5.11 Human Health and Safety Impacts

Potential health impacts to workers and the public are presented in this section. The methods used to estimate health impacts from radiological and chemical sources are described in Volume II, Appendix F. The health impacts included in this section are those related to

- airborne release of radionuclides and chemicals from routine and accident conditions (excluding transportation)
- waterborne releases (via groundwater) over the long term
- construction activities
- operations
- fugitive releases of criteria pollutants
- inadvertent intrusion into disposal facilities.

Potential health effects included in this section are for the following populations of individuals:

- construction workers – workers involved with construction activities
- involved workers – workers directly involved in the activity being discussed
- non-involved workers – workers physically near the activity being discussed, but not directly involved in the activity
- maximally exposed individual (MEI) from atmospheric release – hypothetical member of the public who receives, through airborne emissions, the highest health impacts from onsite activities
- maximally exposed individual from waterborne releases – hypothetical member of the public who receives, through waterborne emissions, the highest health impacts from onsite activities
- local populations – the populations within 50 miles (80 km) of the center of the Hanford Site that are exposed to airborne releases
- downstream populations – the entire populations of Pasco, Kennewick, and Richland (Tri-Cities), Washington, and downstream populations represented by Portland, Oregon
- maximally exposed individual from inadvertent intrusion into disposal facilities – hypothetical individual receiving the highest impacts following inadvertent intrusion into the disposal facilities.

Impacts from construction activities include injuries to workers and impacts on air quality. Details of the air quality impact analysis for construction are presented in Section 5.2. The analysis of impacts on water quality (from waterborne releases to groundwater) is described in Section 5.3. Those sections compare air and water concentrations to appropriate limits. Results from those analyses have been extended to the estimates of human health impacts that are presented in this section. The analysis of impacts from potential releases and exposures to radionuclides and chemicals as a result of transportation of wastes is described in Section 5.8.

Health impacts are presented by alternative group and are based on conservative assumptions used in this EIS. The methods, assumptions, and related information for routine release assessment and accident analysis are provided in Volume II, Appendix F.

Construction worker injuries are estimated using standard construction worker accident rate information (described in Section 4.10) and the construction workforce projections for each facility that involve construction for a given alternative. The analysis includes all of the operations involving construction for each alternative. Consideration is also given to the type of construction activity (that is, heavy equipment operation versus building construction). Worker injuries during normal operations are evaluated using incident rates for industrial accidents.

Radiation doses as a total effective dose equivalent (TEDE) for workers involved in waste management activities were estimated using historical worker dose rates for Hanford facilities and the projection of the workforce involved (FH 2004).

Releases of radionuclides and chemicals to the atmosphere are evaluated for each solid waste facility based on the projected waste throughput volumes. Estimates of the annual release of pollutants to the atmosphere are made based on these processing volumes, the concentration of radionuclides and chemicals, and the release fractions for each facility. These release rates are used to estimate air concentrations at points of maximum exposure for the onsite worker and the offsite MEI. Individuals are assumed to be exposed to these transported pollutants through exposure pathways defined for each of two hypothetical exposure scenarios: industrial and resident gardener. The industrial scenario is used to evaluate the maximum health impacts for onsite, non-involved workers who are assumed to be located 100 m (329 ft) from the release point. This distance represents a reasonably close point for a permanent work location (for example, a nearby building) for an individual not associated with the facility from which the releases occur. The 100-m (329-ft) distance also allows for elevated release plumes to reach near the ground providing the potential for exposure for the individual (at shorter distances from the source the plume might miss the individual entirely). The resident gardener scenario is used to evaluate potential public exposures. For airborne releases, the resident gardener is an offsite individual located 20.6 km (13 mi) east-southeast of the 200 Areas, which is approximately across the Columbia River from the 300 Area. This location was chosen because it corresponds to the location of the MEI for recent sitewide releases of airborne effluents (see Figure 5.33). Consequences from accidental releases are based primarily on previously reported accident assessments for the facilities involved in the alternatives.

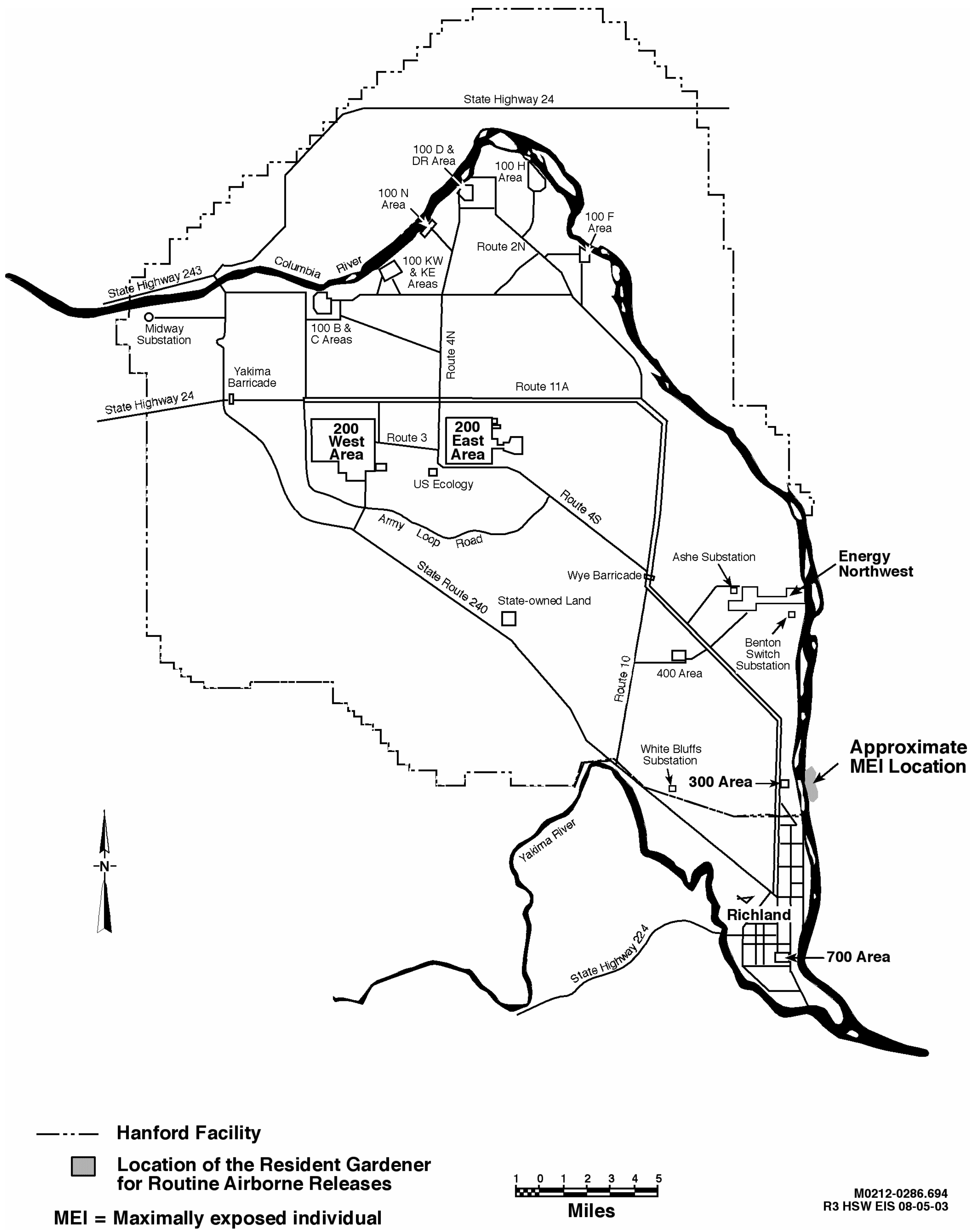

Figure 5.33. Location of the Resident Gardener for Routine Airborne Releases

Consequences of operating advanced processing lines (APLs) would be similar to those from processing TRU waste at WRAP, although timing of the consequences may vary from assumptions based on operating WRAP as the sole facility for processing TRU waste. If both WRAP and the APLs were to operate simultaneously, the annual impacts from atmospheric emissions could be somewhat greater than those estimated for WRAP alone, but they would persist for a shorter period of time. The total collective doses from operating one or more facilities to process TRU waste would be extremely small.

Releases of radionuclides and chemicals to the unsaturated soil beneath the Hanford solid waste disposal facilities in the 200 Areas would occur as the waste packages degrade and water seeps through the waste. The movement of pollutants from these releases to the affected environment has been analyzed and described in Section 5.3. Hypothetical future users of the groundwater downgradient from the waste disposal facilities on the Hanford Site might be exposed to contaminants in the water. Potential human health impacts from use of such groundwater were estimated for four locations, three located 1 km downgradient from the HSW disposal facilities and one near the Columbia River,[a] representative points of access by a hypothetical resident gardener after 2146 (in the absence of active institutional controls), and the location where the peak water concentrations are predicted. These locations (sites of hypothetical wells for evaluating groundwater use scenarios) correspond to points of analysis used for groundwater analyses as addressed in Section 5.3 and detailed in Volume II, Appendix G. A specific location is not defined because the location of the peak water concentration changes over time. For these locations, the resident gardener is assumed to live at the location and use the well as the source of all domestic and irrigation water. Details of these exposure scenarios are presented in Volume II, Appendix F, Section F.1.4.

The impacts to populations downstream from Hanford also were evaluated for the Tri-Cities region in Washington and for Portland, Oregon. The entire population of both areas was assumed to use the Columbia River as the sole source of drinking water (presently not the case for Portland nor the Tri-Cities). The population used for the Tri-Cities was 125,407 (MRSC 2001); for Portland, 538,180 (PSU 2002). The concentration in the river (used in the calculations) was based on the total amount of radionuclides reaching the river over the next 10,000 years, as evaluated for the water quality analysis in Section 5.3. To obtain the average concentrations of radionuclides in river water, the release to the river was diluted by the average Columbia River flow rate of about 3300 m^3/sec for the Tri-Cities and about 5300 m^3/sec for Portland.

(a) Although water might be drawn directly from the river for irrigation, it was assumed that well water would be used for domestic purposes.

(b) The National Council on Radiation Protection and Measurements continues to hold that a dose of 1 mrem/yr is a dose "'below which efforts to reduce the radiation exposure to the individual are unwarranted' (Section 17 of NCRP 1993)" (NCRP 2000). Regardless, in this HSW EIS, doses are reported as calculated, however small they may be. Thus doses will be seen that are several to many orders of magnitude below 1 mrem/yr, and while these may be useful for comparative purposes, they should not be construed as having any physical meaning in terms of detriment to health.

(c) For an individual, the probability of an LCF cannot exceed one (certainty). Similarly, the number of LCFs among population groups occurs as whole numbers; the calculated value is given in parentheses. This calculated value represents an inferred incremental contribution to total cancer deaths in the exposed population.

Results of the consequence analyses are presented as annual radiation dose[(b)] and lifetime radiation dose for individual exposures, as well as collective radiation dose for population exposures. The associated human health impacts are represented as the lifetime risk of a latent cancer fatality (LCF)[(c)] based on Federal Guidance Report No. 13 (Eckerman et al 1999). Consistent with that guidance, a health effects coefficient of 0.0006 LCFs per person-rem TEDE was used to estimate the consequences of radiation exposure to both workers and members of the public. This coefficient is intended to apply to low radiation doses at low dose rates, which are typical of those received from most types of environmental exposures.

For some hypothetical radiological accidents discussed in the HSW EIS, the estimated dose to an onsite or offsite individual may be greater than the dose to which the health effects coefficient specified by Eckerman et al (1999) was intended to apply. Depending on the radionuclides involved and the exposure pathways considered, the LCF risk may be up to twice that indicated by the LCF conversion factors for doses greater than 20 rem but less than a few hundred rem. For doses greater than a few hundred rem, there is a potential for short-term health effects other than cancer and hereditary effects, again, depending on the radionuclides and exposure pathways associated with a particular accident scenario. Additional information on the basis for radiological health consequences is given in Volume II, Appendix F. For further discussion of related uncertainties see Section 3.5.

The routine operations health impacts from carcinogenic chemicals are presented as the lifetime risk of cancer incidence from exposure in the given scenario. For non-carcinogenic chemicals, the impacts are expressed as a hazard quotient. Both types of impacts are presented as the sum over all chemicals in the release of the given type. A hazard quotient of one represents an exposure level that is considered safe for most members of the population (EPA 1991). A value greater than one may represent an exposure that is detrimental to public health.

The health impacts to workers from chemicals due to accidents are evaluated by comparing chemical air concentrations with the emergency response planning guideline (ERPG) or the temporary emergency exposure limit (TEEL). These are described in Volume II, Appendix F. Although ERPGs are the official, preferred measure, ERPGs have not been established for many chemicals. Where ERPGs were not available, the TEELs were used.

The following sections present details of the human health impacts analyses for the six alternative groups considered in this HSW EIS. For a summary comparison of impacts among the alternatives, see Table 3.6 in Section 3.6. The impacts from the operational phase are presented for all alternative groups in Section 5.11.1, followed by the long-term health impacts resulting from contaminant transport through the groundwater (Section 5.11.2).

5.11.1 Operational Human Health and Safety Impacts

The impacts from the operational phase are presented by alternative group in the following sections.

5.11.1.1 Alternative Group A

The following sections present the potential human health impacts for Alternative Group A for the Hanford Only, Lower Bound, and Upper Bound waste volumes.

5.11.1.1.1 Construction

Primary impacts from construction activities would be air quality and injuries to construction workers. The construction activities would result in the emission of criteria pollutants (40 CFR 50) from the use of combustion engines and earthmoving activities. Impacts are measured by comparison of air concentrations with regulatory limits at the point of maximum potential public exposure. The air quality analysis (Section 5.2) indicates that maximum emissions of all criteria pollutants (including sulfur dioxide, carbon monoxide, nitrogen dioxide, and particulate material [PM_{10}]) from construction activities would result in air concentrations below the regulatory limits. As a consequence, no impacts on public health from emissions would be expected. Impacts from industrial accidents during construction are discussed in Section 5.11.1.1.3.

5.11.1.1.2 Normal Operations

Potential impacts to public health from normal operations include impacts from atmospheric releases of radionuclides and chemicals from solid waste management operations. Radiation doses for workers involved with waste management operations are also evaluated.

Alternative Group A involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere. These operations include waste package verification, treatment, and packaging at the Waste Receiving and Processing Facility (WRAP), treatment and packaging of waste at the modified T Plant Complex; and treatment of leachate from mixed low-level waste (MLLW) trenches using pulse driers. The annual releases have been estimated for each year of operation for the facilities involved in this alternative. Details of the release calculations are presented in Volume II, Appendix F, Section F.1.

5.11.1.1.2.1 Health Impacts from Routine Radionuclide Releases

Tables 5.34, 5.35, and 5.36 display the calculated doses and health impacts to non-involved workers and the public from routine atmospheric releases of radionuclides for the Hanford Only, Lower Bound, and Upper Bound waste volumes, respectively. The tables present the maximum annual dose to the non-involved workers and the public, the collective dose to the public, and the associated risk of LCF for these exposures occurring during the period covered by Alternative Group A. Given that the cancer risk estimates and doses are small in comparison to regulatory limits,[a] no adverse health impacts would be expected from radionuclide releases.

(a) The maximum annual radiation dose presented in this section may be compared to the regulatory limit of 10 mrem/year (WAC 246-247; 40 CFR 61; DOE 1993).

5.11.1.1.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur from the same waste processes involving radionuclide release when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere are presented in Table 5.37 for all waste volumes. The results for the Hanford Only waste volume are the same as those for the Lower Bound waste volume because the processing volumes for mixed waste streams are nearly identical for both cases (only mixed wastes contain chemicals that may be released to the atmosphere). Because the peak hazard quotients are all less than 1, and because the cancer risk estimates are small, minimal adverse health impacts would be expected from chemical releases. Chemical releases from leachate treatment using a pulse drier are believed to be small compared with other processing (for example, WRAP) and are not included in the analysis of chemical health impacts.

Table 5.34. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group A, Hanford Only Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of an LCF[(c)]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.2E-03	7E-10	2004	1.3E-05
		Modified T Plant Complex	4.8E-01	3E-07	2003	3.9E-02
		Leachate Treatment[(d,e)]	4.3E-07	3E-13	2026	3.2E-09
MEI Offsite	Resident Gardener	WRAP	9.9E-05	6E-11	2004	1.1E-05
		Modified T Plant Complex	1.5E-03	9E-10	2003	1.1E-04
		Leachate Treatment	3.0E-11	2E-17	2026	1.6E-12
		Total	1.6E-03	1E-09	2003	1.2E-04
			(person-rem)	**Number of LCFs[(f)]**	**Year**	**(person-rem)**
Population[(g)]	Population within 80 km (50 mi)	WRAP	9.1E-03	0 (5E-06)	2004	7.4E-04
		Modified T Plant Complex	1.4E-01	0 (8E-05)	2003	7.4E-03
		Leachate Treatment	2.1E-09	0 (1E-12)	2026	1.1E-10
		Total	1.5E-01	0 (9E-05)	2003	8.1E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

5.11.1.1.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the alternative (FH 2004). The exposure to involved workers is summarized in Table 5.38 for the Hanford Only waste volume, in Table 5.39 for the Lower Bound waste volume, and in Table 5.40 for the Upper Bound waste volume. The worker category "Other" includes engineers, maintenance and construction personnel, and general support staff (for example, administrative and clerical workers). All estimated radiation doses to workers are well below regulatory limits.[a]

Table 5.35. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group A, Lower Bound Waste Volume

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose[b] (mrem)	Probability of an LCF[c]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-03	9E-10	2004	1.6E-04
		Modified T Plant Complex	5.8E-01	3E-07	2003	4.8E-02
		Leachate Treatment[d, e]	1.3E-07	8E-14	2026	7.4E-09
MEI Offsite	Resident Gardener	WRAP	1.2E-04	7E-11	2004	1.3E-05
		Modified T Plant Complex	1.7E-03	1E-09	2003	1.2E-04
		Leachate Treatment	6.8E-11	4E-17	2026	3.6E-12
		Total	1.8E-03	1E-09	2003	1.3E-04
			(person-rem)	**Number of LCFs[f]**	**Year**	**(person-rem)**
Population[g]	Population within 80 km (50 mi)	WRAP	1.1E-02	0 (6E-06)	2004	8.8E-04
		Modified T Plant Complex	1.6E-01	0 (9E-05)	2003	8.5E-03
		Leachate Treatment	6.2E-09	0 (4E-12)	2026	2.5E-10
		Total	1.7E-01	0 (1E-04)	2003	9.4E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

(a) The annual limit for occupational exposures is 5000 mrem/year (10 CFR 835).

Table 5.36. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group A, Upper Bound Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of an LCF[(c)]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	2.2E-03	1E-09	2004	1.9E-04
		Modified T Plant Complex	8.9E-01	5E-07	2006	7.2E-02
		Leachate Treatment[(d, e)]	1.9E-07	1E-13	2026	1.1E-08
MEI Offsite	Resident Gardener	WRAP	2.1E-04	1E-10	2004	1.6E-05
		Modified T Plant Complex	2.3E-03	1E-09	2006	1.7E-04
		Leachate Treatment	8.4E-11	5E-17	2026	4.5E-12
		Total	2.5E-03	1E-09	2006	1.9E-04
			(person-rem)	**Number of LCFs[(f)]**	**Year**	**(person-rem)**
Population[(g)]	Population within 80 km (50 mi)	WRAP	1.9E-02	0 (1E-05)	2004	1.1E-03
		Modified T Plant Complex	2.2E-01	0 (1E-04)	2006	1.5E-02
		Leachate Treatment	7.6E-09	0 (5E-12)	2026	3.1E-10
		Total	2.4E-01	0 (1E-04)	2006	1.6E-02

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

Table 5.37. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Chemicals – Alternative Group A, All Waste Volumes

Volume	Exposed Group	Exposure Scenario[a]	Facility	Risk of Cancer Incidence[b]	Peak Annual Hazard Quotient[c]
Hanford Only and Lower Bound	Worker Onsite (non-involved)	Industrial	WRAP	1.2E-09	8.9E-05
			Modified T Plant Complex	3.2E-08	2.3E-03
			Total	NA	NA
	MEI Offsite	Resident Gardener	WRAP	5.6E-11	3.4E-06
			Modified T Plant Complex	6.1E-11	7.2E-06
			Total	1.2E-10	1.1E-05
	Population	Population within 80 km (50 mi)	WRAP	0 (5E-06)[d]	NA[e, f]
			Modified T Plant Complex	0 (6E-06)[d]	NA
			Total	0 (1E-05)[d]	NA
Upper Bound	Worker Onsite (non-involved)	Industrial	WRAP	5.3E-09	6.9E-04
			Modified T Plant Complex	1.8E-07	2.4E-03
			Total	NA	NA
	MEI Offsite	Resident Gardener	WRAP	2.3E-10	2.5E-05
			Modified T Plant Complex	2.0E-10	2.5E-05
			Total	4.2E-10	5.0E-05
	Population	Population within 80 km (50 mi)	WRAP	0 (2E-05)[d]	NA[e,f]
			Modified T Plant Complex	0 (2E-05)[d]	NA
			Total	0 (4E-05)[d]	NA

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The individual risk of cancer incidence is evaluated for the exposure duration defined for the given exposure scenario starting in the year that provides the highest total impact.
(c) Hazard quotients are reported for the year of highest exposure.
(d) Population risk from cancer is expressed as the inferred number of fatal and non-fatal cancers in the exposed population over the lifetime of the population from intakes during the remediation period. The actual value must be a whole number (cancers).
(e) Hazard quotients are designed as a measure of impacts on an individual and are not meaningful for population exposures.
(f) NA = not applicable.

Table 5.38. Occupational Radiation Exposure – Alternative Group A, Hanford Only Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	8	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[(d)]	0.4	54	1.1	0 (7E-04)
Total					765	0 (5.0E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.39. Occupational Radiation Exposure – Alternative Group A, Lower Bound Waste Volume

Facility	Operating Period	Worker Category[a]	Workers (FTE)[b]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[c]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[e]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[f]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	8	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[d]	0.8	54	2.2	0 (9E-04)
Total					766	0 (5.0E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.40. Occupational Radiation Exposure – Alternative Group A, Upper Bound Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (Person-rem)	Workforce LCF[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	32	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.5	0 (3E-03)
		RCT	18	13	7.4	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	20	34	12	0 (7E-03)
		RCT	13	35	8.2	0 (5E-03)
	2020–2026	Operator	7	34	1.7	0 (1E-03)
		RCT	5	35	1.2	0 (7E-04)
	2027–2044	Operator	3	34	1.8	0 (1E-03)
		RCT	2	35	1.3	0 (8E-04)
Pulse Driers	2026–2077	Operator [(d)]	1.2	54	3.3	0 (2E-03)
Total					774	0 (5.0E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

5.11.1.1.3 Accidents

The impacts of accidents involving radiological and chemical contaminants and industrial accidents are evaluated in this section. The impacts of these accidents are expected to bound impacts of events that could be initiated by malevolent intent. Waste management operations would involve a continuing potential for industrial accidents and accidental release of contaminants in four Hanford facilities: the Central Waste Complex (CWC) for waste storage, the WRAP for waste treatment, the T Plant Complex (or similar new waste processing facility) for waste treatment, and the HSW disposal facilities for waste disposal. Accident information for each of these facilities is presented in the sections that follow. Additional information on radiological and chemical accidents is provided in Volume II, Appendix F, Section F.2 (including adjustment methods used to derive radiological consequence data).

Non-radiological consequences were evaluated by comparing estimated air concentrations with the TEEL or ERPG for a given chemical. Additional information, including definitions of ERPG/TEEL levels, is presented in Volume II, Appendix F.

Human health and safety impacts to workers actually involved in accidents (involved workers) are addressed in the general sense and not for each particular facility or potential accident for any of the alternative groups because the potential consequences would be highly variable, ranging from no effect to a fatality for one or more workers. The most likely consequence for any involved worker would be no or small impact. Workers involved in an accident could receive physical injuries or be killed during an accident, receive a range of radiation doses (none likely to be fatal), or be exposed to a range of hazardous chemical concentrations that could be high but of relatively short duration and, again, thought unlikely to be fatal. The reason for an optimistic outlook on radiation dose or chemical exposure for the involved worker under accident conditions is that in situations where there is a potential for radioactive or chemical risks, additional precautions are taken and workers are typically accompanied by a health physics technician.

The greatest likelihood of worker fatalities would be from physical trauma received during an accident. For example, the drum explosion and ion exchange module explosion accidents could result in involved worker fatalities if the workers were in the explosion blast zone. Most accidents would involve only one or two workers; the exception would be low probability, beyond-design-basis seismic events where a number of involved workers could be affected. Depending on the type of facility, worker location, and time of accident, zero to perhaps a dozen worker fatalities could result. Burial ground workers would probably be the least affected by extensive seismic structural damage for the types of facilities considered. Similarly, CWC workers would be more likely to avoid obstacles and debris and exit the facilities since there are no massive storage structures in this area. Workers in other waste management facilities could be more affected by falling debris as a result of extensive seismic damage.

Anticipated health impacts to all workers from industrial accidents during construction and operations would be 620 to 640 total recordable cases, 260 lost workday cases, and 8900 to 9200 lost workdays. A total of about 20,600 to 21,200 worker-years would be required to complete all activities over the operational period. Of that total, about 2800 to 3400 worker-years are for site support and waste generator services that do not appear in the direct facility worker and impact estimates in the following sections. About 97 to 99 percent of these health impacts are from operations.

5.11.1.1.3.1 Storage – CWC

No new storage would be needed at the CWC under Alternative Group A; therefore, no new construction would be required. Operations would continue at existing levels during the near-term, possibly increasing then declining as completion of waste processing is approached.

Radiological consequences. Six accident scenarios involving radioactive material at the CWC were evaluated as part of the Interim Safety Basis (Vail 2001a). These accidents were a handling/forklift-caused drum failure, a drum-handling fire, a flammable gas explosion, a truck impact and fire, a design-basis earthquake, and a beyond-design-basis earthquake. They were selected for analysis using a hazard identification and assessment process and have estimated annual frequencies of occurrence ranging from 0.11 per year to 4.0E-06 per year, categorized as Anticipated and Extremely Unlikely, respectively. Accident consequences shown in terms of radiation dose and potential LCFs are presented in Table 5.41.

The largest consequences to the offsite MEI would be from a beyond-design-basis earthquake. This MEI would receive a dose of about 13 rem and have an 8E-03 probability of an LCF. This accident would also result in the largest consequences to the population. About 30 LCFs would be expected. LCFs in the population would be expected for all analyzed accidents except a handling/forklift drum failure.

Table 5.41. Radiological Consequences of Accidents at the CWC

Accident	Estimated Annual Frequency	Offsite MEI		Offsite Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person-rem)	Number of LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Handling/Forklift Drum Failure	1.1E-01	0.0026	2E-06	11.5	0 (7E-03)	1.2	0.0007
Drum-Handling Fire	1.1E-04	0.7	4E-04	3000	2	310	0.2
Flammable Gas Explosion	4.2E-04	1.0	6E-04	4300	3	460	0.3
Truck Impact and Fire	4.0E-06	11.0	6E-03	47,000	30	4900	[(d)]
Design-Basis Earthquake	3.3E-03	1.1	6E-04	4700	3	480	0.3
Beyond-Design-Basis Earthquake	[(c)]	13	8E-03	56,000	30	5900	[(d)]

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.
(c) Not quantified in reference but frequency less than design-basis earthquake.
(d) This accident would likely result in a fatality.

The largest consequences to a non-involved worker would be from the truck impact and fire and the beyond-design-basis earthquake accidents. The non-involved worker would receive a dose of about 4900 rem and 5900 rem, respectively. Both of these doses would likely result in a fatality.

Non-radiological (chemical) consequences. Given that MLLW is also stored in the CWC, non-radioactive hazardous materials may be involved in the same accident scenarios as radioactive materials. The radiological accident analysis determined that two accidents having the largest consequences are the flammable gas explosion and the truck impact and fire accidents. Potential non-radiological consequences of these two accident scenarios were assumed in the safety analysis (Vail 2001a) to provide a reasonable upper limit for all accidents. Accident consequences are presented in Table 5.42, which shows the ratio of estimated concentrations to TEEL values. A value less than 1 indicates an acceptable condition. A blank ratio in the table indicates a more restrictive TEEL level was previously met (for example, the ratio was less than 1) and evaluation of higher TEEL-level ratios is unnecessary.

The air concentration at the location of the offsite MEI would be well below the TEEL/ERPG-1 level for all chemicals except beryllium. The air concentration at the location of the MEI would exceed the TEEL/ERPG-1 level beryllium because of the truck impact and fire accident. A hypothetically exposed individual would not be expected to experience or develop irreversible or other serious health effects or symptoms that might impair his or her ability to take protective action. No impacts would be expected.

For the onsite non-involved worker, the TEEL/ERPG-3 level might be exceeded for beryllium for both of these accidents. This individual might experience or develop a life-threatening effect. TEEL/ERPG-2 levels might also be exceeded for mercury, lead, potassium hydroxide, phosphoric acid, and sodium hydroxide. An individual might experience or develop irreversible or other serious health effects or symptoms that might impair his or her ability to take protective action. The TEEL/ERPG-1 levels might also be exceeded for cadmium, nitric acid, and hydrofluoric acid.

Like the radiological consequences to involved workers, non-radiological consequences could be highly variable—ranging from no exposure to high concentrations of chemicals—depending upon whether or not a worker were directly in the plume of immediately released material, and for how long.

Industrial accidents – construction. No new construction would take place at the CWC under Alternative Group A, and no industrial accidents from construction would occur.

Industrial accidents – operations. Direct operations staffing in the CWC would total 3200 worker-years. Estimated health and safety impacts would be 85 total recordable cases, 36 lost workday cases, and 1200 lost workdays.

Table 5.42. Non-Radiological Air Concentrations for Accidents at the CWC

Chemical	Onsite Worker Conc. (mg/m^3)	Offsite MEI Conc. (mg/m^3)	TEEL-1 (mg/m^3)	TEEL-2 (mg/m^3)	TEEL-3 (mg/m^3)	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Drum Explosion											
Ammonium fluoride	1.0E+00	2.3E-03	2.5	2.5	40	4.2E-01	(c)	(c)	9.3E-04	(c)	(c)
Ammonium nitrate	1.0E+00	2.3E-03	10	10	500	1.0E-01	(c)	(c)	2.3E-04	(c)	(c)
Ammonium sulfate	2.1E+00	4.5E-03	125	500	500	1.7E-02	(c)	(c)	3.6E-05	(c)	(c)
Beryllium	7.7E-01	1.6E-03	0.005	0.025	0.1	1.5E+02	3.1E+01	7.7E+00	3.3E-01	(c)	(c)
Carbon tetrachloride	4.9E+00	1.1E-02	125	600	4000	4.0E-02	8.2E-03	(c)	8.5E-05	(c)	(c)
Hydrofluoric acid	7.0E+00	1.5E-02	1.5	15	40	4.7E+00	4.7E-01	(c)	1.0E-02	(c)	(c)
Nitric acid	8.2E+00	1.7E-02	2.5	12.5	50	3.3E+00	6.5E-01	(c)	7.0E-03	(c)	(c)
Phosphoric acid	7.0E+00	1.5E-02	3	5	500	2.3E+00	1.4E+00	1.4E-02	5.2E-03	(c)	(c)
Potassium hydroxide	7.5E+00	1.6E-02	2	2	150	3.8E+00	3.8E+00	5.0E-02	8.2E-03	(c)	(c)
Sodium hydroxide	1.0E+01	2.1E-01	0.5	5	50	2.1E+01	2.1E+00	2.1E-01	4.3E-01	(c)	(c)
Sulfuric acid	4.4E-01	9.7E-04	2	10	30	2.2E-01	(c)	(c)	4.8E-04	(c)	(c)
Truck Impact and Fire											
Ammonium fluoride	3.5E-01	7.4E-04	2.5	2.5	40	1.4E-01	(c)	(c)	3.0E-04	(c)	(c)
Ammonium nitrate	3.5E-01	7.4E-04	10	10	500	3.5E-02	(c)	(c)	7.4E-05	(c)	(c)
Ammonium sulfate	6.8E-01	1.4E-03	125	500	500	5.4E-03	(c)	(c)	1.2E-05	(c)	(c)
Beryllium	6.0E+00	1.4E-02	0.005	0.025	0.1	1.2E+03	2.4E+02	6.0E+01	2.7E+00	5.4E-01	(c)
Carbon tetrachloride	1.6E+00	3.5E-03	125	600	4000	1.2E-02	(c)	(c)	2.8E-05	(c)	(c)
Hydrofluoric acid	2.3E+00	4.9E-03	1.5	15	40	1.5E+00	1.5E-01	(c)	2.5E-03	(c)	(c)
Nitric acid	1.0E+01	2.1E-02	2.5	12.5	50	4.2E+00	8.3E-01	(c)	8.5E-03	(c)	(c)
Phosphoric acid	2.3E+00	4.9E-03	3	5	500	7.5E-01	(c)	(c)	1.6E-03	(c)	(c)
Potassium hydroxide	2.4E+00	5.3E-03	2	2	150	1.2E+00	1.2E+00	1.6E-02	2.7E-03	(c)	(c)
Sodium hydroxide	1.4E+01	3.0E-02	0.5	5	50	2.8E+01	2.8E+00	2.8E-01	6.0E-02	(c)	(c)
Sulfuric acid	1.4E-01	3.1E-04	2	10	30	6.9E-02	(c)	(c)	1.5E-04	(c)	(c)
Mercury	1.7E+00	3.8E-03	0.025	0.1	10	6.9E+01	1.7E+01	1.7E-01	3.8E-02	(c)	(c)
Cadmium	1.7E+00	3.8E-03	0.03	4	9	5.8E+01	4.3E-01	(c)	1.3E-01	(c)	(c)
Polychlorinated biphenyls (PCBs)	3.5E-01	7.5E-04	3	5	5	1.2E-01	6.9E-02	(c)	2.5E-04	(c)	(c)
Lead	1.7E+00	3.8E-03	0.15	0.25	100	1.2E+01	6.9E+00	1.7E-02	2.5E-02	(c)	(c)

(a) Onsite = non-involved worker.
(b) Offsite = offsite MEI.
(c) Ratio not presented because a more restrictive TEEL level was previously met and evaluation of higher TEEL-level ratio is unnecessary.

5.11.1.1.3.2 Treatment – Waste Receiving and Processing Facility

Radiological consequences. Seven accident scenarios involving radioactive material at the WRAP were evaluated in the WRAP Final Safety Analysis Report (Tomaszewski 2001). These accident scenarios were a handling/forklift drum failure, a drum-handling fire, a container-handling explosion, a fire in a process enclosure (glovebox), an explosion in process enclosure (glovebox), design-basis earthquake, and beyond-design-basis earthquake. These accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence are described qualitatively and quantitatively. The frequencies of occurrence range from anticipated (with an associated annual frequency range of 1 to 0.01) to a much lower frequency for the beyond-design-basis earthquake. Accident consequences, shown in terms of radiation dose and potential LCF, are presented in Table 5.43.

The largest consequences to the MEI would be from a beyond-design-basis earthquake. The MEI would receive a dose of about 1.1 rem and have a 7E-04 probability of an LCF. Six of the seven accidents examined would result in one to three LCFs in the population.

The largest consequences to a non-involved worker would be from a beyond-design-basis earthquake. The non-involved worker would receive a dose of about 500 rem and have a 0.3 probability of an LCF.

Table 5.43. Radiological Consequences of Accidents at WRAP

Accident	Estimated Annual Frequency	Offsite MEI		Offsite Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF[a]	Dose (person-rem)	Number LCFs[b]	Dose (rem)	Prob. LCF[a]
Handling/Forklift Drum Failure	Anticipated[c]	0.0014	8E-07	6.0	0 (0.003)	0.6	3E-04
Drum-Handling Fire	2.0E-03	0.31	2E-04	1400	1 (0.8)	140	9E-02
Container-Handling Explosion	3.0E-03	0.74	5E-04	3300	2	340	2E-01
Process Enclosure Fire	2.0E-03	0.20	1E-04	900	1 (0.5)	100	6E-02
Process Enclosure Explosion	3.0E-03	0.67	4E-04	2900	2	300	2E-01
Design-Basis Earthquake	1.0E-03	0.92	6E-04	4100	2	420	3E-01
Beyond-Design-Basis Earthquake	[d]	1.1	7E-04	4800	3	500	3E-01

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.
(c) Anticipated accidents are estimated to occur with a frequency ranging from 0.01 to 1.0 per year.
(d) Frequency was not specified in the source document.

Non-radiological (chemical) consequences. Because MLLW would also be handled at the WRAP, non-radioactive hazardous materials may be involved in accidents. A process enclosure fire was evaluated for non-radiological consequences. The accident scenario for this analysis is the same as evaluated for radiological consequences of the process enclosure fire, where containers rupture and burn. A fire in the process enclosure is postulated due to the mixing of incompatible materials or damage to the packaging of pyrophoric material that allows ignition to take place. Because no mitigation credit is taken for the process enclosure, the consequence of this event is greater than any container fire at the WRAP. Other potential accidents would be associated with consequences that are similar to, or lower than, those from this event. Accident consequences are presented in Table 5.44.

The air concentration at the location of the offsite MEI could exceed the TEEL/ERPG-1 level for beryllium, cadmium, and mercury. Hypothetically exposed individuals would not be expected to experience or develop irreversible or other serious health effects or symptoms that might impair their ability to take protective action.

For the onsite, non-involved worker, the TEEL/ERPG-3 level might be exceeded for beryllium, cadmium, mercury, and sodium oxide. This hypothetically exposed individual might experience or develop a life-threatening effect. The TEEL/ERPG-2 level could also be exceeded for uranyl nitrate hexahydrate, nitric acid, phosphoric acid, sodium, sodium hydroxide, and naphthylamine tritium. At the TEEL/ERPG-2 level, an individual might experience or develop irreversible or other serious health effects or symptoms that might impair his or her ability to take protective action. No other chemical would exceed the TEEL/ERPG-1 levels; therefore, no serious health effects or symptoms would be expected.

Like the radiological consequences to involved workers, non-radiological consequences could be highly variable—ranging from no exposure to high concentrations of chemicals—depending upon whether or not a worker were directly in the plume of immediately released material, and for how long.

Industrial accidents. Direct operations staffing in the WRAP would total 1800 worker-years. Estimated health and safety impacts would be 48 total recordable cases, 20 lost workday cases, and 710 lost workdays.

Table 5.44. Non-Radiological Air Concentrations for a Process Enclosure Fire Accident at WRAP

Chemical	Onsite Worker Conc. (mg/m^3)	Offsite MEI Conc. (mg/m^3)	TEEL-1 (mg/m^3)	TEEL-2 (mg/m^3)	TEEL-3 (mg/m^3)	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Ammonia	3.9E-01	8.5E-04	15	100	500	2.6E-02	(c)	(c)	5.7E-05	(c)	(c)
Ammonium nitrate	6.9E+00	1.5E-02	10	10	500	6.9E-01	(c)	(c)	1.5E-03	(c)	(c)
Beryllium	6.1E+00	1.3E-02	0.005	0.025	0.1	1.2E+03	2.4E+02	6.1E+01	2.7E+00	5.3E-01	(c)
Butyl alcohol	7.0E-01	1.5E-03	150	150	4000	4.7E-03	(c)	(c)	1.0E-05	(c)	(c)
Cadmium	7.8E+01	1.7E-01	0.03	4	9	2.6E+03	2.0E+01	8.7E+00	5.7E+00	4.3E-02	(c)
Carbon tetrachloride	1.3E+01	2.9E-02	125	600	4000	1.1E-01	(c)	(c)	2.3E-04	(c)	(c)
Cyclohexane	3.3E+00	7.1E-03	3000	4000	4000	1.1E-03	(c)	(c)	2.4E-06	(c)	(c)
Dichloroethane	1.0E+00	2.2E-03	7.5	200	200	1.4E-01	(c)	(c)	2.9E-04	(c)	(c)
Dioxane	2.2E+01	4.8E-02	75	350	1500	2.9E-01	(c)	(c)	6.3E-04	(c)	(c)
Ethyl acetate (acetic ether)	7.8E-01	1.7E-03	1500	1500	7500	5.2E-04	(c)	(c)	1.1E-06	(c)	(c)
Hydrogen peroxide	4.4E-01	9.5E-04	12.5	60	125	3.5E-02	(c)	(c)	7.6E-05	(c)	(c)
Indole-2-C-14 picrate	8.6E-05	1.9E-07	0.3	0.5	10	2.9E-04	(c)	(c)	6.2E-07	(c)	(c)
Manganese	5.2E-02	1.1E-04	3	5	500	1.7E-02	(c)	(c)	3.8E-05	(c)	(c)
Mercury	3.8E+01	8.3E-02	0.025	0.1	10	1.5E+03	3.8E+02	3.8E+00	3.3E+00	(c)	(c)
Methanol	1.1E+00	2.4E-03	250	1250	6000	4.4E-03	(c)	(c)	9.5E-06	(c)	(c)
Napthylamine tritium	8.6E+01	1.9E-01	7.5	50	300	1.1E+01	1.7E+00	2.9E-01	2.5E-02	(c)	(c)
Nitric acid	3.0E+01	6.6E-02	2.5	12.5	50	1.2E+01	2.4E+00	6.1E-01	2.7E-02	(c)	(c)
Phosphoric acid	4.4E+01	9.5E-02	3	5	500	1.5E+01	8.7E+00	8.7E-02	3.2E-02	(c)	(c)
Propane	7.8E-01	1.7E-03	3500	3500	3500	2.2E-04	(c)	(c)	4.9E-07	(c)	(c)
Sodium	2.3E+00	4.9E-03	2	2	10	1.1E+00	(c)	(c)	2.5E-03	(c)	(c)
Sodium hydroxide	3.2E+01	7.0E-02	0.5	5	50	6.4E+01	6.4E+00	6.4E-01	1.4E-01	(c)	(c)
Sodium hypochlorite	6.5E-03	1.4E-05	75	500	500	8.6E-05	(c)	(c)	1.9E-07	(c)	(c)
Sodium oxide	4.1E+01	9.0E-02	10	10	10	4.1E+00	4.1E+00	4.1E+00	9.0E-03	(c)	(c)
Styrene	2.4E+00	5.3E-03	200	1000	4000	1.2E-02	(c)	(c)	2.6E-05	(c)	(c)
Tetrahydrofuran	1.2E+00	2.7E-03	750	3000	6000	1.7E-03	(c)	(c)	3.6E-06	(c)	(c)
Tetralin	8.6E-05	1.9E-07	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	7.6E-01	1.6E-03	150	1000	3500	5.0E-03	(c)	(c)	1.1E-05	(c)	(c)
Uranyl nitrate hexahydrate	5.3E+00	1.2E-02	0.6	0.6	10	8.8E+00	8.8E+00	5.3E-01	1.9E-02	(c)	(c)
Vinyl acetate	2.4E+00	5.3E-03	150	250	1500	1.6E-02	(c)	(c)	3.5E-05	(c)	(c)
Vinyl chloride	3.6E+00	7.8E-03	12.5	12.5	200	2.9E-01	(c)	(c)	6.3E-04	(c)	(c)
Zirconium	7.5E-01	1.6E-03	10	10	50	7.5E-02	(c)	(c)	1.6E-04	(c)	(c)

(a) Onsite = non-involved worker.
(b) Offsite = offsite MEI.
(c) Ratio not presented because a more restrictive TEEL level was previously met and evaluation of a higher TEEL-level ratio is unnecessary.
NA = not applicable.

5.11.1.1.3.3 Treatment – Modified T Plant Complex

Radiological consequences – continuing T Plant activities. Six accident scenarios involving current activities and radioactive material at T Plant were evaluated as part of the Interim Safety Basis (Bushore 1999, 2001). These accidents were a spray release in the 221-T canyon, a railcar spill in the 221-T rail tunnel, a filter fire in the 2706-T facility, a LLW drum storage fire in the 214-T building, a filter bank fire in the 219-T building, and a seismic event.

These accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence are described qualitatively and quantitatively. The frequencies of occurrence range from less than 1.E-02 to 1.9.E-05 for the 291-T filter bank fire, categorized as unlikely and extremely unlikely, respectively (see Volume II, Appendix F, Section F.2.2). Accident consequences, shown in terms of radiation dose and potential LCF, are presented in Table 5.45.

The largest consequences to the MEI would be from an outdoor drum-handling accident with fire at the 2706-T facility. The MEI would receive a dose of about 0.70 rem and have a 4E-04 probability of an LCF. Within the population, this accident would result in three LCFs, and three of the other accidents examined would result in one LCF.

The largest consequences to a non-involved worker would also be from an outdoor drum-handling accident with fire at the 2706-T facility. The non-involved worker would receive a dose of about 500 rem and have a 3E-01 probability of an LCF.

Table 5.45. Radiological Consequences of Accidents at the Modified T Plant Complex for Continuing T Plant Activities

Accident	Estimated Annual Frequency	Offsite MEI		Offsite Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person-rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Spray Release, 221-T Canyon	2.0E-05	0.31	2E-04	2100	1	220	1E-01
Railcar Spill, 221-T Rail Tunnel	< 0.01 [c)]	0.10	6E-05	650	0 (0.4)	68	4E-02
2706-T Outdoor Drum Fire	1.0E-03 to 2.5E-04[(c)]	0.70	4E-04	4800	3	500	3E-01
214-T LLW Drum Storage Fire	< 0.01[(c)]	0.15	9E-05	1000	1 (0.6)	110	7E-02
291-T Filter Bank Fire	1.9E-05	0.02	1E-05	140	0 (0.08)	15	9E-03
Seismic Event	[(c, d)]	0.27	2E-04	1900	1	190	1E-01

(a) Prob. LCF = the probably of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.
(c) These less quantitative frequencies are also from Bushore (2001).
(d) For a design-basis earthquake, the annual frequency would be about 1 x 10^{-3} or less. In the source document (Bushore 2001), the consequences of this event were compared to evaluation guidelines for an "extremely unlikely" accident, which would correspond to a frequency ranging from 1 x 10^{-6} to 1 x 10^{-4} per year.

Radiological consequences – New Waste Processing Facility. Four accidents for the proposed new waste processing facility in the modified T Plant Complex were evaluated, based upon the analysis and results of the preliminary safety evaluation for the WRAP Module 2 (WHC 1991). These accidents were a filtered box drop, an unfiltered box drop, a design-basis earthquake with fire, and a tank farm pump spill. These accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence range from anticipated (with an annual frequency range of 1 to 0.01) to an extremely unlikely accident (with an annual frequency range of 1.0E-04 to 1.0E-06). Accident consequences, shown in terms of radiation dose and potential LCFs, are presented in Table 5.46.

The largest consequences to the MEI would be from a design-basis earthquake and fire. The MEI would receive a dose of about 0.31 rem and have a 2E-04 probability of an LCF. This accident also results in the largest consequences to the population, but no LCFs would be expected.

The largest consequences to a non-involved worker would also be from a design-basis earthquake and fire. The non-involved worker would receive a dose of about 77 rem and have a 5E-02 probability of an LCF.

Radiological consequences to involved workers from these accidents could be highly variable depending upon whether or not a worker was directly in the plume of immediately released material.

Non-radiological (chemical) consequences – continuing T Plant activities. The Interim Safety Basis (Bushore 2001) does not contain an analysis of the potential consequences of accidents involving non-radiological constituents of waste streams. The non-radiological consequences of accidents at WRAP, presented previously (Section 5.11.1.1.3.2), are assumed to represent potential non-radiological consequences of continuing T Plant activities.

Table 5.46. Radiological Consequences of Accidents for the Modified T Plant Complex with the New Waste Processing Facility

Accident	Estimated Annual Frequency	Offsite MEI		Offsite Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person-rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Box Drop (filtered)	1.0E-02	8.9E-05	5E-08	0.21	0 (1E-04)	2.2E-02	1E-05
Box Drop (unfiltered)	1.0E-02	1.8E-01	1E-04	430	0 (0.3)	4.5E+01	3E-02
Design-Basis Earthquake and Fire (unfiltered)	1.0E-04	3.1E-01	2E-04	740	0 (0.4)	7.7E+01	5E-02
Tank Farm Pump Spill	7.7E-04	2.6E-09	2E-12	6.3E-06	0 (4E-09)	6.5E-07	4E-10

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.

Non-radiological (chemical) consequences – New Waste Processing Facility. Non-radiological consequences for the new waste processing facility have not been evaluated in detail. However, potential non-radiological impacts from accidents in the WRAP are assumed to be representative for potential impacts from new waste processing facility activities. Potential impacts from accidents in the CWC and Low Level Burial Grounds (LLBGs) would likely be bounding for accidents in the modified T Plant Complex.

Industrial accidents – construction. Employment for the T Plant Complex modification would total 120 worker-years. Estimated health and safety impacts would be 10 total recordable cases, 3 lost workday cases, and 66 lost workdays.

Industrial accidents – operations. Direct operations staffing in the modified T Plant Complex would total 3,900 worker-years. Estimated health and safety impacts would be 100 total recordable cases, 42 lost workday cases, and 1,500 lost workdays.

5.11.1.1.3.4 Disposal – LLBGs

Disposal and storage of solid radioactive waste generated at the Hanford Site would continue in the HSW disposal facilities of the 200 West and 200 East Areas. Accidents involving the LLW and MLLW trenches were evaluated in the Solid Waste Burial Grounds Interim Safety Basis by Vail (2001c) and the Solid Waste Burial Grounds Interim Safety Analysis by Vail (2001b).

Radiological consequences – LLW trenches. The radiological consequences associated with the disposal of LLW (Cat 1, Cat 3, and GTC3) are addressed in this section. Non-radiological (chemical) consequences were not evaluated due to the nature of the waste.

Five credible accidents at the trenches were evaluated as part of the Interim Safety Basis (Vail 2001c) and the Interim Safety Analysis (Vail 2001b). They were a heavy equipment accident with fire, a heavy equipment accident without fire, a drum explosion, an explosion involving an ion-exchange module, and a seismic event. Two other accidents involving high-integrity containers (HICs)—a heavy equipment accident with fire and a seismic event—were also addressed.

These accidents were selected for analysis through a hazard identification and assessment process and have estimated annual frequencies of occurrence ranging from 4.0E-02 per year to 5.3E-04 per year, categorized as anticipated and unlikely, respectively. Accident consequences, shown in terms of both radiation dose and LCFs, are presented in Table 5.47.

The largest consequences to the MEI would be from a heavy equipment accident with fire involving the high integrity containers (HICs). The MEI would receive a dose of about 0.39 rem and have a 2E-04 probability of a LCF. This accident also results in the largest consequences to the population, with one LCF.

Table 5.47. Radiological Consequences of Accidents at the Low-Level Waste Trenches

Accident	Estimated Annual Frequency	Offsite MEI		Offsite Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person -rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Heavy Equipment Accident with Fire	5.3E-04	0.027	2E-05	140	0 (0.08)	14	8E-03
Heavy Equipment Accident without Fire	1.3E-02	0.0022	1E-06	11	0 (0.007)	1	7E-04
Drum Explosion	4.0E-02	0.049	3E-05	250	0 (0.2)	26	2E-02
Explosion in Ion-Exchange Module	1.0E-02	0.019	1E-05	97	0 (0.06)	10	6E-03
Seismic Event[(c)]	1.0E-03	0.016	1E-05	79	0 (0.05)	8.3	5E-03
HIC Operations							
Heavy Equipment Accident with Fire	5.3E-04	0.39	2E-04	2000	1	210	1E-01
Seismic Event	1.0E-03	0.045	3E-05	220	0 (0.1)	23	1E-02

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.
(c) This estimate is based on a breach of 500 drums, which is a conservative estimate of the number of stacked, uncovered drums at the face of the waste trenches. Vail (2001c) back-calculates the number of drums breached from the site radiological risk guideline for onsite worker dose and this is not appropriate for this analysis.

The largest consequences to a non-involved worker would be from a heavy equipment accident with fire involving the HICs. The non-involved worker would receive a dose of about 210 rem and have an 1E-01 probability of an LCF.

Radiological consequences – MLLW trenches. The radiological consequences of five accidents at the MLLW trenches were evaluated as part of the Interim Safety Analysis (Vail 2001b). These accidents were a heavy equipment (for example, a bulldozer) accident with fire, a heavy equipment accident with no fire, a drum explosion, a seismic event, and a leachate collection system spray release. These accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence range from 4.0E-02 per year for anticipated accidents to 1.0E-02 to 1.0E-04 per year for unlikely accidents. Accident consequences, shown in terms of both radiation dose and LCFs, are presented in Table 5.48.

The largest consequences to the MEI would be from a drum explosion. The MEI would receive a dose of about 4.9E-02 rem and have a 3E-05 probability of a LCF. This accident also results in the largest consequences to the population but no LCFs would be expected.

The largest consequences to a non-involved worker would also be from a drum explosion. The non-involved worker would receive a dose of about 26 rem and have a 2E-02 probability of an LCF.

Table 5.48. Radiological Consequences of Accidents at the MLLW Trenches

Accident	Estimated Annual Frequency	Offsite MEI		Offsite Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person-rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Heavy Equipment Accident with Fire	5.4E-04	0.029	2E-05	140	0 (0.09)	14	8E-03
Heavy Equipment Accident without Fire	1.3E-02	0.0022	1E-06	11	0 (0.007)	1.1	7E-04
Drum Explosion	4.0E-02	0.049	3E-05	240	0 (0.2)	26	2E-02
Seismic Event[(c)]	1.0E-03	0.017	1E-05	83	0 (0.05)	9	5E-03
Leachate Collection System Spray Release	Unlikely[(d)]	0.00048	3E-07	2.4	0 (0.001)	0.25	2E-03

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.
(c) This estimate is based on a breach of 500 drums, which is a conservative estimate of the number of stacked, uncovered drums at the face of the waste trenches. Vail (2001c) back-calculates the number of drums breached from the site radiological risk guideline for onsite worker dose and this is not appropriate for this analysis.
(d) No frequency provided. Estimated at "unlikely" (1.0E-02 to 1.0E-04).

Non-radiological (chemical) consequences. The quantity and form of hazardous constituents in the MLLW trenches are subject to land disposal restrictions and other regulations that are prescriptive in how mixed waste must be treated prior to emplacement. No organic chemicals would be present. The Interim Safety Analysis by Vail (2001b) evaluated four of the previous accidents for non-radiological consequences at the MLLW trenches, including the heavy equipment accident with fire, a heavy equipment accident with no fire, a drum explosion, and a seismic event. Chemicals were assumed to be at the maximum allowable concentrations and the waste was in bulk form (rather than in containers). Accident consequences are presented in Tables 5.49 through 5.52.

For all accidents, the air concentration at the location of the offsite MEI would be well below the TEEL/ERPG-1 level for all chemicals. No impacts would be expected. For the onsite non-involved worker, the TEEL/ERPG-3 levels could be reached or exceeded for three chemicals—molybdenum, nickel, and selenium—for the heavy equipment accident with fire and only selenium for the seismic event. A hypothetically exposed individual may experience or develop a life-threatening effect as a result of a one-hour exposure to any one of these chemicals. The TEEL/ERPG-2 levels would be exceeded for 16 chemicals for the heavy equipment accident with fire, and 13 chemicals for the seismic event. An individual might experience or develop irreversible or other serious health effects or symptoms that might impair the ability to take protective action.

Radiological consequences – ILAW disposal. The radiological consequences associated with the disposal of ILAW (as MLLW) in a new disposal facility near the PUREX Plant are addressed in this section. There would be no non-radiological (chemical) consequences due to the processing and physical form of the waste, so non-radiological impacts were not evaluated.

Table 5.49. Non-Radiological Air Concentrations for a Heavy Equipment Accident with Fire at the LLBGs

Chemical	Onsite Worker Conc. (mg/m^3)	Offsite MEI Conc. (mg/m^3)	TEEL-1 (mg/m^3)	TEEL-2 (mg/m^3)	TEEL-3 (mg/m^3)	Onsite(a) TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite(b) TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	2.0E+02	3.9E-01	30	50	250	6.8	4.1	0.8	1.3E-02	(c)	(c)
Antimony	1.0E+01	2.0E-02	1.5	2.5	50	6.8	4.1	0.2	1.3E-02	(c)	(c)
Arsenic	2.0E-01	3.9E-04	0.03	1.4	5	6.8	0.15	(c)	1.3E-02	(c)	(c)
Barium	1.0E+01	2.0E-02	1.5	2.5	12.5	6.8	4.1	0.8	1.3E-02	(c)	(c)
Beryllium	1.0E-03	2.0E-06	0.005	0.025	0.1	0.2	(c)	(c)	4.0E-04	(c)	(c)
Cadmium	4.1E-02	7.8E-05	0.03	4	9	1.4	0.01	(c)	2.6E-03	(c)	(c)
Calcium hydroxide	1.0E+02	2.0E-01	15	25	500	6.8	4.1	0.2	1.3E-02	(c)	(c)
Chromium	1.0E+01	2.0E-02	1.5	2.5	250	6.8	4.1	0.04	1.3E-02	(c)	(c)
Cobalt	4.1E-01	7.8E-04	0.1	0.1	20	4.1	4.1	0.02	7.8E-03	(c)	(c)
Copper	2.0E+01	3.9E-02	3	5	100	6.8	4.1	0.2	1.3E-02	(c)	(c)
Iron oxide dust	1.0E+02	2.0E-01	15	25	500	6.8	4.1	0.2	1.3E-02	(c)	(c)
Lead	1.0E+00	2.0E-03	0.15	0.25	100	6.8	4.1	0.01	1.3E-02	(c)	(c)
Magnesium	1.0E+02	2.0E-01	30	50	250	3.4	2.0	0.4	6.5E-03	(c)	(c)
Manganese	1.0E+02	2.0E-01	3	5	500	34	20	0.2	6.5E-02	(c)	(c)
Mercury	2.1E-02	4.0E-05	0.025	0.1	10	0.8	(c)	(c)	1.6E-03	(c)	(c)
Molybdenum	1.0E+02	2.0E-01	15	25	60	6.8	4.1	1.7	1.3E-02	(c)	(c)
Nickel	2.0E+01	3.9E-02	4.5	10	10	4.5	2.0	2.0	8.7E-03	(c)	(c)
Potassium hydroxide	4.1E-01	8.0E-04	2	2	150	0.2	(c)	(c)	4.0E-04	(c)	(c)
Selenium	4.1E+00	7.8E-03	0.6	1	1	6.8	4.1	4.1	1.3E-02	(c)	(c)
Silver	2.0E-01	3.9E-04	0.3	0.5	10	0.7	(c)	(c)	1.3E-03	(c)	(c)
Sodium hydroxide	4.1E-01	8.0E-04	0.5	5	50	0.8	(c)	(c)	1.6E-03	(c)	(c)
Thallium	2.0E+00	3.9E-03	0.3	2	15	6.8	1.0	0.1	1.3E-02	(c)	(c)
Vanadium pentoxide	1.0E-01	2.0E-04	0.075	0.5	35	1.4	0.2	(c)	2.7E-03	(c)	(c)
Zinc oxide	2.0E+02	3.9E-01	15	15	500	14	14	0.41	2.6E-02	(c)	(c)

(a) Onsite = non-involved worker.
(b) Offsite = offsite MEI.
(c) Ratio not presented because a more restrictive TEEL level was previously met and evaluation of higher TEEL-level ratio is unnecessary.

Table 5.50. Non-Radiological Air Concentrations for a Heavy Equipment Accident Without Fire at the LLBGs

Chemical	Onsite Worker Conc. (mg/m³)	Offsite MEI Conc. (mg/m³)	TEEL-1, (mg/m³)	TEEL-2, (mg/m³)	TEEL-3, (mg/m³)	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	4.1E+00	7.8E-03	30	50	250	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Antimony	2.0E-01	3.9E-04	1.5	2.5	50	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Arsenic	4.1E-03	7.8E-06	0.03	1.4	5	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Barium	2.0E-01	3.9E-04	1.5	2.5	12.5	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Beryllium	2.1E-05	4.0E-08	0.005	0.025	0.1	4.2E-03	(c)	(c)	8.0E-06	(c)	(c)
Cadmium	8.2E-04	1.6E-06	0.03	4	9	2.7E-02	(c)	(c)	5.2E-05	(c)	(c)
Calcium hydroxide	2.0E+00	3.9E-03	15	25	500	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Chromium	2.0E-01	3.9E-04	1.5	2.5	250	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Cobalt	8.2E-03	1.6E-05	0.1	0.1	20	8.2E-02	(c)	(c)	1.6E-04	(c)	(c)
Copper	4.1E-01	7.8E-04	3	5	100	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Iron oxide dust	2.0E+00	3.9E-03	15	25	500	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Lead	2.0E-02	3.9E-05	0.15	0.25	100	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Magnesium	2.0E+00	3.9E-03	30	50	250	6.8E-02	(c)	(c)	1.3E-04	(c)	(c)
Manganese	2.0E+00	3.9E-03	3	5	500	6.8E-01	(c)	(c)	1.3E-03	(c)	(c)
Mercury	4.2E-04	8.0E-07	0.025	0.1	10	1.7E-02	(c)	(c)	3.2E-05	(c)	(c)
Molybdenum	2.0E+00	3.9E-03	15	25	60	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Nickel	4.1E-01	7.8E-04	4.5	10	10	9.1E-02	(c)	(c)	1.7E-04	(c)	(c)
Potassium hydroxide	8.3E-03	1.6E-05	2	2	150	4.1E-03	(c)	(c)	8.0E-06	(c)	(c)
Selenium	8.2E-02	1.6E-04	0.6	1	1	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Silver	4.1E-03	7.8E-06	0.3	0.5	10	1.4E-02	(c)	(c)	2.6E-05	(c)	(c)
Sodium hydroxide	8.3E-03	1.6E-05	0.5	5	50	1.7E-02	(c)	(c)	3.2E-05	(c)	(c)
Thallium	4.1E-02	7.8E-05	0.3	2	15	1.4E-01	(c)	(c)	2.6E-04	(c)	(c)
Vanadium pentoxide	2.1E-03	4.0E-06	0.075	0.5	35	2.8E-02	(c)	(c)	5.3E-05	(c)	(c)
Zinc oxide	4.1E+00	7.8E-03	15	15	500	2.7E-01	(c)	(c)	5.2E-04	(c)	(c)

(a) Onsite = non-involved worker.
(b) Offsite = offsite MEI.
(c) Ratio not presented because a more restrictive TEEL level was previously met and evaluation of higher TEEL-level ratio is unnecessary.

Table 5.51. Non-Radiological Air Concentrations for a Drum Explosion at the LLBGs

Chemical	Onsite Worker Conc. (mg/m^3)	Offsite MEI Conc. (mg/m^3)	TEEL-1 (mg/m^3)	TEEL-2 (mg/m^3)	TEEL-3 (mg/m^3)	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	9.3E+00	1.8E-02	30	50	250	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Antimony	4.6E-01	8.9E-04	1.5	2.5	50	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Arsenic	9.3E-03	1.8E-05	0.03	1.4	5	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Barium	4.6E-01	8.9E-04	1.5	2.5	12.5	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Beryllium	4.7E-05	9.1E-08	0.005	0.025	0.1	9.4E-03	(c)	(c)	1.8E-05	(c)	(c)
Cadmium	1.9E-03	3.6E-06	0.03	4	9	6.2E-02	(c)	(c)	1.2E-04	(c)	(c)
Calcium hydroxide	4.6E+00	8.9E-03	15	25	500	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Chromium	4.6E-01	8.9E-04	1.5	2.5	250	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Cobalt	1.9E-02	3.6E-05	0.1	0.1	20	1.9E-01	(c)	(c)	3.6E-04	(c)	(c)
Copper	9.3E-01	1.8E-03	3	5	100	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Iron oxide dust	4.6E+00	8.9E-03	15	25	500	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Lead	4.6E-02	8.9E-05	0.15	0.25	100	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Magnesium	4.6E+00	8.9E-03	30	50	250	1.5E-01	(c)	(c)	3.0E-04	(c)	(c)
Manganese	4.6E+00	8.9E-03	3	5	500	1.5E+00	0.9	(c)	3.0E-03	(c)	(c)
Mercury	9.4E-04	1.8E-06	0.025	0.1	10	3.8E-02	(c)	(c)	7.3E-05	(c)	(c)
Molybdenum	4.6E+00	8.9E-03	15	25	60	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Nickel	9.3E-01	1.8E-03	4.5	10	10	2.1E-01	(c)	(c)	4.0E-04	(c)	(c)
Potassium hydroxide	1.9E-02	3.6E-05	2	2	150	9.4E-03	(c)	(c)	1.8E-05	(c)	(c)
Selenium	1.9E-01	3.6E-04	0.6	1	1	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Silver	9.3E-03	1.8E-05	0.3	0.5	10	3.1E-02	(c)	(c)	5.9E-05	(c)	(c)
Sodium hydroxide	1.9E-02	3.6E-05	0.5	5	50	3.8E-02	(c)	(c)	7.3E-05	(c)	(c)
Thallium	9.3E-02	1.8E-04	0.3	2	15	3.1E-01	(c)	(c)	5.9E-04	(c)	(c)
Vanadium pentoxide	4.7E-03	9.1E-06	0.075	0.5	35	6.3E-02	(c)	(c)	1.2E-04	(c)	(c)
Zinc oxide	9.3E+00	1.8E-02	15	15	500	6.2E-01	(c)	(c)	1.2E-03	(c)	(c)

(a) Onsite = non-involved worker.
(b) Offsite = offsite MEI.
(c) Ratio not presented because a more restrictive TEEL level was previously met and evaluation of higher TEEL-level ratio is unnecessary.

Table 5.52. Non-Radiological Air Concentrations for a Seismic Event Without Fire at the LLBGs

Chemical	Onsite Worker Conc. (mg/m^3)	Offsite MEI Conc. (mg/m^3)	TEEL-1 (mg/m^3)	TEEL-2 (mg/m^3)	TEEL-3 (mg/m^3)	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	7.4E+01	1.4E-01	30	50	250	2.5	1.5	0.3	4.8E-03	(c)	(c)
Antimony	3.7E+00	7.1E-03	1.5	2.5	50	2.5	1.5	0.07	4.8E-03	(c)	(c)
Arsenic	7.4E-02	1.4E-04	0.03	1.4	5	2.5	0.05	(c)	4.8E-03	(c)	(c)
Barium	3.7E+00	7.1E-03	1.5	2.5	12.5	2.5	1.5	0.3	4.8E-03	(c)	(c)
Beryllium	3.8E-04	7.3E-07	0.005	0.025	0.1	0.08	(c)	(c)	1.5E-04	(c)	(c)
Cadmium	1.5E-02	2.9E-05	0.03	4	9	0.5	(c)	(c)	9.5E-04	(c)	(c)
Calcium hydroxide	3.7E+01	7.1E-02	15	25	500	2.5	1.5	0.1	4.8E-03	(c)	(c)
Chromium	3.7E+00	7.1E-03	1.5	2.5	250	2.5	1.5	0.01	4.8E-03	(c)	(c)
Cobalt	1.5E-01	2.9E-04	0.1	0.1	20	1.5	1.5	7.4E-03	2.9E-03	(c)	(c)
Copper	7.4E+00	1.4E-02	3	5	100	2.5	1.5	0.07	4.8E-03	(c)	(c)
Iron oxide dust	3.7E+01	7.1E-02	15	25	500	2.5	1.5	0.1	4.8E-03	(c)	(c)
Lead	3.7E-01	7.1E-04	0.15	0.25	100	2.5	1.5	0.004	4.8E-03	(c)	(c)
Magnesium	3.7E+01	7.1E-02	30	50	250	1.2	0.7	(c)	2.4E-03	(c)	(c)
Manganese	3.7E+01	7.1E-02	3	5	500	12	7.4	0.07	2.4E-02	(c)	(c)
Mercury	7.6E-03	1.5E-05	0.025	0.1	10	0.3	(c)	(c)	5.8E-04	(c)	(c)
Molybdenum	3.7E+01	7.1E-02	15	25	60	2.5	1.5	0.6	4.8E-03	(c)	(c)
Nickel	7.4E+00	1.4E-02	4.5	10	10	1.6	0.7	(c)	3.2E-03	(c)	(c)
Potassium hydroxide	1.5E-01	2.9E-04	2	2	150	0.08	(c)	(c)	1.5E-04	(c)	(c)
Selenium	1.5E+00	2.9E-03	0.6	1	1	2.5	1.5	1.5	4.8E-03	(c)	(c)
Silver	7.4E-02	1.4E-04	0.3	0.5	10	0.2	(c)	(c)	4.8E-04	(c)	(c)
Sodium hydroxide	1.5E-01	2.9E-04	0.5	5	50	0.3	(c)	(c)	5.8E-04	(c)	(c)
Thallium	7.4E-01	1.4E-03	0.3	2	15	2.5	0.4	(c)	4.8E-03	(c)	(c)
Vanadium pentoxide	3.8E-02	7.3E-05	0.075	0.5	35	0.5	(c)	(c)	9.7E-04	(c)	(c)
Zinc oxide	7.4E+01	1.4E-01	15	15	500	5	5	0.15	9.5E-03	(c)	(c)

(a) Onsite = non-involved worker.
(b) Offsite = offsite MEI.
(c) Ratio not presented because a more restrictive TEEL was previously met and evaluation of higher TEEL-level ratio is unnecessary.

A preliminary hazards assessment (Burbank 2002) identified 198 hazardous conditions grouped into 15 accident categories; quantitative results were reported for two accidents. A bulldozer accident was assumed to occur and shear off the tops of six ILAW containers. A crane accident had the crane falling into a trench with the boom striking an exposed container array 10 packages wide by 5 packages wide. Accident consequences, shown in terms of both radiation dose and LCF, are presented in Table 5.53.

The largest consequences to the MEI would be from the crane accident. The MEI would receive a dose of about 3.0E-05 rem and have a 2E-08 probability of an LCF. This accident also results in the largest consequences to the population, with about a 5E-05 probability of an LCF.

The largest consequences to workers would also be from the crane accident. The non-involved worker would receive a dose of about 0.04 rem and have a 3E-05 probability of an LCF.

LLBGs industrial accidents. This section addresses potential health and safety impacts from construction and operation of LLW and MLLW trenches and supporting facilities (pulse driers) in the LLBGs. Estimated health and safety impacts from construction and operation of MLLW trenches are included in totals for the LLBGs presented below.

LLBGs industrial accidents – construction. Construction of new trenches and pulse driers for MLLW trenches would require a total of 7 to 10 worker-years. The estimated health and safety impacts would be less than one total recordable case and less than one lost workday case.

LLBGs industrial accidents – operations. Direct operations staffing in the LLBGs would total 3800 worker-years. Estimated health and safety impacts would be 100 total recordable cases, 42 lost workday cases, and 1500 lost workdays.

ILAW industrial accidents. Industrial impacts are not separated by construction and operations. A total of about 5000 worker-years would be required for construction, operations, and closure. The estimated health and safety impacts would be about 200 total recordable cases, 84 lost workday cases, and about 2900 lost workdays.

Table 5.53. Radiological Consequences of Accidents Involving ILAW Disposal

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person-rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Bulldozer Accident	NA	1.9E-05	1E-08	5.0E-02	3E-05	2.3E-02	1E-05
Crane Accident	NA	3.4E-05	2E-08	9.0E-02	5E-05	4.3E-02	3E-05

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.
NA = not available.

5.11.1.2 Alternative Group B

Alternative Group B is similar to Alternative Group A except that use of commercial treatment facilities would be minimized with construction of a new waste processing facility, instead of modifying the T Plant Complex. New LLW and MLLW trenches would be constructed using the current design instead of the wider, deeper trench designs. Alternative Group B would involve the same waste processing and the same waste management approaches. The alternative includes the establishment of necessary facilities for storage, inspection, treatment, and final disposal or shipment offsite for all included waste streams. In addition, Alternative Group B includes the same sources, waste streams, and volumes of waste as Alternative Group A.

As in Alternative Group A, all of the wastes would be removed from storage and treated as necessary for disposal in the HSW disposal facilities or sent to the WIPP. After about 10 years, wastes would only be held in storage for short periods of time to allow for characterization and evaluation prior to treatment or disposal. Under Alternative Group B, the analyses use the Hanford Only, Upper, and Lower Bound of forecasted disposal waste volumes for LLW and MLLW.

5.11.1.2.1 Construction

New construction activities are anticipated for HSW disposal facilities and the new waste processing facility. The primary impacts from construction activities would be to air quality and injuries to construction workers. No impacts to construction workers are expected from radiation and chemicals because new construction activities would be performed away from areas of known contamination. Impacts to non-involved workers (from other onsite activities) are expected to bound potential air quality impacts to construction workers. Impacts from industrial accidents during construction are discussed in Section 5.11.1.2.3.

The construction activities may involve emission of criteria pollutants from the use of combustion engines and earthmoving activities. The potential impacts from these activities are described in Section 5.2 and are summarized here. Impacts are measured by comparing air concentrations at the point of maximum potential public exposure. The analysis indicated that emissions of criteria pollutants (including sulfur dioxide, carbon monoxide, nitrogen dioxide, and PM_{10}) from construction activities would result in air concentrations below the regulatory limits. As a consequence, no health impacts would be expected from these emissions.

5.11.1.2.2 Normal Operations

Potential impacts to public health from normal operations include air quality impacts from atmospheric releases of radionuclides and chemicals from waste operations. Long-term impacts from releases to groundwater from LLBGs are discussed in Sections 5.11.2 and 5.3.

Alternative Group B involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere. These operations include waste package verification, treatment, and packaging at WRAP; processing of materials and equipment at the modified T Plant Complex; treatment and processing of waste in the new waste processing facility; and treatment of leachate from MLLW trenches using pulse driers. Annual releases have been estimated for each year of operation for the facilities involved in this alternative. Details of the release calculations are described in Volume II, Appendix F.

5.11.1.2.2.1 Health Impacts from Routine Radionuclide Releases

The expected doses and health impacts to non-involved workers and the public from routine atmospheric releases of radionuclides are presented in Table 5.54 for the Hanford Only waste volume, Table 5.55 for the Lower Bound waste volume, and in Table 5.56 for the Upper Bound waste volume. The tables present the maximum annual dose to the non-involved workers and the MEI, and the collective dose to the public along with the probability of developing an LCF for the individual and the number of LCFs expected for the public. Given that the cancer risk estimates and doses are small in comparison to regulatory limits,[a] no adverse health impacts would be expected from radionuclide releases.

5.11.1.2.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving release of radionuclides when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere are presented in Table 5.57 for all waste volumes. The results for the Hanford Only waste volume are the same as those for the Lower Bound waste volume because the processing volumes for mixed waste streams are nearly identical for both (only mixed wastes contain chemicals that may be released to the atmosphere). Because all the peak hazard quotients are less than 1, and because the cancer risk estimates are small, no adverse health impacts would be expected from chemical releases.

5.11.1.2.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the alternative as provided the Technical Information Document (FH 2004). The potential radiation exposure to workers for Alternative Group B are summarized in Table 5.58 for the Hanford Only waste volume, in Table 5.59 for the Lower Bound waste volume, and in Table 5.60 for the Upper Bound waste volume. All estimated radiation doses to workers are well below regulatory limits.[b]

(a) The maximum annual radiation dose presented in this section may be compared to the regulatory limit of 10 mrem/year (WAC 246-247; 40 CFR 61; DOE 1993).

(b) The annual limit for occupational exposures is 5000 mrem/year (10 CFR 835).

Table 5.54. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group B, Hanford Only Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Prob. of LCFs[(c)]	Maximum Annual Dose Year	Maximum Annual Dose mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.2E-03	7E-10	2004	1.3E-04
		T Plant Complex	4.8E-01	3E-07	2003	3.9E-02
		NWPF[(d)]	2.8E-02	2E-08	2015	2.0E-03
		Leachate Treatment[(e,f)]	6.9E-08	4E-14	2026	4.9E-09
MEI Offsite	Resident Gardener	WRAP	9.9E-05	6E-11	2004	1.1E-05
		T Plant Complex	1.0E-03	6E-10	2003	7.9E-05
		NWPF	9.7E-04	6E-10	2015	6.7E-05
		Leachate Treatment	2.2E-10	1E-16	2027	1.2E-11
		Total	2.1E-03	1E-09	2003	1.6E-04
			(person-rem)	**Number of LCFs[(g)]**	**Year**	**(person-rem)**
Population[(h)]	Population within 80 km (50 mi)	WRAP	9.1E-03	0 (5E-06)	2004	7.4E-04
		T Plant Complex	9.2E-02	0 (6E-05)	2003	5.5E-03
		NWPF	8.8E-02	0 (5E-05)	2015	4.7E-03
		Leachate Treatment	2.0E-08	0 (1E-11)	2026	8.2E-10
		Total	1.9E-01	0 (1E-04)	2003	1.1E-02

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) NWPF = new waste processing facility.
(e) Leachate treatment is a pulse drier operation.
(f) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(g) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(h) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

Table 5.55. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group B, Lower Bound Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Prob. of LCFs[(c)]	Maximum Annual Dose	
					Year	Mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-03	9E-10	2004	1.6E-04
		T Plant Complex	5.8E-01	3E-07	2003	4.8E-02
		NWPF[(d)]	2.8E-02	2E-08	2015	2E-03
		Leachate Treatment[(e,f)]	5.0E-07	3E-13	2026	2.8E-08
MEI Offsite	Resident Gardener	WRAP	1.2E-04	7E-11	2004	1.3E-05
		T Plant Complex	1.2E-03	7E-10	2003	9.5E-05
		NWPF	9.7E-04	6E-10	2015	6.7E-05
		Leachate Treatment	2.6E-10	2E-16	2027	1.4E-11
		Total	2.3E-03	1E-09	2003	1.8E-04
			(person-rem)	Number of LCFs[(g)]	Year	(person-rem)
Population[(h)]	Population within 80 km (50 mi)	WRAP	1.1E-02	0 (6E-06)	2004	8.8E-04
		T Plant Complex	1.1E-01	0 (7E-05)	2003	6.7E-03
		NWPF	8.8E-02	0 (5E-05)	2015	4.7E-03
		Leachate Treatment	2.3E-08	0 (1E-11)	2026	9.6E-10
		Total	2.1E-01	0 (1E-04)	2003	1.3E-02

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) NWPF = new waste processing facility.
(e) Leachate treatment is a pulse drier operation.
(f) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(g) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(h) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

Table 5.56. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group B, Upper Bound Waste Volume

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose[b] (mrem)	Prob. of LCFs[c]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	2.2E-03	1E-09	2004	1.9E-04
		T Plant Complex	8.9E-01	5E-07	2006	7.2E-02
		NWPF[d]	2.8E-02	2E-08	2015	2.0E-03
		Leachate Treatment[e,f]	8.4E-07	5E-13	2026	4.7E-08
MEI Offsite	Resident Gardener	WRAP	2.1E-04	1E-10	2004	1.6E-05
		T Plant Complex	2.0E-03	1E-09	2006	1.5E-04
		NWPF	9.7E-04	6E-10	2015	6.7E-05
		Leachate Treatment	4.3E-10	3E-16	2026	2.3E-11
		Total	3.2E-03	2E-09	2006	2.3E-04
			Dose (person-rem)	**Number of LCFs[g]**	**Year**	**Dose (person-rem)**
Population[h]	Population within 80 km (50 mi)	WRAP	2.0E-02	0 (1E-05)	2004	1.1E-03
		T Plant Complex	1.8E-01	0 (1E-04)	2006	1.0E-02
		NWPF	8.8E-02	0 (5E-05)	2015	4.7E-03
		Leachate Treatment	3.9E-08	0 (2E-11)	2026	1.9E-09
		Total	2.9E-01	0 (2E-04)	2006	1.6E-02

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) NWPF = new waste processing facility.
(e) Leachate treatment is a pulse drier operation.
(f) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(g) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(h) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

Table 5.57. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Chemicals – Alternative Group B, All Waste Volumes

Volume	Exposed Group	Exposure Scenario[a]	Facility	Risk of Cancer Incidence[b]	Peak Annual Hazard Quotient[c]
Hanford Only and Lower Bound	Worker Onsite (non-involved)	Industrial	WRAP	1.2E-09	8.9E-05
			T Plant Complex	3.2E-08	2.3E-03
			NWPF[d]	1.7E-07	9.1E-03
	MEI Offsite	Resident Gardener	WRAP	5.6E-11	3.4E-06
			T Plant Complex	3.3E-11	2.0E-06
			NWPF	6.9E-09	3.7E-04
			Total	7.0E-09	3.8E-04
	Population	Population within 80 km (50 mi)	WRAP	0 (5.0E-06)[e]	NA[f, g]
			T Plant Complex	0 (3.0E-06)[e]	NA
			NWPF	0 (6.0E-04)[e]	NA
			Total	0 (6.0E-04)[e]	NA
Upper Bound	Worker Onsite (non-involved)	Industrial	WRAP	5.3E-09	6.9E-04
			T Plant Complex	1.8E-07	2.4E-02
			NWPF	1.7E-07	9.1E-03
	MEI Offsite	Resident Gardener	WRAP	2.3E-10	2.5E-05
			T Plant Complex	1.7E-10	2.0E-05
			NWPF	6.9E-09	3.7E-04
			Total	7.3E-09	4.2E-04
	Population	Population within 80 km (50 mi)	WRAP	0 (2.0E-05)[e]	NA[f, g]
			T Plant Complex	0 (2.0E-05)[e]	NA
			NWPF	0 (6.0E-04)[e]	NA
			Total	0 (7.0E-04)[e]	NA

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The individual risk of cancer incidence is evaluated for the exposure duration defined for the given exposure scenario starting in the year that provides the highest total impact.
(c) Hazard quotients are reported for the year of highest exposure.
(d) NWPF = new waste processing facility.
(e) Population risk from cancer is expressed as the inferred number of fatal and non-fatal cancers in the exposed population over the lifetime of the population from intakes during the remediation period. The actual value must be a whole number (cancers).
(f) Hazard quotients are designed as a measure of impacts on an individual and are not meaningful for population exposures.
(g) NA = not applicable.

Table 5.58. Occupational Radiation Exposure – Alternative Group B, Hanford Only Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCFs[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.1	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	20	13	1.9	0 (1E-03)
T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (4E-03)
New Waste Processing Facility	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	7.6	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[(d)]	2.8	54	8.0	0 (5E-03)
Total					772	0 (4.6E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.59. Occupational Radiation Exposure – Alternative Group B, Lower Bound Waste Volume

Facility	Operating Period	Worker Category[a]	Workers (FTE)[b]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCFs[c]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[e]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.1	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	20	13	1.9	0 (1E-03)
T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (4E-03)
New Waste Processing Facility	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[f]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	7.6	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[d]	3.3	54	9.4	0 (6E-03)
Total					773	0 (4.6E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.60. Occupational Radiation Exposure – Alternative Group B, Upper Bound Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCFs[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
New Waste Processing Facility	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	20	34	12	0 (7E-03)
		RCT	13	35	8.2	0 (5E-03)
	2020–2026	Operator	7	34	1.7	0 (1E-03)
		RCT	5	35	1.2	0 (7E-04)
	2027–2044	Operator	3	34	1.8	0 (1E-03)
		RCT	2	35	1.3	0 (8E-04)
Pulse Driers	2026–2077	Operator[(d)]	5.6	54	16	0 (9E-03)
Total					786	0 (4.7E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

5.11.1.2.3 Accidents

The impacts of accidents involving radiological and chemical contaminants and industrial accidents are evaluated in this section. The impacts of these accidents are expected to bound impacts of events that could be initiated by malevolent intent. Continuing waste management operations under Alternative Group B would involve a continuing potential for accidental release that would be very similar to those discussed for Alternative Group A in four Hanford facilities: the CWC for waste storage, the WRAP for waste treatment, the modified T Plant Complex for waste treatment, and the HSW disposal facilities for waste disposal. Alternative Group B also adds a new treatment facility, the new waste processing facility, for which potential health impacts from accidents were evaluated. Health and safety impacts from industrial accidents would differ only slightly from Alternative Group A from construction activities for the new waste processing facility and LLBGs under Alternative Group B.

Anticipated health impacts to all workers from industrial accidents during construction and operations would be 640 to 660 total recordable cases, 260 to 270 lost workday cases, and 9000 to 9300 lost workdays. A total of about 20,800 to 21,400 worker-years would be required to complete all activities. Of these worker-years about 2800 to 3400 are site support and waste generator-paid workers that do not appear in the direct facility worker and impact estimates in the following sections. About 94 to 97 percent of these health impacts are from operations.

5.11.1.2.3.1 Storage – CWC

Potential radiological, non-radiological, and industrial accidents and impacts for the CWC would be the same as for Alternative Group A (see Section 5.11.1.1.3.1).

5.11.1.2.3.2 Treatment – WRAP

Potential radiological, non-radiological, and industrial accidents and impacts for the WRAP would be the same as for Alternative Group A (see Section 5.11.1.1.3.2).

5.11.1.2.3.3 Treatment – T Plant Complex

Potential radiological, non-radiological, and industrial accidents and impacts for continuing the existing T Plant activities are described under Alternative Group A (see Section 5.11.1.1.3.3).

5.11.1.2.3.4 Treatment – New Waste Processing Facility

The DOE would construct a new waste processing treatment facility in the 200 West Area to augment existing capabilities for treatment of contact-handled (CH) MLLW. DOE would provide onsite treatment for CH MLLW at this facility in addition to non-standard, remote-handled (RH) MLLW and TRU waste.

Radiological consequences. Radiological consequences of accidents would be the same as those described for the modified T Plant Complex described under Alternative Group A (see Section 5.11.1.1.3.3).

Non-radiological (chemical) consequences. Non-radiological consequences for the new waste processing facility have not been evaluated in detail. However, potential non-radiological impacts from accidents in the WRAP and the modified T Plant Complex are expected to be representative of potential impacts from the new waste processing facility. Potential impacts from accidents in the CWC and LLBGs would likely be bounding for accidents in the new waste processing facility.

Industrial accidents – construction. Direct employment for the new waste processing facility construction would total 278 worker-years. The estimated health and safety impacts would be 23 total recordable cases, 8 lost workday cases, and 150 lost workdays.

Industrial accidents – operations. Alternative Group B direct operations staffing in the new waste processing facility would be the same as described for the modified T Plant Complex under Alternative Group A (see Section 5.11.1.1.3.3).

5.11.1.2.3.5 Disposal – HSW Disposal Facilities

Potential radiological and non-radiological (chemical) accidents and impacts for the HSW disposal facilities under Alternative Group B would be the same as for Alternative Group A. Industrial accidents are discussed below.

Industrial accidents – construction. Slightly more impacts would be expected for LLBG construction under Alternative Group B than under Alternative Group A and would require 54 to 83 worker-years. The estimated health and safety impacts would be 4 to 6 total recordable cases, 1 to 2 lost workday cases, and 24 to 41 lost workdays.

Industrial accidents – operations. Industrial accidents from LLBG operations would be the same as for Alternative Group A (see Section 5.11.1.1.3.4).

ILAW industrial accidents. Industrial accidents from ILAW trench construction, operations, and closure would be the same as for Alternative Group A (see Section 5.11.1.1.3.4).

5.11.1.3 Alternative Group C

Alternative Group C is similar to Alternative Group A except for the disposal location of some of the waste streams. See Section 5.0 for a summary of the characteristics for this alternative.

5.11.1.3.1 Construction

Primary impacts from construction activities would be air quality and injuries to construction workers. The construction activities would result in the emission of criteria pollutants, as identified in (40 CFR 50) from the use of combustion engines and earthmoving activities. Impacts are measured by comparison of air concentrations with regulatory limits at the point of maximum potential public exposure. The air quality analysis (Section 5.2) indicates that maximum emissions of all criteria pollutants (including sulfur dioxide, carbon monoxide, nitrogen dioxide, and PM_{10}) from construction activities would result in air concentrations below the regulatory limits. As a consequence, no impacts on public health from emissions would be expected. Impacts from industrial accidents during construction are discussed in Section 5.11.1.3.3.

5.11.1.3.2 Normal Operations

Potential impacts to public health from normal operations include air quality impacts from atmospheric releases of radionuclides and chemicals from waste operations. Long-term impacts from releases to groundwater from LLBGs are discussed in Sections 5.11.2 and 5.3.

Alternative Group C involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere and are the same operations as for Alternative Group A. These operations include waste package verification, treatment, and packaging at the WRAP; treatment and packaging of waste at the modified T Plant Complex; and treatment of leachate from MLLW trenches using pulse driers. The annual releases have been estimated for each year of operation for the facilities involved in this alternative. Details of the release calculations are presented in Volume II, Appendix F, Section F.1.

5.11.1.3.2.1 Health Impacts from Routine Radionuclide Releases

The expected doses and health impacts to non-involved workers and public from routine atmospheric releases of radionuclides are presented in Table 5.61 for the Hanford Only waste volume, Table 5.62 for the Lower Bound waste volume, and in Table 5.63 for the Upper Bound waste volume. The tables present the maximum annual dose to the non-involved workers and the MEI, the collective dose to public along with the probability of developing an LCF for the individual, and the number of LCFs expected for the public. Given that the cancer risk estimates and doses are small in comparison to regulatory limits,[a] no adverse health impacts would be expected from radionuclide releases.

5.11.1.3.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving release of radionuclides when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere for Alternative Group C are the same as for Alternative Group A, as presented in Table 5.36 for all waste volumes. The results are the same because the same processing and atmospheric releases occur for both alternative groups. Because all the peak hazard quotients are less than 1, and because the cancer risk estimates are small, no adverse health impacts would be expected from chemical releases.

5.11.1.3.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the alternative, as provided in the Technical Information

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(a) The maximum annual radiation dose presented in this section may be compared to the regulatory limit of 10 mrem/year (WAC 246-247; 40 CFR 61; DOE 1993).

Table 5.61. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group C, Hanford Only Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of LCFs[(c)]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.2E-03	7E-10	2004	1.3E-04
		Modified T Plant Complex	4.8E-01	3E-07	2003	3.9E-02
		Leachate Treatment[(d,e)]	5.8E-08	3E-14	2026	3.2E-09
MEI Offsite	Resident Gardener	WRAP	9.9E-05	6E-11	2004	1.1E-05
		Modified T Plant Complex	1.5E-03	9E-10	2003	1.1E-04
		Leachate Treatment	3.0E-11	2E-17	2026	1.6E-12
		Total	1.6E-03	1E-09	2003	1.2E-04
			(person-rem)	**Number of LCFs[(f)]**	**Year**	**(person-rem)**
Population[(g)]	Population within 80 km (50 mi)	WRAP	9.1E-03	0 (5E-06)	2004	7.4E-04
		Modified T Plant Complex	1.4E-01	0 (8E-05)	2003	7.4E-03
		Leachate Treatment	2.7E-09	0 (2E-12)	2026	1.1E-10
		Total	1.5E-01	0 (9E-05)	2003	8.1E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

Document (FH 2004). The potential radiation exposure to workers for Alternative Group C are summarized in Table 5.64 for the Hanford Only waste volume, in Table 5.65 for the Lower Bound waste volume, and in Table 5.66 for the Upper Bound waste volume. The results are very similar to the Alternative Group A results except for pulse drier treatment of leachate. All estimated radiation doses to workers are well below regulatory limits.[(a)]

5.11.1.3.3 Accidents

Potential impacts of accidents under Alternative Group C would be identical to those described for Alternative Group A (see Section 5.11.1.1.3).

(a) The annual limit for occupational exposures is 5000 mrem/year (10 CFR 835).

Table 5.62. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group C, Lower Bound Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of LCFs[(c)]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-03	9E-10	2004	1.6E-04
		Modified T Plant Complex	5.8E-01	3E-07	2003	4.8E-02
		Leachate Treatment[(d,e)]	6.0E-08	4E-14	2026	3.3E-09
MEI Offsite	Resident Gardener	WRAP	1.2E-04	7E-11	2004	1.3E-05
		Modified T Plant Complex	1.7E-03	1E-09	2003	1.2E-04
		Leachate Treatment	3.1E-11	2E-17	2026	1.6E-12
		Total	1.8E-03	1E-09	2003	1.3E-04
			(person-rem)	**Number of LCFs[(f)]**	**Year**	**(person-rem)**
Population[(g)]	Population within 80 km (50 mi)	WRAP	1.1E-02	0 (6E-06)	2004	8.8E-04
		Modified T Plant Complex	1.6E-01	0 (9E-05)	2003	8.5E-03
		Leachate Treatment	2.8E-09	0 (2E-12)	2026	1.2E-10
		Total	1.7E-01	0 (1E-04)	2003	9.4E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

5.11.1.4 Alternative Group D

Alternative Group D is similar to Alternative Group A except for the disposal location of some of the waste streams. See Section 5 for a summary of the characteristics for the three subalternatives (D_1, D_2, and D_3) to this alternative group.

5.11.1.4.1 Construction

Primary impacts from construction activities would be air quality and injuries to construction workers. The construction activities would result in the emission of criteria pollutants (40 CFR 50) from the use of combustion engines and earthmoving activities. Impacts are measured by comparison of air concentrations with regulatory limits at the point of maximum potential public exposure. The air quality analysis (Section 5.2) indicates that maximum emissions of all criteria pollutants (including sulfur dioxide, carbon monoxide, nitrogen dioxide, and PM_{10}) from construction activities would result in air

Table 5.63. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group C, Upper Bound Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of LCFs[(c)]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	2.2E-03	1E-09	2004	1.9E-04
		Modified T Plant Complex	8.9E-01	5E-07	2006	7.2E-02
		Leachate Treatment[(d,e)]	1.2E-07	7E-14	2026	6.7E-09
MEI Offsite	Resident Gardener	WRAP	2.1E-04	1E-10	2004	1.6E-05
		Modified T Plant Complex	2.3E-03	1E-09	2006	1.7E-04
		Leachate Treatment	6.2E-11	4E-17	2026	3.3E-12
		Total	2.5E-03	1E-09	2006	1.9E-04
			(person-rem)	Number of LCFs[(f)]	Year	(person-rem)
Population[(g)]	Population within 80 km (50 mi)	WRAP	1.9E-02	0 (1E-05)	2004	1.1E-03
		Modified T Plant Complex	2.2E-01	0 (1E-04)	2006	1.5E-02
		Leachate Treatment	5.6E-09	0 (3E-12)	2026	2.3E-10
		Total	2.4E-01	0 (1E-04)	2006	1.6E-02

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

concentrations below the regulatory limits. As a consequence, no impacts on public health from emissions would be expected. Impacts from industrial accidents during construction are discussed in Section 5.11.1.4.3.

5.11.1.4.2 Normal Operations

Potential impacts to public health from normal operations include air quality impacts from atmospheric releases of radionuclides and chemicals from waste operations. Long-term impacts from releases to groundwater from LLBGs are discussed in Sections 5.11.2 and 5.3.

Alternative Group D involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere and are the same as operations for Alternative Group A. These operations include waste package verification, treatment, and packaging at the WRAP; treatment and packaging of waste at the modified T Plant Complex; and treatment of leachate from MLLW trenches using pulse

Table 5.64. Occupational Radiation Exposure – Alternative Group C, Hanford Only Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (1E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	8	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[(d)]	0.4	54	1.1	0 (7E-04)
Total					765	0 (5E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.65. Occupational Radiation Exposure – Alternative Group C, Lower Bound Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	8	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[(d)]	0.4	54	1.1	0 (7E-04)
Total					765	0 (5E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.66. Occupational Radiation Exposure – Alternative Group C, Upper Bound Waste Volume

Facility	Operating Period	Worker Category[a]	Workers (FTE)[b]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[c]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[e]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	32	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.5	0 (3E-03)
		RCT	18	13	7.4	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[f]	2002–2019	Operator	20	34	12	0 (7E-03)
		RCT	13	35	8.2	0 (5E-03)
	2020–2026	Operator	7	34	1.7	0 (1E-03)
		RCT	5	35	1.2	0 (7E-04)
	2027–2044	Operator	3	34	1.8	0 (1E-03)
		RCT	2	35	1.3	0 (8E-04)
Pulse Driers	2026–2077	Operators[d]	0.8	54	2.2	0 (1E-03)
Total					773	0 (5E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

driers. The annual releases have been estimated for each year of operation for the facilities involved in this alternative. Details of the release calculations are presented in Volume II, Appendix F, Section F.1.

5.11.1.4.2.1 Health Impacts from Routine Radionuclide Releases

The expected doses and health impacts to non-involved workers and public from routine atmospheric releases of radionuclides are presented in Table 5.67 for the Hanford Only waste volume, Table 5.68 for the Lower Bound waste volume, and in Table 5.69 for the Upper Bound waste volume. The tables present the maximum annual dose to the non-involved workers and the MEI, and the collective dose to the public along with the probability of developing an LCF for the individual and the number of LCFs expected for the public. Given that the cancer risk estimates and doses are small in comparison to regulatory limits,[(a)] no adverse health impacts would be expected from radionuclide releases.

Table 5.67. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group D, Hanford Only Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of LCFs[(c)]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.2E-03	7E-10	2004	1.3E-04
		Modified T Plant Complex	4.8E-01	3E-07	2003	3.9E-02
		Leachate Treatment[(d,e)]	1.5E-07	9E-14	2026	8.2E-09
MEI Offsite	Resident Gardener	WRAP	9.9E-05	6E-11	2004	1.1E-05
		Modified T Plant Complex	1.5E-03	9E-10	2003	1.1E-04
		Leachate Treatment	7.6E-11	5E-17	2026	4.0E-12
		Total	1.6E-03	1E-09	2003	1.2E-04
			(person-rem)	Number of LCFs[(f)]	Year	(person-rem)
Population[(g)]	Population within 80 km (50 mi)	WRAP	9.1E-03	0 (5E-06)	2004	7.4E-04
		Modified T Plant Complex	1.4E-01	0 (8E-05)	2003	7.4E-03
		Leachate Treatment	6.9E-09	0 (4E-12)	2026	2.8E-10
		Total	1.5E-01	0 (9E-05)	2003	8.1E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

(a) The maximum annual radiation dose presented in this section may be compared to the regulatory limit of 10 mrem/year (WAC 246-247; 40 CFR 61; DOE 1993).

Table 5.68. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group D, Lower Bound Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of LCFs[(c)]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-03	9E-10	2004	1.6E-04
		Modified T Plant Complex	5.8E-01	3E-07	2003	4.8E-02
		Leachate Treatment[(d,e)]	1.7E-07	1E-13	2026	9.1E-09
MEI Offsite	Resident Gardener	WRAP	1.2E-04	7E-11	2004	1.3E-05
		Modified T Plant Complex	1.7E-03	1E-09	2003	1.2E-04
		Leachate Treatment	8.5E-11	5E-17	2026	4.5E-12
		Total	1.8E-03	1E-09	2003	1.3E-04
			(person-rem)	**Number of LCFs[(f)]**	**Year**	**(person-rem)**
Population[(g)]	Population within 80 km (50 mi)	WRAP	1.1E-02	0 (6E-06)	2004	8.8E-04
		Modified T Plant Complex	1.6E-01	0 (9E-05)	2003	8.5E-03
		Leachate Treatment	7.7E-09	0 (5E-12)	2026	3.2E-10
		Total	1.7E-01	0 (1E-04)	2003	9.4E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

Table 5.69. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – Alternative Group D, Upper Bound Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of LCFs[(c)]	Maximum Annual Dose Year	Maximum Annual Dose mrem
Worker Onsite (non-involved)	Industrial	WRAP	2.2E-03	1E-09	2004	1.9E-04
		Modified T Plant Complex	8.9E-01	5E-07	2006	7.2E-02
		Leachate Treatment[(d,e)]	3.7E-07	2E-13	2026	2.1E-09
MEI Offsite	Resident Gardener	WRAP	2.1E-04	1E-10	2004	1.6E-05
		Modified T Plant Complex	2.3E-03	1E-09	2006	1.7E-04
		Leachate Treatment	1.9E-10	1E-16	2026	1.0E-11
		Total	2.5E-03	1E-09	2006	1.9E-04
			(person-rem)	Number of LCFs[(f)]	Year	(person-rem)
Population[(g)]	Population within 80 km (50 mi)	WRAP	1.9E-02	0 (1E-05)	2004	1.1E-03
		Modified T Plant Complex	2.2E-01	0 (1E-04)	2006	1.5E-02
		Leachate Treatment	1.7E-08	0 (1E-11)	2026	7.1E-10
		Total	2.4E-01	0 (1E-04)	2006	1.6E-02

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

5.11.1.4.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving release of radionuclides when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere for Alternative Group D are the same as for Alternative Group A, as presented in Table 5.25 for all waste volumes. The results are the same because the same processing and atmospheric releases occur for both alternative groups. Because all the peak hazard quotients are less than 1, and because the cancer risk estimates are small, no adverse health impacts would be expected from chemical releases.

5.11.1.4.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the alternative, as provided in the Technical Information Document (FH 2004). The potential radiation exposure to workers for Alternative Group D are summarized in Table 5.70 for the Hanford Only waste volume, in Table 5.71 for the Lower Bound waste volume, and in Table 5.72 for the Upper Bound waste volume. The results are very similar to the Alternative Group A results except for pulse drier treatment of leachate. All estimated radiation doses to workers are well below regulatory limits.[a]

5.11.1.4.3 Accidents

Potential impacts of accidents under Alternative Group D would be identical to those described for Alternative Group A (see Section 5.11.1.1.3).

5.11.1.5 Alternative Group E

Alternative Group E is similar to Alternative Groups A and D except for the disposal location of some of the waste streams. See Section 5 for a summary of the characteristics for the three subalternatives (E_1, E_2, and E_3) to this alternative group.

5.11.1.5.1 Construction

Primary impacts from construction activities would be air quality and injuries to construction workers. The construction activities would result in the emission of criteria pollutants (40 CFR 50) from the use of combustion engines and earthmoving activities. Impacts are measured by comparison of air concentrations with regulatory limits at the point of maximum potential public exposure. The air quality analysis (Section 5.2) indicates that maximum emissions of all criteria pollutants (including sulfur dioxide, carbon monoxide, nitrogen dioxide, and PM_{10}) from construction activities would result in air concentrations below the regulatory limits. As a consequence, no impacts on public health from emissions would be expected. Impacts from industrial accidents during construction are discussed in Section 5.11.1.5.3.

5.11.1.5.2 Normal Operations

Potential impacts to public health from normal operations include air quality impacts from atmospheric releases of radionuclides and chemicals from waste operations. Long-term impacts from releases to groundwater from LLBGs are discussed in Sections 5.11.2 and 5.3.

Alternative Group E involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere and are the same operations as for Alternative Group A. These operations include waste package verification, treatment, and packaging at the WRAP; treatment and packaging of waste at the modified T Plant Complex; and treatment of leachate from MLLW trenches using pulse driers. The annual releases have been estimated for each year of operation for the facilities involved in this alternative. Details of the release calculations are presented in Volume II, Appendix F, Section F.1.

(a) The annual limit for occupational exposures is 5000 mrem/year (10 CFR 835).

Table 5.70. Occupational Radiation Exposure – Alternative Group D, Hanford Only Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate, (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	8	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[(d)]	1.0	54	2.8	0 (2E-03)
Total					767	0 (4.6E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.71. Occupational Radiation Exposure – Alternative Group D, Lower Bound Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	8	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2077	Operator[(d)]	1.1	54	3.1	0 (2E-03)
Total					767	0 (4.6E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.72. Occupational Radiation Exposure – Alternative Group D, Upper Bound Waste Volume

Facility	Operating Period	Worker Category[(a)]	Workers (FTE)[(b)]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCF[(c)]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	104	0 (6E-02)
ILAW	2008–2028	Workers	70	300[(e)]	443	0 (3E-01)
	2032–2046	Workers	20	14	4.1	0 (2E-03)
CWC	2002–2046	Operator	12	54	29	0 (2E-02)
		RCT	4	45	8.6	0 (5E-03)
		Other	55	17	42	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	32	13	1.9	0 (1E-03)
Modified T Plant Complex	2002–2032	Operator	20	9	5.5	0 (3E-03)
		RCT	18	13	7.4	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
	2013–2031	Operator	10	13	2.6	0 (2E-03)
		RCT	10	13	2.4	0 (1E-03)
		Other	20	13	4.9	0 (3E-03)
Generator Staff[(f)]	2002–2019	Operator	20	34	12	0 (7E-03)
		RCT	13	35	8.2	0 (5E-03)
	2020–2026	Operator	7	34	1.7	0 (1E-03)
		RCT	5	35	1.2	0 (7E-04)
	2027–2044	Operator	3	34	1.8	0 (1E-03)
		RCT	2	35	1.3	0 (8E-04)
Pulse Driers	2026–2077	Operators[(d)]	2.5	54	6.9	0 (4E-03)
Total					778	0 (4.7E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

5.11.1.5.2.1 Health Impacts from Routine Radionuclide Releases

The expected doses and health impacts to non-involved workers and public from routine atmospheric releases of radionuclides for the Alternative Group E cases are the same as those for Alternative Group D, as presented in Table 5.67 for the Hanford Only waste volume, Table 5.68 for the Lower Bound waste volume, and in Table 5.69 for the Upper Bound waste volume. The tables present the maximum annual dose to the non-involved workers and the MEI, and the collective dose to public along with the probability of developing an LCF for the individual and the number of LCFs expected for the public. Given that the cancer risk estimates and doses are small in comparison to regulatory limits,[a] no adverse health impacts would be expected from radionuclide releases.

5.11.1.5.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving release of radionuclides when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere for Alternative Group E are the same as for Alternative Group A, as presented in Table 5.25 for all waste volumes. The results are the same because the same processing and atmospheric releases occur for both alternative groups. Because all the peak hazard quotients are less than 1, and because the cancer risk estimates are small, no adverse health impacts would be expected from chemical releases.

5.11.1.5.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the alternative, as provided in the Technical Information Document (FH 2004). The potential radiation exposure to workers for Alternative Group E are the same as those for Alternative Group D as summarized in Table 5.70 for the Hanford Only waste volume, in Table 5.71 for the Lower Bound waste volume, and in Table 5.72 for the Upper Bound waste volume. All estimated radiation doses to workers are well below regulatory limits.[b]

5.11.1.5.3 Accidents

The potential impacts of accidents under Alternative Group E would be identical to those described for Alternative Group A (see Section 5.11.1.1.3).

5.11.1.6 No Action Alternative

Under the No Action Alternative, DOE would continue operation of the waste management facilities and activities that are ongoing at the Hanford Site. Additional storage facilities would be constructed as needed, but no new treatment facilities would be constructed. DOE would continue operation of the WRAP and the modified T Plant Complex. The commercial contracts for thermal treatment and stabilization would be used only at their minimum levels, and the other wastes would remain in storage.

(a) The maximum annual radiation dose presented in this section may be compared to the regulatory limit of 10 mrem/year (WAC 246-247; 40 CFR 61; DOE 1993).

(b) The annual limit for occupational exposures is 5000 mrem/year (10 CFR 835).

With the No Action Alternative, disposal of LLW and MLLW would continue in existing trenches in the LLBGs. New trenches for LLW would be constructed using the current design. When existing MLLW trenches are full, additional MLLW would be stored in an expanded CWC. Only certified TRU waste would be sent to the WIPP. The No Action Alternative provides for continued storage of the wastes through 2046.

5.11.1.6.1 Construction

As part of the No Action Alternative, new construction activities are anticipated at the CWC and the HSW disposal facilities. Additional storage facilities would be constructed at the CWC to meet the needs for expected volumes of TRU waste, continued generation of RH-MLLW, non-standard containers of MLLW, and CH-MLLW. Under this alternative, DOE would continue to dispose of LLW using the existing trenches and new trenches within the HSW disposal facilities.

The primary impacts from construction activities would be to air quality and injury of construction workers. No impacts to construction workers are expected from radiation or chemicals because new construction activities would be performed away from areas of known contamination. Impacts to non-involved workers (from other onsite activities) are expected to bound potential air quality impacts to construction workers. Impacts from industrial accidents during construction are discussed in Section 5.11.1.6.3.

The construction activities would result in the emission of criteria pollutants (40 CFR 50) from the use of combustion engines and earth moving activities. Impacts are measured by comparison of air concentrations at the point of maximum potential public exposure. The air quality analysis (Section 5.2) indicated that all emissions of criteria pollutants (including sulfur oxides, carbon monoxide, nitrogen oxides, and PM_{10}) from construction activities result in air concentrations below regulatory limits. As a consequence, no health impacts would be expected from these emissions.

5.11.1.6.2 Normal Operations

Potential impacts to public health from normal operations include air quality impacts from atmospheric releases of radionuclides and chemicals from waste operations. Long-term impacts from releases to groundwater from LLBGs are discussed in Sections 5.11.2 and 5.3.

The No Action Alternative involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere. These operations include waste package verification, treatment, and packaging at the WRAP; processing of materials and equipment at the modified T Plant Complex; and treatment of leachate from MLLW trenches using pulse driers. The annual releases have been estimated for each year of operation for the facilities involved in the No Action Alternative. Details of the release calculations are described in Volume II, Appendix F.

5.11.1.6.2.1 Health Impacts from Routine Radionuclide Releases

The calculated doses and health impacts to non-involved workers and public from routine atmospheric releases of radionuclides are presented in Table 5.73 for the Hanford Only waste volume and in Table 5.74 for the Lower Bound waste volume. The tables present the maximum annual dose to the non-involved workers and the public, the collective dose to the public, and the associated risk of LCF for the exposures that occur during the period covered by the No Action Alternative. Given that the cancer risk estimates and doses are small in comparison to regulatory limits,[(a)] no adverse health impacts would be expected from radionuclide releases.

Table 5.73. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – No Action Alternative, Hanford Only Waste Volume

Exposed Group	Exposure Scenario[(a)]	Facility	Lifetime Dose[(b)] (mrem)	Probability of an LCFs[(c)]	Maximum Annual Dose Year	Maximum Annual Dose (mrem)
Worker Onsite (non-involved)	Industrial	WRAP	1.2E-03	7E-10	2004	1.3E-04
		T Plant Complex	4.8E-01	3E-07	2003	3.9E-02
		Leachate Treatment[(d,e)]	2.1E-08	2E-14	2029	3.7E-09
MEI Offsite	Resident Gardener	WRAP	9.9E-05	6E-11	2004	1.1E-05
		T Plant Complex	1.0E-03	6E-10	2003	7.9E-05
		Leachate Treatment	1.1E-11	6E-18	2029	1.8E-12
		Total	1.1E-03	7E-10	2003	8.9E-05
			(person-rem)	**Number of LCFs[(f)]**	**Year**	**(person-rem)**
Population[(g)]	Population within 50 mi. (80 km)	WRAP	9.1E-03	0 (5E-06)	2004	7.4E-04
		T Plant Complex	9.2E-02	0 (6E-05)	2003	5.5E-03
		Leachate Treatment	9.5E-10	0 (6E-13)	2029	1.3E-10
		Total	1.0E-01	0 (6E-05)	2003	6.3E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

(a) The maximum annual radiation dose presented in this section may be compared to the regulatory limit of 10 mrem/year (WAC 246-247; 40 CFR 61; DOE 1993).

Table 5.74. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides – No Action Alternative, Lower Bound Waste Volume

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose[b] (mrem)	Probability of an LCFs[c]	Maximum Annual Dose Year	Maximum Annual Dose (mrem)
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-03	9E-10	2004	1.6E-04
		T Plant Complex	5.8E-01	3E-07	2003	4.8E-02
		Leachate Treatment[d,e]	2.1E-08	2E-14	2029	3.7E-09
MEI Offsite	Resident Gardener	WRAP	1.2E-04	7E-11	2004	1.3E-05
		T Plant Complex	1.2E-03	7E-10	2003	9.5E-05
		Leachate Treatment	1.1E-11	6E-18	2029	1.8E-12
		Total	1.3E-03	8E-10	2003	1.1E-04
			(person-rem)	**Number of LCFs[f]**	**Year**	**(person-rem)**
Population[g]	Population within 50 mi. (80 km)	WRAP	1.1E-02	0 (6E-06)	2004	8.8E-04
		T Plant Complex	1.1E-01	0 (7E-05)	2003	6.7E-03
		Leachate Treatment	9.5E-10	0 (6E-13)	2029	1.3E-10
		Total	1.2E-01	0 (7E-05)	2003	7.6E-03

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener, 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The lifetime dose is the radiation dose received from intake during the exposure period and up to 50 years after exposure due to radionuclides deposited in the body during the exposure period.
(c) LCF = latent cancer fatality.
(d) Leachate treatment is a pulse drier operation.
(e) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in this table.
(f) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(g) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.

Potential impacts to public health from normal operations include impacts from atmospheric releases of radionuclides and chemicals from waste operations. Radiation dose to workers involved with waste operations is also evaluated.

5.11.1.6.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving radionuclide release when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere are presented in Table 5.75. The results for the Hanford Only waste volume are the same as those for the Lower Bound waste volume because the processing volumes for mixed waste streams are nearly identical for both cases (only mixed wastes contain chemicals that may be released to the atmosphere). Given that the peak hazard quotients are all less than 1, and because the cancer risk estimates are small, no adverse health impacts would be expected from chemical releases.

Table 5.75. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Chemicals – No Action Alternative

Exposed Group	Exposure Scenario[a]	Facility	Risk of Cancer Incidence[b]	Peak Annual Hazard Quotient[c]
Worker Onsite (non-involved)	Industrial	WRAP	1.2E-09	8.9E-05
		T Plant Complex	3.2E-08	2.3E-03
MEI Offsite	Resident Gardener	WRAP	5.6E-11	3.4E-06
		T Plant Complex	3.3E-11	2.0E-06
		Total	8.9E-11	5.3E-06
Population	Population within 50 mi. (80 km)	WRAP	0 (5.0E-06)[d]	NA[e,f]
		T Plant Complex	0 (3.0E-06)[d]	NA
		Total	0 (8.0E-06)[d]	NA

(a) The exposure duration for the industrial scenario is 20 years and for the resident gardener 30 years. The exposure scenarios are described in Volume II, Appendix F.
(b) The individual risk of cancer incidence is evaluated for the exposure duration defined for the given exposure scenario starting in the year that provides the highest total impact.
(c) Hazard quotients are reported for the year of highest exposure.
(d) Population risk from cancer is expressed as the inferred number of fatal and non-fatal cancers in the exposed population over the lifetime of the population from intakes during the remediation period. The actual value must be a whole number (cancers).
(e) Hazard quotients are designed as a measure of impacts on an individual and are not meaningful for population exposures.
(f) NA = not applicable.

5.11.1.6.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the No Action Alternative, as provided in the Technical Information Document (FH 2004). The exposure to involved workers is summarized in Table 5.76 for the Hanford Only waste volume. The estimated impacts are the same for the Hanford Only waste volume and the Lower Bound waste volume because the labor requirements are essentially the same. The worker category "Other" includes engineers, maintenance personnel, and general support staff (for example, administrative and clerical workers). All estimated radiation doses to workers are well below regulatory limits.[a]

5.11.1.6.3 Accidents

The impacts of accidents involving radiological and chemical contaminants and industrial accidents are evaluated in this section. The impacts of these accidents are expected to bound impacts of events that could be initiated by malevolent intent. Continuing waste management operations under the No Action Alternative would involve a continuing potential for accidental release that would be very similar to those discussed for Alternative Group A in four Hanford facilities: the CWC for waste storage, the WRAP for

(a) The annual limit for occupational exposures is 5000 mrem/year (10 CFR 835).

Table 5.76. Occupational Radiation Exposure – No Action Alternative, Hanford Only Waste Volume

Facility	Operating Period	Worker Category[a]	Workers (FTE)[b]	Average Dose Rate (mrem/yr)	Workforce Dose (person-rem)	Workforce LCFs[c]
LLW and MLLW Trenches	2002–2046	Operator	14	54	34	0 (2E-02)
		RCT	4	45	8.5	0 (5E-03)
		Other	66	35	103	0 (6E-02)
ILAW	2008–2028	Workers	52	300[e]	422	0 (3E-01)
	2032–2046	Workers	37	14	5.2	0 (3E-03)
CWC	2002–2008	Operator	12	54	4.5	0 (3E-03)
		RCT	4	45	1.3	0 (8E-04)
		Other	55	17	6.5	0 (4E-03)
	2009–2032	Operator	30	54	39	0 (2E-02)
		RCT	10	45	11	0 (7E-03)
		Other	140	17	57	0 (3E-02)
	2033–2046	Operator	48	54	36	0 (2E-02)
		RCT	17	45	11	0 (6E-03)
		Other	218	17	52	0 (3E-02)
WRAP	2002–2032	Operator	13	18	7.3	0 (4E-03)
		RCT	9	36	10	0 (6E-03)
		Other	29	13	12	0 (7E-03)
	2033–2039	Operator	9	18	1.2	0 (7E-04)
		RCT	6	36	1.6	0 (1E-03)
		Other	21	13	1.9	0 (1E-03)
T Plant Complex	2002–2032	Operator	20	9	5.6	0 (3E-03)
		RCT	18	13	7.3	0 (4E-03)
		Other	38	7	8.2	0 (5E-03)
	2033–2046	Operator	14	9	1.7	0 (1E-03)
		RCT	13	13	2.3	0 (1E-03)
		Other	27	7	2.6	0 (2E-03)
Generator Staff[f]	2002–2019	Operator	15	34	9.2	0 (6E-03)
		RCT	12	35	7.6	0 (5E-03)
	2020–2026	Operator	5	34	1.2	0 (7E-04)
		RCT	3	35	0.7	0 (4E-04)
	2027–2044	Operator	1	34	0.6	0 (4E-04)
		RCT	1	35	0.6	0 (4E-04)
Pulse Driers	2026–2039	Operator[d]	0.5	54	0.5	0 (8E-04)
Total					873	1 (5.2E-01)

(a) RCT = radiation control technician.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) LCF = latent cancer fatality. Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Operators are provided by contract with the vendor operating the pulse drier unit. Radiological monitoring (RCT) resources are included with the RCT resources for LLW/MLLW trenches.
(e) The dose rates for placement of ILAW into disposal facilities are higher than for other solid waste management operations because the material emits more radiation.
(f) Staff in the solid waste support services group that work as needed in various solid waste facilities.

waste treatment, the modified T Plant Complex also for waste treatment, and the LLBGs for waste disposal. Potential radiological impacts of accidents from ILAW disposal would be somewhat lower than other alternatives.

Potential health impacts to workers from industrial accidents would be the same as Alternative Group A for treatment activities in the WRAP and are not discussed further. Differences would be expected for the CWC, modified T Plant Complex, and LLBGs (including ILAW disposal) and are discussed below.

Anticipated health impacts to all workers from industrial accidents during construction and operations would be 770 total recordable cases, 320 lost workday cases, and 10,900 lost workdays. A total of about 25,700 worker-years would be required to complete all activities. Of these worker-years, about 2600 are site support and waste generator-paid workers that do not appear in the direct facility worker and impact estimates in the following sections. About 95 to 97 percent of these health impacts are from operations.

5.11.1.6.3.1 Storage – Central Waste Complex

Potential radiological and non-radiological accidents and impacts for the CWC under the No Action Alternative would be similar to those for Alternative Group A (see Section 5.11.1.1.3.1) but also include two cases of a melter drop accident (filtered and unfiltered) shown in Table 5.77. Accidents described under Alternative Group A, which also apply to the No Action Alternative, have higher estimated consequences than the melter drop and would bound the consequences of that event.

Industrial Accidents-Construction. Construction of long-term storage buildings at the CWC would require 330 worker-years. The estimated health and safety impacts would be 27 recordable cases, 9 lost workday cases, and 180 lost workdays.

Industrial Accidents-Operations. Direct operations staffing in the CWC would require 8700 worker-years. The estimated health and safety impacts would be 230 recordable cases, 97 lost workday cases, and 3400 lost workdays.

Table 5.77. Radiological Consequences of Melter Storage Accidents at the CWC

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-Involved Worker	
		Dose (rem)	Prob. LCF(a)	Dose (person-rem)	Number LCFs(b)	Dose (rem)	Prob. LCF(a)
HWVP Melter Drop (filtered)	3.1E-04	1.7E-05	1E-08	0.042	0 (3E-05)	4.4E-03	3E-06
HWVP Melter Drop (unfiltered)	3.1E-04	3.5E-02	2E-05	84	0 (5E-02)	8.7E+00	5E-03

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Value indicated in parentheses if less than one fatality estimated.

5.11.1.6.3.2 Treatment – WRAP

Potential radiological, non-radiological, and industrial accidents and impacts for the WRAP under the No Action Alternative would be the same as for Alternative Group A (see Section 5.11.1.1.3.2).

5.11.1.6.3.3 Treatment – Modified T Plant Complex

Potential radiological and non-radiological (chemical) accidents and impacts for modified T Plant Complex under the No Action Alternative would be the same as for the continuing T Plant activities under Alternative Group A (see Section 5.11.1.1.3.3).

Industrial accidents – construction. Under the No Action Alternative, there would be no new construction at the modified T Plant Complex. No construction impacts would occur.

Industrial accidents – operations. Direct operations staffing would be less than either Alternative Group A or Group B, requiring 3100 worker-years. The estimated health and safety impacts would be 82 total recordable cases, 34 lost workday cases, and 1200 lost workdays. These estimates are based on Hanford Site non-construction occupational injury statistics from 1996 through 2000 (see Section 4.9).

5.11.1.6.3.4 Disposal – LLBGs

Under the No Action Alternative, potential radiological and non-radiological accidents and impacts for the LLBGs would be the same as for Alternative Group A except for a radiological accident involving ILAW disposal (see Section 5.11.1.1.3.4). The radiological impact of an accident involving ILAW would involve one ILAW container and, therefore, be about one-sixth of the impacts estimated for the bulldozer accident in Table 5.44. Industrial accidents are discussed below.

Industrial accidents – construction. Construction under the No Action Alternative would require 44 worker-years, slightly less than the lower bound of Alternative Group B but more than Alternative Group A. The estimated health and safety impacts would be 4 total recordable cases, 1 lost workday case, and 24 lost workdays.

Industrial accidents – operations. Industrial accidents from LLBG operations would be the same as Alternative Group A and are not discussed further.

ILAW industrial accidents. Industrial impacts include both construction and operations. A total of about 5,200 worker-years would be required to construct vaults and temporary storage facilities, maintain permanent disposal operations and facilities, and perform closure activities. The estimated health and safety impacts would be about 200 total recordable cases, 84 lost workday cases, and 2900 lost workdays.

5.11.2 Long-Term Human Health and Safety Impacts

This section considers potential impacts on human health over long time periods. The impacts are evaluated for releases to soil and groundwater, with subsequent transport to the Columbia River, and for inadvertent intrusion into the disposal facilities in the absence of institutional controls.

5.11.2.1 Water Pathway Scenarios

The impacts from waterborne pathways are presented in the following sections for each alternative. The results are presented for each waste category as appropriate to each alternative. The impacts from previously disposed of waste are the same for all alternatives and waste volumes because the waste is currently in place and is not planned to be moved under any alternative. The impacts for the previously disposed of waste are presented along with the results for each alternative for completeness of each table. Downstream impacts from material entering the Columbia River are also evaluated.

Releases of radionuclides and chemicals to the unsaturated soil beneath the disposal facilities may occur as the waste packages degrade and water seeps through the waste. The potential sources of groundwater contamination are wastes contained in the disposal facilities, the mixed waste trenches in the 200 East and the 200 West Areas, and, for some alternative groups, the ERDF site southeast of the 200 West Area. These wastes include LLW disposed of before 1970 and during the 1970-1988 time-frame. In addition, LLW categories disposed of after 1988 include Cat 1 wastes, Cat 3 wastes, MLLW, ILAW, and melters from the vitrification processing. Contributions from ILAW are taken from the ILAW performance assessment (Mann et al. 2001).

The estimated health impacts, based on the groundwater analyses, are represented as the radiation dose received by a hypothetical person that might reside on the Hanford Site in the future. Three scenarios were evaluated for use of groundwater: 1) a hypothetical resident gardener, 2) a hypothetical resident gardener with a sauna/sweat lodge exposure pathway, and 3) an individual drinking 2 L of groundwater per day. Details of these exposure scenarios are presented in Volume II, Appendix F. In the following sections, the estimated annual doses for the hypothetical resident gardener scenarios are compared to the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a). The estimated annual drinking water doses may be compared with the DOE benchmark 4-mrem/yr standard for public drinking water systems (DOE 1993). As discussed in Section 5.3, the DOE 4-mrem/yr drinking water standard (as effective dose equivalent) does not correspond exactly to the 4-mrem/yr dose to the total body or maximum organ used to establish the drinking water MCLs in 40 CFR 141.

The groundwater scenarios were evaluated at points along the lines of analysis described in the groundwater transport discussions in Section 5.3.2 and Volume II, Appendix G, Section G.1.1. These lines of analysis are about 1 km (0.6 mi) from disposal facility boundaries in the 200 East and West Areas, about 1 km (0. 6 mi) from the ERDF boundary, and at the locations of peak radionuclide concentration in groundwater near the Columbia River. Because groundwater flows in different directions from the 200 East Area disposal facilities, there are two lines of analysis for the 200 East Area disposal facilities: one northwest (NW) of the 200 East Area LLBGs; the other southeast (SE) of the near-PUREX location. As discussed in the following sections, most of the variation in potential health impacts from using groundwater containing radionuclides resulted from the alternative locations and configurations for new disposal facilities; differences between the Hanford Only and Upper Bound waste volumes were minimal.

Potential long-term health risks to downstream populations using the Columbia River for drinking water were also evaluated over a 10,000-year period following closure of the disposal facilities, and results are presented in the following sections. No health effects were predicted in the these downstream populations for any alternative. However, as with the groundwater scenarios, variation in potential health risks from using Columbia River water downstream of Hanford resulted from the alternative locations and configurations for new disposal facilities; differences in results between the Hanford Only and Upper Bound waste volumes were minimal.

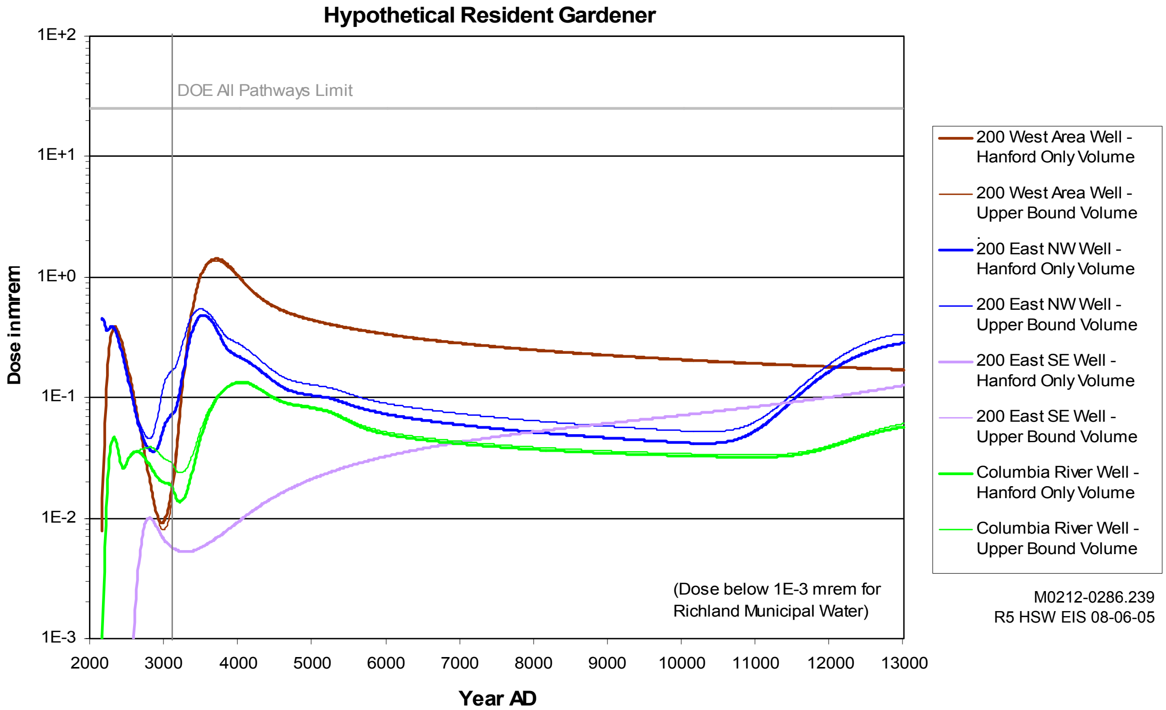
5.11.2.1.1 Alternative Group A

The potential consequences to the MEI are presented in Figure 5.34 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed in the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 9,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.78 for the Hanford Only waste volume, in Table 5.79 for the Lower Bound waste volume, and in Table 5.80 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.81 through 5.84 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, from the 200 East Area (NW), and from the 200 East Area (SE), and near the Columbia River, respectively.



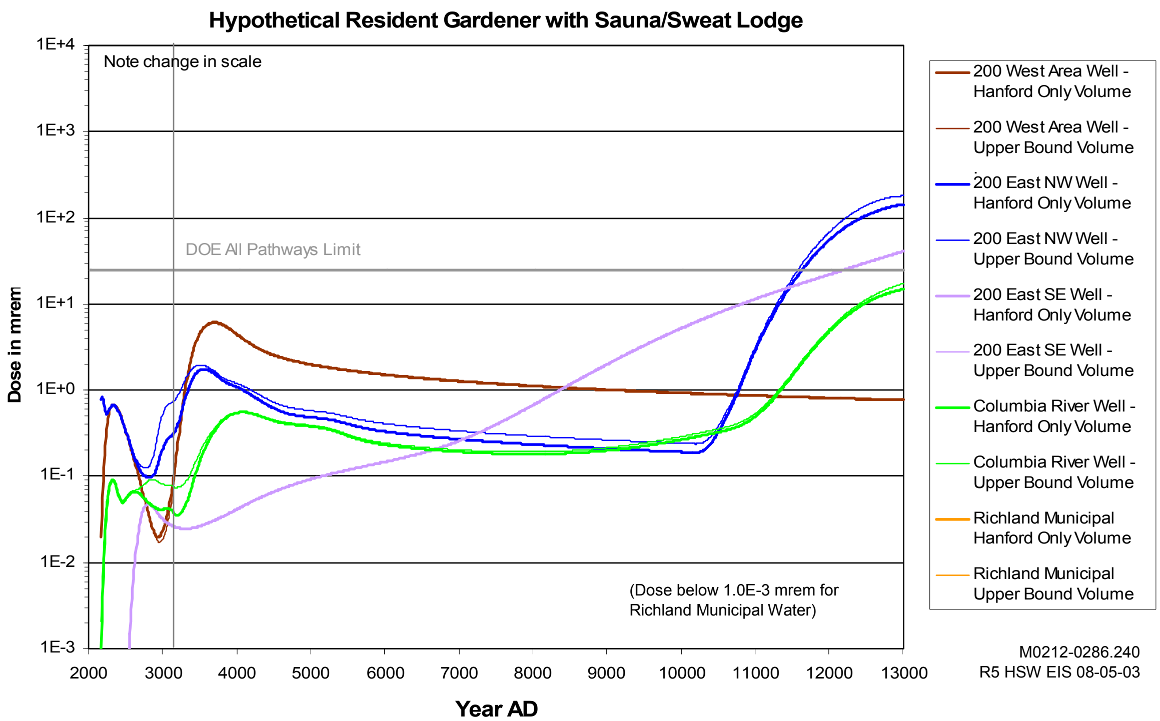


Figure 5.34. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group A, Hanford Only and Upper Bound Waste Volumes

Table 5.78. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group A, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (6E-06)	2.9E-02	0 (2E-05)
Projected	1.7E-01	0 (1E-04)	4.7E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.79. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group A, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.8E-01	0 (1E-04)	4.7E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.80. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group A, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.7E-02	0 (1E-05)	4.6E-02	0 (3E-05)
Projected	1.8E-01	0 (1E-04)	4.9E-01	0 (3E-04)
Total	2.1E-01	0 (1E-04)	5.7E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.81. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group A

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	**Years post-2046**
Hanford Only	Carbon-14	0.0	Not present
	Technetium-99	3.6E-01	1640
	Iodine-129	1.1E-01	280
	Uranium[(a)]	0.0	Not present
	Total	4.2E-01	1660
Upper Bound	Carbon-14	0.0	Not present
	Technetium-99	3.5E-01	1630
	Iodine-129	1.1E-01	280
	Uranium[(a)]	0.0	Not present
	Total	4.0E-01	1650

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.82. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group A

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	**Years post-2046**
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	9.2E-02	1,520
	Iodine-129	1.1E-01	120
	Uranium[(a)]	5.7E-02	10,000
	Total	1.5E-01	1,480
Upper Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	1.0E-01	1,470
	Iodine-129	1.1E-01	120
	Uranium[(a)]	7.1E-02	10,000
	Total	1.7E-01	1,440

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.83. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Southeast from the 200 East Area, Alternative Group A

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not present
	Technetium-99	1.9E-2	10,000
	Iodine-129	3.2E-3	10,000
	Uranium[(a)]	2.1E-2	10,000
	Total	4.4E-2	10,000
Upper Bound	Carbon-14	0.0	Not present
	Technetium-99	1.9E-2	10,000
	Iodine-129	3.2E-3	10,000
	Uranium[(a)]	2.1E-2	10,000
	Total	4.4E-2	10,000
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.84. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group A

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-4	10,000
	Technetium-99	3.2E-2	2,040
	Iodine-129	1.3E-2	270
	Uranium[(a)]	4.7E-3	10,000
	Total	4.0E-2	2,000
Upper Bound	Carbon-14	1.2E-4	10,000
	Technetium-99	3.2E-2	2,040
	Iodine-129	1.3E-2	270
	Uranium[(a)]	4.8E-3	10,000
	Total	3.9E-2	1,990
(a) The entry for uranium includes the contributions from all uranium isotopes.			

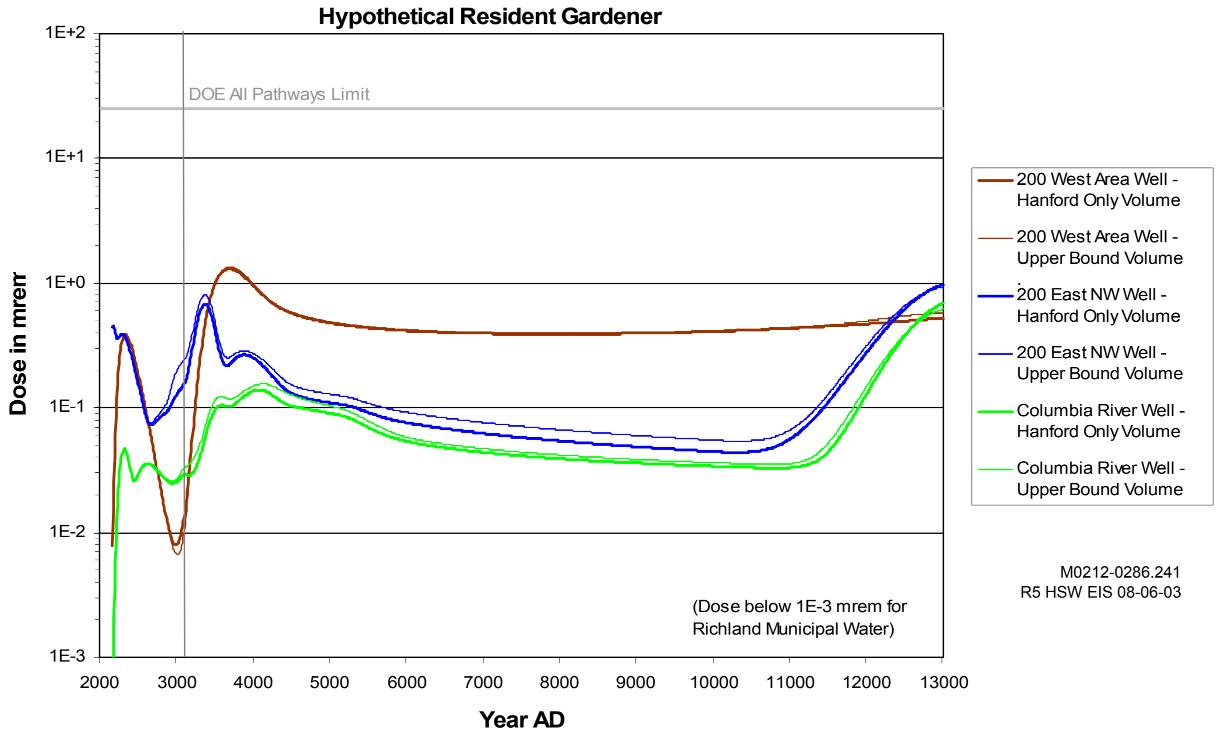
5.11.2.1.2 Alternative Group B

The potential consequences to the MEI are presented in Figure 5.35 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 8,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.85 for the Hanford Only waste volume, in Table 5.86 for the Lower Bound waste volume, and in Table 5.87 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels that would be expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.88 through 5.90 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, from the 200 East Area (NW), and near the Columbia River, respectively.



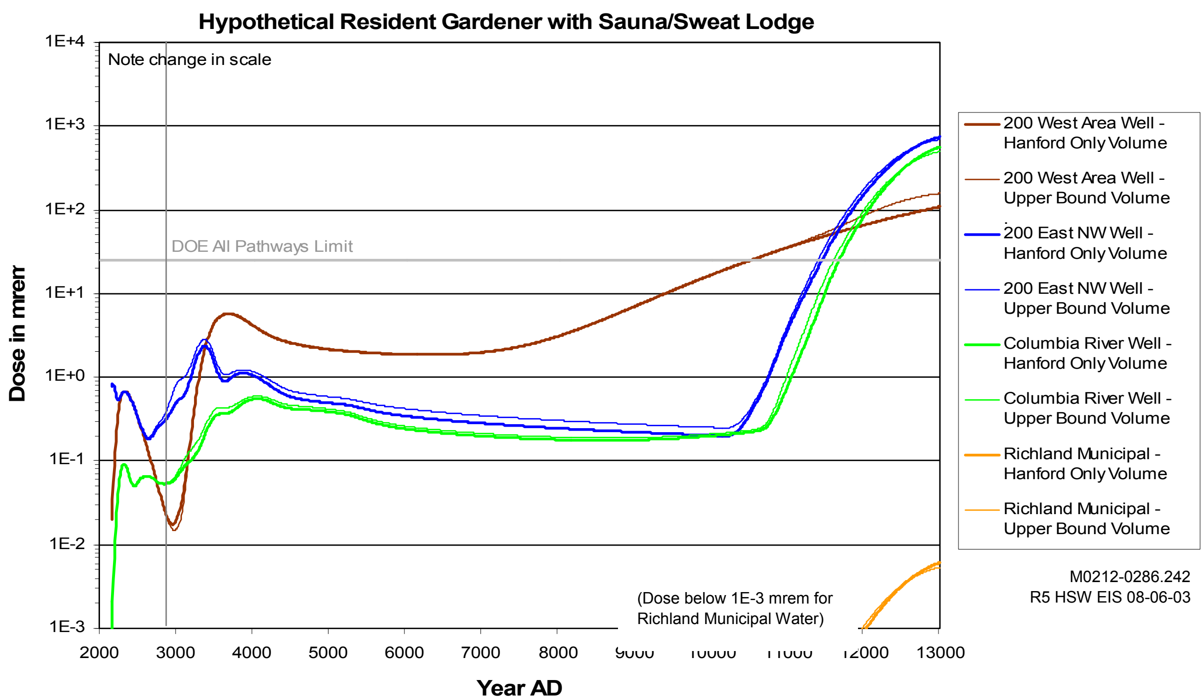


Figure 5.35. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group B, Hanford Only and Upper Bound Waste Volumes

Table 5.85. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group B, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	7.2E-03	0 (4E-06)	1.9E-02	0 (1E-05)
Projected	1.8E-01	0 (1E-04)	4.7E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.86. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group B, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	7.3E-03	0 (4E-06)	2.0E-02	0 (1E-05)
Projected	18E-01	0 (1E-04)	4.8E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.87. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group B, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.3E-02	0 (8E-06)	3.5E-02	0 (2E-05)
Projected	1.9E-01	0 (1E-04)	5.2E-01	0 (3E-04)
Total	2.2E-01	0 (1E-04)	5.9E-01	0 (4E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.88. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group B

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	3.4E-01	1,640
	Iodine-129	1.1E-01	280
	Uranium[(a)]	6.2E-02	10,000
	Total	3.9E-01	1,650
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.4E-01	1,620
	Iodine-129	1.1E-01	280
	Uranium[(a)]	8.3E-02	10,000
	Total	3.9E-01	1,650

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.89. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group B

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	1.2E-01	1,330
	Iodine-129	1.1E-01	120
	Uranium[(a)]	1.6E-01	10,000
	Total	2.1E-01	1,330
Upper Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	1.5E-01	1,320
	Iodine-129	1.1E-01	120
	Uranium[(a)]	1.9E-01	10,000
	Total	2.5E-01	1,320

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.90. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group B

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	4.3E-04	2,330
	Technetium-99	3.1E-02	2,020
	Iodine-129	1.3E-02	270
	Uranium[(a)]	5.3E-03	10,000
	Total	4.0E-02	2,000
Upper Bound	Carbon-14	1.2E-03	2,330
	Technetium-99	3.3E-02	2,000
	Iodine-129	1.4E-02	1,510
	Uranium[(a)]	6.9E-03	10,000
	Total	4.2E-02	1,990

(a) The entry for uranium includes the contributions from all uranium isotopes.

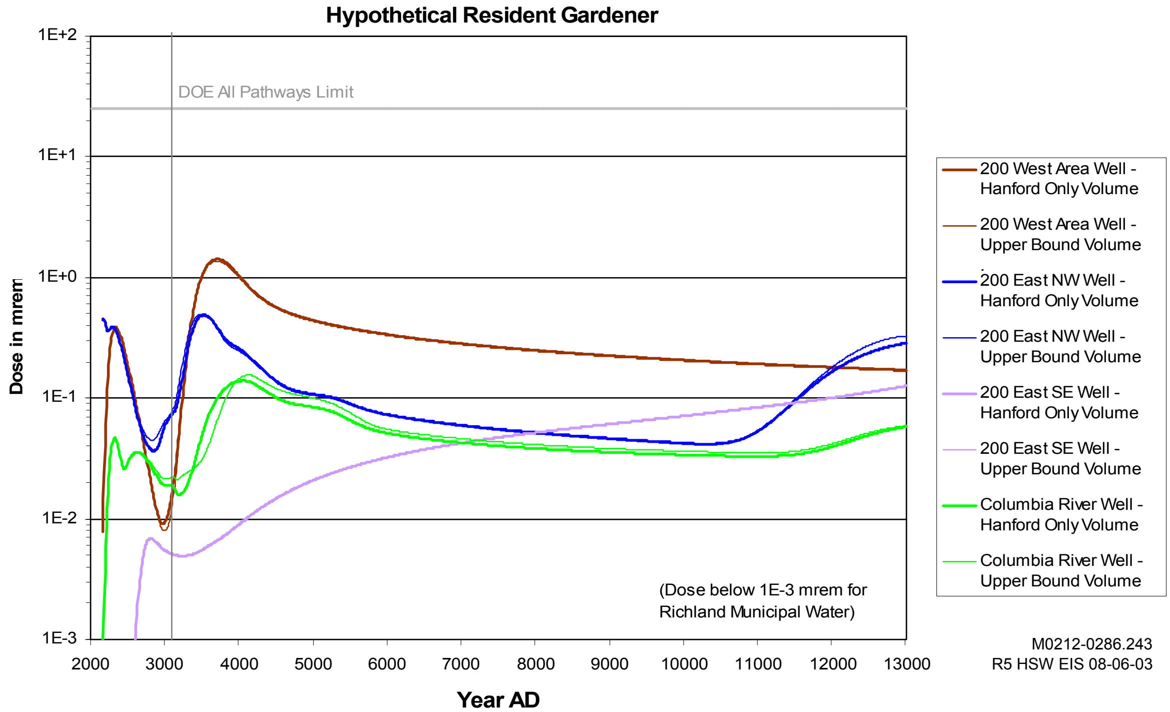
5.11.2.1.3 Alternative Group C

The potential consequences to the MEI are presented in Figure 5.36 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 9,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.91 for the Hanford Only waste volume, in Table 5.92 for the Lower Bound waste volume, and in Table 5.93 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.94 through 5.97 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, from the 200 East Area (NW), from the 200 East Area (SE), and near the Columbia River, respectively.



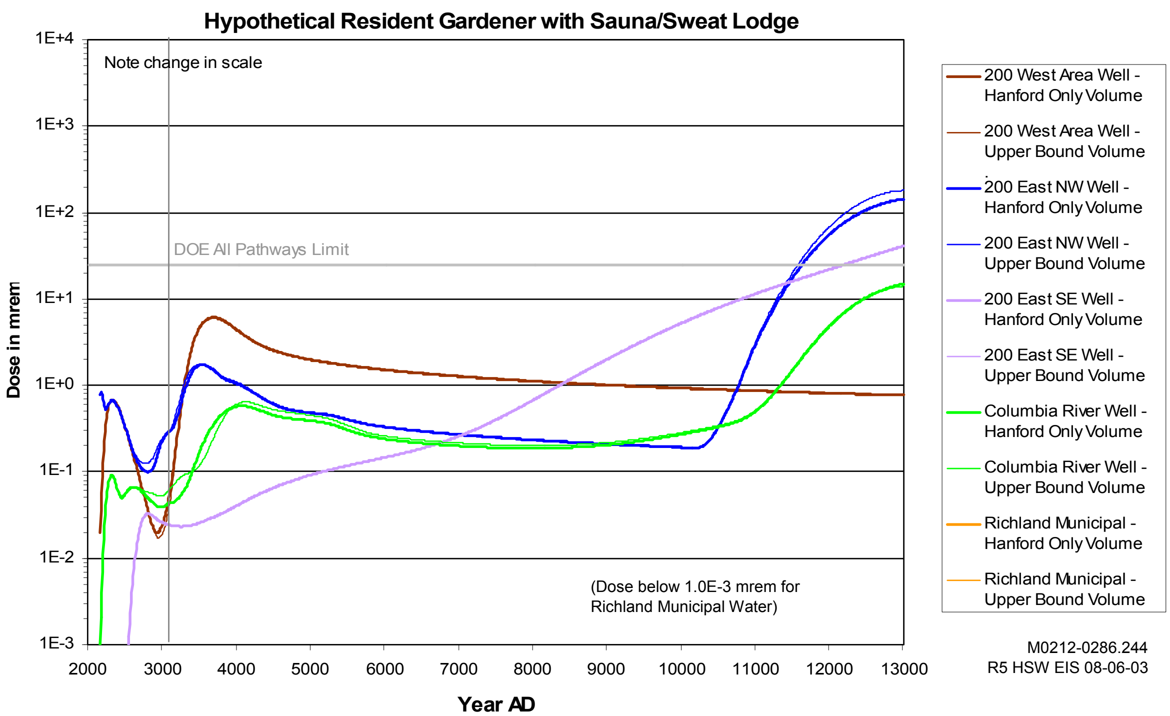


Figure 5.36. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group C, Hanford Only and Upper Bound Waste Volumes

Table 5.91. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group C, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (6E-06)	9E-02	0 (2E-05)
Projected	1.8E-01	0 (1E-04)	4.7E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.92. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group C, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-03	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.8E-01	0 (1E-04)	4.7E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.93. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group C, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.7E-02	0 (1E-05)	4.6E-02	0 (3E-05)
Projected	1.8E-01	0 (1E-04)	4.9E-01	0 (3E-04)
Total	2.1E-01	0 (1E-04)	5.7E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.94. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group C

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	3.6E-01	1640
	Iodine-129	1.1E-01	280
	Uranium[(a)]	0.0	Not Present
	Total	4.2E-01	1660
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.6E-01	1630
	Iodine-129	1.1E-01	280
	Uranium[(a)]	0.0	Not Present
	Total	4.2E-01	1650
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.95. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group C

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	9.0E-02	1,500
	Iodine-129	1.1E-01	120
	Uranium[(a)]	5.7E-02	10,000
	Total	1.5E-01	1,470
Upper Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	9.1E-02	1,480
	Iodine-129	1.1E-01	120
	Uranium[(a)]	7.1E-02	10,000
	Total	1.5E-01	1,440
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.96. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Southeast from the 200 East Area, Alternative Group C

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	1.9E-02	10,000
	Iodine-129	3.2E-03	10,000
	Uranium[(a)]	2.1E-02	10,000
	Total	4.4E-02	10,000
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	1.9E-02	10,000
	Iodine-129	3.2E-03	10,000
	Uranium[(a)]	2.1E-02	10,000
	Total	4.4E-02	10,000
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.97. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group C

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-04	10,000
	Technetium-99	3.3E-02	2,030
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.7E-03	10,000
	Total	4.2E-02	2,000
Upper Bound	Carbon-14	1.2E-04	10,000
	Technetium-99	3.7E-02	2,080
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.7E-03	10,000
	Total	4.7E-02	2,080

(a) The entry for uranium includes the contributions from all uranium isotopes.

5.11.2.1.4 Alternative Group D

There are three subalternatives considered for Alternative Group D with variations on disposal options for the waste streams. See Section 5.0 for a summary of the characteristics for the three subalternatives (D_1, D_2, and D_3) to this alternative group.

Potential long-term radiological impacts on groundwater are presented in the same manner as above for the other alternative groups using the 1-km lines of analysis. However, in response to comments received during the public comment periods on the drafts of the HSW EIS, impacts that might occur from use of groundwater 100 m downgradient from LLW management areas also were addressed for Alternative Group D in Section 5.3.6.5. The drinking water doses associated with maximum potential concentrations provided there are summarized here in Table 5.98.

As may be seen in Table 5.98 the highest drinking water doses (less than 3 mrem/yr, and below the benchmark drinking water standards) were calculated to result from wastes disposed of prior to 1996. The time of arrival of contaminants in groundwater that could lead to such doses would be well within the 100-year active institutional control period. During the institutional control period, restrictions on groundwater use would preclude individuals from receiving the peak doses shown in the table. After the end of the active institutional control period, doses in all cases would be below the DOE 4-mrem-per-year benchmark drinking water standard.

Table 5.98. Hypothetical Drinking Water Dose from Groundwater 100 Meters Downgradient of LLW Management Areas[(a)]

Hanford Only Waste Volume		Alternative D_1 Post-2007 Waste Disposed of Near PUREX		Alternative D_2 Post-2007 Waste Disposed of in LLBG 218-E-12B		Alternative D_3 Post-2007 Waste Disposed of at ERDF	
		Peak Dose, mrem/yr	**Year AD**	**Peak Dose, mrem/yr**	**Year AD**	**Peak Dose, mrem/yr**	**Year AD**
Pre-2007 Waste Streams							
Pre-1996	East Area	2.7	2050	2.7	2050	2.7	2,050
	West Area	1	2100	1	2100	1	2,100
Cat 1 & Cat 3 1996–2007	218-W-5	0.076	2990	0.076	2990	0.076	2,990
MLLW 1996–2007	218-W-5	0.37	2950	0.38	2990	0.38	2,990
MLLW 1996–2007 Grouted	218-W-5	0.0021	2980	0.0021	2980	0.0021	2,980
Post-2007 Waste Streams							
ILAW		0.059	12,000	0.24	12,000	0.2	12,000
Cat 1 LLW and MLLW		0.11	3330	0.53	3330	0.6	3,690
Cat 3 LLW		0.22	2930	0.91	2930	0.86	3,310
Grouted MLLW and Melter		0.015	2630	0.054	2630	0.049	3,010
Upper Bound Waste Volume		**Alternative D_1 Post-2007 Waste Disposed of Near PUREX**		**Alternative D_2 Post-2007 Waste Disposed of in 218-E-12B**		**Alternative D_3 Post-2007 Waste Disposed of at ERDF**	
		Peak Dose, mrem/yr	**Year AD**	**Peak Dose, mrem/yr**	**Year AD**	**Peak Dose, mrem/yr**	**Year AD**
Pre-2007 Waste Streams							
Pre-1996	East Area	2.7	2050	2.7	2050	2.7	2050
	West Area	1	2100	1	2100	1	2100
Cat 1 & Cat 3 1996–2007	218-W-5	0.089	2990	0.089	2990	0.089	2990
MLLW 1996–2007	218-E-12B	0.47	2570	0.47	2580	0.47	2570
	218-W-5	0.22	2950	0.23	2990	0.23	2990
MLLW 1996–2007 Grouted	218-E-12B	0.032	2890	0.032	2890	0.032	2890
	218-W-5	0.02	3280	0.02	3280	0.02	3280
Post-2007 Waste Streams							
ILAW		0.059	12,000	0.24	12,000	0.2	12,000
Cat 1 LLW		0.018	12,000	0.058	3340	0.046	3700
Cat 3 LLW and Grouted MLLW		0.24	2930	1	2930	0.74	3320
MLLW		0.1	3330	0.43	3330	0.34	3700
Melters		0.0052	2630	0.013	2630	0.0097	3020

(a) Note that these doses are not additive because they are at different locations and occur at different points in time.

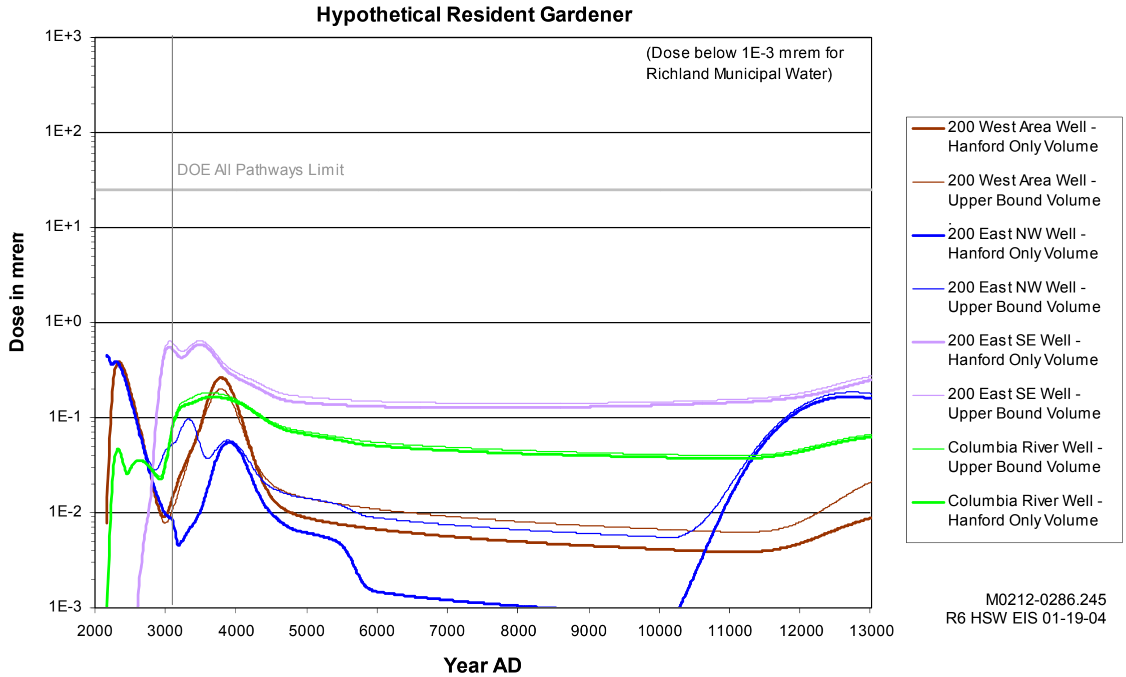
5.11.2.1.4.1 Alternative Group D_1

The potential consequences to the MEI are presented in Figure 5.37 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 9,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.99for the Hanford Only waste volume, in Table 5.100 for the Lower Bound waste volume, and in Table 5.101 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.102 through 5.105 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, from the 200 East Area (NW), from the 200 East Area (SE), and near the Columbia River, respectively.



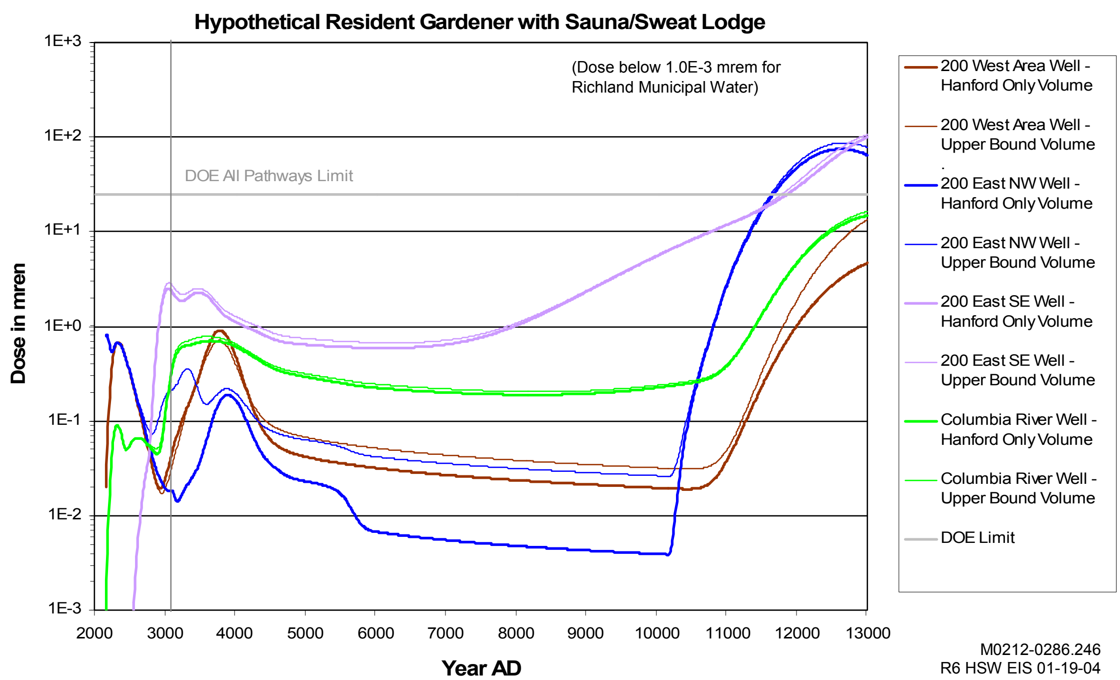


Figure 5.37. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group D_1, Hanford Only and Upper Bound Waste Volumes

Table 5.99. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_1, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	**Estimated Cancer Fatalities**	**Population Dose (person-rem)**	**Estimated Cancer Fatalities**
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (6E-06)	2.9E-02	0 (2E-05)
Projected	1.5E-01	0 (9E-05)	4.1E-01	0 (2E-04)
Total	1.8E-01	0 (1E-04)	4.7E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.100. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_1, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	**Estimated Cancer Fatalities**	**Population Dose (person-rem)**	**Estimated Cancer Fatalities**
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.7E-01	0 (1E-04)	4.7E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.101. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_1, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	**Estimated Cancer Fatalities**	**Population Dose (person-rem)**	**Estimated Cancer Fatalities**
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	2.0E-02	0 (1E-05)	5.3E-02	0 (3E-05)
Projected	1.8E-01	0 (1E-04)	4.7E-01	0 (3E-04)
Total	2.1E-01	0 (1E-04)	5.6E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.102. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group D_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	**Years post-2046**
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	4.6E-02	1,730
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.1E-03	10,000
	Total	1.2E-01	280
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.7E-02	1,720
	Iodine-129	1.1E-01	280
	Uranium[(a)]	2.0E-03	10,000
	Total	1.2E-01	280

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.103. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group D_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	**Years post-2046**
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	9.6E-03	1,850
	Iodine-129	1.1E-01	120
	Uranium[(a)]	4.8E-02	10,000
	Total	1.1E-01	120
Upper Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	1.9E-02	1,270
	Iodine-129	1.1E-01	120
	Uranium[(a)]	5.4E-02	10,000
	Total	1.1E-01	120

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.104. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Southeast from the 200 East Area, Alternative Group D_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.0E-05	10,000
	Technetium-99	1.5E-01	1000
	Iodine-129	5.2E-02	1,450
	Uranium[(a)]	2.9E-02	10,000
	Total	1.8E-01	1,430
Upper Bound	Carbon-14	4.5E-05	10,000
	Technetium-99	1.7E-01	1010
	Iodine-129	5.2E-02	1,450
	Uranium[(a)]	3.3E-02	10,000
	Total	1.9E-01	1,430
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.105. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group D_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-04	10,000
	Technetium-99	4.1E-02	1,600
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.7E-03	10,000
	Total	5.0E-02	1,640
Upper Bound	Carbon-14	1.2E-04	10,000
	Technetium-99	4.5E-02	1,530
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.9E-03	10,000
	Total	5.5E-02	1,560
(a) The entry for uranium includes the contributions from all uranium isotopes.			

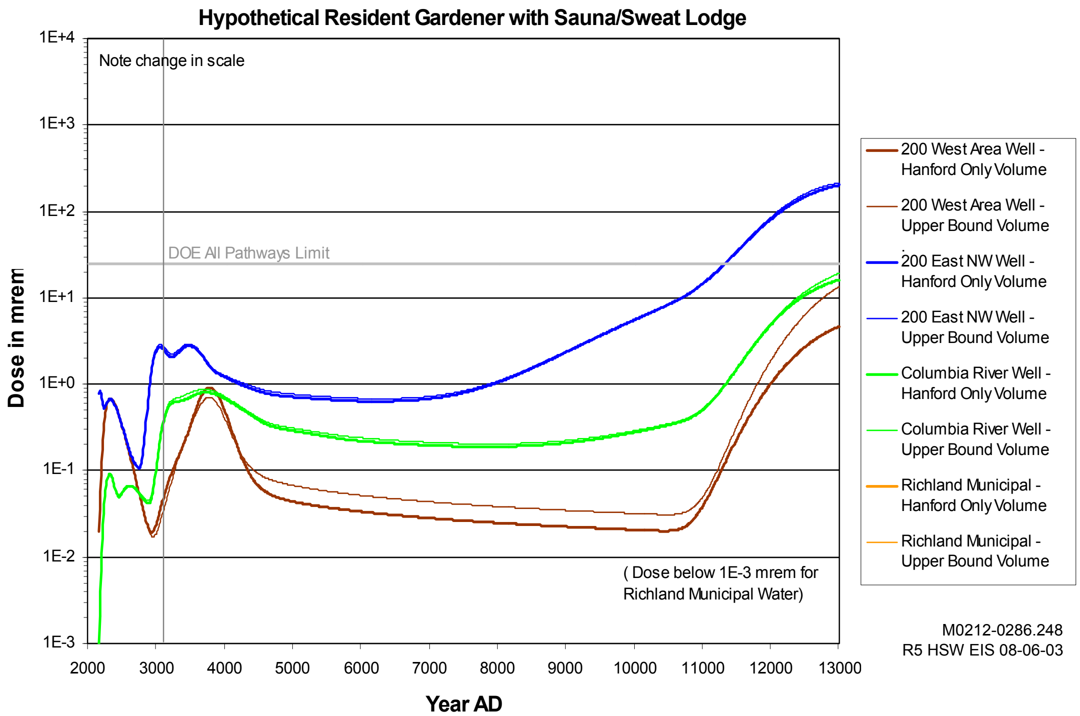
5.11.2.1.4.2 Alternative Group D_2

The potential consequences to the MEI are presented in Figure 5.38 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 9,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.106 for the Hanford Only waste volume, in Table 5.107 for the Lower Bound waste volume, and in Table 5.108 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.109 through 5.111 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, from the 200 East Area (NW), and near the Columbia River, respectively.



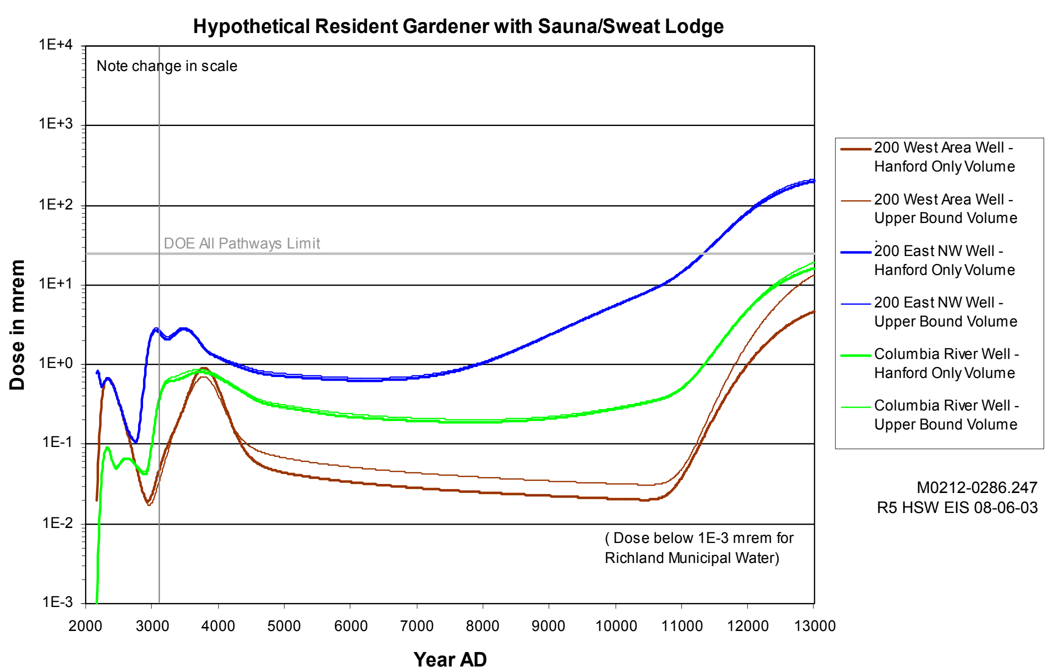


Figure 5.38. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group D_2, Hanford Only and Upper Bound Waste Volumes

Table 5.106. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_2, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (6E-06)	2.9E-02	0 (2E-05)
Projected	1.6E-01	0 (1E-04)	4.3E-01	0 (3E-04)
Total	1.9E-01	0 (1E-04)	5.0E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.107. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_2, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.6E-01	0 (1E-04)	4.4E-01	0 (3E-04)
Total	1.9E-01	0 (1E-04)	5.0E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.108. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_2, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.7E-02	0 (1E-05)	4.6E-02	0 (3E-05)
Projected	1.7E-01	0 (1E-04)	4.5E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.109. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group D_2

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	4.7E-02	1,730
	*-Iodine-129	1.1E-01	280
	Uranium[(a)]	1.1E-03	10,000
	Total	1.2E-01	280
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.7E-02	1,720
	Iodine-129	1.1E-01	280
	Uranium[(a)]	2.0E-03	10,000
	Total	1.2E-01	280

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.110. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group D_2

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	1.6E-01	1000
	Iodine-129	1.1E-01	120
	Uranium[(a)]	8.2E-02	10,000
	Total	2.2E-01	1,440
Upper Bound	Carbon-14	2.6E-03	10,000
	Technetium-99	1.7E-01	1,010
	Iodine-129	1.1E-01	120
	Uranium[(a)]	8.7E-02	10,000
	Total	2.3E-01	1,430

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.111. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group D_2

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-04	10,000
	Technetium-99	4.6E-02	1,670
	Iodine-129	1.4E-02	1,680
	Uranium[(a)]	4.7E-03	10,000
	Total	6.0E-02	1,670
Upper Bound	Carbon-14	1.2E-04	10,000
	Technetium-99	4.9E-02	1,650
	Iodine-129	1.5E-02	1,650
	Uranium[(a)]	4.9E-03	10,000
	Total	6.4E-02	1,650

(a) The entry for uranium includes the contributions from all uranium isotopes.

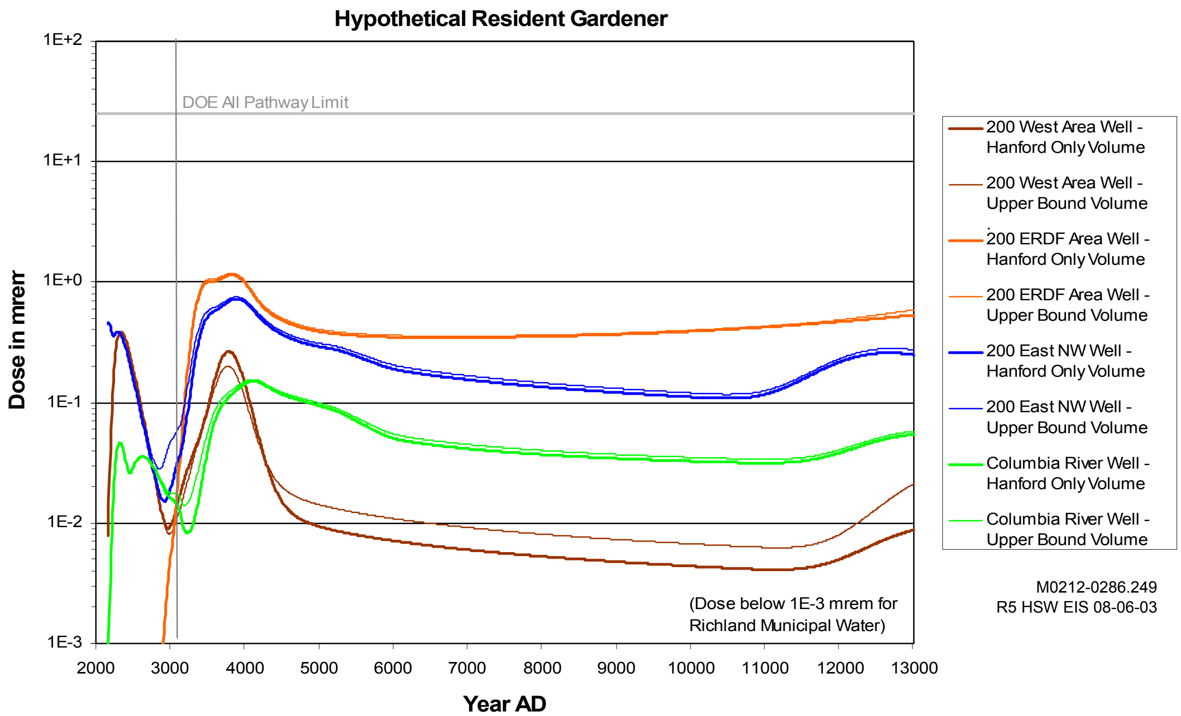
5.11.2.1.4.3 Alternative Group D_3

The potential consequences to the MEI are presented in Figure 5.39 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 8,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.112 for the Hanford Only waste volume, in Table 5.113 for the Lower Bound waste volume, and in Table 5.114 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.115 through 5.118 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, the ERDF, the 200 East Area (NW), and near the Columbia River, respectively.



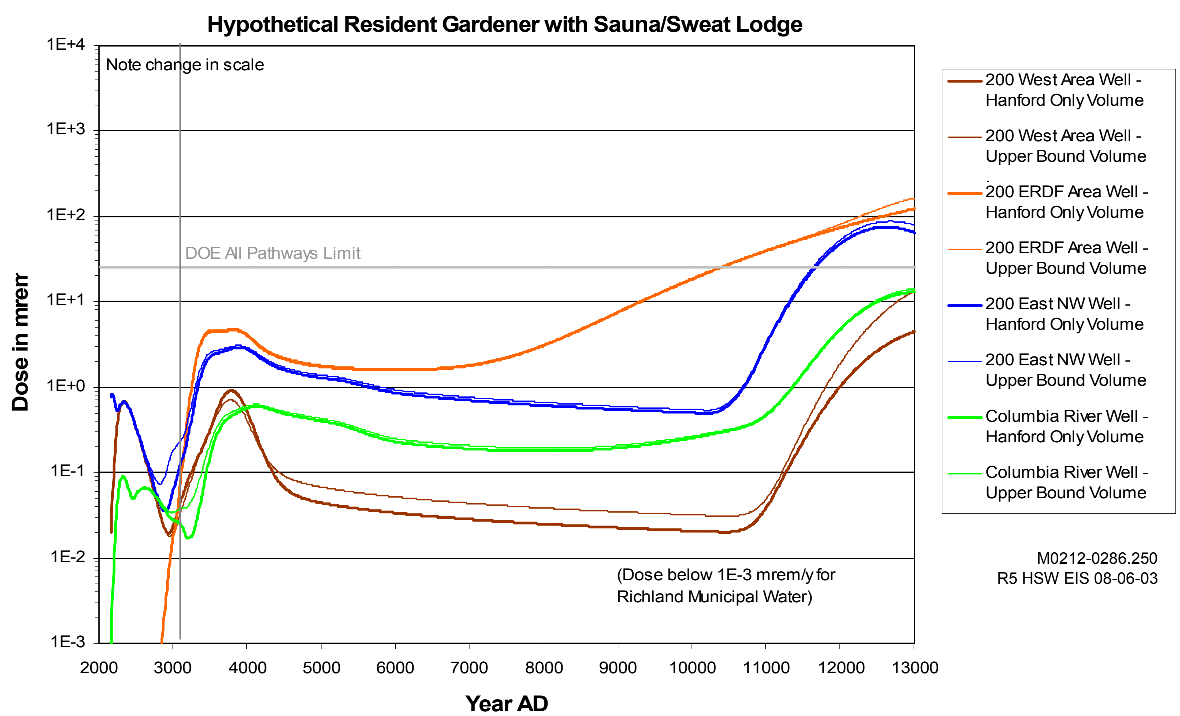


Figure 5.39. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group D_3, Hanford Only and Upper Bound Waste Volumes

Table 5.112. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_3, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-03	0 (6E-06)	2.9E-02	0 (2E-05)
Projected	1.8E-01	0 (1E-04)	4.9E-01	0 (3E-04)
Total	2.1E-01	0 (1E-04)	5.5E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.113. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_3, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.8E-01	0 (1E-04)	4.9E-01	0 (3E-04)
Total	2.1E-01	0 (1E-04)	5.6E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.114. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group D_3, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.7E-02	0 (1E-05)	4.6E-02	0 (3E-05)
Projected	1.9E-01	0 (1E-04)	5.1E-01	0 (3E-04)
Total	2.2E-01	0 (1E-04)	5.9E-01	0 (4E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.115. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group D_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	4.7E-02	1,730
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.1E-03	Not Present
	Total	1.2E-01	280
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.7E-02	1,720
	Iodine-129	1.1E-01	280
	Uranium[(a)]	2.0E-03	10,000
	Total	1.2E-01	280

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.116. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the ERDF Site, Alternative Group D_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	2.7E-01	1,470
	Iodine-129	8.2E-02	1,810
	Uranium[(a)]	7.1E-02	10,000
	Total	3.4E-01	1,780
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	2.8E-01	1,470
	Iodine-129	8.3E-02	1,810
	Uranium[(a)]	7.9E-02	10,000
	Total	3.6E-01	1,780

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.117. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group D_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	1.7E-01	1,820
	Iodine-129	1.1E-01	120
	Uranium[(a)]	4.8E-02	10,000
	Total	2.2E-01	1,840
Upper Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	1.7E-01	1,810
	Iodine-129	1.1E-01	120
	Uranium[(a)]	5.4E-02	10,000
	Total	2.3E-01	1,840
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.118. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group D_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-04	10,000
	Technetium-99	3.4E-02	2,080
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.6E-03	10,000
	Total	4.5E-02	2,070
Upper Bound	Carbon-14	1.2E-04	10,000
	Technetium-99	3.5E-02	2,070
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.7E-03	10,000
	Total	4.7E-02	2,070
(a) The entry for uranium includes the contributions from all uranium isotopes.			

5.11.2.1.5 Alternative Group E

There are three subalternatives considered for Alternative Group E with variations on disposal options for the waste streams. See Section 5.0 for a summary of the characteristics for the three subalternatives (E_1, E_2, and E_3) to this alternative group.

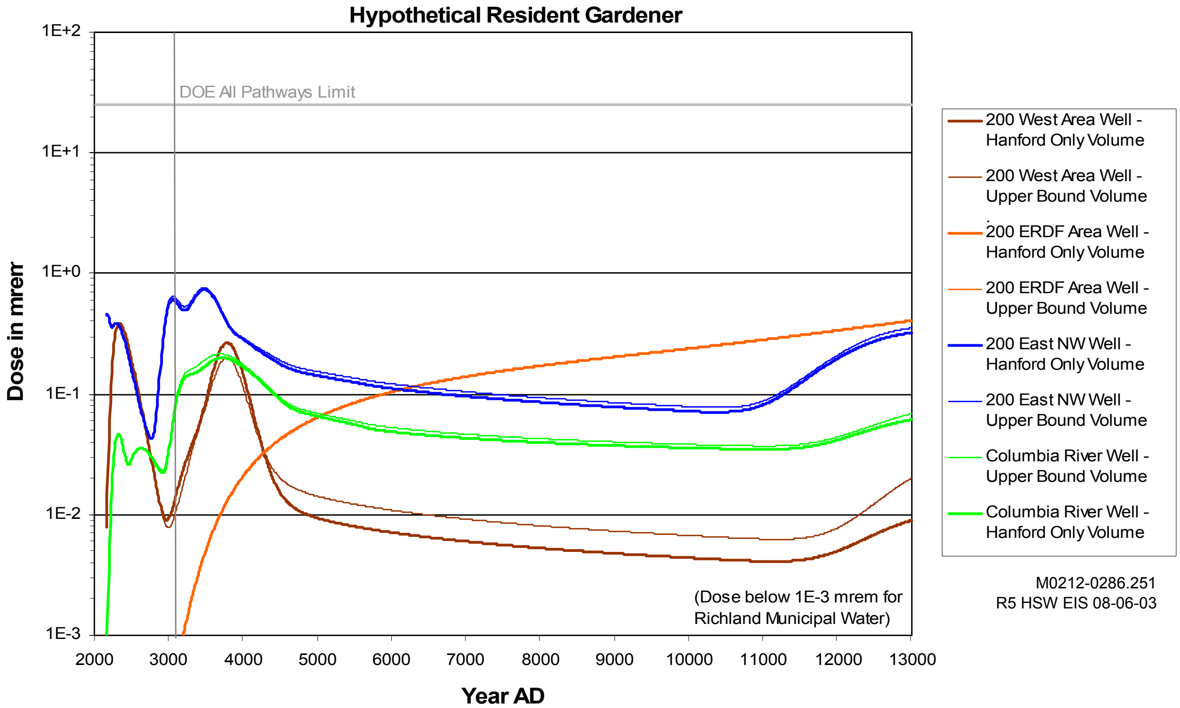
5.11.2.1.5.1 Alternative Group E_1

The potential consequences to the MEI are presented in Figure 5.40 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 8,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.119 for the Hanford Only waste volume, in Table 5.120 for the Lower Bound waste volume, and in Table 5.121 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.122 through 5.125 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, the ERDF, the 200 East Area (NW), and near the Columbia River, respectively.



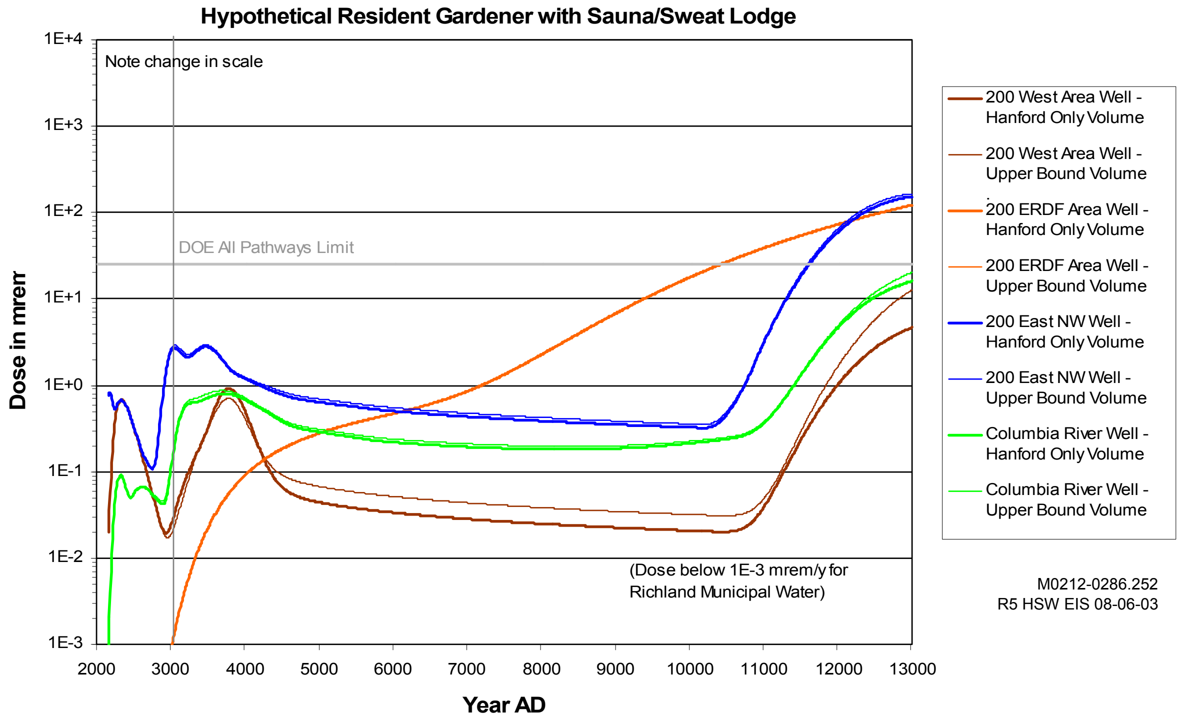


Figure 5.40. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group E_1, Hanford Only and Lower Bound Waste Volumes

Table 5.119. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_1, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (6E-06)	2.9E-02	0 (2E-05)
Projected	1.6E-01	0 (1E-04)	4.4E-01	0 (3E-04)
Total	1.9E-01	0 (1E-04)	5.0E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.120. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_1, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.6E-01	0 (1E-04)	4.4E-01	0 (3E-04)
Total	1.9E-01	0 (1E-04)	5.0E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.121. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_1, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.7E-02	0 (1E-05)	4.6E-02	0 (3E-05)
Projected	1.7E-01	0 (1E-04)	4.5E-01	0 (3E-04)
Total	2.0E-01	0 (1E-04)	5.3E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.122. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group E_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	4.7E-02	1,730
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.1E-03	10,000
	Total	1.2E-01	280
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.7E-02	1,720
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.8E-03	10,000
	Total	1.2E-01	280
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.123. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the ERDF Site, Alternative Group E_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	6.5E-02	10,000
	Iodine-129	1.1E-01	10,000
	Uranium[(a)]	7.1E-02	10,000
	Total	1.5E-01	10,000
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	6.5E-02	10,000
	Iodine-129	1.1E-02	10,000
	Uranium[(a)]	7.1E-02	10,000
	Total	1.5E-01	10,000
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.124. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group E_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	1.6E-01	1,000
	Iodine-129	1.1E-01	120
	Uranium[(a)]	6.1E-02	10,000
	Total	2.2E-01	1,420
Upper Bound	Carbon-14	2.6E-03	10,000
	Technetium-99	1.8E-01	1,010
	Iodine-129	1.1E-01	120
	Uranium[(a)]	7.2E-02	10,000
	Total	2.4E-01	1,400
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.125. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group E_1

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-04	10,000
	Technetium-99	4.5E-02	1,660
	Iodine-129	1.4E-02	1,670
	Uranium[(a)]	4.7E-03	10,000
	Total	6.0E-02	1,670
Upper Bound	Carbon-14	1.2E-04	10,000
	Technetium-99	4.9E-02	1,640
	Iodine-129	1.5E-02	1,640
	Uranium[(a)]	5.0E-02	10,000
	Total	6.4E-02	1,640
(a) The entry for uranium includes the contributions from all uranium isotopes.			

5.11.2.1.5.2 Alternative Group E_2

The potential consequences to the MEI are presented in Figure 5.41 for a hypothetical individual residing 1 km (0.6 mi) downgradient from the disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE all-pathway dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr

(DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 8,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/days) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.126 for the Hanford Only waste volume, in Table 5.127 for the Lower Bound waste volume, and in Table 5.128 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.129 through 5.133 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, the ERDF, the 200 East Area (NW), the 200 East Area (SE), and near the Columbia River, respectively.

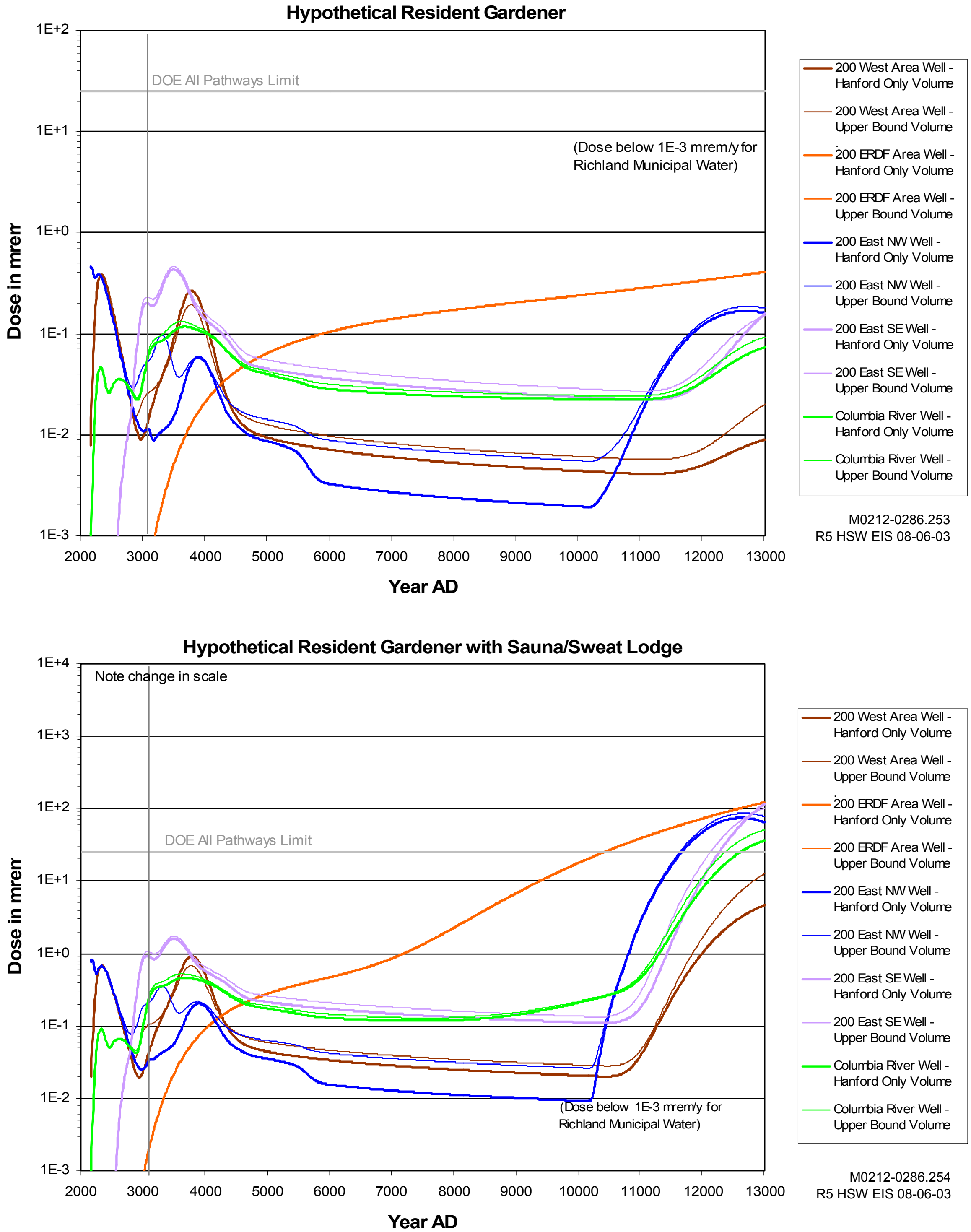


Figure 5.41. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group E_2, Hanford Only and Upper Bound Waste Volumes

Table 5.126. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_2, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[a]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (6E-06)	2.9E-02	0 (2E-05)
Projected	1.5E-01	0 (9E-05)	4.1E-01	0 (2E-04)
Total	1.8E-01	0 (1E-04)	4.8E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.127. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_2, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[a]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.5E-01	0 (9E-05)	4.2E-01	0 (2E-04)
Total	1.8E-01	0 (1E-04)	4.8E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.128. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_2, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[a]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.7E-02	0 (1E-05)	4.6E-02	0 (3E-05)
Projected	1.6E-01	0 (1E-04)	4.3E-01	0 (3E-04)
Total	1.9E-01	0 (1E-04)	5.1E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.129. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group E_2

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	4.7E-02	1,730
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.1E-03	10,000
	Total	1.2E-01	280
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.7E-02	1,710
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.8E-03	10,000
	Total	1.2E-02	280

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.130. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the ERDF Site, Alternative Group E_2

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	6.5E-02	10,000
	Iodine-129	1.1E-02	10,000
	Uranium[(a)]	7.1E-02	10,000
	Total	1.5E-01	10,000
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	6.5E-02	10,000
	Iodine-129	1.1E-02	10,000
	Uranium[(a)]	7.1E-02	10,000
	Total	1.5E-01	10,000

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.131. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group E_2

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	1.1E-02	1,840
	Iodine-129	1.1E-01	120
	Uranium[a]	4.8E-02	10,000
	Total	1.1E-01	120
Upper Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	1.9E-02	1,260
	Iodine-129	1.1E-01	120
	Uranium[a]	5.4E-02	10,000
	Total	1.1E-01	120
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.132. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Southeast from the 200 East Area, Alternative Group E_2

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	9.1E-05	10,000
	Technetium-99	1.8E-01	1,410
	Iodine-129	5.6E-02	1,450
	Uranium[a]	1.2E-02	10,000
	Total	2.3E-01	1,430
Upper Bound	Carbon-14	4.5E-05	10,000
	Technetium-99	1.9E-01	1,060
	Iodine-129	5.6E-02	1,450
	Uranium[a]	1.9E-02	10,000
	Total	2.4E-01	1,430
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.133. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group E_2

Volume Case	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-04	10,000
	Technetium-99	2.6E-02	1,630
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.7E-03	10,000
	Total	3.5E-02	1,620
Upper Bound	Carbon-14	1.2E-04	10,000
	Technetium-99	2.9E-02	1,580
	Iodine-129	1.3E-02	270
	Uranium[(a)]	5.0E-03	10,000
	Total	4.0E-02	1,570

(a) The entry for uranium includes the contributions from all uranium isotopes.

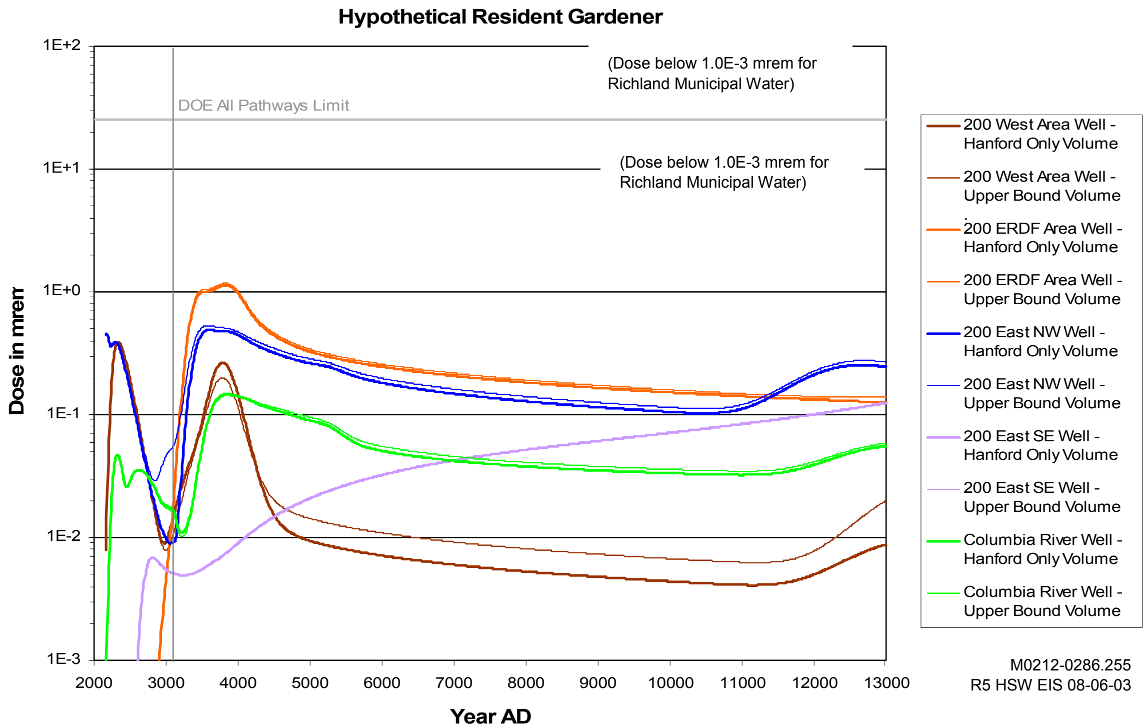
5.11.2.1.5.3 Alternative Group E_3

The potential consequences to the MEI are presented in Figure 5.42 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Upper Bound waste volumes. The results for the Lower Bound waste volume are nearly indistinguishable from the Hanford Only waste volume and are not displayed on the figure.

The estimated annual doses for the hypothetical resident gardener are well below the DOE dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 9,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.134 for the Hanford Only waste volume, in Table 5.135 for the Lower Bound waste volume, and in Table 5.136 for the Upper Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.137 through 5.141 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, the ERDF site, the 200 East Area (NW), the 200 East Area (SE), and near the Columbia River, respectively.



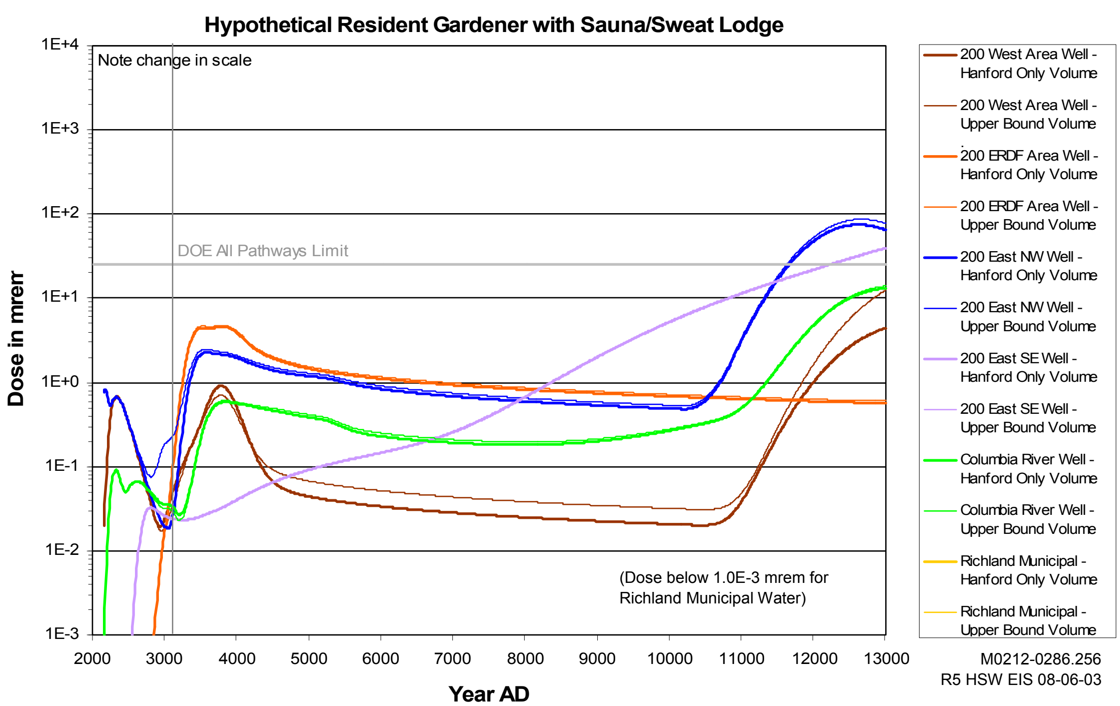


Figure 5.42. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group E_3, Hanford Only and Upper Bound Waste Volumes

Table 5.134. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_3, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (6E-06)	2.9E-02	0 (2E-05)
Projected	1.8E-01	0 (1E-04)	4.9E-01	0 (3E-04)
Total	2.1E-01	0 (1E-04)	5.5E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.135. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_3, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.1E-02	0 (7E-06)	2.9E-02	0 (2E-05)
Projected	1.8E-01	0 (1E-04)	4.9E-01	0 (3E-04)
Total	2.1E-01	0 (1E-04)	5.5E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.136. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – Alternative Group E_3, Upper Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	1.3E-02	0 (8E-06)[(a)]	3.3E-02	0 (2E-05)
Disposed of 1996–2007	1.5E-02	0 (9E-06)	4.0E-02	0 (2E-05)
Projected	1.9E-01	0 (1E-04)	5.1E-01	0 (3E-04)
Total	2.2E-01	0 (1E-04)	5.8E-01	0 (3E-04)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.

Table 5.137. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, Alternative Group E_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	4.7E-02	1,730
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.1E-03	10,000
	Total	1.2E-01	280
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.7E-02	1,720
	Iodine-129	1.1E-01	280
	Uranium[(a)]	1.8E-03	10,000
	Total	1.2E-01	280
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.138. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the ERDF Site, Alternative Group E_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	7.6E-08	10,000
	Technetium-99	2.6E-01	1,470
	Iodine-129	8.1E-02	1,810
	Uranium[(a)]	0.0	Not Present
	Total	3.4E-01	1,780
Upper Bound	Carbon-14	2.5E-05	10,000
	Technetium-99	2.8E-01	1,470
	Iodine-129	8.2E-02	1,810
	Uranium[(a)]	0.0	Not Present
	Total	3.5E-01	1,770
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.139. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, Alternative Group E_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	1.4E-02	1,530
	Iodine-129	1.1E-01	120
	Uranium[(a)]	4.8E-02	10,000
	Total	1.4E-01	1,550
Upper Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	1.5E-02	1,510
	Iodine-129	1.1E-01	120
	Uranium[(a)]	5.4E-02	10,000
	Total	1.6E-01	1,520

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.140. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Southeast from the 200 East Area, Alternative Group E_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	1.9E-02	10,000
	Iodine-129	3.2E-03	10,000
	Uranium[(a)]	2.1E-02	10,000
	Total	4.4E-02	10,000
Upper Bound	Carbon-14	0.0	Not Present
	Technetium-99	1.9E-02	10,000
	Iodine-129	3.2E-03	10,000
	Uranium[(a)]	2.1E-02	10,000
	Total	4.4E-02	10,000

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.141. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, Alternative Group E_3

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	1.2E-04	10,000
	Technetium-99	3.3E-02	1,790
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.6E-03	10,000
	Total	4.4E-02	1,800
Upper Bound	Carbon-14	1.2E-04	10,000
	Technetium-99	3.5E-02	1,790
	Iodine-129	1.3E-02	270
	Uranium[(a)]	4.7E-03	10,000
	Total	4.5E-02	1,790

(a) The entry for uranium includes the contributions from all uranium isotopes.

5.11.2.1.6 No Action Alternative

The potential consequences to the MEI are presented in Figure 5.43 for a hypothetical individual residing 1 km (0.6 mi) downgradient from disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results are presented for the Hanford Only and Lower Bound waste volumes (there is no Upper Bound waste volume for the No Action Alternative).

The estimated annual doses for the hypothetical resident gardener are well below the DOE dose limit of 25 mrem/yr (DOE 2001a) for these locations within the 10,000-year timeframe. The estimated annual doses also are below the benchmark DOE drinking water dose limit of 4 mrem/yr (DOE 1993) for these locations within the 10,000-year timeframe. The results for the hypothetical resident gardener with the sauna/sweat lodge exposure pathway are below the 25-mrem annual limit within the 1000-year timeframe, but exceed the limit at later times (after about 9,000 years).

Impacts on users of Columbia River water downstream of Hanford were based on the collective population drinking water dose (2 L/day) for the Tri-Cities, Washington, population and a population the size of Portland, Oregon, and located at about that point on the Columbia River. The doses are calculated over the 10,000-year period and are presented in Table 5.142 for the Hanford Only waste volume and in Table 5.143 for the Lower Bound waste volume. All estimated collective radiation doses to downstream populations resulting from drinking Columbia River water are below levels expected to result in any LCFs.

The estimated annual drinking water dose for each of the groundwater points of analysis, represented as wells, are presented for comparison with the DOE benchmark drinking water dose of 4 mrem/yr (DOE 1993). The results are presented in Tables 5.144 through 5.147 for the locations 1 km (0.6 mi) downgradient from the 200 West Area, the 200 East Area (NW), the 200 East Area (SE), and near the Columbia River, respectively.

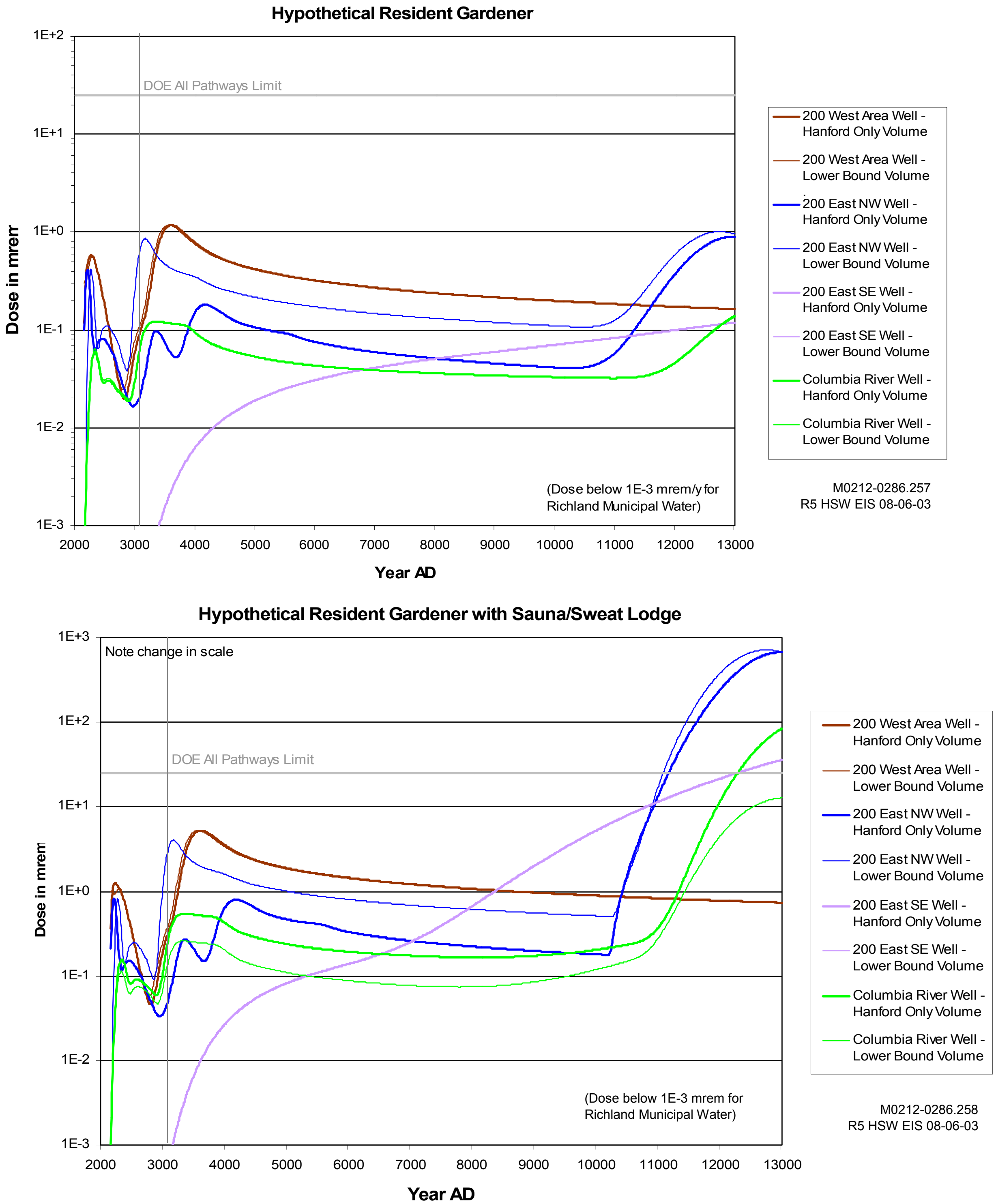


Figure 5.43. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – No Action Alternative, Hanford Only and Upper Bound Waste Volumes

Table 5.142. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – No Action Alternative, Hanford Only Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	6.3E-03	0 (4E-06)[a]	1.7E-02	0 (1E-05)
Disposed of 1996–2007	1.5E-01	0 (9E-05)	4.0E-01	0 (2E-04)
Projected (ILAW)	1.4E-02	0 (8E-06)	3.9E-02	0 (2E-05)
Total	1.5E-01	0 (9E-05)	4.1E-01	0 (2E-04)
(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.				

Table 5.143. Population Health Impacts from Drinking Water Downstream of Hanford over 10,000 Years – No Action Alternative, Lower Bound Waste Volume

Waste Type	Tri-Cities, Washington		Portland, Oregon	
	Population Dose (person-rem)	Estimated Cancer Fatalities	Population Dose (person-rem)	Estimated Cancer Fatalities
Previously Disposed of	6.3E-03	0 (4E-06)[a]	1.7E-02	0 (1E-05)
Disposed of 1996–2007	1.5E-01	0 (9E-05)	4.0E-01	0 (2E-04)
Projected (ILAW)	1.4E-02	0 (4E-06)	3.9E-02	0 (1E-05)
Total	1.6E-01	0 (9E-05)	4.1E-01	0 (2E-04)
(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be a whole number.				

Table 5.144. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient from the 200 West Area, No Action Alternative

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	3.2E-01	1560
	Iodine-129	1.2E-01	280
	Uranium[a]	0.0	Not Present
	Total	3.5E-01	1560
Lower Bound	Carbon-14	0.0	Not Present
	Technetium-99	3.2E-01	1560
	Iodine-129	1.2E-01	280
	Uranium[a]	0.0	Not Present
	Total	3.5E-01	1560
(a) The entry for uranium includes the contributions from all uranium isotopes.			

Table 5.145. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Northwest from the 200 East Area, No Action Alternative

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	2.5E-03	10,000
	Technetium-99	4.7E-02	2,140
	Iodine-129	1.1E-01	120
	Uranium[a]	2.3E-01	10,000
	Total	2.4E-01	10,000
Lower Bound	Carbon-14	2.5E-03	10,000
	Technetium-99	1.9E-02	10,000
	Iodine-129	1.1E-01	120
	Uranium[a]	4.5E-01	10,000
	Total	4.8E-01	10,000

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.146. Maximum Annual Drinking Water Dose for a Hypothetical Well 1 km Downgradient Southeast from the 200 East Area, No Action Alternative

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	0.0	Not Present
	Technetium-99	1.9E-02	10,000
	Iodine-129	3.2E-03	10,000
	Uranium[a]	2.1E-02	10,000
	Total	4.3E-02	10,000
Lower Bound	Carbon-14	0.0	Not Present
	Technetium-99	1.9E-02	10,000
	Iodine-129	3.2E-03	10,000
	Uranium[a]	2.1E-02	10,000
	Total	4.3E-02	10,000

(a) The entry for uranium includes the contributions from all uranium isotopes.

Table 5.147. Maximum Annual Drinking Water Dose for a Hypothetical Well Near the Columbia River, No Action Alternative

Waste Volume	Radionuclide	Maximum Annual Dose	
		Dose, mrem	Years post-2046
Hanford Only	Carbon-14	7.2E-05	10,000
	Technetium-99	3.2E-02	1,300
	Iodine-129	1.6E-02	280
	Uranium[(a)]	1.3E-02	10,000
	Total	3.7E-02	1,310
Lower Bound	Carbon-14	7.2E-05	10,000
	Technetium-99	3.4E-02	1,370
	Iodine-129	1.6E-02	280
	Uranium[(a)]	1.3E-02	10,000
	Total	3.9E-02	1,370

(a) The entry for uranium includes the contributions from all uranium isotopes.

5.11.2.2 Intrusion into Disposal Facilities

Although considered highly unlikely, inadvertent intrusion into disposal facilities by humans or other biota is possible if institutional controls are absent. The impacts of such intrusions, assuming they were to occur, are presented in this section.

5.11.2.2.1 Inadvertent Human Intrusion

Two scenarios were analyzed: 1) impacts on a resident gardener (maximally exposed individual) who drilled a well into waste and mixed the radionuclide-laden drilling mud into soil in which a garden was planted and 2) impacts on a resident gardener who excavated a basement for a dwelling/house and similarly mixed the excavated radionuclide-laden soil into soil in which a garden was planted. Except for metals, grout, and asphalt, it was assumed that waste extracted from the disposal facilities would be indistinguishable from surrounding soil. Details of the exposure scenarios are presented in Volume II, Appendix F.

Both the drilling and excavation scenarios use a maximum inventory in LLW, corresponding to spent B Plant filters from recovery and encapsulation of strontium and cesium from tank waste. That waste stream contains the maximum radionuclide inventory of any LLW previously disposed of, or expected to be disposed of, without the additional containment provided by HICs or by in-trench grouting. The use of that inventory for the intruder scenarios provides a bounding case.

5.11.2.2.2 Drilling Scenario

It is assumed that a well is drilled directly through waste buried under a Modified RCRA Subtitle C Barrier. A 5-m (16-ft) long, 30-cm (12-in) diameter core of waste was removed and mixed instantaneously into the top 15 cm (6 in) of clean soil. A garden was cultivated in the now contaminated soil. Pathways considered in the derivation of the dose conversion factors included ingestion of vegetables grown in the contaminated soil, ingestion of contaminated soil, inhalation of radionuclides, and external exposure to contaminated soil while working in the garden or residing in the house built on top of the waste site. Details of the dose estimation methods are provided in Volume II, Appendix F.

Dose estimates and probabilities of the resident gardener experiencing an LCF because of intrusions at various points in time after loss of active institutional control (assumed to be 100 years) are presented in Table 5.148. No radiological consequences in the form of LCFs would be anticipated from intrusion, via drilling, into the LLBGs.

5.11.2.2.3 Excavation Scenario

It is assumed that during the construction of a nominal 139 m^2 (1500 ft^2) home that 300 m^3 (11,000 ft^3) of waste is exhumed, spread over, and mixed with the residential garden soil. A garden is then cultivated in the now contaminated soil. Pathways considered in the derivation of the dose conversion factors included ingestion of vegetables grown in the contaminated soil, ingestion of contaminated soil, inhalation of radionuclides, and external exposure to contaminated soil while working in the garden or residing in the house built on top of the disposal facility. This excavation scenario would only apply to the No Action Alternative. The thickness of the barriers installed in the action alternatives is assumed to preclude excavation into the waste.

The excavation scenario provided the greatest estimated impacts for intruder scenarios. This result was because the excavation intruder exhumed the most waste and contaminated soil that was spread about the garden. Total doses and the associated probability of an LCF from the excavation scenario are listed in Table 5.149. For intrusion by excavation in the year 2146, the intruder's lifetime dose was estimated to be 14,000 rem, and the probability of acute adverse health effects (including possible fatality) from such a dose would be high.

Table 5.148. Maximum Impacts to an Individual from Drilling into Low Level Burial Grounds

Consequence	Time Since Year 2046					
	100 Years	**200 Years**	**300 Years**	**500 Years**	**1000 Years**	**10,000 Years**
Total Dose (rem)	65	6.2	0.69	0.11	0.097	0.083
Maximum Dose from Single Radionuclide (rem)	34	3.5	0.35	0.038	0.038	0.038
Radionuclide Giving the Maximum Dose	Cesium-137	Cesium-137	Cesium-137	Uranium-238	Uranium-238	Uranium-238
Prob. of LCF[(a)]	4.0E-02	4.0E-03	4.0E-04	7.0E-05	6.0E-05	5.0E-05

(a) The probability of a latent cancer fatality is calculated using p(LCF) = (0.0006)(dose in rem).

Table 5.149. Maximum Impacts to an Individual from Excavation into Low Level Burial Grounds

Consequence	Time Since Year 2046					
	100 Years	200 Years	300 Years	500 Years	1000 Years	10,000 Years
Total Dose (rem)	14,000	1400	150	23	21	18
Maximum Dose from Single Radionuclide (rem)	7,400	740	75	8.1	8.1	8.1
Radionuclide Giving the Maximum Dose	Cesium-137	Cesium-137	Cesium-137	Uranium-238	Uranium-238	Uranium-238
Prob. of LCF[a]	[b]	0.8	0.09	0.01	0.01	0.01

(a) The probability of a latent cancer fatality is calculated using p(LCF) = (0.0006)(dose in rem).
(b) This health effects coefficient for estimating the probability of LCF is not applicable at high doses and dose rates.

5.11.2.2.4 Biotic Intrusion

Intrusions into uncapped or vegetation-controlled disposal facilities by deep-rooted plants and burrowing animals are known vectors for contamination migration to the surface environment and thus might pose a potential for radiological exposure for onsite workers (Johnson et al. 1994). In addition, intrusion into LLBGs by small burrowing animals has been documented by Hakonson (1986) and Perkins et al. (2001). Known biotic vectors on the disposal facilities have included, in order of frequency, Russian thistle, also known as tumbleweed (*Salsola kali*), western subterranean termite (*Reticulitermes hesperus*), harvester ant (*Pogonomyrmex owyhee*), northern pocket gopher (*Thomomys talpoides*), Townsend's ground squirrel (*Spermophilus townsendii*), and badger (*Taxidea taxus*). A biological control program designed to specifically deal with biotic vectors has been in place on the Hanford Site since 1998, and incidents of biotic-related contamination spread have decreased from a high of 130 incidents in 1999 to 41 in 2001 (Markes and McKinney 2001).

During and after the operational period, the deep-rooted plant of concern is the Russian thistle (DOE-RL 1998), a nuisance weed that has a rooting depth of up to 4.6 m (15 ft). Russian thistle grows in any type of well-drained, un-compacted soil with sunny exposure. Russian thistle could colonize uncapped disposal facilities if they were left fallow for one or more growing seasons. In particular, soil-to-plant concentration ratios for strontium-90 uptake in tumbleweeds can exceed 10 because of a naturally occurring oxalate chelator exuded by the plant roots. To avoid spread of contamination in the disposal facilities during the operational period, waste would be covered with clean soil and the soil surface would be kept free of weeds and burrowing animals through the use of herbicides and other control measures as needed. Biotic intrusion into HICs and in-trench grouted wastes would not be expected to occur.

In all alternative groups except the No Action Alternative, a Modified RCRA Subtitle C Barrier would be placed over the HSW disposal facilities. Although Russian thistle roots might occur in the upper layers of the barrier, a 25-cm (10-in) layer of asphalt just above the trench backfill (at grade) would discourage both deep-rooted plants and burrowing animals.

In the No Action Alternative, only the MLLW trenches would be covered with the Modified RCRA Subtitle C Barrier and, as a consequence, avoidance of surface contamination by tumbleweeds would likely rely on use of herbicides or cultivation of certain species like wheatgrass that would choke out the tumbleweeds and provide for evapotranspiration and reduction in infiltration of water into the waste sites.