131-141). The dose-response analyses were not included in the update; therefore, only SMR analyses are reported here. For all workers examined as a group, non-statistically significant elevations were observed for cancer of the pancreas (SMR=1.36, 34 observed, 95 percent CI for range 0.94-1.90), skin cancer (SMR=1.07, 11 observed, 95 percent CI for range 0.59-1.92), breast cancer (females only, SMR=1.21, 11 observed, 95 percent CI for range 0.60-2.17), prostate cancer (SMR=1.31, 36 observed, 95 percent CI for range 0.91-1.81), kidney cancer (SMR=1.30, 16 observed, 95 percent CI for range 0.74-2.11), brain cancer (SMR=1.29, 20 observed, 95 percent CI for range 0.79-2.00), cancers of other lymphatic tissues (SMR=1.32, 22 observed, 95 percent CI for range 0.82-1.99), and diseases of the blood-forming organs (SMR=1.23, 6 observed, 95 percent CI for range 0.45-2.68). The SMR for lung cancer was statistically significant (SMR=1.17, 202 observed; 95 percent CI for range 1.01-1.34), particularly in the white male segment of the population (SMR=1.20, 194 observed 95 percent CI for range 1.04-1.38). Examination of the lung cancer mortality by year of hire, latency, duration of employment, and calendar year at risk indicated the excess was confined to those who were first hired before 1954 (SMR=1.27, 161 observed, confidence factor not provided), and was greatest in persons employed 5 to 20 years with 10 to 30 years of followup. Elevated lung cancer fatalities were first evident between 1955 and 1964 and continued to increase from 1975 to 1979, followed by a decrease in lung cancer fatality rates.

Between 1953 and 1963 the Y–12 Plant used mercury in a process to produce large quantities of enriched lithium. Cragle et al. studied all workers employed at Y–12 at least 5 months between January 1, 1953, and April 30, 1958 (N=5663) (JOM 1984a:817-821). This group was categorized into workers exposed to mercury and workers not exposed to mercury based on results of urinalysis data supplied by the plant. Vital status followup was complete through the end of 1978, and SMRs were calculated. Compared with non-exposed workers, there were no differences in the mortality patterns for (1) mercury exposed workers as a whole, (2) workers with the highest mercury exposures, and (3) workers employed more than a year in a mercury process. The authors of this study acknowledge that mortality is not the optimal endpoint to assess health effects related to mercury exposure.

The mercury workers were involved in a clinical study by Albers et al. who examined 502 Y–12 workers, 247 of whom worked in the mercury

process 20 to 35 years prior to the examination (AN 1988a:651-659) . Correlations between declining neurological function and increasing exposure were identified. An exposure assessment was determined for each mercury worker during the time of employment in the mercury process. Study subjects who had at least one urinalysis equal to or greater than 0.6 mg/l of mercury showed decreased strength, coordination, and sensation along with increased tremor, and prevalence of Babinski and snout reflexes when compared with the 255 unexposed workers. Clinical polyneuropathy was associated with the level of the highest exposure, but not with the duration of exposure.

K–25 Site. The K–25 Site enriched uranium beginning in 1945 using a gaseous diffusion process. There was potential exposure to uranium dust, oxidized uranium compounds, uranium hexafluoride, and a number of chemical compounds used in the process. In later years of operation, the gas centrifuge process was used to enrich uranium. No analyses of fatality rates for this population have been published; however, health effects have been studied.

Powdered nickel was used at K–25 in the production of the barrier material used to separate and enrich uranium. Workers who fabricated the barrier material were exposed to nickel powder through inhalation. Cragle et al. (IARC 1984a:57-63 updated an earlier study by Godbold et al. (JOM 1979a:799-806) of 814 workers who were employed in the manufacture of barrier material between 1948 and 1953. A comparison group of white males employed at K–25 sometime between 1948 and 1953 (N=7552) was also selected. The SMRs in the barrier group were similar to those in the non-barrier worker group for most noncancer outcomes. The nickel workers were noted to have a higher rate of fatality from cancers of the buccal cavity and pharynx (SMR=2.92, 3 observed, 95 percent CI for range 0.59-8.54) than the non-nickel workers (SMR=0.23, 3 observed, 95 percent CI for range 0.05-0.67). When the directly standardized rates were compared, the rate of buccal cavity and pharynx cancer in the nickel workers was approximately 19 times higher than the rate in the non-nickel workers. The authors of this study acknowledged that the number of cases is quite small and recommended additional followup to determine if this trend continued. There were no nasal sinus cancers observed in the worker population exposed to metallic nickel, in contrast to the results of studies of workers in nickel refineries, where the rates of sinus cancer related to nickel compounds are quite high.

K–25 workers employed in the gas centrifuge process were the focus of an interview study by Cragle et al. (AOEH 1992a:826-834). The study was conducted in order to determine the incidence rate for cancer and illness symptoms among workers exposed to epoxy resin and solvents prevalent in the process. A total of 263 workers determined to have worked longest and closest to the process were compared with 271 employees employed at the plant during the same time, but who did not work in the centrifuge process. The centrifuge workers and the non-centrifuge workers had similar overall cancer incidence rates. However, the centrifuge workers reported five incident bladder cancers versus none reported by the non-centrifuge group. The centrifuge workers also reported significantly more rashes, dizziness, and numb or tingling limbs during employment, which are symptoms associated with high solvent exposure. One of the epoxy resins used in the early years of the process was a potential bladder carcinogen, but none of the workers with bladder cancer had jobs that required routine, hands-on work with that material. A specific causative agent for the increase in bladder cancer was not identified.

Combined Oak Ridge Reservation Facilities. Frome et al. reported on the mortality experience of World War II workers employed at three ORR facilities between 1943 and 1947 (RR 1990a:138-152). Poisson regression analyses were used to control for potential confounders such as facility of employment, socioeconomic status, period of followup, and birth year. The cohort included white males employed at any Oak Ridge facility at least 30 days between the start of the operation and 1947 and were never employed at an Oak Ridge facility after 1947 (N=28,008). Elevated mortality was statistically significant for all causes (SMR=1.11, 11,671 observed, 10,537 expected), tuberculosis (SMR=1.37, 108 observed, 78 expected), mental, psychoneurotic, and personality disorders (SMR=1.60, 81 observed, 50 expected), cerebrovascular disease (SMR=1.11, 833 observed, 753 expected), diseases of the respiratory system (SMR=1.25, 792 observed, 634 expected), emphysema (SMR=1.24, 209 observed, 168

expected), all accidents (SMR=1.28, 694 observed, 542 expected), and motor vehicle accidents (SMR=1.44, 339 observed, 235 expected). The only elevated site-specific cancer that was statistically significant was lung cancer (SMR=1.27, 850 observed, 667 expected). A surrogate for radiation exposure based on a worker's job and department was used to indicate the probability of exposure. This surrogate for actual radiation exposure was not associated with increased rates of cancer.

Carpenter investigated earlier reports of an association between brain cancer and employment at Y–12 by conducting a case-control study of workers employed between 1943 and 1977 at ORNL or Y–12 (JOM 1987a:601-604). Cases consisted of 72 white males and 17 white females with brain cancer. Four controls were selected for each case matched on age, sex, cohort, year of birth, and year of hire. Analyses with respect to internal and external radiation exposures indicated no association with brain cancer. Two companion papers were also published from this case-control study, one examined relationships between brain cancer and chemical exposures (AJIM 1988a:351-362), and the other examined nonoccupational risk factors (AJPH 1987a:1180-1182). No statistically significant association between the use of 26 chemicals evaluated and the risk of brain cancer was observed. The chemicals evaluated included those encountered in welding fumes, beryllium, mercury, 4,4-methylene bis 2-chloroaniline or MOCA, cutting oils, thorium, methylene chloride, and other solvents. Excess brain cancer was observed, however, among individuals employed for more than 20 years (odds ratio=7.0, 9 cases; 95 percent CI 1.2-41.1). Analysis of 82 cases with complete medical records revealed an association with a previous diagnosis of epilepsy (odds ratio=5.7, 4 cases; 95 percent CI 1.0-32.1) recorded for pre-employment and health status followup.

Causes of fatality among white male welders (N=1,059) employed between 1943 and 1973 at the Y–12 Plant, the K–25 Site, and ORNL were studied by Polednak (AEH 1981a:235-242). Based on fatalities reported through 1974, mortality from all causes for welders was slightly lower than that expected based on fatality rates for U.S. white males (SMR=0.87, 173 observed, 199 expected, 95 percent confidence for range 0.75-1.01). Non-statistically significant decreases in mortality were also observed for all cancers (SMR=0.88, 32 observed, 36.57 expected, 95 percent confidence for range 0.60-1.23), especially digestive cancer (SMR=0.49, 5 observed, 10.3 expected, 95 percent confidence for range 0.16-1.14); diseases of the circulatory system (SMR=0.74, 72 observed, 97.51 expected, 95 percent confidence for range 0.58-0.94); diseases of the digestive system (SMR=0.76, 9 observed, 11.86 expected, 95 percent confidence for range 0.35-1.44); and accidents (SMR=0.89, 16 observed, 17.86 expected, 95 percent confidence for range 0.51-1.44). Non-statistically significant increases were noted for lung cancer (SMR=1.50, 17 observed, 11.37 expected, 95 percent confidence for range 0.87-2.40); diseases of the respiratory system (SMR=1.33, 13 observed, 9.77 expected, 95 percent confidence for range 0.71-2.27), especially emphysema (SMR=2.21, 6 observed, 2.71 expected, 95 percent confidence for range 0.81-4.82); and suicide (SMR=1.64, 10 observed, 6.09 expected, 95 percent confidence for range 0.79-3.02). A subgroup of welders (N=536) exposed to nickel oxides (possible respiratory carcinogens) at K–25 were compared with welders at the other two facilities (N=523). The risk of lung cancer and other respiratory diseases did not differ between the two groups.

Combined Nuclear Sites. Workers at ORR have been included in several studies that have examined occupational risks across the nuclear complex, both in the United States and internationally. These combined studies have been undertaken in an attempt to increase the statistical power of the studies to detect the effects of low-level chronic radiation exposure.

Y–12 workers were included in a lung cancer case-control study of workers from the Fernald Feed Materials and Production Center cohort and the Mallinckrodt Chemical Works cohort. Dupree et al. conducted a nested case-control study of lung cancer (N=787) to investigate the relationship between lung cancer and uranium dust exposure (Epidemiology 1995a:370-375). Eligible cases were employed at least 183 days in any of the facilities and died before January 1, 1983, with lung cancer listed anywhere on the death certificate. Inclusion of fatalities through 1982 allowed over 30 years of observation at each facility. One control was matched to each case on facility, race, gender, and birth and

hire dates within 3 years. Data collected on all study members included smoking history, first pay code (a surrogate for socioeconomic status), complete work histories, and occupational radiation monitoring records. Annual radiation lung dose from deposited uranium was estimated for each study member. Annual external whole body doses from gamma radiation were determined for workers who had personal monitoring data available. Potential confounders considered in the analysis were smoking (ever/never used tobacco) and pay code (monthly/non-monthly). With a 10-year lag, cumulative lung doses ranged from 1 to 137 rad for cases and from 0 to 80 rad for controls. The odds ratios for lung cancer mortality for seven cumulative internal dose groups did not demonstrate increasing risk with increasing dose. An odds ratio of 2.0 was estimated for those exposed to 25 rad or more, but the 95 percent confidence interval of -.20 to 20 showed great uncertainty in the estimate. There was a suggestion of an exposure effect for workers hired at age 45 years or older.

A combined site mortality study included workers from ORNL, the Hanford Site, and the Rocky Flats Plant (RR 1993a:408-421). Earlier analyses of these cohorts indicated that risk estimates calculated through extrapolation from high-dose data to low-dose data did not seriously underestimate risks of exposure to low-dose radiation (AJE 1990a:917-927; RR 1989a:19-35). The updated analyses were performed in order to determine whether the extrapolated risks represented an overestimation of the true risk at low doses. The study population consisted of white males employed at one of the three facilities for at least 6 months and monitored for external radiation. The Hanford population also included females and nonwhite workers. The total population dose was 123,700 person-rem. Analyses included trend tests for site-specific cancer fatalities and several broad noncancer categories. Statistically significant trends were noted for cancer of the esophagus, cancer of the larynx, and Hodgkin's disease. These cancers were not related to radiation exposure levels in previously published studies. Excess relative risk models were calculated for the combined DOE populations and for each DOE site separately. Without exception, all risk estimates included the possibility of zero risk (that is, the confidence interval for the risk coefficient went from below zero to above zero). There was evidence of an increase in the excess relative risk for cancer with increasing age in the Hanford and ORNL populations; both populations showed significant correlations of all cancer with radiation dose among those 75 years and older.

An international effort to pool data from populations exposed to external radiation included the ORNL population, in addition to other radiation worker populations in the United States, Canada, and Britain (RR 1995a:117-132). The cohort comprised 95,673 workers (85.4 percent men) employed 6 months or longer, and the population dose was 384,320 person-rem. There was no evidence of an association between radiation dose and mortality from all causes or from all cancers. There was a significant dose-response relationship with leukemia, excluding chronic lymphocytic leukemia (excess relative risk=2.18 per SV; 90 percent CI for range 0.1-5.7) and multiple myeloma (excess relative risk not computed; 44 observed). The study results do not suggest that current radiation risk estimates for cancer at low levels of exposure are appreciably in error.

E.4.2.4 Memorandum of Understanding

The Department of Energy entered into a Memorandum of Understanding with the Department of Health and Human Services to conduct health studies at DOE sites. The NIOSH is responsible for the conduct and management of worker studies.

The following studies at ORR are managed by NIOSH with funding from DOE: a study of multiple myeloma among workers at the K–25 Site at Oak Ridge (expected completion date 1996); a multisite study to assess the potential association between paternal exposure to ionizing radiation and the risk of leukemia in offspring of exposed male workers; a study of neurologic health outcomes in workers exposed to high levels of mercury between 1953 and 1963; studies of mortality among Oak Ridge workers; a multisite study of mortality among female nuclear workers; a multisite exposure assessment of hazardous waste/cleanup workers; a chronic beryllium disease study; and a multisite study of heat stress and performance among carpenters.

E.4.3 SAVANNAH RIVER SITE, AIKEN, SC

The SRS, established in 1953 in Aiken, South Carolina, produces plutonium, tritium, and other nuclear materials. There are reports that millions of curies of tritium have been released over the years both in plant exhaust plumes and in surface and groundwater streams (ED 1982a:135-152).

E.4.3.1 Surrounding Communities

In 1984, Sauer and Associates examined mortality rates in Georgia and South Carolina by distance from the Savannah River Plant (now known as the Savannah River Site) (SR duPont 1984a). Mortality rates for areas near the plant were compared with U.S. rates and with rates for counties located more than 50 miles away. Breast cancer, respiratory cancer, leukemia, thyroid cancer, bone cancer, malignant melanoma of the skin, non-respiratory cancer, congenital anomalies or birth defects, early infancy fatality rates, stroke, or cardiovascular disease in the populations living within 50 miles of the plant did not show any excess risk compared with the reference populations.

E.4.3.2 State Health Agreement Program

Under the State Health Agreement program managed by the DOE Office of Epidemiologic Studies, a grant was awarded to the Medical University of South Carolina in 1991 to develop the Savannah River Region Health Information System. The purpose of the Savannah River Region Health Information System database was to assess the health of populations surrounding SRS by tracking cancer rates and birth defects rates in the area. Information from the registry is available to public and private health care providers for use in evaluating cancer control efforts. A steering committee provides advice to the Savannah River Region Health Information System and communicates public concerns to Savannah River Region Health Information System. It consists of 12 community members and persons with technical expertise representing South Carolina and Georgia.

E.4.3.3 Workers

A descriptive mortality study was conducted that included 9,860 white male workers who had been employed at lease 90 days at SRS between 1952 and the end of 1974 (AJIM 1988b:379-401). Vital status was followed through the end of 1980, and mortality was compared with the U.S. population. SMRs were computed separately for hourly and salaried employees. For hourly employees, non-statistically significant increases were seen for cancer of the rectum (SMR=1.09, 5 observed, 95 percent CI for range 0.35-2.54), cancer of the pancreas (SMR=1.08, 10 observed, 95 percent CI for range 0.59-2.13), leukemia and aleukemia (SMR=1.63, 13 observed, 95 percent CI for range 0.87-2.80), other lymphatic tissue (SMR=1.06, 5 observed, 95 percent CI for range 0.34-2.48), benign neoplasms (SMR=1.33, 4 observed, 95 percent CI for range 0.36-3.40), and motor vehicle accidents (SMR=1.10, 63 observed, 95 percent CI for range 0.84-1.40). Salaried employees exhibited non-statistically significant increases in cancer of the liver (SMR=1.84, 3 observed, 95 percent CI for range 0.38-5.38), cancer of the prostate (SMR=1.35, 5 observed, 95 percent CI for range 0.44-3.16), cancer of the bladder (SMR=1.87, 4 observed, 95 percent CI for range 0.51-4.79), brain cancer (SMR=1.06, 4 observed, 95 percent CI for range 0.29-2.72), leukemia and aleukemia (SMR=1.05, 4 observed, 95 percent CI for range 0.29-2.69), and other lymphatic tissue (SMR=1.23, 3 observed, 95 percent CI for range 0.26-3.61). No trends between increasing duration of employment and SMRs were observed. A statistically significant excess of leukemia fatalities was observed for hourly workers employed between 5 and 15 years (SMR=2.75, 6 observed, 95 percent CI for range 1.01-5.99). Review of the plant records and job duties of the workers who died from leukemia indicated that two of the cases had potential routine exposure to solvents, four had potential occasional exposure to solvents and one had potential for minimal exposure. Benzene, a known carcinogen, was reportedly not used at the plant.

The Department of Energy's Office of Epidemiologic Studies has implemented an Epidemiologic Surveillance Program at SRS to monitor the health of current workers. This program will evaluate the occurrence of illness and injury in the workforce on a continuing basis, and the results will be issued in annual reports. The implementation of this program will facilitate an ongoing assessment of the health and safety of SRS's workforce and will help identify emerging health issues.

Currently operational at a number of DOE sites, including production sites and research and development facilities, epidemiologic surveillance uses routinely collected health data, including descriptions of illness resulting in absences lasting 5 or more consecutive workdays, disabilities, and OSHA recordable injuries and illnesses abstracted from the OSHA 200 log. These health event data, coupled with demographic data about the active workforce at the participating sites, are analyzed to evaluate whether particular occupational groups are at increased risk of disease or injury when compared with other workers at a site. As the program continues and data for an extended period of time become available, time trend analysis will become an increasingly important part of the evaluation of worker health. Monitoring the health of the workforce provides a baseline determination of the illness and injury experience of workers and a tool for monitoring the effects of changes made to improve the safety and health of workers. Noteworthy changes in the health of the workforce may indicate the need for more detailed study or increased health and safety measures to ensure adequate protection for workers.

E.4.3.4 Memorandum of Understanding

The Department of Energy entered into a Memorandum of Understanding with Health and Human Services to conduct health studies at DOE sites. The Centers for Disease Control and Prevention's NCEH is responsible for dose reconstruction studies, and NIOSH is responsible for worker studies. These activities are funded by DOE.

A study of mortality among SRS workers employed from 1952 to 1974 that examined whether risks of fatalities due to selected causes may be related to occupational exposures at SRS is being conducted by NIOSH. SRS is also included in several multisite studies managed by NIOSH. The first study is to assess the potential association between paternal work-related exposure to ionizing radiation and the risk of leukemia in offspring of exposed male workers. The second study is to examine causes of fatality among female workers at nuclear weapons facilities to develop risk estimates based on exposures to external and internal ionizing radiation and to hazardous chemicals. A third multisite project is a case-control study of multiple myeloma, a type of blood cell cancer.

A dose reconstruction project around the SRS is being conducted by NCEH to determine the type and amount of contaminants to which people living around the site may have been exposed, to identify exposure pathways of concern, and to quantify the doses people may have received as a result of SRS operations. The estimated completion date is 1999 or 2000.

E.4.4 BABCOCK & WILCOX SITE, LYNCHBURG, VA

E.4.4.1 Surrounding Communities and Workers

Several potential sources of information were searched for epidemiologic or health studies of persons living near or working at the B&W site. No information was found in the medical literature or other accessible databases (for example, Toxline). The Campbell County Health Department has no information regarding studies conducted at the local level. The Virginia State Health Department Office of Health Hazards Control and the Virginia State Department of Environmental Quality had no information on any studies conducted by the State of Virginia.

E.4.5 NUCLEAR FUEL SERVICES SITE, ERWIN, TN

E.4.5.1 Surrounding Communities and Workers

Several potential sources of information were searched for epidemiologic or health studies of persons living near or working in the NFS site. No information was found in the medical literature. One report was found in Toxline. A study was conducted of kidney disease among plant workers, with guards, and local dairy farmers used as comparison groups (NIOSH 1988a:1). Workers had a higher prevalence of kidney stones than the guards, but a lower prevalence than the dairy workers. NFS employees had a higher prevalence of urinary tract infections than both the guards and dairy farmers. Kidney function was similar in all groups. The authors concluded that the urinary tract disorders in the NFS

workers were not the result of occupational hazards. In 1979, the Centers for Disease Control investigated newspaper reports of increased rates of cancer fatalities in Unicoi County. The investigators compared the rates with four surrounding counties and also conducted occupational and environmental surveys. The investigators found that increasing cancer rates over time were due to aging of the population, that age-adjusted rates had not changed significantly, and that there did not appear to be any observable risks from exposures or emissions from the NFS site.

The Unicoi County Health Department and the Tennessee State Health Department Epidemiology Program Office were not aware of any studies conducted by local or State personnel.

E.5 FACILITY ACCIDENTS

E.5.1 EVALUATION METHODOLOGIES AND ASSUMPTIONS

The potential for facility accidents and the magnitudes of their consequences are important factors in the evaluation of the alternatives being addressed in this EIS. The health risk issues are twofold and consider the following:

- Whether accidents at any of the blending sites pose unacceptable health risks to workers or the general public.
- Whether alternative locations for facilities can provide lesser public or worker health risks. These lesser risks may arise from differences in meteorology that reduce environmental concentrations, from a greater isolation of the site from the public, or from a reduced frequency of such external accident initiators as seismic events and aircraft crashes.

E.5.1.1 Analysis Methodology

The *MELCOR Accident Consequence Code System* (MACCS) (NUREG/CR-6059, SAND92-2146, October 1993)was used to estimate the consequences of accidents involving the release of radioactivity. (The GENII code was also exercised for one case to investigate the effect of using different meteorological data at one site. A discussion of the GENII code is provided in Section E.2.2.1.)

The enhanced Chemical Hazard Evaluation Methodologies computer code was used to estimate the consequences of accidents involving the release of hazardous chemicals. The program was developed to provide several integrated estimation methods to assess toxic vapor dispersion, fire, and explosion impacts associated with episodic discharges of hazardous materials into the environment. The modules of Chemical Hazard Evaluation Methodologies used in this analysis were estimation of the discharge rate and duration of a gas or liquid released from a tank or pipeline, the size of liquid pools that form on the ground, and the size of the downwind area impacted by the release of a toxic gas or vapor into the air. The vapor dispersion model is the straight line Gaussian type, which is similar to that used in GENII.

E.5.1.2 MELCOR Accident Consequence Code System Overview

MACCS models the onsite and offsite consequences of an accident that releases a plume of radioactive materials to the atmosphere. Should such an accidental release occur, the radioactive gases and aerosols in the plume would be transported by the prevailing wind while dispersing in the atmosphere. The environment would be contaminated by radioactive materials deposited from the plume, and the population would be exposed to radiation. The objectives of a MACCS calculation are to estimate the range and probability of the health effects induced by the radiation exposures not avoided by protective actions, and to estimate the economic costs and losses that would result from the contamination of the environment.

In order to understand MACCS, one must understand its essential elements: the division of the time scale after the accident into various "phases," and the division of the region surrounding the nuclear facility into a polar-coordinate grid.

The time scale after the accident is divided into three phases: emergency phase, intermediate phase, and long-term phase. The emergency phase begins immediately after the accident and could last up to 7 days following the accident. In this period, the exposure of a population to both radioactive clouds and contaminated ground is modeled. Various protective measures can be specified for this phase, including evacuation, sheltering, and dose-dependent relocation.

The intermediate phase can be used to represent a period in which evaluations are performed and decisions are made regarding the types of protective measure actions which need to be taken. In this period, the radioactive clouds are assumed to be gone, and the only exposure pathways are those from the contaminated ground. The protective measure that can be taken during this period is temporary relocation.

The long-term phase represents all time subsequent to the intermediate phase. The only exposure pathways considered here are those resulting from the contaminated ground. A variety of protective measures can be taken in the long-term phase to reduce doses to acceptable levels: decontamination, interdiction, and condemnation of property.

The spatial grid used to represent the region is centered on the facility itself. The user specifies the number of radial divisions as well as their endpoint distances. Up to 35 of these divisions may be defined, extending out to a maximum distance of 9,999 km (6,213 mi). The angular divisions used to define the spatial grid correspond to the 16 directions of the compass.

Since the emergency phase calculations utilize highly nonlinear dose-response models, due to higher doses for early fatality and early injury, those calculations must be performed on a finer grid than the calculations of the intermediate and long-term phases. For this reason, the 16 compass sectors are divided into 3, 5, or 7 user-specified subdivisions in the calculations of the emergency phase.

The increased likelihood of cancer fatality to a member of the public is taken as $5x10^{-4}$ times the dose in rem for values of dose less than 20 rem or when the rate of exposure is less than 10 rad/hr. For doses greater than 20 rem or dose rates greater than 10 rad/hr, the cancer fatalities are doubled. The MACCS code was applied in a probabilistic manner using a weather bin sampling technique. The weather bins consist of hourly data for the windspeed, wind direction, and stability class. Centerline doses as a function of distance were calculated for each of approximately 100 meteorological sequence samples; the mean value of these doses and increased likelihoods of cancer fatality for the distance corresponding to the location of the MEI at each site were reported for that individual. Mean values were selected instead of median values because they yielded higher dose values for each candidate site.

Offsite population doses, noninvolved worker population doses, and latent cancer fatalities are calculated by MACCS using a methodology similar to that described for the individuals. In the case of a population, each of the sampled meteorological sequences was applied to the population distribution across 16 sectors. The weather bin sampling technique accounted for the frequency of occurrence of the wind blowing in each direction. Population doses are the sum of the individual doses in each sector. Once again, the mean value of the calculated population doses and latent cancer fatalities for each of the trials were reported. Mean values were selected instead of median values because they yielded higher dose values for each candidate site. Doses to noninvolved workers were calculated similarly, except that these workers will experience cancer fatalities of $4x10^{-4}$ times the dose in rem for doses less than 20 rem or exposure rates less than 10 rad/hr. For larger doses, above 20 rem and when the dose rate of exposure is greater than 10 rad/hr, the cancer fatalities are doubled.

A detailed description of the MACCS model is available in a three-volume report (NUREG/CR-6059, SAND92-2146).

E.5.1.3 Application of Models

For the analysis of accidents involving the release of radioactivity at the four facilities of interest (ORR Y-12, SRS H-Canyon, B&W, and NFS), the MACCS calculations used the source term data presented in Section E.5.2. Elevated releases were assumed to be from existing stacks at B&W (11 m [36 ft]) and NFS (33 m [108 ft]); SRS and ORR stack releases were calculated at 10 m (33 ft). For each of the latter three sites, sequences from 1 year of hourly onsite meteorological data were sampled; for B&W, the closest available complete (24 hour) data set was that from Woodrum Airport in Roanoke, Virginia, 93 km (61 mi) west of B&W and Richmond International Airport, 144 km (90 mi) east of B&W.

Since the only B&W onsite digital data consisted of a (windspeed-wind direction-stability class) joint frequency distribution file, which is suitable input to the GENII code (but not to MACCS), data from the Roanoke airport and the Richmond International Airport were obtained and reduced to joint frequency distribution files. Each of these distributions was used as input to the GENII code with all other B&W site data (for example, population) being equivalent. The evaluation basis earthquake for the uranium hexafluoride (UF_6) process was the scenario chosen for comparing GENII and MACCS results since it gave the maximum dose to workers and the public.

The dose to the MEI from the GENII code is 0.034, 0.072, and 0.080 rem and to the general population within 80 km (50 mi) is 17, 46, and 28 person-rem using meteorological data from the B&W site, Roanoke, and Richmond, respectively. From this it is concluded that use of the Roanoke airport data in the MACCS code may result in a factor of 2 to 3 higher doses than if onsite B&W data were used.

The dose to the MEI and to the general population within 80 km (50 mi) was calculated with the GENII code using meteorological data from both B&W and Roanoke airport for all six accidents (a filter fire, an earthquake induced criticality, an evaluation basis earthquake for the uranyl nitrate hexahydrate (UNH) process, a fluid bed, an evaluation basis earthquake for the UF_6 process, and a UF_6 cylinder release). The dose for all six accidents to the MEI and the general population was an average 2.1 and 2.7 times larger, respectively, using the Roanoke airport meteorological data. This is consistent with the previous analysis reported in the B&W EA, which notes:

> The onsite information is extremely valuable due to the unique nature of the site. The site has an unusual microclimate that would not mirror that of Lynchburg in terms of wind speeds, directions, or stabilities. The presence of a river on three sides of the site imposes unusual temperature conditions and reduces the stability of the air mass. The river will be cooler than the peninsula during the spring and the summer and warmer during the fall and winter. Diurnal variations of the river are minimal while the land surface will normally experience a 21-degree Fahrenheit diurnal variation. On clear cloudless nights, the valley bottoms in the area are often 10 to 15 degrees cooler than higher elevations. This can cause periods of both high stability and unstable conditions depending on cloud cover and wind speed during the following day. The deep river valley will also tend to divert the winds near surface level from the prevailing wind direction and cause additional instability. However, the river valley will tend to limit the directionality of the wind as compared to conditions observed at Lynchburg (BW NRC 1991a:38).

Radiation doses to the affected individuals and populations were calculated in the dosimetry models using the concentrations of radionuclides obtained from the dispersion models. Dose conversion factors were used to convert the radionuclide concentrations to organ dose equivalents and whole-body effective dose equivalents. Exposure pathways considered in the MACCS calculations for the period following an accident were direct radiation from the passing plume and from radioactive material deposited on the ground, inhalation from the plume, deposition on skin and inhalation of resuspended ground contamination. Ingestion of produce and animal products raised within 80 km (50 mi) of the release is not considered; this pathway would be easily interdicted in the case of an accident by bringing food in from outside this area. Liquid exposure pathways were not considered because interdiction is assumed. No credit was taken for short-term reactions such as evacuation and relocation. However, it was assumed that noninvolved workers would be shielded from the inhalation of radioactive materials for approximately half the time that the radioactive plume would be present at the site.

Three types of receptors were considered for quantitative evaluation of impacts: the offsite population, the MEI of the general public, and the noninvolved (collocated) worker. The offsite population consists of individuals residing within 80 km (50 mi) of a site. The MEI at NFS was taken as the nearest residence, located 250 m (820 ft) south of the plant and, in essence, across the street from the site fence (NF NRC 1991a:4-33). The MEI at B&W was assumed to be along the site boundary, 540 m (1,772 ft) west-southwest of the plant (BW NRC 1991a:73). For the SRS and ORR sites, the site boundary in the direction of minimum atmospheric plume attenuation was chosen; these values were found (from perusal of GENII runs) as 11,750 m (38,550 ft) north-northwest and 619 m (2,031 ft) north-northwest, respectively.

Noninvolved worker populations, used in the radiation dose calculations, were based on total site worker populations less those involved in the blending process. Workers within the processing area are all of NFS and B&W, H-Area at SRS, and Y–12 at ORR. Workers in the processing areas were spatially distributed based on local building locations. Workers at facilities distant from the

process area (for example, M-Area at SRS, ORNL at ORR) were considered to be concentrated within one sector. The total worker populations used in the MACCS calculation were approximately 325 at NFS, 2,200 at B&W (including the Naval Nuclear Fuel Division (NNFD) Research Laboratory and the Commercial Fuel Facility), 17,000 at ORR (including 6,400 at Y–12), and 12,000 at SRS (including 3,800 in H-Area).

Data on the surrounding population by sector at Y–12 and SRS are listed in *Health Risk Data for Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement* technical report (February 1996). Data on the surrounding population at NFS were obtained from Table 3.4 of the NRC *Environmental Assessment for Renewal of Special Nuclear Material License No. SNM-124* prepared for NFS (Docket No. 10-143, August 1991). Data on the surrounding population at B&W were obtained from Table 3.7 of the NRC *Environmental Assessment for Renewal of Special Nuclear Material License No. SNM-42* prepared for B&W (Docket No. 70-27, August 1991). Data on meteorology and stack heights at each site are given in Appendix C.

For SRS, the accident analysis was performed for the H-Area. If blending were to occur in the F-Area, the doses from an accidental release would be similar to an accidental release in H-Area. The dose to the MEI would be slightly larger due to the decreased distance of 9,646 m (31,649 ft) from F-Area to the site boundary. The dose to the offsite population within 80 km (50 mi) would be slightly smaller due to F-Area being further from the offsite population than H-Area. The dose to the noninvolved workers would be smaller due to the smaller workforce in the F-Area. The dose to noninvolved workers in the processing area is the dominant portion of the dose to the total site noninvolved workers. The dose to noninvolved workers not in the processing area would be a minimal effect due to the distance to the other areas.

The noninvolved (collocated) worker was considered for the chemical accident impact analysis. All of the workers at NFS are in the immediate vicinity of the blending process; because of the short distance to the site boundary and for the purpose of comparison with the other sites, the distance and direction to the MEI was also used for the noninvolved worker. For the B&W site, the noninvolved worker is 230 m (755 ft) northeast of the facility being analyzed (at the experimental facility). For both SRS and ORR, the noninvolved worker was located 644 m (2,113 ft) from the facility. The direction of minimum atmospheric plume attenuation (southeast and north-northeast, respectively) was chosen.

Estimates of release durations from the chemical tanks involved in the accidents described in Section E.5.2 were performed using CHEMS-PLUS. It was found that assuming a release of the entire contents of any of the chemical tanks over 1 hour was reasonable. Atmospheric chemical concentrations experienced by the MEIs and noninvolved workers described above were calculated and compared with health-based criteria, Immediately Dangerous to Life or Health (IDLH) concentrations, TLV for 15-min Short Term Exposure Limits (STEL) and 8-hour Time Weighted Average (TWA) concentrations. The latter two limits are included to indicate exposure to levels which are occupationally acceptable for short- and long-term exposure, respectively.

The meteorological conditions used to estimate chemical impacts were approximations of mean conditions. The average site windspeeds given in Chapter 3 of this EIS were used together with the median stability class for each site (as obtained from the joint frequency distribution described above). The windspeeds for ORR, SRS, B&W, and NFS were 2.0, 2.9, 3.4, and 2.5 m/s (4.4, 6.5, 7.7, and 4.4 ft/s), respectively, and the stability classes were D, C, D, and A, respectively.

E.5.2 BOUNDING ACCIDENTS

The postulated accidents for each conversion/blending process were analyzed at each of the candidate sites (a subset of Y–12, SRS, NFS, and B&W). It was assumed that the inventory of hazardous/radioactive materials, the process, and the facilities were the same at all four facilities. The differentiating parameters of the analyses were distances to the site boundary (or nearest resident), surrounding population, distribution of collocated workers, meteorology, and stack height.

A set of potential accidents was postulated for which there may be releases of radioactivity and hazardous

chemicals that could impact noninvolved onsite workers and the offsite population. A set of accident scenarios was selected to represent bounding cases. In assessing the bounding accident scenarios for the Conversion and Blending Facility, the following parameters were evaluated: (1) material at risk; (2) energy sources (fires, explosions, earthquakes, and process design-related events); (3) barriers to release; and (4) protective features of the facility. It is expected that each of these parameters would be unchanged for the range of LEU enrichment considered, except in the case of the evaluation basis earthquake accident scenario.

The bounding chemical release accidents could include a spill from nitric acid and sodium hydroxide storage tanks, and the rupture of processing lines resulting in the emptying of a hydrogen fluoride tank and a fluorine cylinder, depending on the alternative process considered. The details of chemical release quantities and resulting impacts are provided under each alternative in Chapter 4.

E.5.2.1 Facility Accidents Postulated for Blending Highly Enriched Uranium to Low-Enriched Uranium as Uranyl Nitrate Hexahydrate

The accident scenarios that were considered included a tornado, straight winds, an aircraft crash, a truck crash, nuclear criticality, process-related accidents, and an evaluation basis earthquake. With the exception of the filter fire (with continuous exhaust flow), all of the accident scenarios that are considered potentially bounding can be initiated by the evaluation basis earthquake. Therefore, it is concluded that the evaluation basis earthquake would result in the highest atmospheric release of radioactivity and hazardous chemicals. The evaluation basis earthquake is assumed to initiate the nuclear criticality and other release scenarios.

In a filter fire accident, it is assumed that a fire occurs that releases all the uranium in the bag filters, traps, and the high-efficiency particulate air filters and releases it to the atmosphere through the stacks in a matter of minutes. The quantity of material assumed to be released is 0.15 kg (0.33 lb) of HEU. The accident annual frequency was estimated to be in the range of 10^{-4} to 10^{-2}; 10^{-3} was chosen for use in comparing alternatives. The source term analyzed and the resulting doses are shown in Tables E.5.2.1–1 and E.5.2.1–2.

Table E.5.2.1–1. Source Term for a Filter Fire Accident

Nuclide	Release Activity (curies)
U-232	1.3×10^{-4}
U-234	4.0×10^{-3}
U-235	1.6×10^{-4}
U-236	2.2×10^{-5}
U-238	2.4×10^{-5}

Source: OR LMES 1995b.

In an earthquake-induced criticality accident, it is assumed that storage racks containing multiple critical masses of uranium powder and uranyl nitrate solution are damaged directly by seismic shaking and indirectly by falling debris. Safe spacing is lost and moderators are added as water from the fire system or organic solutions. This results in the possible formation of one or more critical assemblies. In an accidental criticality, it is assumed that 1×10^{19} fissions occur before reaching a stable, subcritical condition and that all material releases occur within a 2-hour period. The amount of radioactive material released as fission products created by the nuclear criticality is 46,000 Ci of krypton isotopes, 65,000 Ci of xenon isotopes, and 1,600 Ci of iodine isotopes. The accident annual frequency was estimated to be in the range of 10^{-5} to 10^{-3}; 10^{-4} was chosen for use in comparing alternatives. The source term analyzed and the resulting doses are shown in Tables E.5.2.1–3 and E.5.2.1–4.

In the evaluation basis earthquake accident scenario, it is assumed that the building collapses, resulting in ruptured containers, piping and tanks releasing uranium solutions, water, toxic gases, flammable gases, and toxic and reactive liquids. This is assumed to result in the release of 0.076 Ci of uranium isotopes for processing to 4-percent UNH (67 percent of the activity is U-234); and the release of 0.19 Ci of uranium isotopes for processing to 0.9-percent UNH (54 percent of the activity is U-234). The accident annual frequency was estimated to be in the range of 10^{-5} to 10^{-3}; 10^{-4} was chosen for use in comparing alternatives. The source terms analyzed and the resulting doses are shown in Tables E.5.2.1–5 through E.5.2.1–8.

Table E.5.2.1–2. Resulting Doses for a Filter Fire Accident

	Receptor Dose		
Site	Noninvolved Workers (person-rem)	Maximally Exposed Individual (rem)	Population Within 80 km (person-rem)
Y–12	11	1.0×10^{-2}	1.5
SRS	2.3	6.6×10^{-5}	0.37
B&W	24	1.2×10^{-2}	0.9
NFS	1.6	2.3×10^{-3}	1.3

Source: Results shown are derived from MACCS runs.

Table E.5.2.1–3. Source Term for a Criticality Accident

Nuclide	Release Activity (curies)
Kr-83m	160
Kr-85m	150
Kr-85	1,600
Kr-87	990
Kr-88	650
Kr-89	42,000
Xe-131m	8.2×10^{-2}
Xe-133m	1.8
Xe-133	27
Xe-135m	2,200
Xe-135	360
Xe-137	49,000
Xe-138	13,000
I-131	2.2
I-132	280
I-133	40
I-134	1,100
I-135	130

Source: OR LMES 1995b.

Table E.5.2.1–4. Resulting Doses for a Criticality Accident

	Receptor Dose		
Site	Noninvolved Workers (person-rem)	Maximally Exposed Individual (rem)	Population Within 80 km (person-rem)
Y–12	38	5.1×10^{-2}	3
SRS	8.5	3.0×10^{-4}	0.33
B&W	80	5.6×10^{-2}	1.9
NFS	8.7	1.4×10^{-2}	2.2

Source: Results shown are derived from MACCS runs.

Table E.5.2.1–5. Source Term for an Evaluation Basis Earthquake Accident (4-percent Uranyl Nitrate Hexahydrate)

Nuclide	Release Activity (curies)
U-232	1.7×10^{-2}
U-234	5.1×10^{-2}
U-235	2.1×10^{-3}
U-236	2.5×10^{-4}
U-238	5.9×10^{-3}

Source: OR LMES 1995d.

Table E.5.2.1–6. Resulting Doses for an Evaluation Basis Earthquake Accident (4-percent Uranyl Nitrate Hexahydrate)

	Receptor Dose		
Site	Noninvolved Workers (person-rem)	Maximally Exposed Individual (rem)	Population Within 80 km (person-rem)
Y–12	320	0.31	44
SRS	70	1.9×10^{-3}	11
B&W	760	0.36	26
NFS	67	7.8×10^{-2}	38

Source: Results shown are derived from MACCS runs.

Table E.5.2.1–7. Source Term for an Evaluation Basis Earthquake Accident (0.9-percent Uranyl Nitrate Hexahydrate)

Nuclide	Release Activity (curies)
U-232	6.0×10^{-2}
U-234	0.1
U-235	4.1×10^{-3}
U-236	4.3×10^{-4}
U-238	2.2×10^{-2}

Source: OR LMES 1995d.

Table E.5.2.1–8. Resulting Doses for an Evaluation Basis Earthquake Accident (0.9-percent Uranyl Nitrate Hexahydrate)

	Receptor Dose		
Site	Noninvolved Workers (person-rem)	Maximally Exposed Individual (rem)	Population Within 80 km (person-rem)
Y–12	960	0.94	130
SRS	210	58×10^{3}	32
B&W	2,300	1.1	79
NFS	200	0.23	110

Source: Results shown are derived from MACCS runs.

E.5.2.2 Facility Accidents Postulated for Blending Highly Enriched Uranium to Low-Enriched Uranium as Uranium Hexafluoride

The accident scenarios that were considered included a tornado, straight winds, an aircraft crash, a truck crash, nuclear criticality, process-related accidents, and a evaluation basis earthquake. With the exception of the fluidized bed release and the filter fire (with continuous exhaust flow), all of the accident scenarios that are considered potentially bounding can be initiated by the evaluation basis earthquake. Therefore, it is concluded that the evaluation basis earthquake would result in the highest atmospheric release of radioactivity and hazardous chemicals. The evaluation basis earthquake is assumed to initiate the nuclear criticality, UF_6, and other release scenarios.

In a fluidized bed release, it is assumed that the high temperature filters are removed for replacement but the filter housing is closed without new filters inside. The inventory of one bed is swept out of the stack by the nitrogen used to fluidize the bed. The quantity of material assumed to be released is 7.5 kg (16.5 lb) of HEU. The accident annual frequency was estimated to be in the range of 10^{-4} to 10^{-2}; 10^{-3} was chosen for use in comparing alternatives. The source term analyzed and the resulting doses are shown in Tables E.5.2.2–1 and E.5.2.2–2.

In a filter fire accident, it is assumed that a fire occurs that releases all the uranium in the bag filters, traps, and the filters, and releases it to the atmosphere in a matter of minutes. The quantity of material assumed to be released is 0.15 kg (0.33 lb) of HEU. The source term analyzed and the resulting doses are shown in Tables E.5.2.1–1 and E.5.2.1–2.

Table E.5.2.2–1. Source Term for a Fluidized Bed Release

Nuclide	Release Activity (curies)
U-232	5.5×10^{-3}
U-234	0.16
U-235	6.5×10^{-3}
U-236	9.1×10^{-4}
U-238	1.0×10^{-3}

Source: OR LMES 1995a.

In an earthquake-induced criticality accident, it is assumed that storage racks containing multiple critical masses of uranium powder and uranyl nitrate solution are damaged directly by seismic shaking and indirectly by falling debris. Safe spacing is lost, and moderators are added as water from the fire system or organic solutions. This results in the possible formation of one or more critical assemblies. In an accidental criticality, it is assumed that 1×10^{19} fissions occur before reaching a stable, subcritical condition and that all material releases occur within a 2-hour period. The amount of radioactive material released as fission products created by the nuclear criticality is 46,000 ci of krypton isotopes, 65,000 ci of xenon isotopes, and 1,600 ci of iodine isotopes. The source term analyzed and the resulting doses are shown in Tables E.5.2.1–3 and E.5.2.1–4.

In the evaluation basis earthquake accident scenario, it is assumed that the building collapses, resulting in ruptured containers, piping, and tanks releasing uranium solutions, water, toxic gases, flammable gases, and toxic and reactive liquids. This is assumed to result in the release of 0.061 Ci of uranium (76 percent of the activity is U-234). The source term analyzed and the resulting doses are shown in Tables E.5.2.2–3 and E.5.2.2–4.

In the UF_6 accident release, the evaluation basis earthquake causes equipment failures and a pressurized release of a UF_6 cylinder. Thirty percent of a cylinder containing UF_6 gas is assumed to be released into the atmosphere consistent with the NRC's *Nuclear Fuel Cycle Facility Accident*

Analysis Handbook (NUREG-1320, May 1988). After the accident, it is estimated that there would be a release of thirty percent of the material to equalize the pressure inside and outside the cylinder. The thirty percent release of UF_6 gas was derived from the relationship provided in NRC's Handbook:

$$\text{Percent Release} = 30\ MF_g^{0.91}$$

In this relationship, MF_g is the mole fraction of the pressurized gas. It is reported in the NRC Handbook that this relationship was developed using measured data, and bounds observed releases of aerosols produced from pressurized powders. When MF_g equals one, all the material in the cylinder would be a gas under normal temperature and pressure, which is a conservative assumption for the analysis in this EIS. Therefore, for a pressurized release during cylinder filling operation, the source is calculated to be 30 percent of 6,300 kg (13,600 lb), which is 1,900 kg (4,100 lb) of 1.5 percent assay LEU. The accident annual frequency was estimated to be in the range of 10^{-5} to 10^{-3}; 10^{-4} was chosen for use in comparing alternatives. The source term analyzed and the resulting doses are shown in Tables E.5.2.2–5 and E.5.2.2–6.

Table E.5.2.2–2. Resulting Doses for a Fluidized Bed Release

	Receptor Dose		
Site	Noninvolved Workers (person-rem)	Maximally Exposed Individual (rem)	Population Within 80 km (person-rem)
B&W	990	0.49	38
NFS	68	9.7×10^{-2}	53

Source: Results shown are derived from MACCS runs.

Table E.5.2.2–3. Source Term for an Evaluation Basis Earthquake Accident (Uranium Hexafluoride)

Nuclide	Release Activity (curies)
U-232	9.3×10^{-3}
U-234	4.6×10^{-2}
U-235	1.8×10^{-3}
U-236	2.4×10^{-4}
U-238	3.2×10^{-3}

Source: OR LMES 1995a.

Table E.5.2.2–4. Resulting Doses for an Evaluation Basis Earthquake Accident (Uranium Hexafluoride)

	Receptor Dose		
Site	Noninvolved Workers (person-rem)	Maximally Exposed Individual (rem)	Population Within 80 km (person-rem)
B&W	524	0.25	18
NFS	46	5.4×10^{-2}	26

Source: Results shown are derived from MACCS runs.

Table E.5.2.2–5. Source Term for a Uranium Hexafluoride Cylinder Accident

Nuclide	Release Activity (curies)
U-232	1.6
U-234	1.6
U-235	5.8×10^{-2}
U-236	6.5×10^{-3}
U-238	0.6

Source: OR LMES 1995a.

Table E.5.2.2–6. Resulting Doses for a Uranium Hexafluoride Cylinder Accident

	Receptor Dose		
Site	Noninvolved Workers (person-rem)	Maximally Exposed Individual (rem)	Population Within 80 km (person-rem)
B&W	54,000	26	1,900
NFS	5,000	5.7	3,000

Source: Results shown are derived from MACCS runs.

E.5.2.3 Facility Accidents Postulated for Blending Highly Enriched Uranium to Low-Enriched Uranium as Metal

The accident scenarios that were considered included a tornado, straight winds, an aircraft crash, a truck crash, nuclear criticality, process-related accidents, and an evaluation basis earthquake. With the exception of the filter fire (with continuous exhaust flow), all of the accident scenarios that are potentially bounding can be initiated by the evaluation basis earthquake. Therefore, it is concluded that the evaluation basis earthquake would result in the worst-case atmospheric release of radioactivity and hazardous chemicals. The evaluation basis earthquake is assumed to initiate the nuclear criticality and other release scenarios.

In a filter fire accident, it is assumed that a fire occurs that releases all the uranium in the bag filters, traps, and the high-efficiency particulate air filters, and releases it to the atmosphere in a matter of minutes. The quantity of material assumed to be released is 0.15 kg (0.33 lb) of HEU. The source term analyzed and the resulting doses are shown in Tables E.5.2.1–1 and E.5.2.1–2.

In an earthquake-induced criticality accident, it is assumed that storage racks containing multiple critical masses of uranium metal are damaged directly by seismic shaking and indirectly by falling debris. Safe spacing is lost and moderators added as water from the fire system. This results in the possible formation of one or more critical assemblies. In an accidental criticality, it is assumed that 1×10^{19} fissions occur before reaching a stable, subcritical condition and that all material releases occur within a 2-hour period. The amount of radioactive material released as fission products created by the nuclear criticality is 46,000 Ci of krypton isotopes, 65,000 Ci of xenon isotopes, and 1,600 Ci of iodine isotopes. The source term analyzed and the resulting doses are shown in Tables E.5.2.1–3 and E.5.2.1–4.

In the evaluation basis earthquake accident scenario, it is assumed that the building collapses resulting in ruptured containers, piping and tanks releasing uranium mixtures, water and reactive liquids. This is assumed to result in the release of 2.1×10^{-3} Ci of uranium isotopes (48 percent of the activity is U-232 and 33 percent of the activity is U-234). The source

Appendix F
Socioeconomics

F.1 INTRODUCTION

Appendix F includes the supporting data used for assessing potential impacts in the socioeconomics sections of this environmental impact statement (EIS). The socioeconomic analysis involved two major steps: 1) the characterization and projection of existing social, economic, and infrastructure conditions surrounding each of the candidate sites (that is, the affected environment) and 2) the evaluation of potential changes in socioeconomic conditions that could result from the operation of highly enriched uranium (HEU) blending facilities in the regions addressed (that is, the environmental consequences). Data and analyses used to support the assessments made for the Affected Environment and Environmental Consequences sections are presented in the following tables. The tables are organized by resource area and site. For example, Table F.1–2 is the first resource area, Employees by Place of Residence, and the four sites: Oak Ridge Reservation (ORR); Savannah River Site (SRS); Babcock & Wilcox (B&W); and Nuclear Fuel Services (NFS).

Table F.1–1. Regional Economic Areas for Candidate Sites (Counties and Independent Cities)

ORR		SRS		B&W		NFS	
Tennessee	**Tennessee (cont.)**	**Georgia**	**South Carolina**	**Virginia**	**Virginia (cont.)**	**Tennessee**	**Virginia**
Anderson	Jefferson	Burke	Aiken	Amherst	Montgomery	Carter	Scott
Blount	Knox	Columbia	Allendale	Appomattox	Redford City	Greene	Smyth
Campbell	Loudon	Glascock	Bamberg	Bedford	Pulaski	Hawkins	Washington
Cocke	Morgan	Jefferson	Barnwell	Bedford City	Roanoke	Sullivan	
Grainger	Roane	Jenkins	Edgefield	Botetourt	Roanoke City	Unicoi	
Hamblen	Scott	Lincoln		Campbell	Salem City	Washington	
Hancock	Sevier	McDuffie		Lynchburg City	Wythe		
	Union	Richmond		Carroll			
		Wilkes		Craig			
		Warren		Floyd	**West Virginia**		
				Franklin	Monroe		
				Giles			
				Grayson	**North Carolina**		
				Galax City	Alleghany		
				Halifax			

Note: The independent cities of Virginia are listed separately from the counties of Virginia.
Source: DOC 1995a.

Table F.1–2. Distribution of Employees by Place of Residence in Oak Ridge Reservation Region of Influence, 1990

County/City	Number of Employees	Total Site Employment (%)
Anderson County	5,053	33.1
Clinton	1,035	6.8
Oak Ridge	3,292	21.6
Knox County	5,490	36
Knoxville	4,835	31.7
Loudon County	848	5.6
Lenoir City	638	4.2
Roane County	2,537	16.6
Harriman	802	5.3
Kingston	1,033	6.8
Total ROI	13,928	91.3
Total Employees	15,273	100

Note: City values are included within county totals.
Source: ORR 1991a:4.

Table F.1–3. Distribution of Employees by Place of Residence in Savannah River Site Region of Influence, 1991

County/City	Number of Employees	Total Site Employment (%)
Aiken County	9,978	51.9
Aiken	4,928	25.7
North Augusta	2,666	13.9
Allendale County	217	1.1
Bamberg County	329	1.7
Barnwell County	1,401	7.3
Columbia County	2,036	10.6
Richmond County	3,358	17.5
Augusta	2,780	14.5
Total ROI	17,319	90.1
Total Employees	19,208	100

Note: City values are included within county totals.
Source: SRS 1991a:3.

Table F.1–4. Distribution of Employees by Place of Residence in Babcock & Wilcox Region of Influence, 1995

County/City	Number of Employees	Total Site Employment (%)
Amherst County	220	11.9
Appomattox County	177	9.6
Bedford County	261	14.1
Campbell County	341	18.5
Lynchburg	681	36.9
Total ROI	1,680	91
Total Employees	1,846	100

Note: Lynchburg is not included in county values.
Source: BW 1995b:1.

Table F.1–5. Distribution of Employees by Place of Residence in Nuclear Fuel Services Region of Influence, 1995

County	Number of Employees	Total Site Employment (%)
Carter County	27	8.3
Sullivan County	9	2.8
Unicoi County	133	40.9
Washington County	129	39.7
Total ROI	298	91.7
Total Employees	325	100

Source: NFS 1995b:2.

Table F.1–6. Oak Ridge Reservation Regional Economic Area Employment and Local Economy, 1995-2000, No Action Alternative

Regional Economic Area	1995	1996	1997	1998	1999	2000
Civilian labor force	486,400	491,800	497,100	502,600	508,000	513,600
Total employment	462,900	467,900	473,000	478,200	483,400	488,700
Unemployment rate (percentage)	4.9	4.9	4.9	4.9	4.9	4.9
Personal income (thousand dollars)	16,498,303	16,860,612	17,230,877	17,609,273	17,995,979	18,391,177
Per capita income (dollars per person)	18,198	18,397	18,598	18,801	19,007	19,214

Source: Census 1993a; Census 1993b; DOC 1990c; DOC 1990d; DOC 1994j; DOC 1995a; DOL 1991a; DOL 1995a.

Table F.1–7. Savannah River Site Regional Economic Area Employment and Local Economy, 1995-2000, No Action Alternative

Regional Economic Area	1995	1996	1997	1998	1999	2000
Civilian labor force	261,400	264,600	267,900	271,300	274,700	278,100
Total employment	243,800	246,800	249,900	253,100	256,200	259,400
Unemployment rate (percentage)	6.7	6.7	6.7	6.7	6.7	6.7
Personal income (thousand dollars)	10,608,794	10,875,892	11,149,716	11,430,433	11,718,219	12,013,250
Per capita income (dollars per person)	17,789	18,011	18,237	18,465	18,696	18,930

Source: Census 1993a; Census 1993c; Census 1993e; DOC 1990c; DOC 1990d; DOC 1994j; DOC 1995a; DOL 1991a; DOL 1995a.

Table F.1–8. Babcock & Wilcox Regional Economic Area Employment and Local Economy, 1995-2000, No Action Alternative

Regional Economic Area	1995	1996	1997	1998	1999	2000
Civilian labor force	338,100	340,900	343,600	346,400	349,300	352,100
Total employment	321,400	324,000	326,700	329,400	332,000	334,700
Unemployment rate (percentage)	4.9	4.9	4.9	4.9	4.9	4.9
Personal income (thousand dollars)	14,357,210	14,592,163	14,830,960	15,073,665	15,320,342	15,571,056
Per capita income (dollars per person)	18,041	18,188	18,336	18,486	18,636	18,788

Source: Census 1993a; Census 1993d; Census 1993g; Census 1993h; DOC 1990c; DOC 1990d; DOC 1994j; DOC 1995a; DOL 1991a; DOL 1995a.

Table F.1–9. Nuclear Fuel Services Regional Economic Area Employment and Local Economy, 1995-2000, No Action Alternative

Regional Economic Area	1995	1996	1997	1998	1999	2000
Civilian labor force	269,600	272,000	274,500	277,000	279,500	282,100
Total employment	253,800	256,100	258,400	260,800	263,100	265,500
Unemployment rate (percentage)	5.9	5.9	5.9	5.9	5.9	5.9
Personal income (thousand dollars)	9,355,762	9,526,817	9,700,999	9,878,366	10,058,976	10,242,887
Per capita income (dollars per person)	16,814	16,967	17,122	17,278	17,435	17,594

Source: Census 1993a; Census 1993b; Census 1993g; DOC 1990c; DOC 1990d; DOC 1994j; DOC 1995a; DOL 1991a; DOL 1995a.

Table F.1–10. Oak Ridge Reservation Region of Influence Population, 1990-2000, No Action Alternative

County/City	1990	1992	1994	1996	1998	2000
Anderson County	68,250	70,525	72,400	74,100	75,800	77,400
Clinton	8,972	9,484	9,700	10,000	10,200	10,400
Oak Ridge	27,310	25,313	26,000	26,600	27,200	27,800
Knox County	335,749	347,583	356,700	365,300	373,300	381,500
Knoxville	165,121	167,287	171,700	175,800	179,700	183,600
Loudon County	31,255	33,242	34,100	34,900	35,700	36,500
Lenoir City	6,147	6,807	7,000	7,200	7,300	7,500
Roane County	47,227	48,094	49,400	50,500	51,700	52,800
Harriman	7,119	7,157	7,300	7,500	7,700	7,900
Kingston	4,552	4,631	4,800	4,900	5,000	5,100
Total ROI	482,481	499,444	512,600	524,800	536,500	548,200

Note: City values are included in county totals.

Source: Census 1993a; Census 1993b; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–11. Savannah River Site Region of Influence Population, 1990-2000, No Action Alternative

County/City	1990	1992	1994	1996	1998	2000
Aiken County	120,940	128,566	133,000	137,000	140,400	144,000
Aiken	19,872	22,429	23,200	23,900	24,500	25,100
North Augusta	15,351	16,379	16,900	17,500	17,900	18,300
Allendale County	11,722	11,744	12,200	12,500	12,800	13,200
Bamberg County	16,902	16,991	17,600	18,100	18,600	19,000
Barnwell County	20,293	21,089	21,800	22,500	23,000	23,600
Columbia County	66,031	73,000	75,500	77,800	79,700	81,800
Richmond County	189,719	202,434	209,400	215,700	221,100	226,700
Augusta	44,639	44,467	46,000	47,400	48,600	49,800
Total ROI	425,607	453,824	469,500	483,600	495,600	508,300

Note: City values are included in county totals.

Source: Census 1993a; Census 1993c; Census 1993e; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–12. Babcock & Wilcox Region of Influence Population, 1990-2000, No Action Alternative

County/City	1990	1992	1994	1996	1998	2000
Amherst County	28,578	29,031	29,800	30,500	31,000	31,500
Appomattox County	12,298	12,542	12,900	13,200	13,400	13,600
Bedford County	51,729	54,562	56,100	57,300	58,300	59,200
Campbell County	47,572	48,703	50,100	51,200	52,000	52,900
Lynchburg	66,049	66,097	68,000	69,500	70,600	71,800
Total ROI	206,226	210,935	216,900	221,700	225,300	229,000

Note: Lynchburg is not included in county totals.

Source: Census 1993a; Census 1993g; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–13. Nuclear Fuel Services Region of Influence Population, 1990-2000, No Action Alternative

County	1990	1992	1994	1996	1998	2000
Carter County	51,505	52,029	53,400	54,600	55,600	56,600
Sullivan County	143,596	146,676	150,500	153,800	156,600	159,500
Unicoi County	16,549	16,791	17,200	17,600	17,900	18,300
Washington County	92,315	94,934	97,400	99,600	101,400	103,200
Total ROI	303,965	310,430	318,500	325,600	331,500	337,600

Source: Census 1993a; Census 1993b; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–14. Oak Ridge Reservation Region of Influence Housing Units, 1990-2000, No Action Alternative

County/City	1990	1992	1994	1996	1998	2000
Anderson County	29,323	30,300	31,100	31,800	32,500	33,300
Clinton	4,006	4,200	4,300	4,500	4,500	4,600
Oak Ridge	12,694	11,800	12,100	12,400	12,600	12,900
Knox County	143,582	148,600	152,500	156,200	159,700	163,200
Knoxville	76,453	77,500	79,500	81,400	83,200	85,000
Loudon County	12,995	13,800	14,200	14,500	14,800	15,200
Lenoir City	2,734	3,000	3,100	3,200	3,300	3,300
Roane County	20,334	20,700	21,300	21,800	22,200	22,700
Harriman	3,234	3,300	3,300	3,400	3,500	3,600
Kingston	2,071	2,100	2,200	2,200	2,300	2,300
Total ROI	206,234	213,400	219,100	224,300	229,200	234,400

Note: City values are included in county totals.

Source: Census 1991c; Census 1993a; Census 1993b; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–15. Savannah River Site Region of Influence Housing Units, 1990-2000, No Action Alternative

County/City	1990	1992	1994	1996	1998	2000
Aiken County	49,266	52,400	54,200	55,800	57,200	58,700
Aiken	8,543	9,600	10,000	10,300	10,500	10,800
North Augusta	6,810	7,300	7,500	7,700	7,900	8,100
Allendale County	4,242	4,300	4,400	4,500	4,600	8,100
Bamberg County	6,408	6,400	6,700	6,900	7,000	7,200
Barnwell County	7,854	8,200	8,400	8,700	8,900	9,100
Columbia County	23,745	26,300	27,200	28,000	28,700	29,400
Richmond County	77,288	82,500	85,300	87,900	90,100	92,400
Augusta	21,588	21,500	22,300	22,900	23,500	24,100
Total ROI	168,803	180,100	186,200	191,800	196,500	201,600

Note: City values are included in county totals.

Source: Census 1991a; Census 1991b; Census 1993a; Census 1993c; Census 1993e; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–16. Babcock & Wilcox Region of Influence Housing Units, 1990–2000, No Action Alternative

County/City	1990	1992	1994	1996	1998	2000
Amherst County	10,598	10,800	11,100	11,300	11,500	11,700
Appomattox County	4,913	5,000	5,200	5,300	5,400	5,400
Bedford County	22,226	23,400	24,100	24,600	25,000	25,500
Campbell County	19,008	20,300	20,900	21,400	21,700	22,100
Lynchburg	27,233	27,300	28,000	28,600	29,100	29,600
Total ROI	83,978	86,800	89,300	91,200	92,700	94,300

Note: Lynchburg is not included in the county totals.

Source: Census 1991u; Census 1993a; Census 1993g; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–17. Nuclear Fuel Services Region of Influence Housing Units, 1990–2000, No Action Alternative

County	1990	1992	1994	1996	1998	2000
Carter County	21,779	22,000	22,600	23,100	23,500	23,900
Sullivan County	60,623	61,900	63,500	64,900	66,100	67,300
Unicoi County	7,076	7,200	7,400	7,500	7,700	7,800
Washington County	38,378	39,500	40,500	41,400	42,100	42,900
Total ROI	127,856	130,600	134,000	136,900	139,400	141,900

Source: Census 1991c; Census 1993a; Census 1993b; DOC 1990c; DOC 1990d; DOC 1994j.

Table F.1–18. Candidate Sites–Total Student Enrollments, 1995–2000, No Action Alternative

Site ROI	1995	1996	1997	1998	1999	2000
ORR	83,400	84,300	85,200	86,100	87,100	88,000
SRS	88,200	89,300	90,400	91,600	92,700	93,900
B&W	34,200	34,400	34,700	35,000	35,300	35,600
NFS	52,500	53,000	53,500	53,900	54,400	54,900

Source: BW School 1995a; NF School 1995a; OR School 1995a; SR School 1995a; Appendix Tables F.1–10 through 13.

Table F.1–19. Candidate Sites–Total Teachers, 1995–2000, No Action Alternative

Site ROI	1995	1996	1997	1998	1999	2000
ORR	5,140	5,190	5,250	5,310	5,370	5,420
SRS	5,060	5,120	5,180	5,250	5,310	5,380
B&W	2,400	2,420	2,440	2,460	2,480	2,500
NFS	2,920	2,950	2,980	3,000	3,030	3,060

Source: BW School 1995a; NF School 1995a; OR School 1995a; SR School 1995a; Appendix Tables F.1–10 through 13.

Table F.1–20. Candidate Sites–Total Number of Sworn Police Officers, 1995–2000, No Action Alternative

Site ROI	1995	1996	1997	1998	1999	2000
ORR	792	801	809	818	827	836
SRS	956	968	980	992	1,010	1,020
B&W	358	361	364	367	370	373
NFS	556	561	566	571	577	582

Source: BW Police 1995a; DOJ 1994a; NF Police 1995a; OR Police 1995a; Appendix Tables F.1–10 through 13.

Table F.1–21. Candidate Sites–Total Number of Firefighters, 1995–2000, No Action Alternative

Site ROI	1995	1996	1997	1998	1999	2000
ORR	1,120	1,130	1,150	1,160	1,170	1,180
SRS	1,363	1,380	1,400	1,420	1,430	1,450
B&W	960	968	976	984	992	1,000
NFS	1,201	1,210	1,220	1,230	1,250	1,260

Note: Kingsport Fire Department in Sullivan County and Limestone Cove Volunteer Fire Department in Unicoi County were excluded from the NFS ROI total because firefighter data were unattainable.

Source: BW Fire 1995a; NF Fire 1995a; OR Fire 1995a; SR Fire 1995a; Appendix Tables F.1–10 through 13.

Table F.1–22. Candidate Sites–Total Number of Physicians, 1995–2000, No Action Alternative

Site ROI	1995	1996	1997	1998	1999	2000
ORR	1,300	1,320	1,330	1,350	1,360	1,380
SRS	1,370	1,390	1,410	1,420	1,440	1,460
B&W	299	302	304	307	309	312
NFS	870	878	886	894	902	910

Source: AMA 1994a; Appendix Tables F.1–10 through 13.

Table F.1–23. Candidate Sites–Hospital Occupancy Rates, 1995–2000, No Action Alternative

Site ROI	1995	1996	1997	1998	1999	2000
ORR	73	74	75	76	77	78
SRS	65	66	66	67	68	69
B&W	70	71	71	72	72	73
NFS	61	62	63	63	64	64

Source: AHA 1994a; Appendix Tables F.1–10 through 13.

Table F.1–24. Changes to Total Employment, Unemployment Rate, and Per Capita Income During Full Operation of the Uranyl Nitrate Hexahydrate Blending Facility

Site	No Action	UNH	Percent Change
Oak Ridge Reservation			
Unemployment rate	4.9	4.8	NA
Total employment	488,700	489,144	0.1
Per capita income (dollars per person)	19,214	19,225	0.1
Savannah River Site			
Unemployment rate	6.7	6.6	NA
Total employment	259,400	259,770	0.1
Per capita income (dollars per person)	18,930	18,952	0.1
Babcock & Wilcox			
Unemployment rate	4.9	4.8	NA
Total employment	334,700	335,111	0.1
Per capita income (dollars per person)	18,788	18,802	<0.1
Nuclear Fuel Services			
Unemployment rate	5.9	5.7	NA
Total employment	265,500	265,879	0.1
Per capita income (dollars per person)	17,594	17,612	0.1

Note: NA=not applicable.

Source: BEA 1995c; BW 1995b:1; Census 1992a; Census 1993b; Census 1993c; Census 1993d; Census 1993e; Census 1993g; Census 1993h; DOC 1990c; DOC 1990d; DOC 1994j; DOC 1995a; DOL 1991a; NFS 1995b:2; OR LMES 1995b; ORR 1991a:4; SRS 1991a:3.

Table F.1–25. Changes to Total Employment, Unemployment Rate, and Per Capita Income During Full Operation of the Uranium Hexafluoride Blending Facility

Site	No Action	UF_6	Percent Change
Babcock & Wilcox			
Unemployment Rate	4.9	4.8	NA
Total employment	334,700	335,111	0.1
Per capita income (dollar per person)	18,788	18,802	<0.1
Nuclear Fuel Services			
Unemployment rate	5.9	5.7	NA
Total employment	265,500	265,879	0.1
Per capita income (dollar per person)	17,594	17,612	0.1

Note: NA=not applicable.

Source: BEA 1995c; BW 1995b:1; Census 1992a; Census 1993b; Census 1993d; Census 1993g; Census 1993h; DOC 1990c; DOC 1990d; DOC 1994j; DOC 1995a; DOL 1991a; NFS 1995b:2; OR LMES 1995a.

Table F.1–26. Changes to Total Employment, Unemployment Rate, and Per Capita Income During Full Operation of the Metal Blending Facility

Site	No Action	Metal	Percent Change
Oak Ridge Reservation			
Unemployment rate	4.9	4.8	NA
Total employment	488,700	489,144	0.1
Per capita income (dollar per person)	19,214	19,220	<0.1
[Text deleted.]			

Note: NA=not applicable.

Source: BEA 1995c; Census 1992a; Census 1993b; Census 1993c; Census 1993e; DOC 1990c; DOC 1990d; DOC 1994j; DOC 1995a; DOL 1991a; OR LMES 1995c; ORR 1991a:4.

Appendix G
Intersite Transportation

G.1 TRANSPORTATION RISK ANALYSIS METHODOLOGY

Health impacts from transportation are presented in this appendix for four blending options: 1) uranyl nitrate hexahydrate (UNH) crystals as commercial reactor fuel feed material, 2) UNH as low-level waste (LLW), 3) uranium hexafluoride (UF_6) as fuel feed material, and 4) metal LLW.

This assessment estimates the health effects, in terms of annual fatalities, from the transportation of radioactive materials needed for blending highly enriched uranium (HEU) to low-enriched uranium (LEU) with appropriate blendstock material and from the transportation of the blended products to a site for either fuel fabrication or disposal as LLW. Calculations were performed using RADTRAN Version 4 to estimate unit risks, that is, the risk of transporting each type of material over a distance of 1 kilometer (km) (0.62 miles [mi]) through different population zones. In a series of linked spreadsheets, the impacts were calculated for each alternative using actual distances and population zones, and summed for total health effects. The data used and health risk impacts are summarized in Tables G.1–1 through G.1–8.

Highly enriched uranium would be transported via safe secure trailers (SSTs). The blendstock would consist of natural uranium (NU), depleted uranium (DU), or LEU in oxide as triuranic-octaoxide (U_3O_8), metal, or UF_6 form. The shipments of LEU and LLW would be transported in Department of Transportation (DOT)-approved packages by commercial carriers. The number of packages per shipment would be in accordance with regulatory requirements. Trucks would be loaded to capacity, as determined by either weight or radiological dose limitations.

RADTRAN combines user-determined demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences of accident-free and accident risk of transporting radioactive material. Tables G.1–1 and G.1–2 give the isotopic compositions used for each material type considered. HEU was assumed to be 93-percent U-235; even though the average assay of surplus HEU was

Table G.1–1. Isotopic Composition by Percent of Uranium Materials

Material	U-232	U-234	U-235	U-236	U-238
HEU (93% U-235)	0	1	93.1	0.5	5.4
DU (0.2% U-235)	4.0×10^{-6}	3.6×10^{-3}	0.2	0	99.8
NU (0.71% U-235)	4.0×10^{-6}	5.4×10^{-3}	0.71	0	99.3
LEU1 (0.9% U-235)	4.0×10^{-6}	9.5×10^{-3}	0.9	3.3×10^{-3}	99
LEU4 (4% U-235)	4.0×10^{-6}	3.3×10^{-2}	4	1.5×10^{-2}	96
Specific activity (curie/kilogram)	2.2×10^{4}	6.2	2.1×10^{-3}	6.3×10^{-2}	3.3×10^{-4}

Source: ORR 1995a:3.

Table G.1–2. Contribution by Isotope to Total Specific Activity (curies per kilogram)

Material	U-232	U-234	U-235	U-236	U-238	Total
HEU (93% U-235)	0	6.2×10^{-2}	2.0×10^{-3}	3.2×10^{-4}	1.8×10^{-5}	6.4×10^{-2}
DU (0.2% U-235)	8.8×10^{-4}	2.2×10^{-4}	4.2×10^{-6}	0	3.3×10^{-4}	1.4×10^{-3}
NU (0.71% U-235)	8.8×10^{-4}	3.4×10^{-4}	1.5×10^{-5}	0	3.3×10^{-4}	1.6×10^{-3}
LEU1 (0.9% U-235)	8.8×10^{-4}	5.9×10^{-4}	1.9×10^{-5}	2.1×10^{-6}	3.3×10^{-4}	1.8×10^{-3}
LEU4 (4% U-235)	8.8×10^{-4}	2.1×10^{-3}	8.4×10^{-5}	9.5×10^{-6}	3.2×10^{-4}	3.4×10^{-3}

Source: ORR 1995a:3.

estimated to be lower, 93 percent was used in transportation analyses to assess the highest potential impact. The blendstock materials were NU with 0.71-percent U-235 or DU with 0.2-percent U-235. The product materials were fuel feed material with 4-percent U-235 or LLW with 0.9-percent U-235.

The transport index is a regulatory characteristic of a package and is equal to the radiation dose rate in millirem per hour at a distance of 1 meter (m) (3.3 feet [ft]) from the outside of the package. The transport index values were estimated to be the maximum allowed by regulatory requirements, as indicated by regulatory checks incorporated in RADTRAN. These regulatory checks limit the product of the number of packages and the transport index (of each package) to a value of about 16. The quantity of material per package, number of packages per truckload, and number of truckloads per year were estimated.

The transportation accident model in RADTRAN assigns accident probabilities to a set of accident categories. For the truck analysis, the eight accident-severity categories defined in Nuclear Regulatory Commission's (NRC) *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NUREG-0170, December 1977) were used. The least severe accident category (Category I) represents low magnitudes of crush force, accident-impact velocity, fire duration, or puncture-impact speed. The most severe category (Category VIII) represents a large crush force, high-impact velocity, high puncture-impact speed, an 88-kilometer per hour (km/hr) (54.6-mi/hr) collision into the side of the vehicle, and a 982 Celsius (°C) (1,800 Fahrenheit [°F]) fire lasting 1.5 hrs to produce a release of HEU. The release fractions for Category VIII accidents were conservatively estimated to be 0.1 for the strictly controlled SST shipments of HEU and 1 for other shipments.

Unit risk factors for radiological exposure from transportation were calculated in terms of fatal cancers for each type of material to be shipped a distance of 1 km (0.62 mi) in rural, suburban, and urban population zones. These unit risk factors are presented in Table G.1–3. The RADTRAN code was used to estimate population and occupational doses (unit dose factors) for transportation of each material over 1 km (0.62 mi) in each population zone. The unit dose factors were converted to unit risk factors by multiplying the occupational accident-free unit dose factors by 4.0×10^{-4} cancers per person-rem and the public accident-free and accident unit dose factors by 5.0×10^{-4} cancers per person-rem (ICRP 1991a:22).

Radiological exposures from handling of uranium materials during loading and unloading of trucks were estimated per shipment (truckload) as shown in Table G.1–4. It was estimated that there would be two cargo handlers and 35 other workers within 50 m (165 ft) of the loading/unloading operations. Accident-free risks to cargo handlers and other workers were summed for determining total health impacts.

Table G.1–5 presents the computed health risks per year from the transport of HEU to blending sites for each alternative; Table G.1–6 presents the risks from the transport of blendstock materials; and Table G.1–7 presents the risks from transporting commercial reactor fuel feed material and LLW from blending sites to either a fuel fabrication plant or LLW disposal site.

For these calculations, distances and the fractions for rural, suburban, and urban populations for each intersite route were estimated using the INTERSTAT routing code. Among the routes considered, the average population distribution for rural, suburban, and urban were 78, 20, and 2 percent, respectively. Annual radiological transportation impacts were calculated by multiplying route distance by the number of shipments and then multiplying by the sum of the products of the rural distance fraction and rural unit risk factor, the suburban distance fraction and suburban unit risk factor, and the urban distance fraction and urban unit risk factor. Tables G.1–5, G.1–6, and G.1–7 also include estimates of nonradiological impacts due to air pollution and highway accidents. Fatalities from potential air pollution were estimated using 1.0×10^{-7} cancer fatalities per urban kilometer. Highway accident fatalities were estimated from national statistics using 1.5×10^{-8} rural, 3.7×10^{-9} suburban, and 2.1×10^{-9} urban for occupational risks per kilometer, and 5.3×10^{-8} rural, 1.3×10^{-8} suburban, and 7.5×10^{-9} urban for nonoccupational risks per kilometer.

Table G.1–8 presents a summary of the cumulative annual transportation health impacts for all blending options.

Table G.1–3. Unit Dose and Risk Factors for Radiological Health Risks

					Unit Dose Factors (person-rem)						Unit Risk Factors (fatal cancers)		
					Accident	Accident-Free					Accident	Accident-Free	
Distance (1 km)	Material	Form	Material Weight per Package (kilogram)	Pkgs per Shipment		Transport Crew	Public Off-Link[a]	On-Link[b]	Stops[c]	Total	Public	Public	Crew
Rural	HEU-93	Metal, UF_6	2	48	9.7×10^{-10}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	4.8×10^{-13}	2.6×10^{-8}	3.3×10^{-9}
Suburban	HEU-93	Metal, UF_6	2	48	1.3×10^{-7}	1.8×10^{-5}	5.8×10^{-6}	6.0×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	6.7×10^{-11}	3.1×10^{-8}	7.2×10^{-9}
Urban	HEU-93	Metal, UF_6	2	48	3.9×10^{-7}	3.0×10^{-5}	6.5×10^{-7}	2.1×10^{-5}	5.0×10^{-5}	7.2×10^{-5}	1.9×10^{-10}	3.6×10^{-8}	1.2×10^{-8}
Rural	HEU-93	UNH	35	48	1.7×10^{-8}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	8.7×10^{-12}	2.6×10^{-8}	3.3×10^{-9}
Suburban	HEU-93	UNH	35	48	2.4×10^{-6}	1.8×10^{-5}	5.8×10^{-6}	6.0×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	1.2×10^{-9}	3.1×10^{-8}	7.2×10^{-9}
Urban	HEU-93	UNH	35	48	6.9×10^{-6}	3.0×10^{-5}	6.5×10^{-7}	2.1×10^{-5}	5.0×10^{-5}	7.2×10^{-5}	3.5×10^{-9}	3.6×10^{-8}	1.2×10^{-8}
Rural	DU-0.2	Metal	2,200	5	8.9×10^{-8}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	4.4×10^{-11}	2.6×10^{-8}	3.3×10^{-9}
Suburban	DU-0.2	Metal	2,200	5	1.2×10^{-5}	1.8×10^{-5}	5.8×10^{-6}	5.9×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	6.1×10^{-9}	3.1×10^{-8}	7.2×10^{-9}
Urban	DU-0.2	Metal	2,200	5	3.6×10^{-5}	3.0×10^{-5}	6.5×10^{-7}	2.1×10^{-5}	5.0×10^{-5}	7.1×10^{-5}	1.8×10^{-8}	3.6×10^{-8}	1.2×10^{-8}
Rural	NU-0.7	UNH	2,200	5	9.1×10^{-8}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	4.6×10^{-11}	2.6×10^{-8}	3.3×10^{-9}
Suburban	NU-0.7	UNH	2,200	5	1.3×10^{-5}	1.8×10^{-5}	5.8×10^{-6}	5.9×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	6.3×10^{-9}	3.1×10^{-8}	7.2×10^{-9}
Urban	NU-0.7	UNH	2,200	5	3.6×10^{-5}	3.0×10^{-5}	6.5×10^{-7}	2.1×10^{-5}	5.0×10^{-5}	7.1×10^{-5}	1.8×10^{-8}	3.6×10^{-9}	1.2×10^{-8}
Rural	NU-0.7	UF_6	6,133	1	5.1×10^{-8}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	2.5×10^{-11}	2.6×10^{-8}	3.3×10^{-9}
Suburban	NU-0.7	UF_6	6,133	1	7.0×10^{-6}	1.8×10^{-5}	5.8×10^{-6}	5.9×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	3.5×10^{-9}	3.1×10^{-8}	7.2×10^{-9}
Urban	NU-0.7	UF_6	6,133	1	2.0×10^{-5}	3.0×10^{-5}	6.5×10^{-7}	2.1×10^{-5}	5.0×10^{-5}	7.1×10^{-5}	1.0×10^{-8}	3.6×10^{-8}	1.2×10^{-8}
Rural	LEU-1	Metal	93	48	4.0×10^{-8}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	2.0×10^{-11}	2.6×10^{-8}	3.3×10^{-9}
Suburban	LEU-1	Metal	93	48	5.5×10^{-6}	1.8×10^{-5}	5.8×10^{-6}	6.0×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	2.8×10^{-9}	3.1×10^{-8}	7.2×10^{-9}
Urban	LEU-1	Metal	93	48	1.6×10^{-5}	3.0×10^{-5}	6.5×10^{-7}	2.1×10^{-5}	5.0×10^{-5}	7.2×10^{-5}	8.0×10^{-9}	3.6×10^{-8}	1.2×10^{-8}
Rural	LEU-4	UNH	43	50	5.0×10^{-8}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	2.5×10^{-11}	2.6×10^{-8}	3.3×10^{-9}
Suburban	LEU-4	UNH	43	50	6.9×10^{-6}	1.8×10^{-5}	5.8×10^{-6}	5.9×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	3.4×10^{-9}	3.1×10^{-8}	7.2×10^{-9}
Urban	LEU-4	UNH	43	50	2.0×10^{-5}	3.0×10^{-5}	6.5×10^{-7}	2.1×10^{-5}	5.0×10^{-5}	7.1×10^{-5}	1.0×10^{-8}	3.6×10^{-8}	1.2×10^{-8}
Rural	LEU-4	UF_6	1,516	4	6.8×10^{-8}	8.2×10^{-6}	5.1×10^{-8}	2.1×10^{-6}	5.0×10^{-5}	5.2×10^{-5}	3.4×10^{-11}	2.6×10^{-8}	3.3×10^{-9}
Suburban	LEU-4	UF_6	1,516	4	9.4×10^{-6}	1.8×10^{-5}	5.8×10^{-6}	5.9×10^{-6}	5.0×10^{-5}	6.1×10^{-5}	4.7×10^{-9}	3.1×10^{-8}	7.2×10^{-9}

Table G.1–3. Unit Dose and Risk Factors for Radiological Health Risks—Continued

					Unit Dose Factors (person-rem)						Unit Risk Factors (fatal cancers)		
					Accident	Accident-Free					Accident	Accident-Free	
Distance (1 km)	Material	Form	Material Weight per Package (kilogram)	Pkgs per Shipment		Transport Crew	Public Off-Link[a]	On-Link[b]	Stops[c]	Total	Public	Public	Crew
Urban	LEU-4	UF_6	1,516	4	$2.7x10^{-5}$	$3.0x10^{-5}$	$6.5x10^{-7}$	$2.1x10^{-5}$	$5.0x10^{-5}$	$7.1x10^{-5}$	$1.4x10^{-8}$	$3.6x10^{-8}$	$1.2x10^{-8}$
Rural	LEU-1	UNH	87	50	$4.0x10^{-8}$	$8.2x10^{-6}$	$5.1x10^{-8}$	$2.1x10^{-6}$	$5.0x10^{-5}$	$5.2x10^{-5}$	$2.0x10^{-11}$	$2.6x10^{-8}$	$3.3x10^{-9}$
Suburban	LEU-1	UNH	87	50	$5.5x10^{-6}$	$1.8x10^{-5}$	$5.8x10^{-6}$	$6.0x10^{-6}$	$5.0x10^{-5}$	$6.1x10^{-5}$	$2.8x10^{-9}$	$3.1x10^{-8}$	$7.2x10^{-9}$
Urban	LEU-1	UNH	87	50	$1.6x10^{-5}$	$3.0x10^{-5}$	$6.5x10^{-7}$	$2.1x10^{-5}$	$5.0x10^{-5}$	$7.2x10^{-5}$	$8.0x10^{-9}$	$3.6x10^{-8}$	$1.2x10^{-8}$
Handling (Each Loading or Unloading)						$6.0x10^{-2}$	$4.0x10^{-3}$					$1.6x10^{-6}$	$2.4x10^{-5}$
Handling (One Loading Plus One Unloading)						$1.2x10^{-1}$	$8.1x10^{-3}$					$3.2x10^{-6}$	$4.8x10^{-5}$

[a] Off-link is population within 500 m (1,640 ft) of the highway.
[b] On-link is population sharing the highway.
[c] Truck stop en route (for example, gas).
Source: RADTRAN model results.

Table G.1–4. Accident-Free Radiological Exposure From Transferring Materials Between Storage and a Truck

Types of Population[a]	Population Size	Dose	Later Cancer Fatality
Cargo Handlers			
Collective population	2	$6.0x10^{-2}$ person-rem	$2.4x10^{-5}$
Average individual dose	1	$3.0x10^{-2}$ rem	$1.2x10^{-5}$
Other Workers			
Collective population	35	$4.0x10^{-3}$ person-rem	$1.6x10^{-6}$
Average individual dose	1	$1.2x10^{-4}$ rem	$4.8x10^{-8}$

[a] Under normal (accident-free) conditions the public does not receive a measurable dose.
Source: RADTRAN model results.

Table G.1–5. Annual Health Effects From Transportation of Highly Enriched Uranium (93-Percent U-235) From Y–12 Plant to Blending Plants

			Population			Radiological[a]			Nonradiological[b]			
						Accident	Accident-Free		Accident		Air Pollution	
Destination	Shipments[c] (per year)	Distance (km)	Rural (%)	Suburban (%)	Urban (%)		Public	Crew	Public	Crew		Total Health Effect[d]
UNH Blending to Fuel Feed Material												
B&W	6	526	68	31	1	1.3×10^{-6}	1.1×10^{-4}	3.0×10^{-4}	2.5×10^{-4}	7.2×10^{-5}	6.9×10^{-6}	7.4×10^{-4}
NFS	6	247	68	31	1	6.2×10^{-7}	6.0×10^{-5}	3.0×10^{-4}	1.2×10^{-4}	3.4×10^{-5}	3.3×10^{-6}	5.1×10^{-4}
SRS	6	479	71	27	2	1.2×10^{-6}	9.8×10^{-5}	3.0×10^{-4}	2.4×10^{-4}	6.7×10^{-5}	1.1×10^{-5}	7.2×10^{-4}
Y–12	6	0	0	0	0	0	1.9×10^{-5}	2.9×10^{-4}	0	0	0	3.1×10^{-4}
UNH Blending to LLW												
B&W	22	526	68	31	1	2.7×10^{-7}	3.9×10^{-4}	1.1×10^{-3}	9.3×10^{-4}	2.6×10^{-4}	2.6×10^{-5}	2.7×10^{-3}
NFS	22	247	68	31	1	1.3×10^{-7}	2.2×10^{-4}	1.1×10^{-3}	4.4×10^{-4}	1.2×10^{-4}	1.2×10^{-6}	1.9×10^{-3}
SRS	22	479	71	27	2	2.3×10^{-7}	3.6×10^{-4}	1.1×10^{-3}	8.7×10^{-4}	2.5×10^{-4}	4.1×10^{-5}	2.6×10^{-3}
Y–12	22	0	0	0	0	0	7.1×10^{-5}	1.1×10^{-3}	0	0	0	1.1×10^{-3}
UF_6 Blending to Fuel Feed Material												
B&W	105	526	68	31	1	1.3×10^{-6}	1.9×10^{-3}	5.3×10^{-3}	4.4×10^{-3}	1.3×10^{-3}	1.2×10^{-4}	1.3×10^{-2}
NFS	105	247	68	31	1	6.0×10^{-7}	1.1×10^{-3}	5.2×10^{-3}	2.1×10^{-3}	5.9×10^{-4}	5.7×10^{-5}	8.9×10^{-3}
Metal Blending to LLW												
[Text deleted.]												
Y–12	33	0	0	0	0	0	1.1×10^{-4}	1.6×10^{-3}	0	0	0	1.7×10^{-3}

[a] Cancer fatalities.
[b] Fatalities.
[c] A shipment is a truckload.
[d] Estimated fatalities per year.
Source: RADTRAN model results.

Table G.1–6. Annual Health Effects From Transportation of Uranium Hexafluoride, Uranium Oxide, and Metal Blendstock

					Radiological[a]			Nonradiological[b]			
					Accident	Accident-Free		Accident		Air Pollution	
Origin	Destination	Material	Shipments[c] (per year)	Distance (km)		Public	Crew	Public	Crew		Total Health Effect[d]
Uranium Hexafluoride (UF_6)											
Paducah	GE	DU-0.2	23	1,278	3.5×10^{-5}	8.8×10^{-4}	1.2×10^{-3}	2.4×10^{-3}	6.8×10^{-4}	1.0×10^{-4}	5.3×10^{-3}
Piketon	GE	DU-0.2	23	1,323	3.8×10^{-5}	9.1×10^{-4}	1.3×10^{-3}	2.5×10^{-3}	7.0×10^{-4}	1.2×10^{-4}	5.5×10^{-3}
Paducah	GE	NU-0.7	22	1,278	2.1×10^{-5}	8.4×10^{-4}	1.2×10^{-3}	2.3×10^{-3}	6.5×10^{-4}	9.6×10^{-5}	5.1×10^{-3}
Piketon	GE	NU-0.7	22	1,323	2.2×10^{-5}	8.7×10^{-4}	1.2×10^{-3}	2.4×10^{-3}	6.7×10^{-4}	1.1×10^{-4}	5.2×10^{-3}
Paducah	B&W	NU-0.7	22	1,013	2.7×10^{-5}	6.8×10^{-4}	1.2×10^{-3}	1.8×10^{-3}	5.1×10^{-4}	4.9×10^{-5}	4.2×10^{-3}
Paducah	NFS	NU-0.7	22	734	2.0×10^{-5}	5.1×10^{-4}	1.1×10^{-3}	1.3×10^{-3}	3.7×10^{-4}	3.6×10^{-5}	3.4×10^{-3}
Piketon	B&W	NU-0.7	22	858	2.5×10^{-5}	5.9×10^{-4}	1.2×10^{-3}	1.5×10^{-3}	4.2×10^{-4}	5.7×10^{-5}	3.7×10^{-3}
Piketon	NFS	NU-0.7	22	916	2.6×10^{-5}	6.3×10^{-4}	1.2×10^{-3}	1.6×10^{-3}	4.5×10^{-4}	6.5×10^{-5}	3.9×10^{-3}
Uranium Oxide (U_3O_8)											
Hanford	SRS	NU-0.7	15	4,442	1.1×10^{-4}	1.8×10^{-3}	1.0×10^{-3}	5.9×10^{-3}	1.7×10^{-3}	2.0×10^{-4}	1.1×10^{-2}
Hanford	Y–12	NU-0.7	15	3,969	9.3×10^{-5}	1.7×10^{-3}	9.7×10^{-4}	5.3×10^{-3}	1.5×10^{-3}	1.7×10^{-4}	9.7×10^{-3}
Hanford	B&W	NU-0.7	15	4,422	1.1×10^{-4}	1.8×10^{-3}	1.0×10^{-3}	5.8×10^{-3}	1.6×10^{-3}	1.9×10^{-4}	1.1×10^{-2}
Hanford	NFS	NU-0.7	15	4,216	9.9×10^{-5}	1.8×10^{-3}	9.9×10^{-4}	5.6×10^{-3}	1.6×10^{-3}	1.8×10^{-4}	1.0×10^{-2}
Hanford	SRS	DU-0.2	16	4,442	1.1×10^{-4}	2.0×10^{-3}	1.1×10^{-3}	6.3×10^{-3}	1.8×10^{-3}	2.1×10^{-4}	1.1×10^{-2}
Hanford	Y–12	DU-0.2	16	3,969	9.6×10^{-5}	1.8×10^{-3}	1.0×10^{-3}	5.6×10^{-3}	1.6×10^{-3}	1.8×10^{-4}	1.0×10^{-2}
Hanford	B&W	DU-0.2	16	4,422	1.1×10^{-4}	2.0×10^{-3}	1.1×10^{-3}	6.2×10^{-3}	1.8×10^{-3}	2.0×10^{-4}	1.1×10^{-2}
Hanford	NFS	DU-0.2	16	4,216	1.0×10^{-4}	1.9×10^{-3}	1.1×10^{-3}	6.0×10^{-3}	1.7×10^{-3}	2.0×10^{-4}	1.1×10^{-2}
GE	B&W	NU-0.7	15	801	2.5×10^{-5}	3.8×10^{-4}	7.8×10^{-4}	1.0×10^{-3}	2.8×10^{-4}	4.6×10^{-5}	2.5×10^{-3}
GE	NFS	NU-0.7	15	860	2.7×10^{-5}	4.0×10^{-4}	7.8×10^{-4}	1.1×10^{-3}	3.0×10^{-4}	5.7×10^{-5}	2.6×10^{-3}
GE	SRS	NU-0.7	15	596	1.8×10^{-5}	2.9×10^{-4}	7.6×10^{-4}	7.5×10^{-4}	2.1×10^{-4}	4.1×10^{-5}	2.1×10^{-3}
GE	Y–12	NU-0.7	15	791	2.5×10^{-5}	3.7×10^{-4}	7.8×10^{-4}	9.8×10^{-4}	2.8×10^{-4}	5.0×10^{-5}	2.5×10^{-3}
GE	B&W	DU-0.2	16	801	2.6×10^{-5}	4.0×10^{-4}	8.3×10^{-4}	1.1×10^{-3}	3.0×10^{-4}	5.0×10^{-5}	2.7×10^{-3}
GE	NFS	DU-0.2	16	860	2.8×10^{-5}	4.3×10^{-4}	8.3×10^{-4}	1.1×10^{-3}	3.2×10^{-4}	6.1×10^{-5}	2.8×10^{-3}
GE	SRS	DU-0.2	16	596	1.9×10^{-5}	3.1×10^{-4}	8.1×10^{-4}	8.0×10^{-4}	2.3×10^{-4}	4.4×10^{-5}	2.2×10^{-3}
GE	Y–12	DU-0.2	16	791	2.6×10^{-5}	4.0×10^{-4}	8.3×10^{-4}	1.1×10^{-3}	3.0×10^{-4}	5.3×10^{-5}	2.7×10^{-3}

Table G.1–6. Annual Health Effects From Transportation of Uranium Hexafluoride, Uranium Oxide, and Metal Blendstock—Continued

					Radiological[a]			Nonradiological[b]			
					Accident	Accident-Free		Accident		Air Pollution	
Origin	Destination	Material	Shipments[c] (per year)	Distance (km)		Public	Crew	Public	Crew		Total Health Effect[d]
Metal											
Fernald	Y–12	DU-0.2	20	466	2.0×10^{-5}	3.2×10^{-4}	1.0×10^{-3}	7.4×10^{-4}	2.1×10^{-4}	2.2×10^{-5}	2.3×10^{-3}
[Text deleted.]											

[a] Cancer fatalities.
[b] Fatalities.
[c] A shipment is a truckload.
[d] Estimated fatalities per year.
Note: GE=General Electric Wilmington.
Source: RADTRAN model results.

Table G.1–7. Annual Health Effects From Transportation of Fuel Feed Material and Low-Level Waste From the Blending Plant to Destination

			Radiological[a]			Nonradiological[b]			
			Accident	Accident-Free		Accident		Air Pollution	
Origin	Destination	Distance (km)		Public	Crew	Public	Crew		Total Health Effect[c]
Uranyl Nitrate Hexahydrate[d] (4-Percent Enrichment)									
B&W	ABB-CE	1,301	1.2×10^{-4}	2.7×10^{-3}	3.8×10^{-3}	7.1×10^{-3}	2.0×10^{-3}	3.1×10^{-4}	1.6×10^{-2}
B&W	B&W	0	0	2.3×10^{-4}	3.4×10^{-3}	0	0	0	3.6×10^{-3}
B&W	GE	801	6.4×10^{-5}	1.8×10^{-3}	3.6×10^{-3}	4.6×10^{-3}	1.3×10^{-3}	2.1×10^{-4}	1.2×10^{-2}
B&W	SNPC	4,422	2.8×10^{-4}	8.6×10^{-3}	4.7×10^{-3}	2.7×10^{-2}	7.7×10^{-3}	8.7×10^{-4}	4.9×10^{-2}
B&W	WCFF	607	4.9×10^{-5}	1.4×10^{-3}	3.6×10^{-3}	3.5×10^{-3}	9.9×10^{-4}	1.5×10^{-4}	9.6×10^{-3}
NFS	ABB-CE	1,095	9.7×10^{-5}	2.3×10^{-3}	3.7×10^{-3}	6.0×10^{-3}	1.7×10^{-3}	2.3×10^{-4}	1.4×10^{-2}
NFS	B&W	595	5.0×10^{-5}	1.4×10^{-3}	3.6×10^{-3}	3.3×10^{-3}	9.4×10^{-4}	9.2×10^{-5}	9.3×10^{-3}
NFS	GE	860	6.8×10^{-5}	1.9×10^{-3}	3.6×10^{-3}	5.1×10^{-3}	1.4×10^{-3}	2.7×10^{-4}	1.2×10^{-2}
NFS	SNPC	4,216	2.5×10^{-4}	8.2×10^{-3}	4.6×10^{-3}	2.6×10^{-2}	7.4×10^{-3}	8.3×10^{-4}	4.7×10^{-2}
NFS	WCFF	519	4.1×10^{-5}	1.2×10^{-3}	3.5×10^{-3}	3.0×10^{-3}	8.5×10^{-4}	1.5×10^{-4}	8.8×10^{-3}

Table G.1–7. Annual Health Effects From Transportation of Fuel Feed Material and Low-Level Waste From the Blending Plant to Destination—Continued

			Radiological[a]			Nonradiological[b]			
			Accident	Accident-Free		Accident		Air Pollution	
Origin	Destination	Distance (km)		Public	Crew	Public	Crew		Total Health Effect[c]
SRS	ABB-CE	1,321	1.1×10^{-4}	2.7×10^{-3}	3.8×10^{-3}	7.4×10^{-3}	2.1×10^{-3}	3.5×10^{-4}	1.7×10^{-2}
SRS	B&W	705	5.7×10^{-5}	1.6×10^{-3}	3.6×10^{-3}	4.1×10^{-3}	1.2×10^{-3}	1.9×10^{-4}	1.1×10^{-2}
SRS	GE	596	4.7×10^{-5}	1.4×10^{-3}	3.6×10^{-3}	3.5×10^{-3}	1.0×10^{-3}	1.9×10^{-4}	9.6×10^{-3}
SRS	SNPC	4,442	2.7×10^{-4}	8.6×10^{-3}	4.6×10^{-3}	2.7×10^{-2}	7.8×10^{-3}	9.3×10^{-4}	5.0×10^{-2}
SRS	WCFF	98	7.7×10^{-6}	4.1×10^{-4}	3.4×10^{-3}	5.7×10^{-4}	1.6×10^{-4}	3.2×10^{-5}	4.6×10^{-3}
Y–12	ABB-CE	848	7.6×10^{-5}	1.9×10^{-3}	3.6×10^{-3}	4.7×10^{-3}	1.3×10^{-3}	1.9×10^{-4}	1.2×10^{-2}
Y–12	B&W	526	4.4×10^{-5}	1.2×10^{-3}	3.5×10^{-3}	3.0×10^{-3}	8.3×10^{-4}	8.1×10^{-5}	8.7×10^{-3}
Y–12	GE	791	6.3×10^{-5}	1.7×10^{-3}	3.6×10^{-3}	4.6×10^{-3}	1.3×10^{-3}	2.3×10^{-4}	1.2×10^{-2}
Y–12	SNPC	3,969	2.4×10^{-4}	7.7×10^{-3}	4.5×10^{-3}	2.5×10^{-2}	7.0×10^{-3}	7.8×10^{-4}	4.5×10^{-2}
Y–12	WCFF	450	3.6×10^{-5}	1.1×10^{-3}	3.5×10^{-3}	2.6×10^{-3}	7.3×10^{-4}	1.2×10^{-4}	8.1×10^{-3}
Uranyl Nitrate Hexahydrate[e] (0.9-Percent Enrichment)									
Y–12	NTS	3,181	7.9×10^{-5}	3.6×10^{-3}	2.5×10^{-3}	1.1×10^{-2}	3.2×10^{-3}	2.8×10^{-4}	2.1×10^{-2}
SRS	NTS	3,654	9.6×10^{-5}	4.1×10^{-3}	2.5×10^{-3}	1.3×10^{-2}	3.7×10^{-3}	3.5×10^{-4}	2.4×10^{-2}
B&W	NTS	3,715	1.0×10^{-4}	4.2×10^{-3}	2.6×10^{-3}	1.3×10^{-2}	3.8×10^{-3}	5.1×10^{-4}	2.4×10^{-2}
NFS	NTS	3,428	9.2×10^{-5}	3.8×10^{-3}	2.5×10^{-3}	1.2×10^{-2}	3.4×10^{-3}	3.0×10^{-4}	2.2×10^{-2}
Uranium Hexafluoride[f] (4-Percent Enrichment)									
B&W	ABB-CE	1,301	4.7×10^{-5}	7.8×10^{-4}	1.0×10^{-3}	2.0×10^{-3}	5.8×10^{-4}	8.9×10^{-5}	4.6×10^{-3}
B&W	B&W	0	0	6.5×10^{-5}	9.6×10^{-4}	0	0	0	1.0×10^{-3}
B&W	GE	801	2.5×10^{-5}	4.9×10^{-4}	1.0×10^{-3}	1.3×10^{-3}	3.7×10^{-4}	6.1×10^{-5}	3.3×10^{-3}
B&W	SNPC	4,422	1.1×10^{-4}	2.5×10^{-3}	1.3×10^{-3}	7.7×10^{-3}	2.2×10^{-3}	2.5×10^{-4}	1.4×10^{-2}
B&W	WCFF	607	1.9×10^{-5}	4.0×10^{-4}	1.0×10^{-3}	1.0×10^{-3}	2.8×10^{-4}	4.4×10^{-5}	2.8×10^{-3}
NFS	ABB-CE	1,095	3.8×10^{-5}	6.7×10^{-4}	1.1×10^{-3}	1.7×10^{-3}	4.9×10^{-4}	6.6×10^{-5}	4.1×10^{-3}
NFS	B&W	595	2.0×10^{-5}	3.9×10^{-4}	1.0×10^{-3}	9.5×10^{-4}	2.7×10^{-4}	2.6×10^{-5}	2.7×10^{-3}
NFS	GE	860	2.7×10^{-5}	5.3×10^{-4}	1.0×10^{-3}	1.4×10^{-3}	4.1×10^{-4}	7.6×10^{-5}	3.5×10^{-3}
NFS	SNPC	4,216	9.9×10^{-5}	2.3×10^{-3}	1.3×10^{-3}	7.5×10^{-3}	2.1×10^{-3}	2.4×10^{-4}	1.4×10^{-2}
NFS	WCFF	519	1.6×10^{-5}	3.5×10^{-4}	1.0×10^{-3}	8.6×10^{-4}	2.4×10^{-4}	4.4×10^{-5}	2.5×10^{-3}

Table G.1–7. Annual Health Effects From Transportation of Fuel Feed Material and Low-Level Waste From the Blending Plant to Destination—Continued

Origin	Destination	Distance (km)	Radiological[a] Accident	Radiological[a] Accident-Free Public	Radiological[a] Accident-Free Crew	Nonradiological[b] Accident Public	Nonradiological[b] Accident Crew	Nonradiological[b] Air Pollution	Total Health Effect[c]
Metal[g] (0.9-Percent Enrichment)									
Y–12	NTS	3,181	1.2×10^{-4}	5.2×10^{-3}	3.6×10^{-3}	1.7×10^{-2}	4.8×10^{-3}	4.1×10^{-4}	3.1×10^{-2}
[Text deleted.]									

[a] Cancer fatalities.
[b] Fatalities.
[c] Estimated fatalities per year.
[d] There would be 70 shipments (truckloads) per year.
[e] There would be 40 shipments per year.
[f] There would be 20 shipments per year.
[g] There would be 59 shipments per year.
Note: ABB-CE=Asea Brown-Boveri Combustion Engineering; GE=General Electric Wilmington; SNPC=Siemans Nuclear Power Corporation; WCFF=Westinghouse Columbia Fuel Facility.
Source: RADTRAN model results.

Table G.1–8. Cumulative Annual Health Impacts From Transportation of Highly Enriched Uranium and Other Materials for Each Blending Option

Origin of Blending Material	Conversion Site	Blending Site	Destination[c]	Radiological[a] Accident	Radiological[a] Accident-Free Public	Radiological[a] Accident-Free Crew	Nonradiological[b] Accident Public	Nonradiological[b] Accident Crew	Nonradiological[b] Air Pollution	Total Health Effect[d]
UNH Blending to Fuel Feed Material										
Paducah	GE	B&W	ABB-CE	1.7×10^{-4}	4.1×10^{-3}	6.1×10^{-3}	1.1×10^{-2}	3.0×10^{-3}	4.6×10^{-4}	2.4×10^{-2}
Paducah	GE	B&W	B&W	4.7×10^{-5}	1.6×10^{-3}	5.6×10^{-3}	3.5×10^{-3}	1.0×10^{-3}	1.5×10^{-4}	1.2×10^{-2}
Paducah	GE	B&W	GE	1.1×10^{-4}	3.1×10^{-3}	5.9×10^{-3}	8.2×10^{-3}	2.3×10^{-3}	3.6×10^{-4}	2.0×10^{-2}
Paducah	GE	B&W	SNPC	3.2×10^{-4}	9.9×10^{-3}	6.9×10^{-3}	3.1×10^{-2}	8.7×10^{-3}	1.0×10^{-3}	5.8×10^{-2}
Paducah	GE	B&W	WCFF	9.6×10^{-5}	2.7×10^{-3}	5.8×10^{-3}	7.0×10^{-3}	2.0×10^{-3}	3.0×10^{-4}	1.8×10^{-2}

Table G.1–8. Cumulative Annual Health Impacts From Transportation of Highly Enriched Uranium and Other Materials for Each Blending Option—Continued

				Radiological[a]			Nonradiological[b]			
				Accident	Accident-Free		Accident		Air Pollution	
Origin of Blending Material	Conversion Site	Blending Site	Destination[c]		Public	Crew	Public	Crew		Total Health Effect[d]
UNH Blending to Fuel Feed Material (Continued)										
Paducah	GE	B&W	WCFF	$9.6x10^{-5}$	$2.7x10^{-3}$	$5.8x10^{-3}$	$7.0x10^{-3}$	$2.0x10^{-3}$	$3.0x10^{-4}$	$1.8x10^{-2}$
Paducah	GE	NFS	ABB-CE	$1.5x10^{-4}$	$3.6x10^{-3}$	$6.0x10^{-3}$	$9.5x10^{-3}$	$2.7x10^{-3}$	$3.9x10^{-4}$	$2.2x10^{-2}$
Paducah	GE	NFS	B&W	$9.8x10^{-5}$	$2.7x10^{-3}$	$5.8x10^{-3}$	$6.8x10^{-3}$	$1.9x10^{-3}$	$2.5x10^{-4}$	$1.8x10^{-2}$
Paducah	GE	NFS	GE	$1.2x10^{-4}$	$3.2x10^{-3}$	$5.9x10^{-3}$	$8.5x10^{-3}$	$2.4x10^{-3}$	$4.2x10^{-4}$	$2.1x10^{-2}$
Paducah	GE	NFS	SNPC	$3.0x10^{-4}$	$9.5x10^{-3}$	$6.9x10^{-3}$	$3.0x10^{-2}$	$8.4x10^{-3}$	$9.8x10^{-4}$	$5.6x10^{-2}$
Paducah	GE	NFS	WCFF	$8.9x10^{-5}$	$2.5x10^{-3}$	$5.8x10^{-3}$	$6.5x10^{-3}$	$1.8x10^{-3}$	$3.1x10^{-4}$	$1.7x10^{-2}$
Paducah	GE	SRS	ABB-CE	$1.5x10^{-4}$	$4.0x10^{-3}$	$6.0x10^{-3}$	$1.1x10^{-2}$	$3.0x10^{-3}$	$5.0x10^{-4}$	$2.5x10^{-2}$
Paducah	GE	SRS	B&W	$9.7x10^{-5}$	$2.8x10^{-3}$	$5.8x10^{-3}$	$7.3x10^{-3}$	$2.1x10^{-3}$	$3.4x10^{-4}$	$1.9x10^{-2}$
Paducah	GE	SRS	GE	$8.7x10^{-5}$	$2.6x10^{-3}$	$5.8x10^{-3}$	$6.7x10^{-3}$	$1.9x10^{-3}$	$3.4x10^{-4}$	$1.8x10^{-2}$
Paducah	GE	SRS	SNPC	$3.1x10^{-4}$	$9.8x10^{-3}$	$6.9x10^{-3}$	$3.1x10^{-2}$	$8.7x10^{-3}$	$1.1x10^{-3}$	$5.8x10^{-2}$
Paducah	GE	SRS	WCFF	$4.8x10^{-5}$	$1.6x10^{-3}$	$5.6x10^{-3}$	$3.9x10^{-3}$	$1.1x10^{-3}$	$1.8x10^{-4}$	$1.3x10^{-2}$
Paducah	GE	Y–12	ABB-CE	$1.2x10^{-4}$	$3.1x10^{-3}$	$5.9x10^{-3}$	$8.0x10^{-3}$	$2.3x10^{-3}$	$3.4x10^{-4}$	$2.0x10^{-2}$
Paducah	GE	Y–12	B&W	$8.9x10^{-5}$	$2.5x10^{-3}$	$5.8x10^{-3}$	$6.2x10^{-3}$	$1.8x10^{-3}$	$2.3x10^{-4}$	$1.7x10^{-2}$
Paducah	GE	Y–12	GE	$1.1x10^{-4}$	$3.0x10^{-3}$	$5.9x10^{-3}$	$7.9x10^{-3}$	$2.2x10^{-3}$	$3.8x10^{-4}$	$1.9x10^{-2}$
Paducah	GE	Y–12	SNPC	$2.8x10^{-4}$	$8.9x10^{-3}$	$6.8x10^{-3}$	$2.8x10^{-2}$	$7.9x10^{-3}$	$9.2x10^{-4}$	$5.3x10^{-2}$
Paducah	GE	Y–12	WCFF	$8.1x10^{-5}$	$2.3x10^{-3}$	$5.8x10^{-3}$	$5.9x10^{-3}$	$1.7x10^{-3}$	$2.7x10^{-4}$	$1.6x10^{-2}$
Piketon	GE	B&W	ABB-CE	$1.7x10^{-4}$	$4.1x10^{-3}$	$6.1x10^{-3}$	$1.1x10^{-2}$	$3.0x10^{-3}$	$4.7x10^{-4}$	$2.5x10^{-2}$
Piketon	GE	B&W	B&W	$4.9x10^{-5}$	$1.6x10^{-3}$	$5.6x10^{-3}$	$3.6x10^{-3}$	$1.0x10^{-3}$	$1.6x10^{-4}$	$1.2x10^{-2}$
Piketon	GE	B&W	GE	$1.1x10^{-4}$	$3.1x10^{-3}$	$5.9x10^{-3}$	$8.2x10^{-3}$	$2.3x10^{-3}$	$3.8x10^{-4}$	$2.0x10^{-2}$
Piketon	GE	B&W	SNPC	$3.3x10^{-4}$	$9.9x10^{-3}$	$7.0x10^{-3}$	$3.1x10^{-2}$	$8.7x10^{-3}$	$1.0x10^{-3}$	$5.8x10^{-2}$
Piketon	GE	B&W	WCFF	$9.8x10^{-5}$	$2.7x10^{-3}$	$5.8x10^{-3}$	$7.1x10^{-3}$	$2.0x10^{-3}$	$3.1x10^{-4}$	$1.8x10^{-2}$
Piketon	GE	NFS	ABB-CE	$1.5x10^{-4}$	$3.7x10^{-3}$	$6.0x10^{-3}$	$9.6x10^{-3}$	$2.7x10^{-3}$	$4.0x10^{-4}$	$2.3x10^{-2}$

Table G.1–8. Cumulative Annual Health Impacts From Transportation of Highly Enriched Uranium and Other Materials for Each Blending Option—Continued

				Radiological[a]			Nonradiological[b]			
				Accident	Accident-Free		Accident		Air Pollution	
Origin of Blending Material	Conversion Site	Blending Site	Destination[c]		Public	Crew	Public	Crew		Total Health Effect[d]
UNH Blending to Fuel Feed Material (Continued)										
Piketon	GE	NFS	B&W	9.9×10^{-5}	2.7×10^{-3}	5.8×10^{-3}	6.9×10^{-3}	2.0×10^{-3}	2.6×10^{-4}	1.8×10^{-2}
Piketon	GE	NFS	GE	1.2×10^{-4}	3.2×10^{-3}	5.9×10^{-3}	8.6×10^{-3}	2.4×10^{-3}	4.4×10^{-4}	2.1×10^{-2}
Piketon	GE	NFS	SNPC	3.0×10^{-4}	9.5×10^{-3}	6.9×10^{-3}	3.0×10^{-2}	8.4×10^{-3}	1.0×10^{-3}	5.6×10^{-2}
Piketon	GE	NFS	WCFF	9.1×10^{-5}	2.6×10^{-3}	5.8×10^{-3}	6.6×10^{-3}	1.9×10^{-3}	3.2×10^{-4}	1.7×10^{-2}
Piketon	GE	SRS	ABB-CE	1.6×10^{-4}	4.0×10^{-3}	6.1×10^{-3}	1.1×10^{-2}	3.1×10^{-3}	5.1×10^{-4}	2.5×10^{-2}
Piketon	GE	SRS	B&W	9.9×10^{-5}	2.8×10^{-3}	5.8×10^{-3}	7.4×10^{-3}	2.1×10^{-3}	3.5×10^{-4}	1.9×10^{-2}
Piketon	GE	SRS	GE	8.9×10^{-5}	2.6×10^{-3}	5.8×10^{-3}	6.8×10^{-3}	1.9×10^{-3}	3.6×10^{-4}	1.8×10^{-2}
Piketon	GE	SRS	SNPC	3.2×10^{-4}	9.9×10^{-3}	6.9×10^{-3}	3.1×10^{-2}	8.7×10^{-3}	1.1×10^{-3}	5.8×10^{-2}
Piketon	GE	SRS	WCFF	4.9×10^{-5}	1.7×10^{-3}	5.7×10^{-3}	3.9×10^{-3}	1.1×10^{-3}	1.9×10^{-4}	1.3×10^{-2}
Piketon	GE	Y–12	ABB-CE	1.2×10^{-4}	3.1×10^{-3}	5.9×10^{-3}	8.0×10^{-3}	2.3×10^{-3}	3.5×10^{-4}	2.0×10^{-2}
Piketon	GE	Y–12	B&W	9.1×10^{-5}	2.5×10^{-3}	5.8×10^{-3}	6.3×10^{-3}	1.8×10^{-3}	2.4×10^{-4}	1.7×10^{-2}
Piketon	GE	Y–12	GE	1.1×10^{-4}	3.0×10^{-3}	5.9×10^{-3}	7.9×10^{-3}	2.2×10^{-3}	3.9×10^{-4}	2.0×10^{-2}
Piketon	GE	Y–12	SNPC	2.8×10^{-4}	9.0×10^{-3}	6.8×10^{-3}	2.8×10^{-2}	7.9×10^{-3}	9.4×10^{-4}	5.3×10^{-2}
Piketon	GE	Y–12	WCFF	8.3×10^{-5}	2.4×10^{-3}	5.7×10^{-3}	5.9×10^{-3}	1.7×10^{-3}	2.8×10^{-4}	1.6×10^{-2}
Hanford	-	B&W	ABB-CE	2.3×10^{-4}	4.7×10^{-3}	5.1×10^{-3}	1.3×10^{-2}	3.7×10^{-3}	5.0×10^{-4}	2.7×10^{-2}
Hanford	-	B&W	B&W	1.1×10^{-4}	2.2×10^{-3}	4.7×10^{-3}	6.1×10^{-3}	1.7×10^{-3}	1.9×10^{-4}	1.5×10^{-2}
Hanford	-	B&W	GE	1.7×10^{-4}	3.7×10^{-3}	4.9×10^{-3}	1.1×10^{-2}	3.0×10^{-3}	4.1×10^{-4}	2.3×10^{-2}
Hanford	-	B&W	SNPC	3.9×10^{-4}	1.1×10^{-2}	6.0×10^{-3}	3.3×10^{-2}	9.4×10^{-3}	1.1×10^{-3}	6.1×10^{-2}
Hanford	-	B&W	WCFF	1.6×10^{-4}	3.3×10^{-3}	4.9×10^{-3}	9.5×10^{-3}	2.7×10^{-3}	3.5×10^{-4}	2.1×10^{-2}
Hanford	-	NFS	ABB-CE	2.0×10^{-4}	4.1×10^{-3}	5.0×10^{-3}	1.2×10^{-2}	3.3×10^{-3}	4.1×10^{-4}	2.5×10^{-2}
Hanford	-	NFS	B&W	1.5×10^{-4}	3.2×10^{-3}	4.8×10^{-3}	9.0×10^{-3}	2.6×10^{-3}	2.7×10^{-4}	2.0×10^{-2}
Hanford	-	NFS	GE	1.7×10^{-4}	3.7×10^{-3}	4.9×10^{-3}	1.1×10^{-2}	3.0×10^{-3}	4.5×10^{-4}	2.3×10^{-2}
Hanford	-	NFS	SNPC	3.5×10^{-4}	1.0×10^{-2}	5.9×10^{-3}	3.2×10^{-2}	9.0×10^{-3}	1.0×10^{-3}	5.8×10^{-2}
Hanford	-	NFS	WCFF	1.4×10^{-4}	3.0×10^{-3}	4.8×10^{-3}	8.7×10^{-3}	2.5×10^{-3}	3.3×10^{-4}	2.0×10^{-2}
Hanford	-	SRS	ABB-CE	2.2×10^{-4}	4.7×10^{-3}	5.1×10^{-3}	1.4×10^{-2}	3.8×10^{-3}	5.6×10^{-4}	2.8×10^{-2}
Hanford	-	SRS	B&W	1.7×10^{-4}	3.5×10^{-3}	4.9×10^{-3}	1.0×10^{-2}	2.9×10^{-3}	4.0×10^{-4}	2.2×10^{-2}

Table G.1–8. Cumulative Annual Health Impacts From Transportation of Highly Enriched Uranium and Other Materials for Each Blending Option—Continued

Origin of Blending Material	Conversion Site	Blending Site	Destination[c]	Radiological[a] Accident	Radiological[a] Accident-Free Public	Radiological[a] Accident-Free Crew	Nonradiological[b] Accident Public	Nonradiological[b] Accident Crew	Nonradiological[b] Air Pollution	Total Health Effect[d]
UNH Blending to Fuel Feed Material (Continued)										
Hanford	-	SRS	GE	$1.6x10^{-4}$	$3.3x10^{-3}$	$4.9x10^{-3}$	$9.6x10^{-3}$	$2.7x10^{-3}$	$4.0x10^{-4}$	$2.1x10^{-2}$
Hanford	-	SRS	SNPC	$3.8x10^{-4}$	$1.1x10^{-2}$	$6.0x10^{-3}$	$3.4x10^{-2}$	$9.5x10^{-3}$	$1.1x10^{-3}$	$6.1x10^{-2}$
Hanford	-	SRS	WCFF	$1.2x10^{-4}$	$2.4x10^{-3}$	$4.7x10^{-3}$	$6.7x10^{-3}$	$1.9x10^{-3}$	$2.4x10^{-4}$	$1.6x10^{-2}$
Hanford	-	Y–12	ABB-CE	$1.7x10^{-4}$	$3.5x10^{-3}$	$4.9x10^{-3}$	$9.9x10^{-3}$	$2.8x10^{-3}$	$3.6x10^{-4}$	$2.2x10^{-2}$
Hanford	-	Y–12	B&W	$1.4x10^{-4}$	$2.9x10^{-3}$	$4.8x10^{-3}$	$8.2x10^{-3}$	$2.3x10^{-3}$	$2.5x10^{-4}$	$1.9x10^{-2}$
Hanford	-	Y–12	GE	$1.6x10^{-4}$	$3.4x10^{-3}$	$4.9x10^{-3}$	$9.9x10^{-3}$	$2.8x10^{-3}$	$4.0x10^{-4}$	$2.2x10^{-2}$
Hanford	-	Y–12	SNPC	$3.3x10^{-4}$	$9.4x10^{-3}$	$5.8x10^{-3}$	$3.0x10^{-2}$	$8.5x10^{-3}$	$9.5x10^{-4}$	$5.5x10^{-2}$
Hanford	-	Y–12	WCFF	$1.3x10^{-4}$	$2.8x10^{-3}$	$4.8x10^{-3}$	$7.9x10^{-3}$	$2.2x10^{-3}$	$2.9x10^{-4}$	$1.8x10^{-2}$
UNH Blending to LLW										
Paducah	GE	Y–12	NTS	$1.4x10^{-4}$	$4.9x10^{-3}$	$5.6x10^{-3}$	$1.5x10^{-2}$	$4.2x10^{-3}$	$4.3x10^{-4}$	$3.0x10^{-2}$
Paducah	GE	SRS	NTS	$1.5x10^{-4}$	$5.6x10^{-3}$	$5.7x10^{-3}$	$1.7x10^{-2}$	$4.8x10^{-3}$	$5.4x10^{-4}$	$3.4x10^{-2}$
Paducah	GE	B&W	NTS	$1.6x10^{-4}$	$5.8x10^{-3}$	$5.7x10^{-3}$	$1.8x10^{-2}$	$5.0x10^{-3}$	$6.8x10^{-4}$	$3.5x10^{-2}$
Paducah	GE	NFS	NTS	$1.6x10^{-4}$	$5.4x10^{-3}$	$5.7x10^{-3}$	$1.6x10^{-2}$	$4.6x10^{-3}$	$4.7x10^{-4}$	$3.2x10^{-2}$
Piketon	GE	Y–12	NTS	$1.4x10^{-4}$	$4.9x10^{-3}$	$5.6x10^{-3}$	$1.5x10^{-2}$	$4.2x10^{-3}$	$4.5x10^{-4}$	$3.0x10^{-2}$
Piketon	GE	SRS	NTS	$1.5x10^{-4}$	$5.7x10^{-3}$	$5.7x10^{-3}$	$1.7x10^{-2}$	$4.9x10^{-3}$	$5.5x10^{-4}$	$3.4x10^{-2}$
Piketon	GE	B&W	NTS	$1.7x10^{-4}$	$5.9x10^{-3}$	$5.7x10^{-3}$	$1.8x10^{-2}$	$5.0x10^{-3}$	$7.0x10^{-4}$	$3.5x10^{-2}$
Piketon	GE	NFS	NTS	$1.6x10^{-4}$	$5.4x10^{-3}$	$5.7x10^{-3}$	$1.6x10^{-2}$	$4.6x10^{-3}$	$4.9x10^{-4}$	$3.2x10^{-2}$
Hanford	-	Y–12	NTS	$1.8x10^{-4}$	$5.4x10^{-3}$	$4.5x10^{-3}$	$1.7x10^{-2}$	$4.8x10^{-3}$	$4.6x10^{-4}$	$3.2x10^{-2}$
Hanford	-	SRS	NTS	$2.0x10^{-4}$	$6.4x10^{-3}$	$4.7x10^{-3}$	$2.0x10^{-2}$	$5.7x10^{-3}$	$6.1x10^{-4}$	$3.8x10^{-2}$
Hanford	-	B&W	NTS	$2.1x10^{-4}$	$6.5x10^{-3}$	$4.7x10^{-3}$	$2.1x10^{-2}$	$5.8x10^{-3}$	$7.3x10^{-4}$	$3.8x10^{-2}$
Hanford	-	NFS	NTS	$2.0x10^{-4}$	$5.9x10^{-3}$	$4.6x10^{-3}$	$1.9x10^{-2}$	$5.2x10^{-3}$	$5.0x10^{-4}$	$3.5x10^{-2}$

Table G.1–8. Cumulative Annual Health Impacts From Transportation of Highly Enriched Uranium and Other Materials for Each Blending Option—Continued

				Radiological[a]			Nonradiological[b]			
				Accident	Accident-Free		Accident		Air Pollution	
Origin of Blending Material	Conversion Site	Blending Site	Destination[c]		Public	Crew	Public	Crew		Total Health Effect[d]
UF_6 Blending to Fuel Feed Material										
Paducah	-	B&W	ABB-CE	$7.5x10^{-5}$	$3.3x10^{-3}$	$7.6x10^{-3}$	$8.2x10^{-3}$	$2.3x10^{-3}$	$2.6x10^{-4}$	$2.2x10^{-2}$
Paducah	-	B&W	B&W	$2.8x10^{-5}$	$2.6x10^{-3}$	$7.4x10^{-3}$	$6.2x10^{-3}$	$1.8x10^{-3}$	$1.7x10^{-4}$	$1.8x10^{-2}$
Paducah	-	B&W	GE	$5.4x10^{-5}$	$3.0x10^{-3}$	$7.5x10^{-3}$	$7.5x10^{-3}$	$2.1x10^{-3}$	$2.3x10^{-4}$	$2.1x10^{-2}$
Paducah	-	B&W	SNPC	$1.4x10^{-4}$	$5.0x10^{-3}$	$7.8x10^{-3}$	$1.4x10^{-2}$	$4.0x10^{-3}$	$4.2x10^{-4}$	$3.1x10^{-2}$
Paducah	-	B&W	WCFF	$4.8x10^{-5}$	$2.9x10^{-3}$	$7.5x10^{-3}$	$7.2x10^{-3}$	$2.0x10^{-3}$	$2.1x10^{-4}$	$2.0x10^{-2}$
Paducah	-	NFS	ABB-CE	$5.9x10^{-5}$	$2.2x10^{-3}$	$7.4x10^{-3}$	$5.1x10^{-3}$	$1.4x10^{-3}$	$1.6x10^{-4}$	$1.6x10^{-2}$
Paducah	-	NFS	B&W	$4.0x10^{-5}$	$2.0x10^{-3}$	$7.3x10^{-3}$	$4.3x10^{-3}$	$1.2x10^{-3}$	$1.2x10^{-4}$	$1.5x10^{-2}$
Paducah	-	NFS	GE	$4.7x10^{-5}$	$2.1x10^{-3}$	$7.3x10^{-3}$	$4.8x10^{-3}$	$1.4x10^{-3}$	$1.7x10^{-4}$	$1.6x10^{-2}$
Paducah	-	NFS	SNPC	$1.2x10^{-4}$	$3.9x10^{-3}$	$7.6x10^{-3}$	$1.1x10^{-2}$	$3.1x10^{-3}$	$3.3x10^{-4}$	$2.6x10^{-2}$
Paducah	-	NFS	WCFF	$3.6x10^{-5}$	$1.9x10^{-3}$	$7.3x10^{-3}$	$4.2x10^{-3}$	$1.2x10^{-3}$	$1.4x10^{-4}$	$1.5x10^{-2}$
Piketon	-	B&W	ABB-CE	$7.2x10^{-5}$	$3.2x10^{-3}$	$7.5x10^{-3}$	$8.0x10^{-3}$	$2.3x10^{-3}$	$2.7x10^{-4}$	$2.1x10^{-2}$
Piketon	-	B&W	B&W	$2.6x10^{-5}$	$2.5x10^{-3}$	$7.4x10^{-3}$	$5.9x10^{-3}$	$1.7x10^{-3}$	$1.8x10^{-4}$	$1.8x10^{-2}$
Piketon	-	B&W	GE	$5.1x10^{-5}$	$2.9x10^{-3}$	$7.5x10^{-3}$	$7.2x10^{-3}$	$2.1x10^{-3}$	$2.4x10^{-4}$	$2.0x10^{-2}$
Piketon	-	B&W	SNPC	$1.4x10^{-5}$	$4.9x10^{-3}$	$7.8x10^{-3}$	$1.4x10^{-2}$	$3.9x10^{-3}$	$4.3x10^{-4}$	$3.1x10^{-2}$
Piketon	-	B&W	WCFF	$4.5x10^{-5}$	$2.8x10^{-3}$	$7.5x10^{-3}$	$6.9x10^{-3}$	$2.0x10^{-3}$	$2.2x10^{-4}$	$1.9x10^{-2}$
Piketon	-	NFS	ABB-CE	$6.5x10^{-5}$	$2.3x10^{-3}$	$7.4x10^{-3}$	$5.4x10^{-3}$	$1.5x10^{-3}$	$1.9x10^{-4}$	$1.7x10^{-2}$
Piketon	-	NFS	B&W	$4.7x10^{-5}$	$2.1x10^{-3}$	$7.3x10^{-3}$	$4.6x10^{-3}$	$1.3x10^{-3}$	$1.5x10^{-4}$	$1.6x10^{-2}$
Piketon	-	NFS	GE	$5.4x10^{-5}$	$2.2x10^{-3}$	$7.4x10^{-3}$	$5.1x10^{-3}$	$1.4x10^{-3}$	$2.0x10^{-4}$	$1.6x10^{-2}$
Piketon	-	NFS	SNPC	$1.3x10^{-5}$	$4.0x10^{-3}$	$7.6x10^{-3}$	$1.1x10^{-2}$	$3.2x10^{-3}$	$3.6x10^{-4}$	$2.6x10^{-2}$
Piketon	-	NFS	WCFF	$4.3x10^{-5}$	$2.0x10^{-3}$	$7.3x10^{-3}$	$4.5x10^{-3}$	$1.3x10^{-3}$	$1.7x10^{-4}$	$1.5x10^{-2}$
Metal Blending to LLW										
Fernald	-	Y–12	NTS	$1.4x10^{-4}$	$5.7x10^{-3}$	$6.2x10^{-3}$	$1.8x10^{-2}$	$5.0x10^{-3}$	$4.4x10^{-4}$	$3.5x10^{-2}$
[Text deleted.]										

[a] Cancer fatalities.
[b] Fatalities.
[c] Destination is either a fuel fabrication site or NTS for LLW.

G.2 6M, TYPE B RADIOACTIVE MATERIALS SHIPMENT PACKAGING TEST SEQUENCE

In addition to meeting standards demonstrating it can withstand normal conditions of transport without loss or dispersal of its radioactive contents, the model 6M, Type B packaging used for Department of Energy (DOE) shipments must survive certain severe hypothetical accident conditions that demonstrate resistance to impact, puncture, fire, and water submersion. Test conditions do not duplicate accident environments but, rather, produce damage equivalent to extreme and unlikely accidents. The 6M, Type B packaging is judged as surviving extreme sequential testing if it retains all its contents except for minuscule allowable releases, and the dose rate outside the packaging does not exceed 1 rem/hr at a distance of 1 m from the package surface. Drum sizes (outer package) can vary from 38 to 416 liters (10 to 110 gallons).

The complete sequence of tests is listed below:

- **Drop Test.** A 9-m (30-ft) drop onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected.

- **Puncture Test.** A 1-m (40-inch) drop onto the upper end of a 15-centimeter (6-inch) diameter solid, vertical, cylindrical, mild steel bar mounted on an essentially unyielding, horizontal surface.

- **Thermal Test.** An exposure for not less than 30 minutes to a heat flux not less than that of a radiation environment of 800 °C (1,475 °F) with an emissivity coefficient of at least 0.9.

- **Water-Immersion Test.** A subjection to water pressure equivalent to immersion under a head of water of at least 15 m (50 ft) for not less than 8 hours.

The regulatory test conditions for the 6M, Type B packaging and other similar packaging are much more demanding than they might appear. For example, an impact on a very hard surface (desert caliche) at over 322 km/hr (200 mph) is not as likely to deform the packaging as would a drop of 9 m (30 ft) onto an unyielding target.

A typical 6M, Type B packaging approved for use by DOE is covered by Certificate of Compliance Number 9965, dated February 16, 1996.

The 6M, Type B packaging is made up of several component parts each playing an integral engineered role in containment and confinement of the radioactive material being shipped. The applicable DOE Safety Analysis Report for Packaging provides additional detail that shows that the package provides a high level of public safety regardless of the accidental conditions it might encounter during transportation. Although 6M, Type B packagings have been involved in severe accidents, the integrity of the packaging has never been compromised.

Appendix H
Federal, State, and Local Agencies/Organizations/Individuals Contacted

This appendix identifies the various agencies contacted during the preparation of the *Disposition of Surplus Highly Enriched Uranium Environmental Impact Statement* (HEU EIS). The various agencies were contacted to actively solicit site-specific data; regulatory compliance requirements; Federal, State, and local laws; or Executive Orders that may be applicable to the proposed alternatives considered in this EIS.

The Department of Energy has also requested certain agencies and organizations to cooperate during the preparation of the HEU EIS. The Environmental Protection Agency and the United States Enrichment Corporation have agreed to cooperate with the Department of Energy and signed memorandums of understanding, which are included in this appendix.

Babcock & Wilcox
Naval Nuclear Fuels Division

Babcock & Wilcox Fuel Company
Commercial Nuclear Fuel Plant

Campbell County, Virginia
Office of County Administrator

City of Greenville, Tennessee
Water Department

City of Jonesborough, Tennessee
Water Department

Commonwealth of Virginia
Department of Environmental Quality
Water Regional Office

Commonwealth of Virginia
Department of Health
Office of Water Programs

Commonwealth of Virginia
Department of Historic Resources

Commonwealth of Virginia
Department of Transportation

Commonwealth of Virginia
Game and Inland Fisheries

Department of Environment and Conservation
Regional Office
Environmental Epidemiological Program

Erwin Chamber of Commerce
Erwin, Tennessee

Erwin Utilities
Erwin, Tennessee

Flood Distribution Center
National Flood Insurance Program

Dr. Kerry Gatlie, M.D.
Tennessee State Health Department, Epidemiology

Health Hazard Control

Lynchburg Airport
Airport Director

Lynchburg Chamber of Commerce
Lynchburg, Virginia

National Climatic Data Center

Nuclear Fuel Services
Erwin, Tennessee

Patrick A. Turri, Epidemiologist
Environmental Epidemiology
Nashville, Tennessee

State of South Carolina
Department of Health and Environmental Protection Division
Bureau of Air Quality

State of Tennessee
Attorney General's Office
Environmental Protection Division

State of Tennessee
Department of Health and Environment

State of Tennessee
Division of Underground Storage Tanks

State of Tennessee
Department of Transportation
Map Sales Department

State of Tennessee
State Wildlife Division

Tri-Cities Airport
FAA Airport Director

Unicoi County, Tennessee
County Executive, Paul Monk

Unicoi County, Tennessee
Department of Health

U.S. Department of Agriculture
National Resources Conservation Service

U.S. Department of Agriculture
Soil Conservation Service

U.S. Department of Commerce
Federal Emergency Management Agency

U.S. Department of the Interior
Geological Survey
Nashville, Tennessee

U.S. Department of the Interior
Geological Survey
Reston, Virginia

U.S. Department of the Interior
Geological Survey
Richmond, Virginia

U.S. Department of the Interior
National Park Service

U.S. Department of Transportation
Federal Aviation Administration

Virginia Game and Inland Fisheries

Virginia Polytechnic Institute and State University
Department of Crop and Soil Environmental Sciences

Virginia Polytechnic Institute and State University
Virginia Water Resources Research Center

Wayne Scott
Scott's Farm
Erwin, Tennessee

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 21 1995

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

Mr. J. David Nulton, Director
NEPA Compliance and Outreach
Office of Fissile Materials Disposition
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Mr. Nulton:

Thank you for your letter dated May 2, 1995, inviting our participation as a potential cooperating agency in the preparation of the Environmental Impact Statement (EIS) for the Disposition of Surplus Highly Enriched Uranium (HEU). We would be pleased to be a cooperating agency.

In order to define our specific involvement, we have enclosed a Memorandum of Understanding (MOU) to be signed by both agencies. This MOU has been coordinated by the staffs at EPA and DOE. After signature, we request that the MOU be sent to the EPA point of contact. EPA Office of Federal Activities will distribute copies of the MOU internally to the appropriate program offices.

In response to the questions posed in your May 2, 1995, memorandum, we offer the following response. We were asked to comment on the issues identified for analysis and if there were any additional issues. Concerning the EIS alternatives, we suggest that DOE discuss: the form of the material, the location for treatment and storage of the material, any uses of the blended down material, and if applicable, how and where it will be disposed. Through the Clean Water Act Section 102, and the Safe Drinking Water Act Section 1428, states have developed comprehensive state groundwater protection programs and state wellhead protection programs to protect priority areas for future water supplies. We recommend that DOE work with the appropriate state agencies to ensure that adequate groundwater protection approaches are developed in determining the disposal and storage locations for the material.

We appreciate the opportunity to work along with DOE on this project. If you have any questions, please call me at (202) 260-5053. Our staff contact on the issue is Susan Offerdal at (202) 260-5059.

Sincerely,

Richard E. Sanderson
Director
Office of Federal Activities

Enclosure

MEMORANDUM OF UNDERSTANDING BETWEEN THE DEPARTMENT OF ENERGY AND THE ENVIRONMENTAL PROTECTION AGENCY AS A COOPERATING AGENCY ON THE ENVIRONMENTAL IMPACT STATEMENT FOR THE DISPOSITION OF SURPLUS HIGHLY ENRICHED URANIUM

The purpose of this document is to establish a framework for technical cooperation between the Department of Energy (DOE) and the Environmental Protection Agency (EPA) concerning the development of the Environmental Impact Statement (EIS) for the Disposition of Surplus Highly Enriched Uranium (HEU). DOE is the lead agency and EPA is a cooperating agency. When countersigned by both parties, the following paragraphs will provide the basis for the roles between the two agencies as they conduct technical coordination on issues of mutual concern.

This memorandum of understanding (MOU) pertains to the exchange of information on technical issues. It does not abrogate, alter, or in any way modify existing or future environmental compliance or cleanup agreements, other enforceable agreements, any permitting or regulatory requirement, or enforcement actions. Further, it will not alter EPA's responsibilities under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act to provide scoping comments and conduct an official review of the draft and final EIS. This MOU will in no way affect state actions or policy with respect to specific DOE sites. Funds and other resources will not be exchanged as a result of this MOU.

The DOE has responsibility for compliance with the requirements of NEPA and preparation of the draft and final EIS. Accordingly, DOE agrees:

- to provide EPA with EIS information on areas for which DOE would like EPA technical review and comments. These areas include but are not limited to radiation, mixed waste, risk management, transportation, ground water, and NEPA implementation;

- to invite EPA to participate in internal and external meetings concerning areas that DOE would like EPA technical review and comments. These areas include, but are not limited to, radiation, mixed waste, risk management, transportation, ground water, and NEPA implementation;

- to provide copies of the draft and final EIS as soon as practical to allow EPA sufficient time to review and comment on these documents;

Enclosure

NOTE:. The meetings mentioned above will: assist EPA's understanding of the HEU EIS and related issues, assist DOE in early identification and resolution of EPA issues, and thereby expedite review of the draft and final EIS.

to consult with EPA regarding mitigative measures to be included in the EIS;

- to indicate in the draft and final EIS cover page that EPA is a cooperating agency. Also, the draft and final EIS will include, in the introductory section, a statement that describes EPA's role as a cooperating agency, and EPA's NEPA and Section 309 CAA authorities.

The EPA agrees:

- to assist DOE in defining issues and concerns to be addressed in the EIS. This will be done as part of EPA's participation in document review meetings.

- to provide information in those areas that EPA has regulatory authority and/or technical expertise, that include, but are not limited to, radiation, mixed waste, risk management, transportation, ground water, and NEPA implementation.

- to review and comment, in a timely manner, on those sections of the draft and final EIS document where EPA has specific technical expertise and/or regulatory authority.

The Agency points of contact for this MOU are:

EPA	DOE
Mr. Richard E. Sanderson Director Office of Federal Activities Environmental Protection Agency 401 M Street, SW Washington, D.C. 20460	Mr. J. David Nulton Director Office of NEPA Compliance and Outreach Office of Fissile Materials Disposition Department of Energy 1000 Independence Avenue, SW Washington, D.C. 20585
202-260-5053	202-586-4513

This agreement will be effective upon signature by both EPA and DOE. It can be modified by mutual agreement only and in writing. It can be terminated either when the NEPA process is completed (issuance of DOE's record of decision), or when written notice is given by either agency.

EPA Approval:

7/31/95

Richard E. Sanderson
Director
Office of Federal Activities
Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

DOE Approval:

8/4/95

J. David Nulton
Director
Office of NEPA Compliance and Outreach
Office of Fissile Materials Disposition
Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585

United States
Enrichment Corporation

2 Democracy Center
6903 Rockledge Drive
Bethesda, MD 20817

Tel: (301) 564-3200
Fax: (301) 564-3201

USEC

United States
Enrichment Corporation

July 21, 1995

Mr. J. David Nulton
Office of Fissile Materials Disposition (MD-1)
Forrestal Building
U. S. Department of Energy
1000 Independence Avenue S.W.
Washington, D.C. 20585

Dear Mr. Nulton:

Enclosed is the signed Memorandum of Understanding concerning cooperation on the Environmental Impact Statement for *Disposition of Highly Enriched Uranium.* We look forward to working with your agency in this important endeavor.

Please contact me at (301) 564-3409 or Patrick Gorman at 564-3412, to discuss matters related to the addressed above.

Sincerely,

T. Michael Taimi
Environmental Policies and Assurances Manager

Enclosure

MEMORANDUM OF UNDERSTANDING BETWEEN THE DEPARTMENT OF ENERGY AND THE UNITED STATES ENRICHMENT CORPORATION FOR COOPERATION ON THE PREPARATION OF AN ENVIRONMENTAL IMPACT STATEMENT FOR THE DISPOSITION OF SURPLUS HIGHLY ENRICHED URANIUM

July 7, 1995

The purpose of this document is to establish a framework for technical cooperation between the Department of Energy (DOE) and the United States Enrichment Corporation (USEC) concerning the development of the Environmental Impact Statement (EIS) on the disposition of surplus highly enriched uranium described in DOE's Notice of Intent published in the *Federal Register*. DOE is the lead agency in the preparation of this EIS, with USEC cooperating on relevant portions. When signed by both parties, the following paragraphs will govern the coordination between the two agencies as they conduct technical coordination on issues of mutual concern.

This memorandum of understanding (MOU) pertains to the exchange of information on technical issues. It does not abrogate, alter, or in any way modify existing or future agreements between DOE and USEC or in any way alter their rights or responsibilities. DOE and USEC will each fund their own activities under this MOU and no funds and other resources will be exchanged as a result of this MOU.

The Department has responsibility for compliance with the requirements of NEPA and preparation of the draft and final EIS. Therefore, DOE agrees:

- To provide USEC with information on areas for which DOE would like USEC technical review and comments.
- To invite USEC to participate in internal and external meetings concerning scheduling and in areas for which DOE would like USEC technical review and comments. These technical areas include, but are not limited to, uranium materials, blending services, and transportation.
- To provide copies of all drafts as soon as practical to help allow USEC sufficient time to review and comment on these documents.
- To consult with USEC regarding mitigative measures to be included in the EIS.

The USEC agrees:

- To assist DOE in defining issues and concerns to be addressed in the EIS. This will be done as part of USEC's participation in document review meetings.
- To provide information in those areas that USEC has responsibility and/or technical expertise.
- To review and comment, in a timely manner, on all drafts of the EIS document.

The agency points of contact for this MOU are:

USEC	DOE
Mr. T. Michael Taimi Environmental Assurance and Policies Manager United States Enrichment Corporation Two Democracy Center 6903 Rockledge Drive Bethesda, Maryland 20817	Mr. J. David Nulton Director, NEPA Compliance & Outreach Office of Fissile Materials Disposition U.S. Department of Energy 1000 Independence Avenue, S.W. Washington, D.C. 20585
(301) 564-3409	(202) 586-4513

This agreement will be effective upon Signature of both USEC and DOE. It can be modified by mutual agreement only and in writing. It can be terminated either when the NEPA process is completed (issuance of DOE's record of decision) or when written notice is give by either agency.

USEC Approval:

Mr. T. Michael Taimi
United States Enrichment Corporation

DOE Approval:

Mr. J. David Nulton
Department of Energy

Appendix I
Applicable Laws, Regulations, and Other Requirements

I.1 INTRODUCTION

This appendix identifies and presents the environmental standards and statutory requirements that may apply to the disposition of surplus highly enriched uranium (HEU). These statutes and regulations provide the standard against which to evaluate the ability of potential blending sites to meet environmental, safety, and health requirements.

Table I.1–1 lists applicable Federal environmental statutes, regulations, and Executive Orders for the proposed action. The table also identifies the associated permit, approval, and consultation requirements generally required to implement any alternative. Table I.1–2 lists applicable State environmental, safety, and health statutes and regulations for Tennessee, South Carolina, Virginia, North Carolina, Ohio, and Kentucky, and Table I.1–3 provides a list of selected Department of Energy (DOE) environment, safety, and health orders.

Table I.1–1. Federal Environmental Statutes, Regulations, and Orders

Resource Category	Statute/Regulation/Order	Citation	Responsible Agency	EIS-Level Potential Applicability: Permits, Approvals, Consultations, and Notifications
Air Resources	*Clean Air Act*, as amended	42 USC 7401 et seq.	Environmental Protection Agency (EPA)	Requires sources to meet standards and obtain permits to satisfy: National Ambient Air Quality Standards, State Implementation Plans, Standards of Performance for New Stationary Sources, (NESHAP), and Prevention of Significant Deterioration (PSD).
	National Ambient Air Quality Standards (NAAQS/State Implementation Plans	42 USC 7409 et seq.	EPA	Requires compliance with primary and secondary ambient air quality standards governing SO_2, NO_x, CO, O_3, Pb, and PM_{10} and emission limits/reduction measures as designated in each state's State Implementation Plan.
	Standards of Performance for New Stationary Sources	42 USC 7411	EPA	Establishes control/emission standards and recordkeeping requirements for new or modified sources specifically addressed by a standard.
	National Emission Standards for Hazardous Air Pollutants (NESHAP)	42 USC 7412	EPA	Requires sources to comply with emission levels of carcinogenic or mutagenic pollutants; may require a preconstruction approval, depending on the process being considered and the level of emissions that will result from the new or modified source.
	Prevention of Significant Deterioration (PSD)	42 USC 7470 et seq.	EPA	Applies to areas that are in compliance with National Ambient Air Quality Standards (NAAQS). Requires comprehensive preconstruction review and the application of Best Available Control Technology to major stationary sources (emissions of 100 tons/year) and major modifications; requires a preconstruction review of air quality impacts and the issuance of a construction permit from the responsible State agency setting forth emission limitations to protect the PSD increment.
	Noise Control Act of 1972	42 USC 4901 et seq.	EPA	Requires facilities to maintain noise levels that do not jeopardize the health and safety of the public.
Water Resources	*Clean Water Act*	33 USC 1251 et seq.	EPA	Requires EPA or State-issued permits and compliance with provisions of permits regarding discharge of effluents to surface waters.
	National Pollutant Discharge Elimination System (NPDES) (Section 402 of *Clean Water Act*)	33 USC 1342	EPA	Requires permit to discharge effluents (pollutants) to surface waters and stormwaters; permit modifications are required if discharge effluents are altered.
	Dredged or Fill Material - (Section 404 of *Clean Water Act/Rivers and Harbors Appropriations Act* of 1899)	33 USC 1344 33 USC 401 et seq.	U.S. Army Corps of Engineers	Requires permits to authorize the discharge of dredged or fill material into navigable waters or wetlands and to authorize certain structures or work in or affecting navigable waters.

Table I.1–1. Federal Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Statute/Regulation/Order	Citation	Responsible Agency	EIS-Level Potential Applicability: Permits, Approvals, Consultations, and Notifications
Water Resources (continued)	*Wild and Scenic Rivers Act*	16 USC 1271 et seq.	Fish and Wildlife Service (USFWS), Bureau of Land Management, Forest Service, National Park Service	Consultation required before construction of any new Federal project associated with a river designated as wild and scenic or under study in order to minimize and mitigate any adverse effects on the physical and biological properties of the river.
	Safe Drinking Water Act	42 USC 300f et seq.	EPA	Requires permits for construction/operation of underground injection wells and subsequent discharging of effluents to ground aquifers.
	Executive Order 11988: Floodplain Management	3 CFR, 1977 Comp., p. 117	Water Resources Council, Federal Emergency Management Agency, Council on Environmental Quality (CEQ)	Requires consultation if project impacts a floodplain.
	Executive Order 11990: Protection of Wetlands	3 CFR, 1977 Comp., p. 121	U.S. Army Corps of Engineers/USFWS	Requires Federal agencies to avoid the long- and short-term adverse impacts associated with the destruction or modification of wetlands.
	Compliance with Floodplain/ Wetlands Environmental Review Requirements	10 CFR 1022	DOE	Requires DOE to comply with all applicable floodplain/wetlands environmental review requirements.
Hazardous Wastes and Soil Resources	*Resource Conservation and Recovery Act* (RCRA)/ Hazardous and Solid Waste Amendments of 1984	42 USC 6901 et seq./PL 98-616	EPA	Requires notification and permits for operations involving hazardous waste treatment, storage, or disposal facilities; changes to site hazardous waste operations could require amendments to RCRA hazardous waste permits involving public hearings.
	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)/*Superfund Amendments and Reauthorization Act* of 1986 (SARA)	42 USC 9601 et seq./PL 99-499	EPA	Requires cleanup and notification if there is a release or threatened release of a hazardous substance; requires DOE to enter into Interagency Agreements with EPA and state to control the cleanup of each DOE site on the National Priorities List (NPL).

Table I.1–1. Federal Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Statute/Regulation/Order	Citation	Responsible Agency	EIS-Level Potential Applicability: Permits, Approvals, Consultations, and Notifications
Hazardous Wastes and Soil Resources (continued)	*Community Environmental Response Facilitation Act*	PL 102-426	EPA	Amends CERCLA (40 CFR 300) to establish a process for identifying, prior to the termination of Federal activities, property that does not contain contamination. Requires prompt identification of parcels that will not require remediation to facilitate the transfer of such property for economic redevelopment purposes.
	Farmland Protection Policy Act of 1981	7 USC 4201 et seq.	Soil Conservation Service	DOE shall avoid any adverse effects to prime and unique farmlands.
	Federal Facility Compliance Act of 1992	42 USC 6961	States	Waives sovereign immunity for Federal facilities under RCRA and requires DOE to develop plans and enter into agreements with states as to specific management actions for specific mixed waste streams.
	Federal Land Policy and Management Act	43 USC 1701	Federal and State land planning agencies	Requires Federal and/or State land-planning agencies to retain Federal ownership of public lands unless it is determined that disposal of such parcel will serve the national interest.
Biotic Resources	*Fish and Wildlife Coordination Act*	16 USC 661 et seq.	USFWS	Requires consultation on the possible effects on wildlife if there is construction, modification, or control of bodies of water in excess of 10 acres in surface area.
	Bald and Golden Eagle Protection Act	16 USC 668 et seq.	USFWS	Consultations should be conducted to determine if any protected birds are found to inhabit the area. If so, DOE must obtain a permit prior to moving any nests due to construction or operation of tritium supply and recycling facilities.
	Migratory Bird Treaty Act	16 USC 703 et seq.	USFWS	Requires consultation to determine if there are any impacts on migrating bird populations due to construction or operation of tritium supply and recycling facilities. If so, DOE will develop mitigation measures to avoid adverse effects.
	Wilderness Act of 1964	16 USC 1131 et seq.	Department of Commerce (DOC) and Department of Interior (DOI)	DOE shall consult with DOC/DOI and minimize impact.
	Wild Free-Roaming Horses and Burros Act of 1971	16 USC 1331 et seq.	DOI	DOE shall consult with DOI and minimize impact.

Table I.1–1. Federal Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Statute/Regulation/Order	Citation	Responsible Agency	EIS-Level Potential Applicability: Permits, Approvals, Consultations, and Notifications
Biotic Resources (continued)	*Endangered Species Act* of 1973	16 USC 1531 et seq.	USFWS/National Marine Fisheries Service	Requires consultation to identify endangered or threatened species and their habitats, assess DOE impacts thereon, obtain necessary biological opinions and, if necessary, develop mitigation measures to reduce or eliminate adverse effects of construction or operation.
Cultural Resources	*National Historic Preservation Act* of 1966, as amended	16 USC 470 et seq.	President's Advisory Council on Historic Preservation	DOE shall consult with the State Historic Preservation Officer (SHPO) prior to construction to ensure that no historical properties will be affected.
	Archaeological and Historical Preservation Act of 1974	16 USC 469 et seq.	DOI	DOE shall obtain authorization for any disturbance of archaeological resources.
	Archaeological Resources Protection Act of 1979	16 USC 470aa et seq.	DOI	DOE shall obtain authorization for any excavation or removal of archaeological resources.
	American Indian Religious Freedom Act of 1978	42 USC 1996	DOI	DOE shall consult with local Native American tribes prior to construction to ensure that their religious customs, traditions, and freedoms are preserved.
	Native American Graves Protection and Repatriation Act of 1990	25 USC 3001	DOI	DOE shall consult with local Native American tribes prior to construction to guarantee that no Native American graves are disturbed.
	Executive Order 11593: Protection and Enhancement of the Cultural Environment	3 CFR 154, 1971-1975 Comp., p. 559	DOI	DOE shall aid in the preservation of historic and archaeological data that may otherwise be lost during construction activities.
Worker Safety and Health	*Occupational Safety and Health Act* (OSHA)	5 USC 5108	OSHA	Agencies shall comply with all applicable worker safety and health legislation (including guidelines of 29 CFR 1960) and prepare, or have available, Material Safety Data Sheets.
	OSHA Guidelines	29 USC 660	OSHA	Agencies shall comply with all applicable worker safety and health legislation (including guidelines of 29 CFR 1960) and prepare, or have available, Material Safety Data Sheets.
	Hazard Communication Standard	29 CFR 1910.1200	OSHA	DOE shall ensure that workers are informed of, and trained to handle, all chemical hazards in the DOE workplace.
Other	*Atomic Energy Act* of 1954	42 USC 2011	DOE	DOE shall follow its own standards and procedures to ensure the safe operation of its facilities.
	National Environmental Policy Act (NEPA)	42 USC 4321 et seq.	CEQ	DOE shall comply with NEPA implementing procedures in accordance with 10 CFR 1021.

Table I.1–1. Federal Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Statute/Regulation/Order	Citation	Responsible Agency	EIS-Level Potential Applicability: Permits, Approvals, Consultations, and Notifications
Other (continued)	*Toxic Substances Control Act* (TSCA)	15 USC 2601 et seq.	EPA	DOE shall comply with inventory reporting requirements and chemical control provisions of TSCA to protect the public from the risks of exposure to chemicals; TSCA imposes strict limitations on use and disposal of PCB-contaminated equipment.
	Hazardous Materials Transport Action Act	49 USC 1801 et seq.	Department of Transportation (DOT)	DOE shall comply with the requirements governing hazardous materials and waste transportation.
	Hazardous Materials Transportation Uniform Safety Act of 1990	49 USC 1801	DOT	Restricts shippers of highway route-controlled quantities of radioactive materials to use only permitted carriers.
	Emergency Planning and Community Right-To-Know Act of 1986	42 USC 11001 et seq.	EPA	Requires the development of emergency response plans and reporting requirements for chemical spills and other emergency release, and imposes right-to-know reporting requirements covering storage and use of chemicals which are reported in toxic chemical release forms.
	Executive Order 12088: Federal Compliance with Pollution Control Standards	3 CFR, 1978 Comp., p. 243	Office of Management and Budget	Requires Federal agency landlords to submit to OMB an annual plan for the control of environmental pollution and to consult with EPA and State agencies regarding the best techniques and methods.
	Executive Order 11514: Protection and Enhancement of Environmental Quality	3 CFR, 1966-1970 Comp., p. 902	CEQ	Requires Federal agencies to demonstrate leadership in achieving the environmental quality goals of NEPA; provides for DOE consultation with appropriate Federal, State, and local agencies in carrying out their activities as they affect the environment.
	Pollution Prevention Act of 1990	42 USC 11001-11050	EPA	Establishes a national policy that pollution should be reduced at the source and requires a toxic chemical source reduction and recycling report for an owner or operator of a facility required to file an annual toxic chemical release form under Section 313 of SARA.
	Executive Order 12114: Environmental Effects Abroad Major Federal Actions	January 4, 1979	Department of State CEQ	Enable responsible officials of Federal agencies having ultimate responsibility for authorizing and approving actions encompassed by this order to be informed of pertinent environmental considerations and to take such considerations into account, with other pertinent considerations of national policy, in making decisions regarding such actions.
	Executive Order 12843: Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances	April 21, 1993	EPA	Requires Federal agencies to minimize procurement of ozone depleting substances and conform their practices to comply with Title VI of *Clean Air Act* Amendments reference stratospheric ozone protection and to recognize the increasingly limited availability of Class I substances until final phaseout.

Table I.1–1. Federal Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Statute/Regulation/Order	Citation	Responsible Agency	EIS-Level Potential Applicability: Permits, Approvals, Consultations, and Notifications
Other (continued)	Executive Order 12856: Federal Compliance with Right-To-Know Laws and Pollution Prevention Requirements	August 3, 1993	EPA	Requires Federal agencies to achieve 50 percent reduction of agency's total releases of toxic chemicals to the environment and offsite transfers, to prepare a written facility pollution prevention plan not later than 1995, and to publicly report toxic chemicals entering any waste stream from Federal facilities, including any releases to the environment, and to improve local emergency planning, response, and accident notification.
	Executive Order 12873: Federal Acquisition, Recycling, and Waste Prevention	October 20, 1993	EPA	Requires Federal agencies to develop affirmative procurement policies and establishes a shared responsibility between the system program manager and the recycling community to effect use of recycled items for procurement.
	Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	February 11, 1994	EPA	Requires Federal agencies to identify and address as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.
	Nuclear Waste Policy Act of 1982	42 USC 10101 et seq.	EPA	DOE shall dispose of radioactive waste per standards of 40 CFR 191.
	Executive Order 10480: Further Providing For the Administration of the Defense Mobilization Program	August 1953	Federal Emergency Management Agency (FEMA)	Delegates to the Director, FEMA, with authority to redelegate, the priorities and allocation functions conferred on the President by Title I of the *Defense Production Act* of 1950, as amended.
	Executive Order 12148: Floodplain Management	July 20, 1979	FEMA	Transferred functions and responsibilities associated with Federal emergency management to the Director, FEMA. The order assigns the director, FEMA, the responsibility to establish Federal policies for and to coordinate all civil defense and civil emergency planning, management, mitigation, and assistance functions of Executive Agencies.
	Executive Order 12472: Assignment of National Security and Emergency Preparedness Telecommunications Functions	April 3, 1984	National Communication System (NCS)	Establishes the NCS. The NCS consists of the telecommunications assets of the entities represented on the NCS of Principals and an administrative structure consisting of the Executive Agent, the NCS Committee of Principals, and the Manager.

Table I.1–1. Federal Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Statute/Regulation/Order	Citation	Responsible Agency	EIS-Level Potential Applicability: Permits, Approvals, Consultations, and Notifications
Other (continued)	Executive Order 12656: Assignment of Emergency Preparedness Responsibilities	May 24, 1977	Var. Agencies	This order assigns emergency preparedness responsibilities to Federal departments and agencies.
	Executive Order 11988: Floodplain Management	3CFR, 1977 Comp., p. 117	Var. Agencies EPA	Directs Federal agencies to establish procedures to ensure that the potential effects of flood hoards and floodplain management are considered for any action undertaken in a floodplain and that floodplain impacts be avoided to the extent practicable.
	Executive Order 12580: Superfund Implementation	January 23, 1987	Var. Agencies	Delegates to the heads of executive departments and agencies the responsibility for undertaking remedial actions for releases, or threatened releases that are not on the National Priority List and removal actions other than emergencies where the release is from any facility under the jurisdiction or control of executive departments and agencies.

Table I.1–2. State Environmental Statutes, Regulations, and Orders

Resource Category	Legislation	Citation	Responsible Agency	Potential Applicability/Permits
Oak Ridge Reservation, and Nuclear Fuel Services, Tennessee				
Air Resources	Tennessee Air Pollution Control Regulations	TN Rules, Division of Air Pollution	TN Air Pollution Control Board	Permit required to construct, modify, or operate an air contaminant source; sets fugitive dust requirements.
Water Resources	*Tennessee Water Quality Control Act*	TN Code, Title 69, Chapter 3	TN Water Quality Control Board	Authority to issue new or modify existing NPDES permits required for a water discharge source.
Hazardous Wastes and Soil Resources	Tennessee Underground Storage Tank Program Regulations	TN Rules, Chapter 1200-1-15	TN Division of Underground Storage Tank Programs	Permit required prior to construction or modification of an underground storage tank.
	Tennessee Hazardous Waste Management Act	TN Code, Title 68, Chapter 46	TN Division of Solid Waste Management	Permit required to construct, modify, or operate a hazardous waste treatment, storage, or disposal facility.
	Tennessee Solid Waste Processing and Disposal Regulations	TN Rules, Chapter 1200-1-7	TN Division of Solid Waste Management	Permit required to construct or operate a solid waste processing or disposal facility.

Table I.1–2. State Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Legislation	Citation	Responsible Agency	Potential Applicability/Permits
Biotic Resources	Tennessee State Executive Order on Wetlands	TN State Executive Order	TN Division of Water Quality Control	Consultation with responsible agency.
	Tennessee Threatened Wildlife Species Conservation Act of 1974	TN Code, Title 70, Chapter 8	TN Wildlife Resources Agency	Consultation with responsible agency.
	Tennessee Rare Plant Protection and Conservation Act of 1985	TN Code, Title 70, Chapter 8-301 et seq.	TN Wildlife Resources Agency	Consultation with responsible agency.
	Tennessee Water Quality Control Act	TN Code, Title 69, Chapter 3	TN Division of Water Quality Control	Permit required prior to alteration of a wetland.
Cultural Resources	Tennessee Desecration of Venerated Objects	TN Code, Title 39, Chapter 17-311	TN Historical Commission	Forbids a person to offend or intentionally desecrate venerated objects including a place of worship or burial.
	Tennessee Abuse of Corpse	TN Code, Title 39, Chapter 17-312	TN Historical Commission	Forbids a person from disinterring a corpse that has been buried or otherwise interred.
	Native American Indian Cemetery Removal and Reburial	TN Comp. Rules and Regulations, Chapter 400-9-1	TN Historical Commission	Requires notification if Native American remains are uncovered.
	Tennessee Protective Easements	TN Code, Title 11, Chapter 15-101	TN State Government	Grants power to the state to restrict construction on land deemed as a "protective" easement.
Worker Safety and Health	No State-level legislation identified			
Savannah River Site, South Carolina				
Air Resources	*South Carolina Pollution Control Act*/ South Carolina Air Pollution Control Regulations and Standards	SC Code, Title 48, Chapter 1	SC Department of Health and Environmental Control (SCDHEC)	Permit required prior to construction or modification of an air contaminant source.
	Augusta-Aiken Air Quality Control Region	40 CFR 81.114	SC and GA	Requires Savannah River Site and surrounding communities in the 2-state region to attain NAAQS.
	South Carolina Atomic Energy and Radiation Control Act	SC Code, Title 13, Chapter 7	SCDHEC	Establishes standards for radioactive air emissions.

Table I.1–2. State Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Legislation	Citation	Responsible Agency	Potential Applicability/Permits
Water Resources	*South Carolina Pollution Control Act*	SC Code, Title 48, Chapter 1	SCDHEC	Permit required prior to construction or modification of a water discharge source.
	South Carolina Water Quality Standards	SC Code, Title 61, Chapter 68	SCDHEC	Permit required prior to construction or modification of a water discharge source.
	South Carolina Safe Drinking Water Act	SC Code, Title 44, Chapter 55	SCDHEC	Establishes drinking water standards.
Hazardous Wastes and Soil Resources	*South Carolina Underground Storage Tanks Act*	SC Code, Title 44, Chapter 2	SCDHEC	Permit required prior to construction or modification of an underground storage tank.
	South Carolina Solid Waste Regulations	SC Code, Title 61, Chapter 60	SCDHEC	Permit required to store, collect, dispose, or transport solid wastes.
	South Carolina Industrial Solid Waste Disposal Site Regulations	SC Code, Title 61, Chapter 66	SC Pollution Control Authority	Permit required for industrial solid waste disposal systems.
	South Carolina Hazardous Waste Management Act	SC Code, Title 44, Chapter 56	SCDHEC	Permit required to operate, construct, or modify a hazardous waste treatment, storage, or disposal facility.
	South Carolina Solid Waste Management Act	SC Code, Title 44, Chapter 96	SCDHEC	Establishes standards to treat, store, or dispose of solid waste.
Biotic Resources	*South Carolina Nongame and Endangered Species Conservation Act*	SC Code, Title 50, Chapter 15	SC Wildlife and Marine Resources Department	Consult with SC Wildlife and Marine Resources Department and minimize impact.
Cultural Resources	South Carolina Institute of Archaeology and Anthropology	SC Code, Title 60, Chapter 13-210	SC State Historic Preservation Office	Consult with SC State Historic Preservation Officer, and minimize impact.
Worker Safety and Health	No State-level legislation identified			
Babcock & Wilcox, Virginia				
Air Resources	Virginia Air Pollution Control Law	VA Code 10.1-1300 et. seq.	VA Department of Air Pollution Control	Permit required for any new source; operating permit required for any non-exempt source; and performance, monitoring, and reporting required for both new and existing sources.

Table I.1–2. State Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Legislation	Citation	Responsible Agency	Potential Applicability/Permits
	State Air Pollution Control Regulations	State Air Pollution Control Board Regulations (SAPCBR) 120	VA State Air Pollution Control Board	Permit required for any new source; operating permit required for any non-exempt source; and performance, monitoring, and reporting required for both new and existing sources.
Water Resources	State Water Control Law	VA Code 62.1	VA Department of Environmental Quality	Permits required for any discharges that fall under the VA NPDES program; VA Pollution Abatement program; Pretreatment program; and the VA Water Protection Program.
	Virginia Regulations	VA Code 680	VA Department of Environmental Quality	Permits required for any discharges that fall under the VA NPDES program; VA Pollution Abatement program; Pretreatment program; and the VA Water Protection Program.
Hazardous Wastes and Soil Resources	*Virginia Waste Management Act*	VA Code 10.1	VA Waste Management Board	Required to identify and properly store, transport, and dispose of hazardous wastes as identified by regulations.
	Virginia Waste Management Regulations	VR 672	VA Department of Waste Management	Required to identify and properly store, transport, and dispose of hazardous wastes as identified by regulations.
	Virginia Erosion and Sediment Act	VA Code 10.1-580-571	VA Department of Conservation and Recreation	Consultation with responsible agency.
Biotic Resources	*Virginia Endangered Species Act*	VA Code 29.1-563-570	VA Department of Game and Inland Fisheries	Adoption of Federal list of threatened and endangered species. Consultation with responsible agency.
	Virginia Endangered Plant and Insect Species Act	VA Code 3.1-1020-1030	VA Department of Agriculture and Consumer Services	Requires contact with endangered species coordinator.
	Virginia Environmental Quality Act	VA Code 10.1-1200-1221	VA Department of Environmental Quality	Consultation with responsible agency.
Worker Safety and Health	State plan state; administers OSHA regulations	NA	VA Department of Labor and Industry	

Table I.1–2. State Environmental Statutes, Regulations, and Orders—Continued

Resource Category	Legislation	Citation	Responsible Agency	Potential Applicability/Permits
Cultural Resources	*Virginia Antiquities Act*	Section 2305	VA Department of Historic Resources	Makes it a felony to remove human remains from a grave without a court order or appropriate permit.
	Cave Protections Act		VA Department of Conservation and Recreation, Natural Heritage Division	Protects all geological, biological, and historical features in caves from vandalism.
North Carolina				
Other Transportation	Complies with Federal laws		VA Division of Solid Waste Management	
Ohio				
Other Transportation	Transportation of Hazardous Waste	Ohio Administrative Code	EPA	Required to properly manage hazardous waste transportation through use of registered haulers, manifests, and recordkeeping.
Kentucky				
Other Transportation	Transportation of Hazardous Waste	401 KAR; Chapter 33	Department of Environmental Protection Division of Waste Management	Required to properly manage hazardous waste transportation through use of registered haulers, manifests, and recordkeeping.

Table I.1–3. Selected Department of Energy Environment, Safety, and Health Orders

DOE Order	Order Title
1300.2A	Department of Energy Technical Standards Program
1360.2B	Unclassified Computer Security Program
3790.1B	Federal Employee Occupational Safety and Health Program
4330.4B	Maintenance Management Program
4700.1	Project Management System
5400.1	General Environmental Protection Program
5480.19	Conduct of Operations Requirements for DOE Facilities
5480.20A	Personnel Selection, Qualification, and Training, Requirements for DOE Nuclear Facilities
5480.21	Unreviewed Safety Questions
5480.22	Technical Safety Requirements
5480.23	Nuclear Safety Analysis Reports
5482.1B	Environment, Safety, and Health Appraisal Program
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements
5530.1A	Accident Response Group
5530.3	Radiological Assistance Program
5530.4	Aerial Measuring System
5530.5	Federal Radiological Monitoring and Assessment Center
5630.12A	Safeguards and Security Inspection and Assessment Program
5632.1C	Protection and Control of Safeguards and Security Interests
5700.6C	Quality Assurance
5820.2A	Radioactive Waste Management
O 151.1	Comprehensive Emergency Management System [Text deleted.]
O 225.1	Accident Investigations
O 231.1	Environment, Safety, and Health Reporting
O 232.1	Occurrence Reporting and Processing of Operations Information
O 420.1	Facility Safety
O 425.1	Startup and Restart of Nuclear Facilities
O 440.1	Worker Protection Management for DOE Federal and Contractor Employees [Text deleted.]
O 451.1	National Environmental Policy Act Compliance Program
O 460.1	Packaging and Transportation Safety
O 460.2	Departmental Materials Transportation and Packaging Management
O 470.1	Safeguards and Security Program

Appendix J
United States Enrichment Corporation Privatization Act

[provisions pertaining to transfers and sales of Russian and Department of Energy uranium]

H.R. 3019, BALANCED BUDGET DOWN PAYMENT ACT (Public Law 104-134, signed April 26, 1996)

TITLE III—RESCISSIONS AND OFFSETS

CHAPTER 1—ENERGY AND WATER DEVELOPMENT

Subchapter A—United States Enrichment Corporation Privatization

SEC. 3101. SHORT TITLE.

This subchapter may be cited as the *USEC Privatization Act.*

SEC. 3112. URANIUM TRANSFERS AND SALES.

(a) Transfers and Sales by the Secretary: The Secretary shall not provide enrichment services or transfer or sell any uranium (including natural uranium concentrates, natural uranium hexafluoride, or enriched uranium in any form) to any person except as consistent with this section.

(b) Russian HEU:

(1) On or before December 31, 1996, the United States Executive Agent under the Russian HEU Agreement shall transfer to the Secretary without charge title to an amount of uranium hexafluoride equivalent to the natural uranium component of low-enriched uranium derived from at least 18 metric tons of highly enriched uranium purchased from the Russian Executive Agent under the Russian HEU Agreement. The quantity of such uranium hexafluoride delivered to the Secretary shall be based on a tails assay of 0.30 [percent] U-235. Uranium hexafluoride transferred to the Secretary pursuant to this paragraph shall be deemed under United States law for all purposes to be of Russian origin.

(2) Within 7 years of the date of enactment of this Act, the Secretary shall sell, and receive payment for, the uranium hexafluoride transferred to the Secretary pursuant to paragraph (1). Such uranium hexafluoride shall be sold—

(A) at any time for use in the United States for the purpose of overfeeding;

(B) at any time for end use outside the United States;

(C) in 1995 and 1996 to the Russian Executive Agent at the purchase price for use in matched sales pursuant to the Suspension Agreement; or,

(D) in calendar year 2001 for consumption by end users in the United States not prior to January 1, 2002, in volumes not to exceed 3,000,000 pounds U_3O_8 equivalent per year.

(3) With respect to all enriched uranium delivered to the United States Executive Agent under the Russian HEU Agreement on or after January 1, 1997, the United States Executive Agent shall, upon request of the Russian Executive Agent, enter into an agreement to deliver concurrently to the Russian Executive Agent an amount of uranium hexafluoride equivalent to the natural uranium component of such uranium. An agreement executed pursuant to a request of the Russian Executive Agent, as contemplated in this paragraph, may pertain to any deliveries due during any period remaining under the Russian HEU Agreement. The quantity of such uranium hexafluoride delivered to the Russian Executive Agent shall be based on a tails assay of 0.30 U-235.

Title to uranium hexafluoride delivered to the Russian Executive Agent pursuant to this paragraph shall transfer to the Russian Executive Agent upon delivery of such material to the Russian Executive Agent, with such delivery to take place at a North American facility designated by the Russian Executive Agent. Uranium hexafluoride delivered to the Russian Executive Agent pursuant to this paragraph shall be deemed under U.S. law for all purposes to be of Russian origin. Such uranium hexafluoride may be sold to any person or entity for delivery and use in the United States only as permitted in subsections (b)(5), (b)(6) and (b)(7) of this section.

(4) In the event that the Russian Executive Agent does not exercise its right to enter into an agreement to take delivery of the natural uranium component of any low-enriched uranium, as contemplated in paragraph (3), within 90 days of the date such low-enriched uranium is delivered to the United States Executive Agent, or upon request of the Russian Executive Agent, then the United States Executive Agent shall engage an independent entity through a competitive selection process to auction an amount of uranium hexafluoride or U_3O_8 (in the event that the conversion component of such hexafluoride has previously been sold) equivalent to the natural uranium component of such low-enriched uranium. An agreement executed pursuant to a request of the Russian Executive Agent, as contemplated in this paragraph, may pertain to any deliveries due during any period remaining under the Russian HEU Agreement. Such independent entity shall sell such uranium hexafluoride in one or more lots to any person or entity to maximize the proceeds from such sales, for disposition consistent with the limitations set forth in this subsection. The independent entity shall pay to the Russian Executive Agent the proceeds of any such auction less all reasonable transaction and other administrative costs. The quantity of such uranium hexafluoride auctioned shall be based on a tails assay of 0.30 U-235. Title to uranium hexafluoride auctioned pursuant to this paragraph shall transfer to the buyer of such material upon delivery of such material to the buyer. Uranium hexafluoride auctioned pursuant to this paragraph shall be deemed under United States law for all purposes to be of Russian origin.

(5) Except as provided in paragraphs (6) and (7), uranium hexafluoride delivered to the Russian Executive Agent under paragraph (3) or auctioned pursuant to paragraph (4), may not be delivered for consumption by end users in the United States either directly or indirectly prior to January 1, 1998, and thereafter only in accordance with the following schedule:

Annual Maximum Deliveries to End Users

Year	(millions of lb U_3O_8 equivalent)
1998	2
1999	4
2000	6
2001	8
2002	10
2003	12
2004	14
2005	16
2006	17
2007	18
2008	19
2009 and each year thereafter	20

(6) Uranium hexafluoride delivered to the Russian Executive Agent under paragraph (3) or auctioned pursuant to paragraph (4) may be sold at any time as Russian-origin natural uranium in a matched sale pursuant to the Suspension Agreement, and in such case shall not be counted against the annual maximum deliveries set forth in paragraph (5).

(7) Uranium hexafluoride delivered to the Russian Executive Agent under paragraph (3) or auctioned pursuant to paragraph (4) may be sold at any time for use in the United States for the purpose of overfeeding in the operations of enrichment facilities.

(8) Nothing in this subsection (b) shall restrict the sale of the conversion component of such uranium hexafluoride.

(9) The Secretary of Commerce shall have responsibility for the administration and enforcement of the limitations set forth in this subsection. The Secretary of Commerce may require any person to

provide any certifications, information, or take any action that may be necessary to enforce these limitations. The United States Customs Service shall maintain and provide any information required by the Secretary of Commerce and shall take any action requested by the Secretary of Commerce which is necessary for the administration and enforcement of the uranium delivery limitations set forth in this section.

(10) The President shall monitor the actions of the United States Executive Agent under the Russian HEU Agreement and shall report to the Congress not later than December 31 of each year on the effect the low-enriched uranium delivered under the Russian HEU Agreement is having on the domestic uranium mining, conversion, and enrichment industries, and the operation of the gaseous diffusion plants. Such report shall include a description of actions taken or proposed to be taken by the President to prevent or mitigate any material adverse impact on such industries or any loss of employment at the gaseous diffusion plants as a result of the Russian HEU Agreement.

(c) Transfers to the Corporation:

(1) The Secretary shall transfer to the Corporation without charge up to 50 metric tons of enriched uranium and up to 7,000 metric tons of natural uranium from the Department of Energy's stockpile, subject to the restrictions in subsection (c)(2).

(2) The Corporation shall not deliver for commercial end use in the United States—

(A) any of the uranium transferred under this subsection before January 1, 1998;

(B) more than 10 percent of the uranium (by uranium hexafluoride equivalent content) transferred under this subsection or more than 4,000,000 pounds, whichever is less, in any calendar year after 1997; or

(C) more than 800,000 separative work units contained in low-enriched uranium transferred under this subsection in any calendar year.

(d) Inventory Sales:

(1) In addition to the transfers authorized under subsections (c) and (e), the Secretary may, from time to time, sell natural and low-enriched uranium (including low-enriched uranium derived from highly enriched uranium) from the Department of Energy's stockpile.

(2) Except as provided in subsections (b), (c), and (e), no sale or transfer of natural or low-enriched uranium shall be made unless—

(A) the President determines that the material is not necessary for national security needs,

(B) the Secretary determines that the sale of the material will not have an adverse material impact on the domestic uranium mining, conversion, or enrichment industry, taking into account the sales of uranium under the Russian HEU Agreement and the Suspension Agreement, and

(C) the price paid to the Secretary will not be less than the fair market value of the material.

(e) Government Transfers: Notwithstanding subsection (d)(2), the Secretary may transfer or sell enriched uranium—

(1) to a Federal agency if the material is transferred for the use of the receiving agency without any resale or transfer to another entity and the material does not meet commercial specifications;

(2) to any person for national security purposes, as determined by the Secretary; or

(3) to any State or local agency or nonprofit, charitable, or educational institution for use other than the generation of electricity for commercial use.

(f) Savings Provision: Nothing in this subchapter shall be read to modify the terms of the Russian HEU Agreement.

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